



TS3™ High-Speed Camera

Operator's Manual

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Chapter Summary (Where to find things in this manual)

Chapter 1, TS3 Product Overview

The first chapter contains general information regarding the TS3 product family, common applications for which the camera is used, and the basic guide to the component parts of the camera. Look here for the names and locations of all camera controls and indicators.

Chapter 2, Getting Started

This chapter guides the user through the camera setup process from unpacking the camera to attaching, connecting, or installing the pieces necessary to begin using the camera: i.e. the power supply and/or battery, lenses, mass memory devices, etc., as well as optional devices such as triggers, monitors, PCs, etc.

Chapter 3, Camera Setup

This chapter is about learning to use the TS3 user interface and setting the camera up for use, including naming the camera and setting up the time. It also covers controls for the built-in LCD display, connecting with an external display, and connecting the TS3 to a computer network.

Chapter 4, Recording with the TS3

Chapter 4 covers the recording process from setting up the recording parameters to Arming and Triggering the camera. It also covers bit selection, image processing and saving the imagery in its different formats.

Chapter 5, Synchronizing Cameras

Cameras may be synchronized to external timing devices as well as to other cameras. This chapter tells you how to do it on the TS3.

Chapter 6, TS3 Web-Application

TS3 camera's Web-Application makes it easy to control the camera from virtually any device that can attach to a network and run a standard internet browser. No need to load any software! Chapter 6 walks you through the Web-App and how to control the camera, and capture and manage imagery with it.

Appendices

Technical details are to be found in the appendices. These include a glossary of terms, camera and sensor specifications, lens FOV vs. resolutions tables, an index, connector schematics, and back focus adjustment procedures.

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1 TS3 Product Overview

1-1 TS3 Product Description

The Fastec TS3 is a high-speed digital camera line with models capable of capturing high resolution 1280 x 1024 pixel images at 500 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 TS3, 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 TS3 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.



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, speed up line setup and changeovers, lower scrap and rejected material costs, and reduce downtime and maintenance expenses.



Hundreds of universities worldwide use Fastec cameras for a variety of research studies. Animal locomotion, mechanical engineering, flow visualization, combustion studies, biomechanics & kinesiology, physics, chemistry, tensile testing, and more.



High-speed cameras are used 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, counter measure and defensive systems and components. High-speed cameras are key for testing projectiles for determining ballistics, detonics and fragmentation characteristics; in airborne stores separation; and in vehicle armor design testing materials and survivability.

1-2 TS3 Product Differentiation

Fastec Imaging sells a number of different TS3 high-speed digital camera models. These cameras are offered in either monochrome or color with various high-speed digital image recording capability using a wide range of recording rates, sensor resolutions, and on-board memory options. The cameras comprise an 8-bit (mono) or 24-bit(color) pixel resolution for HISPEC models, while the TS3 models boast 10-bit (mono) or 24-bit (color) resolutions. All cameras are equipped with a standard C-mount lens mount, and 1/4-20 tripod mount. Additional lens mount options are available for TS3 models.

TS3 cameras support the following modes of operation:

- Standalone operation: The TS3's built in 7" LCD display, SSD, SD-Card, or USB download, and battery power allow it to be fully functional without the connection to a host PC.
- Remote operation using Fastec Web Application: With the Web Application, any host device with a common Web browser may be used to control the camera.

The TS3 camera housing is made of 100% machined aluminum with a hard 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 Standalone mode. Power is supplied by an AC power adapter or a high-capacity Li-Ion battery.

Table 1: TS3100-L, TS3100-S and TS3100-X Models

Camera	Max Resolution / Frame Rate	Standard Memory	Optional Memory	Standard Solid-State Drive	Optional Solid-State Drive
TS3-100-L	(Std): 800 x 600 @1250 fps	2GB	4GB / 8GB	None	64GB / 128GB / 256GB
TS3-100-S	(Full): 1280 x 1024 @ 500 fps	2GB	4GB / 8GB	None	64GB / 128GB / 256GB
TS3-100-X	(Full): 1280 x 1024 @ 500 fps	4GB	8GB	64GB	128GB / 256GB

Table 2: Part Number Legend

TS3100XXXxxx	Component	Options	Examples
---	Drive (GB SSD)	--- / 064 / 128 / 256	TS3100LC2 = Std. Resolution, Color, 2GB (no SSD)
---	Memory (GB)	2 / 4 / 8	TS3100SM2 = Full Resolution, Mono, 2GB (no SSD)
---	Sensor (Mono/Color)	S / M	TS3100XM4064 = Full Resolution, Mono, 4GB with 64GB SSD
---	Model	L / S / X	

1-3 TS3 Controls, Indicators, and Connectors

Table 3: Camera Part Locations

Camera Part	Link to View
LED Indicators	Figure 1: TS3 Back View / Figure 2: TS3 Front View
Arm Button	Figure 1: TS3 Back View
Display Button	Figure 1: TS3 Back View
Menu Button	Figure 1: TS3 Back View
D-Pad (Directional Pad)	Figure 1: TS3 Back View
Trigger Button	Figure 3: TS3 Top View
ON/OFF Button	Figure 3: TS3 Top View
Strap Attachments	Figure 3: TS3 Top View / Figure 5: TS3 Bottom View
C-Mount	Figure 2: TS3 Front View
C-Mount Lock Screws	Figure 3: TS3 Top View / Figure 5: TS3 Bottom View
Lens Mount Holes	Figure 3: TS3 Top View
1/4-20 Tripod Mounts	Figure 3: TS3 Top View / Figure 5: TS3 Bottom View
USB Port	Figure 3: TS3 Top View
USB OTG Port	Figure 4: TS3 Side View (Door open)
SD-Card Slot	Figure 4: TS3 Side View (Door open)
Gig-E Connector	Figure 4: TS3 Side View (Door open)
Sync I/O Connector	Figure 4: TS3 Side View (Door open)
HDMI Connector	Figure 4: TS3 Side View (Door open)
Power Connector	Figure 4: TS3 Side View (Door open)
Battery Door	Figure 5: TS3 Bottom View
Battery Door Latch	Figure 5: TS3 Bottom View
Battery Clasp	Figure 5: TS3 Bottom View

