

FASTEC Imaging

HIGH-SPEED IMAGING IN THE PALM OF YOUR HAND



TS3, TS4 and TS5 High-Speed Cameras Operator's Manual

Firmware / Software Version 2.5.x

2021-5

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Reader Response

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1 Product Overview

1-1 Product Description

The Fastec TSx is a high-speed digital camera line with models capable of capturing high resolution 1920 x 1080-pixel images at 634 frames per second and smaller-resolution images at much higher frame rates. Recording image data at high frame rates makes it possible to play back high-quality video sequences in slow motion, enabling the user a greatly enhanced ability to analyze events that occur much too quickly for human vision to perceive.

The TSx, with its many modes of operation, including its unique stand-alone capabilities and its high-speed imaging performance, resolution, and sensitivity, make it an excellent choice for many different applications. For ad hoc testing and troubleshooting, when setup time is precious, the TSx comes through as a point and shoot camera. For multi-camera use or where the camera might be set up and left in more remote applications, its networking and master/slave capabilities come into play. When the action becomes fast and furious, FasFire mode helps to capture many triggered events. When triggering is not an option and for very long events, models with LR Recording (LR) modes capture all the action by streaming image data to built-in SSDs.



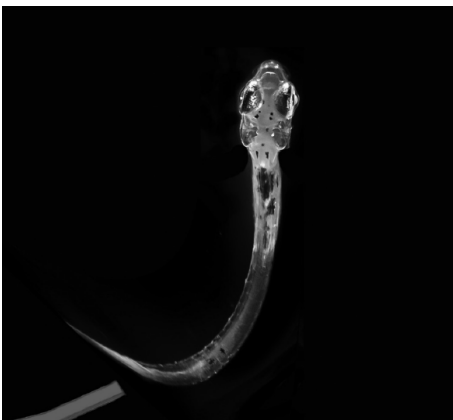
Fastec Imaging high-speed cameras are used in hundreds of different industrial manufacturing sites to analyze motion in machinery and production line processes. Reduce jams, optimize line setup and changeovers, lower scrap and rejected material costs and reduce downtime and maintenance expenses.

Universities worldwide use Fastec cameras for a variety of research studies such as animal locomotion, mechanical engineering, flow visualization, combustion studies, biomechanics & kinesiology, physics, chemistry, tensile testing and more.

High-speed cameras are used in mining and blasting applications to determine the effects of blasts on structures or vehicles or determine the actual firing times of blast holes and the nature of the rock movement. Delay detonators provide the timing blasts

needed under specific blasting conditions. Blast holes firing at incorrect times reduce rock fragmentation, effect blast movement and can increase blast vibrations.

Military customers worldwide use high-speed video to design and test weapons as well as countermeasure and defensive systems and components. TSx cameras have been used for “chase plane” applications such as airborne stores separation and in-flight aeronautics testing.



1-2 Models

Fastec Imaging sells several different TSx high-speed digital camera models. These cameras are offered in either monochrome or color with various high-speed digital-image recording capabilities using a wide range of recording rates, sensor resolutions, and on-board memory options. All cameras are equipped with a standard C-mount lens mount, and 1/4-20 tripod mount. Additional lens mount options are available.

All TSx cameras support the following modes of operation:

- Stand-alone operation: A built-in 7" LCD touch display, SSD, SD Card, USB port, and battery power allow it to be fully functional without the connection to a host control device such as a computer.
- Remote operation using FasMotion software installed on a computer or using the Fastec Web Application. With the Web Application, any host device with a common Web browser may be used to control the camera.

TS3L models have a maximum frame rate of 1250 fps, which they can do at their maximum resolution of 800 x 600.

TS3S and TS4 models have a maximum frame rate of over 60,000 fps at a small resolution (48 x 32) and a maximum resolution of 1280 x 1024, at which it can record at 510 fps. See "Appendix D: TS3 / TS4 Record / Resolution Tables" on page 93.

TS5 cameras are based on a 12-bit 5 Megapixel sensor. All models make use of the advanced feature set of this sensor, which include features not available on the TS3 or TS4, specifically binning and sub-sampling.

All TS4 cameras as well as TS3 and TS5 cameras with the "D" (Dual mode) can be operated in "Long Record" mode in which they record directly to an onboard SSD instead of to volatile memory. While the very highest record rates are only possible in "Standard" mode (recording to memory), high-speed recordings of much longer durations are possible in Long Record mode.

The TSx camera housing is made of 100% machined aluminum with a black anodized finish. It is both attractive and extremely durable. LEMO connectors are used for critical power and Sync/Trigger connections. An aluminum side panel door protects USB-OTG, HDMI, Gig-E, Sync/Trigger, and Power connectors as well as the SD card slot when the camera is operating in stand-alone mode. Power is supplied by an AC power adapter or a high-capacity Li-Ion battery.

Table 1-1: TSx Models

Camera	Max Resolution @ fps	Standard Memory	Max Memory	Sensor Size (No Binning / Subsampling)	Optional Solid-State Drive
TS3L	800 x 600 @ 1250fps	4GB	8GB	14mm	256GB* / 512GB/ 1TB / 2TB
TS3S	1280 x 1024 @ 510fps	4GB	8GB	22.9mm	256GB* / 512GB/ 1TB / 2TB
TS4	1280 x 1024 @ 510fps	8GB	8GB	22.9mm	512GB / 1TB/2TB
TS5L	800 x 600 @ 1677fps	4GB	8GB	5mm	256GB* / 512GB/ 1TB / 2TB
TS5S	1280 x 1024 @ 991fps	4GB	8GB	8.2mm	256GB* / 512GB/ 1TB / 2TB
TS5H	1920 x 1080 @ 634fps	4GB	8GB	11mm	256GB* / 512GB/ 1TB / 2TB
TS5Q	2560 x 2048 @ 253fps	4GB	8GB	16.4mm	256GB* / 512GB/ 1TB / 2TB

More example frame rates including rates for LR modes are listed in "Appendix D: TS3 / TS4 Record / Resolution Tables" on page 93 and "Appendix E: TS5 Record / Resolution Tables" on page 98.

*256GB SSDs are not available on Dual Mode cameras

1-3 Controls, Indicators, and Connectors

Table 1-2: Camera Part Locations

Camera Part	Link to View
LED Indicators	"Figure 1-1: TSx Back View" / "Figure 1-2: TSx Front View"
Arm Button	"Figure 1-1: TSx Back View"
Display Button	"Figure 1-1: TSx Back View"
Menu Button	"Figure 1-1: TSx Back View"
D-Pad (Directional Pad)	"Figure 1-1: TSx Back View"
Trigger Button	"Figure 1-3: TSx Top View"
ON/OFF Button	"Figure 1-3: TSx Top View"
Strap Attachments	"Figure 1-3: TSx Top View" / "Figure 1-5: TSx Bottom View"
C-Mount	"Figure 1-2: TSx Front View"
C-Mount Lock Screws	"Figure 1-3: TSx Top View" / "Figure 1-5: TSx Bottom View"
Lens Mount Holes	"Figure 1-3: TSx Top View"
1/4-20 Tripod Mounts	"Figure 1-3: TSx Top View" / "Figure 1-5: TSx Bottom View"
USB Port	"Figure 1-3: TSx Top View"
USB OTG Port	"Figure 1-4: TSx Side View (Door open)"
SD Card Slot	"Figure 1-4: TSx Side View (Door open)"
Gig-E Connector	"Figure 1-4: TSx Side View (Door open)"
Sync I/O Connector	"Figure 1-4: TSx Side View (Door open)"
HDMI Connector	"Figure 1-4: TSx Side View (Door open)"
Power Connector	"Figure 1-4: TSx Side View (Door open)"
Battery Door	"Figure 1-5: TSx Bottom View"
Battery Door Latch	"Figure 1-5: TSx Bottom View"
Battery Clasp	"Figure 1-5: TSx Bottom View"

Figure 1-1: TSx Back View

Note: See "Appendix M: Physical Measurements" on page 118 for dimensions.

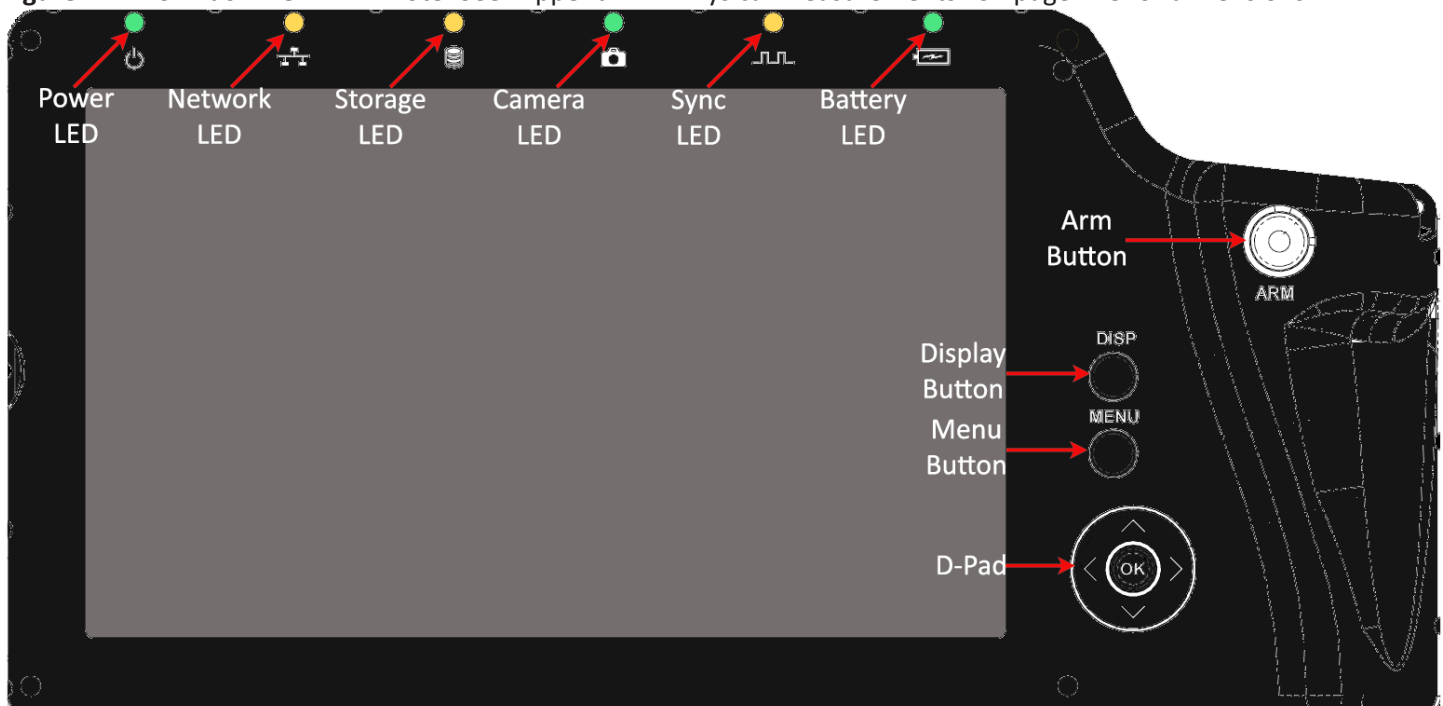


Figure 1-2: TSx Front View

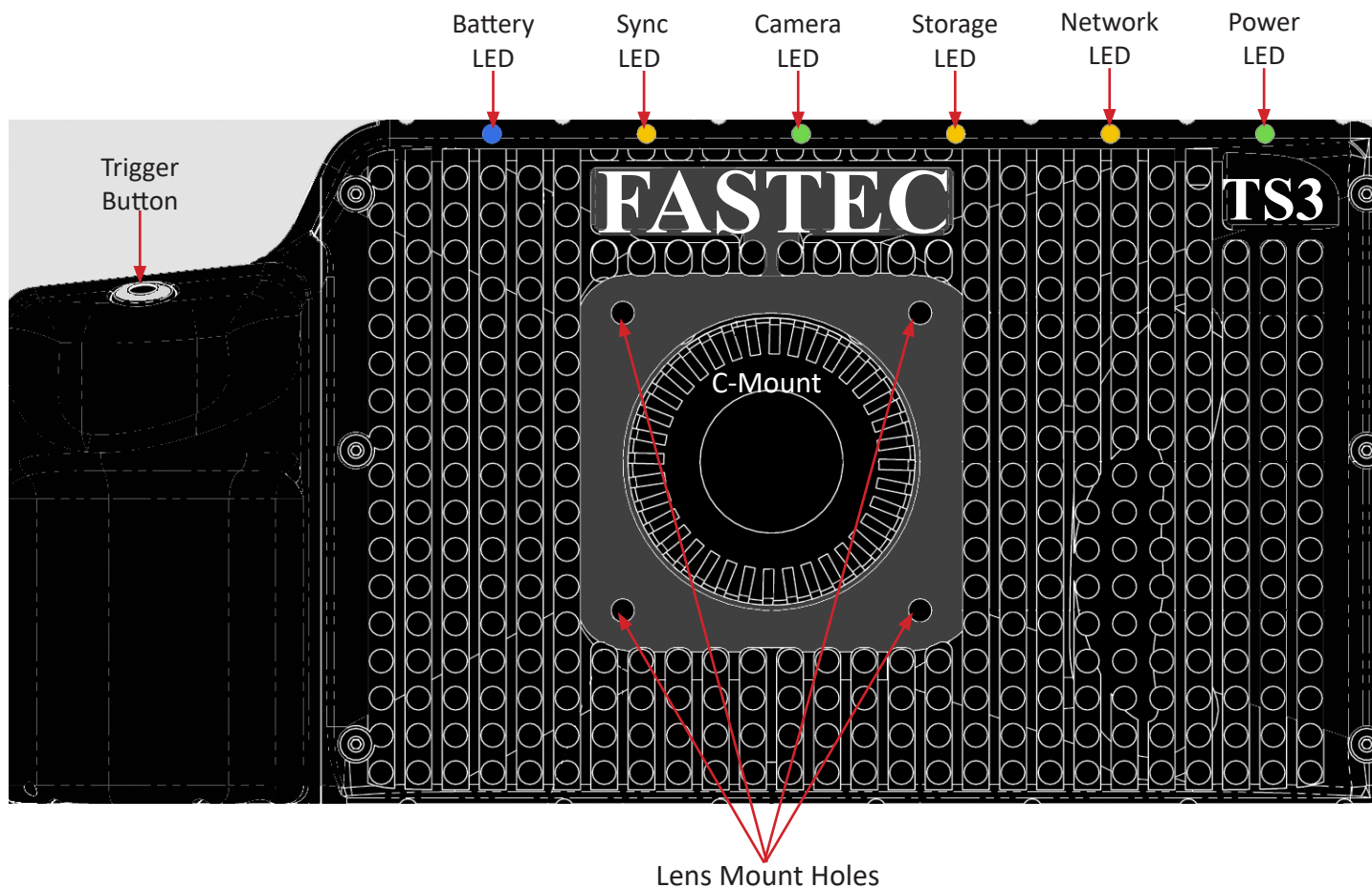


Figure 1-3: TSx Top View

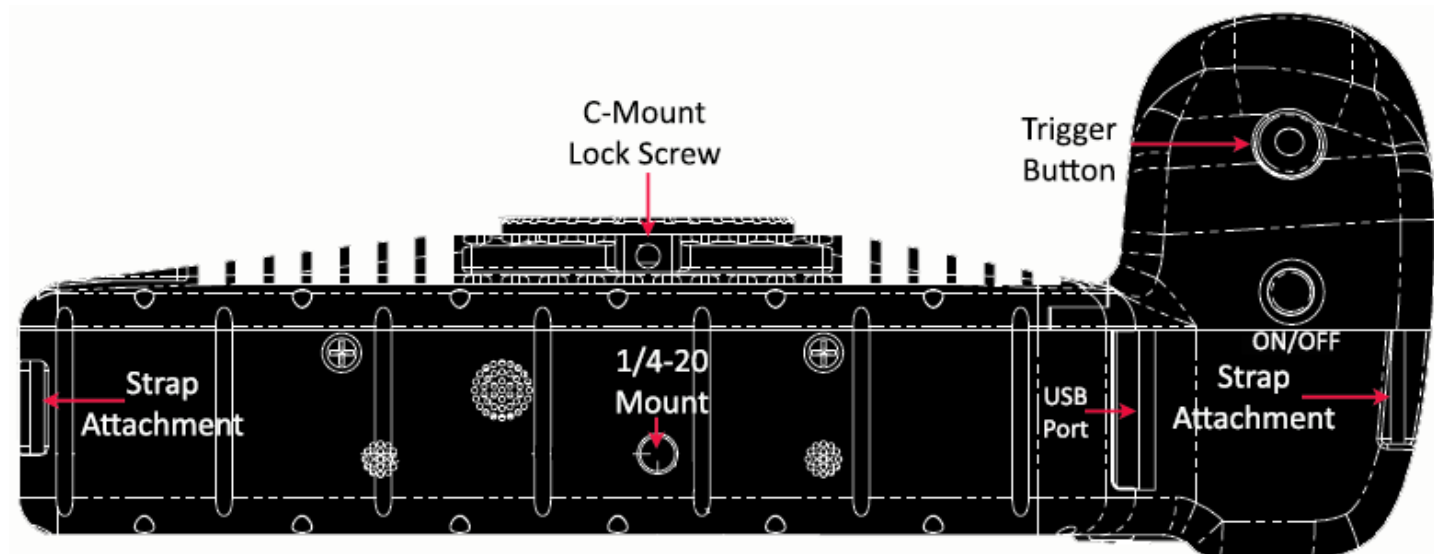


Figure 1-4: TSx Side View (Door open)

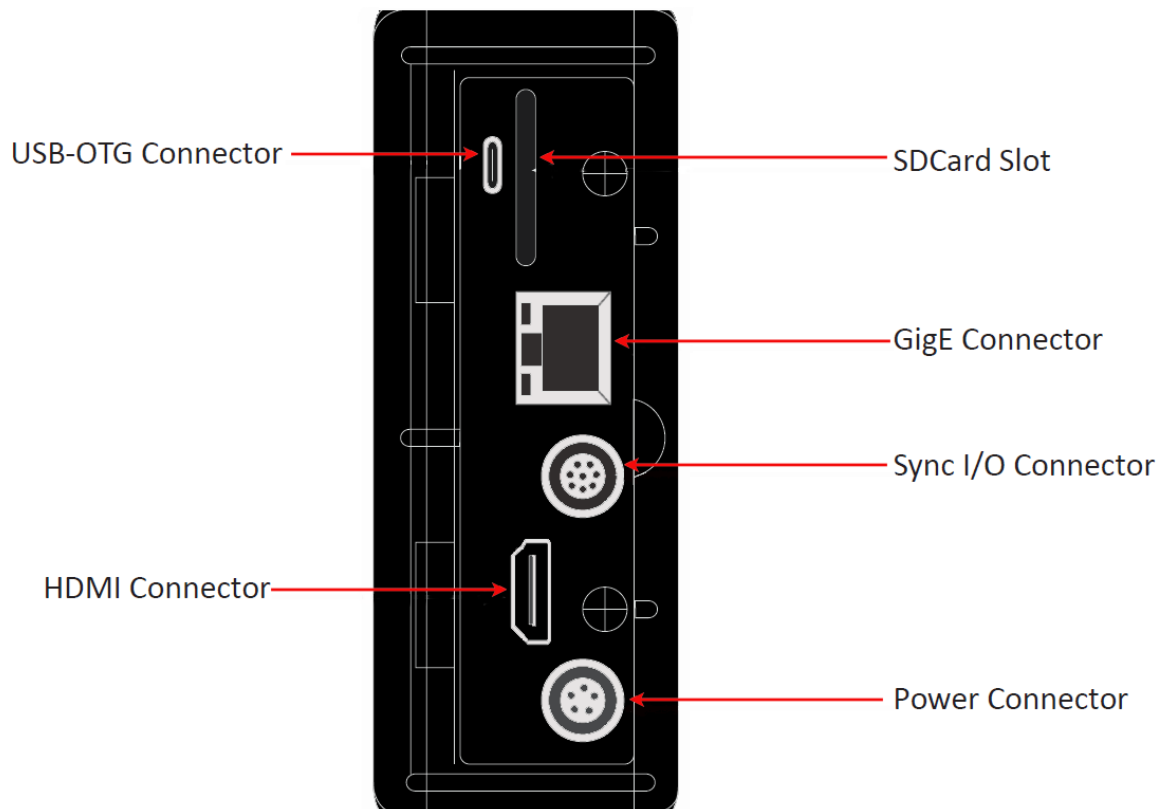
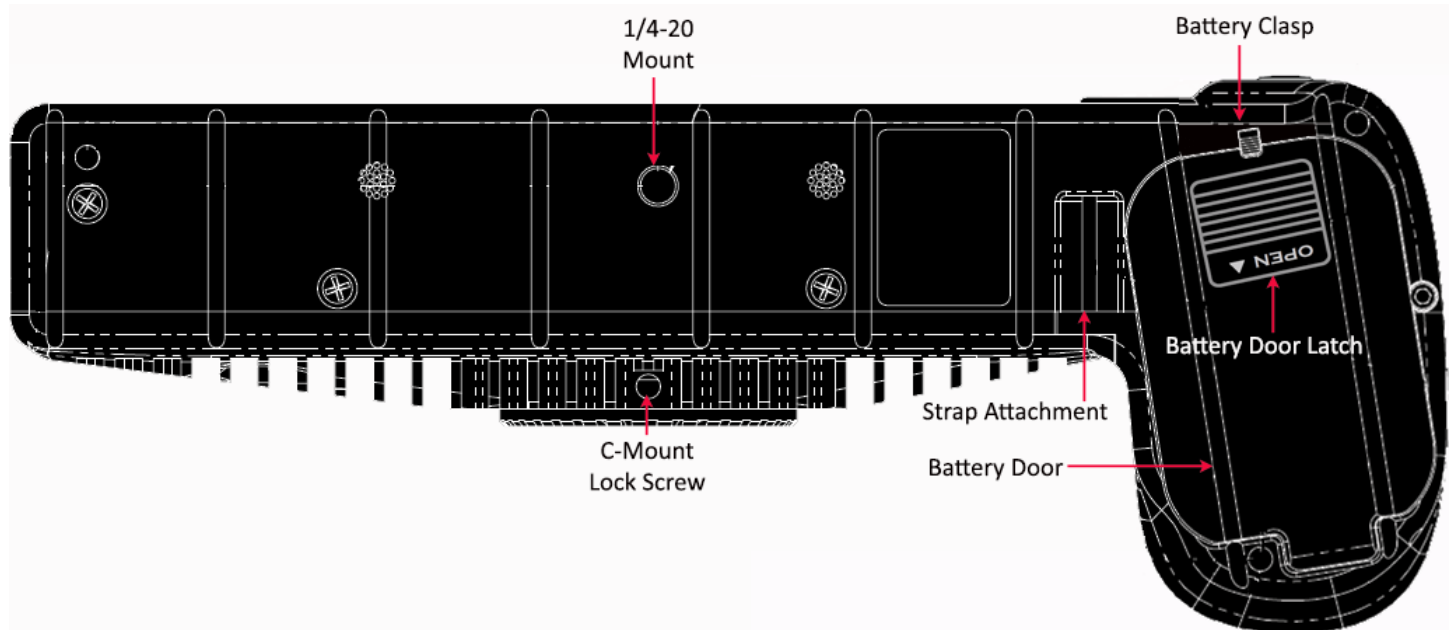


Figure 1-5: TSx Bottom View



1-4 Care and Maintenance of the TSx

Camera Exterior

The TSx exterior is made of durable anodized aluminum.

- Do not allow moisture to penetrate the camera case
- Clean exterior with a lint-free cloth.
- Do not use reagents, solvents, or adhesives.

TSx Touch Display

- Take care with the glass on the display as it may break if it is struck or if the camera is dropped.
- Avoid contacting the display with sharp objects as the thin polarizing membrane may be scratched.
- Wipe off any water droplets from the display as they may cause spots.
- Clean the display with a soft cotton or microfiber cloth.
- Do not leave the display in direct sunlight for extended periods of time as it is sensitive to ultraviolet light.
- Do not leave a fixed image on the display for extended periods of time as image retention may occur.

Optics

When changing lenses or lens mounts, be sure to keep the optical opening covered and clean. Any contamination on the camera optics may result in blemishes on the images.

- Remove dust or dirt from the filter glass with air whenever possible. Use air from a squeeze bulb or compressed air can.
- Use a lens pen or brush, if necessary, to remove dust.
- Never use household glass cleaners or solvents on optical surfaces.

Camera Storage

- Store the camera in a dust-free protective bag or box, preferably in a cool dry space.
- Never store the camera in the presence of oxidizing agents, solvents, or any other types of reactive chemicals.
- Remove the battery if the camera will not be in use for more than a few days.
- **Always charge batteries to about 40% before storing.** If the cell voltage drops too low, the battery will not perform optimally and may completely lose its ability to keep a charge.

Battery Contact Cleaning

TSx batteries and internal battery connectors both have gold-plated contacts that are not subject to corrosion. These contacts may build up a film of contaminants over time that might affect battery performance.

- Clean battery connector pins with DeoxIT® or similar product every two to three months. (See "Appendix Q: Battery" on page 125.)

1-5 Getting Help

Contact Your Distributor:

Your Fastec distributor is eager to help and is always interested to get updates regarding your application, successes, and challenges. They may direct you back to the factory for support but will want to follow up with you to ensure that your issues are addressed.

If you are unsure how to contact your distributor, please visit <http://www.fastecimaging.com>

Fastec Contact Information:

You may contact Fastec directly by email or phone with any questions regarding camera setup and imaging workflow for your application or with any problems you may have using the camera.

TSx cameras were designed for remote access. It is possible for the support staff at Fastec to logon to your camera via the internet using a remote desktop application such as TeamViewer to help diagnose and resolve any issue you may have.

If your camera ever requires shipment back to the Fastec factory for upgrades or repairs, make sure to get the proper RMA number and shipping instructions from Fastec before shipping.

Email: Support@fastecimaging.com

Phone: (858) 592-2342

2 Getting Started

2-1 Unpacking the Camera

Table 2-1: Package Contents:

Part	STD	OPT	Part #
C-Mount (factory installed and adjusted on the camera)	X		
F-Mount (factory installed and adjusted on the camera)		X	1105-0200
PL-Mount (factory installed and adjusted on the camera)		X	1105-0115
DC Power Supply-- 110/220VAC, 50/60Hz, 12V @ 4.17A, with IEC-320 C8 AC inlet and 5-pin LEMO connector (no power cord included)	X		1105-0250
16 GB SDHC Card	X		1105-0261
32 GB SDHC Card		X	1105-0262
I/O Cable 18": 8-pin LEMO camera connector and 3 BNC connectors for Sync-In, Sync-Out, and Trigger-In / or up to 3 Markers	X		1105-0401
I/O Cable 18": 8-pin LEMO camera connector and 6 BNC connectors for Sync-In, Sync-Out, Trigger-In, Trigger-Out, Arm-In and Arm-Out / or up to 6 Markers		X	1105-0405
Wireless 802.11n USB WiFi Adapter		X	1105-0275
Documentation and Software (on thumb drive)	X		
Battery--Rechargeable Li-Ion 3.7V 15,600mAh (Battery comes fully charged from factory)	X		1105-0050
Battery Charger including 100/240VAC to 12V Power Supply		X	1105-0125
External 12V Li-Ion Battery Pack, 98Wh, w/charger, 4-pin XLR to LEMO cable		X	1105-0253
External 12V Battery Belt, 144Wh, w/charger, LED power gauge, 4-pin XLR to LEMO cable		X	1105-0254
Hoodman 7" LCD Display Cover for glare protection		X	1105-0330

2-2 Installing the Lens

The camera is shipped with a C-mount lens adaptor installed and adjusted at the factory. To install a C-mount lens, follow these steps:

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

NOTE: There are many C-mount lens formats and focal lengths available. The 22.9mm diagonal sensor of the TS3/TS4 is larger than the light circle produced by many C-mount lenses. This is especially true for wide angle lenses, but it is dependent on lens design and format. Vignetting (darkening at the edges of the image) will occur when the image on the sensor, the size and location of which is dependent on resolution and image offset, is not covered by the image circle of the lens. (See "Table 2-2: Lens Selection".)

2. Remove the lens receptacle cover from the camera's C-mount. This is a cover that is installed at the factory to protect the camera optics and sensor from dust contamination.

NOTE: Whenever threading lenses on or off the camera, face the camera lens down so that any contamination on the threads will tend to fall away from the camera rather than into it.

3. Thread the C-mount lens into the lens mount located in the front of the camera. DO NOT over tighten the lens! The lens should be "finger-tight" only--just tight enough that you can adjust focus and aperture without unscrewing the lens.

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

Table 2-2: Lens Selection

Resolution	Sensor Diagonal		Required Lens Format to avoid noticeable Vignetting		Field of View From 10M with 50mm Lens	
	TS3/TS4	TS5*	TS3/TS4	TS5*	TS3/TS4	TS5*
2560 x 2048	NA	16.4mm	NA	1"	NA	2.5 x 2.0m
1920 x 1080	NA	11.0mm	NA	2/3"	NA	1.9 x 1.1m
1280 x 1024	22.9mm	8.2mm	4/3"	1/2"	3.6 x 2.9m	1.3 x 1.0m
1024 x 1024	17.5mm	7.2mm	4/3"*	1/2"	2.9 x 2.9m	1.0 x 1.0m
1280 x 720	20.5mm	7.35mm	4/3"	1/2"	3.6 x 2.0m	1.3 x .7m
800 x 600	14mm	5mm	1"	1/3"	2.2 x 1.7m	800 x 600cm
640 x 480	11.2mm	4mm	2/3"	1/3"	1.8 x 1.3m	640 x 480cm
320 x 256	5.7mm	2mm	1/3"	1/3"	900 x 700cm	320 x 256cm

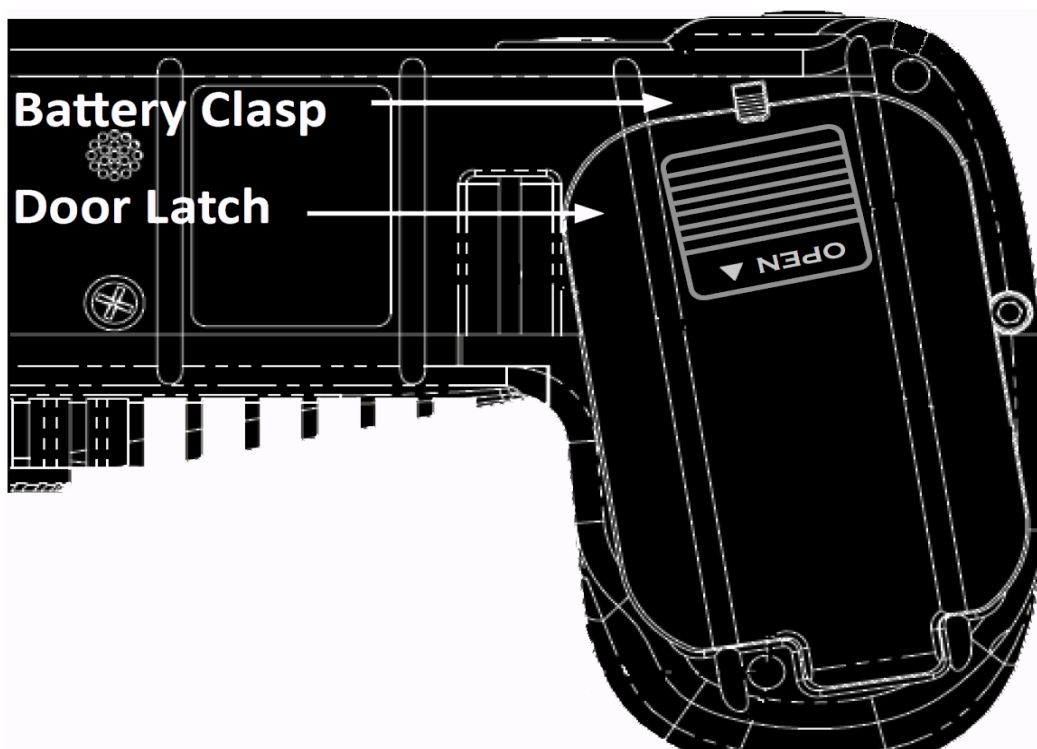
*The 17.5mm diagonal @ 1024 x 1024 is slightly larger than the 16mm specification for 1" C-mount lenses. Many, but not all 1" format lenses will satisfactorily cover this resolution.

This table assumes that the images are centered (no custom offset applied). (See "Offset Control:" on page 31.) It also assumes that binning and sub-sampling are not employed on the TS5.

Note: All F-mount and PL-mount lenses will easily cover the full 22.9m full resolution image plane.

2-3 Powering Up, Charging, and Power Down

Figure 2-1: Battery Access Door



The camera can be powered by its rechargeable 3.7V Li-Ion battery, the external 12V power supply, or one of the optional external batteries. The battery is fully charged at the factory and is shipped inside the camera. The battery door is located on the underside of the camera.

The Li-Ion battery will power the TSx for up to several hours, depending on configuration and mode of operation. See "Figure 6-14: TS5 Advanced Calibration Dialog" on page 84 and "Application Note 8: Running the TSx on Batteries" on page 86.

Removing the Battery

1. Turn the TSx upside down to access the battery compartment.
2. Slide the battery door latch to the “open” position. The spring-loaded door will open.
3. Move the battery clasp away from the edge of the battery and pull on the battery strap.

Installing the Battery

1. Open the battery door (follow steps 1-2, above).
2. Look into the battery compartment and notice the connector at the bottom and the battery strap.
3. Position the battery strap within the compartment so that it has enough slack to accommodate the battery but will not bunch up when the battery is installed.
4. Orient the battery appropriately and slide it into the compartment.
5. With the battery seated properly in the compartment, the battery clasp will close, securing it in place.
6. Fold the loose end of the battery strap over the top of the battery and close the battery access door.
7. Slide the battery door latch closed.
8. The TSx should now power up. If it does not, please follow the instructions below for connecting the DC power supply and charging the battery.
9. Press the Menu button once to get the menus and status bar to appear on the LCD display.

Attaching the External DC Power Supply

The 12V DC Power Supply operates on 100-240VAC, 50-60Hz. The socket is a standard IEC-320 C8 AC inlet, used worldwide for all types of electronic equipment. The power supply is shipped without power cord so that the user may use one appropriate for local power outlets.

1. Attach a power cord to the power supply and connect it to an AC power outlet.
2. Attach the power supply output cord to the camera via LEMO connectors. Note that the LEMO connector is keyed: the red dot on the connector will face the LCD side (back) of the camera.

Powering Up

The TSx will power up when:

- Power (12v to 26v DC) is applied at the Power In connector (see “Figure 1-4: TSx Side View (Door open)” on page 5).

Or:

- A charged battery is inserted into the camera.

Or:

- The camera is connected to a power source and/or has a battery installed and the Power On/Off button is pressed (see “Figure 1-3: TSx Top View” on page 4).

Figure 2-2: Power Up / Charging Menu (TS3 / TS5)

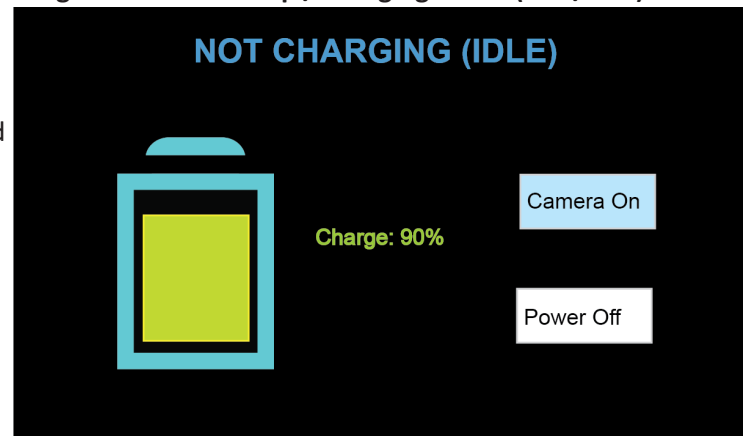
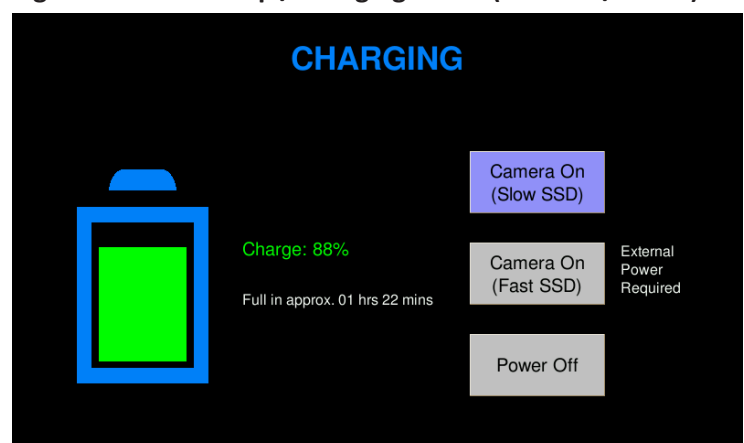


Figure 2-3: Power Up / Charging Menu (TS4-LR3 / TSx-D)



Upon power up, the camera will either boot up in an operational mode or, if it is connected to an external power supply and a battery is installed, it will boot to a power up / charging menu.

The power up / charging menu is different for TS4-LR3 and TSx-D cameras that support “fast” Long Record Mode. For these cameras you have a choice of using the camera in “Slow SSD” or “Fast SSD” modes. “Slow SSD” means that writes to the SSD will be at about 240MB/sec, while “Fast SSD” bumps the write speed up to 480MB/sec. On cameras licensed for both internal and external SSDs, use the “Slow SSD” selection for the external SSD.

It is highly recommended that you use an external power supply such as an AC adapter or battery belt when using “Fast SSD” mode. See “Application Note 8: Running the TSx on Batteries” on page 86 and “Appendix Q: Battery” on page 125.

At the power up / charging menu, select “Camera On” to boot the camera. If you do nothing, the camera will proceed to charge the battery.

WARNING: The battery charge % is calibrated to Standard Basic mode operation, please read “Application Note 8: Running the TSx on Batteries” on page 86.

Figure 2-4: Battery Charge Indicator on Status Bar

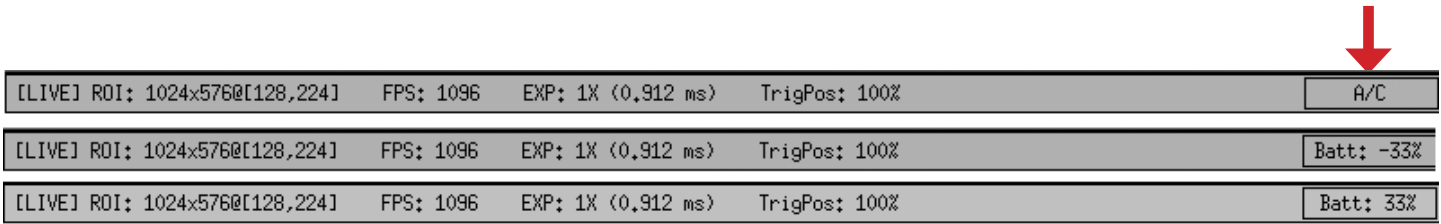


Figure 2-5: Charging Menu

Note: While operating on battery power the Battery Status on the Status bar will show a negative number (See Figure 2-4.) When connected to a power supply (with the battery installed) the number becomes positive. If no battery is present it changes to A/C.

Charging

While the camera is charging, the TSx display will turn off and the battery LED will blink green, amber or red; depending on the percentage of charge (see Table 2-3). The charging menu will still be available by clicking on the Menu button or by touching the screen (if touch is enabled).

The Charging menu reports the charge percentage and the approximate time for a full charge. From the Charging menu you may also restart the TSx by selecting “Camera On” or Power Off by selecting “Power Off.”

Powering Down

If you press the ON/OFF button while the camera is operating, you will see a message on the display asking if you wish to turn the camera off (Figure 2-7).

- If you click “Cancel” or “MENU” the camera will return to its previous operating state.
- If you do nothing, the camera will wait approximately 60 seconds, and then either begin charging

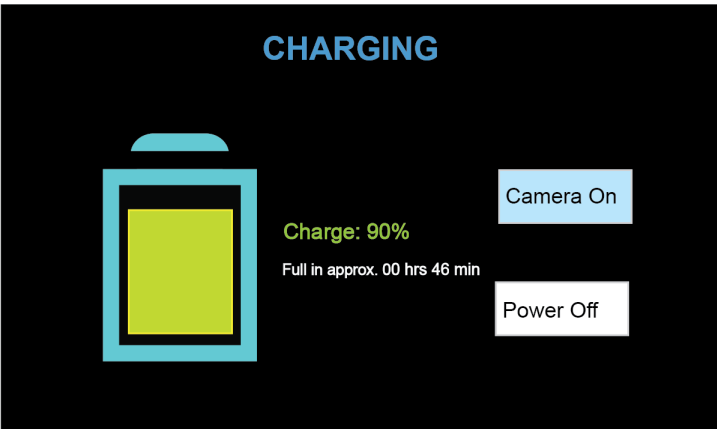
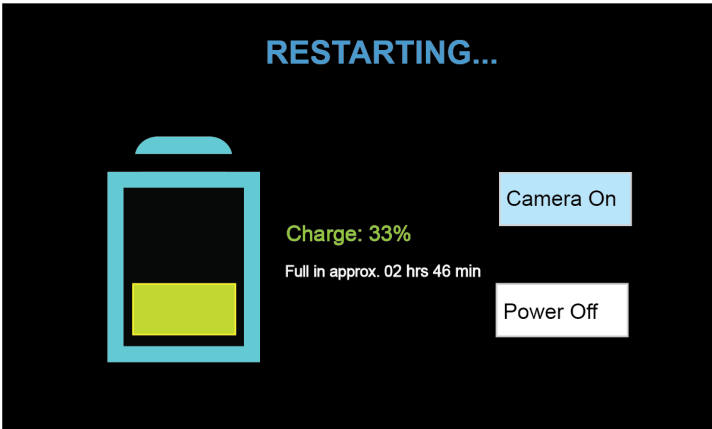


Figure 2-6: Restarting Menu



(if there is a battery installed that is not fully charged and it is connected to a power source) or it will power down.

- If you click on “Power Off” it will power down.

Note that when you power the camera down in this manner all the settings currently in the camera, including all Record and Control settings, will be saved and asserted the next time the camera powers up.

This feature is particularly helpful when you want the camera to boot with Autosave enabled.

Panic Shutdown

Like most electronic devices, the TSx will shut down in “panic” mode if the power button is held down for a few seconds. This method of shutdown acts just the same as removing power from the camera.

When the TSx is powered down by either removing power, or holding the power button down, it is not able to save its current settings. The next time the camera powers up, it will use the last saved settings available.

For more information on the battery, see “Application Note 8: Running the TSx on Batteries” on page 86 and “Appendix Q: Battery” on page 125.

Figure 2-7: Power Off Warning

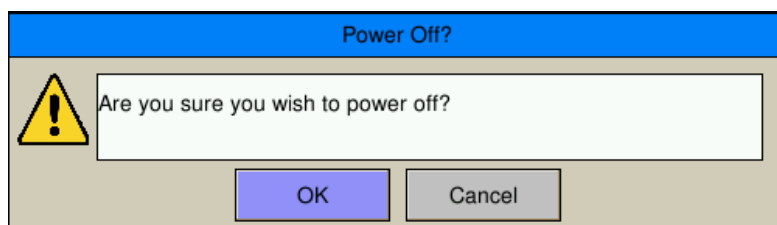


Figure 2-8: Power Off Menu

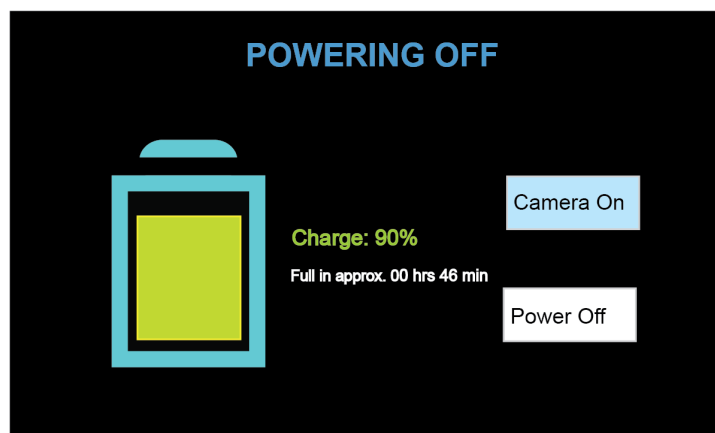










Table 2-3: Battery LED States

The Battery LED changes color depending on the level of charge.

LED Behavior	
	Blue when no battery is present
	Blinking Green when operating on battery and charge is above 40%
	Blinking Amber when operating on battery and charge is above 20%, below 40%
	Blinking Amber (fast) when operating on battery charge is above 10%, below 20%
	Blinking Red (fast) when operating on battery and charge is below 10%
	Solid Green when operating from external power, battery above 40%
	Solid Amber when operating from external power, battery between 10% and 40%
	Solid Red when operating from external power, battery below 10%

2-4 TSx Memory and Mass Storage Options

The TSx camera is equipped with 4GB or 8GB of internal high-speed internal memory. Images stored in this memory may be reviewed on the camera, external monitor via HDMI, or PC and then saved to any of four types of mass storage devices:

1. Solid State Hard drive (optional on the TS3 and TS5) (internal SATA SSD or external eSATA SSD).
2. SD cards (SDHC) inserted by the operator into the SDHC slot on the side of the TSx.
3. USB devices such as thumb drives or USB external hard drives connected via the USB port.
4. Memory devices on networked PCs using FasMotion software (not Web Browser).

Solid State Hard Drives (SSDs)

Solid state drives (SSDs) in sizes up to 2TB are available on the TS3, TS4 and TS5. (See “Table 1-1: TSx Models” on page 2.) These drives serve as mass storage devices for the camera. Image data from the TSx’s high-speed internal memory may be downloaded to the SSD, thus making room for the next high-speed image capture. While the SSD does not add to the recording time of the camera operating in Standard mode, it does allow the user to download large quantities of image data without ever connecting the TSx to a PC or other external device.

SSDs on the TS4, TS3-D, and TS5-D

SSDs are standard equipment on all “Dual Mode” cameras, which include the TS3 and TS5 with the “D” option and the TS4. They may be used as described above, or in Long Record mode whereby the image data is streamed directly to the SSD, thereby greatly adding to the record time.