Figure 1: TS3 Back View

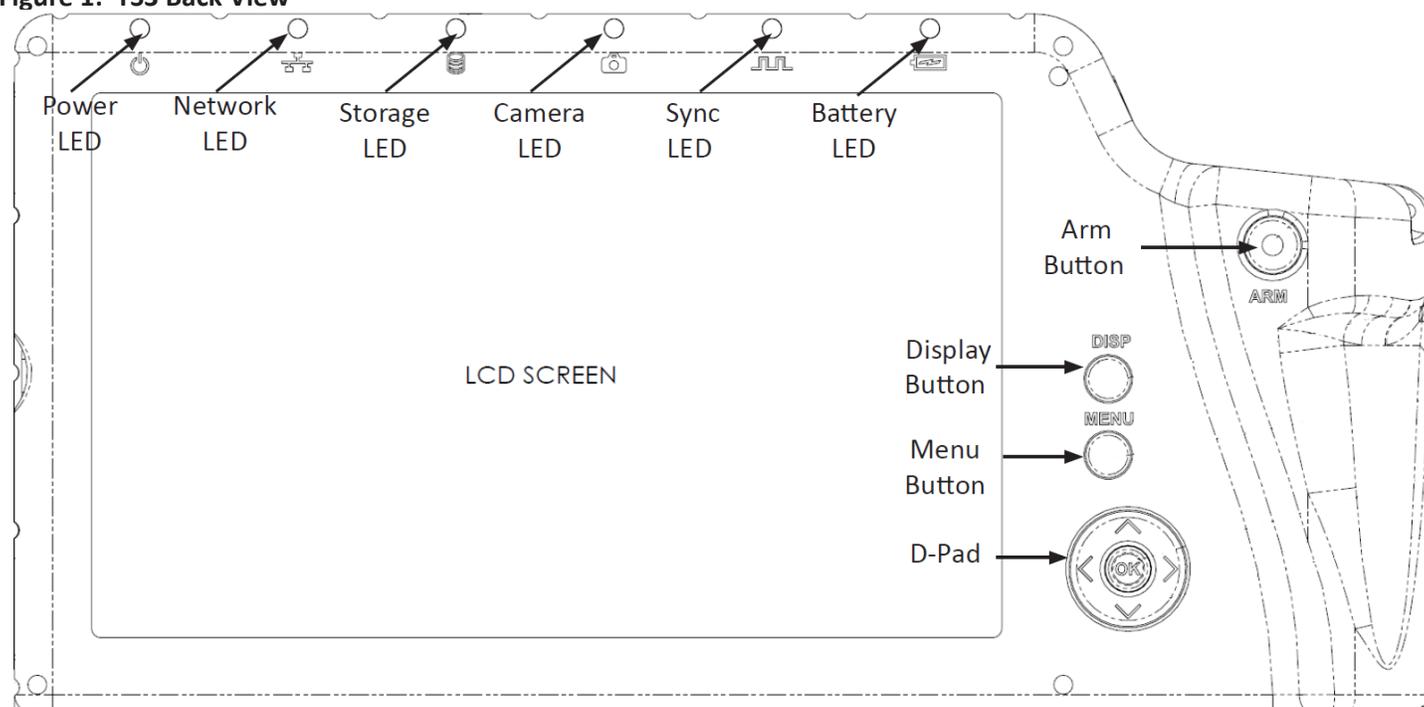


Figure 2: TS3 Front View

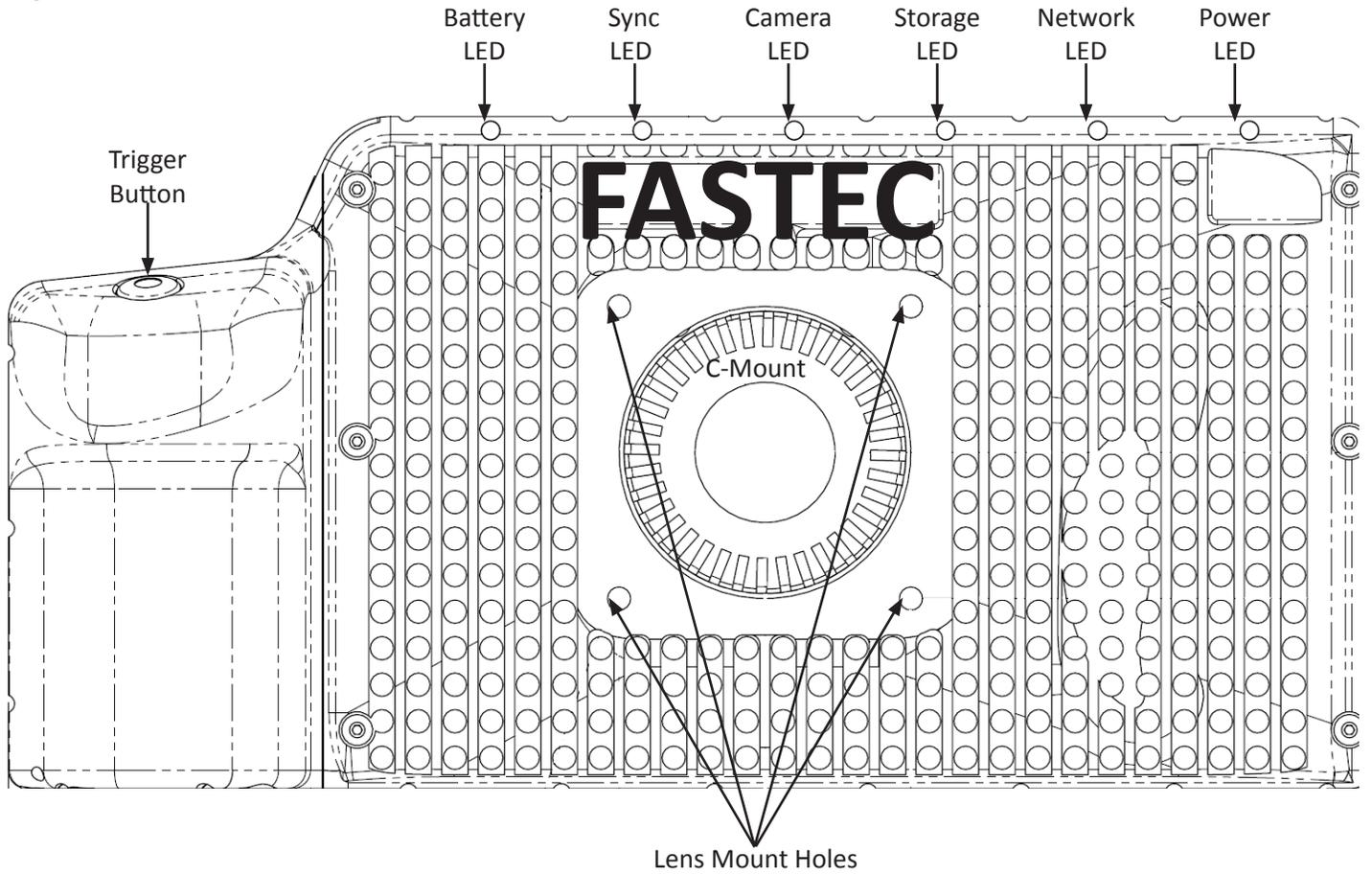


Figure 3: TS3 Top View

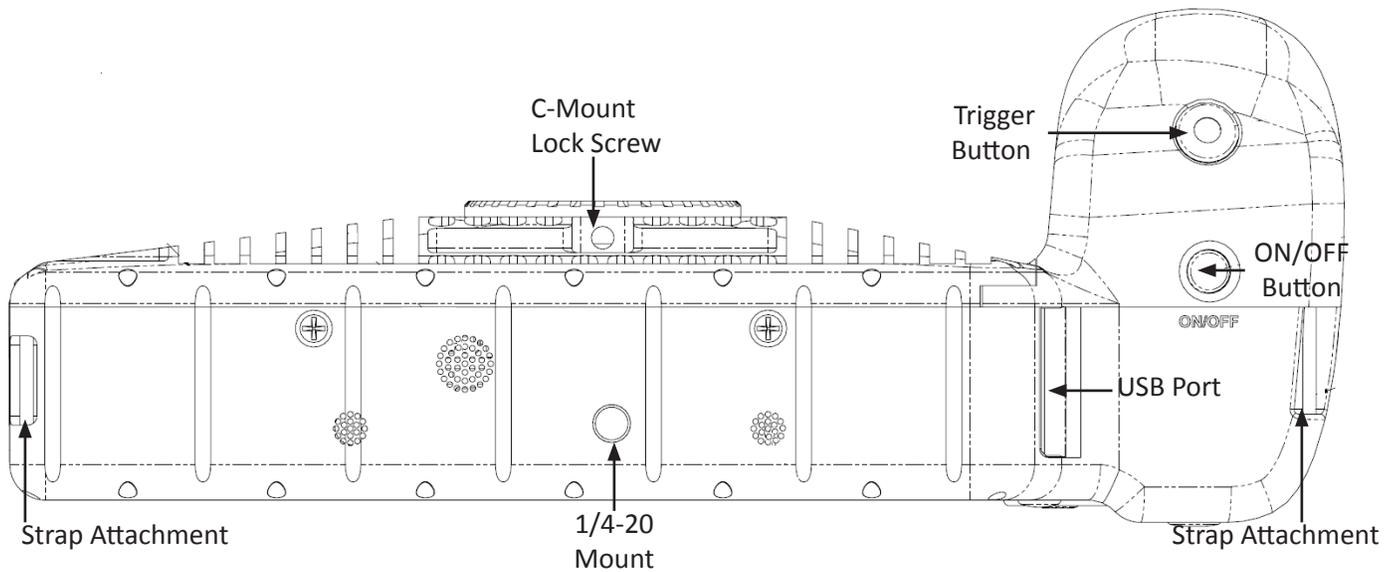


Figure 4: TS3 Side View (Door open)

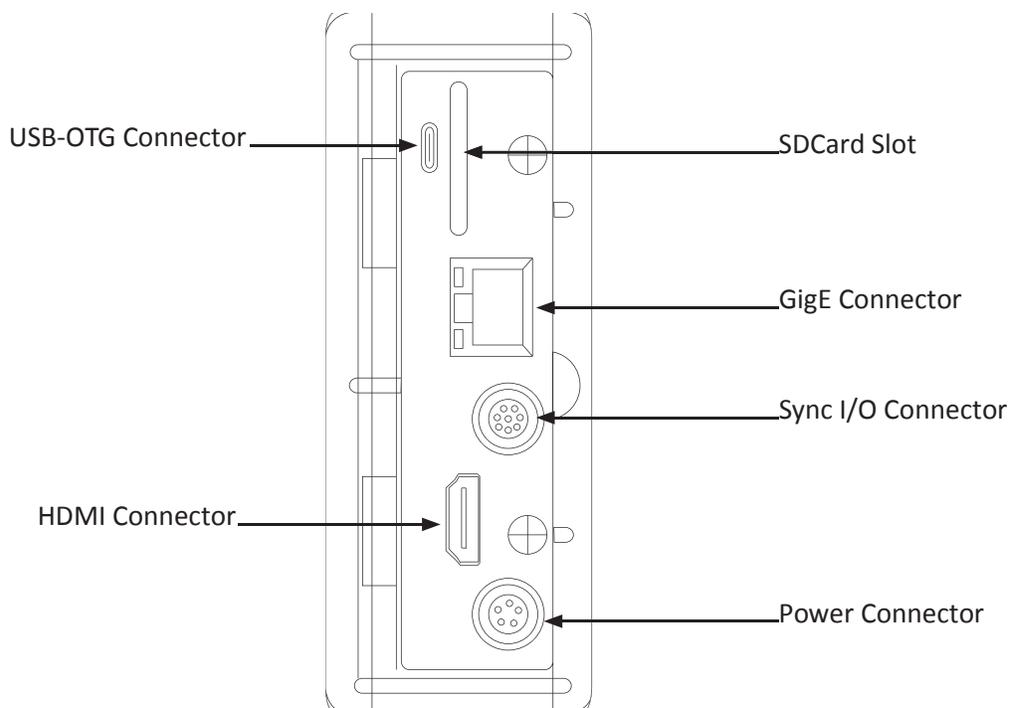
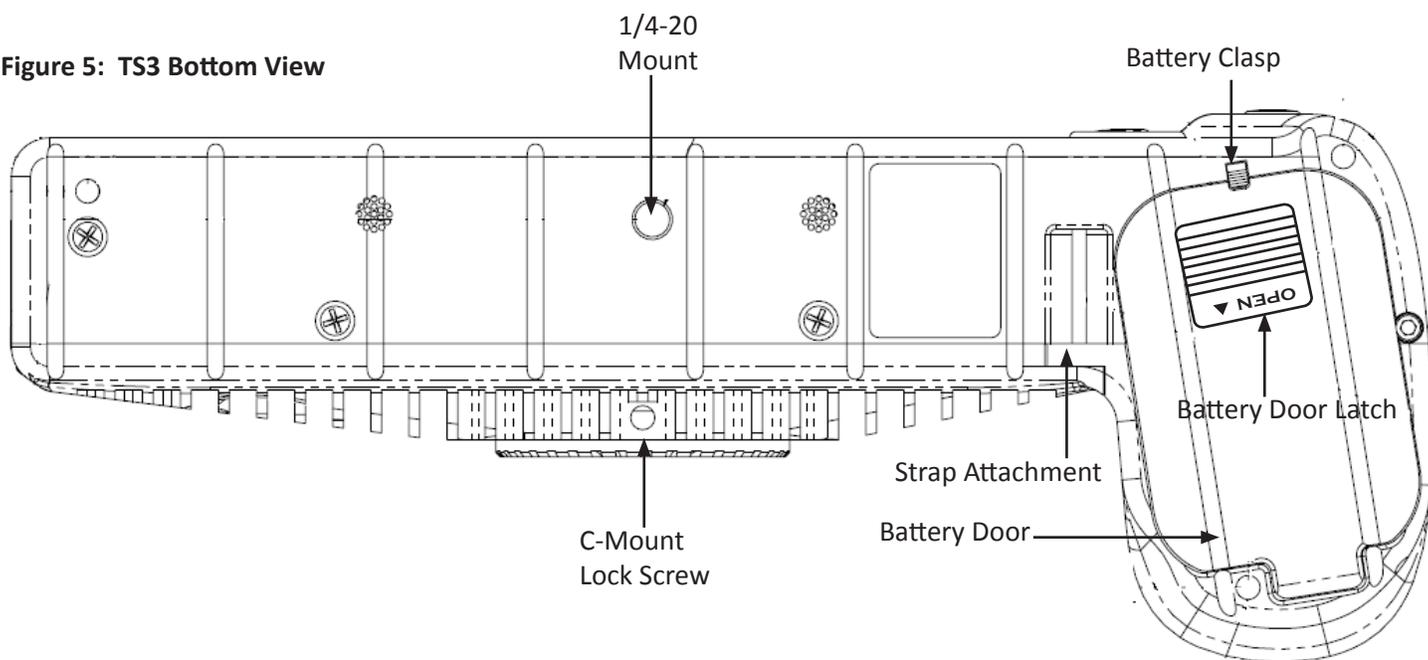


Figure 5: TS3 Bottom View



2 TS3 Getting Started

2-1 Unpacking the Camera

Table 4: Package Contents:

Part	STD	OPT	Part #
TS3 Camera	X		TS3100XXX
C-Mount (factory installed and adjusted on the camera)	X		
F-Mount (factory installed and adjusted on the camera)		X	1105-0200
DC Power Supply-- 110/220VAC, 50/60Hz, 12V @ 4.17A, with IEC 13 socket and 5-pin LEMO connector (no power cord included)	X		1105-0250
8 GB SDHC Card		X	1105-0270
16 GB SDHC Card	X		1105-0271
32 GB SDHC Card		X	1105-0272
I/O Cable--1.3 meter with 8-pin LEMO camera connector and BNC connectors for Sync-In, Sync-Out, and Trigger-In	X		1105-0401
Neck Strap	X		
Documentation and Software (on thumb drive)	X		
Battery--Rechargeable Li-Ion 3.7V 15,600mAh (Battery comes fully charged from factory)	X		1105-0050
Hoodman 7" LCD Display Cover for glare protection		X	1105-0330

Fastec Imaging retails its cameras through independent distributors. Fastec or its distributors can provide the accessory items required for camera operation according to each customer's particular application needs.

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 that there are many C-mount lens formats and focal lengths. For help selecting a lens. (See Table 5: 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** overtighten 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 5: Lens Selection

Resolution	Sensor Diagonal	Required Lens Format to avoid noticeable Vignetting	Field of View From 10M with 50mm Lens
1280 x 1024	22.9mm	1.3"	3.6 x 2.9M
1024 x 1024	17.5mm	1.3"*	2.9 x 2.9M
800 x 600	14mm	1"	2.2 x 1.7M
640 x 480	11.2mm	2/3"	1.8 x 1.3M
256 x 200	4.5mm	1/3"	.72 x .56M

*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.

2-3 Powering Up

The camera can be powered by its rechargeable 3.7V Li-Ion battery or the external 12V power supply. Both are included with the camera. The battery is fully charged at the factory and is shipped outside the camera to avoid accidental discharge. The battery door is located on the underside of the camera.

The Li-Ion battery will power the TS3 for up to several hours depending on configuration and mode of operation.

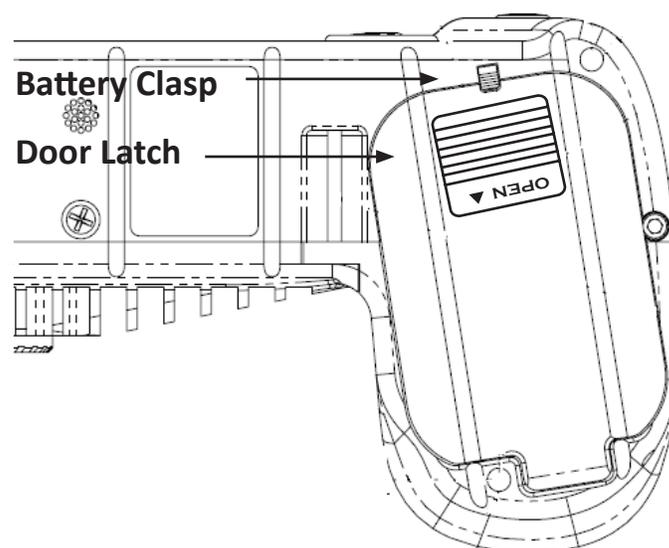
NOTE: When a new battery is installed, it must go through one complete discharge/recharge cycle to calibrate its internal "gas gauge." Until that time you will find that the % of charge shown on the lower right of the camera display as well as on any camera control software will not be correct. (See "Figure 7: Battery Charge Indicator on Status Bar" on page 8.)

Removing the Battery

1. Turn the TS3 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. (See Figure 6: Battery Access Door.)
4. The battery may slide out easily, or you may need to hold the camera upright and shake it to get the internal battery connector to release.

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.
3. Look at the battery and notice the corresponding mating connector.
4. Orient the battery appropriately and slide it into the compartment.

Figure 6: Battery Access Door

5. With the battery seated properly in the compartment, the battery clasp will close, securing it in place.
6. Close the battery access door.
7. Slide the battery door latch closed.
8. The TS3 should now power up. If it does not, please follow the instructions below for connecting the DC power supply and charging the battery.
9. With the TS3 powered up, press the Menu button once to get the menus and status bar to appear on the LCD display.

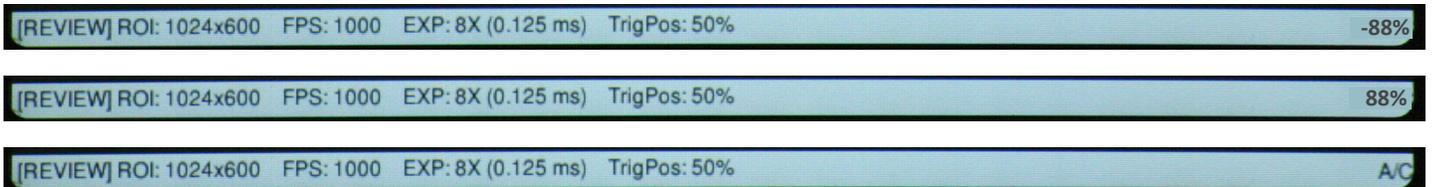
Attaching the External DC Power Supply

The 12V DC Power Supply operates on 100-240VAC, 50-60Hz. The socket is a standard IEC 13, 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.

Note: If the camera was powered down before connecting the power supply, it will now power up. While operating on battery power the Battery Status on the Status bar will show a negative number -88%. (See Figure 7: Battery Charge Indicator on Status Bar.) When connected to a power supply (with the battery installed) the number becomes positive. If no battery is present it changes to A/C>.

Figure 7: Battery Charge Indicator on Status Bar



Charging the Battery

The TS3 battery does *not* charge automatically when the camera is attached to an external power supply while operating. Charging mode is initiated by pressing the ON/OFF button. When the battery is present while the camera is attached to an external power supply, the ON/OFF button will toggle the camera through three states: 1)normal operation; 2)charging (non operational); 3)Off.

Note: Pressing the ON / OFF button toggles the camera between three Modes if both the battery and external power supply are present. It toggles the camera between two Modes: On /OFF if either the battery or the external supply is not present. (See "Table 6: ON / OFF Button" on page 9

Table 6: ON / OFF Button

Battery Present	External Supply	Mode	LEDs	Battery Charge % Indicator
X	X	1. Operating	Power / Camera / Battery (Green, Amber, or Red)	Batt: xx%
X	X	2. Charging	Power / Battery (Green, Amber, or Red)	(LCD off)
X	X	3. Off	None	(LCD off)
	X	1. Operating	Power / Camera / Battery (Blue)	A/C
	X	2. Off	None	(LCD off)
X		1. Operating	Power / Camera / Battery (Green, Amber, or Red)	Batt:-xx%
X		2. Off		(LCD off)

Table 7: Battery LED States

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

Operating / Charging	Charge Status	LED Behavior
Operating	>15%	 Green
Charging	> 15%	 Blinking Green
Operating	< 15% > 5%	 Amber
Charging	<15% >5%	 Blinking Amber
Operating	<5%	 Blinking Red
Charging	<5%	 Blinking Red
Operating	Not Installed	 Blue

2-4 TS3 Memory and Mass Storage Options

The TS3 camera is equipped with from 2GB to 8GB of internal high-speed internal memory that can be partitioned for one or more image sequences. Images stored in this memory may be reviewed on the camera, external monitor via HDMI, or PC, then saved to any of four types of mass storage devices:

1. Solid State Hard drive installed in the TS3 at the factory.
2. SD-Cards (SDHC) inserted by the operator into the SDHC slot on the side of the TS3.
3. USB devices such as thumb drives or USB external hard drives connected via the USB port.
4. Memory devices on a networked PC using Fastec Custom Software (not Web Browser).

TS3 Solid State Hard Drives (Internal SSD)

Solid state hard drives (SSDs) are standard on the TS3 -X series and are available as an option on the L and S series. (See “TS3100-L, TS3100-S and TS3100-X Models” on page 2.) These drives serve as mass storage devices for the camera and are installed in the camera at the factory. Image data from the TS3'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 (the number of images it can record in one session), it does allow the user to download large quantities of image data without ever connecting the TS3 to a PC or other external device.

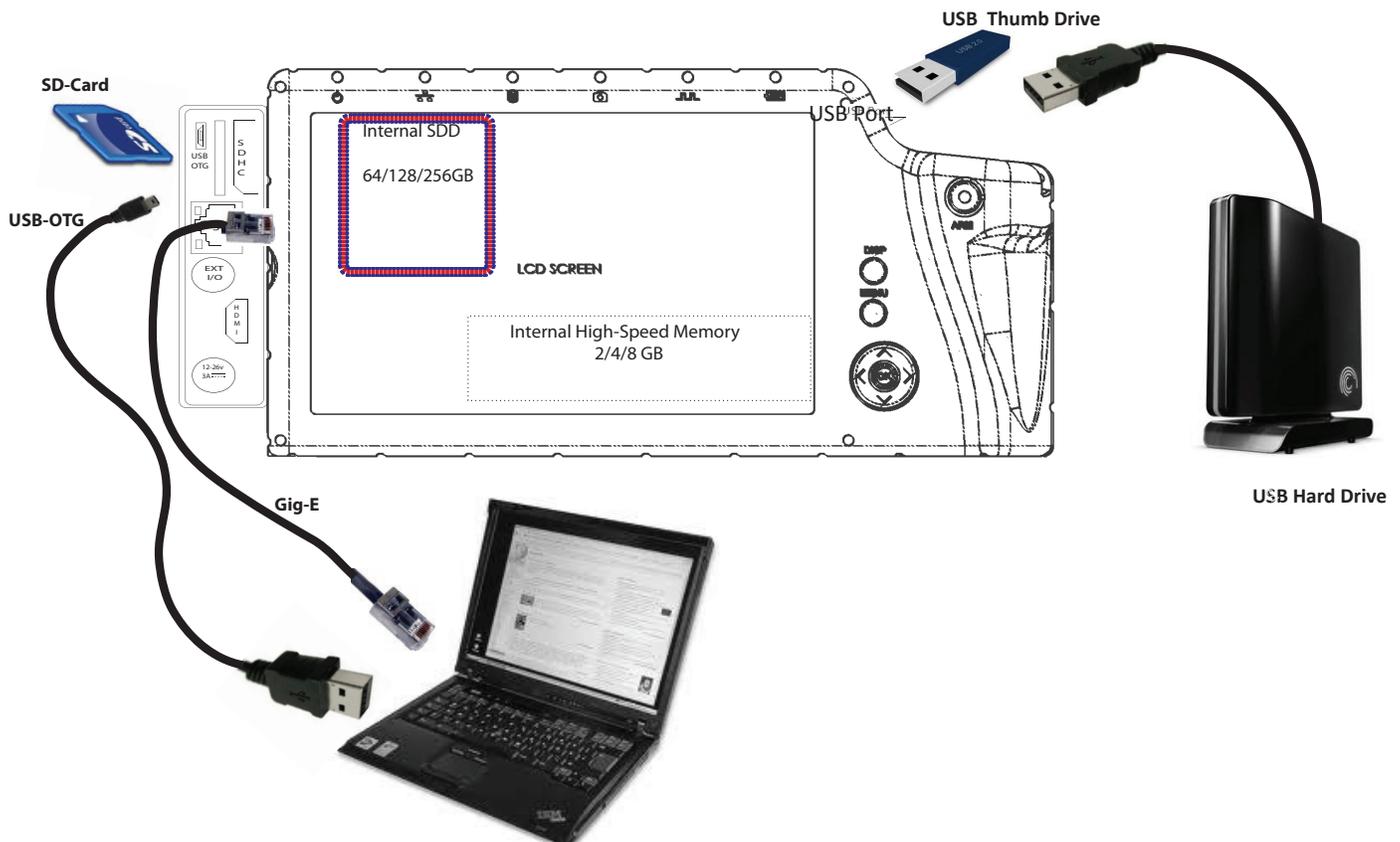
SD-Card

The TS3 is shipped with a 16GB high performance SD-Card. 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 TS3 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.

Figure 8: Mass Storage



USB Port

The TS3 will act as a **Host** to any USB mass storage device connected at the USB port. (See “TS3 Top View” on page 4.) Image data may be saved to these devices.

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 TS3's OTG port, any 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. To use this option:

1. Power up the camera.
2. Install thumb drive and/or SD-Card in the camera.
3. 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 "TS3 Side View (Door open)" on page 5.) As each device is located by the PC an Autoplay window on the PC will open. This is a very simple way to transfer image data to a PC. This is for file access only--there is no way to control the camera via USB-OTG.

When you are finished, you need to eject the media from the PC. Click on the “Safely Remove Hardware and eject Media” icon on your computer's task bar and select “Eject Fastec Camera.”

Note: Any device that is connected to the camera *after* the camera and PC are connected will not be seen by the PC.

Figure 9: USB-OTG on the TS3

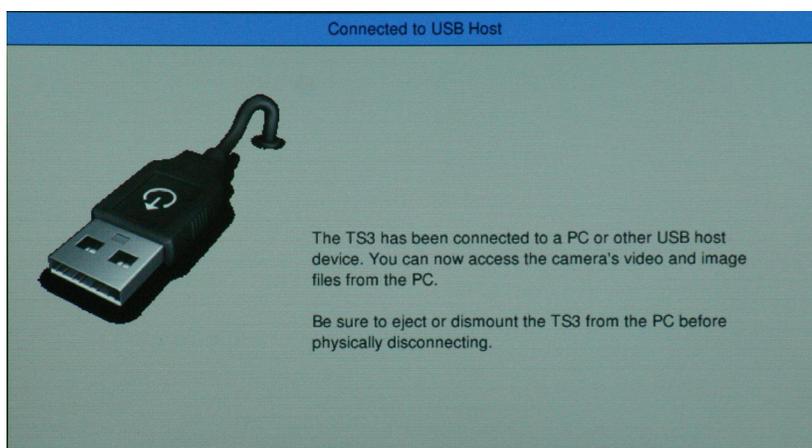


Table 8: TS3 Mass Storage Functionality

	Target Drive(s)	Functions
TS3 Utilities:		
System/Storage/Explore	SDD/USB/SDHC	Move, Copy, and Delete Image files
System/Storage/Format	SDD/USB/SDHC	Format drive
System/Storage/Eject	USB/SDHC	Safely Eject Media
Review/Save	SDD/USB/SDHC	Save image Data from Internal High-Speed Memory
Record Still	SDD/USB/SDHC	Save a single still Image
Autosave	SDD/USB/SDHC	Autoave image Data from Internal High-Speed Memory
PC via Gig-E Connection:		
Explore	SDD/USB/SDHC	Open, Copy files, multiple files, directories From TS3 to PC only
Web Application	SDD/USB/SDHC	Open, Copy files (one at a time) from TS3 to PC only
Custom Software App	PC Drives+SDD/USB/SDHC	All TS3 Utilities
PC via USB-OTG:	SDD/USB/SDHC	Move, Copy and Delete all files and directories to and from TS3

3 TS3 Camera Setup

3-1 Camera Display and Menu Navigation Buttons

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 "TS3 Back View" on page 3.)