SD Card (SDHC only)

The TSx is shipped with a 16GB SDHC SD card. (32GB cards are an available option). This card has two functions:

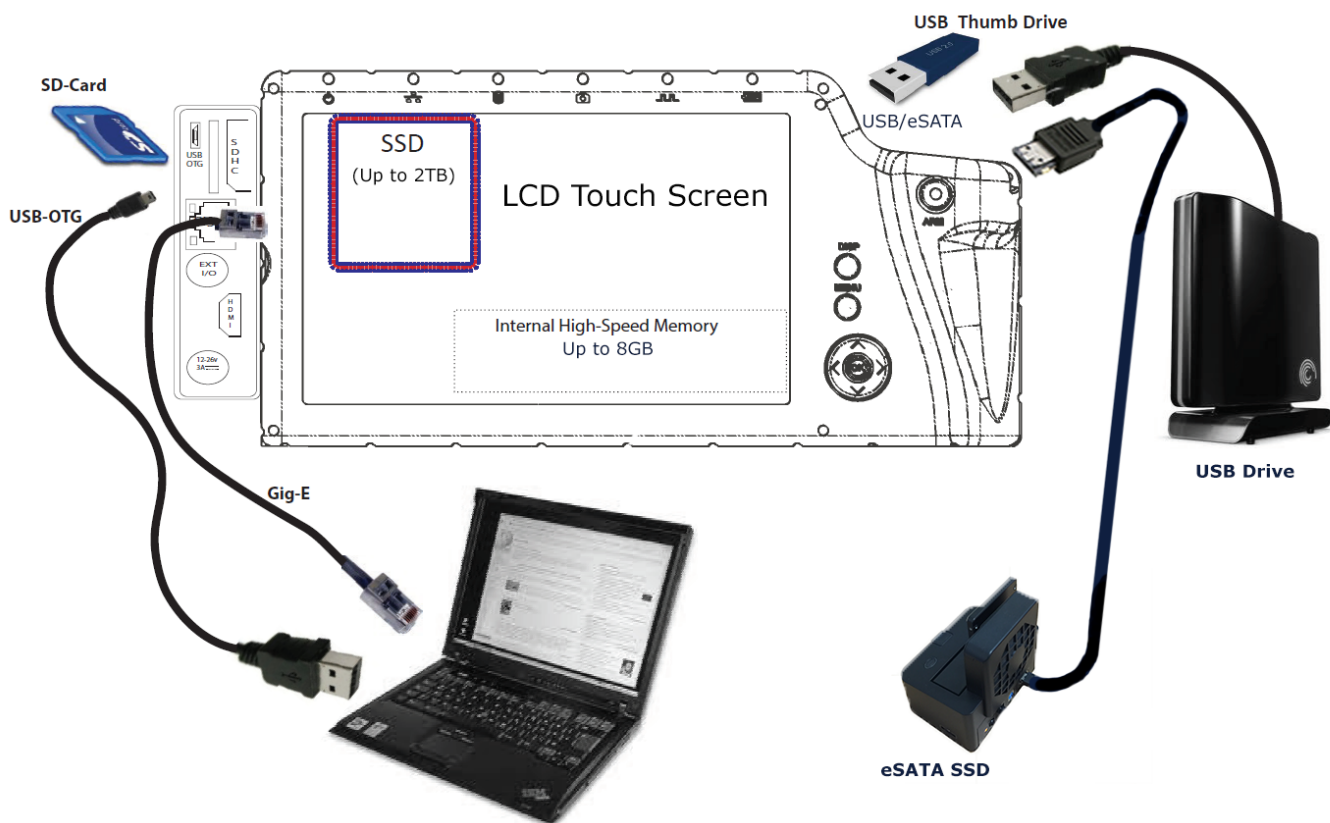
- It can be used as a mass storage device for downloading and distributing images. SD cards and card readers are very commonly used storage devices among PC users and photographers.
- Any field software updates for the TSx from Fastec will be installed via the SD card.

Note: An SD card when used for a software update must be reformatted before it can be reused as a mass storage device. See “Appendix L: TSx Updates” on page 116.

USB Port (USB 2.0)

The TSx will act as a **Host** to any USB 2.0 mass storage device connected at the USB port. (See “Figure 1-3: TSx Top View”.)

Figure 2-9: Mass Storage



USB-On the Go!

The USB-OTG port allows the camera to be connected as a slave to any PC, using a USB-A to USB-Micro-B cable. Once connected via the TSx's OTG port, any FAT-32 formatted mass storage device on the camera can be accessed by the PC. This includes an SD card, Solid State Drive, or thumb drive in the USB port.

Note: This is not supported for the SSD when in Long Record mode because the drive cannot be formatted FAT-32 for streaming.

1. Install thumb drive and/or SD card in the camera. (Any device that is connected to the camera *after* the camera and PC are connected will not be seen by the PC.)
2. Attach the camera to the PC via the camera's USB-OTG port, which is next to the SD card slot on the side of the camera. (See "Figure 1-4: TSx Side View (Door open)" on page 5.) As each device is located by the PC an Autoplay window on the PC will open.
3. Copy files from camera media to PC (not back to camera), and then eject the media from the PC.

Note: Use this method for relatively small image transfers. Much faster and more efficient workflows are available using FasMotion.

Figure 2-10: USB-OTG on the TSx

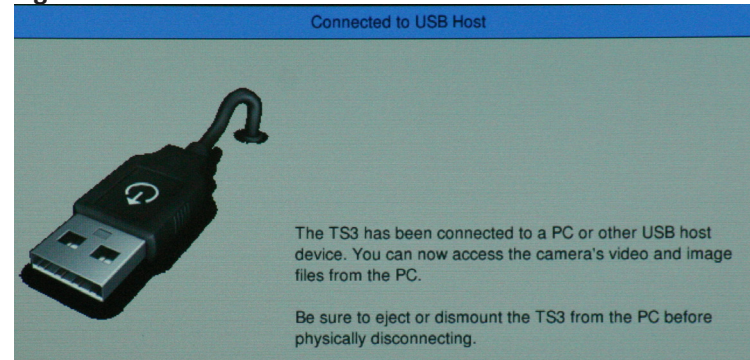


Table 2-4: TSx Mass Storage Functionality

Camera Utilities:	Target Drive(s)	Functions
System/Storage/Explore	SSD/USB/SDHC	Move, Copy, Delete, Load CAP file, review metadata of Image files*
System/Storage/Format	SSD/USB/SDHC	Format drive
System/Storage/Eject	USB/SDHC	Safely Eject Media
Review/Save	SSD/USB/SDHC	Save image Data from Internal High-Speed Memory
Record Still	SSD/USB/SDHC	Save a single still Image
Autosave	SSD/USB/SDHC	Autosave image Data from Internal High-Speed Memory
Stream (Long Record)	SSD/eSATA (proprietary format)	Long Record Basic, Long Record BROCC, Long Record ROC
FasMotion Utilities:		
Storage/Explore	PC Drives+SSD/USB/SDHC	Move, Copy, Delete, Batch, Convert to AVI, Load CAP, review meta-data*
Storage/Format	SSD/USB/SDHC	Format drive, Sanitize SSD
Review/Save	PC Drives+SSD/USB/SDHC	Save image Data from Internal High-Speed Memory, Load CAP file
Record Still	PC Drives+SSD/USB/SDHC	Save a single still Image
Autosave	PC Drives+SSD/USB/SDHC	Autosave image Data to any camera media or to PC
Stream (Long Record)	SSD/ eSATA (proprietary format)	Long Record Basic, Long Record BROCC, Long Record ROC
PC via Gig-E Connection:		
Explore	SSD/USB/SDHC	Open, Copy files, multiple files, directories From TSx to PC only
Web Application	SSD/USB/SDHC	Open, Copy files (one at a time) from TSx to PC only
Storage/Browse	SSD/USB/SDHC	Move, Copy, Delete (1 file at a time), review metadata of Image files*
Storage/Format	SSD/USB/SDHC	Format drive
Review/Save	SSD/USB/SDHC	Save image Data from Internal High-Speed Memory
Record Still	PC Drives+SSD/USB/SDHC	Save a single still Image
Autosave	PC Drives+SSD/USB/SDHC	Autosave image Data from Internal High-Speed Memory
Stream (Long Record)	SSD (proprietary format)	Long Record Basic, Long Record BROCC, Long Record ROC
PC via USB-OTG:	SSD/USB/SDHC/	Copy files and directories from TSx

*NOTE: Move and Delete functions only apply to USB and SDHC; Load CAP file only applies to SSD.

2-5 FasMotion Camera Control Software

Figure 2-11: FasMotion on Windows

The FasMotion software installation programs for Windows and Mac are copied onto the USB thumb drive that shipped with your TSx camera. The latest released versions are always available via the Fastec website, <http://www.fastecimaging.com>.

This software may be used to set up and control ILx and TSx cameras. With it you may configure all recording parameters including Session Length, Resolution, Frame Rate, Exposure, Color Balance, Autosave, Trigger point, and Sync options.

Benefits of using FasMotion software:

- High-quality, full-resolution display is helpful when viewing videos and when setting image display properties.
- Transfer image data from camera memory to PC much faster than other methods.
- Use I/O markers to find moments of interest during playback.
- Use I/O charts to visualize and associate I/O states with image data.
- Save multiple configurations to speed up setup.
- Single or multi-camera control of IL, TS, HS systems
- Automatic notification of available software/firmware updates
- Update and download software/firmware directly from application

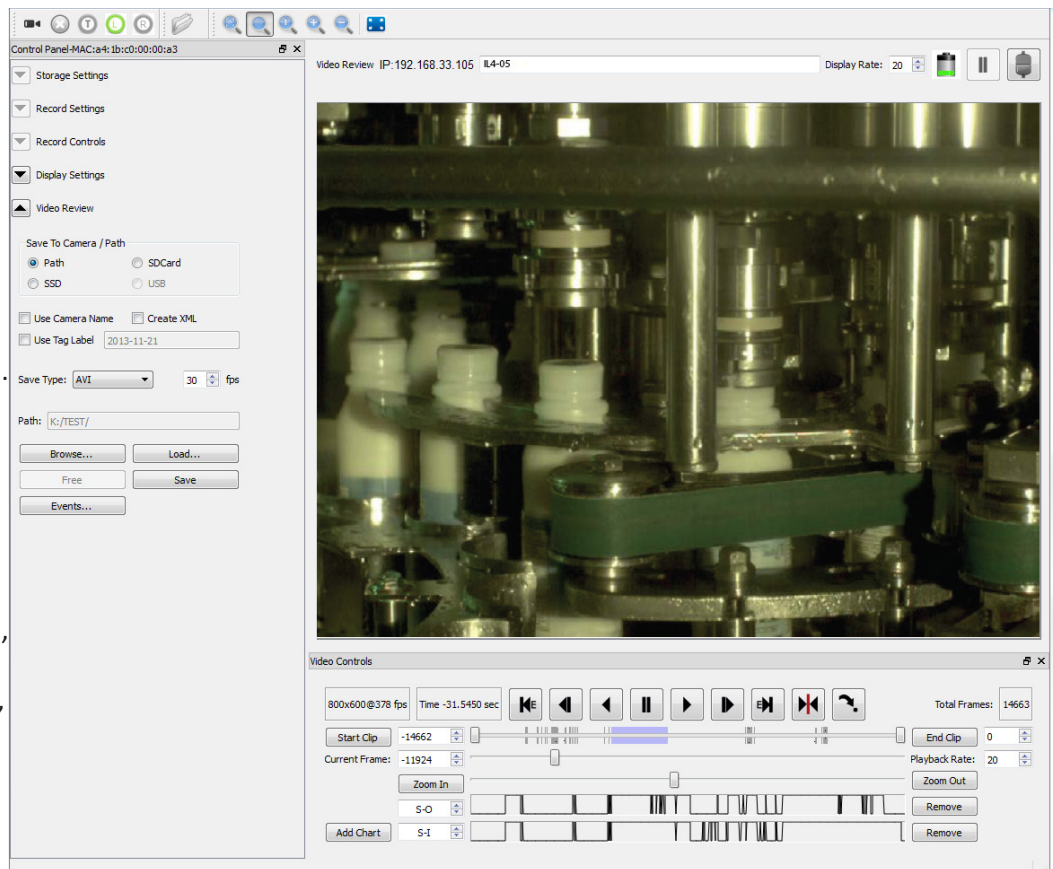
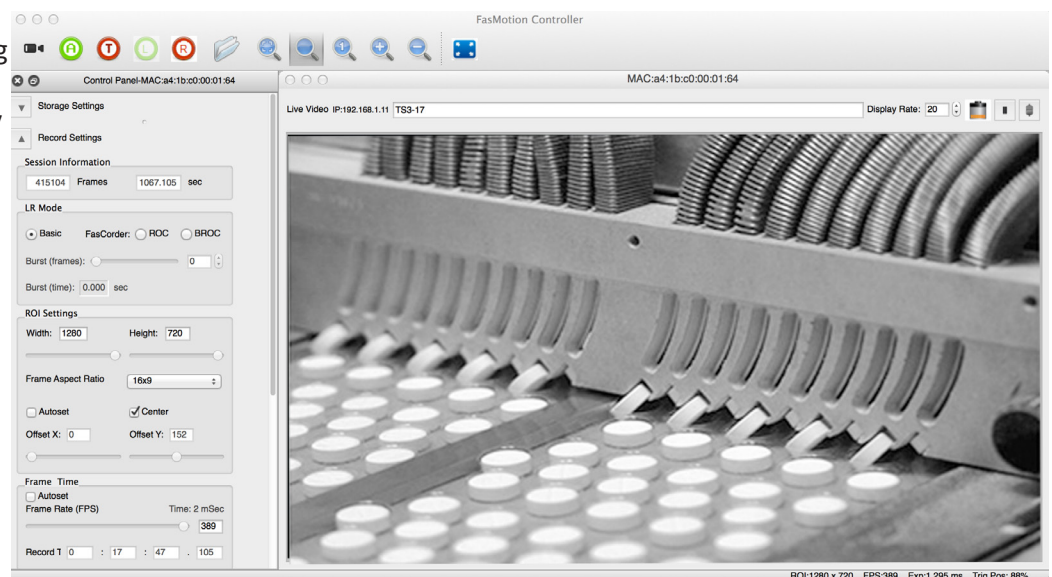


Figure 2-12: FasMotion on Mac



2-6 Web-App

All Fastec IL and TS cameras feature a webserver-based application accessible via common web browsers on computers or mobile devices. No software needs to be loaded.

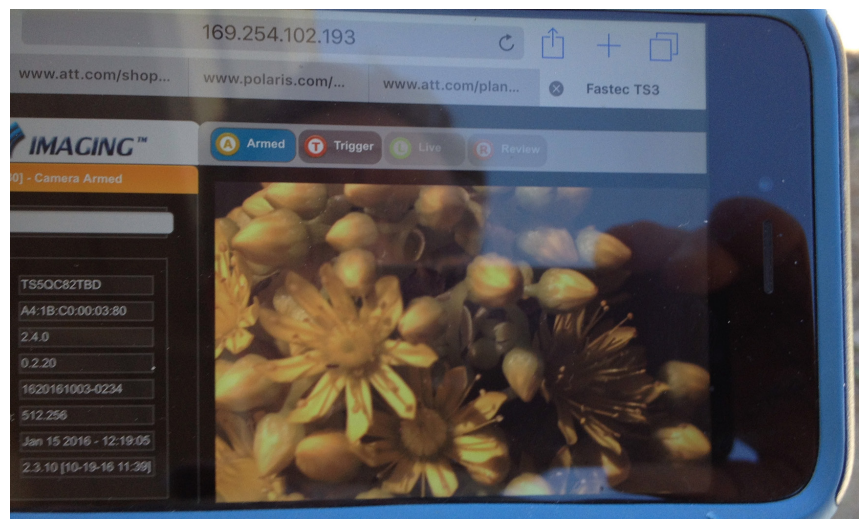
Web-App Feature Overview:

- Single camera control of IL or TS cameras
- Setup and capture video in all modes
- Setup all I/O parameters
- Playback from camera memory, from SSD of CAP (partition capture files) and LR recordings
- Save all file types for captured video to all camera devices (does not save to path via computer or mobile device)

Web-App Device Requirements

- Network connection to camera via LAN
- Internet browser such as Chrome, Firefox, Edge, or Safari
- High-resolution display preferred for menus, photographic setup (frame and focus), and playback
- Touch screen and/or input devices (keyboard and mouse)

Figure 2-13: Web-app on iPhone



2-7 Custom Software via SDK

The Fastec Imaging camera API offers a library of “straight C” functions and associated data structures that enable customer software control of Fastec cameras. The API is designed for portability onto a variety of host platforms (Windows/Linux/Mac) with minimal dependencies, and is intended to integrate with a variety of higher-level application development frameworks such as Microsoft .NET or Qt.

The Fastec Camera SDK is offered without charge to all Fastec customers. Due to its proprietary nature and the level of detailed information included with the SDK, however, Fastec requires an NDA in place for its use.

If interested in access to the SDK or if interested in the development of custom software or features, please contact [Fastec Sales](#).

Figure 2-14: Fastec SDK Menu



3 Camera Setup

3-1 Display and Menu Navigation and Status Bar

The **Display Button**, **Menu Button**, and **Directional Pad (D-Pad)** are found on the back of the camera to the right of the LCD. (See “TSx Back View” on page 3.)

When the camera powers on for the first time, a live image with no menu is displayed.

Pressing the **DISP** button repeatedly toggles through several display modes: Live image, then the image plus an information bar (with record settings and status), another click adds a Histogram, then off. When reviewing video, a set of playback controls is added with the information bar, then the histogram, and then a second information bar appears with timestamps, event markers, and synchronization data. (See “5-5 TSx Timestamps and Markers” on page 63.)

The **MENU** button toggles the on-screen menus on and off. While navigating menus, the Menu button is used to go backward through levels of the menu. For example, if you are navigating a Menu, pressing the Menu button will return you to the Menu Bar. (See Menu Terminology, below.)

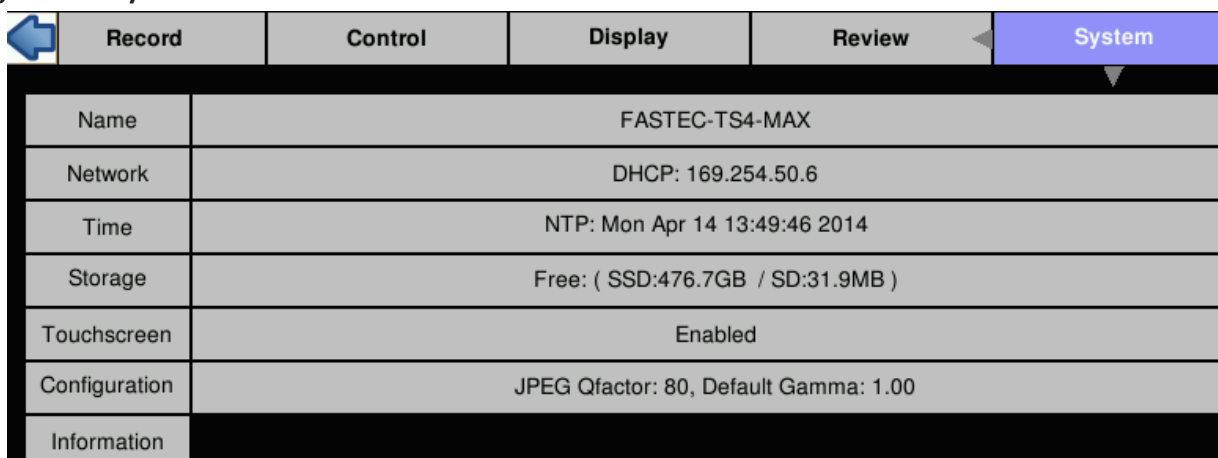
The **D-Pad** is used to move within menus and dialogs. It has an “OK” button in its center for selecting menu items and options.

While navigating through menus, the current location is indicated by a change of color from white or green to gray. When navigating a Menu, the drop-down selections will always appear in the left-most column. The selected menu will appear in white letters in the Menu Bar. Selected or Enabled items turn green once the cursor is moved away from them.

Table 3-1: Menu Terminology

Menu Bar	Across the top of the display: Touch Menu Icon, Record, Control, Display, Review, System
Menu	Having made a selection from the menu bar, a drop-down menu appears, such as the System menu shown below. Present status for items in the selected menu is listed.
Element	The menu options, i.e., Name, Network, etc. are called Menu Elements
Dialog Box	Having chosen an item from a menu, a dialog box may open, such as the Frame Rate and Resolution. This is often a place where the user may make choices and/or input data.
Status Bar	The Status Bar is located at the bottom of the display. Information includes (from left to right) Camera State: LIVE= live view, CAP= recording, REVIEW= playback; Operating Mode: (blank) = Std. Basic, FasFire=Std. FasFire, Autosave=Std. Autosave , LR=Long Record Basic, LR BROCC= Long Record FasCorder BROCC, LR ROC= Long Recording FasCorder ROC; ROI= Resolution; FPS= Frame rate; EXP= Exposure; Trigger Position (shown if not BROCC or ROC); [E] appears if connected to FasMotion; and Power /Batter Status (A/C= no battery, xx% = battery charge)

Figure 3-1: System Menu



Record	Control	Display	Review	System
Name	FASTEC-TS4-MAX			
Network	DHCP: 169.254.50.6			
Time	NTP: Mon Apr 14 13:49:46 2014			
Storage	Free: (SSD:476.7GB / SD:31.9MB)			
Touchscreen	Enabled			
Configuration	JPEG Qfactor: 80, Default Gamma: 1.00			
Information				

3-2 Using the Touchscreen

The TSx 7" display uses touchscreen technology that allows the user to navigate through the menus and enter data with the touch of a finger rather than via the D-Pad.

A special icon in the upper left-hand corner of the screen is present whenever Touch is enabled. Pressing this icon acts the same as pressing the MENU button: it toggles the menus on and off and allows you to navigate backwards through menus and dialogs.

Note: the TSx touchscreen uses “resistive” technology that is sensitive to a light touch of a fingernail or stylus. Unlike “capacitive” technologies used in many smartphones and tablet PCs, it is not sensitive to the flesh of a fingertip.

Figure 3-2: Touchscreen Menu



To enable the Touchscreen:

1. Navigate to the System Menu, then to Touchscreen using the D-Pad.
2. If the touchscreen is currently disabled, there will be a “Disabled” button in the Touchscreen menu. If you click on that, it will turn green, and the text will change to “Enabled.”

Whenever the Touchscreen is enabled, there will be an icon in the upper left hand corner of the screen. Pressing on this has the same results as clicking the MENU button.

Calibration

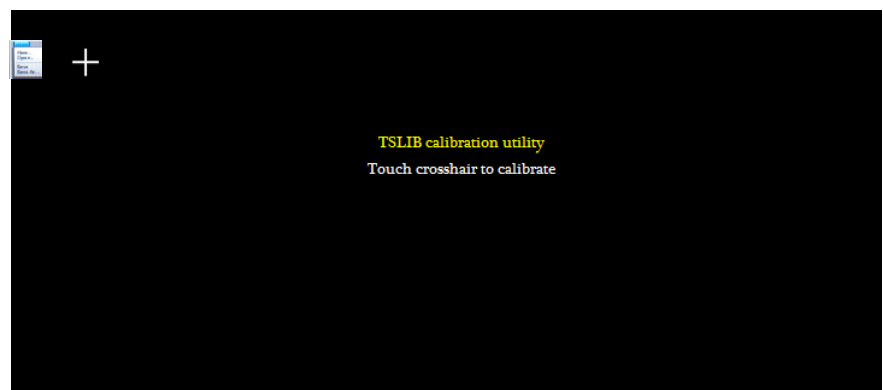
The touchscreen is calibrated at the factory. Routine calibration of the touchscreen is not necessary. Calibration of the touch screen may be done if you feel that the screen is sensing your touches inaccurately. For example, if you use the alpha-numeric keyboard and you are not always getting the intended character where you are touching it, you should re-calibrate the touchscreen.

To calibrate the Touchscreen:

Calibration of the touchscreen is simple and only takes a few seconds.

1. Navigate to the System Menu/ Touchscreen/Calibrate.
2. When you select “Calibrate” you will see a warning message: “Are you sure you want to re-calibrate the touchscreen?” Select “OK.” (This is there to prevent you from accidentally calibrating the touchscreen while handling the camera.)
3. The Calibration screen, “Figure 3-3: Touchscreen Calibration”, will appear and prompt you to touch a cross hair at each corner of the screen, then in the center. Be careful to touch the cross hairs accurately. It is best to use a stylus or other blunt plastic object.

Figure 3-3: Touchscreen Calibration



3-3 Language Selection

Setting the Language in User Preferences:

The TSx camera GUI has several language options to choose from:

1. Navigate to System/Configuration/User Prefs...

Note: If the camera GUI is set to a language that you cannot read, you will be able to find it by looking at Figure 3-5 and Figure 3-6. The menus are laid out the same for each language. The System menu is in the upper left, and Configuration is one item up from the bottom.

2. Use the Language spinner to select the language of your choice. You may use the touch screen for this. The spinner will actually “spin” if given an upward or downward swipe. The D-Pad may also be used to move through the spinner choices. When using the D-Pad the current choice will be highlighted in dark blue as in Figure 3-7.
3. Using touch, click on the language of your choice, or, with the D-Pad, click on the “OK” button. The selected language will now have a check mark next to it.

It is important to make sure the language of your choice has a check mark next to it before exiting the dialog box. Note that in Figure 3-7 English is highlighted in dark blue, but Japanese has a check mark. When the dialog closes, the camera will be in Japanese.

Figure 3-4: Language Selection in User Preferences

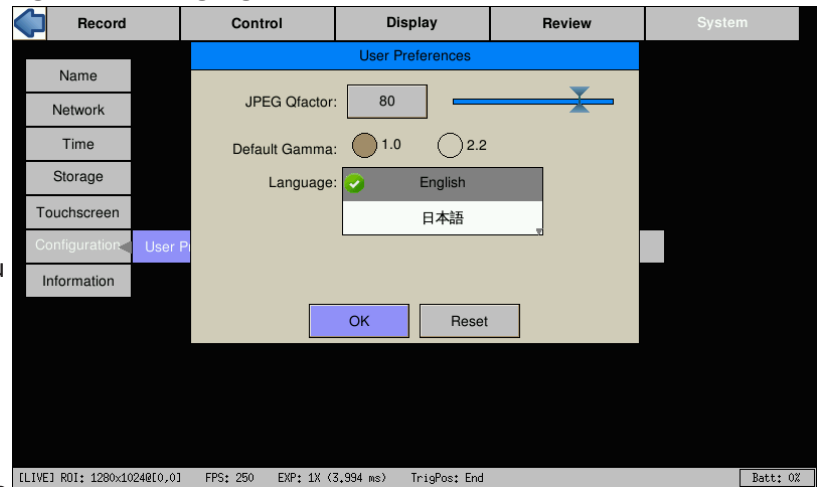


Figure 3-5: Language Selection Spinner

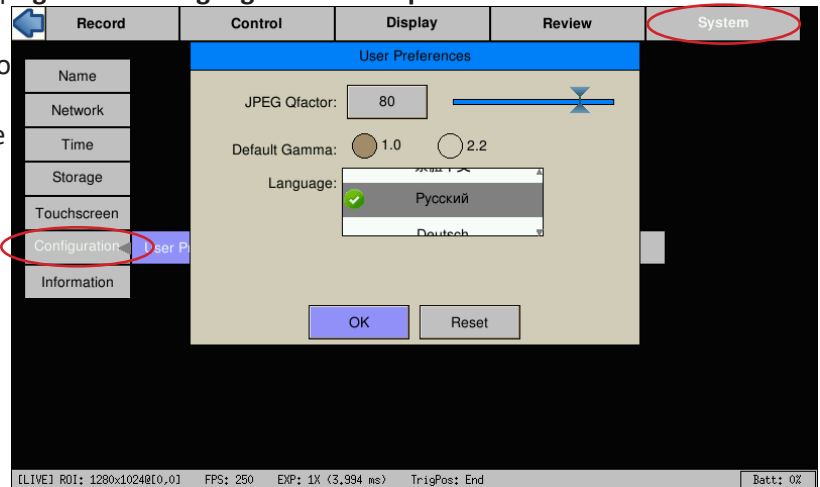


Figure 3-6: Russian Menu

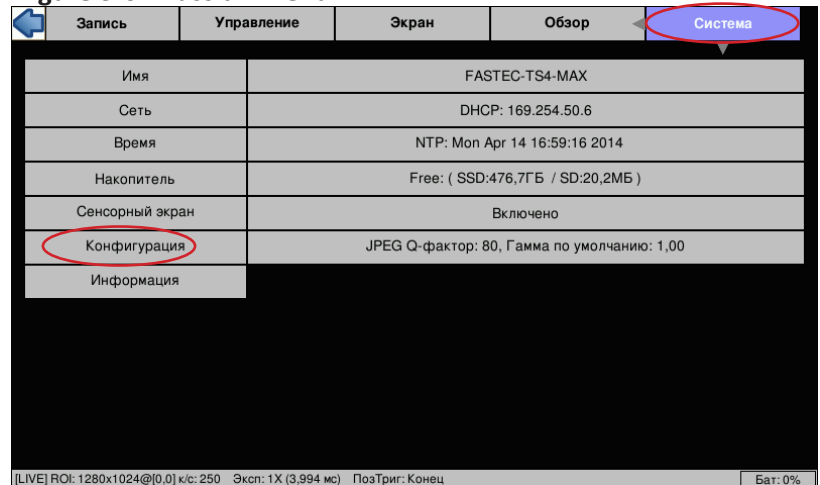


Figure 3-7: Select Language



3-4 Controlling the Displays

Setting Default Gamma in User Preferences:

User Preferences is in the System/Configuration menu.

The Default Gamma setting is used both to set the default output Gamma for displayed and saved images, and to set the Gamma for the LCD display. Gamma of 1.0 (linear) is recommended unless you intend to encode your images with 2.2 Gamma.

JPEG QFactor:

JPEG QFactor sets the quality of the JPEG encoder that is used for Live Display as well as for Saving still images, and JPEG and AVI files. The QFactor may be set low to achieve faster refresh rates via the Web interface, or it may be set high to improve the quality of AVI and JPEG images. The default setting is 80, which yields good quality at a modest file size.

Auto-playback

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

When the Auto-playback box is checked, the camera will play back 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.

LCD and HDMI setup in the Display Menu:

There are three menu elements in the Display menu that control the behavior of the displays. These are:

- LCD Adjust
- LCD Dimmer
- HDMI

The Image Adjust dialog opens when you click on the Edit button in the Image Adjust menu. These controls adjust only the way images are displayed on the LCD. They do not change the images in camera memory or images that are or will be saved.

For any of the three controls here, LCD Brightness, LCD Contrast, and LCD Backlight, changes may be made either by clicking on the + and - boxes, which will change the associated item up or down in increments of 1, or you can click on the edit box itself to open a keypad. See “Figure 3-19: Keypad Dialog Boxes” on page 24.

LCD Brightness and Contrast have a range between -100 and 100 with a default value of 0. LCD Backlight has a range between 0 and 100 with a default value of 100.

Note: The Image Adjust, White Balance, and RGB Gain elements do *not* control the LCD display. These are part of the image processing pipeline that directly influences the saved image. (See “TS3 / TS4 Image Pipeline” on page 49.)

The LCD Dimmer is a timer that turns the LCD off after a few minutes. There are four choices:

- Off--the display will remain on all the time.
- 1 Min. The display will go dark after 1 minutes of non-use.
- 5 Min. The display will go dark after 5 minutes of non-use.
- 10 Min. The display will go dark after 10 minutes of non-use.

Note: Both LCD and HDMI are drains on the battery. Preserve battery power by disabling HDMI and limiting LCD on time.

Figure 3-8: LCD Display Controls

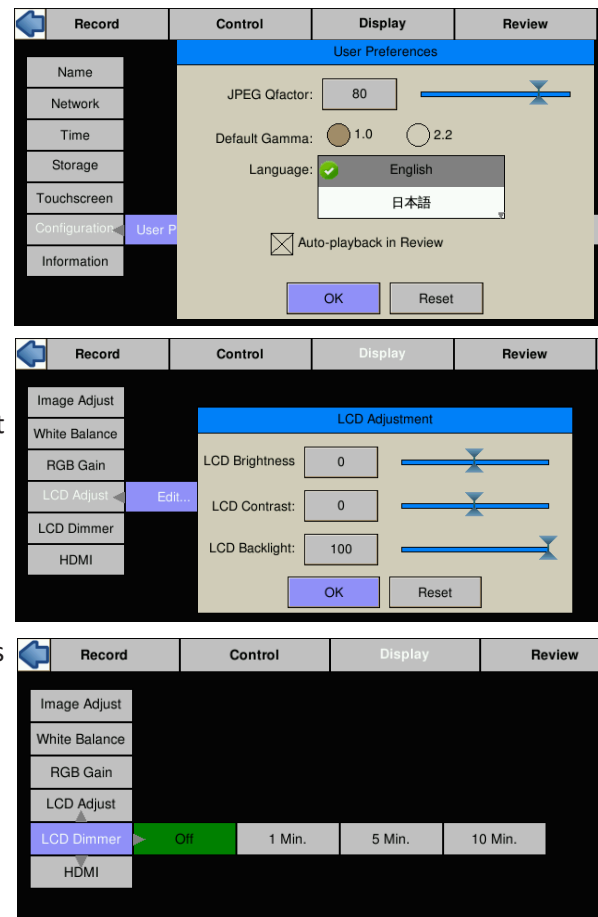


Figure 3-9: HDMI Controls



HDMI Display

While the 7" WVGA 800 x 480 touch-screen display on the TSx is perfectly adequate for setting image captures and even reviewing video, watching the same video on a large flat panel display makes sharing the imagery with others much easier. With the TSx there is no need to download images to a PC to view them on a large display. Use a standard HDMI cable to connect the TSx to an HDMI compatible display.

The **HDMI** output control is also accessed in the Display menu. The HDMI output can be Enabled and Disabled here and the resolution 640 x 480, 720p or 1080p may be selected. (The image is scaled to fit but keeps its original aspect ratio.)

3-5 Connecting to a PC via Ethernet

The TSx may be connected to a PC using the USB-OTG connection, (see”2-4 TSx Memory and Mass Storage Options” on page 11) or via the GbE port. While the **USB-OTG** connection is extremely useful for limited file transfers from FAT-32 formatted media; an **Ethernet connection** has several major advantages:

- 1. It can be used to **control** the camera via the built-in Web Application or FasMotion Camera Control software.
- 2. The camera and PC need not to be physically close to each other for a GbE connection, while the USB-OTG connection is dependent on cables that are limited in length (generally less than 4.5m).
- 3. Once connected to a GbE network, the TSx may be accessed for file transfer via FasMotion, including CAP file and LR image file conversions, which can target any networked drive as a Save destination.
- 4. Using the camera’s **Web Application** (built into the camera) any PC that has network access to a camera can control it without installing any software. This works with popular web browsers such as Google Chrome and Mozilla Firefox.

Setting up Networking on the Camera

The TSx’s Networking settings may be configured manually or using DHCP. When shipped the cameras are set for DHCP. To change the settings:

- 1. Navigate to the System Menu.
- 2. Select Network.
- 3. Choose between DHCP and Static. Choose DHCP if the camera will be placed on a network with a DHCP server running on it. Choose Static if the camera and any PCs used to access it are manually configured.

Auto Configuration

If the TSx is configured for DHCP and it does not find a server, it will auto configure itself with a “Local Link” IP address 169.254.xx.xx.

Most PCs will do the same. So, most of the time, if the TSx is configured for DHCP and you connect it to a PC that is also configured for DHCP, they will automatically begin network communication. (Some PCs may need to boot with the camera connected in order to get a local link address.)

Figure 3-10: TSx to PC Connections

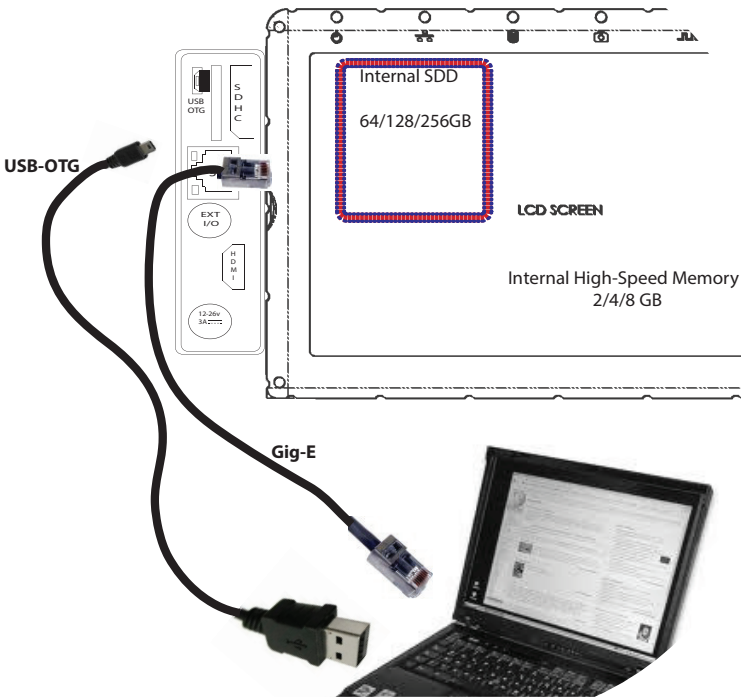


Figure 3-11: Network Menu

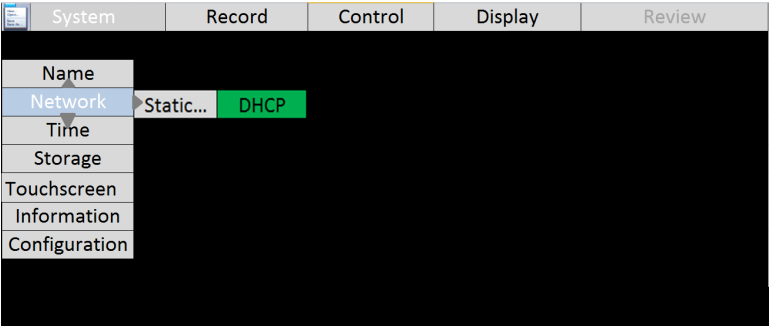


Table 3-2: Network LEDs

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		

If you choose to manually configure the network settings, there is a dialog box that opens to allow typing in the IP Address, Subnet Mask, and Gateway. (If Touchscreen is enabled, you will be able to use it with the alphanumeric keyboard for input of these values.)

If you are unsure of these settings, please consult your network administrator. If you need the MAC address of the camera, it is listed in System/Information/Status.

Note: the camera must be connected to an active network when configuring the IP address.

Figure 3-12: Static IP Dialog Box

3-6 Setting up WiFi

The TSx may be used via WiFi network (no cable necessary) with the WiFi option installed.

WiFi Setup

The TSx must be factory licensed for the WiFi option and you must have the USB WiFi dongle from Fastec installed for the WiFi menu item to appear in the System Menu.

1. Select Access Point... from the System/ WiFi menu.
2. Select SSID. You will now see a list of local WiFi networks.
3. If using an established local network, select it from the list, then provide the Password if needed.
4. If you wish to set up an ad hoc network, select Manual and then type in the name you wish to give to your network, and then click on Peer-to-Peer (ad hoc).
5. After you click on OK, you will notice that the camera defaults to DHCP. If you would prefer to give the camera a static IP address, you may do so being careful to use a valid Address, Net Mask and Gateway.

When connected, the IP address and other network information will appear on the WiFi line of the System Menu. If an ad hoc network is setup, an IP address will not appear until a device such as an iPad is connected.

Note: WiFi will allow you to control the TSx via smartphone, tablet, or any PC on the wireless network via the camera's built-in Web-App. FasMotion software will not operate via WiFi due to bandwidth limitations that are not compatible with the hardware Gig-E optimization used.

Figure 3-13: WiFi Access Point Settings

Figure 3-14: WiFi ad hoc SSID

Connecting to the TSx 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 TSx is using as seen in the WiFi line in the camera's System Menu.
3. Enter the password, if any.

The TSx and your computer or mobile device

are now both connected to the same wireless network. Follow the directions below, in "3-7 Using the TSx with a PC" to begin controlling the TSx via WiFi.

Figure 3-15: WiFi IP Address in System Menu

Record	Control	Display	Review	System
Name	FASTEC-TS3-08			
Network	DHCP: 192.168.33.105			
WiFi	Adhoc: FASTEC TS3, DHCP: 169.254.154.207			
Time	NTP: Mon Sep 9 17:05:40 2013			
Storage	Session Length: 1.50 -- Free: (SSD:89.2GB / SD:6.0GB)			
Touchscreen	Enabled			
Configuration	JPEG Qfactor: 100, Default Gamma: 1.00			
Information				

3-7 Using the TSx with a PC

To get the best performance with the TSx via your PC install FasMotion software. See the FasMotion Manual.

To open the Networked TSx in a Web browser (no software installation), use the **TSx Web App**:

1. Open a web browser on the PC. Type the camera's IP address or camera name into the browser's Location bar. For example, using the information from "Figure 3-15: WiFi IP Address in System Menu", you would type 169.254.154.207 (IP address) or FASTEC-TS3-08 (the 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 User's Guide.

Figure 3-16: Web Browser Screen



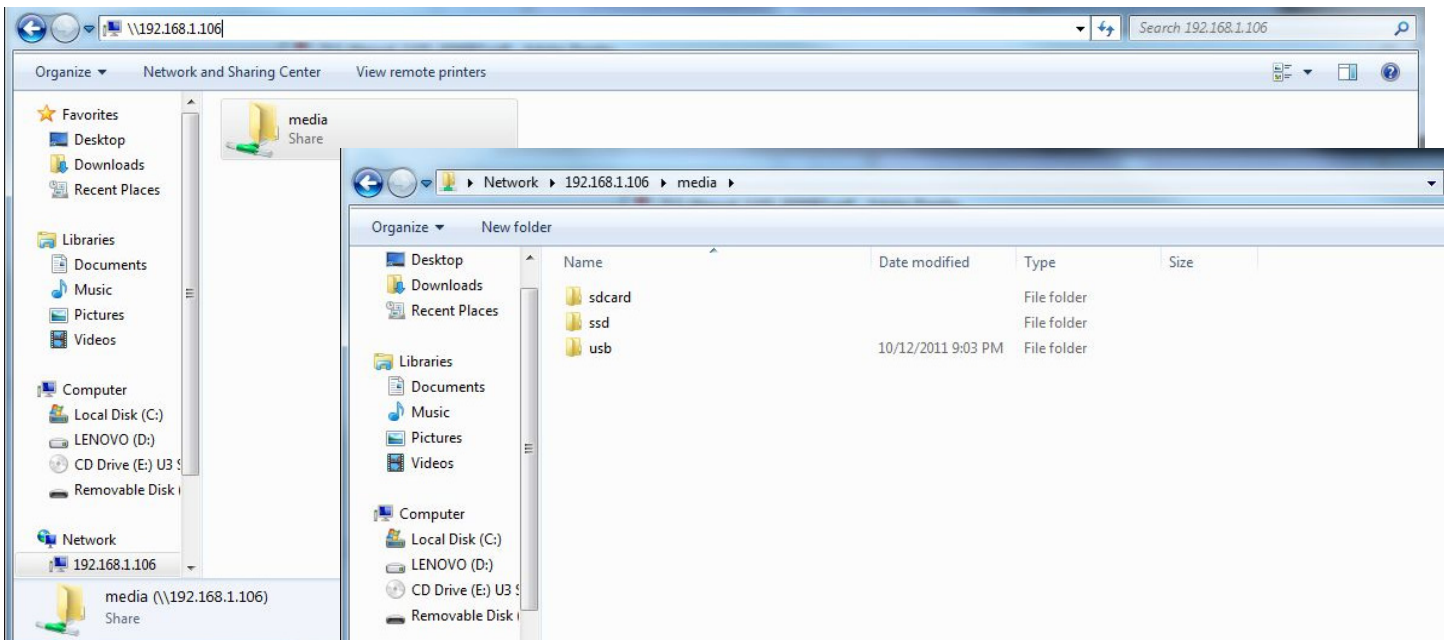
To open the Networked TSx in a Windows Explorer menu (this will not work on all systems):

1. Open either a web browser or Windows Explorer.
2. Type the camera name or IP address in the Location bar, preceded by \\ . So, using the same information as in the example above, type in either \\192.168.1.106, or \\fastec_ts3.

When the camera is viewed in Explorer, you will see the camera name or IP address under Network. Opening that, you will see a directory called “media,” which contains directories for each mass storage device installed on the camera. (See “Table 2-4: TSx Mass Storage Functionality” on page 13.)

NOTE: While using Windows Explorer is a handy way for copying a few images at a time, large image transfers are much more efficient using FasMotion. Please refer to the FasMotion Manual.

Figure 3-17: TSx in Windows Explorer



3-8 TSx Name the Camera

Camera Name

When the TSx leaves the factory its default name is TS3-xxx. For example, looking at “Figure 3-18: Camera Name Menu” the camera used for the screen shot was TS3-17. The camera name can be used both for identification 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.

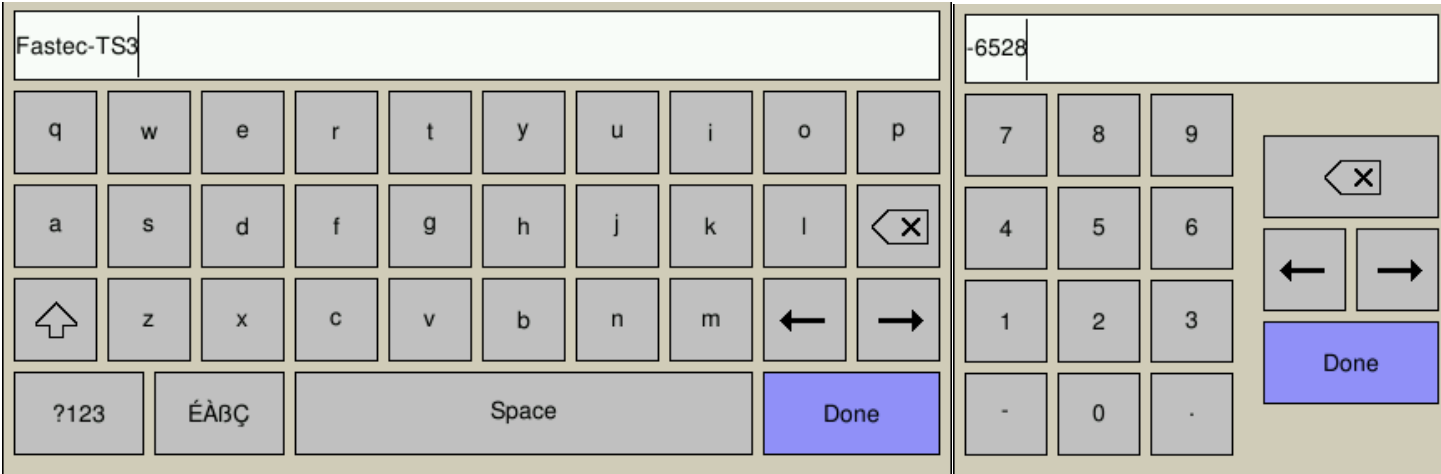
To change the camera name:

1. Navigate to the System Menu.
2. Select “Name.”
3. Move the cursor to the box showing the current name and click “OK” to open the alpha-numeric dialog where you will enter the new camera name. If enabled, you can do this using the Touchscreen. If not you will use the D-Pad.
4. Delete the present camera name using the Backspace button in the dialog box, then enter the new name in its place.

Figure 3-18: Camera Name Menu



Figure 3-19: Keypad Dialog Boxes



3-9 Setting the Time

Time Setup on the TSx is in the System Menu. There are two choices for setting the time of the camera: **User** and **NTP**.

If you select User, the time and date are manually entered into the camera. The camera’s internal clock will maintain reasonable accuracy but may drift over long periods of time. If NTP (Network Time Protocol) is used; the camera will get its time from an external NTP server via the Internet.

Setting the time Manually

- 1. Navigate to the System Menu and select Time.
- 2. Select the format you wish to use for the date and time: MM/DD/YY, DD/MM/YY, or YY/MM/DD.
- 3. Select 24-hour, if you wish to use a 24-hour display rather than a 12-hour.

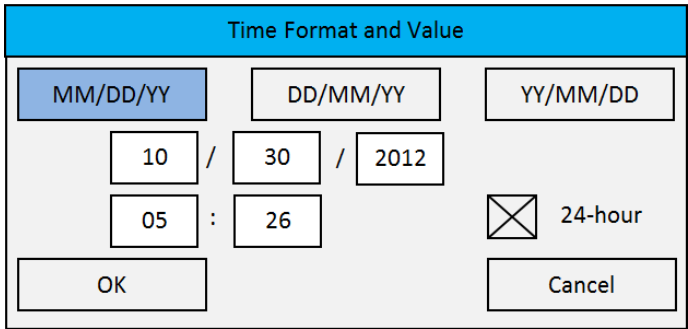
Setting the Time via NTP

- 1. Connect the camera to a network with internet access. There is no need to attach the camera to a PC, although that is often the most obvious way to do it.
- 2. Navigate to the System Menu and select NTP.
- 3. Select an NTP server from the list. If there is a server that you would like to use that is not on the list, you may add it in the dialog box.
- 4. To exit the list, press the right arrow of the D-Pad and select OK. The TSx will now connect to the NTP server and sync its clock. If the camera cannot connect with the server, it will pause its operation for a couple of minutes while it re-tries. The camera will always poll the NTP server when it powers up if it has an Internet connection.

Note: The TSx will not poll the NTP server if the Internet connection is not made, either when the camera boots, or when exiting the NTP dialog. Between times when the camera polls the NTP server, it will maintain time with its internal clock.

- 5. Select “Zone” to set the camera to the local time zone.

Figure 3-20: Time Format Menu



3-10 Storage

The Storage Menu gives the user access and control of the Camera's non-volatile storage, including an internal SSD (if installed), and any other storage media present, such as a USB thumb drive or SD Card.

Explore allows you to access the SSD (Solid State Drive installed internally to the TSx), the SD Card inserted into the slot on the side of the camera, or a USB thumb drive connected via the USB port for file transfer:

1. Navigate to the System Menu.
2. Select Storage.
3. Select Explore
4. A selection menu will open allowing you to pick the storage device you wish to access: SSD, SD Card, or USB. Once you select the storage device, you will see the directory choices: Stills (containing stills taken by the camera), Stacks (stacks of high-speed video saved as TIFF, BMP, JPEG files), and Videos (AVI files).
5. Open the Stills, Stacks, or Videos folder by double-clicking on your choice. This will open the dialog shown in Figure 3-22, displaying the list captured imagery and brief description of the currently selected item.

Note: This list acts like a "spinner" when touch is enabled. Swiping the list up or down will make it spin, allowing you to move through the list quickly.

6. Double click on any item and a File Action dialog will open that will allow you to Copy or Move the item to another storage device on the system or delete it.
7. When done, use the Menu or Back button to navigate away.

Eject, also on the **Storage Menu**, should be used whenever you wish to remove media from the TSx.

NOTE: Failure to eject SD Cards or USB devices before removal may result in incomplete transfers or in device failures.

Figure 3-21: Storage Menu

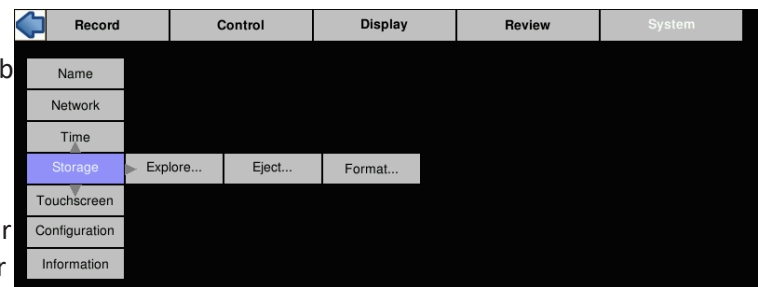


Figure 3-22: System Explore Dialog: File Stacks

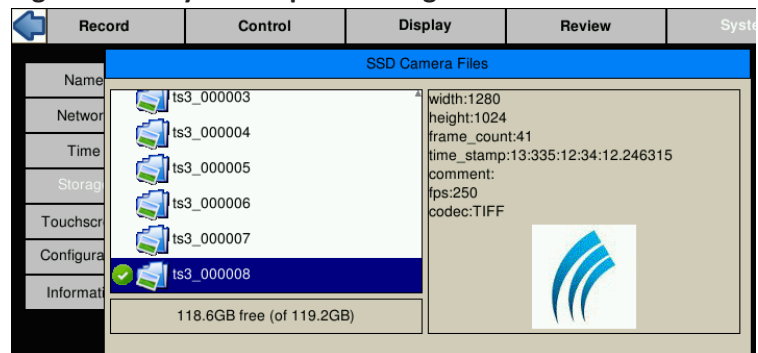


Figure 3-23: File Action Dialog



3-11 Formatting Camera Media

Formatting SD Cards and USB drives:

Formatting SD Cards and USB drives is the easiest and most effective way of deleting all recordings.

Find the Storage Formatting menu by navigating to System / Storage and selecting Format.

When formatting SD Cards and USB drives, you will be given the option of formatting for "Performance" or "Compatibility."

The Compatibility format is FAT-32, which is recognized by most computers. Select this format if you intend to hand the images off to a customer or colleague to ensure compatibility with whatever system they may have.

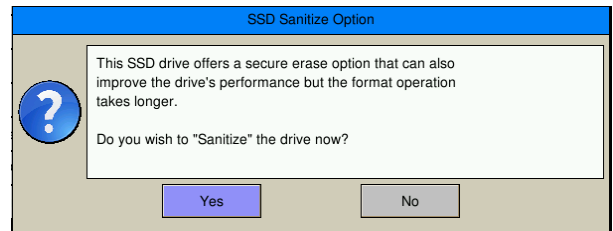
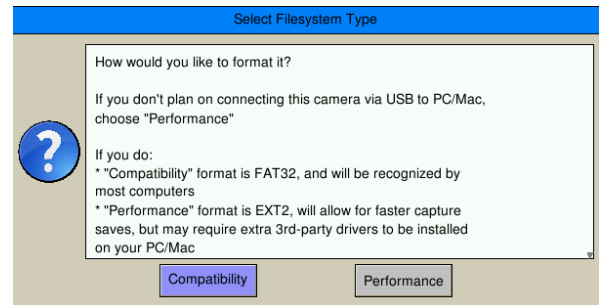
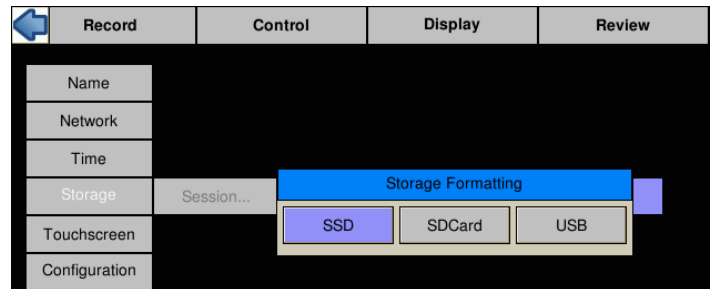
The Performance format is EXT2, which is a Linux format and may require a 3rd-party driver or application (such as DiskInternals Linux Reader) on your MAC or PC. EXT2 will improve file Save times to the SD Card and USB. The improvement is only about 10% for large images such as full-resolution TIFF and BMP images. The greatest improvement (as much as 6x) is seen when saving large numbers of small files, such as saving thousands of low-resolution JPEGs.

Formatting the SSD:

Deletion of files is not allowed on TS4 cameras and TS3 and TS5 cameras capable of writing CAP files to the SSD (cameras with MAC addresses A0 and above). Formatting the SSD is the only way of deleting files from the SSD on these cameras. This should be done often to keep performance as high as possible.

When formatting the SSD on a TS4 and many TS3 and TS5 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 3-24: Storage Formatting Menu



3-12 Configuration and Camera Information

TSx Configurations, which include all camera settings (resolution, frame rate, Preferences, color settings, etc.), may be Saved, Reloaded, or Reset to factory defaults. From the TSx Camera GUI two configurations may be Saved and/or Loaded.

Configurations may also be saved using FasMotion. FasMotion saves configuration files onto PC media and can store any number of configurations.

Note: Camera configurations are version-specific. When a camera firmware update is performed, you should always perform a Hard Reset, which will delete all saved configurations.

1. From the System Menu, navigate to Configuration.
2. Select **Save** to save the current configuration. The configuration may be saved as Configuration #1 or Configuration #2.
3. Select **Load** to load a saved Configuration (Configuration #1, or #2).

General information about the camera, including MAC address and versions of software, FPGA, Sensor and Gig-E are available in Information in the System Menu.

Figure 3-25: Save and Load Configurations

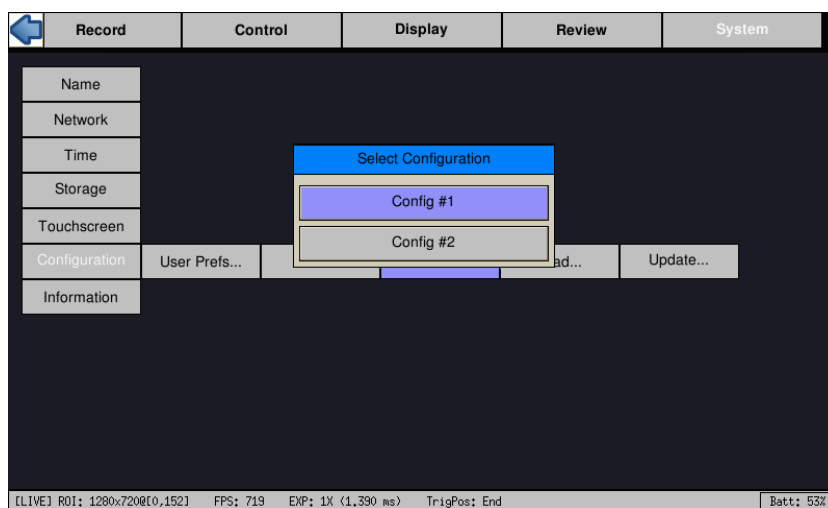
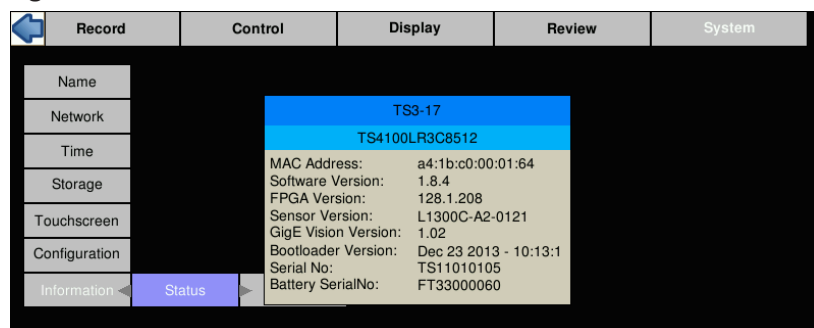


Figure 3-26: Camera Information Box



3-13 Reset

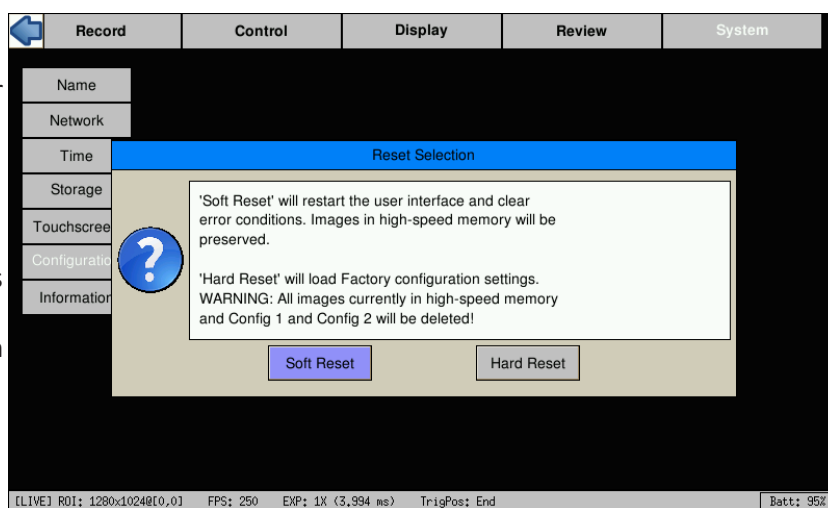
There are two levels of Reset available on the TSx, '**Soft Reset**,' and '**Hard Reset**.'

The '**Soft Reset**' is like a PC reset or warm boot. It does not change any settings or power the system down, it simply restarts the user interface and clears out any error conditions. All user configurations and all image data are preserved.

The '**Hard Reset**' resets the camera configuration back to its factory settings. This eliminates the current user settings as well as any saved configurations (Config 1 and Config 2) and erases any image data in the camera as well as the black calibration frame. For these reasons, the Hard Reset is very seldom done other than after a firmware update.

Always remember to perform a black frame calibration after a hard reset!

Figure 3-27: Reset Dialog Box



4 Recording

4-1 Selecting the Recording Mode

All TSx cameras may record to internal high-speed DRAM memory. With up to 8GB of memory available, maximum recording times for TSx cameras range from about six seconds to several minutes depending on frame rate, resolution, and bit depth. The Dual Mode cameras may record to high-speed DRAM, referred to as Standard mode, or to an internal SSD, when operating in Long Recording (LR) mode. In LR mode, they are capable of maximum record times from about seven minutes to many hours, depending on SSD size and frame rate. Refer to “Appendix D: TS3 / TS4 Record / Resolution Tables” on page 93 for sample record rates by resolution.

Standard Modes (recording to DRAM):

In **Basic** mode, all frame rates, resolutions and session lengths and trigger positions are available.

Basic workflow:

- Record to DRAM. Session length may be set from 250MB to 4GB or 8GB, depending on camera model.
- Review (Playback). Recorded high-speed video is available for immediate playback to the TSx LCD, HDMI monitor, computer, or mobile device.
- Save recordings. Save images to any camera media (SD card, USB device, or SSD (if installed)). Images may also be saved to a Path via FasMotion (see the FasMotion Manual).

Or

- Record to DRAM, as above.
- Autosave/Re-Arm. If Autosave is enabled, the system will save the recording to selected media, and then re-arm the camera for the next recording.

To Select Standard Basic Mode:

- Navigate to the Record menu and select “Mode” and then “Setup.”
- Click on “Basic,” if available, otherwise click on “Standard,” then return to /Record/Mode after the camera reboots in Standard Mode. (Basic will always be available on non-Dual Mode cameras.)
- The Basic Mode Options dialog will open (See Figure 4-2). Trigger, Session, and Autosave settings are displayed here. Click on any item to adjust the setting, and then click OK to accept. Refer to sections “4-8 Configuring the Trigger and External I/O” “4-7 Setting Session Length” and “4-11 Autosave” for details.

In **FasFire** mode, all frame rates, resolutions, and trigger positions supported by the camera are available, but session length is limited to <1/2 DRAM, and Autosave is required.

FasFire workflow:

- Record to DRAM. Session length may be set from .25GB to <1/2 maximum.
- Autosave + Record. The camera re-arms and begins recording while saving the previous partitions. (See “4-12 FasFire” on page 43.)

Figure 4-1: Selecting Recording Mode

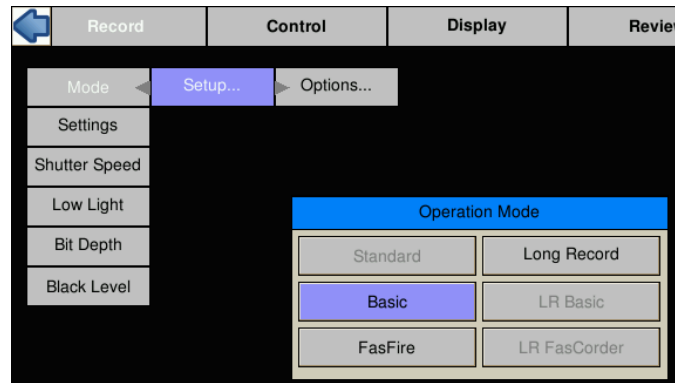


Figure 4-2: Basic Mode Options

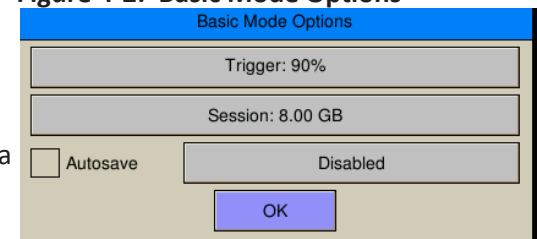
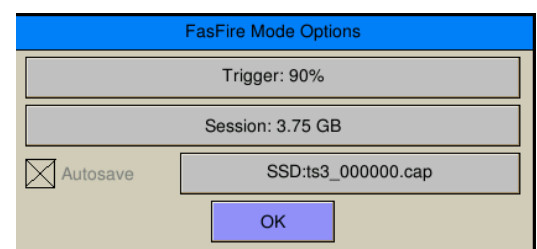


Figure 4-3: FasFire Mode Options



To Select Standard FasFire Mode:

1. Navigate to the Record menu and select "Mode" and then "Setup."
2. Click on "FasFire" if available, otherwise click on "Standard," then return to /Record/Mode after the camera reboots in Standard Mode.
3. The FasFire Mode Options dialog will open (See Figure 4-3). Note that the Session size is automatically adjusted to less than half the DRAM size and that Autosave is enabled. Click on any item to adjust the setting, and then click on OK to accept. Refer to sections "4-8 Configuring the Trigger and External I/O" "4-7 Setting Session Length" and "4-11 Autosave" for details.

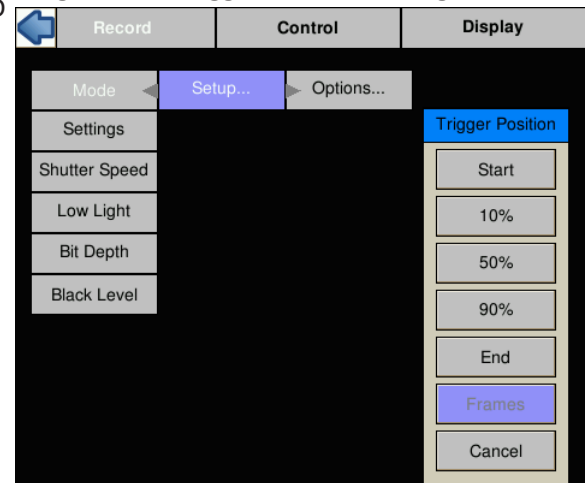
LR Modes (recording to SSD):

In **LR Basic** mode, frame rates and resolutions are based on SSD performance (LR2/LR3). The entire SSD space is reserved for one recording only. All trigger positions are supported.

LR Basic workflow:

- Make one recording to SSD. The session length cannot be set--it is always assumed to be all the space on the SSD. The trigger point may be set as with Standard modes.
- Review (Playback). Recorded high-speed video is available for immediate playback to the TSx LCD, HDMI monitor, computer, or mobile device.
- Save. Clips may be saved to any SD card, USB, or Path. Autosave is not available.

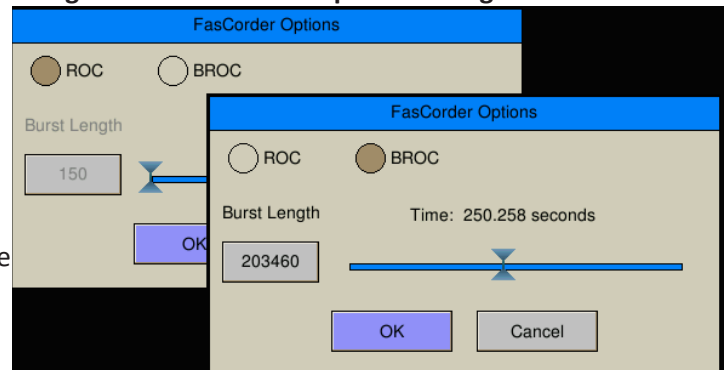
Figure 4-4: Trigger Position Dialog



To Select LR Basic Mode on the Dual Mode Cameras:

1. Navigate to the Record menu and select "Mode" and then "Setup."
2. Click on "LR Basic" if available, otherwise click on "Long Record," then return to /Record/Mode after the camera reboots in LR Mode.
3. The Trigger Position dialog will open (see "4-8 Configuring the Trigger and External I/O" on page 37). (Session Length and Autosave are not available in LR Basic mode.)

Figure 4-5: FasCorder Options Dialog



LR FasCorder ROC (Record on Command) / BROCC (Burst Record on Command) workflow:

- Make multiple recordings to SSD. Record length is governed by toggling the Trigger between Record and Paused states in ROC (Camera LED blinks Red while recording), or by the Burst Length set by the slider or edit box in BROCC mode.
- Review recordings. All recordings are available for playback on one timeline. Use Record Start markers to jump between the recordings during playback.
- Save. Clips may be saved to any SD card, USB, or Path. Autosave is not available.

To Select LR FasCorder Mode on the TS4:

1. Navigate to the Record menu and select "Mode" and then "Setup."
2. Click on "LR FasCorder" if available, otherwise click on "Long Record," then return to /Record/Mode after the camera reboots in LR Mode.
3. The FasCorder Options Dialog will appear. Select either the ROC or BROCC radio button. If ROC is selected the Burst Length slider and edit box will be grayed out as record length will be controlled by the Trigger. If BROCC is selected, use the slider and/or edit box to select the time/# of frames for your recordings.

4-2 Setting Frame Rate and Resolution

Table 4-1: Maximum Frame Rates and Resolutions

Model	Maximum Resolution / Frame rate	Maximum Frame Rate
TS5Q	2650 x 2048 / 253	8470 @ 128 x 64
TS5H	1920 x 1080 / 634	8470 @ 128 x 64
TS5S	1280 x 1024 / 668	8470 @ 128 x 64
TS5L	800 x 600 / 1126	8470 @ 128 x 64
TS3S/TS4	1280 x 1024 / 510	60518 @ 48 x 32
TS3L	800 x 600 / 1250	1250

Table 4-2: Maximum Streaming (LR) Mode Frame Rates and Resolutions

Model	Maximum Resolution / Frame Rate	Maximum Frame Rate
TSQ D	2650 x 2048 / 91	2268 @ 320 x 240
TS5H D	1920 x 1080 / 231	2268 @ 320 x 240
TS5S D	1280 x 1024 / 366	2268 @ 320 x 240
TS5L D	800 x 600 / 942	2268 @ 320 x 240
TS4-LR2	1280 x 1024 / 183	3087 @ 320 x 240
TS3L D	800 x 600 / 993	1250 @ 640 x 480
TS4-LR3 / TS3S D	1280 x 1024 / 366	6165 @ 320 x 240

For more sample frame rates and resolutions please refer to “Appendix D: TS3 / TS4 Record / Resolution Tables” on page 93 and “Appendix E: TS5 Record / Resolution Tables” on page 98.

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 travelling 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 travelling 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 20x as fast.

If you got acceptable imaging of an auto at 60FPS, it may take 1200FPS 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.

Note: The display resolution of the TSx LCD is 800 x 480.

To set the Frame Rate and Resolution of the TSx:

The settings menu has two buttons; one displays the current resolution and the other displays the current frame rate. Click on either of these buttons to open the Recording Settings Dialog.

Select an Aspect Ratio

Click on the Aspect Ratio button (the button marked "5:4" in Figure 4-7) and choose an aspect ratio for your recording.

Select the Resolution

If you have selected any numbered aspect ratio, the Width and Height will lock to maintain that aspect ratio as you adjust the horizontal or vertical resolution, either with the sliders or edit boxes. If the aspect ratio is set to Custom, the Width and Height become independent, allowing for any aspect ratio.

Select the Frame Rate

Select the frame rate by moving the FPS slider or using the edit box.

- If a frame rate is entered that is not supported by the camera, the closest supported frame rate will be recorded. For example, if you enter 5fps, the camera will adjust up to 24fps, which is the lowest frame rate supported. Likewise, if a frame rate that is too high for any given resolution is entered, the camera will adjust down to the highest supported frame rate.
- To quickly adjust to the highest frame rate for the current resolution, click on Max FPS.

To Find the Highest resolution by Frame Rate:

1. Choose your aspect ratio. If the aspect ratio you want is not among the choices, select Custom, and then manually select any resolution with the aspect ratio you want.
2. Click on Max ROI. An edit box will open with the directions, "Enter frame rate." Enter the frame rate you wish to use. The camera will find the highest resolution for the frame rate entered at the current aspect ratio.

Offset Control:

Most of the time, to make use of the best resolving properties of your lens, you will want to center the image at the optical center, which corresponds to the center of the sensor. It is also possible, that you will wish to shift your ROI (Region of Interest) without moving the camera.

Let's say that you have captured images at 1024 x 1024 @ 500fps and are now interested at capturing a 512 x 512 portion of the scene, let's say the bottom right-hand quarter @ 2000fps.

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

Click the "Centered" button to open the ROI Offset Dialog.

Figure 4-6: Settings Menu

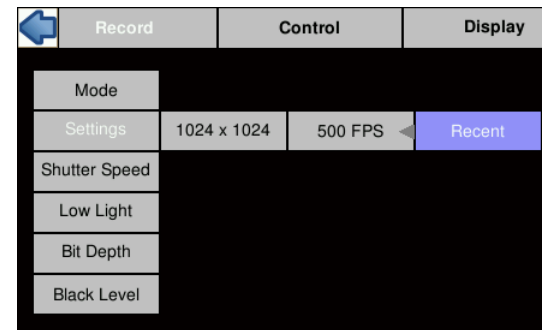


Figure 4-7: Recording Settings Dialog

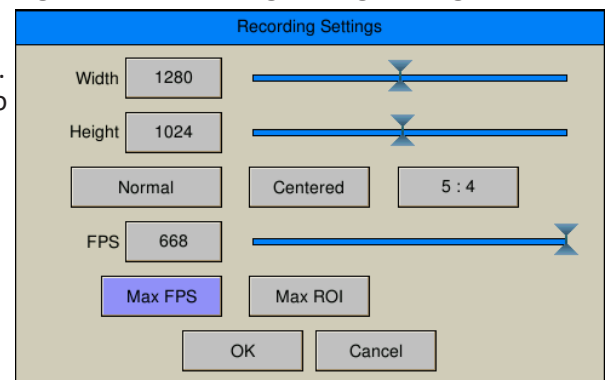


Figure 4-8: Aspect Ratio Choices

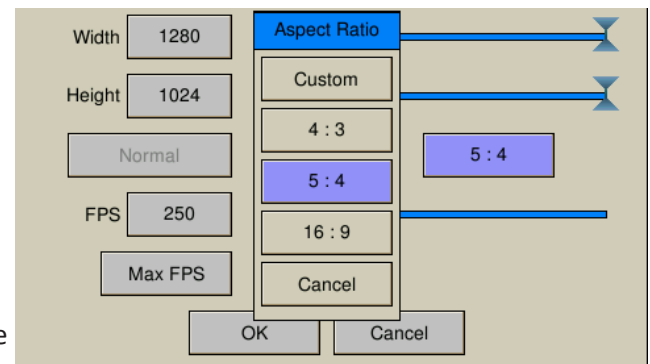
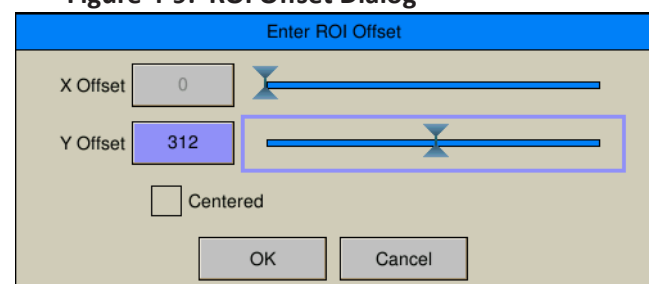


Figure 4-9: ROI Offset Dialog



(When an non-centered offset is in use, that button will display the current offset as (x,y).)

Offset may also be set via FasMotion or the Web-App. Note that whenever you set a new ROI using the on-camera controls, the offset will reset to the centered position.

To Set the Selected Settings:

Once the Resolution, Frame Rate, Binning/Subsampling, and any offset are all selected, Click on OK in the Recording Settings dialog.

Figure 4-10: Settings Info-Box

An info box will open showing the resolution and frame rate you have selected along with the pre- and post- trigger frame count and pre- and post trigger record time. Click on OK to accept.

2560 x 1440 at 359 FPS			
OK	2280 + 1 + 0 = 2281	Frames	Cancel
	6.351 + 0.003 + 0.000 = 6.354	Seconds	

Using the Recent Settings Dialog:

The Recent Settings Dialog may be used to restore a previously used set of resolution and frame rate settings.

The settings stored include:

- Resolution
- Frame Rate
- Bit Selection
- Binning / Subsampling mode
- (Offsets) If no offset is listed, that setting will be centered.

For example, the highlighted setting in Figure 4-11 has a resolution of 2560 x 1440, frame rate of 359fps, 8 bits selected with the 9th bit high, no binning or subsampling, and an offset of (0,168).

Eight sets of settings are available in the Recent Settings dialog. By default, the list consists of the last settings used on the camera and is reset only when the camera has a software update or a “hard reset” is performed. The most recently used setting always migrates to the top of the list.

If you wish to lock a setting so that it cannot be overwritten or to unlock a previously locked setting, highlight that setting and click “Lock Toggle.” The locked settings are marked with an asterisk (*). The locked settings always appear at the top of the list.

To restore a setting on the camera:

1. Click on a setting to restore. The setting will become highlighted.
2. Click on “OK.” An info box will open showing the resolution and frame rate you have selected along with the pre- and post-trigger frame count and pre- and post-trigger record time.

Figure 4-11: Recent Settings Dialog

Recent Settings				
*	2560x1440	359 FPS	8-high	Normal
*	1024x1024	500 FPS	12-bit	2X Binning
*	2560x2048	250 FPS	8-high	Normal
✓	2560x1440	359 FPS	8 Bits [9:2]	Normal @ (0,168)
	2560x1440	359 FPS	8 Bits [9:2]	Normal
	448x248	2578 FPS	8-mid	4X Binning @ (0,0)
	448x248	2578 FPS	8-mid	4X Binning
	1024x576	1172 FPS	8-mid	2X Subsample

OK Cancel Lock Toggle

4-3 Binning and Subsampling on the TS5

Binning:

Binning electronically combines adjacent pixels in groups of 4 (2 x 2 Binning) or groups of 16 (4 x 4 Binning). When pixels are grouped together in this way, the image resolution is divided by 2 or 4, respectively, both horizontally and vertically.

The TS5 sensor has a native pixel resolution of 2560 x 2048. While the highest resolutions supported by the TS5-H, -S, and -L are lower than this, the full 2560 x 2048-pixel array may be utilized for Binning and Subsampling.

The advantages of Binning are:

- Increased frame rates without changing optics.
- Binning reduces noise because the combined pixels tend to reduce the pixel-to-pixel differences.

Subsampling:

Subsampling is much like Binning, in that the resolution is divided without changing the field of view, but instead of electronically combining the pixels, only one pixel is read per group.

The advantages of Subsampling are:

- Increased frame rates without changing optics.
- Better resolving power (sharper images) than with Binning.

To Set the TS5 Binning or Subsampling mode:

The button to open the mode setting will either be set to "Normal," which is the default, or to one of the Binning or Subsample modes.

1. Set the resolution using the Width and Height sliders to the resolution you wish to use.
2. Set the Binning or Subsampling mode.

Note: If the chosen resolution is not supported, the highest resolution available at the present aspect ratio will be substituted.
*Actual sensor pixel resolution

Figure 4-12: TS5_H Record Settings Dialog

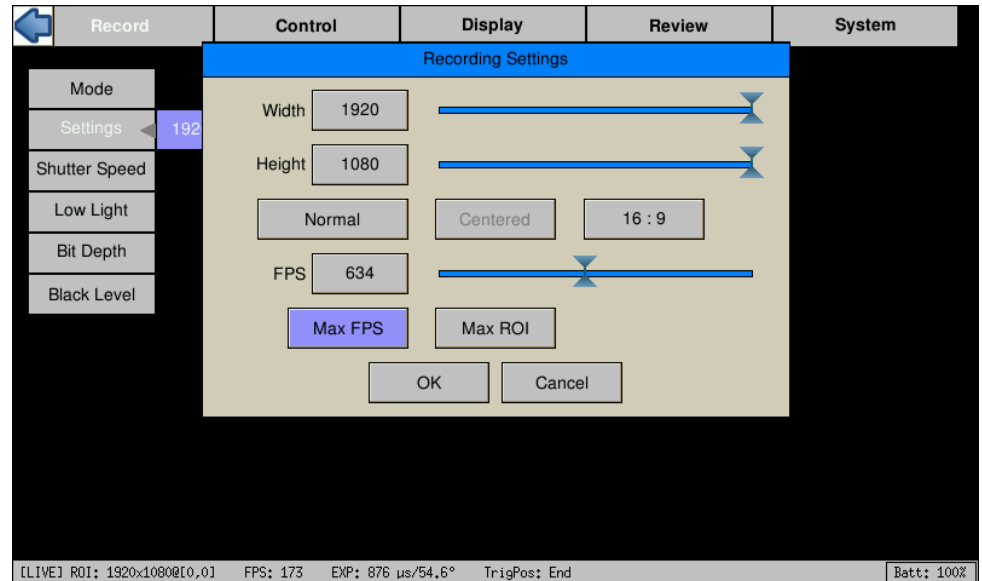


Figure 4-13: Selecting 2X Binning

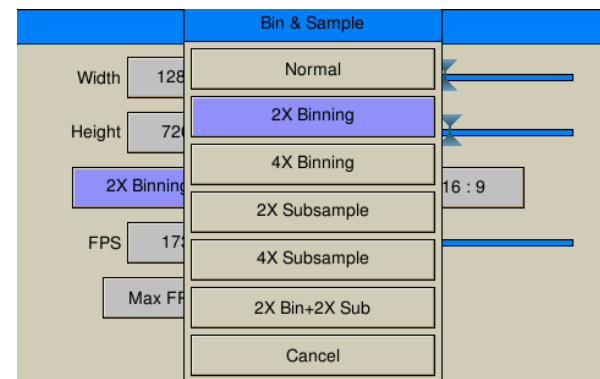


Figure 4-14: 4X Subsampling Selected

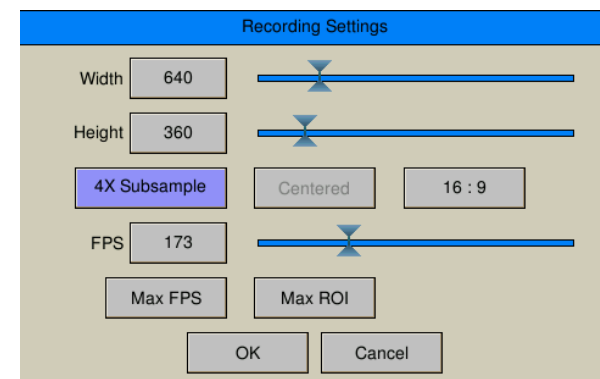


Table 4-3: Sample Binning and Subsampling Resolutions

Native Resolution*	2x Binned	4x Binned	2x Subsampled	4x Subsampled	2x Binned+ 2x Subsampled
2560 x 2048	1280 x 1024	640 x 512	1280 x 1024	640 x 512	640 x 512
2560 x 1440	1280 x 720	640 x 360	1280 x 720	640 x 360	640 x 360
2048 x 2048	1024 x 1024	512 x 512	1024 x 1024	512 x 512	512 x 512
2048 x 1152	1024 x 576	512 x 288	1024 x 576	512 x 288	512 x 288

4-4 Setting Shutter Speed

In the TSx, preset exposure times are expressed as xxxx μ s (1/1), (1/2), (1/4), (1/8) defined as:

For TS3 and TS4:(1/1):

1/(Frame rate) - 6 μ s

For TS5H:(1/1):

1/(Frame rate) - 12 μ s

For all cameras: (1/2), (1/4), (1/8): (1/n)...: 1/(Frame rate*n)

For Example, preset exposure times for 500Ffps for TS3 and TS4:

$1/(500\text{fps}) - 6\mu\text{s} = 1.994\text{ms}$; $1/(500\text{fps} * 2) = 1\text{ms}$; $1/(500\text{FPS} * 4) = 500\mu\text{s}$; $1/(500\text{fps} * 8) = 250\mu\text{s}$

Preset exposure times for 500Ffps for TS5:

$1/(500\text{fps}) - 12\mu\text{s} = 1.988\text{ms}$; $1/(500\text{fps} * 2) = 1\text{ms}$; $1/(500\text{FPS} * 4) = 500\mu\text{s}$; $1/(500\text{fps} * 8) = 250\mu\text{s}$

Minimum exposure for all TS3 / TS4 cameras is .002ms (2 μ s), for TS5 the minimum exposure is .003ms (3 μ s).

Table 4-4: Sample Frame Rates and Shutter Speeds

Frame Rates / Shutter Speeds	60 FPS	250 FPS	500 FPS	1000 FPS	4000 FPS
1X (TS3/4)	1/60 s = 16.660ms	1/250 s = 3.994ms	1/500 s = 1.994ms	1/1000 = .994ms	1/4000 = 244 μ s
1X (TS5)	1/60 s = 16.654ms	1/250 s = 3.988ms	1/500 s = 1.988ms	1/1000 = .988ms	1/4000 = 238 μ s
2X	1/120 s = 8.333ms	1/500 s = 2.0ms	1/1000 s = 1.0ms	1/2000 s = 500 μ s	1/8000 s = 125 μ s
4X	1/240 s = 4.167ms	1/1000 s = 1.0ms	1/2000 s = 500 μ s	1/4000 s = 250 μ s	1/16000 s = 62 μ s
8X	1/480 s = 2.083ms	1/2000 s = 500 μ s	1/4000 s = 250 μ s	1/8000 s = 125 μ s	1/32000 s = 31 μ s

Note: 6 μ s or 12 μ s is subtracted from the 1X exposures because there is a minimum inter-frame time.

Setting the Shutter Speed:

1. Navigate to Record Menu.
2. Select Shutter Speed.
3. Select (1/1), (1/2), (1/4), or (1/8) for preset shutter speeds.
4. Select Advanced to open a slider and edit box for dialing in the exposure with greater precision.

Note: The Advanced Exposure Settings dialog expresses the exposure time in milliseconds and in degrees of shutter angle:

$$(\text{Exposure} / \text{Frame Time}) \times 360^{\circ}$$

Assuming you have installed a lens (See “2-2 Installing the Lens” on page 7), you should now see a live image.

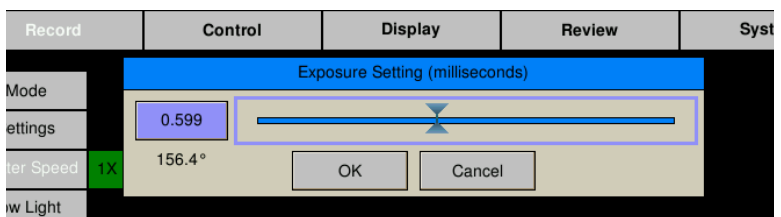
You may need to adjust the lens F-stop or the lighting as well as the shutter speed to get the exposure needed. Press the Display Button once to view a histogram to confirm that the image you see is not clipped (too dark or over-saturated.) See “Application Note 1: Histograms” on page 67.

Note that setting the f-stop to a lower value (more open iris) reduces the depth of focus, while setting the exposure to a higher value (longer exposure) increases motion blur.

Figure 4-15: Shutter Speed Menu



Figure 4-16: Advanced Shutter Speed



4-5 Low Light Mode

There is an option labeled “Low Light.” **THIS IS NOT A SHUTTER SPEED USED FOR RECORDING!** This is a special exposure setting that works in “Live Mode” only--for Live view and *not* while recording.

In some special circumstances, the light available for setting up the TSx for a high-speed event is not the same as what will be used for event itself. For example, you may be using an extremely bright light or light of a spectrum that would be harmful or uncomfortable for people to work under. In Low Light Mode the camera framing and focusing can be done in available light.

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 the Web-App or custom camera software, but not via the on-camera interface.

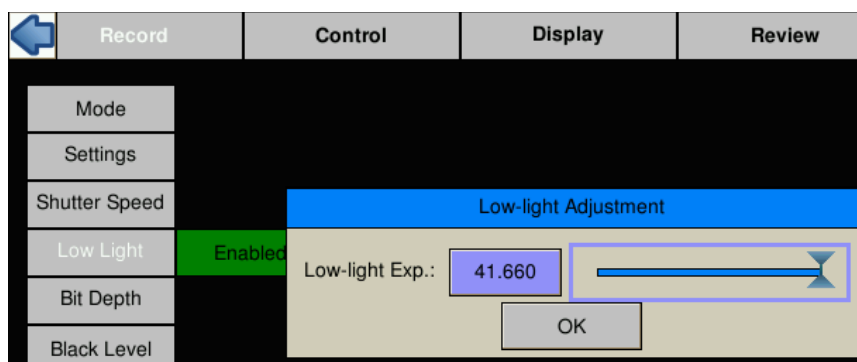
To enter Low Light Mode:

Note: Be careful when using the Low Light feature! **It is 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, as described in “4-4 Setting Shutter Speed”
2. Navigate to the Record/Low Light Menu.
3. If Low Light is not enabled, there will be two items in the menu: “Disabled,” and an exposure setting (41.660ms by default). When you click on the “Disabled” button, it will change to “Enabled.” You will notice immediately that the Live image is much brighter.
4. If you wish to adjust the low-light setting, click on the exposure setting button to open the Low-light Adjustment slider. The edit box may also be used to enter the exposure.

Note: When you Arm the camera to begin recording, Low-light mode will automatically be canceled and the exposure will revert back to its normal setting (which is usually much darker).

Figure 4-17: Low Light Slider



4-6 Setting Bit Depth

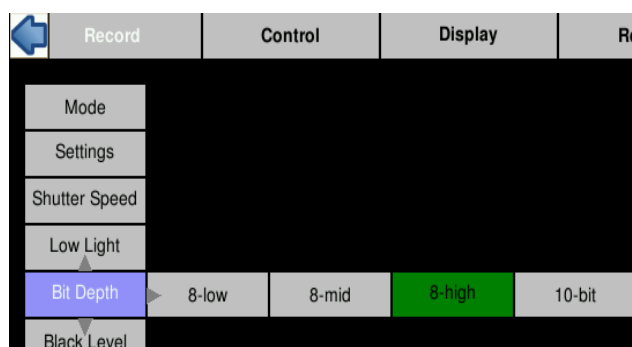
For a description of what bit depth is and the results of changing bit depth, please refer to “Application Note 2: Understanding Bit Depth” on page 69.

Setting the recording bit depth for TS3 and TS4 cameras:

1. Navigate to the Record Menu.
2. Select Bit Depth.
3. Select 8-low, 8-mid, 8-high, or 10-bit. If any of the 8-bit mappings are chosen, the live image will immediately reflect that change. If 10-bit is chosen, the displayed live image will default to 8-high.

Note: The image processor of the TSx does all its calculations in 16-bit space in order to avoid quantization errors that would result in image contouring and reduction of the color palette. When 10 bits are recorded, the extra bits are used in image processing even though only 8 bits (24 bits in color) will ultimately be displayed.

Figure 4-18: Bit Depth Menu TS3 / TS4



Setting the recording bit depth of TS5 cameras:

The TS5's 12-bit sensor affords more bit selection choices than the TS3 or TS4 cameras.

There are presets that work just like those of the TS3 and TS4, as described above.

Specifically, "8-high" and "10-high" presets select the high 8 bits or high 10 bits, respectively. The "8-mid" preset represents a 4x change in slope.

In addition to the presets, there is also an "Advanced" button that opens the Bit Selection Dialog box shown in Figure 4-20.

Here, both bit depth and the high-order bit may be selected. With 12 bits available, there are five possible bit shift positions for 8-bit images; three possible positions for 10-bit images; and only one possibility for 12-bit images. (See Table 4-5.)

Notice that the default is to set the high bit at 12 for each bit depth. This is done because that is the setting for optimal image quality.

IMPORTANT:

Note: Camera frame rates on TS5 cameras are lower in most modes when 12- or 10-bits are selected.

Note: Always perform a Black Level calibration after changing bit depth.