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

Pressing the **Display (DISP) Button** toggles the LCD between three modes: 1) Display off; 2) Display on; and 3) Display on with Histogram.

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.)

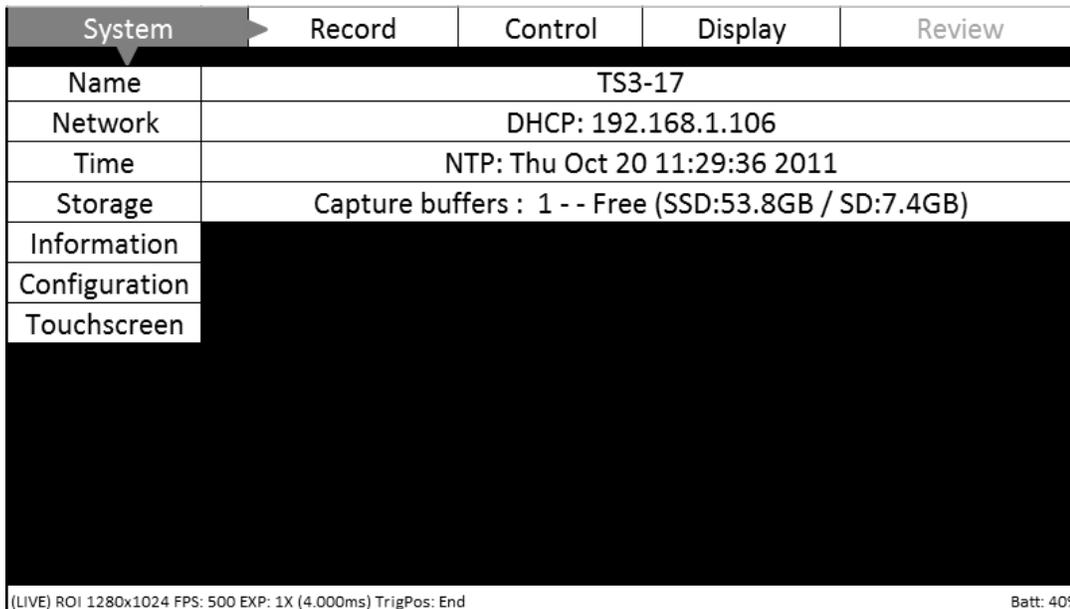
The **D-Pad** is used to move within menus and dialogs. It has an "OK" button in its center for selecting menu items and options.

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 9: Menu Terminology

Menu Bar	Across the top of the display: System, Record, Control, Display, Review
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 are 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. (See "Frame Rate and Resolution Menu" on page 21.) 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): Operating Mode (Live= live view, CAP= recording, REVIEW= playback); ROI= Resolution; FPS= Frame rate; EXP= Exposure; Trigger Position; and Power /Batter Status (A/C= no battery, xx% = battery charge)

Figure 10: System Menu



3-2 Using the Touchscreen

The TS3 7" display uses touchscreen technology that allows the user to enter certain data directly with the touch of a finger rather than via the D-Pad. While most of the menu system is not accessible through the touchscreen at the time of this writing, you will find that it has been implemented in some of the most entry-intensive portions of the user interface.

The touchscreen is implemented for:

- The alphanumeric keyboard. (See "Figure 21: Alphanumeric Dialog Box" on page 18.)
- The playback controls. (See "Figure 40: Playback Buttons" on page 32.)
- The advanced Resolution and Frame Rate controls. (See Figure 25 on page 21.)

Figure 11: Touchscreen Menu

of



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."

Calibration

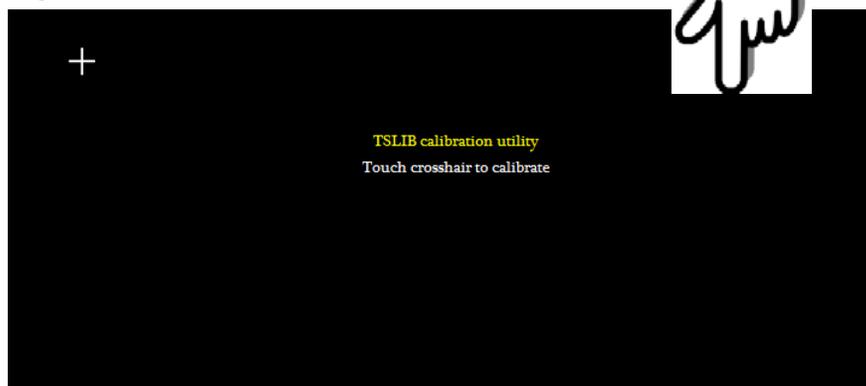
The touchscreen is calibrated at the factory. Routine calibration of the touchscreen is not necessary. Calibration of the touch screen may be done if you feel that the screen is sensing your touches inaccurately. For example if you use the alpha-numeric keyboard and you are not always getting the intended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

To calibrate the Touchscreen:

Calibration of the touchscreen is very 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 12: Touchscreen Calibration, will appear and prompt you to touch a cross hair at each corner of the screen, then in the center.

Figure 12: Touchscreen Calibration



(Look for the touch icon on touch-enabled menus in this manual.)

3-3 Controlling the Displays

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

- LCD Dimmer
- Backlight control
- HDMI

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

- Off--the display will not “time out.”
- 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.

The Backlight control is a brightness adjustment for the LCD. There are two controls for this in the Backlight menu: Less and More.

There is a third element in the menu, which is a number between 0 and 255, that represents the current Backlight brightness.

- Navigate to the Less button and hold down the OK button to make the display darker.
- Navigate to the More button and hold down the OK button to make the display brighter.

The Brightness, Contrast, Gamma, and Bit Depth (if present) elements do *not* control the LCD display. These are part of the image processing pipeline . (See “Image Pipeline” on page 34.)

HDMI Display

While the 7” WVGA 800 x 480 display on the TS3 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 TS3 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 TS3 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. (Any resolution not supported by a display attached to the TS3 will be Grayed out and the button not selectable.)

Figure 13: Display Controls

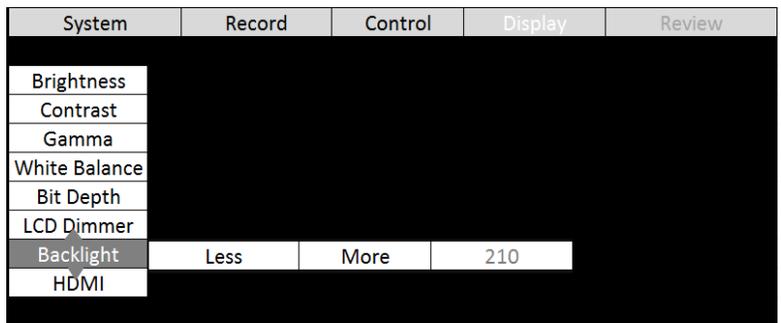
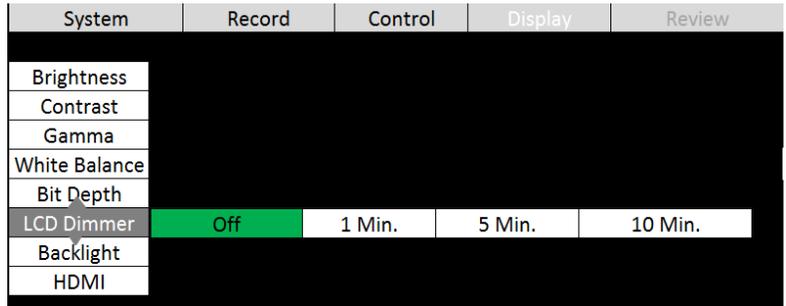
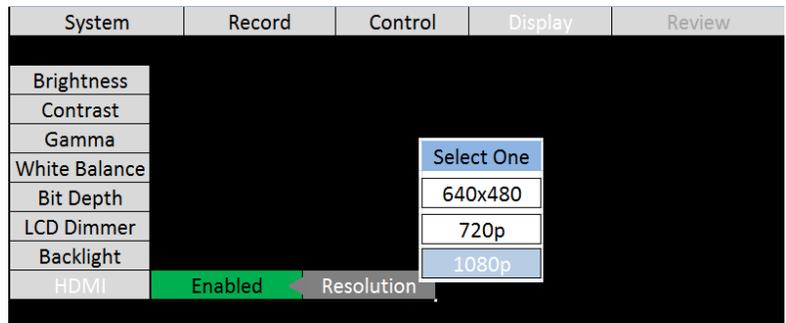


Figure 14: HDMI Controls



3-4 Connecting to a PC via Ethernet

The TS3 may be connected to a PC using the USB-OTG connection, (see 2-4 TS3 Memory and Mass Storage Options) or via the Gig-E port. While the **USB-OTG** connection is extremely useful for file transfers, an Ethernet connection has two major advantages:

1. It can be used to control the camera via the built-in Web Application or a Custom Application.
2. The camera and PC need not to be physically close to each other as with the USB-OTG connection, which is dependent on cables that are limited in length (generally less than 4.5m).

Benefits of TS3 Ethernet connectivity:

1. Once connected to a network, the TS3 may be accessed for file transfer and camera operation (including live views, recording, reviewing, etc.) by any PC on the network. Multiple cameras may be accessed and controlled on a network.
2. 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 TS3'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 or 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.

Autoconfiguration

If the TS3 is configured for DHCP and it does not find a server, it will autoconfigure itself with an IP address 169.254.xx.xx.

Most PCs will do the same. So, most of the time, if the TS3 is configured for DHCP and you connect it to a PC that is also configured for DHCP, they will automatically connect without any further configuration.

Figure 15: TS3 to PC Connections

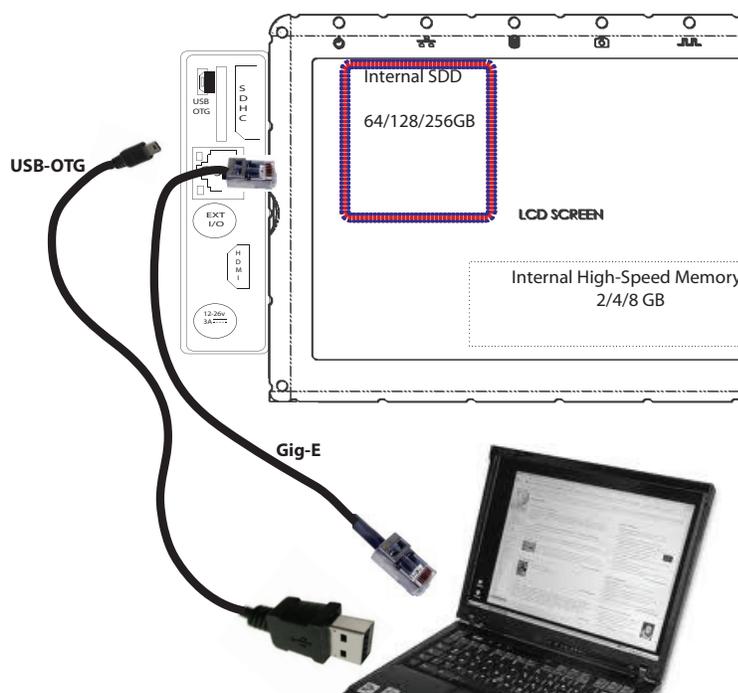


Figure 16: Network Menu

System	Record	Control	Display	Review
Name				
Network	Static...	DHCP		
Time				
Storage				
Information				
Configuration				
Touchscreen				

Table 10: Network LEDs

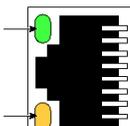
LEDs on RJ-45 Connector	Camera Networking LED
	
Green (Connection)	Amber (activity)
1 Blink = 10Mb	Blinks for all network activity
2 Blinks = 100Mb	
3 Blinks = 1Gb	
	Amber (activity)
	Blinks for camera network activity only

Figure 17: Static IP Dialog Box

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.