Figure 4-19: Bit Depth Menu TS5

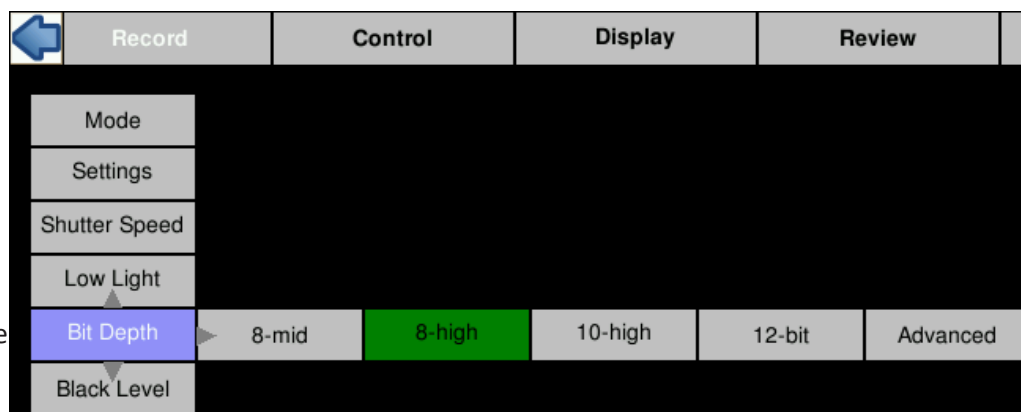


Figure 4-20: TS5 Advanced Bit Selection Dialog

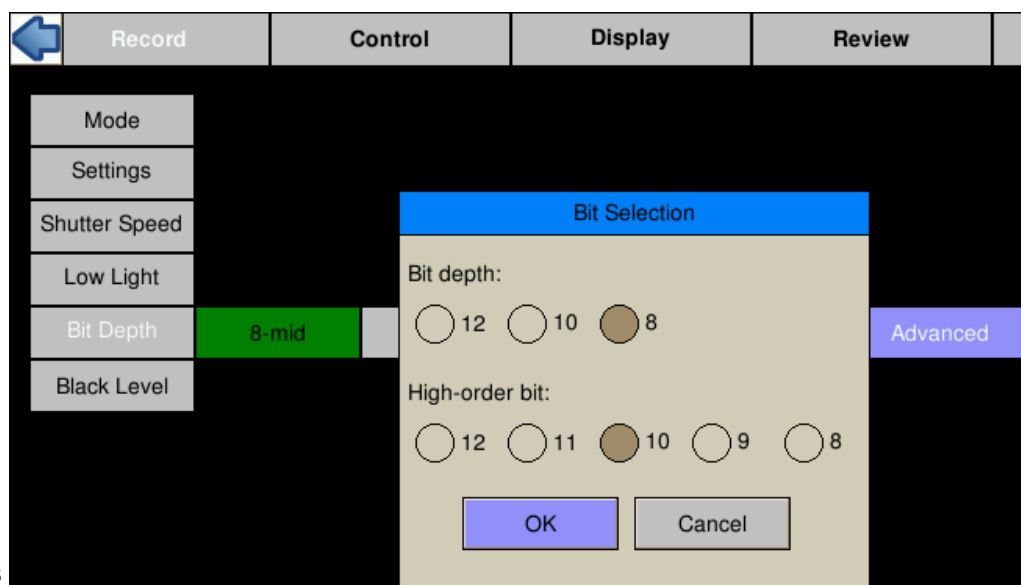


Table 4-5: Bit Depth and High-Order Bit

<<<---Quality-----Digital Gain--->>>

High-Order bit:	12	11	10	9	8
Digital Gain:	1 x	2 x	4 x	8 x	16 x
8-Bit	Default	X	X	X	X
10-Bit	Default	X	X		
12-Bit	Default				

4-7 Setting Session Length

The TSx has 4GB, or 8GB (depending on model and option) of internal high-speed memory used for capturing high-speed imagery. When operating in Standard Basic or FasFire modes, (not Long-Recording modes), all or part of this memory may be used to capture high-speed events. Total recording time will depend on resolution, frame rate, and bit depth.

Configure **Session**:

Session selects the amount of memory to be used for capturing imagery, which dictates the number of frames captured as well as the capture time:

1. Navigate to the Record Menu.
2. Select Mode.
3. Select either Basic Options or FasFire Options, depending on which mode you are in. (See “4-1 Selecting the Recording Mode” on page 28.
4. Click on the “Session” button to open the Session Length Adjustment dialog. See “Figure 4-2: Basic Mode Options” and “Figure 4-2: Basic Mode Options” on page 28.
5. Use the touch-enabled slider to select the amount of memory for the session (in increments of 256MB). Note that the number of frames and session time will change.
6. When the slider is selected, the D-Pad may be used for fine adjustment.

Note: When in FasFire mode, less than 50% of camera DRAM (memory) will be available. When in Basic mode with less than 50% of the DRAM selected and Autosave is enabled, the camera will operate in FasFire mode. (See “4-12 FasFire” on page 43.)

Figure 4-21: Session Length Adjustment

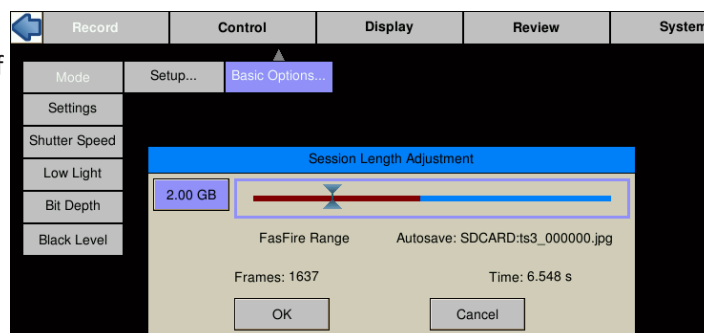
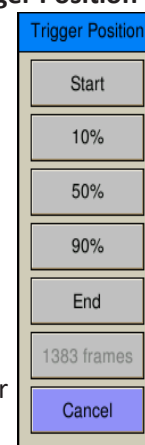


Figure 4-22: Trigger Position



4-8 Configuring the Trigger and External I/O

The trigger Position menu will appear in the camera GUI when setting up Standard Basic, LR Basic, or Standard FasFire mode operation. See section “4-1 Selecting the Recording Mode” on page 28.

Select Start, 10%, 50%, 90% or End.

Note: When controlling the camera via Web-Application or FasMotion software, it is possible to position the trigger in 1% or even 1-frame increments. Figure 4-22 shows how the trigger position set to 1383 frames via the Web-Application or FasMotion is displayed in the Camera GUI.

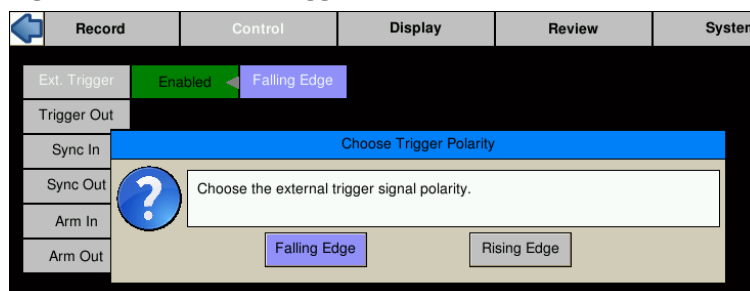
Enabling the External Trigger

There are times when manually pressing the trigger button is not practical. The camera may be mounted in a location that is difficult or dangerous to reach, or it may be that the precision required to activate the trigger is much easier to maintain through electrical means.

1. Navigate to the Control Menu.
2. Select Ext. Trigger.
3. If Disabled, click on the “Disabled” button. It will turn green, and change to “Enabled.”
4. The next button to the right will either say Rising or Falling Edge. If you need to change the setting, click on this button to open the dialog box pictured in “Figure 4-23: External Trigger”

Please refer to “Appendix F: Power and I/O Connections” on page 106 for connection information and warnings.

Figure 4-23: External Trigger



The external trigger is one of six external I/O connections available on the camera. Each of these may be used in one of two ways:

- 1. As a control I/O signal for the camera.
- 2. As an input for an external signal for creating Markers. (See “4-15 Playback: Jump to Markers” on page 48.)

Note the TSx ships 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 signals as well.

Trigger Out

The trigger out dialog includes the options “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 neither of these is selected, then you may select either “Active Low” or “Active High” and a Pulse Width for the signal.

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 Master Frame Rate and Rate divisor edit boxes are enabled, allowing you to set the frame rate lower than the Sync input. (Set Rate Divisor to 2 if you want 1/2 the master rate, etc.)
- When Sync In “Per Sec” is enabled, the Delay edit box is enabled, allowing a shift in integration timing from 0 to 1000µsec to fine-tune the phase relationship between cameras and other devices.
- When Sync Out “Per Frame” 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 “5 TSx Synchronization, Timing and Markers” on page 56.

Figure 4-24: Trigger Out Settings

Trigger Out Settings

☒ Pass Thru

☐ Invert Trigger In

☐ Active Low

☐ Active High

Pulse Width (ms):

-

2

+

OK

Cancel

Figure 4-25: Sync In Settings

Sync In Settings

☒ Per Frame

☐ Per Second

☐ Falling Edge

☒ Rising Edge

Master Frame Rate:

-

250

+

Rate Divisor:

-

1

+

Delay:

-

0

+

Calculated Rate: 250 (Max: 529)

OK

Cancel

Figure 4-26: Sync Out Settings

Sync Out Settings

☐ Per Frame

☐ Per Second

☒ Pass Thru

☐ Active Low

☐ Active High

☐ Invert SyncIn

☐ Shutter

☐ Duty Cycle

-

+

OK

Cancel

Enable Arm In / Arm Out

The TSx may be Armed using the Arm button on the camera, using camera software (FasMotion or the Web-App), or using an “Arm In” signal via the camera’s I/O cable.

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 4-27: Arm In Settings

Arm In Settings

☒ Edge ☐ Level

☐ Falling/Low ☐ Rising/High

☐ Discard unsaved images

OK Cancel

Figure 4-28: Arm Out Settings

Arm Out Settings

☒ Pass Thru ☐ Invert Armln

☐ Active Low ☐ Active High

☐ Pulse Width (ms) - 2 +

OK Cancel

4-9 Black Level Calibration

All digital sensors have a noise signature that is called FPN or Fixed Pattern Noise. In TSx cameras, Black Level Calibration may be used to eliminate FPN. There are three FPN Settings on the TSx:

- FPN off:** No noise correction. Saved images reflect exactly what the sensor detects. Used only when the user has need for completely raw, uncorrected data.
- Sensor FPN:** The sensor's on-board noise suppression is used. This is a good choice when dynamic range is the highest priority.
- Pixel FPN:** A black reference frame is subtracted, pixel for pixel, from each frame. Pixel FPN is the default setting and is recommended for the best image quality.

Calibrate Black Level:

The general rule is to do a Black Level Calibration if ever you believe the image looks noisy with Pixel FPN turned on. 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.
- If the camera's temperature has changed significantly since the last calibration.

To Calibrate the Camera

1. Navigate to Record/Black Level
2. For best results, select Pixel FPN
3. Click on "Calibrate."
4. Click on "Yes" to calibrate. See "Application Note 7: Advanced Calibration" on page 84 for using gain and black level options. There is a prompt to confirm that you have the lens cap on. You will see a little progress bar and you will see a couple of noisy images on the screen. When done, the live image with the lens cap in place should be black.

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

Figure 4-29: Black FPN Settings

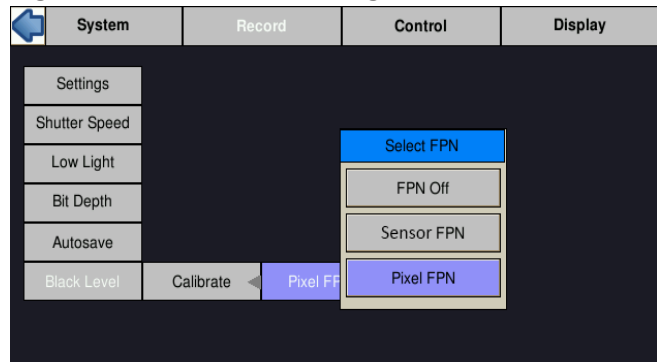
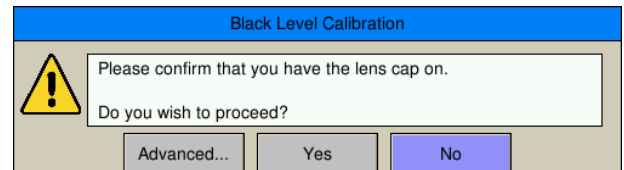


Figure 4-30: Black Level Calibration Dialog



4-10 Record in Standard Basic Mode

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

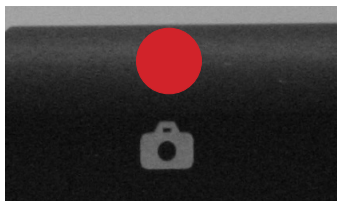
It is optional, but recommended, to take a reference still of the scene:

1. With the TSx in Live Mode (not Recording or Reviewing a recording) press the Trigger button.
2. 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.)

Begin recording in Standard Basic Mode by clicking the Arm button. (See “4-1 Selecting the Recording Mode” on page 28.)

When the Arm Button is pressed the camera begins recording into its circular buffer. The Camera LED will change from Green (Live) to slowly flashing Red. It will record for an indefinite period of time

Figure 4-31: Camera LED



until it gets a Trigger. (See “4-8 Configuring the Trigger and External I/O” on page 37.)

If the Arm Button is pressed a second time, the Recording will abort. A courtesy message will appear asking for confirmation. You will need to use the OK Button on the D-Pad to accept.

The recording state is indicated by a progress bar at the bottom of the TSx LCD display. (See “Figure 4-32: Progress: Armed TSx”) For this example, a 50% Trigger Point has been selected. The yellow/green bar represents the record buffer. The yellow half

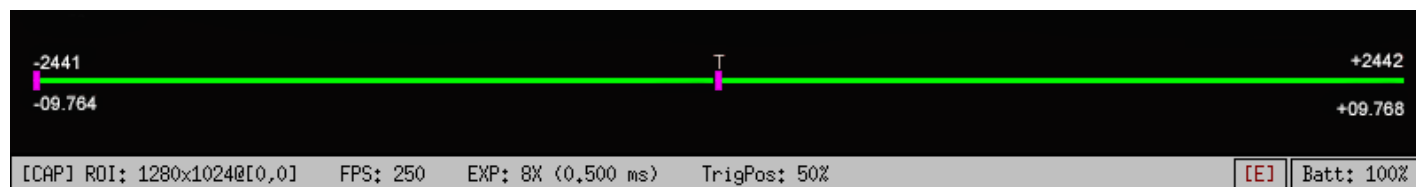
represents the pre-trigger portion; the green represents the post-trigger portion. The “T” in the center of the bar represents the Trigger Point (frame “0”).

The numbers above and below the bar on each side indicate the number of frames and seconds for the pre-trigger portion, to the left, and the post-trigger portion, to the right. In this instance, because the Trigger Point is set at 50%, both the number of frames and amount of time is the same on both ends.

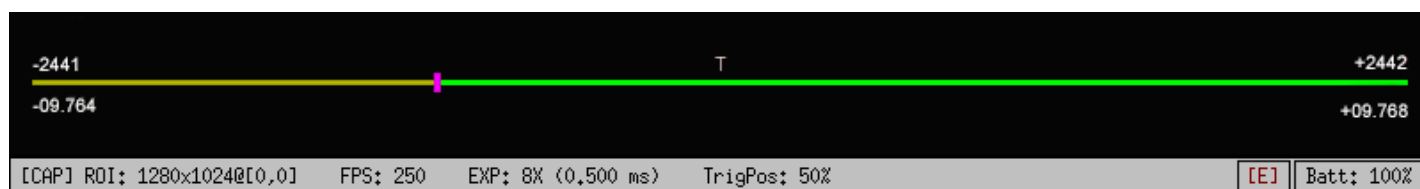
Note: If the TSx is triggered before the pre-trigger portion of the buffer is full, it will immediately cease taking pre-trigger frames, record frame “0” and progress to the post-trigger portion of the recording. When complete, the recording will have contiguous frames, with the full complement of post-trigger frames, but fewer pre-trigger frames. (See “4-8 Configuring the Trigger and External I/O” on page 37.)

Figure 4-32: Progress: Armed TSx

If the recording is canceled by pressing the Arm button before completion, you may elect to retain the images already recorded. (See “Figure 4-38: Cancel Record Warning” on page 45.)

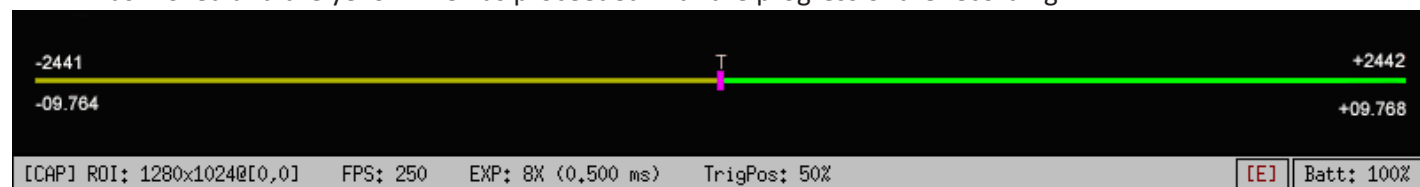


The recording has just been started (the Arm Button has just been pushed). The green progress line



spans the whole distance between the left edge and the trigger point.

The recording has progressed through a little more than half of the pre-trigger portion. The marker has moved and the yellow line has proceeded with the progress of the recording.



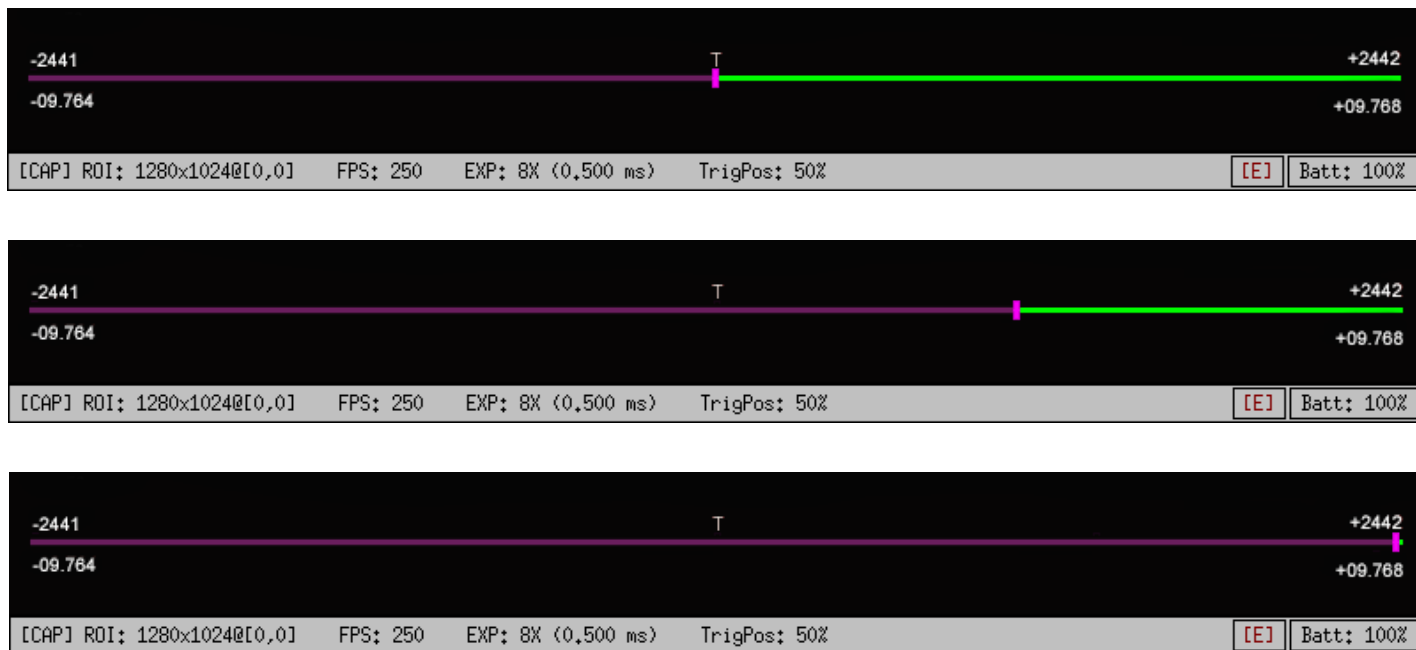
Trigger

Press the Trigger button, (see “TSx Top View” on page 4) or send an electrical trigger signal (see “Appendix F: Power and I/O Connections”).

When triggered, the TSx will capture frame “0” and the post-trigger frames. The progress bar will change color and move from the trigger point to the end as in the three images below.

The TSx will now either enter Review Mode or, if **Autosave** has been enabled, the camera will save the images to a mass storage device and return to Armed Mode, capturing pre-trigger frames and waiting for a Trigger.

Figure 4-33: Recording Progress: Triggered TSx



4-11 Autosave

The TSx 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 TSx with an optional 256GB 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! Even if saving to an SD card, many events may be captured.

Advantages of using Autosave:

- Autosave is the only choice for **multiple unattended events**. For remote locations or locations where networking is not possible, or for long shifts where there may be multiple events of interest that need to be captured without human intervention.
- 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.
- Use Autosave for any unattended event where there is a possibility of a spurious trigger. If this happens to an unattended camera, it is possible that the camera will trigger prematurely. If Autosave is used, there is a good chance that the camera will have returned to Record mode in

time to capture the planned event.

Autosave is available in Standard Basic and FasFire modes.

1. Navigate to the Record menu and select Standard Basic or FasFire.
2. In the settings dialog, make sure that the Autosave check box is checked. (It will be checked automatically if FasFire is selected).
3. A dialog box will open to allow you to set up Start/Stop frames for downloading (the Start/Stop times for the recording are the defaults), the destination drive (mass storage target for downloads), file type options, and options for naming the downloaded files. (See “4-18 Saving Images to Mass Storage” on page 53.)
4. When finished setting up the Autosave settings, click on the OK button.

Note: Autosave will continue re-arming itself, capturing images when triggered, and downloading them until the target drive runs out of space or Autosave is manually cancelled using the Arm button.

Note: A camera that is powered down with Autosave enabled will power up with Autosave enabled. See “2-3 Powering Up, Charging, and Power Down” on page 8.

Figure 4-34: Autosave Dialog

Table 4-6: FasFire Partitions

Session Length	FasFire Partitions	
	4GB DRAM	8GB DRAM
256MB	15	16
512MB	7	15
0.75GB	5	10
1GB	3	7
1.25GB	3	6
1.5GB	2	5
1.75GB	2	4
2GB	1*	3
2.25GB	1*	3
2.5GB	1*	3
2.75GB	1*	2
3GB	1*	2
3.25GB	1*	2
3.5GB	1*	2
3.75GB	1*	2
4 or >4GB	1*	1*

* With only one partition, the camera does not operate in FasFire mode

4-12 FasFire

Note: FasFire mode takes more power than other recording modes. Please refer to “Application Note 8: Running the TSx on Batteries” on page 86.

The TSx is capable of recording images to one memory partition while saving images from another partition to non-volatile media such as an SSD, SD card, or USB device. Depending on the amount of high-speed DRAM memory (4GB or 8GB) on your camera and the Session Length (partition size) you set (see “3-10 Storage” on page 25), the FasFire feature lets you capture many 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.

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 the remaining 7 for FasFire. (See Table 4-5.)

Entering FasFire

The camera will operate in FasFire mode whenever there are at least two FasFire partitions and the camera is set to AutoSave. (Refer to “4-1 Selecting the Recording Mode” on page 28.) In FasFire, as soon as the camera receives an Arm signal, FasFire will commence.

Using the Gas Gauge

Using the DISP button on the TSx to toggle through the displays in FasFire, you will find that there is a “gas gauge” available at the upper left corner of the image.

When the gas gauge is solid green, as in the upper image in Figure 4-35, all memory partitions are empty. This means that either you have not triggered the camera yet, or that all of the partitions you have recorded have been saved.

When you trigger the camera, the gas gauge retracts proportionately to the number of available partitions. The gas gauge in the center image shows that half the available partitions are available, and half are being saved.

If you continue to trigger the camera quickly, you may get down to the last partition. At this point the gas gauge turns red, as in the bottom image.

The gas gauge will recover as soon as partitions are saved to media, so if you wait for a while you will see the gas gauge recovering, a partition at a time, until it is solid green again.

If you do use the last partition, the camera will display the Autosave Progress bar and indicate the number of partitions waiting to be saved. (See “Figure 4-36: Autosave Progress Bar”.) As soon as one partition is free, you will see the gas gauge again and may proceed to record images.

Figure 4-35: FasFire Gas Gauge



Cancelling FasFire

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 Autosave Progress bar will appear.

If you click on Cancel from the Autosave Progress Bar, the camera will return to Live Mode.

There are still recordings in DRAM memory at this point.

If you would like to recover them, go to the Review Menu. (See Figure 4-37.) If you click on "Play," you will see the last partition in "Review" mode, from where you will be able to save the clip.

If you click on "Free," the camera will discard the last buffer and load the next in Review. You are thus able to Play, Save, or discard each partition in turn, working from newest to oldest.

Figure 4-36: Autosave Progress Bar



Figure 4-37: Review Menu with Unsaved Partitions



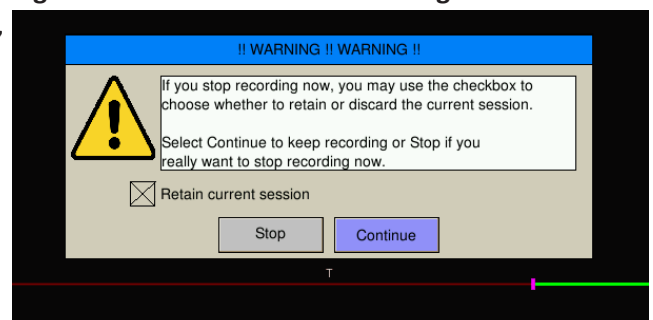
4-13 Long Recording Modes

Long Record Basic mode works much like Standard Basic mode, which is described in "4-10 Record in Standard Basic Mode" on page 40:

1. Press 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 at the beginning, end or somewhere between (presets on the camera are Start, 10%, 50%, 90% and /End).
- When triggered, the camera will record the trigger frame, plus all post-trigger frames on the onboard SSD, then proceeds into Playback.
 - Recording progress along the displayed timeline will appear just as with Standard basic mode. Please refer to Figure 4-32 and Figure 4-33 on page 42.

Note: If you wish to stop recording before all the post-Trigger frames are recorded, you may cancel the recording by pressing Arm, then elect to "Retain the current session" when you stop the recording as shown in Figure 4-38.

Figure 4-38: Cancel Record Warning



There are three basic differences between Long Record Basic and Standard Basic modes:

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

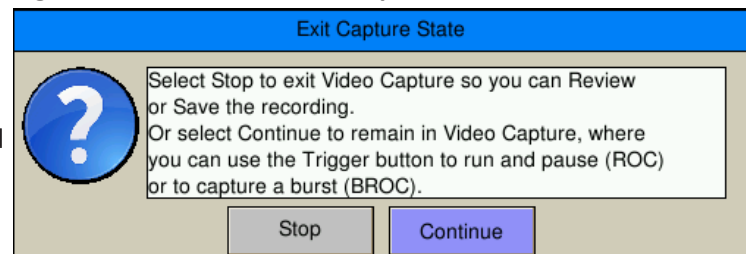
FasCorder ROC mode is convenient when multiple recordings of various durations will be made or when there are pauses in the action that need not be recorded. **FasCorder BROC mode** records a specified number of frames with each trigger. See "4-1 Selecting the Recording Mode" on page 28.

1. Once the camera is set to ROC or BROC mode, press the Arm button. You will now see the recording timeline and a live image on the display. The position bug will be all the way to the left.
2. Press the Trigger button. The TS4 is now recording and streaming the images directly to the onboard SSD. The camera LED will flash red.
3. ROC mode: Press the Trigger button again. The recording will now pause. The camera LED will flash amber. Repeated triggering will cause the camera to alternate between recording and paused states. When recording, the camera LED will flash red. When paused, the LED will flash amber and the position bug will stop. This can be repeated until space on the SSD is exhausted.

BROC mode: The camera LED will flash red while recording a specified number of frames, then the camera will pause with the LED flashing amber. If the trigger is pressed before the specified number of frames have finished recording, the additional frames are appended to the recording.

4. Press the Arm button. A message will appear giving you the option to continue recording or stop and go into Playback.

Figure 4-39: Exit FasCorder Capture



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

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.

4-14 Reviewing Captured Imagery: Playback

Four things to do in Review:

1. **Configure Event Markers**--This makes it easy to find events such as the beginnings of ROC and BROC recordings, or activity on the I/O lines.
2. **Play** the video--play it forward, backward, frame by frame, adjust the cut-in and cut-out points (find the interesting portion of the clip), etc.
3. **Adjust** the image brightness, contrast, gamma, bit depth, color, etc. (See "4-16 Image Processing" on page 49.)

Figure 4-40: Playback Buttons--Markers Present



4. **Save** video to a mass storage device. (See "4-18 Saving Images to Mass Storage" on page 53.)

To Review the video:

In Review Mode there is a series of buttons on the bottom of the display, and a progress bar, very much like the one used for Record Mode to mark the place in the video currently being viewed.

To enter Review / Play:

1. Either complete a recording, which will automatically open Review / Play, or navigate to the Review Menu and select Play. This will only be available when there is a recording in the TSx image buffer, and the camera is not Recording or Saving to storage. When the image buffer is empty the Review Menu text will be grayed, and the menu items will not be accessible.
2. Use the Playback Buttons or touch-enabled slider to move through the imagery. The Status Bar
















will reflect the record frame rate (FPS), the playback speed, current frame number, frame time (relative to the trigger), and the Cut-In and Cut-Out points.

NOTE: The red hatch marks on the timeline in Figure 4-40 show the position of Event Markers. Please refer to “5-5 TSx Timestamps and Markers” on page 63 for details.

The playback buttons may be used with the touchscreen or the D-Pad.

Note: in Standard Basic mode, with the “Auto-playback” box checked in Camera Preferences, the playback window will open with the video playing. (See “Auto-playback” on page 19.)

Table 4-7: Playback Control

	Returns to Live image. (Recorded image is still in buffer.) To return to Play, navigate to Review Menu and select Play.
	Creates new Cut-In point at current frame. To remove Cut-In point, click again, and then move cursor.
	 Go to beginning of clip--goes to Cut-In point. Click a second time and it goes to the very beginning of the video. Or Jump back to the previous Event (when “E” is present).
	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 one frame forward. When highlighted, hold OK button on D-Pad to skip forward.
	 Move to end of clip--goes to Cut-Out point. Click a second time to go to the end of the video. Or Jump forward to the next Event (when “E” is present).
	Creates new Cut-Out point at current frame. To remove Cut-Out point, click again, and then move cursor.
	Jump to Trigger frame.
	Truncate / Delete. In LR ROC or BROCC 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.
	Open Save Partition dialog box to save clip. (Uses current Cut-In/Out points for Start and Stop frames.)

Adjust playback rates using the up and down buttons on the D-Pad:

Table 4-8: Playback Rates

FPS	60	125	250	500	1000	2000	4000	5600
Playback Rates	5	5	5	5	5	5	5	5
	10	10	10	10	10	10	10	10
	15	15	15	15	15	15	15	15
	30	30	30	30	30	30	30	30
	60	60	60	60	60	60	60	60
		120	120	120	120	120	120	120
		125	125	250	500	1000	2000	2800
			250	500	1000	2000	4000	5600

4-15 Playback: Jump to Markers

TSx cameras have six LVTTTL I/O ports that 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 for control or markers or both.

When used for camera control, these ports are defined as Trigger-in, Trigger-out, Sync-in, Sync-out, Arm-in, and Arm-out and labeled as such on the optional 6-BNC I/O cable (PN 1105-0405).

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 “5-5 TSx Timestamps and Markers” on page 63 for more information on use of the I/O ports for markers.

An additional marker, Record Start, is used to mark the beginning of each recording when there are multiple recordings viewable on the timeline, as is the case when using LR FasCorder Mode.

When playing captured video on the TSx, event marker locations may be made visible as red marks on the playback timeline and jumped to using special Jump to Event buttons that only appear when Markers are enabled (see “Figure 4-40: Playback Buttons--Markers Present” on page 46).

Event Marker Logic

The logic governing the use of the event markers is programmable via the Event Marker Control dialog. (Select Review/Events on the camera touchscreen.) Note that the six inputs are represented by six control buttons, labeled T-I, T-O, S-I, etc. The pin numbers are also listed in the dialog for convenience. Each input is programmed separately as follows:

X = The signal will be ignored

O = True when Low

↓ = True when High to Low transition has occurred

1 = True when High

↑ = True when Low to High transition has occurred

C = True when any transition has occurred

G = “Glitch” true if the camera has seen a signal, but its state has not changed since the last frame.

Setting up Event Markers

1. Open the Event Marker Control dialog: click on Review/Events
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 “Or,” or only when **all** the signals are “true” use “And”
5. Click on “OK” to accept the Event Marker controls.

Note: The Event Marker setup is a camera configuration setting and is not associated with the captured video. Like other camera settings they are saved and loaded via System/Configuration/Save and System/Configuration/Load.

Figure 4-41: Event Marker Control Dialog

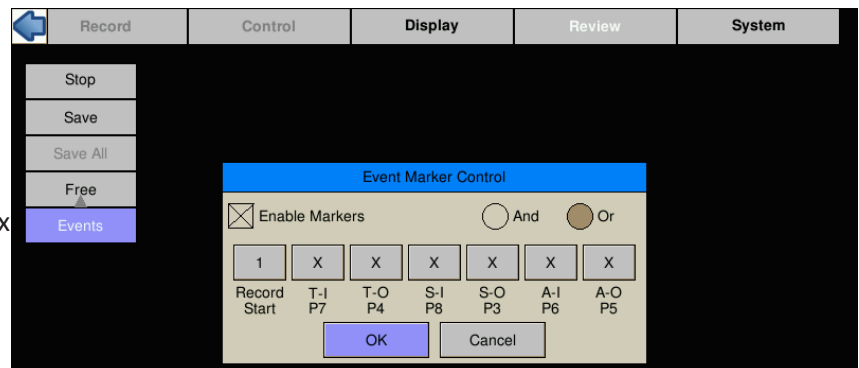
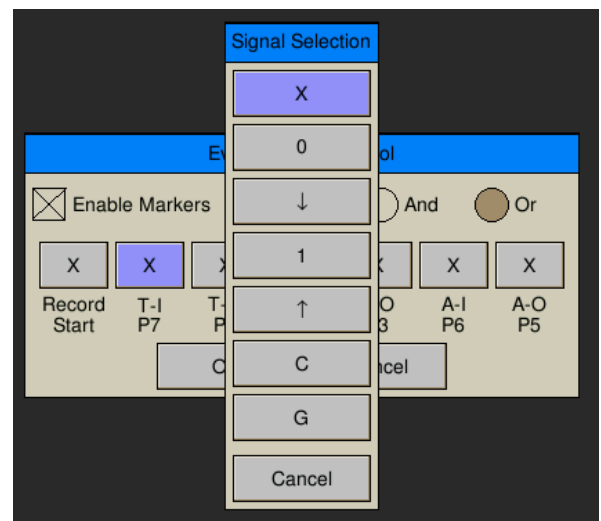


Figure 4-42: Event Marker Signal Selection



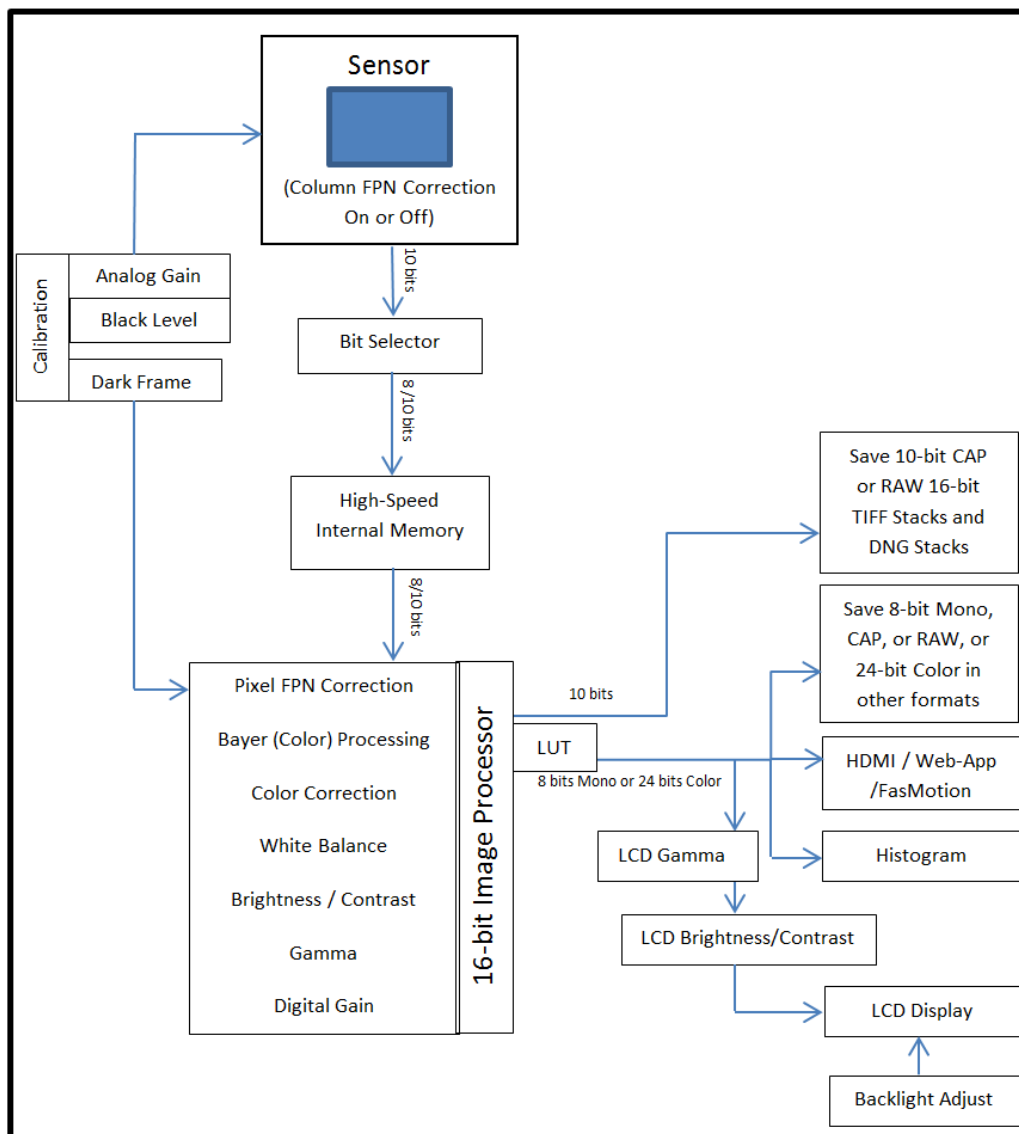
4-16 Image Processing

TS3 / TS4 Image Pipeline

The TS3 / TS4 image processing begins in the LUPA1300-2 sensor, where on-chip FPN corrections occur (if enabled) and the Black and Analog Gain level is set during calibration. Pixel data, also collected during calibration is used for Pixel FPN correction (if enabled). (See “4-9 Black Level Calibration” on page 40.) The TSx does more image processing, some of which can be controlled by the operator. To better understand how this works, please refer to “Figure 4-43: TS3 / TS4 Image Pipeline”

(For more information on the TS3 / TS4 Image Pipeline, please skip ahead to “Bit Selection” on page 50.)

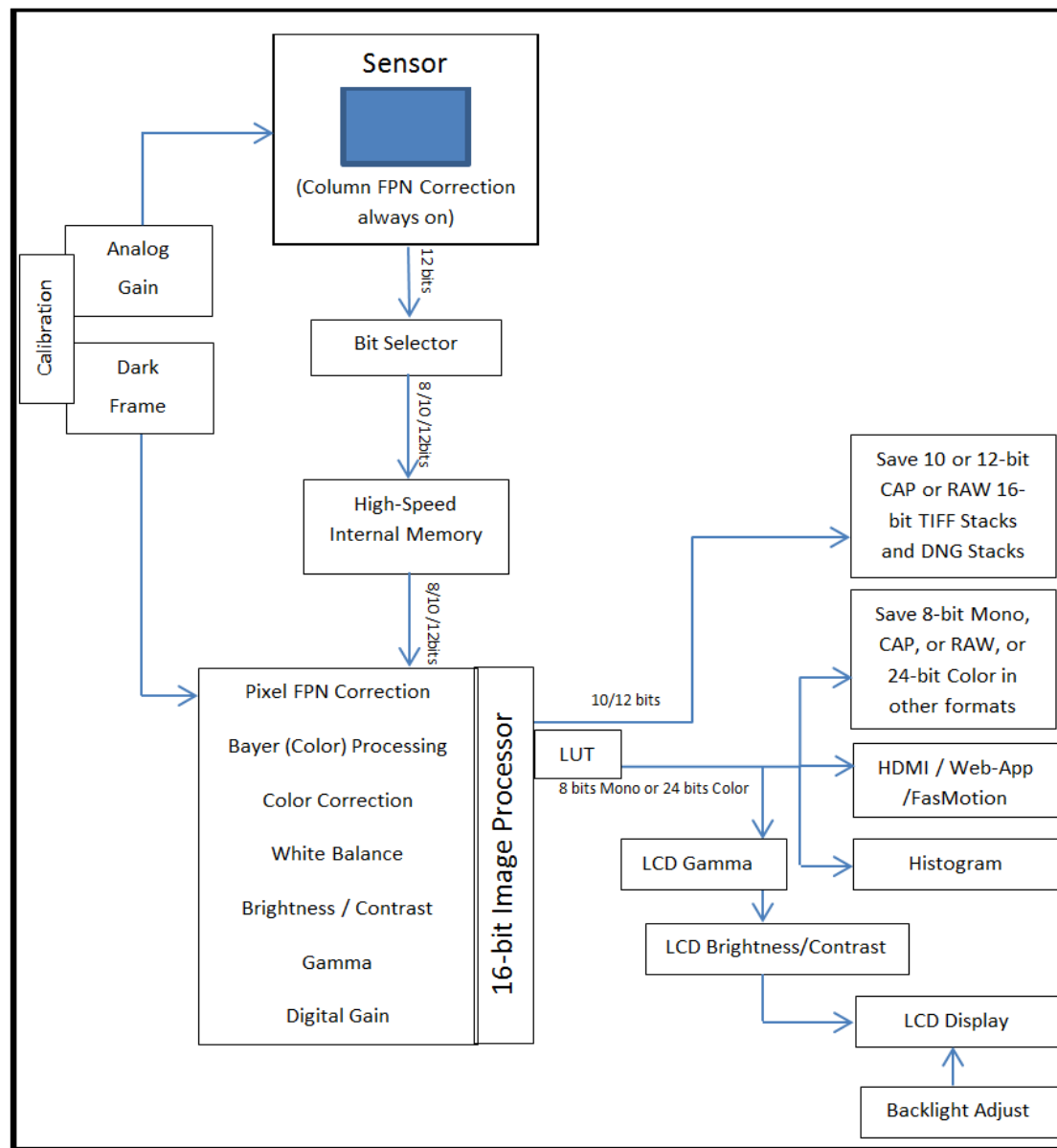
Figure 4-43: TS3 / TS4 Image Pipeline



TS5 Image Processing Pipeline:

The TS5 image processing begins in the Lince5M sensor, where on-chip Column and Row FPN corrections occur (Sensor FPN) and black level is tracked using masked pixels. (Refer to “Figure 4-44: TS5 Image Pipeline” on page 50.) These features are always enabled unless the user specifically selects FPN Off. Analog Gain is set, and Pixel data is collected during calibration for use when Pixel FPN correction is enabled.

Figure 4-44: TS5 Image Pipeline



Bit Selection

The 10-bit or 12-bit sensor output goes to the Bit Selector, then to internal high-speed memory. This selection is made by the user when bit depth is selected. (See "4-6 Setting Bit Depth" on page 35.)

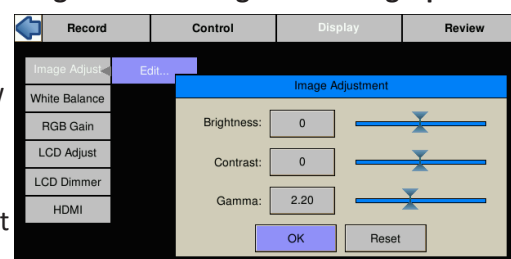
The path for all displayed images and the input to the histogram is: Sensor, to Bit Selector, to Image Processor, to Display / Histogram. It is always 8-bit Mono or 24-bit Color. Live images pass through from high-speed memory to the image processor immediately. Captured images are saved in high-speed memory until the camera powers down or the images are written over.

- Images in the internal high-speed memory have not yet gone through the image processor. This means that the image processing settings have NO effect on the images in high-speed memory-- they only affect the images as they are saved or displayed.
- Images in high-speed memory may be viewed or saved multiple times with different settings.
- Live images seen on the display ALWAYS go through the image processor.

User Control of Image Processor

- Bayer (Color) processing (color cameras only) is done to display a color image. The user may elect to save images that have not gone through Bayer colorization by choosing to download a RAW format (See “4-18 Saving Images to Mass Storage”).
- Color Correction is controlled via “White Balance” in the Display menu. You may choose from several color temperatures: Daylight (5600K), Tungsten (3200K), and Fluorescent (4100K) and Normal setting 1:1:1 (all channels at nominal gain). There is also a “Custom” setting used to white balance using a gray target and an RGB gain dialog for further manual adjustment. See “4-17 Custom Color Correction”
- Brightness and Contrast are controlled via Display / Image Adjust. Users select levels from -100 to +100 (default = 0) using the sliders or by clicking on the number in the edit box to open a keypad.
- Gamma is also adjusted in the Display / Image Adjust dialog. Levels range from 0.20 to 5.00. Gamma 2.2 is the default as it is the most common display gamma for monitors. For a linear display, choose a gamma of 1.00. (See also “3-4 Controlling the Displays” on page 19.)

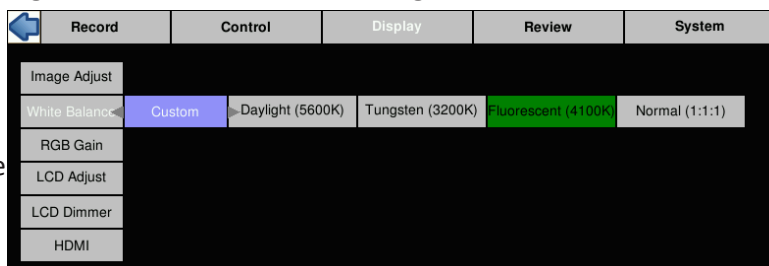
Figure 4-45: Image Processing Options



Setting Image Processing Options:

1. Navigate to the Display Menu
2. Select the image processing option you wish to change: Brightness, Contrast, or Gamma.
3. Experiment with the values in each of these controls to get the best possible image.
4. You may wish to open a histogram (DISP Button) for reference as you use these controls.

Figure 4-46: White Balance Dialog



NOTE: Use the D-Pad to access the 1:1 selection

Note: Selecting from this menu only affects the Displayed image and any (non-RAW) images saved to mass storage devices. It does not affect the either the 8-bit or 10-bit images as they are recorded into the TSx's high-speed internal memory. **Adjustments made here may be done before and/or after the imagery is captured.**

Note: All image processing is done using 16-bit math. If 8 bits are recorded, they will be used as the upper 8 bits of the 16-bit calculations by the image processor. The upper 8 bits of the results are then used as an output. Similarly, if 10 bits are recorded, they will be used as the upper 10 bits of the 16-bit calculations. This is true regardless of the output bit depth, thus the lower two bits of the 10 bits recorded are used when computing color corrections and image adjustments, even if you are viewing or downloading 8-bit (mono)/24-bit (color) formats.

4-17 Custom Color Correction

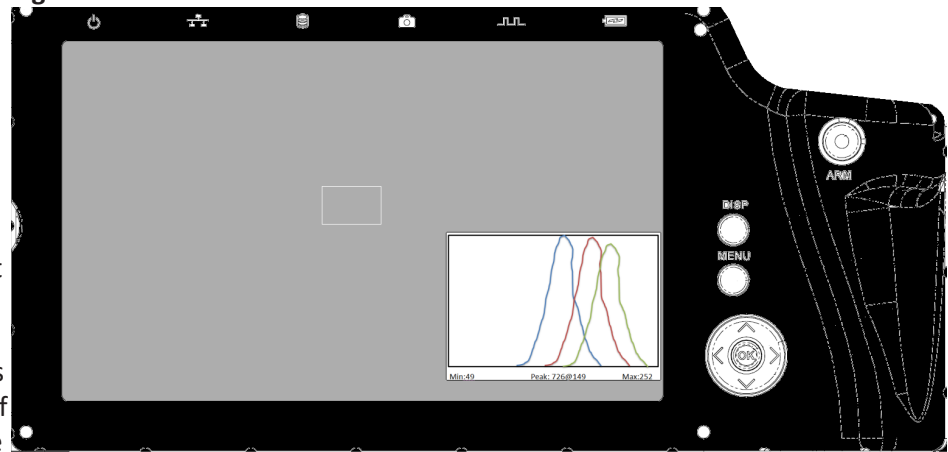
When the preset White Balance options, Daylight, Tungsten, and Fluorescent, do not give you the color reproduction you need, there are a couple of other options available:

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

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 LCD display and a special histogram will appear at the lower right. (See “Figure 4-47: Custom White Balance” on page 52.)

- 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.

Figure 4-47: Custom White Balance

- Adjust the lens aperture so that the histogram shows the pixel values grouped high (to the right side of the box), but not saturated. 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 Blue peak is farthest to the left. This means that the color is skewed slightly towards the yellow, the complement to blue.

Note: The histogram used with Custom White Balance represents only the area of the reticle, not the whole image.

Note: For more information regarding TSx Histograms please refer to “Application Note 1: Histograms” on page 67.

- Press the Trigger button. You will immediately notice a difference in the color.

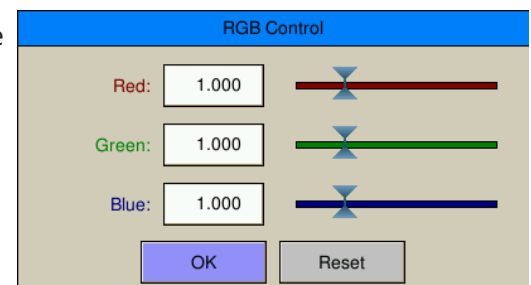
Using RGB Gain Controls

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:

- Navigate to the Display/RGB Gain menu and open the dialog box.
- For any color gain you wish to increase, move the slider to the desired position. Remember to use the D-Pad for fine adjustment.
- If you wish to simply add color-neutral gain to the image, move all three sliders proportionately.

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.

Figure 4-48: RGB Control Dialog

4-18 Saving Images to Mass Storage

Image sequences are saved either as Partition Captures (CAP files), or AVI videos, in which one file contains all the frames of the sequence, or as TIFF, DNG, JPEG, or BMP stacks, which are collections of files, one file per frame of imagery. Partition Capture files (CAP) include all the raw image data in a proprietary uncompressed format. The file-save options change depending on whether 8-bit, 10-bit, or 12-bit image data has been written to internal high-speed memory:

Table 4-9: Image File Save Options

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)

Note: CAP files are only available on cameras with SSDs, SN A0 and up, or after a main board upgrade.

Calculating file sizes for TIFF and BMP images is simple:

$$\text{Resolution} \times \text{Bit depth} / 8 = \text{approximate BMP or TIFF file size in Bytes}$$

(to convert Bytes to KB divide by 1024)

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

$$1280 \times 1024 \times 8 / 8 = 1,310,720 \text{ bytes} = 1,280\text{K}$$

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

$$1280 \times 1024 \times 16 / 8 = 2,621,440 \text{ bytes} = 2,560\text{K}$$

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:

1. Navigate to the Review Menu
2. Select Save. The Save dialog box will appear as in “Figure 4-49: Save Dialog Boxes”. The Start and Stop frames for the Save may be edited for all file formats except for Partition Capture (CAP) files.

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 Cut-In and Cut-Out buttons were used during Review. If you are not sure what the actual beginning and end frame numbers for the video are, you can find them on the far left / far right sides of the record bar. (See “Figure 4-33: Recording Progress: Triggered TSx”)

1. Selecting "Destination" will open a dialog box for selecting the mass storage device to save to.
2. Select "Format" to select the file type. Once you select a file type from the list, the OK button will turn blue. (See "Table 4-9: Image File Save Options" on page 53.)
3. The default name format for image stacks folders is ts3_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 FASTEC-TS3-08_000000.

Figure 4-49: Save Dialog Boxes

4. 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 2013-12-02_000000.

5. Both the Name and the Tag may be used.

6. 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 FASTEC-TS3-08_000000.AVI, or 2013-12-02_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.)

7. A Comment may be added to the file. Comments become part of the information used in Explore (see Figure 3-22 on page 25) and are written to the metadata (see "Appendix J: Contents of <Capture>.txt file")

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

- DCIM. This is an industry standard directory name for Digital Camera Images.
- 100fastc. This is a sub-directory under DCIM.
- ts3_000000. This 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 camera setup values, including resolution, frame rate, camera name, time stamp for the capture, image processing values, color processing values, etc. (See "Appendix J: Contents of <Capture>.txt file")

- <filename>.cfg files. This is a binary file used for MiDAS player.
- An XML file may be saved along with the image data. This XML file has per-frame information for the capture including acquisition timing for each frame with microsecond resolution.

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.).

4-19 Loading CAP Files Back to Memory

Partition Capture files, or CAP files, are the only non-LR mode file format that can be played back on the camera after having been saved on the SSD (on cameras so equipped). To play CAP files, you must first Load them from the SSD into camera memory. Once in memory, a CAP file will be available for Review and Save just as like when it had been recorded. See “4-14 Reviewing Captured Imagery: Playback” on page 46.

Loading CAP files from the Review Menu

CAP files may be loaded from either the Review/Load menu or the System/Storage/Explore menu on the camera GUI.

Figure 4-50: Loading a CAP file from the System Menu

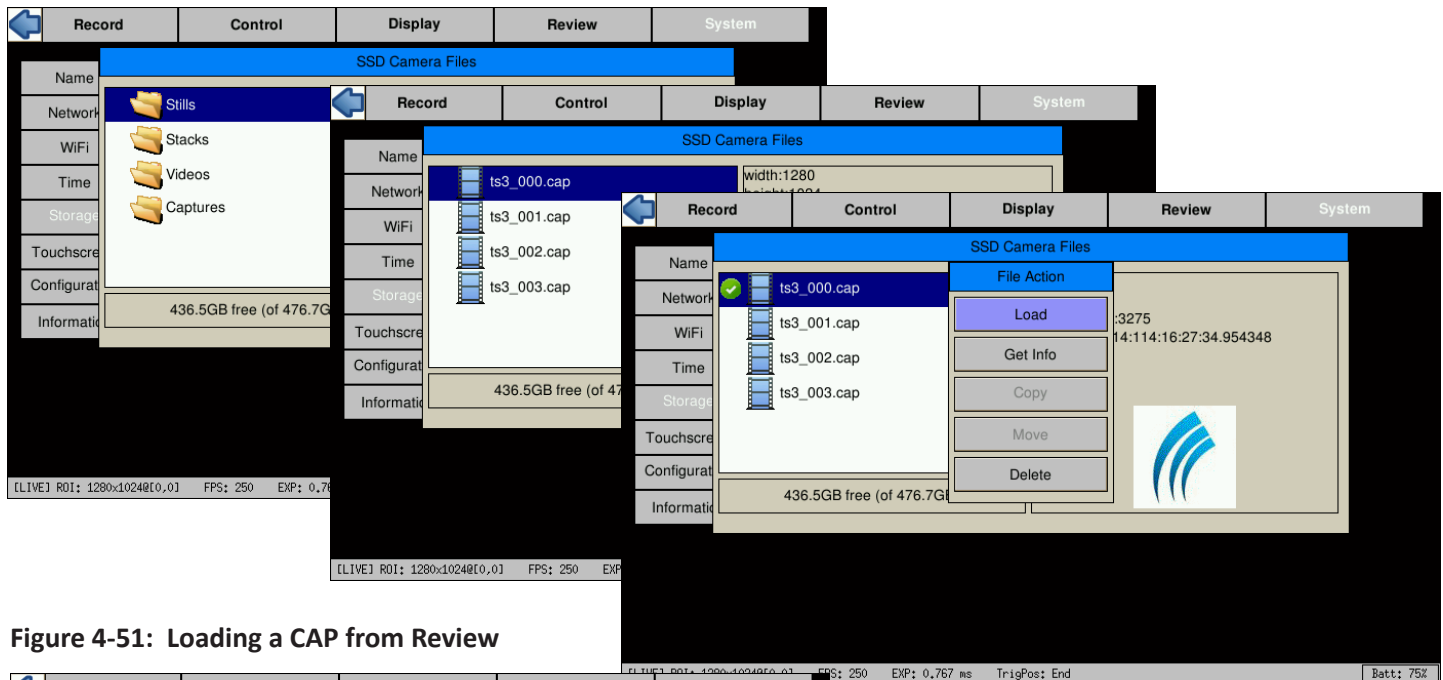
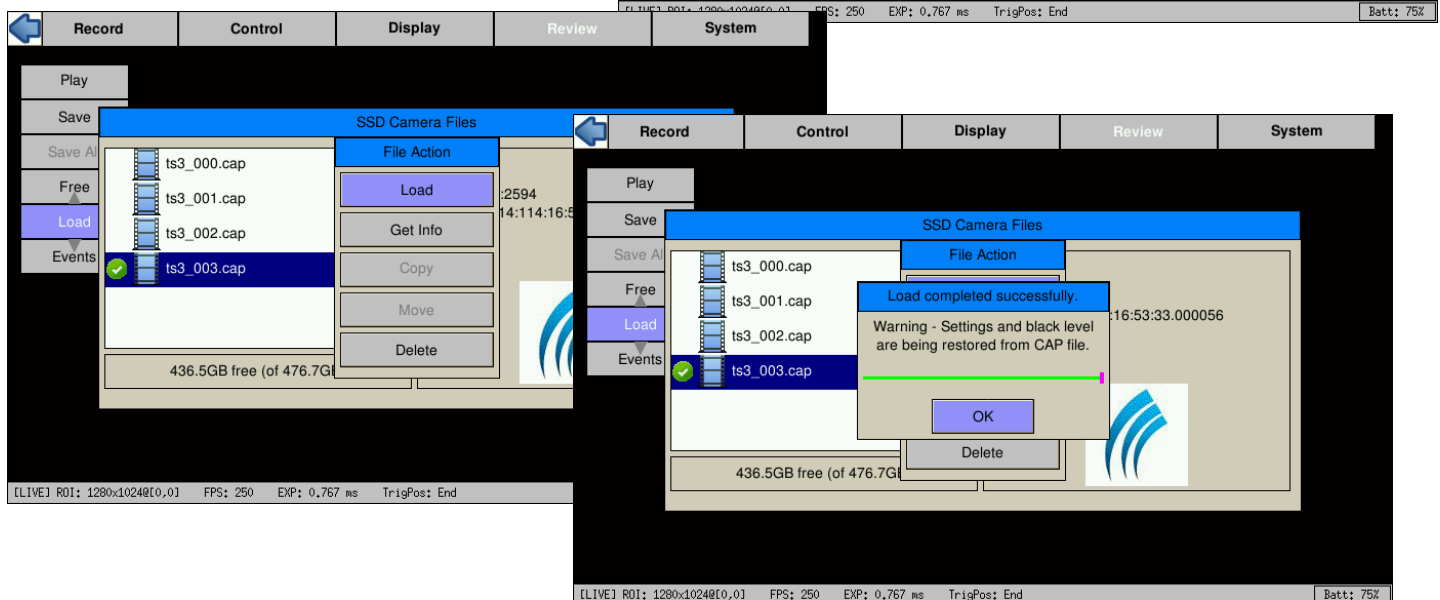


Figure 4-51: Loading a CAP from Review



Note that the settings and black level from the CAP file are copied into the camera when it is loaded. These settings include the session length, resolution and all color and image settings.

5 TSx Synchronization, Timing and Markers

Note: Please refer to “Appendix F: Power and I/O Connections” on page 106 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.

5-1 Sync-In

Note: With Sync-In enabled, you will not get a live image unless a valid sync signal is present.

Per Frame:

The TSx is easily synchronized to an external device such as another camera, or a precision timing generator. The “Per Frame” option is used when you wish the camera to capture one frame per pulse or one frame per some number of pulses (using the Rate Divisor)

To set up Sync-In:

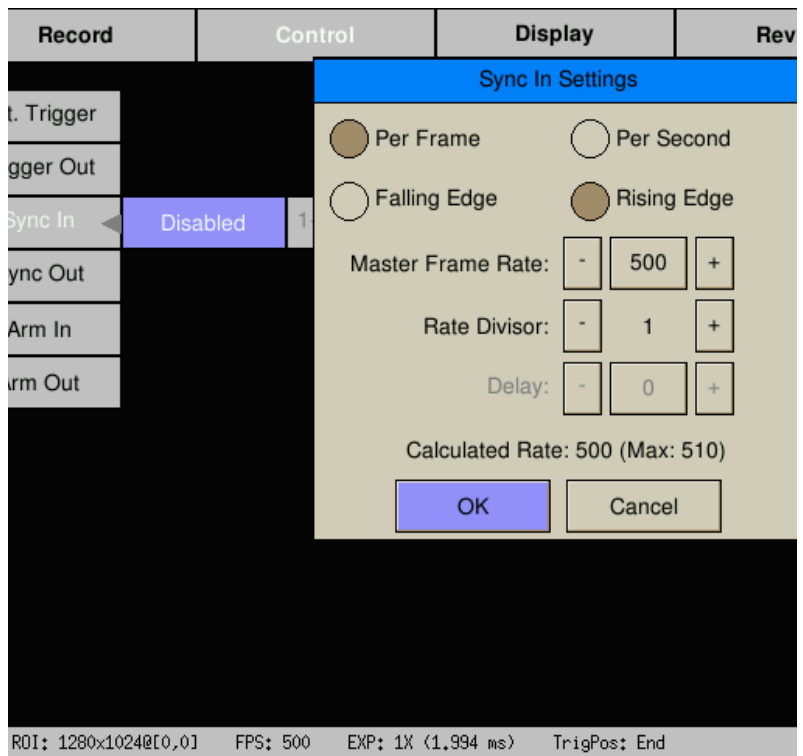
1. Navigate to the Control Menu.
2. Select Sync-In. There are two buttons: Enabled/Disabled, and another that may say “1-PPF, Rising Edge, Divisor=1” --or something similar.
3. Click on “Disabled” to open the Sync-In Settings dialog.
4. Select Rising Edge or falling edge, depending on the input signal.
5. Select Per Frame. (Per Second Synchronization will be covered in “5-2 Sync Out”.)
6. Set the master frame rate. This is the maximum expected speed in Hertz of the input signal. It is important that the input signal does not exceed this because this is the number the camera will use to calculate the maximum exposure time.
7. Upon entering the Sync-In Settings dialog with Sync-In disabled, the default value will be the present camera frame rate.
8. Set the rate divisor. In the example shown in “Figure 5-1: Sync-In Settings Dialog”, the desired frame rate is 500, while the Master Frame rate is also 500, so a divisor of 1 is used.
9. Click on OK to accept the settings.

The camera's frame rate will remain set at 500. If you select a different Master Frame Rate up to 510, the camera would be reset for that rate. Setting a rate higher than allowable for the present resolution (higher than 510 for this example) will cause the Rate Divisor number to change.

Note: Always set the Master Frame Rate to a value equal or greater than the input signal! Setting this value too low may cause the camera to skip pulses resulting in much slower frame rates than anticipated.

For more details, please read the next section, “Sync-In Considerations” on page 57.

Figure 5-1: Sync-In Settings Dialog



Sync-In Considerations

Measuring the Sync-In (Master) Rate:

Once Sync-In is enabled the camera will begin monitoring the Sync-Input and calculate the input rate. If the Sync-In Settings dialog is reopened with Sync-In enabled and a sync signal present, you will be able to read this value. (If Sync-In is disabled when you enter the dialog this value will not be present.)

Camera Dependencies:

- Maximum Frame rate is dependent on Resolution. See "Appendix D: TS3 / TS4 Record / Resolution Tables" for examples. Changing values in the Sync-In Settings dialog will not affect any changes in resolution.
- Maximum exposure is dependent on Frame Rate. The maximum exposure is always the frame time (1/frame rate) minus the reset time (6 μ sec). The maximum exposure may change upon exiting the Sync-In Settings dialog if the "Calculated Rate" is different than the present frame rate setting.
- The Master Frame Rate in the Sync-In Settings dialog defaults to the present Frame Rate, which is set in Record Settings.
- If the Master Frame Rate is edited to a value above the maximum allowable for the present resolution (the example shown in Figure 5-2 as (Max: 510)), the system will set the Rate Divisor to the lowest whole number that will satisfy the requirement that the calculated rate be equal or less than the Max.
- Any Sync pulse that is received before the present frame is read out (1 frame time) will be ignored.

Example:

If the Master rate is set at 1000 as in Figure 5-2, the calculated rate becomes 500, which is the desired frame rate. In practice, however, because the actual sync pulse is 1106, the divide-by-2 rate will be 553, which is faster than the Max allowed at the present resolution (510), causing it to miss every other frame and record at 276 fps.

If the Resolution is adjusted so that the Max frame rate is increased, as in Figure 5-3, and the Master Rate is increased to a rate higher than the measured 1106, the expected frame rate and maximum exposure time will be within the cameras capabilities. The camera will record at 1106/2 (553) fps.

Figure 5-2: Sync-In Master Rate (Set too low)

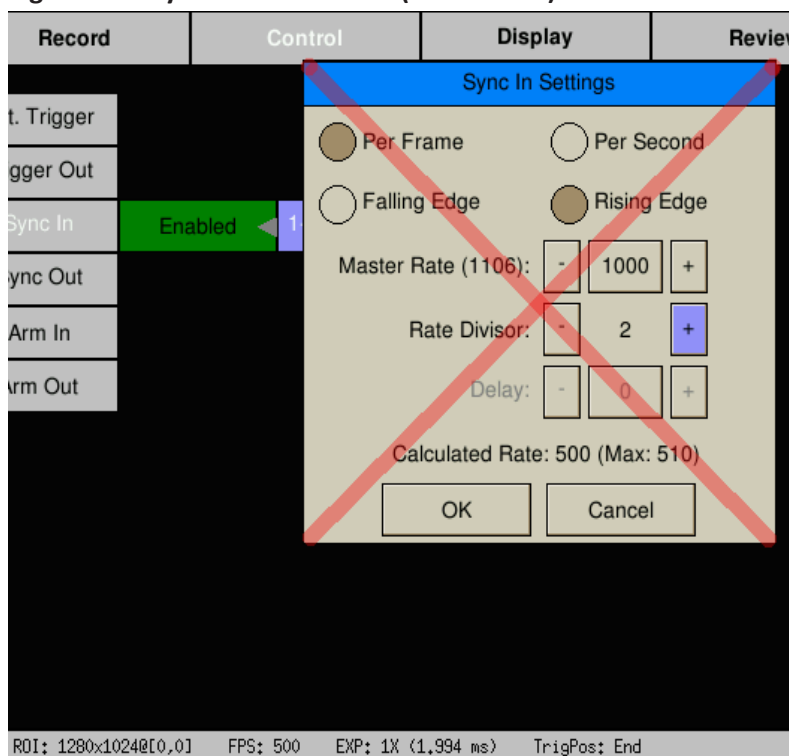


Figure 5-3: Sync-In Master Rate (Set Correctly)

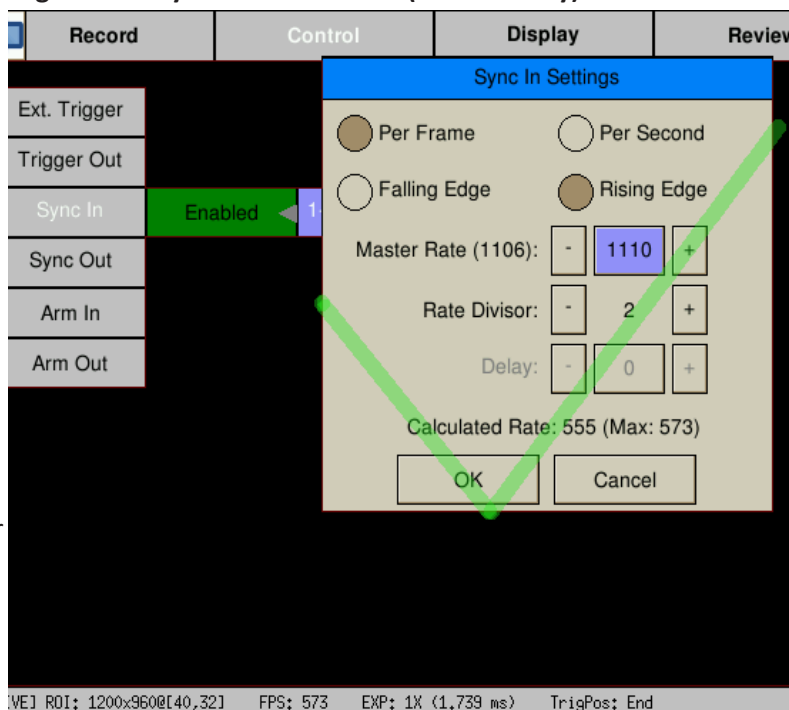


Figure 5-4: Sync: Per Frame Timing

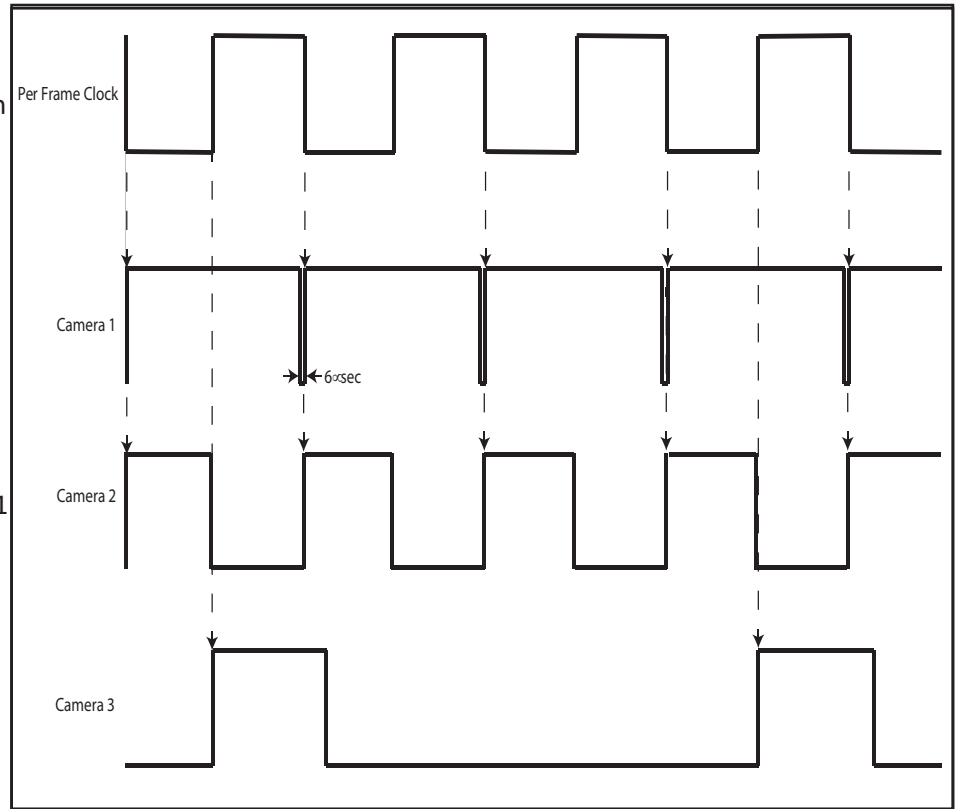
The Frame Clock may be from another Camera (See “5-3 Master/Slave Setup” on page 60) or some other external clock.

Note: for each camera, the signal shown represents the exposure (high = shutter “open”)

Camera 1 is set for Falling Edge, at a 1x shutter. Note that there is a 6 μ sec inter-frame time.

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

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



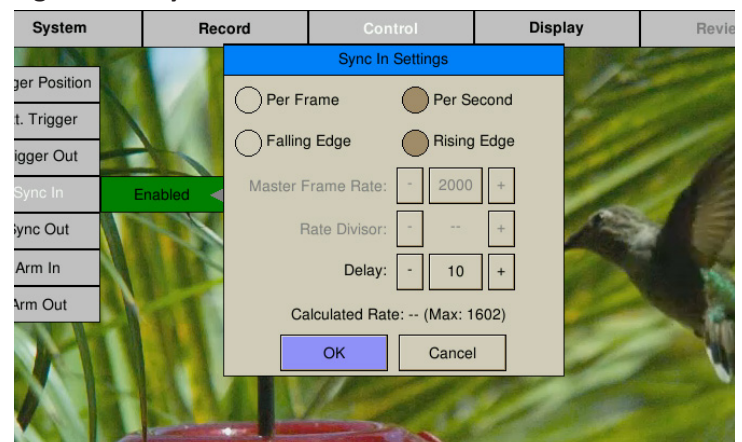
Per Second:

Many commonly available sync sources have a precision 1 Hz output. IRIG and GPS are two that are very often used with high-speed data capture.

The TSx can utilize these signals for synchronization of cameras at any frame rate.

To use Per Second Synchronization:

1. Navigate to the Control Menu and open the Sync-In Settings dialog (as in the previous section).
2. Select “Per Second” in the dialog box. The Master Frame rate and Rate Divisor fields will gray-out.
3. A delay of from 0 to 1000 μ sec may be used to fine-tune integration timing. This may be done to adjust the phase relationship between multiple cameras, or to align exposure start times of cameras with different exposure settings.
4. The Calculated Rate will reflect the frame rate set in Record/Settings. If you wish to change those settings, you will do those as for any normal recording. (See “4-1 Selecting the Recording Mode” on page 28.)

Figure 5-5: Sync-In Per Second

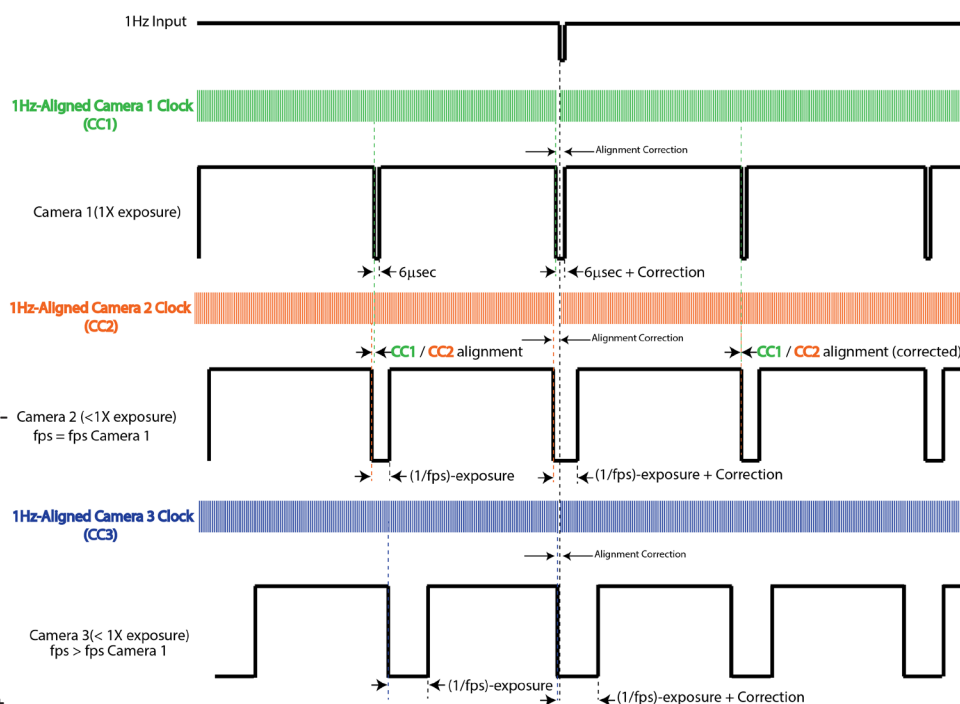
Each Camera derives an internal clock from the 1Hz “Per Second” input signal, (from either the Sync-In or IRIG inputs), which it can use to run at any desired rate, as in normal operation. A small correction may be done at the inter-frame time of the last frame in any given second (see the “alignment correction” on the diagram).

Camera 1 is set with a 1x shutter. The exposure time is $1/\text{fps} - 6\mu\text{sec}$.

Camera 2 is set at the same frame rate as Camera 1, but with a shorter exposure. Note that the frame alignment is at the end of each exposure, not the beginning as with per-frame sync.

Camera 3 is set at a slightly faster frame rate than cameras 1 and 2. Note that the end of the exposure of the last frame of the second will be aligned with cameras (slightly skewed) 1 and 2. Sync timing between camera 3 and the other two cameras will phase in and out depending on the frame rates.

Figure 5-6: Sync: Per Second Timing



5-2 Sync Out

Per Frame

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

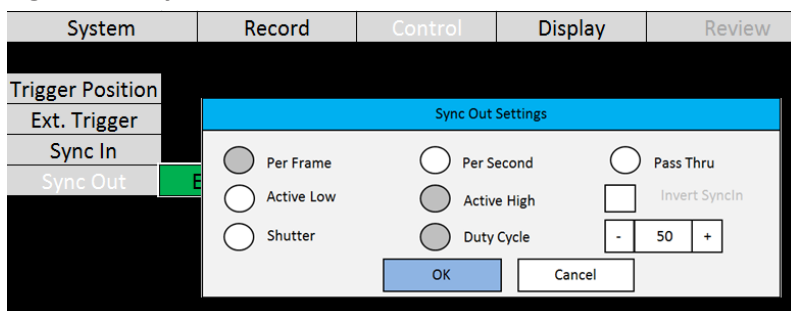
To set up Sync Out:

1. Navigate to the Control Menu.
2. Select Sync Out. There are two buttons: Enabled/Disabled, and another that may say 1-PPF, Shutter, Active High--or something similar.
3. Change the state of the first button to “Enabled” (green), and then click on the second button to open the Sync Out Settings Dialog.
4. 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.
5. The signal can either follow the Shutter (integration time) or you can select Duty Cycle and control the % of frame time ($1/\text{frame rate}$) 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.

Figure 5-7: Sync Out Per Frame



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.

Sync LED

Refer to Table 5-2 on page 66 for Sync LED behavior.

Figure 5-8: Sync Pass Thru

Sync Out Settings		
<input type="radio"/> Per Frame	<input type="radio"/> Per Second	<input checked="" type="radio"/> Pass Thru
<input type="radio"/> Active Low	<input type="radio"/> Active High	<input checked="" type="checkbox"/> Invert SyncIn
<input type="radio"/> Shutter	<input type="radio"/> Duty Cycle	- 50 +
OK		Cancel

5-3 Master/Slave Setup

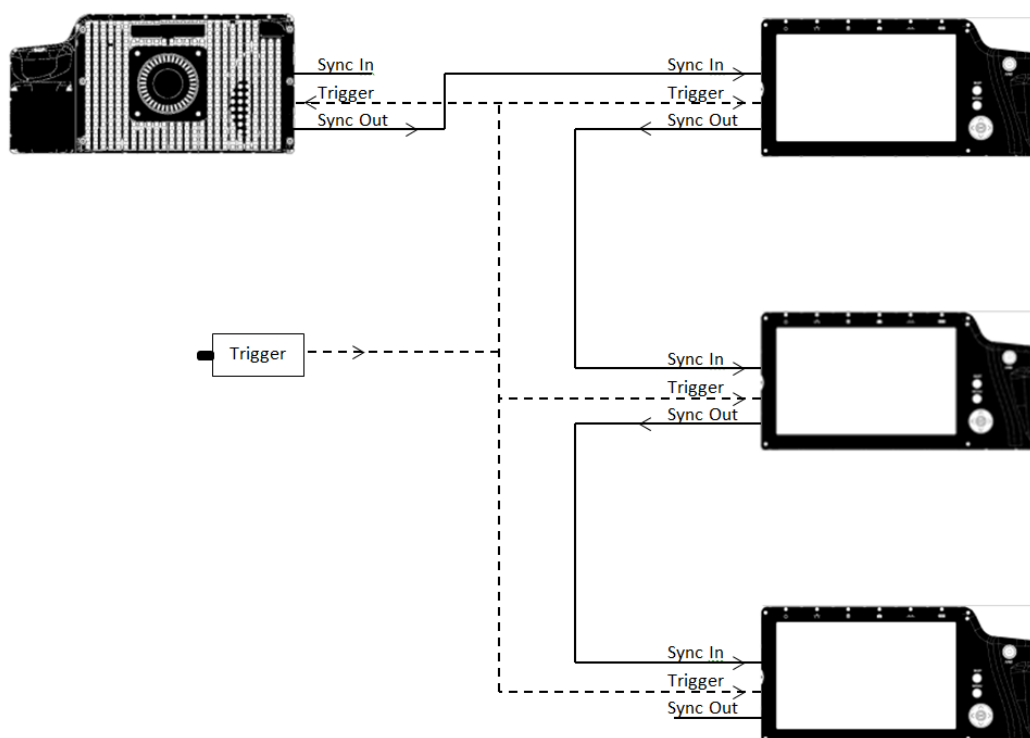
There are many possible configurations used to synchronize groups of cameras. The Master/Slave configuration is often used when a group of cameras is used to capture multiple synchronous views of an event that is not driven by a clock or PLC. For example, when studying animal or human kinetics, the subject (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

Figure 5-9: Master and Slave Cameras



camera.

- Choice of Shutter or Duty Cycle does not matter.
- 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.

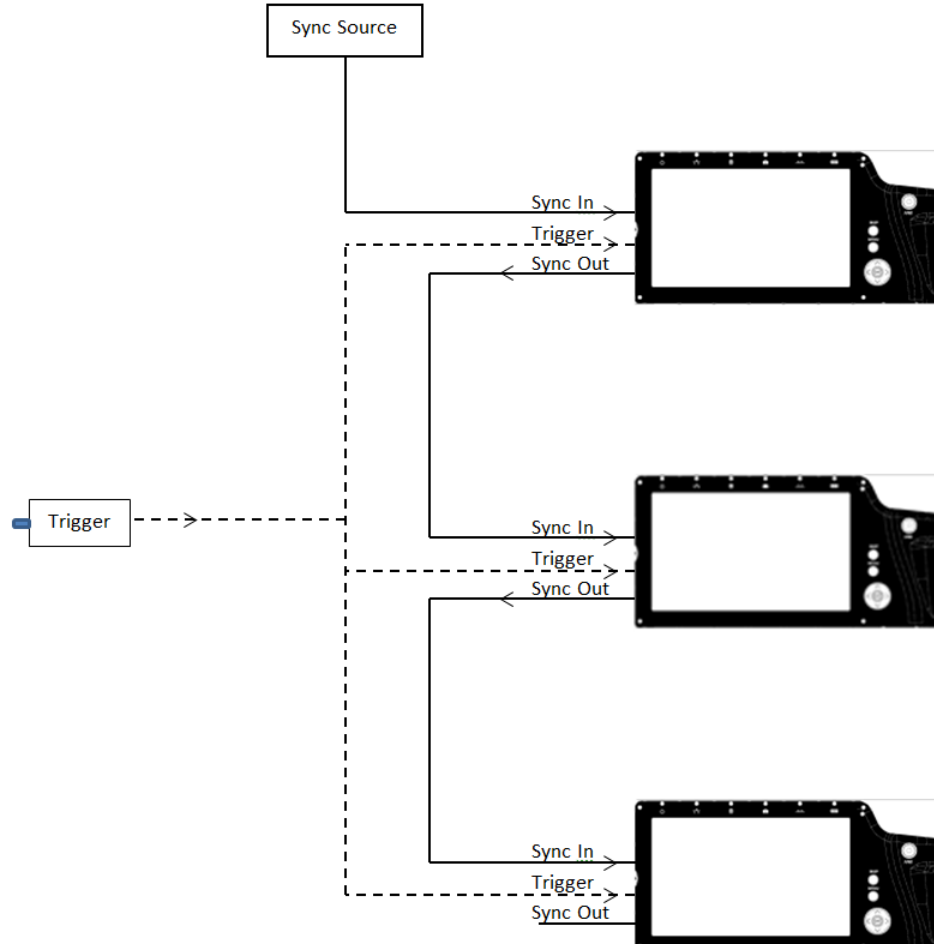
NOTE: For the “common” setup as well as for variations listed below, always make sure that the Post Trigger portion of the recording time for the Master camera is equal to or greater than each of the Slave cameras. This is important because Sync Out pulses cease with the completion of the capture, so 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 5-10: External Sync: Local Grouping



5-4 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 “Appendix F: Power and I/O Connections” on page 106, for electrical specifications.

This sync pulse may be used for a localized group of cameras, in which the cameras are connected as in “Figure 5-10: External Sync: Local Grouping” on page 61 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 5-11: External Sync: Distributed Grouping”.

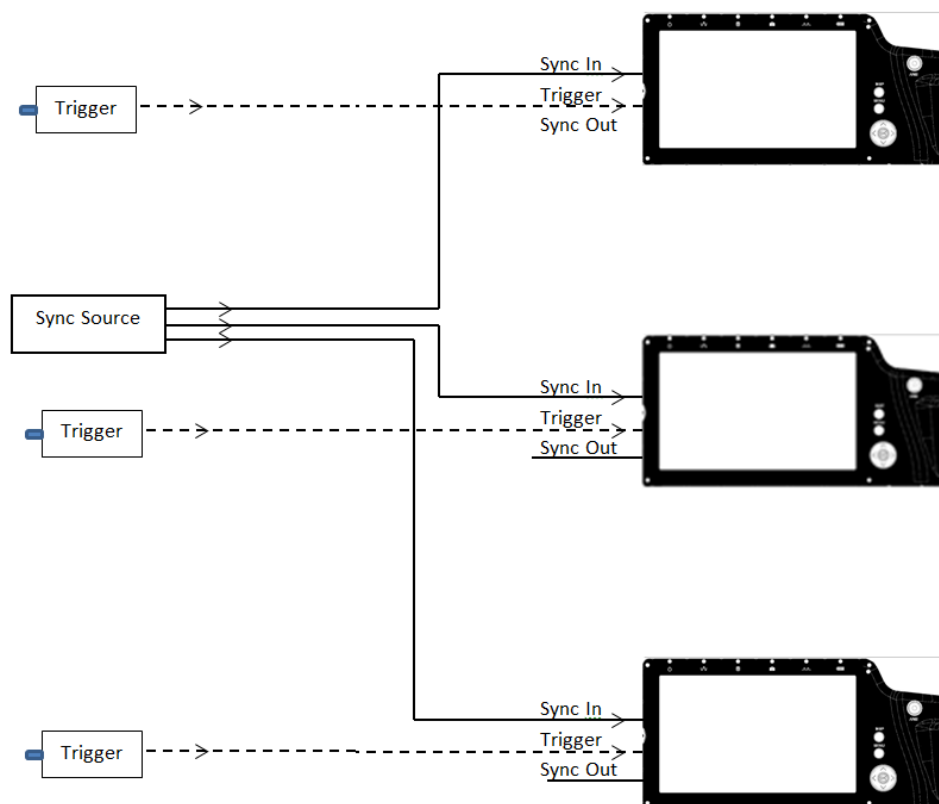
In the case of using a PLC or other local clock, you will need to know the polarity and frequency of the signal to set the cameras up. Optimum frame rates can often be derived using the Rate Divisor function.

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.

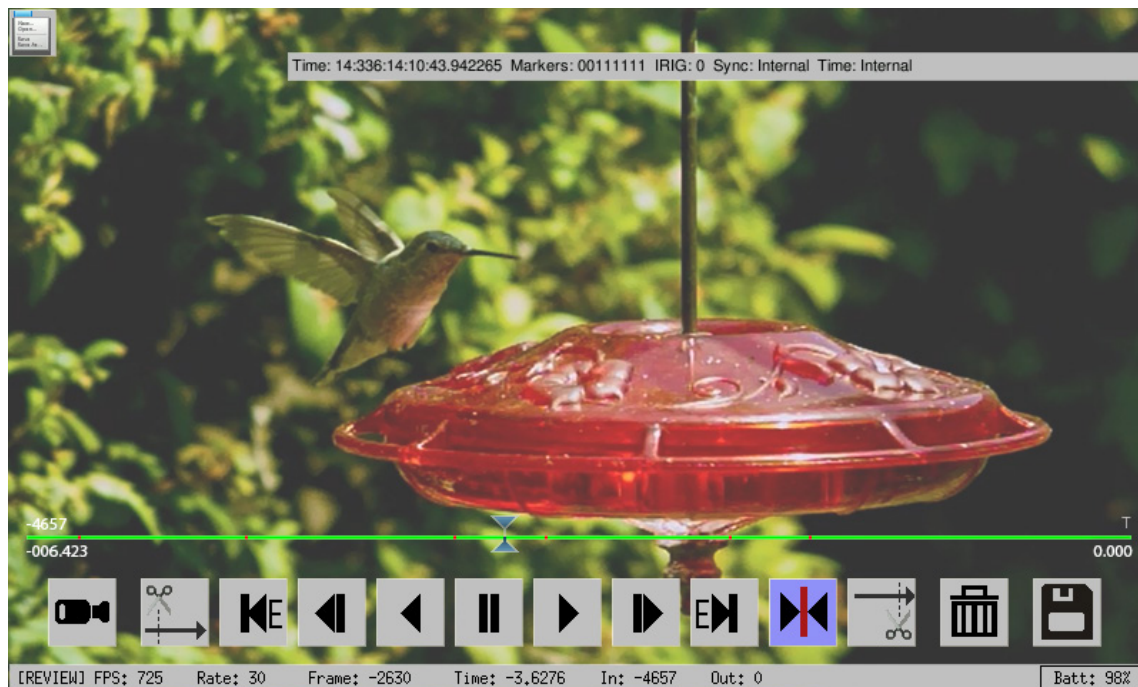
Figure 5-11: External Sync: Distributed Grouping



5-5 TSx Timestamps and Markers

Whenever the TSx records imagery, it also records a timestamp for each frame. This timestamp may be displayed during playback and may also be saved to an XML file (see “Appendix K: Contents of <Capture>.xml file” on page 114 and “4-8 Configuring the Trigger and External I/O” on page 37).

Figure 5-12: Image with Timestamp



Using the DISP button while in playback mode, you can toggle through the available displays. In the figure above, you see that the Info line at the bottom of the image is present as is the Timestamp line at the top of the image. For information on setting up Markers in Playback see “4-15 Playback: Jump to Markers” on page 48.

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

For the example shown in Figure 5-12 this is:

YY = Year: 14 = 2014

DDD = Day: 336 = Dec 2 (See “Appendix P: Day Number Calendar Conversion” on page 123.)

HH:MM= Hour: Minute: 14:10 = 1:10 pm

SS.xxxxxx = Seconds: = 43.942265 (granularity to μ sec)

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, but only if they are accompanied by an XML file.

If you are interested in archiving Marker Data and Timestamps, remember to save the XML file along with the video!

Markers: 00111111 (See “Table 5-1: I/O Pin to Markers” on page 64.)

The Timestamp line includes event markers. In the example shown in Figure 5-12 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 “Appendix F: Power and I/O Connections” on page 106.

IRIG: 0

In the example IRIG was not enabled (0). When IRIG is enabled, you get IRIG: 1.

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 "5-1 Sync-In" on page 56.

The Time is either Internal (using the camera's internal clock), or IRIG (using an IRIG time source.) See "5-6 IRIG Timestamps and Sync" on page 65.

The pin out and default signal list for the markers is seen in Table 5-1. 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.

Note that the markers for Section and Record Start are not tied to I/O pin. These are set by changes in the camera's recording status and are used for finding recordings on the Long Record timeline.

On a camera that has none of its I/O options enabled, all of the I/O pins will normally be high and the I/O Markers in the Timestamp line and in the per-frame metadata will always be 1's as in Table 5-1.

The markers are represented in the XML data in hexadecimal format: "<markers>0x003f"

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.

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 LVTTTL 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. (Press the DISP button until you see the Timestamp line appear.) Scrub the playback bug back and forth along the timeline while watching for changes in the "Markers: xxxxxx" section of the timeline.

You will see the Arm-Out marker go to 0: "Markers: 111110" 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.