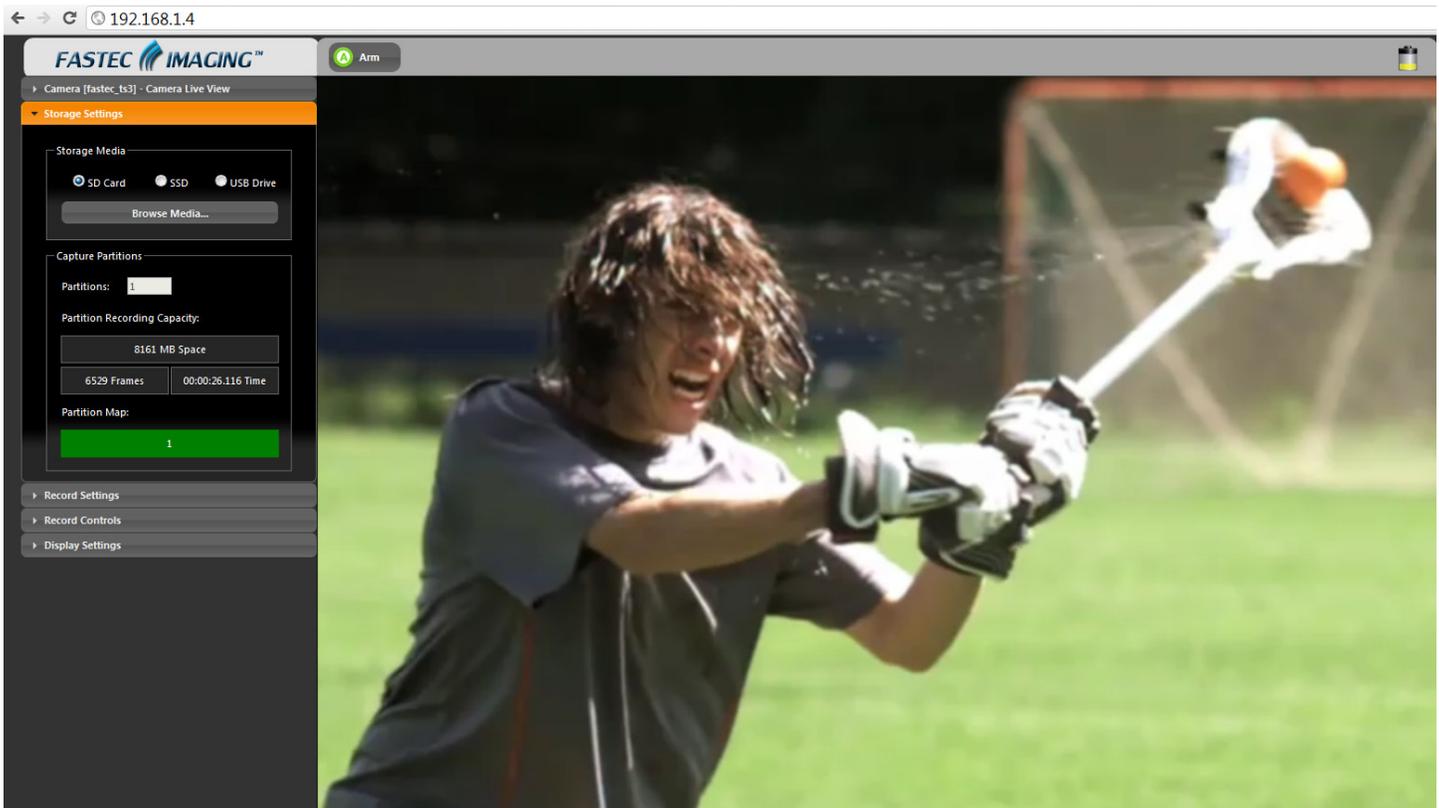
Static IP Address	
Address	0.0.0.0
Net Mask	0.0.0.0
Gateway	0.0.0.0
<input type="button" value="OK"/> <input type="button" value="Cancel"/>	

3-5 Using the TS3 with a PC

To open the Networked TS3 in a Web browser to use the **TS3 Web App**:

1. Open a web browser on the PC. Of the available web browsers, Google Chrome has the best performance when using the Web App.
2. Type the camera's IP address or camera name into the browser's Location bar. For example, using the information from Figure 18: Web Browser Screen, you would type 192.254.66.106 into the browser's Location bar.
3. 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 Chapter 5 of this manual.

Figure 18: Web Browser Screen

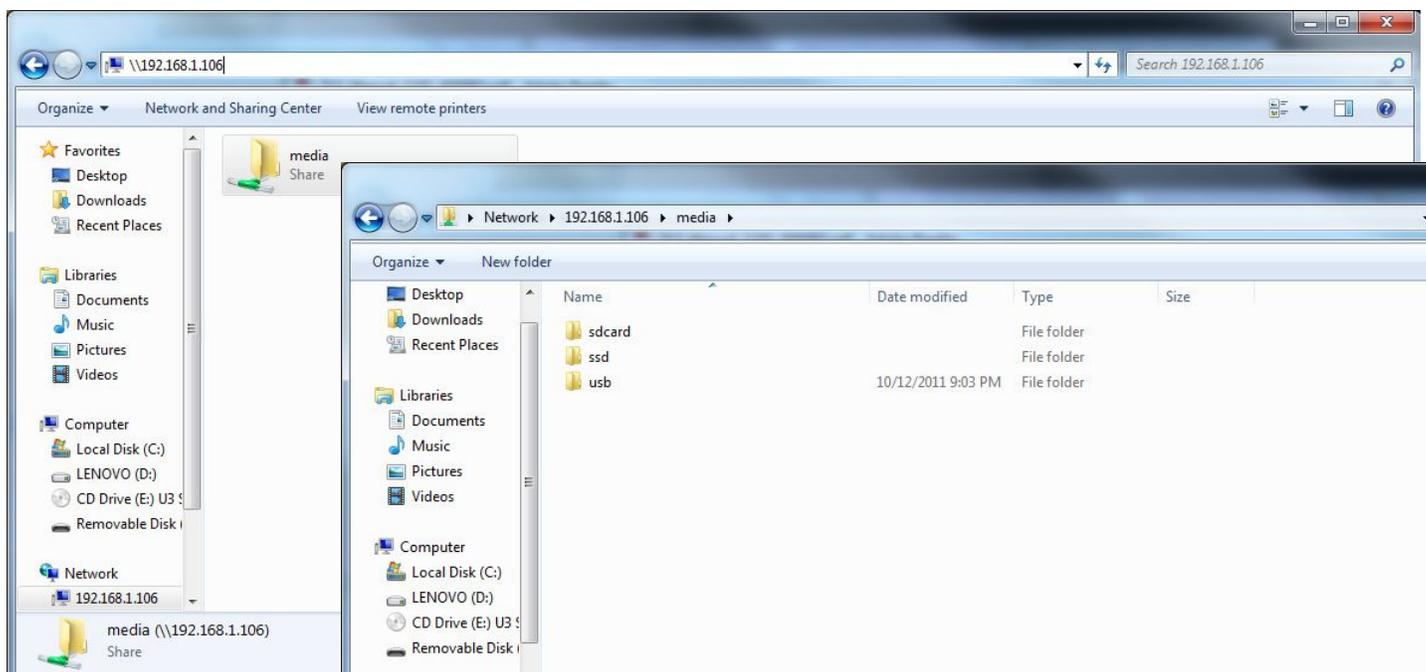


To open the Networked TS3 in a Windows Explorer menu:

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 \\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 8: TS3 Mass Storage Functionality” on page 11.)

Figure 19: TS3 in Windows Explorer



3-6 TS3 Name the Camera

Camera Name

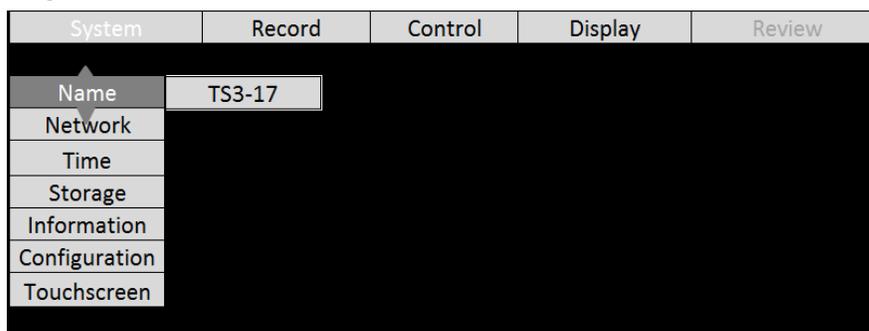
When the TS3 leaves the factory its default name is TS3-xxx. For example, looking at Figure 20: Camera Name Menu the camera used for the screen shot was TS3-17. The camera name can be used both for identification on a network and as part of the filename when saving images.

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:

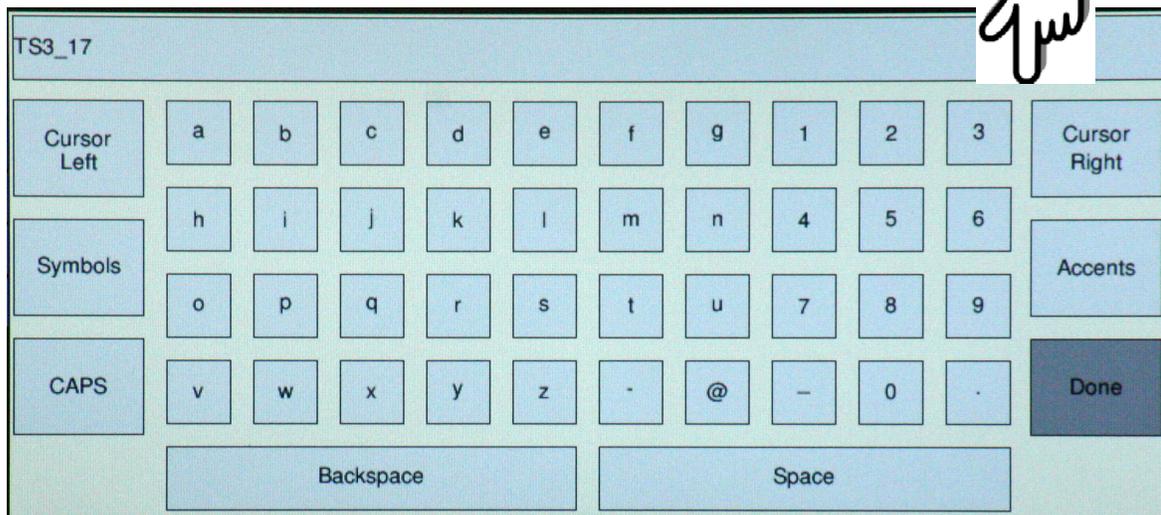
1. Navigate to the System Menu.
2. Select “Name.”
3. Move the cursor to the box showing the current name and click “OK” to open the alpha-numeric dialog where you will enter the new camera name. If enabled, you can do this using the Touchscreen. If not you will use the D-Pad.
4. Delete the present camera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

Figure 20: Camera Name Menu



Caution: There are many symbols available on the keypad that are not valid for camera naming. If you enter symbols that are not usable, those characters and any subsequent characters will be stripped from the camera name as soon as you navigate away from the Name Menu.

Figure 21: Alphanumeric Dialog Box



3-7 Setting the Time

Time Setup on the TS3 is located 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 TS3 will now connect to the NTP server and sync its clock. If the camera cannot connect with the server, it will pause 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 TS3 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 22: Time Format Menu

3-8 Storage Setup

The Storage Menu gives the user some amount of access and control of the Camera memory and any external memory installed i.e. USB thumb drive or SD-Card.

The TS3 has 2GB, 4GB, or 8GB (depending on model and option) of internal high-speed memory used for capturing high-speed imagery. All of this memory may be used to capture one high-speed event, or it may be partitioned to capture multiple events. Total record time will depend on resolution, frame rate, and bit depth.

To **Partition** the TS3 internal memory:

1. Navigate to the System Menu.
2. Select Storage.
3. Select Partition.

A dialog box will open that will allow you to select more or fewer partitions. It also calculates the partition size and the recording time and number of frames that will be captured using the current camera settings.