Table 5-1: I/O Pin to Markers

(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

Figure 5-13: 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>
```


5-6 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 5-14.)

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 can provide 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 “5-5 TSx Timestamps and Markers” on page 63. You will notice in Figure 5-18 that IRIG is set to “1” (locked) and that Time is also set to IRIG.

Figure 5-14: IRIG BNC



Figure 5-15: Enabling IRIG

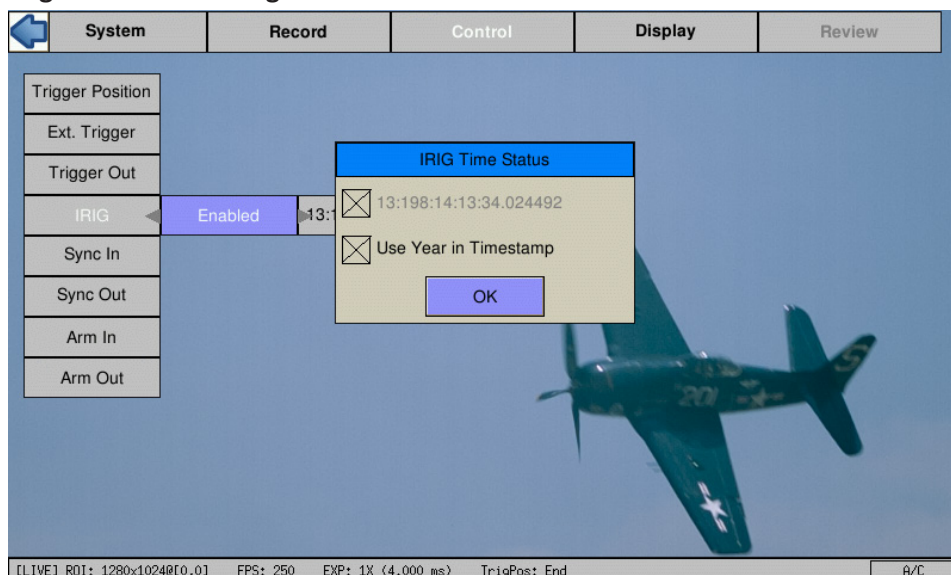


Figure 5-16: IRIG Waiting for Lock

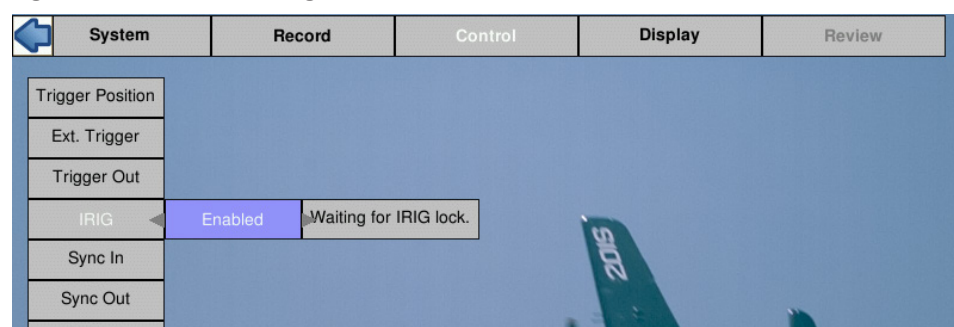


Figure 5-17: IRIG Timestamp in IRIG Menu



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. The functionality is the same as with a Per Second synchronization, but the IRIG signal is used in place of a 1Hz signal at the Sync-In pin. See “Sync-In Per Second” on page 58.

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 immediately 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 5-18: Sync-In Dialog with IRIG Enabled

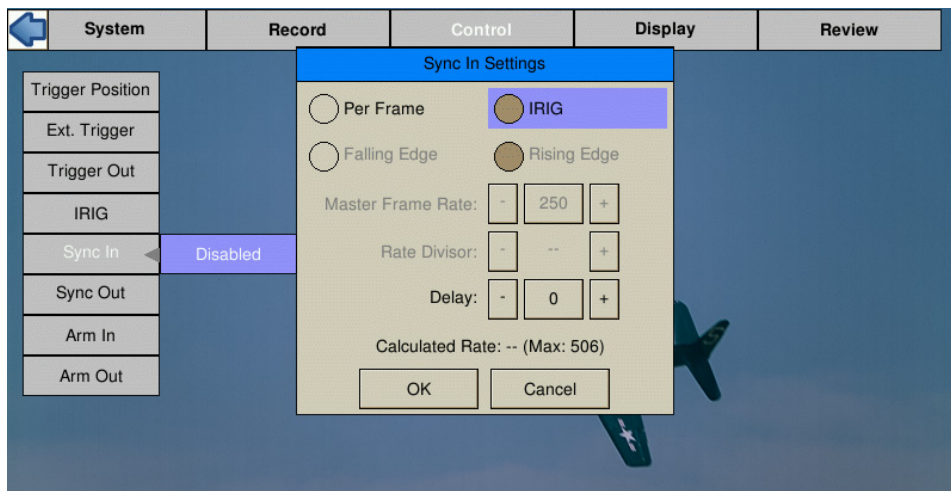


Figure 5-19: IRIG Timestamp in Review



Table 5-2: Sync LED Behavior

Sync LED Behavior	Sync In	IRIG Enable	IRIG-In
	Disabled	No	X
	PPF/PPS + No Signal	No	X
	PPF/PPS + Signal	No	X
	Disabled	Yes	No Signal
	Disabled	Yes	Locking
	Disabled	Yes	Locked
	PPF + No Signal	Yes	No Signal
	PPF + No Signal	Yes	Locking
	PPF + No Signal	Yes	Locked
	PPF + Signal	Yes	No Signal
	PPF + Signal	Yes	Locking
	PPF + Signal	Yes	Locked
	IRIG	Yes	No Signal
	IRIG	Yes	Locking
	IRIG	Yes	Locked

Application Notes

Application Note 1: Histograms

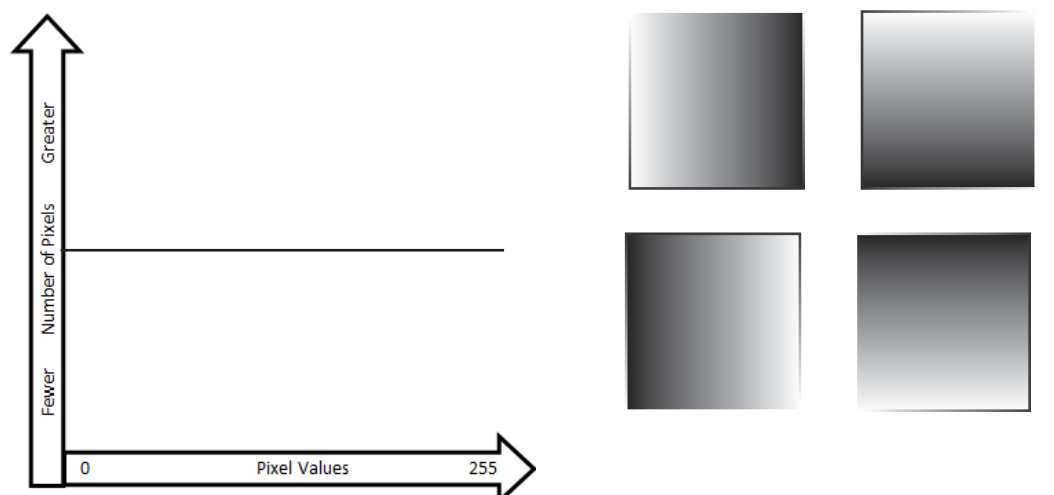
Histograms are available on the TSx to help the user assess the lighting and color balance of the scene framed by the camera. This App Note is provided to help the TSx user understand the information provided by histograms and to offer some basic guidance on their use.

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 6-1: Histogram: Linear Gradient

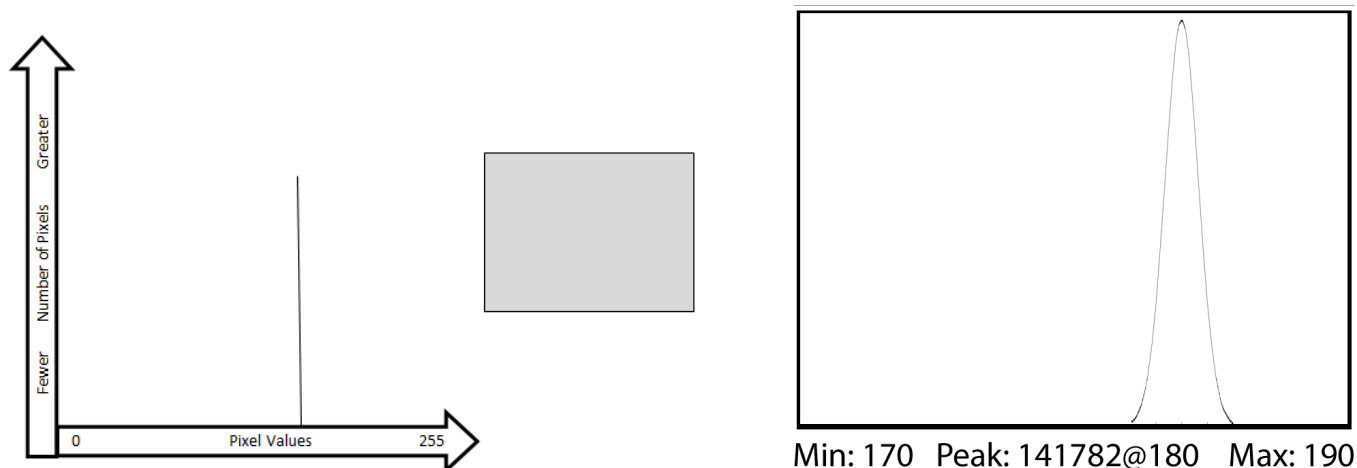


The Mono histogram is a simple single-line graph. The Y-axis (vertical) represents the number of pixels. The X-axis (horizontal) represents pixel values. The first thing to understand is that the histogram offers quantitative information only; it includes no spatial information. Looking at a histogram 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 the pixels have the same value. In practice, because it is unlikely that we will be able to image a perfectly flat field, the

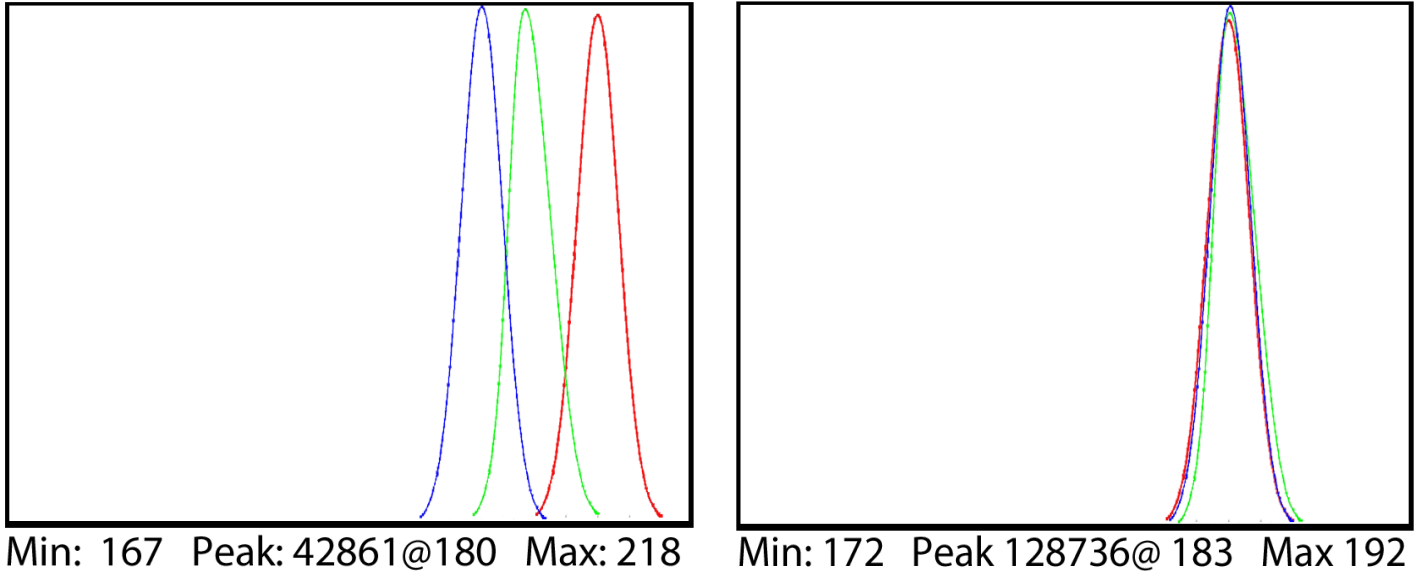
Figure 6-2: Histogram: Mono-tonal



Min: 170 Peak: 141782@180 Max: 190

histogram of a mono-tonal image will be a bell curve. The histogram shown to the right in Figure 6-2 is in the format used on the TSx. It shows minimum, maximum and peak values for the image. The peak value also includes the number of pixels exactly at the peak value: Peak: <# of pixels>@<pixel value>.

Figure 6-3: Histogram: Monotonal Color Image



If we view the same mono-tonal content used in Figure 6-2 on a color camera, we get the more complex histograms seen in Figure 6-3.

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!

TS3 and TS4 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! TS5 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 11511.....1023

8-bit (256) values (in decimal): 0 0 0 0 1 1 1 1 2 2 2 2127.....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 5127.....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):

4. ~~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 TS5, 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.

Figure 6-4: 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, occur without warning. Other times high speed events are tightly controlled. The TSx is designed to handle myriad scenarios. Here are several examples:

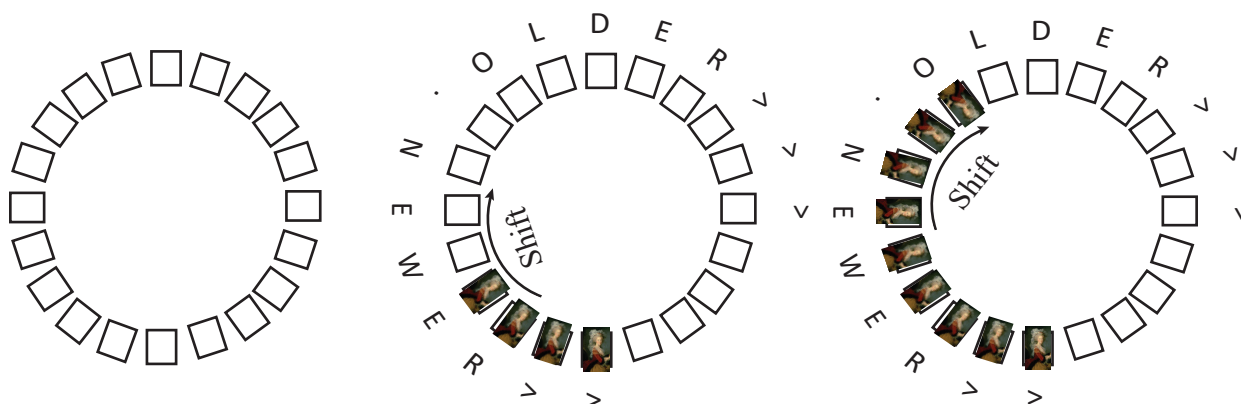
Example 1: Someone is blowing up a balloon until it pops. You want to capture the balloon pop. You have a partition of memory with one second of record time. It is difficult to estimate within a second when that balloon is going to pop!

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.

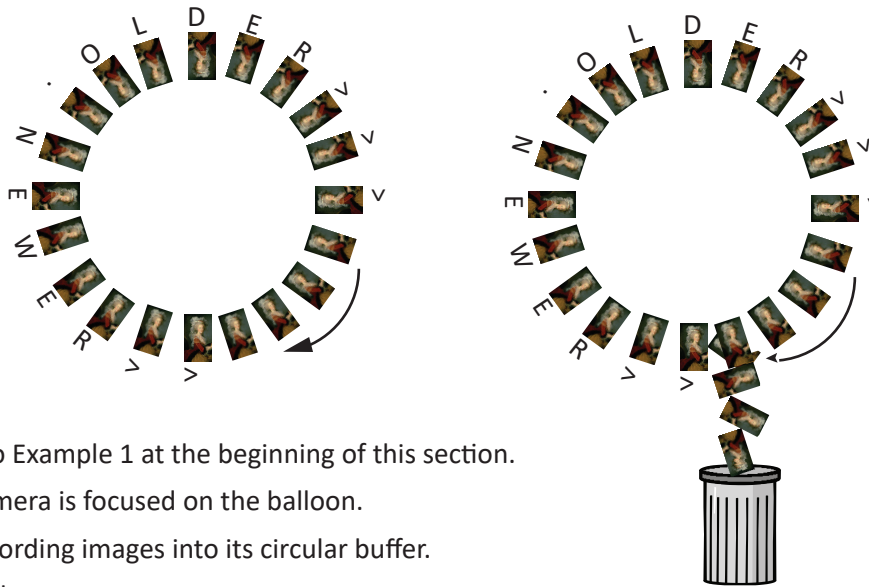
To capture events like the ones in the examples above, the TSx uses a circular image buffer that can capture high-speed imagery indefinitely, though it may only be able to retain a few seconds at a time. The figure below is a representation of a circular buffer. First the empty buffer is seen with 20 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 6-5: 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 6-6: 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.

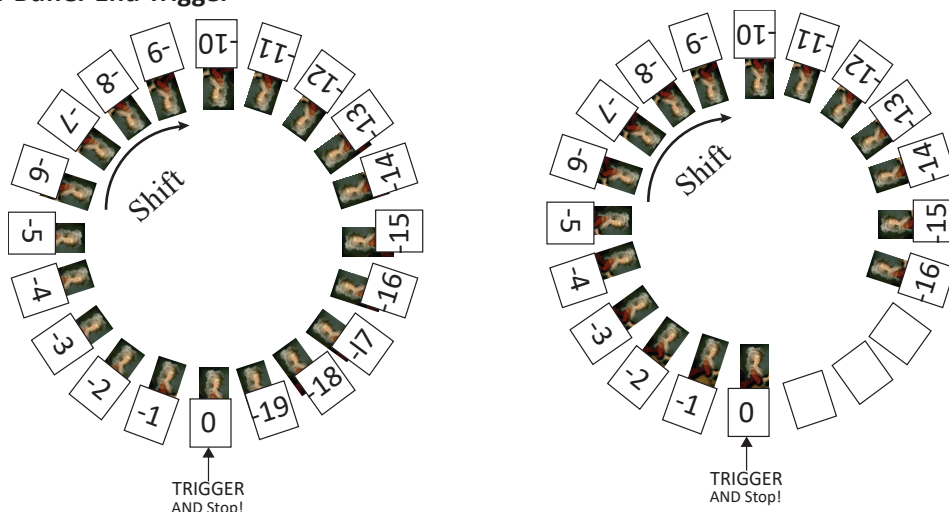
The camera has captured the event, now you just need to make the camera stop before the images are discarded. For this we use an **End Trigger**.

Note: In photography, the term “trigger” is often used in reference to the shutter--usually cameras are triggered to take one image. In high-speed video capture, we use the term in reference to controlling the acquisition of some (often large) number of video frames.

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. At that time, it will 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 6-7: Circular Buffer End Trigger



Referring back 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.

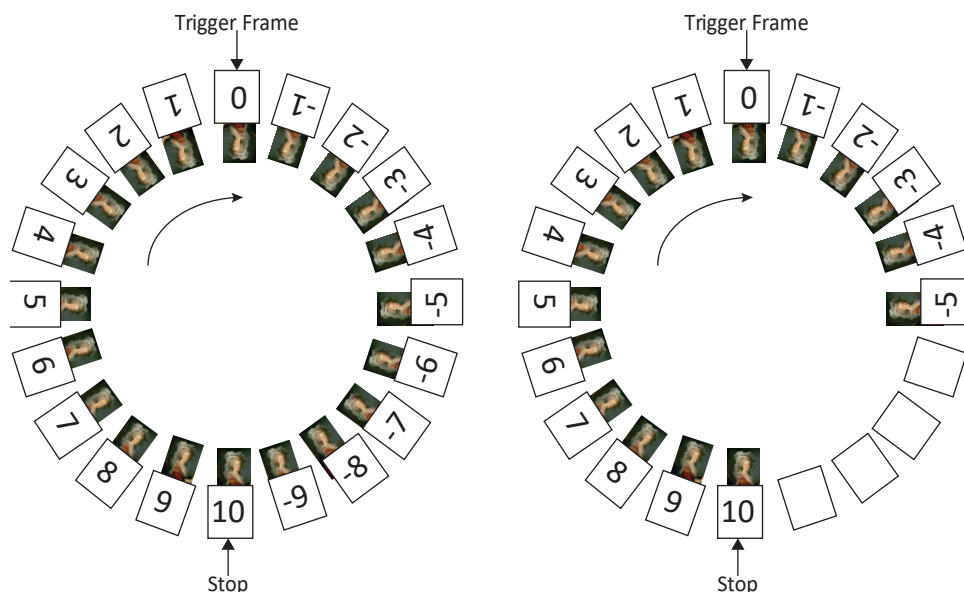
In this case, the camera needs to record the seconds before and after the problem is detected. The TSx has the perfect trigger setting for this. The 50% Trigger divides the image capture into two halves, the images just before the trigger is received (**pre-trigger frames**), and the images immediately 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 has 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 6-8: Circular Buffer 50% Trigger



Referring 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 FasMotion 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 System for Image Transfers

Transferring large volumes of image data from the camera to a computer over the Gigabit Ethernet connection can be 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
- FasMotion 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 FasMotion.
- 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.)

FasMotion Parameters

There are several parameters to be set to optimize performance. FasMotion 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 to get faster transfers.

Figure 6-9: FasMotion User Preferences: Packet Delay

UDP Transfers

The camera system, while controlled by FasMotion, 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.

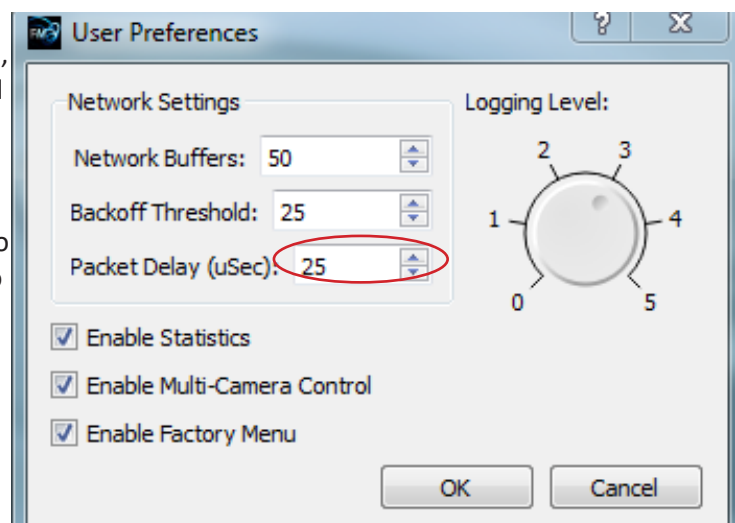
Setting Packet Delay

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 μ sec.

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 FasMotion

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 FasMotion.

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

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 μ sec set in the Camera Find window)
- **Buffer** - number of buffers reserved in PC memory
- **Backoff** - FasMotion 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 FasMotion 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 6-1 on page 79 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 fast, purpose-built system. A raid array used for storage is capable of unusually high sustained transfer rates. Table 6-2 on page 79 is from a benchmark test of a moderate-performance system.

Figure 6-10: FasMotion User Preferences: Enable Statistics

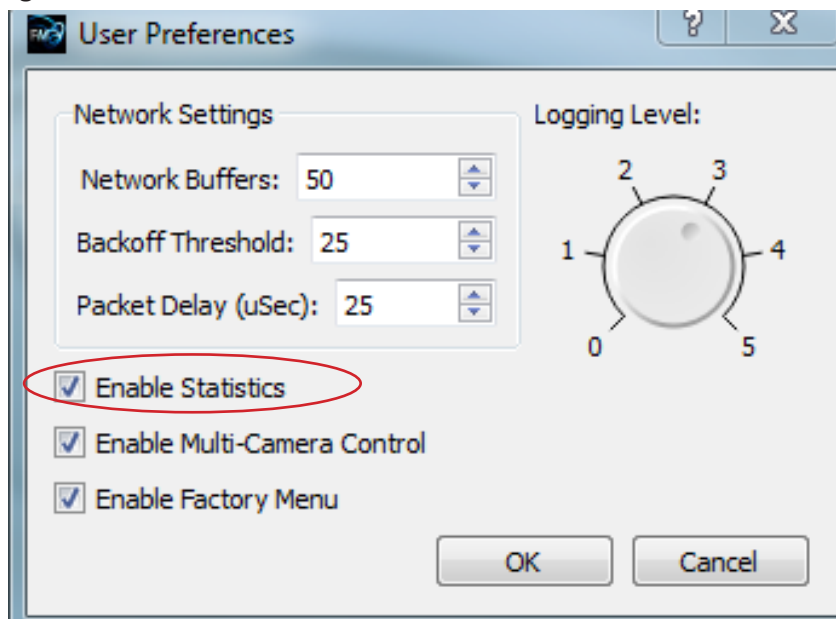


Table 6-1: Image Transfer Performance

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 6-2: 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 6-5: Finding the Correct Packet Delay Value” on page 81, but those used an external target drive.

When the PC is Too Busy:

Referring to Table 6-3, 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 FasMotion reserved 250 buffers--more than enough to buffer the entire transfer. The Min (minimum buffers) never got close to the Backoff number, so the FasMotion never got a chance to slow the camera down before it started missing frames.

To understand what happened here, it is helpful to look at the performance tab in Task Manager. Notice in Figure 6-11 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 FasMotion 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.

Figure 6-11: Memory Usage in Task Manager

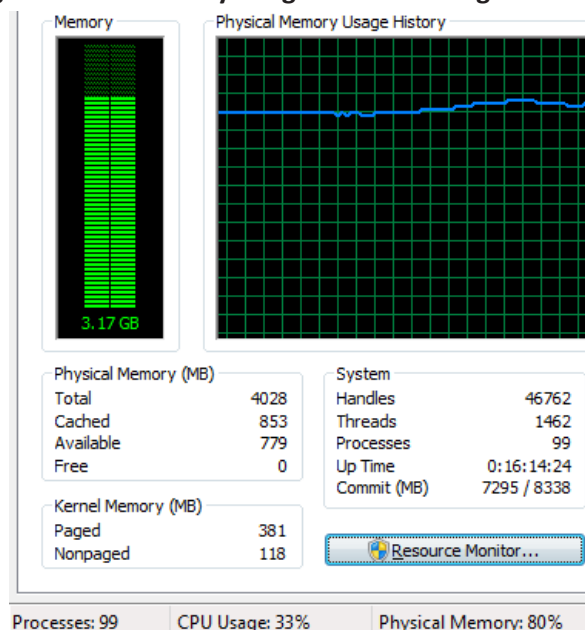


Table 6-3: Missing Frames on a Busy System

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

Use Jumbo Packets!:

Referring to Table 6-4, 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 6-4: 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 6-5, 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 6-5: 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 6-6: 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

TSx cameras are capable of outputting images in 7 different file formats. These formats serve different purposes depending on imaging and work flow requirements.

JPEG images are compressed in order to take the least space. A recording saved as JPEGs results in an image stack, whereby each frame is a file. JPEG compression quality (0-100, with 100 being highest quality, lowest compression) may be selected by the user in the camera User Preferences menu. Default "JPEG Qfactor" is 80, which results in compression of 10:1 to 20:1 for average scenes.

AVI files are basically JPEGs placed in a "wrapper," resulting in one video file that is playable on many popular video players.

BMP and TIF files are almost identical--both being uncompressed, fully processed images. Like JPEGs they are saved as stacks, but are much larger.

DNG, TIF (raw), and CAP files are raw formats, meaning that color images are not interpolated. Color interpolation takes 8-bit images and colorizes them, which produces 24-bit files 3x as large. DNG and TIF (raw) files are smaller than BMP and TIF files. DNG and TIF (raw) are stacks, while CAP files contain a whole "Session" of images.

- JPEG: JPEG compressed, user selectable compression, saved as video stacks. All image and color processing is done on camera. 8-bit data only is preserved so output is 8-bits/pixel mono, or 24-bits/pixel color.*
- AVI: Motion JPEG compressed, user selectable compression, user selectable playback rate, saved as one file. All image and color processing is done on camera. 8-bit data only is preserved so output is 8-bits/pixel mono, or 24-bits/pixel color.*
- DNG: Not compressed, raw format with "as shot" parameters saved within images. 8-bit or 10-bit data preserved (for producing 24-bit or 30-bit color images). Available on color cameras only. All image processing excluding FPN correction, but including color interpolation, brightness, contrast, gamma, color gains, etc. to be done off-camera in 3rd-party software. Compatible with Adobe and Black Magic imaging software. 8-bit images saved 8 bits/pixel; 10-bit images saved 16 bits/pixel
- BMP: Not compressed. Saved as video stacks. Bitmap. All image and color processing is done on camera. 8-bit data only is preserved so output is 8-bits/pixel mono, or 24-bits/pixel color.*
- TIF: Not compressed. Saved as video stacks. Almost identical in size and specification to BMP, but has added "TIFF tags." All image and color processing is done on camera. 8-bit data only is preserved so output is 8-bits/pixel mono, or 24-bits/pixel color.*
- TIF (raw) Not compressed. Saved as video stacks. 8-bit or 10-bit data preserved (for producing 24-bit or 30-bit color images and 8-bit or 10-bit mono images). 8-bit data is saved as un-interpolated 8-bit images. 10-bit data is saved as un-interpolated 16-bit images. Similar to DNG format, except that the "as shot" values must be parsed from the metadata files (not written into the image files).
- CAP: Proprietary Fastec "partition capture" image format. Raw image data from sensor is saved in a file along with FPN correction (black frame), as well as "as shot" parameters. 8-bit or 10-bit data is preserved. CAP files may be loaded back into camera image memory, and then saved again to any media in any of the other formats.

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

*Note: When 10-bit data is recorded, all 10 bits are used in the 16-bit image processor. For formats that only save 8-bit data, this means that all of the image processing done still uses all of the 10-bit data and there still may be a discernible (certainly a measurable) difference in the 8-bit processed images produced. (If you capture both 10-bit and 8-bit images of the same scene, then save them as 8-bit color images, the ones captured in 10 bits will have a higher number of discrete colors than those captured in 8 bits.

Table 6-7: File Format Features

Format	Processing	Size @1280 x 1024		Pro	Con
		8-bit	10-bit		
JPG	JPEG Compression Color Interpolation Brightness, Contrast, Gamma, Gains, FPN*	241K (color)		<ul style="list-style-type: none"> • Small • Popular still format • Easy analysis 	<ul style="list-style-type: none"> • Degrades with re-processing • Huge folders full of files
AVI	JPEG Compression Color Interpolation Brightness, Contrast, Gamma, Gain, FPN*	241K (color)		<ul style="list-style-type: none"> • Small • Popular video format • Nice 1-file archive format 	<ul style="list-style-type: none"> • Degrades with re-processing
DNG	FPN*, ("As-shot" parameters** saved-not processed)	1281K (raw)	2561K (raw)	<ul style="list-style-type: none"> • Maintains highest image fidelity • All bits saved in 10-bit mode • Compatible with high-quality image and video production tools • Compact vs BMP/TIF 	<ul style="list-style-type: none"> • Huge folders full of files
BMP	Color Interpolation Brightness, Contrast, Gamma, Gains, FPN*	3841K (color)		<ul style="list-style-type: none"> • Good image fidelity • Compatible with popular imaging tools 	<ul style="list-style-type: none"> • Huge folders full of files
TIF	Color Interpolation Brightness, Contrast, Gamma, Gains, FPN*	3841K (color)		<ul style="list-style-type: none"> • Good image fidelity • Compatible with popular imaging tools 	<ul style="list-style-type: none"> • Huge folders full of files
TIF(r)	FPN* only	1281K (raw)	2561K (raw)	<ul style="list-style-type: none"> • Maintains highest image fidelity • All bits saved in 10-bit mode • Compact vs BMP/TIF 	<ul style="list-style-type: none"> • Huge folders full of files
CAP	None (black frame and "As-shot" parameters** saved)	1291K (raw)	1725K (raw)	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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 6-8: 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

Application Note 7: Advanced Calibration

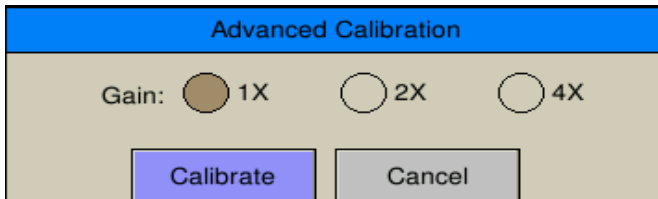
Calibration on the TSx accomplishes two functions:

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

See “4-9 Black Level Calibration” on page 40 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 6-14: 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 FasMotion, 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 6-13. 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 6-12: Black Level Calibration Dialog

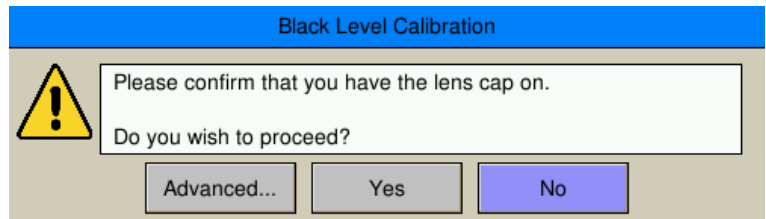


Figure 6-13: TS3 / TS4 Advanced Calibration Dialog

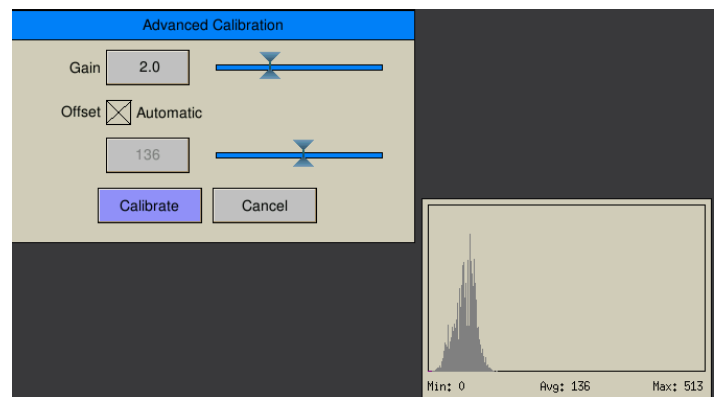
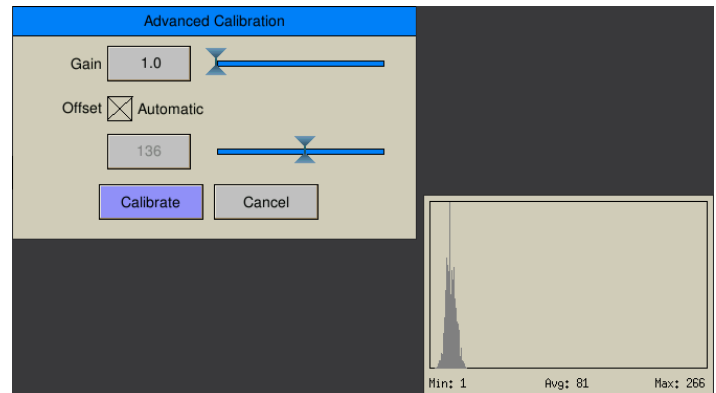


Figure 6-15: Example of Analog Gain



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 very 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

Figure 6-16: Example of Manual Black Level Adjustment



- Reduce the near-black noise by increasing the offset. This is the opposite of the bullet, above. 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 6-16 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.

Application Note 8: Running the TSx on Batteries

This section addresses the issue of running the TSx for long periods of time and in various modes without AC power available.

The TSx is capable of operating for about four hours in Standard Basic Mode, depending on use of the Display, SSD, HDMI, etc. For some models, running in FasFire or Long Record Mode with a fast SSD, the record time is much less. Please refer to “Appendix Q: Battery” on page 125 and pay special attention to “Figure 7-26: Discharge Rate by Mode” on page 127.

Test battery performance for your application for your camera:

There are many models of TSx cameras with many options and many modes of operation for each. The very best way to predict how long your camera may operate on battery in a given setting is to test it before any critical session.

Things that affect battery performance:

- Recording modes that require the camera to write to an internal SSD take the most power.
- TSx display. The display may be set to automatically turn off after one minute, five minutes, or ten minutes. It can also be turned on and off using the DISP button. Allowing the battery to switch off, or manually turning it off when it is not needed will preserve some power.
- HDMI output. The HDMI output should be disabled when not in use. When enabled, this feature will consume power even when there is no HDMI display connected.
- USB devices. USB devices such as flash drives and WiFi dongles are powered by the camera and may consume a considerable amount of power.
- Gigabit Ethernet. The Ethernet connection will draw some power as well. The
- Battery contact wear or contamination. Over time, the battery contacts may develop some resistance, which may affect performance profoundly, lengthening charging times and diminishing record times. Using a contact cleaner/conditioner such as DeoxIT will help to preserve battery performance and enhance battery life.

Using the Gas Gauge:

The Battery Gas Gauge seen in the lower right-hand corner of the camera display as part of the information bar.

The gas gauge is a built-in feature of the battery itself. It is calibrated by cycling the battery from fully charged to fully discharged. This calibration is based on Standard Basic recording modes of the camera system such that the battery percentage is an indication of the level of charge.

When the camera is operating in Standard Basic modes, you can expect that the camera will operate until the gas gauge goes to 0%.

WARNING: If the camera is operating in FasFire or Long Record mode, especially if it is a TS4100LR3 model, recording and saving imagery to an SSD at SATA III speeds or a TS5, the battery will not supply enough power to the camera to operate to 0%. Depending on the camera, mode, features enabled, battery connections, etc. the camera may power down when the gas gauge gets to 50%, 60%, or even 70%. See “Figure 7-26: Discharge Rate by Mode” on page 127.

Note: With version 2.1.x camera firmware, all TS5-D cameras and TS4 LR3 cameras will power up in LR2 mode if external power is not applied. If external power is present at the time the camera powers up, the Charging menu will appear and allow you to choose to operate the camera in “Fast SSD” (LR3) mode, or “Slow SSD” (LR2) mode. It is not recommended to operate these cameras in LR3 mode without external power. See “Figure 2-3: Power Up / Charging Menu (TS4-LR3 / TSx-D)” on page 9.

Using Supplemental Power:

External batteries are available through Fastec that can be used in conjunction with the internal

Figure 6-17: Battery Gas Gauge



battery or as stand-alone power for the TSx.

There are two external batteries currently available for the TSx:

- 12V Battery Pack, 98Wh, which will support camera operations more than 2x as long as the internal battery.
- 12V Battery Belt, 144Wh, which will support camera operation about 3x as long as the internal battery. External batteries may be used in conjunction with internal batteries:
- If you have several charged Fastec (internal) batteries available, use the external battery to power the camera when changing internal batteries without having to power the camera down.
- For more power-intensive recording modes such as FasFire and Long Record modes using the TS4, you may wish to use external batteries as the primary power source. In this case, have a fully-charged internal battery present as well. When the external battery power runs low, you will notice the battery LED begin to blink intermittently and you will see a minus sign on the battery gas gauge %. These are indications that the camera is beginning to run on the internal battery. When this happens, replace the external battery for extended operation.

Figure 6-18: External 98Wh battery Pack



Appendices

Appendix A: Definition of terms

Table 7-1: Definitions

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

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

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

Appendix B: TS3 / 4 Specifications

Table 7-2: Specifications

System Design	Handheld, battery-powered, portable with multiple PC I/O ports
Sensor	10-bit CMOS sensor with 14 μm square pixels, color or monochrome
Resolution	1280 x 1024 pixels maximum
Light Sensitivity	3,200 ISO monochrome, 1,600 ISO color
Record Rate TS4 and TS3S	24 to 510 fps at 1280 x 1024, over 64,000 fps at reduced resolutions
Record Rate TS3L	24 to 1250fps at 800 x 600, 1250fps maximum at reduced resolutions
Shutter	Global electronic shutter from 2 μsec to 41.667ms
Image Memory	TS3: 4GB. Optional upgrade to 8GB; TS4 and TS3-D 8GB
Removable Storage	SD card (SDHC: 32GB maximum), USB Flash drive
Session Length	256MB up to full image memory
File Formats	Stacks – BMP, DNG, JPEG, TIFF (processed or raw); Video – AVI, CAP (raw)
Still Image Format	JPEG
Lens Mount	C-Mount (standard), F-Mount or PL-Mount (optional)
Built-in Monitor	High resolution, 178mm (7") diagonal LCD
PC Communication Ports	USB 2.0 device (micro-B), Ethernet (10/100/1000Base-T)
Control Software	FasMotion (for PC or Mac), web interface (browser on all platforms)
External I/O Sync	Trigger In/Out, Sync In/Out, Arm In/Out (LVTTTL (3.3V) or switch closure)
Video Out	HDMI (1080P60, 1080p 30, 720P, 480P)
Construction	Anodized machined aluminum housing
Power	Rechargeable Li-ion battery (4+ hours operating), or 10-26 VDC external power
Power Consumption	40W maximum
Operating Environment	+5°C to +40°C
Size and Weight	228mm (9.0") W x 114mm (4.5") H x 89mm (3.5") D. 1.8 Kg (3.9 lbs.)
Optional Features	
WiFi	802.11 b/g/n, Security: open, WEP, WPA(2) - PSK
Image Memory	Upgrade to 8GB total (8GB std. on TS4 and TS3-D)
Built-In Storage	Solid State Drive (SSD) 256GB, 512GB, 1TB, 2TB
Long Record	Stream image data directly to onboard SSD (min 8GB memory, 512GB SSD)
Lens Mounts	F-Mount, PL-Mount
TimeStamps and Sync	IRIG-B (modulated and un-modulated)

Appendix C: TS5 Specifications

System Design	Handheld, battery-powered, portable with touchscreen LCD
Sensor	12-bit CMOS sensor with 5µm square pixels, color or monochrome
Sensor Modes	Standard, binning 2x2, 4x4; sub-sampling 2x2, 4x4; 2x bin + 2x sub
Minimum Frame Rate	24fps (all models)
Maximum Frame Rate at Minimum Resolution	64 x 32 @over 29,000fps (all models)
Maximum frame Rate at Maximum Resolution by Model	TS5-Q: QSVGA 2560 x 2048 @ 253fps; TS5-H: HD 1920x1080 @ 634fps; TS5-S: SXGA 1280x1024 @ 991fps (1280 x 1014 @ 1000fps); TS5-L SVGA 800x600 @ 1677fps
Long Record: Max frame Rate at Max Resolution by Model	TS5-Q: QSVGA 2560 x 2048 @ 91fps; TS5-H: HD 1920x1080 @ 231fps; TS5-S: SXGA 1280x1024 @ 366fps; TS5-L SVGA 800x600 @ 993fps
Long Record Opt: Max Frame Rate at Min Resolution	320 x 240 @ 5000fps (cameras with 1TB SSD may do frame rates >6000fps) (all models)
Light Sensitivity	1600 to 12,800* ISO monochrome, 800 to 6400* ISO color (depending on mode)
Shutter	Global electronic shutter from 3µsec to 41.654ms
Image Memory	4GB (std.) or 8GB (optional)
Removable Storage	SD card (SDHC: 32GB maximum), USB flash drive
File Formats	Stacks – BMP, DNG, JPEG, TIFF, TIFF(raw); Video – AVI, CAP(raw); Still – JPEG
Lens Mounts	C-mount (std.), F-mount or PL-mount (optional)
Built-in Monitor	High resolution, 178mm (7") diagonal LCD
Communication Ports	USB 2.0 device (micro-B), Ethernet (10/100/1000Base-T)
Control Software	FasMotion (PC/Mac application), web interface (browser on all platforms)
Six External I/O Ports	Markers, Trigger In/Out, Sync In/Out, Arm In/Out (LVTTTL (3.3V) or switch closure)
Marker Data Views	Camera display info line, playback timeline, FasMotion o-scope mode, XML file
Video Out	HDMI (1080p30, 1080p60, 720p, 480p)
Construction	Anodized machined aluminum housing
Power	Rechargeable Internal Li-ion battery, or 10-26 VDC external
Power Consumption	42W maximum
Operating Environment	+5°C to +40°C
Size and Weight	228mm (9.0") W x 114mm (4.5") H x 89mm (3.5") D. 1.8 Kg (3.9 lbs.)
Optional Features	
WiFi	802.11 b/g/n, Security: open, WEP, WPA(2) - PSK
Built-In Storage	Solid State Drive (SSD): 250GB, 500GB, 1TB, 2TB
Long Record	Streams uncompressed video to SSD at 480MB/sec; 8GB mem. + SSD required

Appendix D: TS3 / TS4 Record / Resolution Tables

NOTE: These tables include only a sampling of resolution and frame rate values. Resolutions are available in increments of 2 x 2 pixels from 48 x 32 to 1280 x 1024 (to 800 x 600 in TS3L models). Minimum resolution in Long Record mode is 320 x 240. All are available via Advanced Settings on the camera GUI, the Web-App or FasMotion software. Frame rates are available in 1fps increments from 24 fps to the maximum rate for any resolution and mode.

NOTE: Maximum Frame rates are limited to 1250fps on TS3L models

4:3 Resolutions (Standard Modes)

Table 7-3: TS3 / TS4 Sample Resolutions, Rates, and Times

Resolution		Frame Rate	4GB Capacity				8GB Capacity			
H.	V.	FPS	8-bit		10-bit		8-bit		10-bit	
			Time (s)	Frames	Time (s)	Frames	Time (s)	Frames	Time (s)	Frames
320	240	60	921.4	55286	687.3	41240	1853.1	111187	1385.6	83139
320	240	125	442.3	55286	329.9	41240	889.5	111187	665.1	83139
320	240	250	221.1	55286	165.0	41240	444.7	111187	332.5	83139
320	240	500	110.6	55286	82.5	41240	222.3	111187	166.3	83139
320	240	1000	55.3	55286	41.2	41240	111.2	111187	83.1	83139
320	240	1250	44.2	55286	33.0	41240	88.9	111187	66.5	83139
320	240	1500	36.9	55286	27.5	41240	74.1	111187	55.4	83139
320	240	2000	27.6	55286	20.6	41240	55.6	111187	41.6	83139
320	240	4000	13.8	55286	10.3	41240	27.8	111187	20.8	83139
320	240	5600	9.9	55286	7.4	41240	19.8	111187	14.8	83139
320	240	6259 (Max)	8.8	55286	6.6	41240	17.8	111187	13.3	83139
640	480	60	230.4	13825	172.3	10337	463.4	27805	346.5	20789
640	480	125	110.6	13825	82.7	10337	222.4	27805	166.3	20789
640	480	250	55.3	13825	41.3	10337	111.2	27805	83.1	20789
640	480	500	27.7	13825	20.7	10337	55.6	27805	41.6	20789
640	480	1000	13.8	13825	10.3	10337	27.8	27805	20.8	20789
640	480	1250	11.1	13825	8.3	10337	22.2	27805	16.6	20789
640	480	1959 (Max)	7.1	13825	5.3	10337	14.2	27805	10.6	20789
800	600	60	147.5	8848	110.5	6628	296.6	17796	222.2	13330
800	600	125	70.8	8848	53.0	6628	142.4	17796	111.1	13330
800	600	250	35.4	8848	26.5	6628	71.2	17796	53.3	13330
800	600	500	17.7	8848	13.3	6628	35.6	17796	26.7	13330
800	600	1000	8.8	8848	6.6	6628	17.8	17796	13.3	13330
800	600	1299 (Max)	6.4	8848	5.1	6628	13.7	17796	10.3	13330
(5:4):										
1280	1024	60	54.0	3240	40.5	2428	108.6	6517	81.4	4884
1280	1024	125	25.9	3240	19.4	2428	52.1	6517	39.1	4884
1280	1024	250	13.0	3240	9.7	2428	26.1	6517	19.5	4884
1280	1024	500	6.5	3240	4.9	2428	13.0	6517	9.8	4884
1280	1024	510 (Max)	6.4	3240	4.8	2428	12.9	6517	9.6	4884

16:9 TS3 / TS4 Resolutions (Standard Modes)

Resolution		Frame Rate	4GB Capacity				8GB Capacity			
H.	V.	FPS	8-bit		10-bit		8-bit		10-bit	
			Time (s)	Frames	Time (s)	Frames	Time (s)	Frames	Time (s)	Frames
480	270	60	546.1	32767	409.6	24577	1098.3	65899	823.8	49428
480	270	125	262.1	32767	196.6	24577	527.2	65899	395.4	49428
480	270	250	131.1	32767	98.3	24577	263.6	65899	197.7	49428
480	270	500	65.5	32767	49.2	24577	131.8	65899	98.8	49428
480	270	1000	32.8	32767	24.6	24577	65.9	65899	49.4	49428
480	270	1500	21.8	32767	16.4	24577	43.9	65899	32.9	49428
480	270	2000	16.4	32767	12.3	24577	32.9	65899	24.7	49428
480	270	3000	10.9	32767	8.2	24577	21.9	65899	16.5	49428
480	270	4187 (Max)	7.8	32767	5.9	24577	15.7	65899	11.8	49428
640	360	60	307.2	18433	229.7	13782	617.9	37072	461.9	27718
640	360	125	147.5	18433	110.3	13782	296.6	37072	221.7	27718
640	360	250	73.7	18433	55.1	13782	148.3	37072	110.9	27718
640	360	500	36.9	18433	27.6	13782	74.1	37072	55.4	27718
640	360	1000	18.4	18433	13.8	13782	37.1	37072	27.7	27718
640	360	1500	12.3	18433	9.2	13782	24.7	37072	18.5	27718
640	360	2600 (Max)	7.1	18433	5.3	13782	14.3	37072	10.7	27718
800	450	60	196.6	11798	147.3	8837	395.4	23727	296.2	17773
800	450	125	94.4	11798	70.7	8837	189.8	23727	142.2	17773
800	450	250	47.2	11798	35.3	8837	94.9	23727	53.3	17773
800	450	500	23.6	11798	17.7	8837	47.4	23727	35.5	17773
800	450	1000	11.8	11798	8.8	8837	23.7	23727	17.8	17773
800	450	1500	7.9	11798	5.9	8837	15.8	23727	11.8	17773
800	450	1727 (Max)	6.8	11798	5.1	8837	13.7	23727	10.3	17773
1024	576	60	120.0	7201	89.8	5390	241.4	14482	180.7	10841
1024	576	125	57.6	7201	43.1	5390	115.9	14482	86.7	10841
1024	576	250	28.8	7201	21.6	5390	58.0	14482	43.4	10841
1024	576	500	14.4	7201	10.8	5390	30.0	14482	21.7	10841
1024	576	750	9.6	7201	7.2	5390	19.3	14482	14.4	10841
1024	576	1106 (Max)	6.5	7201	4.9	5390	13.2	14482	9.9	10841
1280	720	60	76.8	4608	57.6	3454	154.5	9269	115.8	6946
1280	720	125	36.9	4608	27.6	3454	74.1	9269	55.6	6946
1280	720	250	18.4	4608	13.8	3454	37.1	9269	27.8	6946
1280	720	500	9.2	4608	6.9	3454	18.5	9269	13.9	6946
1280	720	725 (Max)	6.4	4608	4.8	3454	12.8	9269	9.6	6946

1:1 TS3 / TS4 Resolutions (Standard Modes)

Resolution		Frame Rate	4GB Capacity				8GB Capacity			
H.	V.	FPS	8-bit		10-bit		8-bit		10-bit	
			Time (s)	Frames	Time (s)	Frames	Time (s)	Frames	Time (s)	Frames
256	256	60	1079.7	64784	803.6	48217	2171.47	130288	1616.2	96970
256	256	125	518.3	64784	385.7	48217	1042.3	130288	775.8	96970
256	256	250	259.1	64784	192.9	48217	521.2	130288	387.9	96970
256	256	500	129.6	64784	96.4	48217	260.6	130288	193.9	96970
256	256	1000	64.8	64784	48.2	48217	130.3	130288	97.0	96970
256	256	1500	43.2	64784	32.1	48217	86.9	130288	64.6	96970
256	256	2000	32.4	64784	24.1	48217	65.1	130288	48.5	96970
256	256	4000	16.2	64784	12.1	48217	32.6	130288	24.2	96970
256	256	6870 (Max)	9.4	64784	7.0	48217	19.0	130288	14.1	96970
400	400	60	442.4	26543	330.2	19809	889.7	53381	664.0	39838
400	400	125	212.3	26543	158.5	19809	427.0	53381	318.7	39838
400	400	250	106.2	26543	79.2	19809	213.5	53381	159.3	39838
400	400	500	53.1	26543	39.6	19809	106.8	53381	79.7	39838
400	400	1000	26.5	26543	19.8	19809	53.4	53381	39.8	39838
400	400	2000	13.3	26543	9.9	19809	26.7	53381	19.9	39838
400	400	3339 (Max)	7.9	26543	5.9	19809	16.0	53381	11.9	39838
512	512	60	270.0	16201	202.1	12128	543.0	32583	406.5	24391