Explore allows you to access the SSD (Solid State Drive installed internally to the TS3), 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. 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). This does not show all of what may be on the mass storage device. You will see only the image data stored there by the TS3.
5. Select the still, stack, or video you wish to manage. A File Action dialog will open that will allow you to Copy or Move the selection to another storage device on the system, or delete the selection.

Eject, also on the **Storage Menu**, should be used whenever you wish to remove media from the TS3.

The **Format** function on the Storage Menu should be used with some caution as formatting any media will remove any data on it.

Figure 23: Partition Setup Menu



3-9 Configuration and Camera Information

TS3 Configurations, which include all Network, Time, and all camera settings, can be Saved, Reloaded, or Reset to factory defaults.

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)
4. Select Reset to load the factory default configuration.

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.

4 Recording with the TS3

4-1 Setting Frame Rate and Resolution

Frame rate and resolution are set together as they are interactive. The maximum frame rate of the camera is based on its resolution as seen in Table 11: Frame Rates and Resolutions, below.

Table 11: Frame Rates and Resolutions

Frame Rates	60	125	250	500	1000	1250	2000	4000
Resolutions								
1280 x 1024	X	X	X	X				
1024 x 1024	X	X	X	X				
1280 x 720	X	X	X	X				
1024 x 600	X	X	X	X	X			
800 x 600	X	X	X	X	X	X		
800 x 480	X	X	X	X	X	X		
640 x 480	X	X	X	X	X	X		
1280 x 256	X	X	X	X	X	X	X	
512 x 512	X	X	X	X	X	X	X	
320 x 240	X	X	X	X	X	X	X	X
320 x 200	X	X	X	X	X	X	X	X
200 x 200	X	X	X	X	X	X	X	X

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 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 don't 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 in order to increase the record time.

Note: The display resolution of the TS3 LCD is 800 x 480. Imagery taken at that resolution will look the best on the display.

To set the **Frame Rate and Resolution** of the TS3:

1. Navigate to the Record Menu / Settings
2. Select either Resolution or Frame Rate. The Dialog box is interactive as the choices for Frame Rate will change with the selection of Resolution and visa-versa. The "Basic" Frame Rate and Resolution dialog box will open.
3. Autoselecting Speed or ROI will simply select the highest Speed for the Resolution chosen, or the highest Resolution (ROI = Region of Interest = Resolution) for the Speed Chosen.
4. Select Advanced to open the Advanced Record Settings. This dialog box makes use of the Touchscreen if it is enabled. (See "3-2 Using the Touchscreen" on page 13.)
5. Here the Auto ROI and Auto Rate settings work the same as in the "Basic" menu, but the resolutions can be refined to any even-numbered pair from 24 x 12 to 1280 x 1024.

Figure 24: Frame Rate and Resolution Menu

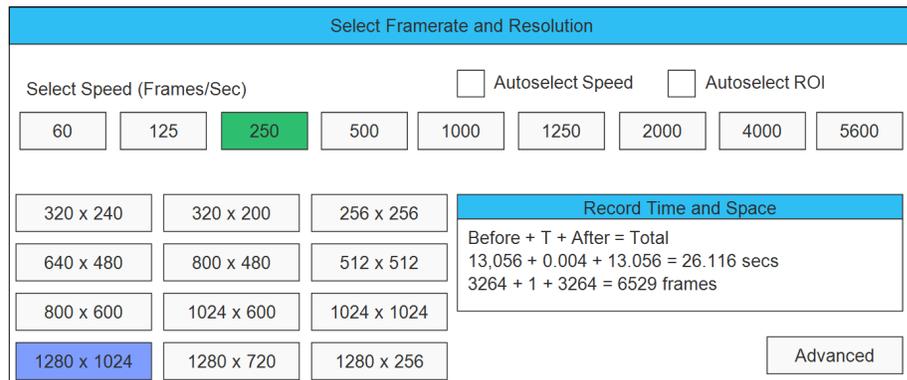
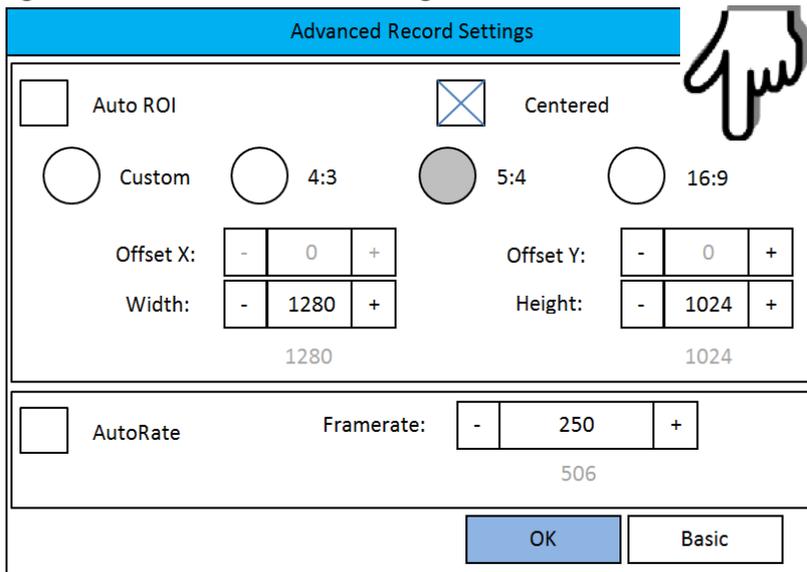


Figure 25: Advanced Record Settings



Note: The gray numbers beneath the Width, Height, and Framerate windows show maximum values associated with present Resolution or Framerate settings.

6. Choose from the four aspect ratio choices: Custom, 4:3, 5:4, 16:9. With the Custom choice the width and height are independent. If any of the others are chosen, the width or height will adjust automatically to maintain 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. In this case you would make sure that the "Center" check box is checked.

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

Lets say, for example, that you have captured images at 1024 x 1024 @ 500fps and are now interested at capturing a 512 x 512 portion of the scene, lets 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 740 and 512.

4-2 Setting Shutter Speed

Choosing the right shutter speed is dependant not only on the speed at which an object is travelling through the FOV, it is also dependant on how the imagery is going to be used.

For motion analysis it is best to get as short an exposure as possible in order 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.

In the TS3, exposure times are expressed as 1X, 2X, 4X, 8X, and MAX. These are defined as:

$$1/(\text{FrameRate} * nX)$$

For 500FPS for example: $1/(500\text{FPS} * 1X) = 2\text{ms}$; $1/(500\text{FPS} * 2X) = 1\text{ms}$; $1/(500\text{FPS} * 4X) = 0.5\text{ms}$, etc. MAX (shortest) exposure time is .002ms (20µs).

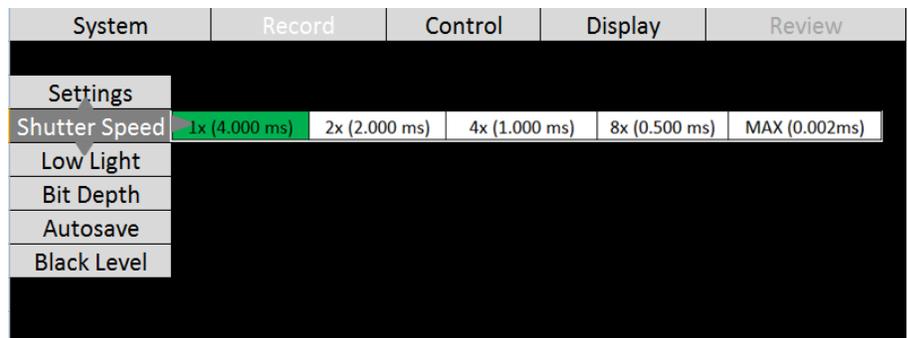
Table 12: Frame Rates and Shutter Speeds

Frame Rates / Shutter Speeds	60 FPS	125 FPS	250 FPS	500 FPS	1000 FPS	1250 FPS	2000 FPS	4000 FPS
1X	16.667ms	8.0ms	4.0ms	2.0ms	1.0ms	.80ms	.50ms	.25ms
2X	8.333ms	4.0ms	2.0ms	1.0ms	.50ms	.40ms	.250ms	.125ms
4X	4.167ms	2.0ms	1.0ms	.50ms	.250ms	.20ms	.125ms	.062ms
8X	2.083ms	1.0ms	.50ms	.250ms	.125ms	.10ms	.062ms	.031ms
MAX	.002ms	.002ms	.002ms	.002ms	.002ms	.002ms	.002ms	.002ms

Figure 26: Shutter Speed Menu

Setting the Shutter Speed:

1. Navigate to Record Menu.
2. Select Shutter Speed.
3. Select 1X, 2X, 4X, 8X, or MAX.
Press the Menu Button a few times until the Menus are cleared from the LCD screen.



Assuming you have installed a lens (See "2-2 Installing the Lens" on page 6), you should now see a live

image. You may need to adjust the lens F-stop or the lighting. Press the Display Button once to view a histogram to confirm that the image you see is not clipped (too dark or over-saturated.)

Note: The camera is capable of setting shutter speeds in increments of one microsecond, but not from the on-camera menus. For finer control of shutter speed, use the Web-Application. (See "6-4 Record Settings" on page 46.)

4-3 Low Light Mode

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

Often the light available for setting up the TS3 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.

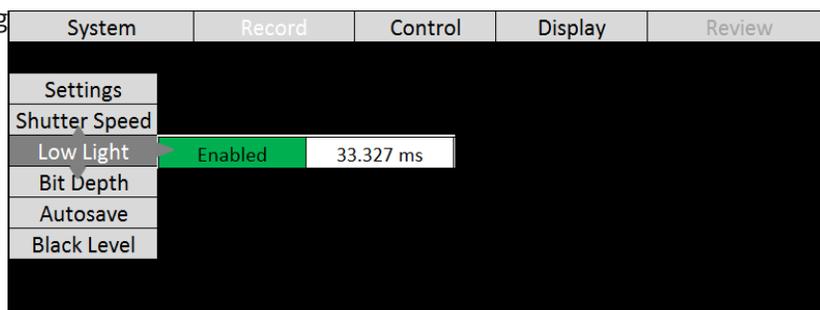
The default shutter speed for Low Light mode is 33.327ms, which is the “1X” shutter speed for 30 FPS. The shutter speed for Low Light may be adjusted via the Web-App or custom camera software, but not via the on-camera interface.

To enter Low Light Mode:

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

1. Set the Shutter Speed just as you need it for the high speed event (as described in 4-2 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 (33.327 ms by default). When you click on the “Disabled” button, it will turn green and change to “Enabled.” You will notice immediately that the Live image is much brighter.
 4. Press the Arm Button.
- The camera will begin recording. You will notice that the image is darker now than in Live Mode.
5. Press Arm again to quit recording. (Click “OK” on the Warning message to Cancel.)

Figure 27: Low Light Menu



4-4 Setting 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. So, 256 (red) x 256 (green) x 256 (blue) equals more than 16 million colors!

The TS3 sensor outputs 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 ... over a billion colors!

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.

Because we will be accessing the imagery on devices such as computers and LCD screens like the one on the TS3, 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. **Mid 8-bit** (dropping the least significant bit and the most significant bit, saving the Mid-order bits):

~~1~~11111111~~1~~

In this case the mapping looks like this:

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

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

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

3. **Low 8-bit** order bits (dropping the two most significant bits and saving the lower 8):

~~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.

Figure 28: High...Mid...and Low-8 Bits of the same Image



The TS3 can record and save 10-bit or 8-bit data. The advantage of recording 10-bit data is that it gives more flexibility in post-processing the imagery. The disadvantage is that it takes more memory to record or save 10-bit data. When recording, you will get about 25% fewer files, and 25% less recording time.

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

To choose the recording bit depth:

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.

If Bit Depth is set to 10 in the Record Menu, a bit depth selection will appear in the The Display Menu. The choices here are 8-low, 8-mid, and 8-high. This selects the 8-bits used for the display and for saving to media.