512	512	125	129.6	16201	97.0	12128	260.7	32583	195.1	24391
512	512	250	64.8	16201	48.5	12128	130.3	32583	97.6	24391
512	512	500	32.4	16201	24.3	12128	65.2	32583	48.8	24391
512	512	1000	16.2	16201	12.1	12128	32.6	32583	24.4	24391
512	512	1500	10.8	16201	8.1	12128	21.7	32583	16.3	24391
512	512	2162 (Max)	7.5	16201	5.6	12128	15.1	32583	11.3	24391
800	800	60	110.6	6636	82.9	4971	222.4	13347	166.6	9998
800	800	125	53.1	6636	39.8	4971	106.8	13347	80.0	9998
800	800	250	26.5	6636	19.9	4971	53.4	13347	40.0	9998
800	800	500	13.3	6636	9.9	4971	26.7	13347	20.0	9998
800	800	977 (Max)	6.8	6636	5.1	4971	13.7	13347	10.2	9998
1024	1024	60	67.7	4059	50.5	3032	135.8	8146	101.6	6098
1024	1024	125	32.5	4059	24.3	3032	65.2	8146	48.8	6098
1024	1024	250	16.2	4059	12.1	3032	32.6	8146	24.4	6098
1024	1024	500	8.1	4059	6.1	3032	16.3	8146	12.2	6098
1024	1024	624 (Max)	6.5	4059	4.9	3032	13.1	8146	9.8	6098

TS4 LR2 in Long Record mode							
Resolution		LR2 8-bit Frame Rates and Times hh:mm:ss			LR2 10-bit Frame Rates and Times hh:mm:ss		
H.	V.	FPS	256GB SSD	512GB SSD	FPS	256GB SSD	512GB SSD
320	240	60	15:13:34	30:27:08	60	11:07:35	22:15:11
320	240	125	7:18:31	14:37:01	125	5:20:27	10:40:53
320	240	250	3:39:15	7:18:31	250	2:40:13	5:20:27
320	240	500	1:49:38	3:39:15	500	1:20:07	2:40:13
320	240	1000	0:54:49	1:49:38	1000	0:40:03	1:20:07
320	240	2000	0:27:24	0:54:49	2000	0:20:02	0:40:03
320	240	3083 (Max)	0:17:47	0:35:34	2253 (Max)	0:13:00	0:25:59
400	400	60	7:13:55	14:27:50	60	5:27:30	10:55:00
400	400	125	3:28:17	6:56:34	125	2:37:12	5:14:24
400	400	250	1:44:08	3:28:17	250	1:18:36	2:37:12
400	400	500	0:52:04	1:44:08	500	0:39:18	1:18:36
400	400	1000	0:26:02	0:52:04	1000	0:19:39	0:39:18
400	400	1464 (Max)	0:17:47	0:35:34	1105 (Max)	0:13:25	0:26:51
512	512	60	4:31:13	9:02:26	60	3:21:49	6:43:38
512	512	125	2:10:11	4:20:22	125	1:36:52	3:13:44
512	512	250	1:05:06	2:10:11	250	0:48:26	1:36:52
512	512	500	0:32:33	1:05:06	500	0:24:13	0:48:26
512	512	901 (Max)	0:18:04	0:36:07	681 (Max)	0:13:26	0:26:53
640	480	60	3:51:26	7:42:52	60	2:51:50	5:43:41
640	480	125	1:51:05	3:42:10	125	1:22:29	2:44:58
640	480	250	0:55:33	1:51:05	250	0:41:14	1:22:29
640	480	500	0:27:46	0:55:33	500	0:20:37	0:41:14
640	480	770 (Max)	0:18:02	0:36:04	580 (Max)	0:13:23	0:26:47
800	600	60	2:27:06	4:54:11	60	1:50:33	3:41:05
800	600	125	1:10:36	2:21:13	125	0:53:04	1:46:07
800	600	250	0:35:18	1:10:36	250	0:26:32	0:53:04
800	600	496 (Max)	0:17:48	0:35:35	373 (Max)	0:13:22	0:26:45
1280	720	60	1:17:07	2:34:14	60	1:29:55	2:59:50
1280	720	125	0:37:01	1:14:02	125	0:43:10	1:26:19
1280	720	259 (Max)	0:17:52	0:35:44	194 (Max)	0:20:50	0:41:40
1024	1024	60	1:07:48	2:15:37	60	0:50:44	1:41:29
1024	1024	125	0:32:33	1:05:06	125	0:24:21	0:48:42
1024	1024	227 (Max)	0:17:55	0:35:51	170 (Max)	0:13:25	0:26:49
1280	1024	60	0:54:13	1:48:27	60	0:40:38	1:21:17
1280	1024	125	0:26:02	0:52:03	125	0:19:30	0:39:01
1280	1024	183 (Max)	0:17:47	0:35:33	136 (Max)	0:13:19	0:26:39

TS4 LR3 and TS3-D in Long Record mode (max fps limited to 1250fps on TS3L models)							
Resolution		LR3 8-bit Frame Rates and Times hh:mm:ss			LR3 10-bit Frame Rates and Times hh:mm:ss		
H.	V.	FPS	256GB SSD	512GB SSD	FPS	256GB SSD	512GB SSD
320	240	60	15:13:34	30:27:08	60	11:07:35	22:15:11
320	240	125	7:18:31	14:37:01	125	5:20:27	10:40:53
320	240	250	3:39:15	7:18:31	250	2:40:13	5:20:27
320	240	500	1:49:38	3:39:15	500	1:20:07	2:40:13
320	240	1000	0:54:49	1:49:38	1000	0:40:03	1:20:07
320	240	2000	0:27:24	0:54:49	2000	0:20:02	0:40:03
320	240	4000	0:13:42	0:27:24	4000	0:10:01	0:20:02
320	240	6167 (Max)	0:08:53	0:17:47	4507 (Max)	0:06:30	0:12:59
400	400	60	7:13:55	14:27:50	60	5:27:30	10:55:00
400	400	125	3:28:17	6:56:34	125	2:37:12	5:14:24
400	400	250	1:44:08	3:28:17	250	1:18:36	2:37:12
400	400	500	0:52:04	1:44:08	500	0:39:18	1:18:36
400	400	1000	0:26:02	0:52:04	1000	0:19:39	0:39:18
400	400	2929 (Max)	0:08:53	0:17:47	2211 (Max)	0:06:43	0:13:25
512	512	60	4:31:13	9:02:26	60	3:21:49	6:43:38
512	512	125	2:10:11	4:20:22	125	1:36:52	3:13:44
512	512	250	1:05:06	2:10:11	250	0:48:26	1:36:52
512	512	500	0:32:33	1:05:06	500	0:24:13	0:48:26
512	512	1802 (Max)	0:09:02	0:18:04	1362 (Max)	0:06:43	0:13:26
640	480	60	3:51:26	7:42:52	60	2:51:50	5:43:41
640	480	125	1:51:05	3:42:10	125	1:22:29	2:44:58
640	480	250	0:55:33	1:51:05	250	0:41:14	1:22:29
640	480	500	0:27:46	0:55:33	500	0:20:37	0:41:14
640	480	1541 (Max)	0:09:01	0:18:01	1160 (Max)	0:06:41	0:13:23
800	600	60	2:27:06	4:54:11	60	1:50:33	3:41:05
800	600	125	1:10:36	2:21:13	125	0:53:04	1:46:07
800	600	250	0:35:18	1:10:36	250	0:26:32	0:53:04
800	600	500	0:17:39	0:35:18	500	0:13:16	0:26:32
800	600	993 (Max)	0:08:53	0:17:47	746 (Max)	0:06:41	0:13:22
1280	720	60	1:17:07	2:34:14	60	1:29:55	2:59:50
1280	720	125	0:37:01	1:14:02	125	0:43:10	1:26:19
1280	720	250	0:18:31	0:37:01	250	0:21:35	0:43:10
1280	720	518 (Max)	0:08:56	0:17:52	389 (Max)	0:10:25	0:20:50
1280	1024	60	0:54:13	1:48:27	60	0:40:38	1:21:17
1280	1024	125	0:26:02	0:52:03	125	0:19:30	0:39:01
1280	1024	365 (Max)	0:08:55	0:17:50	273 (Max)	0:06:41	0:13:22

Appendix E: TS5 Record / Resolution Tables

NOTE: These tables include only a sampling of resolution and frame rate values. Resolutions are available in increments of 2 x 2 pixels from 64 x 32 to the maximum resolution for each model. Minimum resolution in for the TS5-D models in Long Recording mode is 320 x 32. Frame rates are available in 1fps increments from 24 fps to the maximum rate for any resolution and mode. Note that maximum frame rates are higher when binning is enabled on resolutions equal to or less than 768 wide.

Sample TS5 16:9 Resolutions

Table 7-4: TS5 Sample Resolutions, Rates, and Times

Resolution		Time and Frames listed for 8GB cameras (for 4GB cameras divide by 2)							
H.	V.	8-bit			10-bit			12-bit	
		FPS	Time (s)		FPS	Time (s)		FPS	Time (s)
128	72			909,446			677,396		
		125	7275.6		125	5419.2		125	4483.2
		250	3637.8		250	2709.6		250	2241.6
		500	1818.9		500	1354.8		500	1120.8
		1000	909.4		1000	677.4		1000	560.4
		2500	363.7		2500	270.9		2500	224.1
		5000	181.8		5000	135.4		5000	112.0
		10,000	90.9		10,000	67.7		10,000	56.0
		12,099*	75.1		10,139*	66.8		10,139*	55.2
		17,108**	53.1		14,257**	47.5		14,257**	39.3
320	180			145,935			109,103		
		125	1167.5		125	872.8		125	729.8
		250	583.7		250	436.4		250	364.9
		500	291.9		500	218.2		500	182.5
		1000	145.9		1000	109.1		1000	91.2
		2000	72.9		2000	54.5		2000	45.6
		4000	36.4		4000	27.2		4000	22.8
		5329*	27.3		4451*	24.5		4451*	20.4*
448	252			74,477			55,613		
		125	595.8		125	444.9		125	370.7
		250	297.9		250	222.4		250	185.3
		500	148.9		500	111.2		500	92.6
		1000	74.4		1000	55.6		1000	46.3
		2000	37.2		2000	27.8		2000	23.1
		3881*	19.1		3234*	17.1		3234*	14.3
		5995**	12.4		4996**	11.1		4996**	9.2
640	360			36,499			27,289		
		125	292.0		125	218.3		125	14.8
		250	146.0		250	109.2		250	91.3
		500	73.0		500	54.6		500	45.6
		750	48.7		750	36.4		750	30.4
		1000	36.5		1000	27.3		1000	22.8
		1500	24.3		1500	18.2		1500	15.2
		2000	18.2		2000	13.6		2000	11.4
		2757*	13.2		2297*	11.8		2297*	9.9
		4314**	8.4		3595**	7.5		3595**	6.3

* Maximum without binning

**Maximum with binning enabled

Sample TS5 16:9 Resolutions, Continued

Resolution		8GB Capacity (for 4GB cameras divide Time by 2)								
H.	V.	8-bit			10-bit			12-bit		
800	450	FPS	Time (s)	23,360 Frames	FPS	Time (s)	17,498 Frames	FPS	Time (s)	14,600 Frames
		60	389.3		60	291.6		60	243.3	
		125	186.9		125	140.0		125	116.8	
		250	93.4		250	70.0		250	58.4	
		500	46.7		500	35.0		500	29.2	
		1000	23.4		1000	17.5		1000	14.6	
		1500	15.5		1500	11.6		1500	9.7	
		2221	10.5		1851	9.4		1851	7.8	
Supported by TS5-S, H, and Q Models:										
1024	576	125	114.1	14,258 Frames	125	85.4	10,673 Frames	125	889.5	8,903 Frames
		250	57.0		250	42.7		250	444.7	
		500	28.5		500	21.3		500	222.3	
		750	19.0		750	14.2		750	27.8	
		1000	14.2		1000	10.6		1000	8.9	
		1746	8.1		1455	7.3		1455	6.1	
1280	720	125	73.0	9,125 Frames	125	54.7	6,839 Frames	125	45.6	5,703 Frames
		250	36.5		250	27.4		250	22.8	
		500	18.3		500	13.7		500	11.4	
		750	12.2		750	9.1		750	7.6	
		1000	9.1		1000	6.8		1000	5.7	
		1403	6.5		1169	5.8		1169	4.8	
Supported by TS5-H and Q Models:										
1600	900	125	46.7	5,840 Frames	125	35.0	4,374 Frames	125	29.2	3,650 Frames
		250	23.4		250	17.5		250	14.6	
		500	11.7		500	8.7		500	7.3	
		625	9.3		625	7.0		625	5.8	
		758	7.7		633	6.9		633	5.8	
1920	1080	60	67.6	4,055 Frames	60	50.7	3,041 Frames	60	42.2	2,534 Frames
		125	32.4		125	24.3		125	20.3	
		250	16.2		250	12.2		250	10.1	
		500	8.1		500	6.1		500	5.1	
		634	6.4		529	5.7		529	4.8	
Supported by TS5-Q only:										
2560	1440	60	38.0	2,281 Frames	60	28.5	1,709 Frames	60	23.8	1,425 Frames
		125	18.2		125	13.7		125	11.4	
		250	9.1		250	6.8		250	5.7	
		359	6.4		300	5.7		300	4.8	

TS5 5:4 Resolutions

Resolution		8GB Capacity (for 4GB cameras divide Time by 2)								
H.	V.	8-bit			10-bit			12-bit		
		FPS	Time (s)	642,615 Frames	FPS	Time (s)	477,872 Frames	FPS	Time (s)	395,828 Frames
128	102	125	5140.9		125	3823.0		125	3166.6	
		250	2570.5		250	1911.5		250	1583.3	
		500	1285.2		500	955.7		500	791.7	
		1000	642.6		1000	477.8		1000	395.8	
		2000	321.3		2000	238.9		2000	197.9	
		4000	160.6		4000	119.4		4000	98.9	
		8943*	71.8		7452*	64.1		7452*	53.1	
		13,071**	49.1		10,892**	43.8		10,892**	36.3	
		250	200	125	1334.2	166,770 Frames	125	1000.8	125,097 Frames	125
250	667.1			250	500.4		250	420.4		
500	333.5			500	250.2		500	210.2		
1000	166.8			1000	125.1		1000	105.1		
2000	83.4			2000	62.5		2000	52.5		
4828*	34.5			4023*	31.0		4023*	26.1		
7380**	22.5			6150**	20.3		6150**	20.3		
320	256			125	831.6		103,950 Frames	125		621.8
		250	415.8	250	310.9	250		259.9		
		500	207.9	500	155.5	500		129.9		
		1000	104.0	1000	77.7	1000		65.0		
		2000	51.3	2000	38.3	2000		32.0		
		3823*	26.8	3186*	24.0	3186*		20.1		
		5910**	17.3	4925**	15.5	4925**		13.0		
512	410	60	676.3	40,575 Frames	60	506.2	30,372 Frames	60	420.2	25,212 Frames
		125	324.6		125	243.0		125	201.7	
		250	162.3		250	121.5		250	100.9	
		500	81.2		500	60.7		500	50.4	
		1000	40.6		1000	30.4		1000	25.2	
		2431*	16.4		2026*	14.8		2026*	12.2	
		3818**	10.4		3182**	9.4		3182**	7.8	
640	512	60	329.7	19,783 Frames	60	294.8	17,685 Frames	60	270.8	16,247 Frames
		125	158.3		125	141.5		125	130.0	
		250	79.1		250	70.7		250	65.0	
		500	39.6		500	35.4		500	32.5	
		1000	19.8		1000	17.7		1000	16.3	
		1959	13.1		1632*	11.7		1632*	9.8	
		3093**	8.2		2577**	7.4		2577**	6.2	
750	600	60	310.7	18,639 Frames	60	233.6	14,016 Frames	60	194.7	11,680 Frames
		125	149.1		125	112.1		125	93.4	
		250	74.6		250	56.1		250	46.7	
		500	37.3		500	28.0		500	23.4	
		1000	18.6		1000	14.0		1000	11.6	
		1677*	11.1		1398*	10.0		1398*	8.3	
		2657**	7.0		2214**	6.3		2214**	5.2	

TS5 5:4 Resolutions, Continued

Resolution		8GB Capacity (for 4GB cameras divide Time by 2)								
H.	V.	8-bit			10-bit			12-bit		
		FPS	Time (s)	Frames	FPS	Time (s)	Frames	FPS	Time (s)	Frames
Supported by TS5-S, H, and Q Models:				1,014 Frames			7,594 Frames			6,334 Frames
1024	820	60	169.1		60	126.6		60	105.6	
		125	81.2		125	60.8		125	50.7	
		250	40.6		250	30.4		250	25.3	
		500	20.3		500	15.2		500	12.7	
		750	13.5		625	12.2		625	10.1	
		1234	8.1		1028	7.2		1028	6.0	
1280	1024	60	108.3	6,499 Frames	60	81.2	4,870 Frames	60	67.7	4,062 Frames
		125	52.0		125	39.0		125	32.5	
		250	26.0		250	19.5		250	16.3	
		500	13.0		500	9.7		500	8.1	
		991	6.4		826	5.8		826	4.8	
Supported by TS5-H and Q Models:										
1350	1080	60	97.2	5,834 Frames	60	73.0	4,382 Frames	60	60.1	4,382 Frames
		125	46.7		125	35.1		125	28.8	
		250	23.3		250	17.5		250	14.4	
		500	11.7		500	8.8		500	7.2	
		634	9.2		529	8.3		529	6.8	
1500	1200	60	77.9	4,672 Frames	60	58.4	3,504 Frames	60	48.7	2,920 Frames
		125	37.4		125	28.0		125	23.4	
		250	18.7		250	14.0		250	11.7	
		500	9.3		477	7.3		477	6.1	
		571	8.2							
Supported by TS5-Q only:										
2000	1600	60	43.8	2,628 Frames	60	32.8	1,970 Frames	60	27.4	1,642 Frames
		125	21.0		125	15.8		125	13.1	
		250	10.5		250	7.9		250	6.6	
		404	6.5		337	5.8		337	4.9	
2560	2048	60	26.7	1,604 Frames	60	20.0	1,202 Frames	60	16.7	1,002 Frames
		125	12.8		125	9.6		125	8.0	
		253	6.3		211	5.7		211	4.7	

TS5 4:3 Resolutions

Resolution		8GB Capacity (for 4GB cameras divide Time by 2)								
H.	V.	8-bit			10-bit			12-bit		
		FPS	Time (s)	Frames	FPS	Time (s)	Frames	FPS	Time (s)	Frames
128	96	125	5461.4	682,675 Frames	125	4067.0	508,375 Frames	125	3364.2	420,527 Frames
		250	2730.7		250	2033.5		250	1682.1	
		500	1365.4		500	1016.8		500	841.1	
		1000	682.7		1000	508.4		1000	420.5	
		2000	341.3		2000	254.2		2000	210.3	
		4000	170.7		4000	127.1		4000	105.1	
		9485*	72.3		7862*	64.6		7862*	53.4	
		13,718**	49.765		11,432**	44.4		11,432**	36.7	
256	192	125	1368.0	171,001 Frames	125	1018.2	127,278 Frames	125	842.1	105,258 Frames
		250	684.0		250	509.1		250	421.0	
		500	342.0		500	254.6		500	210.5	
		750	228.0		750	169.7		750	140.3	
		1000	171.0		1000	127.3		1000	105.3	
		2000	85.5		2000	63.6		2000	52.6	
		5017*	34.0		4180*	30.4		4180*	25.1	
		7652**	22.3		6377**	19.9		6377**	16.5	
320	240	125	875.7	109,466 Frames	125	654.8	81,852 Frames	125	547.4	68,427 Frames
		250	437.9		250	327.4		250	273.7	
		500	218.9		500	163.7		500	136.9	
		1000	109.5		1000	81.9		1000	68.4	
		2000	54.7		2000	40.9		2000	34.2	
		4065*	26.9		3387*	24.1		3387*	20.2	
		6267**	17.4		5222**	15.6		5222*	13.1	
512	384	60	712.9	42,771 Frames	60	533.6	32,017 Frames	60	443.0	26,578 Frames
		125	342.2		125	256.1		125	212.6	
		250	171.1		250	128.1		250	106.3	
		500	85.5		500	64.0		500	53.2	
		1000	42.8		1000	32.0		1000	26.6	
		2590*	16.5		2158*	14.8		2158*	12.3	
		4061**	10.4		3384**	9.4		3384**	7.8	
640	480	60	456.3	27,375 Frames	60	341.1	20,468 Frames	60	285.2	17,110 Frames
		125	219.0		125	163.7		125	136.9	
		250	109.5		250	81.9		250	68.4	
		500	54.8		500	40.9		500	34.2	
		1000	27.4		1000	20.5		1000	17.1	
		2086*	13.1		1738*	11.7		1738*	9.8	
		3289**	8.3		2741**	7.4		2741**	6.2	

TS5 4:3 Resolutions, Continued

Resolution		8GB Capacity (for 4GB cameras divide Time by 2)								
H.	V.	8-bit			10-bit			12-bit		
800	600	FPS	Time (s)	17,520 Frames	FPS	Time (s)	13,124 Frames	FPS	Time (s)	10,950 Frames
		60	292.0		60	218.7		60	182.5	
		125	140.2		125	105.0		125	87.6	
		250	70.1		250	52.5		250	43.8	
		500	35.0		500	26.2		500	21.9	
		750	23.4		750	17.5		750	14.6	
		1677	10.4		1398	9.3		1398	7.8	
Supported by TS5-S, -H and -Q models:										
1024	768	60	178.2	10,694 Frames	60	133.4	8,005 Frames	60	111.3	6,677 Frames
		125	85.6		125	64.0		125	53.4	
		250	42.8		250	32.0		250	26.7	
		500	21.4		500	16.0		500	13.4	
		750	14.3		750	10.6		750	8.9	
		1316	8.1		1097	7.2		1097	6.0	
1280	960	60	114.1	6,844 Frames	60	85.5	5,129 Frames	60	71.3	4,277 Frames
		125	54.8		125	41.0		125	34.2	
		250	27.4		250	20.5		250	17.1	
		500	13.7		500	10.3		500	8.6	
		1057	6.4		880	5.8		880	4.8	
Supported by TS5-H and -Q models:										
1440	1080	60	90.1	5,407 Frames	60	67.6	4,055 Frames	60	56.3	3,379 Frames
		125	43.3		125	32.4		125	27.0	
		250	21.6		250	16.2		250	13.5	
		500	10.8		500	8.1		500	6.8	
		634(Max)	8.5		529(Max)	7.7		529(Max)	6.4	
Supported by TS5 Q only:										
2000	1500	60	46.7	2,803 Frames	60	35.0	2,101 Frames	60	29.2	1,752 Frames
		125	22.4		125	16.8		125	14.0	
		250	11.2		250	8.4		250	7.0	
		431(Max)	6.5		359(Max)	5.9		359(Max)	4.9	
2560	1920	60	28.5	1,711 Frames	60	21.4	1,282 Frames	60	17.8	1,069 Frames
		125	13.7		125	10.3		125	8.6	
		270f(Max)	6.3		225(Max)	5.7		225(Max)	4.8	

TS5-D Long Record

Resolution		1TB Capacity SSD (for TS5 with 512GB divide by 2, TS5 with 2TB multiply by 2 for approximate times)											
H	V	8 Bits				10 Bits				12 Bits			
		FPS	Hr	Min	Sec	FPS	Hr	Min	Sec	FPS	Hr	Min	Sec
320	180	60	75	10	15	60	59	20	44	60	49	1	28
		125	36	4	55	125	28	29	9	125	23	31	54
		250	18	2	27	250	14	14	34	250	11	45	57
		500	9	1	13	500	7	7	17	500	5	52	58
		1000	4	30	36	1000	3	33	38	1000	2	56	29
		1500	3	0	24	1500	2	22	25	1500	1	57	39
		3000	1	30	12	3000	1	11	12	3000	0	58	49
		3904*	1	9	19	3082*	1	9	19	2546*	1	10	58
		4451**	1	0	47	4451**	0	47	59	4451**	0	39	39
		5000***	0	54	7	5000***	0	42	43	5000***	0	35	17
320	240	60	59	28	32	60	43	27	47	60	37	40	3
		125	28	32	53	125	20	51	44	125	18	4	49
		250	14	16	26	250	10	25	52	250	9	2	24
		500	7	8	13	500	5	12	56	500	4	31	12
		1000	3	34	6	1000	2	36	28	1000	2	15	36
		2000	1	47	3	2000	1	18	14	2000	1	7	48
		3082*	1	9	28	2252*	1	9	28	1952*	1	9	28
		3394**	1	3	5	3394**	0	46	6	3394**	0	39	57
		5000***	0	41	0	4505***	0	34	43	3905***	0	34	43
512	512	60	17	39	24	60	13	8	22	60	10	58	16
		125	8	28	31	125	6	18	25	125	5	15	58
		250	4	14	15	250	3	9	12	250	2	37	59
		500	2	7	7	500	1	34	36	500	1	18	59
		915*	1	9	28	681*	1	9	27	568*	1	9	32
		1634	0	38	54	1362	0	34	43	1137	0	34	44
640	480	60	15	4	0	60	11	11	17	60	9	25	0
		125	7	13	55	125	5	22	13	125	4	31	12
		250	3	36	57	250	2	41	6	250	2	15	36
		500	1	48	28	500	1	20	33	500	1	7	48
		781*	1	9	26	580*	1	9	26	488*	1	9	28
		1562	0	34	43	1160	0	34	43	976	0	34	44
800	600	60	9	34	34	60	7	11	51	60	6	0	38
		125	4	35	47	125	3	27	17	125	2	53	6
		250	2	17	53	250	1	43	38	250	1	26	33
		496*	1	9	30	373*	1	9	28	311*	1	9	34
		500	1	8	56	500	0	51	49	500	0	43	16
		993	0	34	43	746	0	34	44	623	0	34	43

TS5-D Long Record, Continued

Resolution		1TB Capacity SSD (for TS5 with 512GB divide by 2, TS5 with 2TB multiply by 2 for approximate times)											
H	V	8 Bits				10 Bits				12 Bits			
		FPS	Hr	Min	Sec	FPS	Hr	Min	Sec	FPS	Hr	Min	Sec
1280	720	60	5	1	20	60	3	45	14	60	3	8	20
		125	2	24	38	125	1	48	7	125	1	30	24
		250	1	12	19	250	0	54	3	250	0	45	12
		260*	1	9	32	194*	1	9	39	162*	1	9	45
		520	0	34	46	389	0	34	44	325	0	34	46
1280	1024	60	3	31	52	60	2	38	45	60	2	12	24
		125	1	41	42	125	1	16	12	125	1	3	33
		183*	1	9	28	137*	1	9	31	114*	1	9	41
		250	0	50	51	274	0	34	45	228	0	34	50
		366	0	34	44								
Supported by TS5-H and -Q models:													
1350	1080	60	3	9	54	60	2	22	43	60	1	58	56
		125	1	31	9	125	1	8	30	125	0	57	5
		164*	1	9	28	123*	1	9	37	102*	1	9	57
		250	0	45	34	246	0	34	48	205	0	34	48
		328	0	34	44								
1920	1080	60	2	13	43	60	1	40	26	60	1	23	41
		115*	1	9	46	86*	1	10	4	72*	1	9	44
		125	1	4	11	125	0	48	12	125	0	40	10
		231	0	34	44	173	0	34	50	144	0	34	52
Supported by TS5 Q only:													
2560	1440	60	1	15	18	60	0	56	25	60	0	47	4
		65*	1	9	30	48*	1	10	32	40*	1	10	36
		130	0	34	45	97	0	34	54	81	0	34	52
2560	2048	45*	1	10	35	34*	1	10	1	28*	1	10	56
		60	0	52	56	68	0	35	0	57	0	34	50
		91	0	34	54								

*Maximum frame rate in LR2 (Slow SSD or External SSD) mode. See “Figure 2-3: Power Up / Charging Menu (TS4-LR3 / TSx-D)” on page 9.

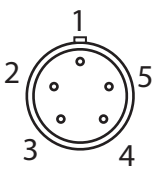

**Maximum frame rate in LR3 (Fast SSD) without binning.

***Maximum frame rate in LR3 (Fast SSD) binning enabled (up to 7500fps for some SSDs).

Appendix F: Power and I/O Connections

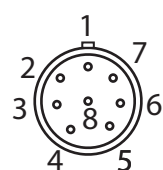
Power Connections For the TSx

Table 7-5: Power Pin Out

(View from Solder cup side of connector) 		Use Lemo 1B.305 compatible plug (FGG.305.CLAD.42.NZ Pictured here) Refer to http://www.lemo.com 
Pin	Signal	
1	+12 to 24VDC	
2	+12 to 24VDC	
3	No Connection	
4	Ground	
5	Ground	

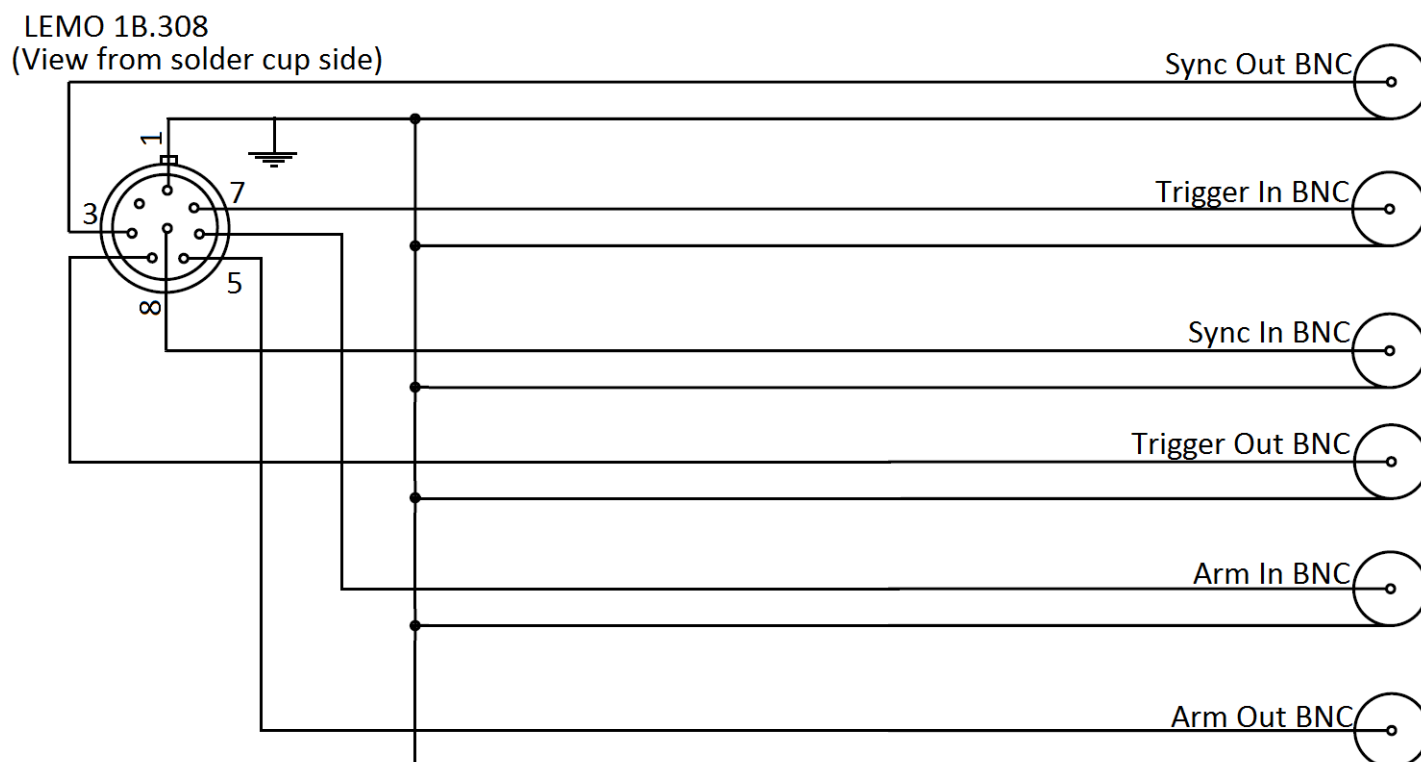
I/O Connections: Sync and Trigger

Table 7-6: I/O Connector Pin Out

(View from Solder cup side of connector) 		Use Lemo 1B.308 compatible plug Refer to http://www.lemo.com
Pin	Signal	
1	Ground	
2	Analog Reserved	
3	LVTTTL Sync Out	
4	LVTTTL Trigger Out	
5	LVTTTL Arm Out	
6	LVTTTL Arm In	
7	LVTTTL Trigger In	
8	LVTTTL Sync In	

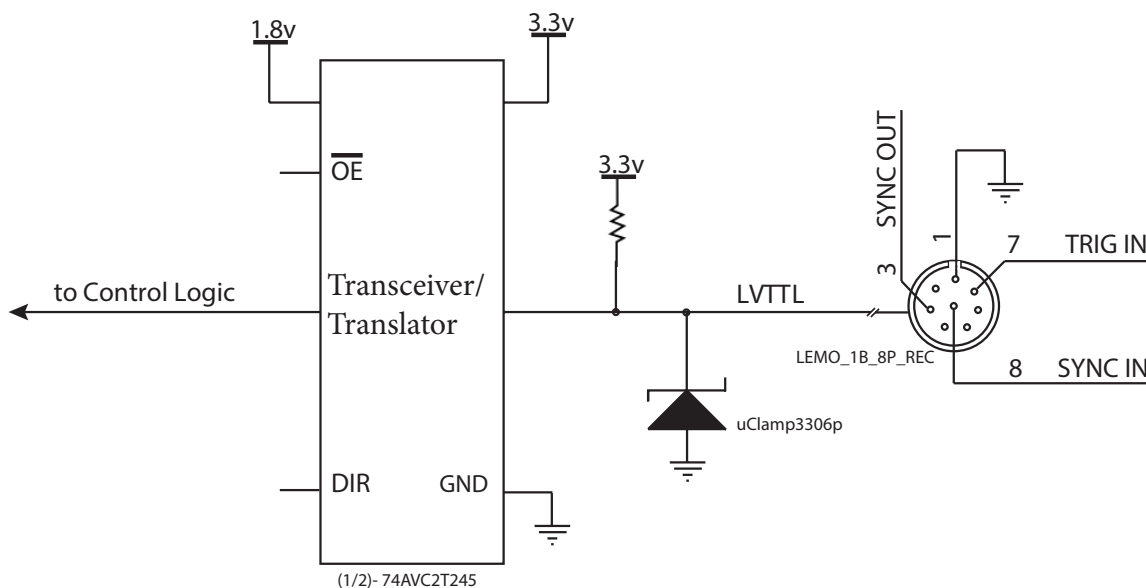
The TSx is shipped with a Sync I/O cable for connecting external Trigger, Sync Out, and Sync In signals. The cable has a LEMO connector for the TSx end and BNC connectors for the three signals.

Figure 7-1: Sync I/O Cable Drawing



(This drawing depicts a 6-signal cable that exposes all available I/O channels. Cameras are shipped with the standard 3-signal cable that exposes Sync Out, Trigger In, and Sync In.)

Figure 7-2: Sync I/O Camera Interface Schematic



The TSx I/O circuits are designed to operate at LVTTTL levels (3.3v). The inputs will respond to simple switch closures.

NOTE: THESE I/O PORTS ARE FOR LVTTTL LEVELS ONLY. VOLTAGES ABOVE 3.3V WILL HARM THE TSx.

For inputs greater than 3.3v:

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

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

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

The PLC to 3.3V Adapter is available directly through Fastec:

support@fastecimaging.com

(858) 592-2342

Figure 7-3: PLC to 3.3V Adapter Schematic

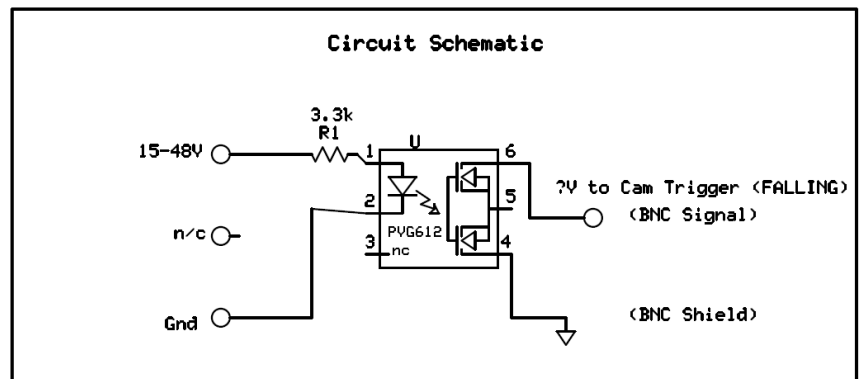


Figure 7-4: PLC 24V as Camera Trigger

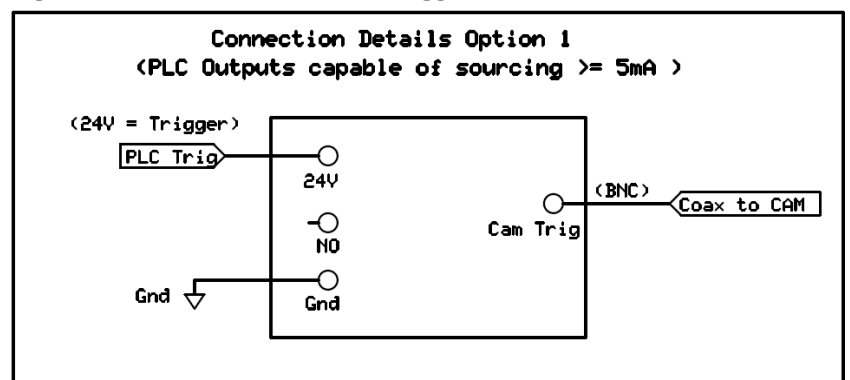
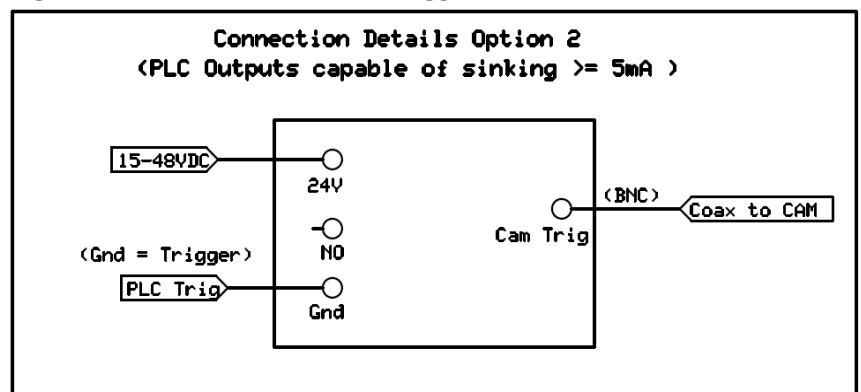


Figure 7-5: PLC Low as Camera Trigger



Appendix G: Adjusting Back Focus

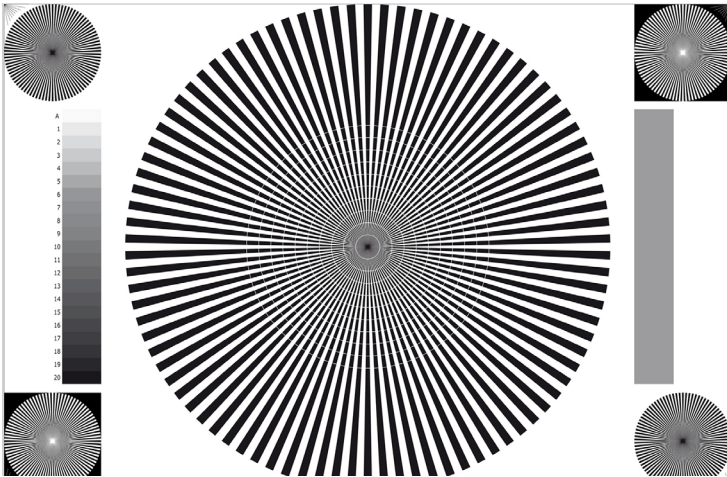
Symptoms of incorrect Back Focus Adjustment:

- Zoom lenses lose focus when zooming in or out. (Not all zoom lenses are designed to remain focused, so be careful not to prematurely jump to the conclusion that the back focus needs adjustment.)
- Lenses will not focus at infinity.
- The witness marks (distance marks) on lenses are always off in the same direction.

Tools required for Back Focus Adjustment:

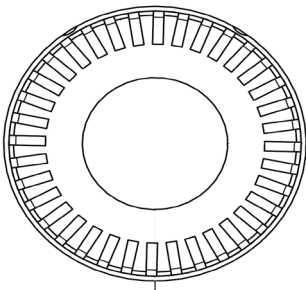
- High quality lens--or lens that you need to use for a particular test --Best if it is very fast--f/1.4 or faster.
- A high quality black and white focus chart can be very helpful. In a pinch, you can print one yourself. An 8 1/2 x 11" or A-Size Siemens Star chart will work for the example here.
- A 3/32" hex Allen wrench (shipped with every camera) for the C-mount lock screws. (See "TSx Top View" on page 4 and "TSx Bottom View" on page 5.)
- 5/32" and 5/64" Allen wrenches will be needed for adjusting F- or PL-mounts. These are shipped with F- or PL-mount equipped cameras.

Figure 7-6: Focus Chart



Adjustment Test Procedure:

Figure 7-7: C-mount



1. Connect the TSx to an LCD display, either via a PC connection or the HDMI port. You will wish to have a very good view of the image--the larger the better.
2. Select the lens you wish to use. For our discussion we will use a 1" format Navitar 50mm f/.95 lens.
3. Decide on a distance. For this discussion we will use 5'.
4. Set your target 5' from the camera. The proper way to measure is from the image plane to the target. The image plane is marked by a slight indentation above the camera LED on the front face of the TSx. Set the target as flat and square to the camera as possible. Usually, taping it to a wall is easiest.

5. Get plenty of flat white light on the target.
6. Set the camera up to frame the image. Using a 50 mm lens at 1.5m, the field of view at 800 x 600 resolution will be just a little larger than the focus chart.
7. Frame and focus the camera on the focus target. If using a color camera, color aliasing will be most noticeable at the point of best focus.
8. Adjust the illumination and/or the exposure setting to get the right exposure, avoiding saturation. Keep the lens set at its largest aperture to ensure the shallowest possible depth of focus.
9. Look at the witness mark on the lens. It should be pointing to 5'. If it is not, take note of exactly where it is

Figure 7-8: Focal Plane Mark on TSx



pointing, then continue on with the adjustment.

Adjusting Back Focus on a C-mount

1. Loosen the two C-Mount Lock screws (see “Figure 1-3: TSx Top View” and “Figure 1-3: TSx Top View”). The C-Mount is threaded onto the TSx Optical Block. Loosening the screws enable turning the C-Mount for adjustment.
2. Turn the C-mount adapter along with the lens until the target is in best focus. Turning clockwise will make it focus farther away, counter-clockwise will make it focus more closely.
3. When you are satisfied that the back focus is adjusted as well as you can get it, tighten the two adjustment screws and reconfirm the focus.

Adjusting Back Focus on F- or PL- mounts

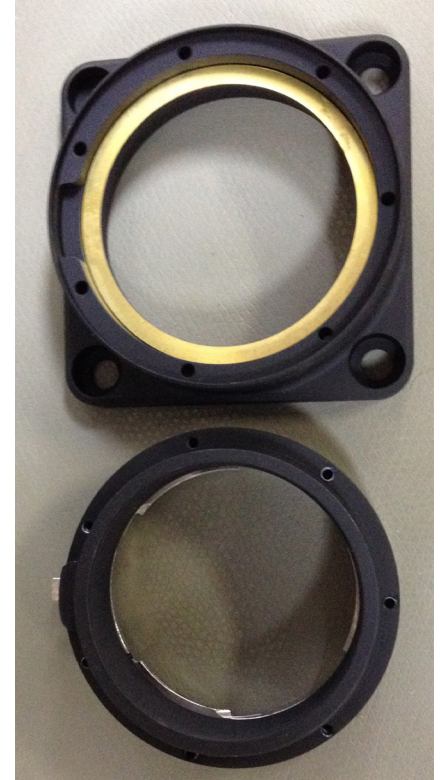
Back focus adjustment on the F- or PL-mounts is accomplished by adding or removing shims that are placed in the barrel of the mount. For this procedure it is handy, although not completely mandatory to have precision calipers on hand to measure the shim stack.

1. First establish if the lens needs to be shimmed out more, or if the shim stack needs to be reduced. If the lens is focusing too close, it might focus at 5' when the lens is set to 6', which means that the present stack height is too large. If the lens is focusing too far, it might focus at 5' when the lens is set to 4', which means that the stack height is not great enough.
2. Remove the lens mount from the camera. Refer to “Appendix H: Switching Lens Mounts” on page 111.
3. Turn the mount so that the side that attaches to the camera is facing you. You will notice 7 screws that hold the two halves of the mount barrel together. Use the 5/64” Allen wrench to remove these seven screws and separate the two halves of the barrel. Notice that the parts are keyed and will only fit together in one orientation.
4. Remove the shim stack. If you have calipers, you can measure the stack and make a note of it.

Figure 7-10: Navitar 50mm f/95 Lens



Figure 7-9: F-mount Barrel and Shims



5. Add, remove or change shims to create a taller or shorter shim height as needed. (Extra shims were shipped with the camera.)

6. Reassemble the lens mount and remount it on the camera to retest. After a couple of iterations, you will develop a feel for how much the back focus changes with the addition or subtraction of a few thousandths an inch of shims. While testing, you may use fewer screws to secure the mount barrel halves to each other and the mount to the camera. Take care to make sure these mechanical connections are tight enough for accurate results.

Appendix H: Switching Lens Mounts

All TSx cameras are equipped with C-mounts. F-mounts and PL-mounts are optional. If a camera is ordered with an optional lens mount, it will ship from the factory with that lens mount installed, unless otherwise specified. The C-mount and necessary tools for switching lens mounts, 3/32", 5/64" and 5/32" Allen wrenches, are included in the shipment. Also included are an assortment of shims that may be used with the F- or PL-mount to adjust the back focus.

Note: The back focus is adjusted at the factory to match the mount to the camera being shipped. The factory uses quality prime lenses for this process. The back focus may need to be adjusted, however, if the lens mount is used on another TSx or ILx camera or if you need to make a fine adjustment for a particular lens.

Removing an F- or PL-mount:

1. Using the 5/32" Allen wrench, remove the four bolts fastening the lens mount to the camera body. Note that the wrench is a special low-profile "stubby" design that fits below the PL-mount ring.
2. With the lens mount removed, you can now see the lens alignment piece. Back off the set screws above and below the optical opening with the 3/32" Allen wrench.
3. Unscrew the lens alignment ring (counter-clockwise). There are two holes in the ring that may be used with a metal rod or spanner to help turn the ring.

Installing the C-mount:

1. Make sure that the set screws above and below the optical opening are backed off well out of the way.
2. Screw on the C-mount ring (clockwise) a few turns.
3. Adjust the back focus. See "Appendix G: Adjusting Back Focus" on page 109.

Installing an F- or PL-mount:

1. Make sure that the set screws above and below the optical opening are backed off well out of the way.
2. Screw on the lens alignment ring (clockwise) until snug. Do not tighten.
3. Tighten the set screws down until they contact the lens alignment ring. They should not be very tight.
4. Note the orientation of the lens mount and consider the direction you wish the lens to be mounted in. (You may wish to have the lens markings facing up or to one side.)
5. Place the F- or PL-mount on the mount surface and attach with the four bolts using the 5/32" Allen wrench.
6. Adjust the back focus if necessary. See "Appendix G: Adjusting Back Focus" on page 109.

Figure 7-11: Removing an F- or PL-mount



Figure 7-12: TSx Lens Alignment Piece

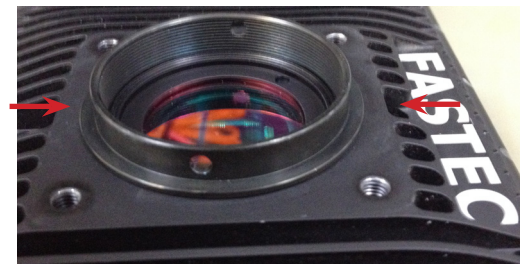
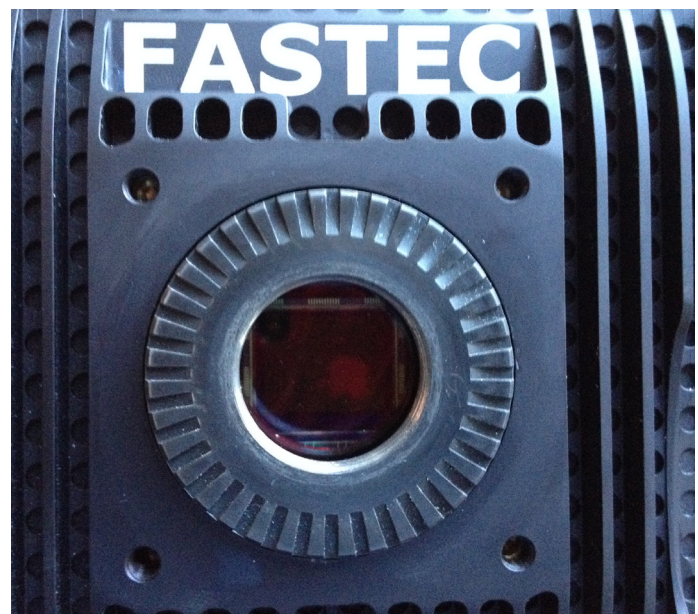


Figure 7-13: TSx With C-mount



Appendix I: Camera Status LEDs

Figure 7-14: Camera Status LEDs

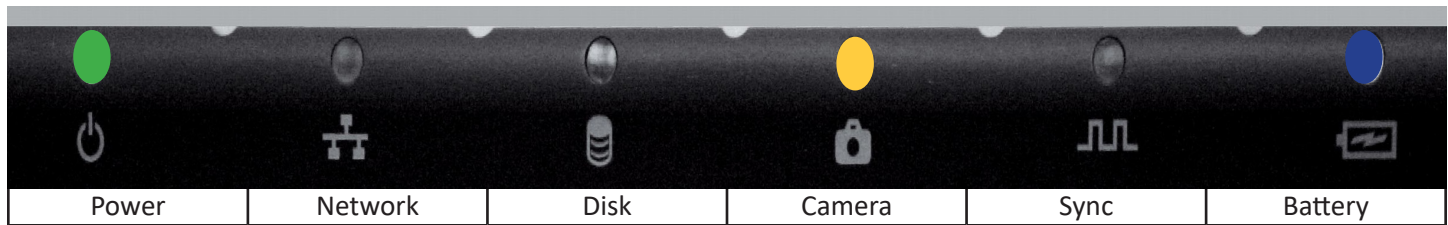


Table 7-7: Camera LED Behavior

Power LED:		Solid Green whenever the TSx is powered up.
Network LED:		Fast blinking Amber whenever the TSx is sending or receiving on the network.
Disk LED:		Fast blinking Amber whenever the TSx SSD or SDHC are accessed.
Camera LED:		Solid Green whenever in Live mode (operating, but not recording).
		Blinking Red slowly (1Hz) when the TSx is Armed, not triggered; Recording in ROC or BROCC
		Blinking Amber slowly (1Hz) when TSx is Armed, not recording in ROC or BROCC
		Blinking Red quickly (2Hz) when the TSx is Triggered in Basic and FasFire
		Blinking Purple slowly (1Hz) when the TSx is Armed in Autosave (recording, not triggered).
		Blinking Purple quickly (2Hz) when the TSx is Triggered in Autosave.
		Solid Amber when in Review mode (playing back recorded images).
		Off when battery is charging
Sync LED:		Solid Yellow: Sync = Per/Frame, IRIG= 0, Signal state= any
		Blinking Purple: Sync = Per Second, IRIG=0, Signal is locking or no signal
		Solid Purple: Sync = Per Second, IRIG=0, Signal Locked
		Off: Sync disabled, IRIG=0
		Blinking Green: IRIG=1, No Signal
		Fast Blink Green: Sync Disabled, IRIG=1, Signal Locking
		Solid Green: Sync Disabled, IRIG=1, Locked
Battery LED:		Solid Blue: Sync=IRIG, IRIG=1, Locked
		Blue when no battery is present
		Blinking Green when operating on battery and charge is above 40%
		Blinking Amber when operating on battery and charge is above 20%, below 40%
		Blinking Amber (fast) when operating on battery charge is above 10%, below 20%
		Blinking Red (fast) when operating on battery and charge is below 10%
		Solid Green when operating from external power, battery above 40%
		Solid Amber when operating from external power, battery between 10% and 40%
		Solid Red when operating from external power, battery below 10%

Appendix J: 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:
 $x = (<\text{resolution}> - 1280)/2$
 $y = (<\text{resolution}> - 1024)/2$
(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 K: Contents of <Capture>.xml file

<pre> <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> </FastecMetadata> </pre>	<p>Frame count = number of saved frames</p> <p>Start frame = First frame saved (from 0)</p> <p>sensor_options: 2x binning 1x subsample (TS5)</p> <p>x = image offset from corner of sensor</p> <p>y = image offset from corner of sensor</p> <p>(These will vary with resolution.</p> <p>If centered:</p> <p>$x = (\text{<resolution>} - 1280)/2$</p> <p>$y = (\text{<resolution>} - 1024)/2$</p> <p>(If not centered, then user values)</p> <p>Sensor = C31L (Color)</p> <p>Sensor = M31L (Mono)</p> <p>Multi-slope = option not implemented</p>
---	---

```

</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>
  </frame>

```

<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)

IRIG = 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)

Appendix L: TSx Updates

If you are notified by Fastec or one of its distributors that an update is available, they will give you a link to download it to a PC. The PC will need to have an SD Card port or have a card reader attached to it. (Note: It is possible to use the camera's SD Card port for this purpose by attaching to the PC via the OTG cable.)

Important!...Save all image data on the camera before updating. File metadata structures may change with updated firmware.

Update Procedure:

1. Navigate to System/Information/Status to see the current Software Version of your TSx.
2. Download the update files to a Windows PC. The camera firmware update file name will be in the form of "ts3_revx.x.x_<Year>_<date>.exe." For example, the latest revision as of the 1st of August, 2013 is: ts3_rev1.6.34_2013_0301.exe and FasMotion_1.6.34.exe. Updates always include both camera firmware and FasMotion software. The version numbers should match. **Update the camera first!**
3. Attach an SDHC card to the PC. If the PC does not have a built in card reader, you may attach a USB card reader to it. **Please note the drive letter the PC assigns the card.**
4. Double click on the update file. The Update Screen will appear. Click Next.
5. A License Agreement will appear. Click the check box to accept the terms and click Next.
6. A screen will appear for selecting the SD Card. Make sure that you have selected the correct drive letter before clicking on Install. A new window with a progress bar will appear.
7. Once the update program has finished writing to the SD Card, a final screen will appear. Click on Finish. Eject, and then remove the SD Card from the PC.

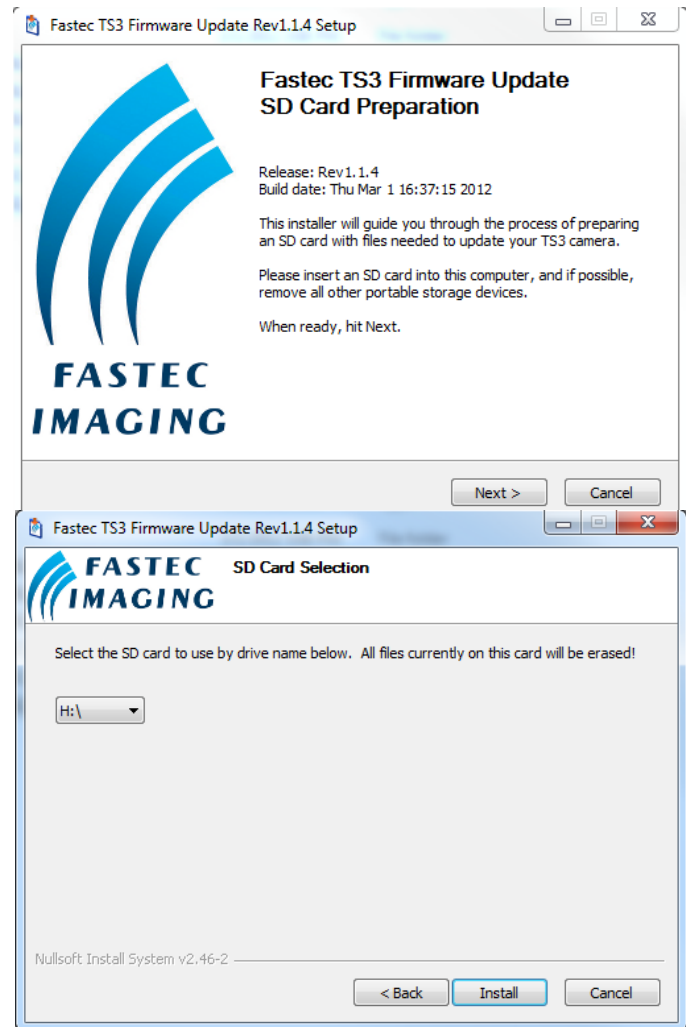
Note: If the update creation verification fails the first time, retry with the same SD Card.

8. Insert the SD Card into the SDHC slot of the TSx.
9. Power up the TSx while pressing the Up Arrow on the D-Pad. When the camera boots up, you will see a blue update screen and a progress bar. When it is finished the camera will boot normally.
10. Navigate again to System/Information/Status to see the new Software Version of your TSx.
11. Go to System/Configuration/Reset and select "Hard Reset." The camera will reboot.
12. Navigate to Record/Black Level and select Calibration.
13. If the TSx has an SSD, it should be formatted before use.
14. Restore the SD Card. (See "Restoring the SD Card" on the next page.)

Table 7-8: Information Status

TS3-08	
FASTEC-TS3100XC8064	
MAC Address:	a4:1b:c0:00:00:08
Software Version:	1.1.4
FPGA Version:	0.1.90
Sensor Version:	L1300C-A2-0030
GigE Vision Version:	1.02
Bootloader Version	Sep 28 2011 - 09:39:2
Batter SerialNo:	FA1 3900008

Figure 7-15: Camera Update Screens



Alternate Update Methods

Update from FasMotion software:

1. Follow #s 3-8 on the previous page.
2. In FasMotion, select "Update" in the Camera menu.
3. The camera should perform the update and reboot.
4. After the camera has rebooted, you will need to reconnect to FasMotion.
5. Follow #s 11-14 on the previous page.

When you reconnect to the camera, check the software version on the "Find Cameras" dialog.

Update from the TSx Camera GUI:

1. Follow #s 3-8 on the previous page.
2. Navigate to System/Configuration and select Update
3. When prompted if you have an Update SD card inserted, click on "Yes."
4. Follow #s 11-14 on the previous page.

Restoring the SD Card

The SD card you have used for the camera update now contains the files and folders listed in Figure 7-16. Refer to the TS3_Release_Notes file for information about the update.

The format of the SD Card has been changed and now there is very little (35MB) accessible space left.

To Restore the SD Card:

1. Attach the SD Card to a Windows PC.
2. Run card_restorer.exe from the SD Card.
3. You will see a message box asking if you wish to re-partition and erase the SD card. Click on "Yes."
4. The next message box will tell you that the process will take a few moments. Click on "OK."
5. Next, you will see a command window open and see some text scrolling by.
6. Finally, you will see a message box saying "Reformatting is now complete!"

Figure 7-16: Contents of Update SD Card

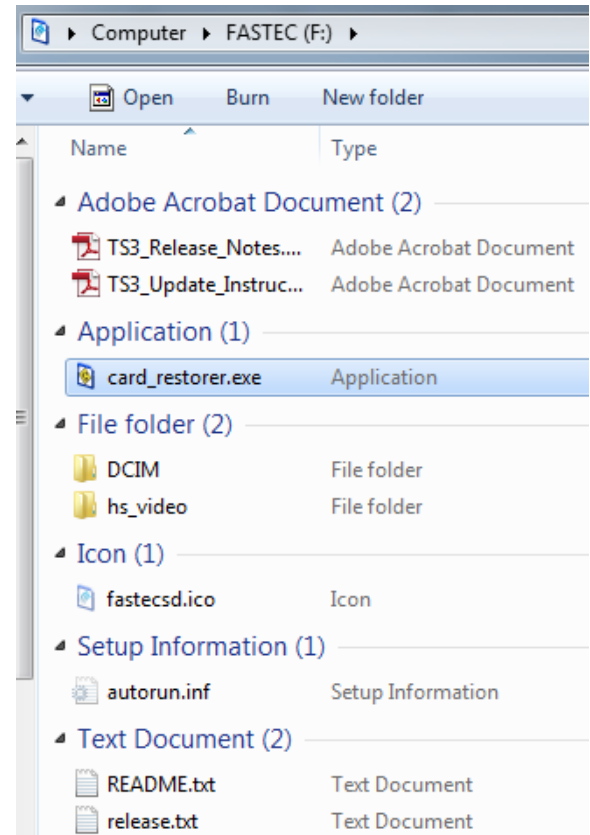


Figure 7-17: SD Card Restorer Messages

The camera firmware updater removable drive [F] will now be re-partitioned and all data on it will be erased!

Are you ABSOLUTELY sure you want to do this?

Yes

No

This make take a few moments. Please click OK and wait for another popup indicating completion.

OK

```
C:\Windows\System32\cmd.exe
Insert new disk for drive F:
and press ENTER when ready... The type of the file system is RAW.
The new file system is FAT32.
QuickFormatting 7579M
Initializing the File Allocation Table (FAT)...
Format complete.
  7.4 GB total disk space.
  7.4 GB are available.

  4,096 bytes in each allocation unit.
  1,936,382 allocation units available on disk.

  32 bits in each FAT entry.
Volume Serial Number is F6BC-64AC
```

Appendix M: Physical Measurements

Figure 7-18: Physical Measurements

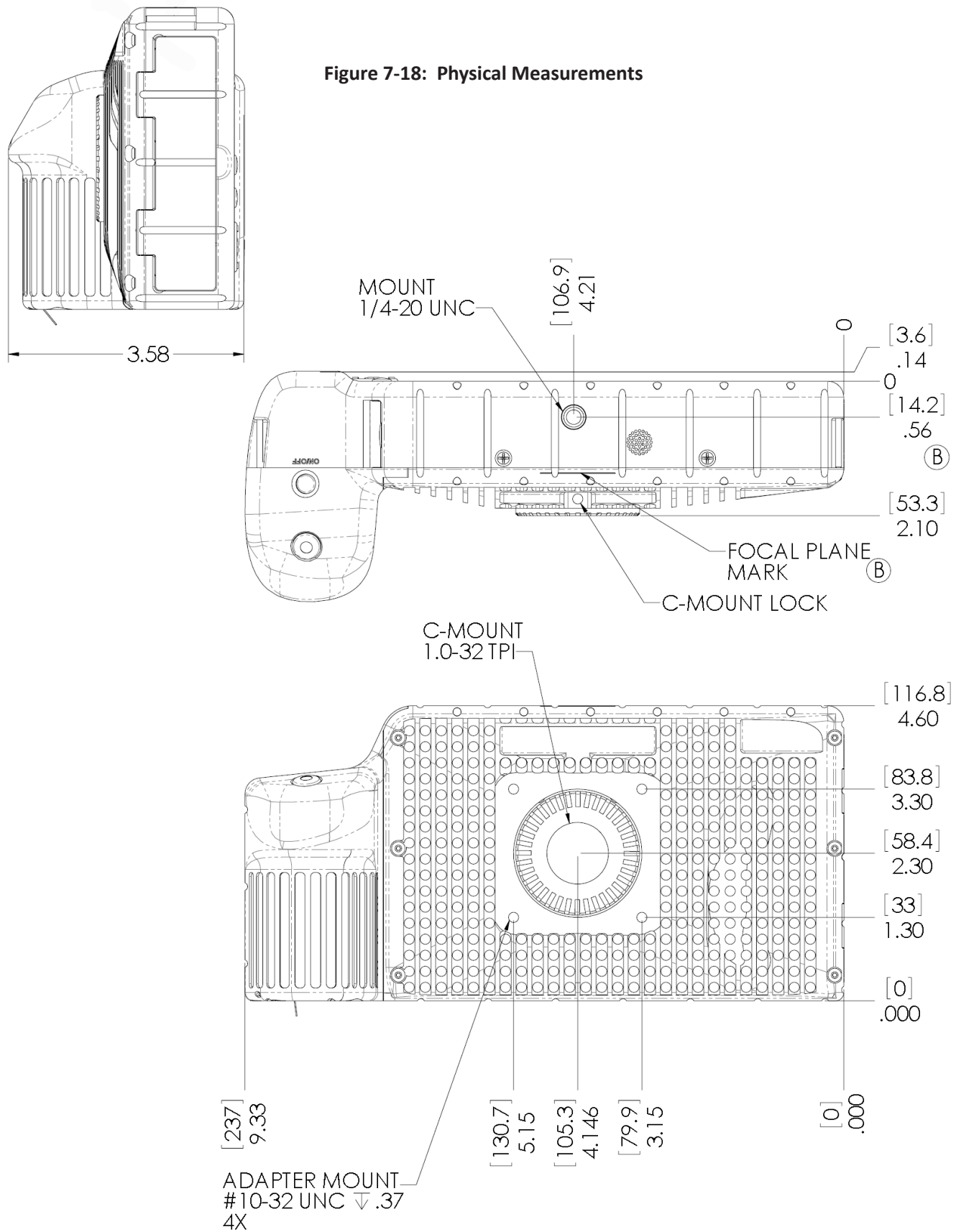
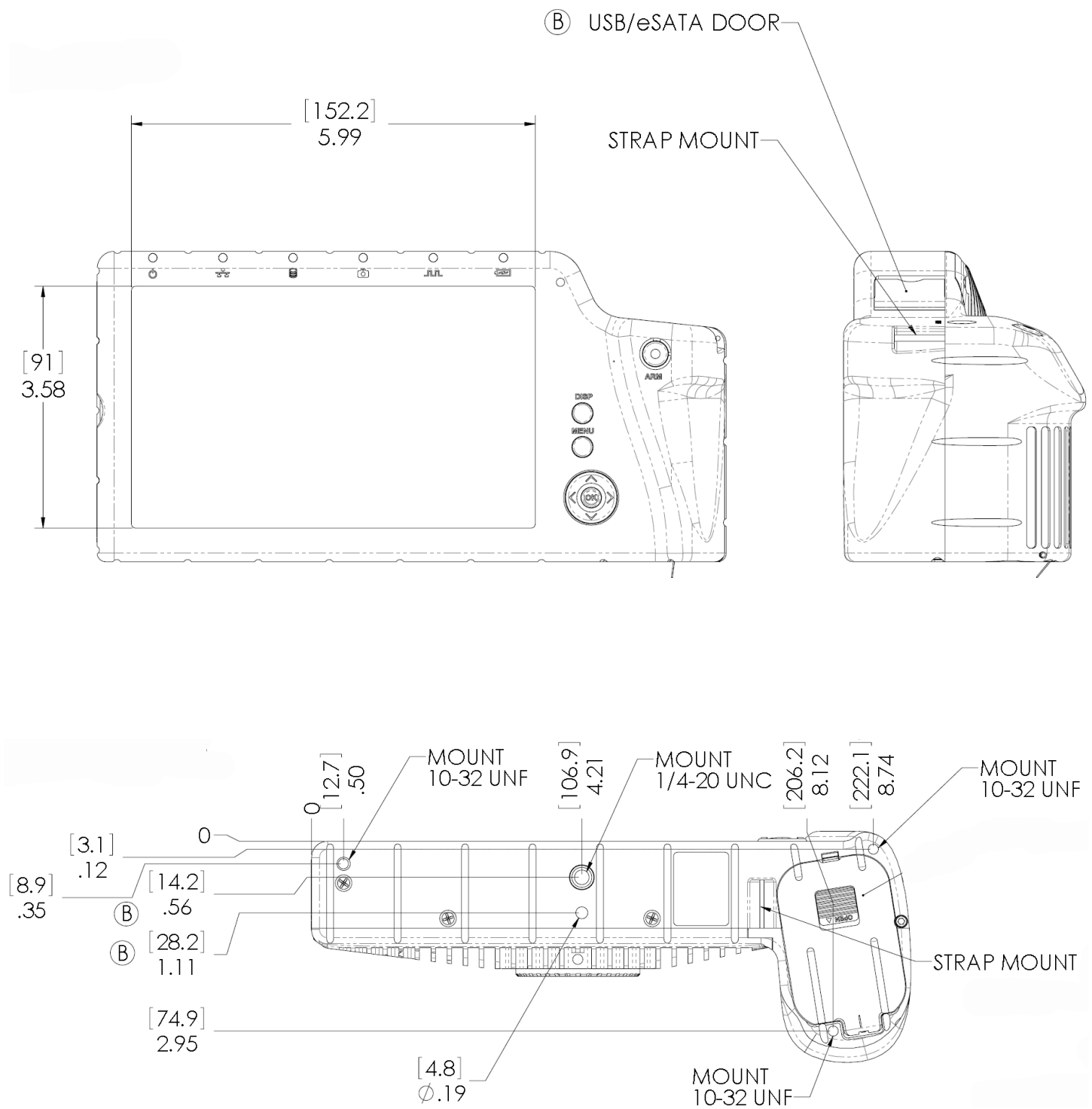


Figure 7-19: Physical Measurements Continued



Appendix N: Crop Factor

Crop Factor is a term used in digital photography that expresses the size of the sensor image plane as compared to that of 35mm film. In Figure 7-20 through Figure 7-22, below, the Black border represents the image on 35mm film; the Red border represents the image on the sensor using the same focal length lens.

Diagonal of 35mm film / Diagonal of the Sensor area used = Crop Factor

The diagonal of 35mm film is 43.3, compared to the 22.95mm diagonal of the TSx, you get a crop factor of 1.89:

43.3mm / 22.95mm = 1.89

The photographic advantage of knowing the crop factor is that if you know the lens you would use for a given field of view with a 35mm camera, you can divide the crop factor into that number to give you the focal length of the lens with the same field of view for your TSx. For example, if you are using a 125mm lens on your 35mm SLR, you will need about a 65mm lens on the TSx at full resolution (125mm / 1.89 = 66.14).

Table 7-9: Crop Factor

H-Res	V-Res	Diagonal	Crop Factor
1280	1024	22.95	1.89
1280	720	20.56	2.11
1024	1024	20.27	2.14
1280	256	18.27	2.37
800	600	14.00	3.09
1024	600	16.62	2.61
640	480	11.20	3.87
800	480	13.06	3.32
512	512	10.14	4.27
320	240	5.60	7.73
320	200	5.28	8.20
256	256	5.07	8.54

Figure 7-20: Crop Factor 1280 x 1024

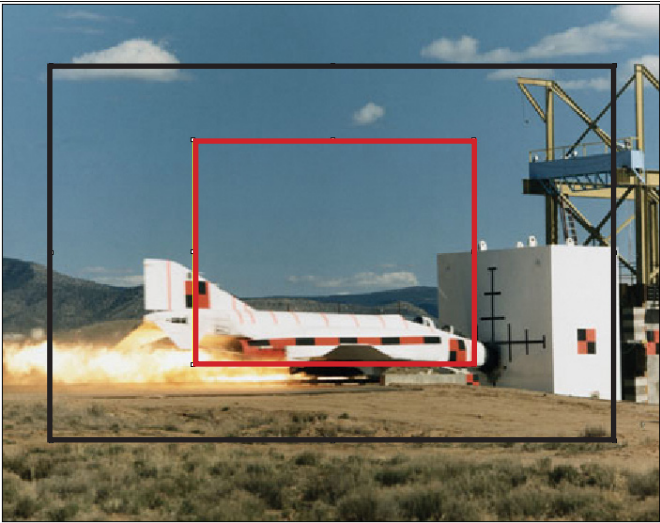


Figure 7-21: Crop Factor 1280 x 720

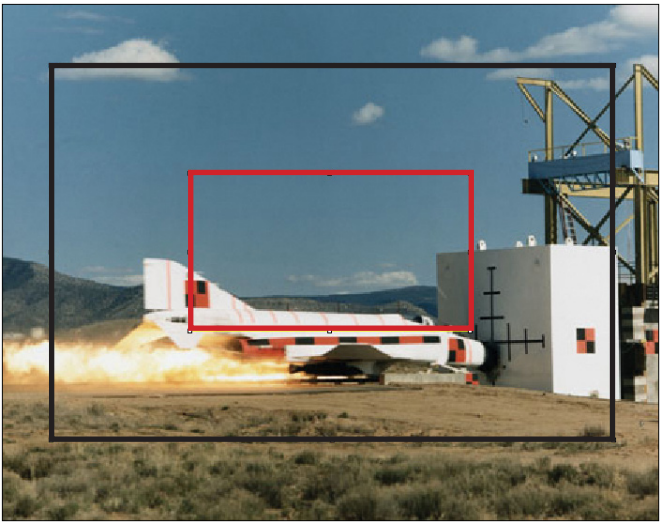
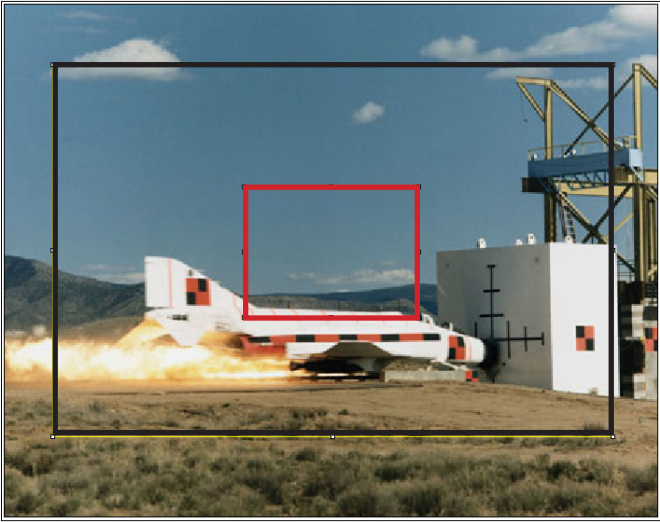


Figure 7-22: Crop Factor 800 x 600



Appendix O: 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 “3-10 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 71).

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 7-23: CAP File Diagram

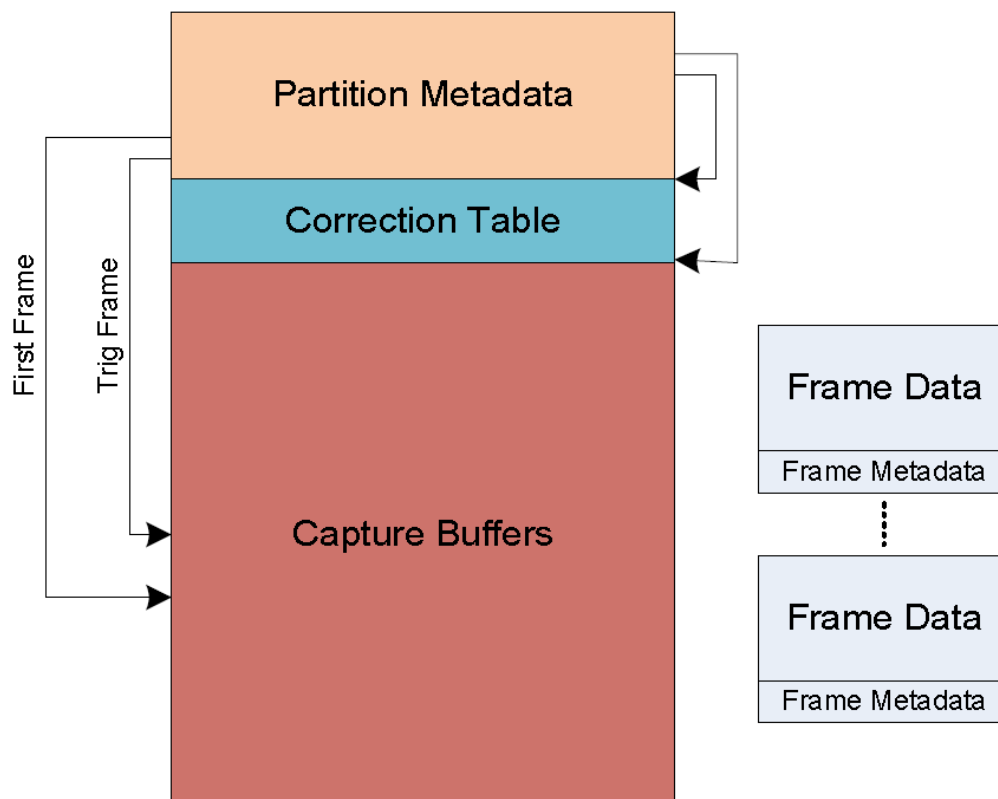


Table 7-10: CAP File Format

Field	Size	Offset		Description
Manufacturer's name	32	0	0000	"FASTEC".
Model name	32	32	0020	"TS3100SC8064" for example.
Serial number	16	64	0040	"0.0.122.A3" for example.
Application version	32	80	0050	"1.5.8" for example.
Camera name	16	112	0070	"FastecA4-7A" for example.
Ethernet MAC address	6	128	0080	The MAC address of the camera.
Bit selection	1	134	0086	0:Low8, 1:Mid8, 2:High8, 3:10Bits
Old Sensor gain	1	135	0087	(Obsolete)
FPGA version	4	136	0088	FPGA version information.
ROI x-offset	2	140	008C	Left side of the ROI window.
ROI y-offset	2	142	008E	Top side of the ROI window.
ROI width	2	144	0090	Width of the ROI window.
ROI height	2	146	0092	Height of the ROI window.
Frames per second	4	148	0094	Number of frames per second.
Shutter speed	4	152	0098	Exposure time in microseconds.
Sensor type	4	156	009C	Type of sensor used, "L13C" for example.
GPS location	64	160	00A0	GPS location information.
Frame count	4	224	00E0	Total number of frames captured.
Frame size	4	228	00E4	Size of the frames in quadwords.
First frame	4	232	00E8	Frame number of the first frame in the capture buffer.
Trigger frame	4	236	00EC	Frame number of the trigger frame in the capture buffer.
Trigger time seconds	4	240	00F0	Linux time of the trigger event.
Trigger time nanoseconds	4	244	00F4	Nanoseconds of trigger event from last second.
Start of video	4	248	00F8	Start of capture buffer, in quadwords.
As-shot neutral	12	252	00FC	The AsShotNeutral value.
Matrix coefficients	36	264	0108	IPM matrix coefficients.
White balance gains	12	300	012C	IPM white balance gain settings.
Multislope settings	2	312	0138	LUPA 1300-2 multislope settings.
Trigger settings	1	314	013A	Trigger position setting in percent, or 127 if position was specified by frame count instead of percent
SyncIn settings	1	315	013B	
SyncOut settings	1	316	013C	
Brightness	1	317	013D	0-255 centered around 128.
Contrast	1	318	013E	0-255 centered around 128.
Gamma	1	319	013F	0-250 centered around 100.
RGB gain settings	3	320	0140	Red, green, blue gain settings.
FPN settings	1	323	0143	Off, sensor or pixel correction.
Correction table offset	4	324	0144	Offset to the correction table.
Correction table length	4	328	0148	Size of the correction table, in quadwords.
Reserved	16	332	014C	Reserved for future use
Trigger frame setting	4	348	015C	Post-trigger frame count setting, if setting is not by percent
Comment	64	352	0160	User comment
sensor_opts	4	416	01A0	sensor binning, subsampling, and HDR options
black_offset	2	420	01A4	black level offset for saved CT in CAP or LR capture
sensor_dac	1	422	01A6	sensor DAC VREF for saved CT in CAP or LR capture
sensor_vrefcol	1	423	01A7	sensor VREFCOL for saved CT in CAP or LR capture
sensor_gain	2	424	01A8	sensor gain in canonical form (x 100)
placeholder	2	426	01AA	reserved, maintain alignment

Appendix P: Day Number Calendar Conversion

Time stamps on the TSx and ILx are written 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 7-11 and Table 7-12 convert calendar dates to day numbers.

Table 7-11: 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 7-12: 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 Q: Battery

Battery Specifications:

Type: Li-Ion rechargeable battery -- TS-specific design

Voltage: 3.7V

Current: 15,600mAh

Power: 58 Whr

Gas Gauge: Internal battery component calibrated at Fastec for the TSx.

Maintaining the Battery:

If an Li-Ion battery is allowed to discharge past a certain minimum voltage, it will no longer charge properly. In the case of the TSx battery, this is approximately 1v. Normal use of the camera (discharging to 0%) will not cause the battery voltage to drop close to its minimum serviceable voltage. Incorrect storage of the battery, however, may cause the voltage to continue to drop and cause it to fail.

- Do not store the camera with the battery installed. Always remove the battery from the camera if it will not be in use for more than two weeks.
- Do not let the battery sit in a discharged state for more than a couple of days. Optimum charge while storing the battery 40%. This ensures that the battery voltage will not drop past its recovery point.

Cleaning the Battery Connections

If battery connections become dirty, a voltage drop across the connection will cause excessive current draw and less than optimal discharging and charging of the battery. In most cases, battery function can be restored by careful cleaning of the battery connections.

Use DeoxIT contact cleaner applied with a lint-free swab on both the battery and on the battery contacts. Use on the contacts within the camera and also on the battery charger, if you have one.

Clean the contacts every two months or as needed. It is best to clean the contacts before any degradation in performance occurs.

Figure 7-24: Battery Connections



Battery Charging

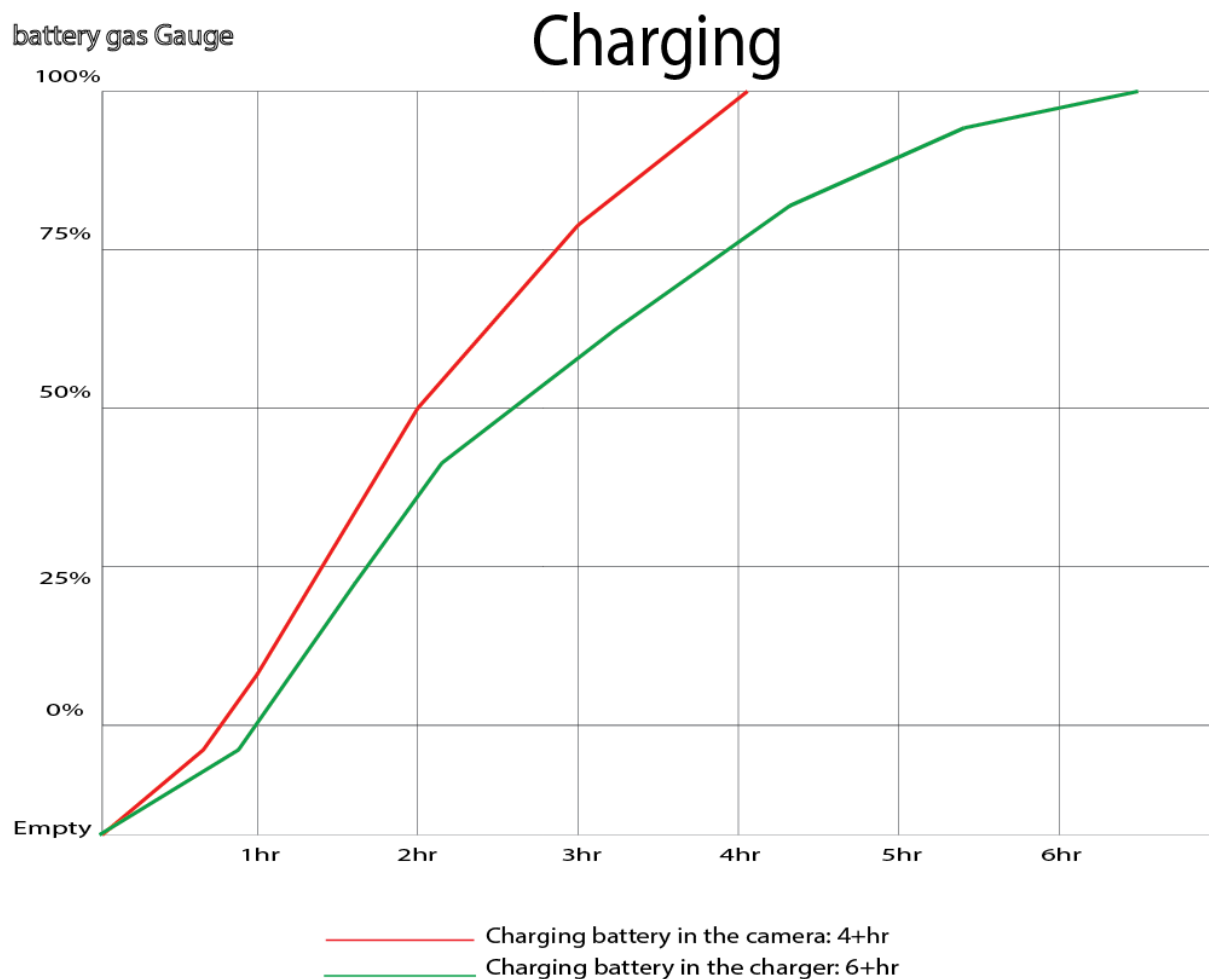
The TSx battery may be charged with the optional battery charger or in the camera. Charging the battery in the camera takes a little over four hours, while the battery charger takes about six and a half hours.

The graph in Figure 7-25 shows “Empty” at a point somewhat below 0%. Empty in this case refers to the battery level at which the camera will no longer boot up.

If the battery connections become contaminated, the charging times will rise.

Note: The battery gas gauge is based on Standard Basic mode in “Live.”

Figure 7-25: Battery Charging Curve



Operation of the TSx on Battery

The TSx will run on battery power for a few hours, depending on operating mode and enabled features and associated hardware used.

For example if the camera is Live with the display off, it will run almost five hours (see the red line on the chart, below). Running in this mode with intermittent use of the display and the touch screen and recording, the camera will run for about four hours. TS5 cameras use slightly more power and will generally run for about 80-90% as long as the TS3.

Recording in LR2 Basic mode (TS4100LR2 cameras), the camera will record, with HDMI output and the display off for more than three hours. (See blue line on the chart, below.)

Recording in LR3 Basic mode (TS4100LR3 and TS3-D cameras), the camera may record, with HDMI output and the display off for a little over one hour. With the display on and HDMI on it may only record for as little as 25 minutes. TS5-D cameras in LR3 mode will often record for only a few minutes using battery power. For this reason, it is best to switch to LR2 mode ("Slow SSD") when operating TS4-LR3, TS3-D or TS5-D cameras on internal battery power. See "Figure 2-3: Power Up / Charging Menu (TS4-LR3 / TSx-D)" on page 9.

WARNING: Do not rely on the gas gauge for LR mode recordings and when using FasFire!

Drain on the battery:

The following features will tend to drain the battery: Writing to the SSD (especially in SATA III mode as with the TS4100LR3), leaving the display on, enabling HDMI, USB devices and Ethernet connectivity.

Figure 7-26: Discharge Rate by Mode