4-5 Configuring the Trigger

Capturing a high-speed event can be a tricky proposition. Often high speed events that we are interested in happen without warning. Other times high speed events are tightly controlled. The TS3 is designed to handle myriad scenarios. Here are several examples:

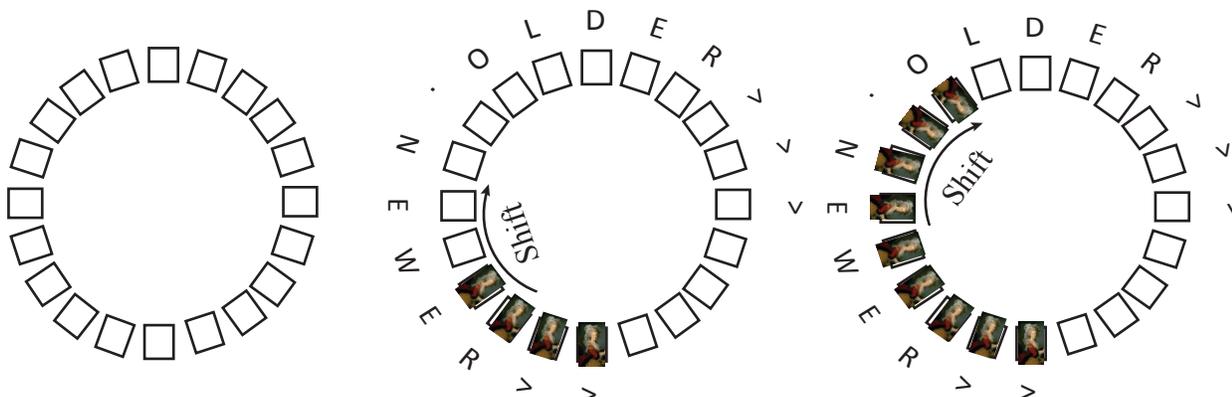
Example 1: Someone is blowing up a balloon until it pops. You want to image the balloon pop. You have a partition of memory with one second of record time. It is very difficult to estimate within a second when that balloon is going to pop!

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 image. 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 event to help understand the cause, as well as the time just after the event to understand how the equipment reacted to the jam.

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

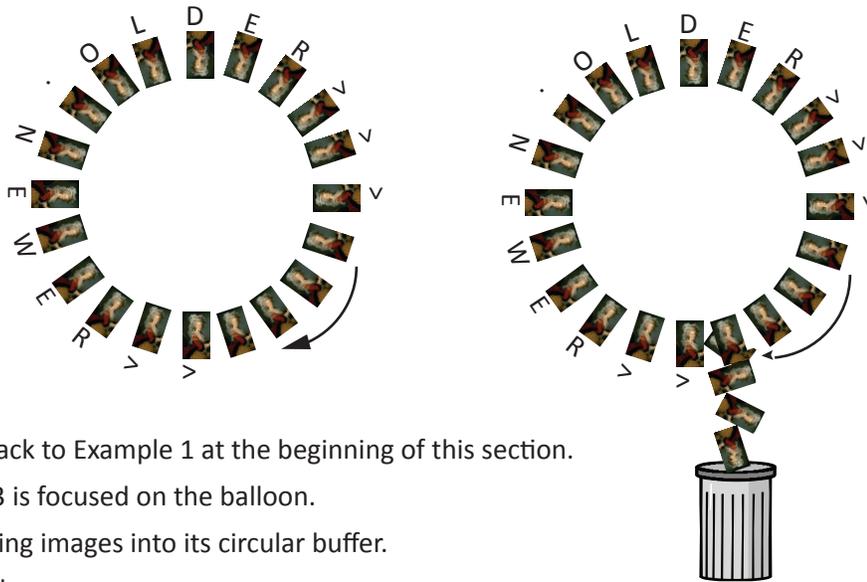
In order to capture events like the ones in the examples above, the TS3 uses a circular image buffer that is able to capture high speed imagery indefinitely, though it may only be able to retain a few seconds at a time. The figure below is a representation of a circular buffer. First the empty buffer is seen with 20 empty slots for images. The second graphic shows the first four frames. With each frame added, the older images are shifted up, the newest ones added at the bottom.

Figure 29: 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 30: Circular Buffer Overflowing



Referring back to Example 1 at the beginning of this section.

- The TS3 is focused on the balloon.
- It is taking images into its circular buffer.
- The balloon pops.

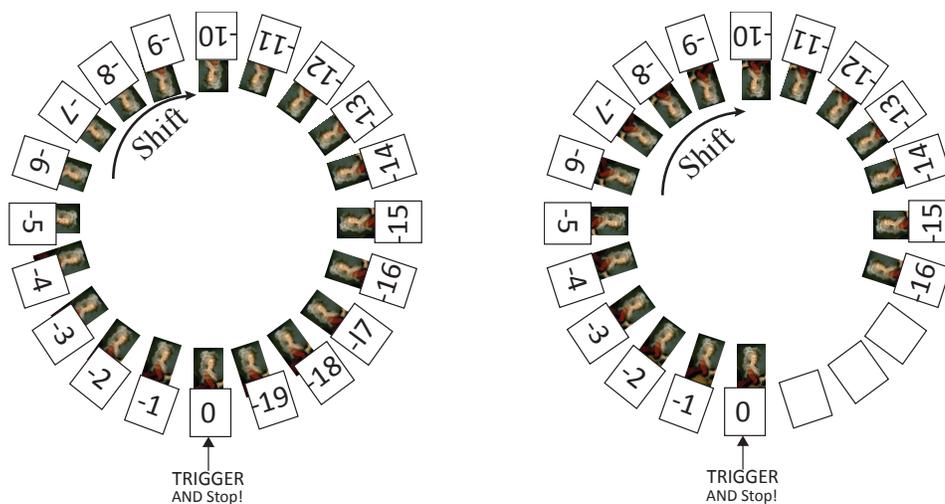
The camera has captured the event, now you just need to make the camera stop before the images are discarded. For this we use an **End Trigger**.

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 (usually very 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 TS3, 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 31: Circular Buffer End Trigger



Referring back to Example 2 in the beginning of this section:

- The TS3 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.

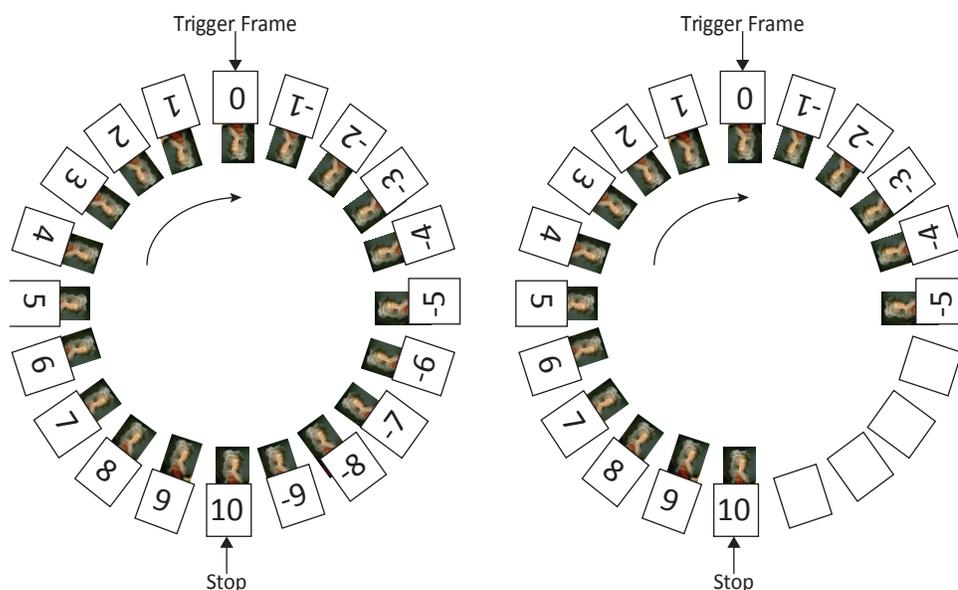
In this case, the camera needs to record the seconds before and after the problem is detected. The TS3 has the perfect trigger setting for this. The 50% Trigger divides the image capture into two halves, the images just before the trigger is received (**pre-trigger frames**), and the images immediately after the trigger is received (**post-trigger frames**).

Using the **50% Trigger** the TS3 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 TS3 is triggered, it keeps recording until it has captured the 1/2 the buffer's worth of post-trigger frames. The buffer now has a number of 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 32: Circular Buffer with 50% Trigger



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

- The TS3 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 TS3 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 TS3 has a **Start Trigger**. Using the Start Trigger, when the TS3 gets a trigger it will record Frame 0, then fill the buffer with post-trigger frames. When played back the video will begin with Frame 0, then proceed with all positive frame numbers.

10% and 90% Triggers

More likely than using the Start Trigger for this application, however, is to use a 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.

There is also a 90% trigger that captures 90% pre-trigger and 10% post trigger frames.

To Set the **Trigger Position** in the TS3:

1. Navigate to the Control Menu.
2. Select **Trigger Position**.
3. Select Start, 10%, 50%, 90% or End.

Note: When controlling the camera via Web-Application or custom software, it is possible to position the trigger in 1% or even 1-frame increments.

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 the text will 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 34: External Trigger.

Please refer to “Appendix D: Power and I/O Connections” on page 58 for connection information and warnings.

Figure 33: Trigger Position

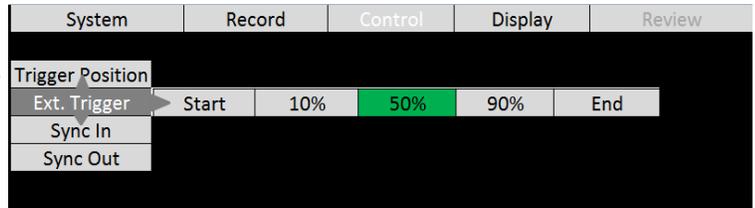
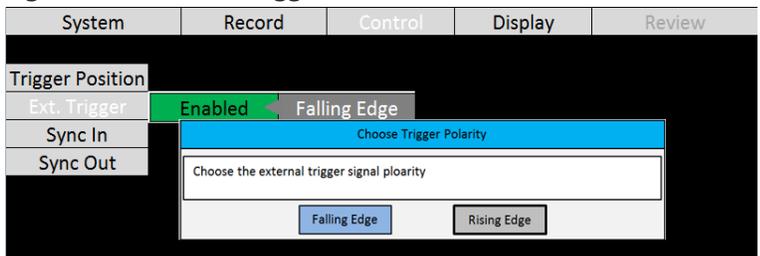


Figure 34: External Trigger



4-6 Black Level Calibration

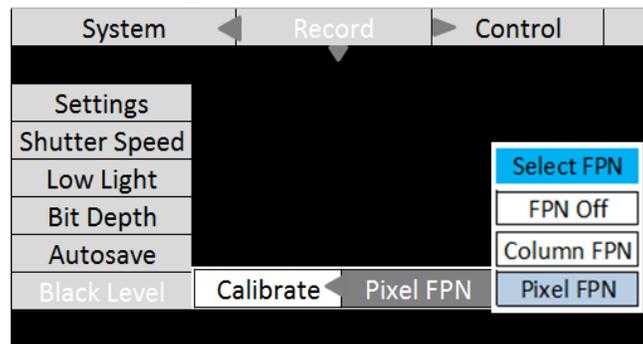
Calibrate Black Level:

- When you first boot the camera up.
- Occasionally as the camera warms up.
- If you change Shutter Speed, Frame Rate, Resolution, or Offset.
- If the image seems noisy.

To Calibrate the Camera

1. Navigate to Record/Black Level
2. Shut out all light to the sensor: close the f-stop down all the way and put a lens cap on it or cover it securely.
3. Click on "Calibrate." 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, if Pixel FPN is on, the live image with the lens cap in place should be black.
4. Next to the Calibrate button, you will see an FPN selection button that will say FPN Off, Column FPN, or Pixel FPN. Click on that button and select the FPN setting you wish to use, based on the following:

Figure 35: Black Level Calibration and Settings



Pixel FPN is a per-pixel image correction that is done in the TS3's image processor engine. It provides the cleanest images available. This is the setting that is most highly recommended, especially if the images will be downloaded or viewed on large, high-contrast displays.

Column FPN is an image correction done on the TS3's sensor. It does not do as good a job cleaning up the images as Pixel FPN. The one advantage of Column FPN is that it reduces image contouring when viewing images on the TS3's LCD display. The contouring is reduced because of the extra bit of noise in the column-corrected images.

FPN Off means that there is no noise correction being used. Calibration should still be done, even if you wish to turn the noise correction off, because, in addition to collecting a dark-field image for per-pixel correction, it sets the black level of the camera at a point where you are assured that the image will not be clipped on the dark end.

4-7 Record: Arm and Trigger

Lights Camera Action!

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

Take a Still.

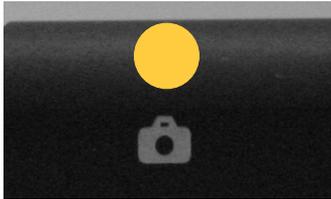
Still Image. It is optional, but recommended, to take a reference still of the scene:

1. With the TS3 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.)

To begin Recording, Press the **Arm Button**.

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 Amber. It will record for an indefinite period of time until it gets a Trigger. (See "4-5 Configuring the Trigger" on page 25.)

Figure 36: Camera LED



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 TS3 LCD display. (See Figure 37: Progress: Armed TS3.) 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.

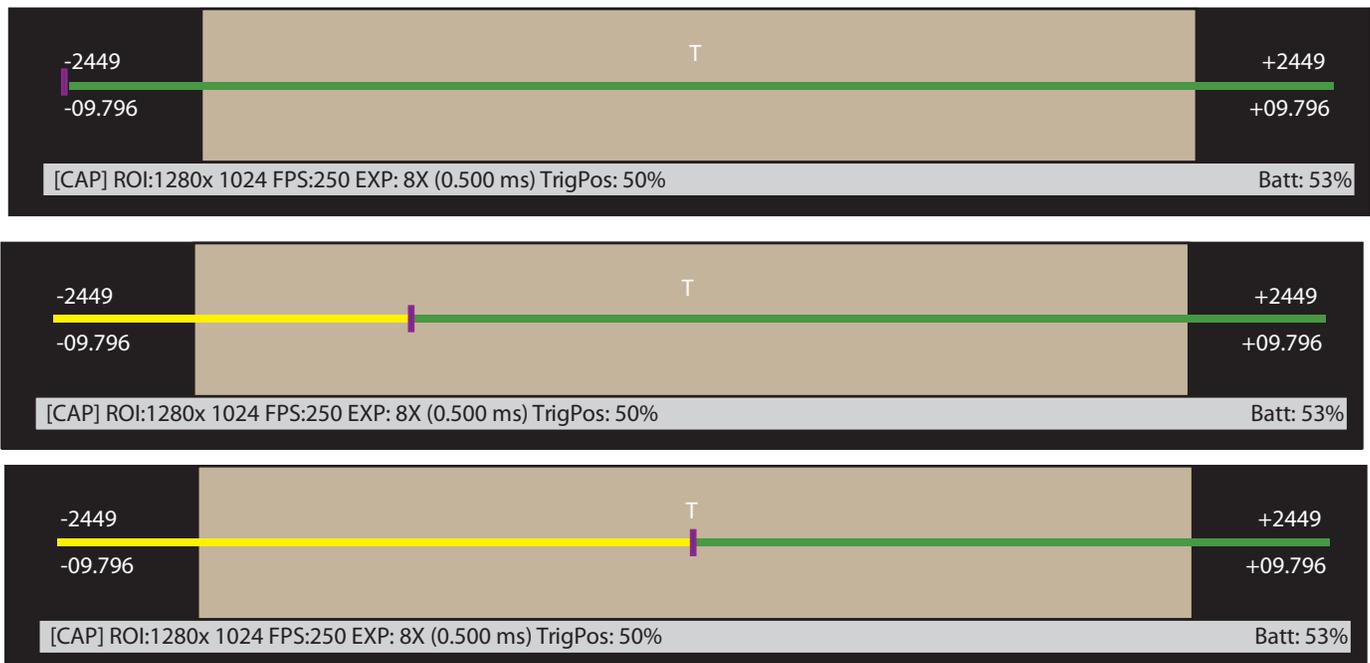
In the first image, the recording has just been started (the Arm Button has just been pushed). The green progress line spans the whole distance between the left edge and the trigger point.

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

Note: If the TS3 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 "4-5 Configuring the Trigger" on page 25.)

In the third image, all of the pre-trigger frames have been recorded. The TS3 is continuing to record new frames as it discards the oldest. It can remain in this state indefinitely waiting for a Trigger.

Figure 37: Progress: Armed TS3

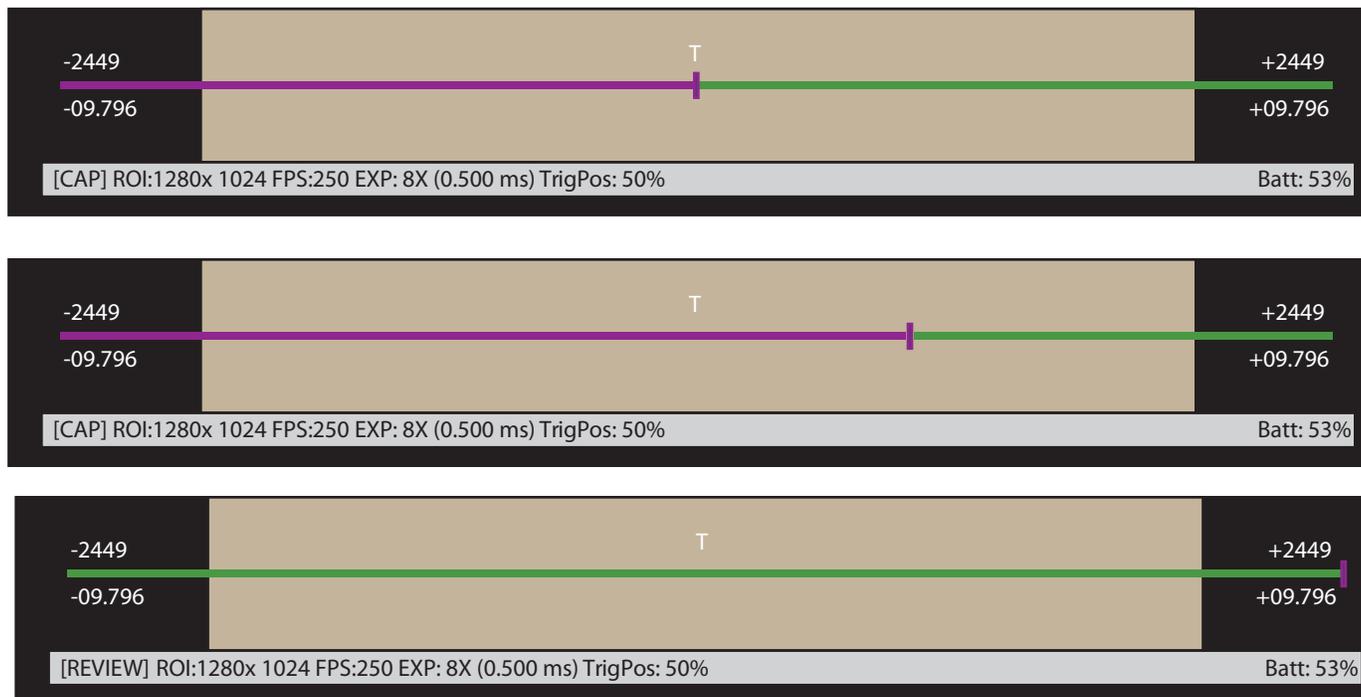


Trigger

Press the Trigger button, (see “TS3 Top View” on page 4) or send an electrical trigger signal (see Appendix D: Power and I/O Connections).

When triggered, the TS3 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. When the recording is complete, the progress bar will turn solid green.

Figure 38: Recording Progress: Triggered TS3



The TS3 will now either enter Review Mode or, if **Autosave** has been enabled, the camera will save the images to a mass storage device and go back to Armed Mode, capturing pre-trigger frames and watching for a Trigger.

4-8 Autosave

The TS3 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 TS3 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 using an SDHC, many events may be captured.

Advantages of using Autosave:

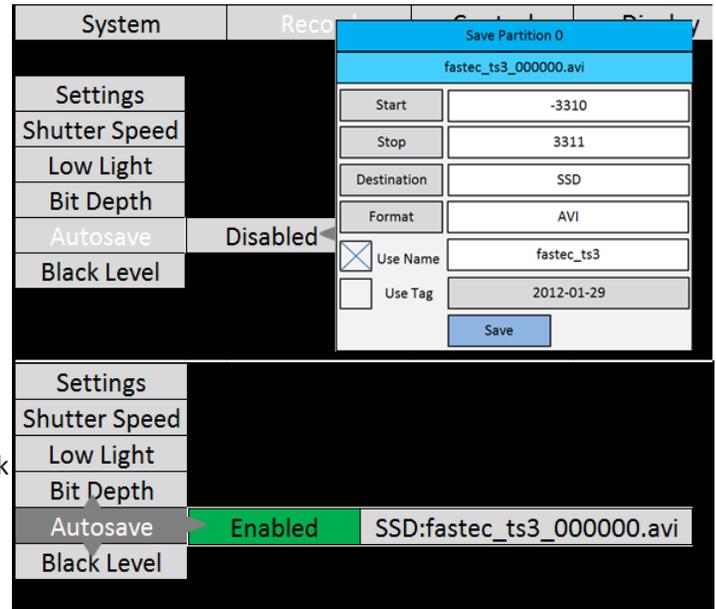
- Autosave is the only choice for **multiple unattended events**. For remote locations or locations where networking is not possible, or for long shifts where there may be multiple events of interest that need to be captured without human intervention.
- Autosave is also useful for **production environments** 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 back to Record mode in time to capture the planned event.

To set up **Autosave**:

1. Navigate to the **Record Menu**
2. Select Autosave.
3. Select Disabled. 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 "4-11 Saving Images to Mass Storage" on page 35.)
4. When finished setting up the Autosave settings, click on the Save button. When you navigate back to the System menu the "Disabled" button will have turned green and say "Enabled." The next button over will reflect the target file name.

Figure 39: Autosave Dialog



4-9 Reviewing Captured Imagery: Playback

Once the recording is complete, if Autosave is not enabled, the TS3 will open the recording in Review Mode. There are three things to do in Review:

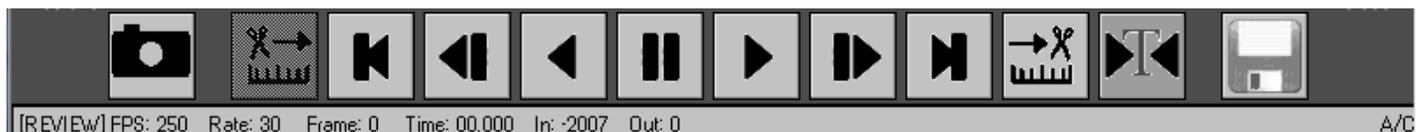
1. **Play** the video--play it forward, backward, frame by frame, adjust the cut-in and cut-out points (find the interesting portion of the clip), etc.
2. **Adjust** the image brightness, contrast, gamma, bit depth, color, etc. (See "4-10 Image Processing" on page 34.)
3. **Save** video to a mass storage device. (See "4-11 Saving Images to Mass Storage" on page 35.)

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.



Figure 40: Playback Buttons



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 TS3 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 are not accessible.
2. Use the Playback Buttons 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.

Table 14: Playback Control

The playback buttons may be used with the touchscreen, if enabled (see “3-2 Using the Touchscreen” on page 13) or the D-Pad.

	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, then move cursor.
	Go to beginning of clip--goes to Cut-In point.
	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.
	Creates new Cut-Out point at current frame. To remove Cut-Out point, click again, then move cursor.
	Jump to Trigger frame.
	Open Save Partition dialog box to save clip. (Uses current Cut-In/Out points for Start and Stop frames.)

Table 15: Payback Rates

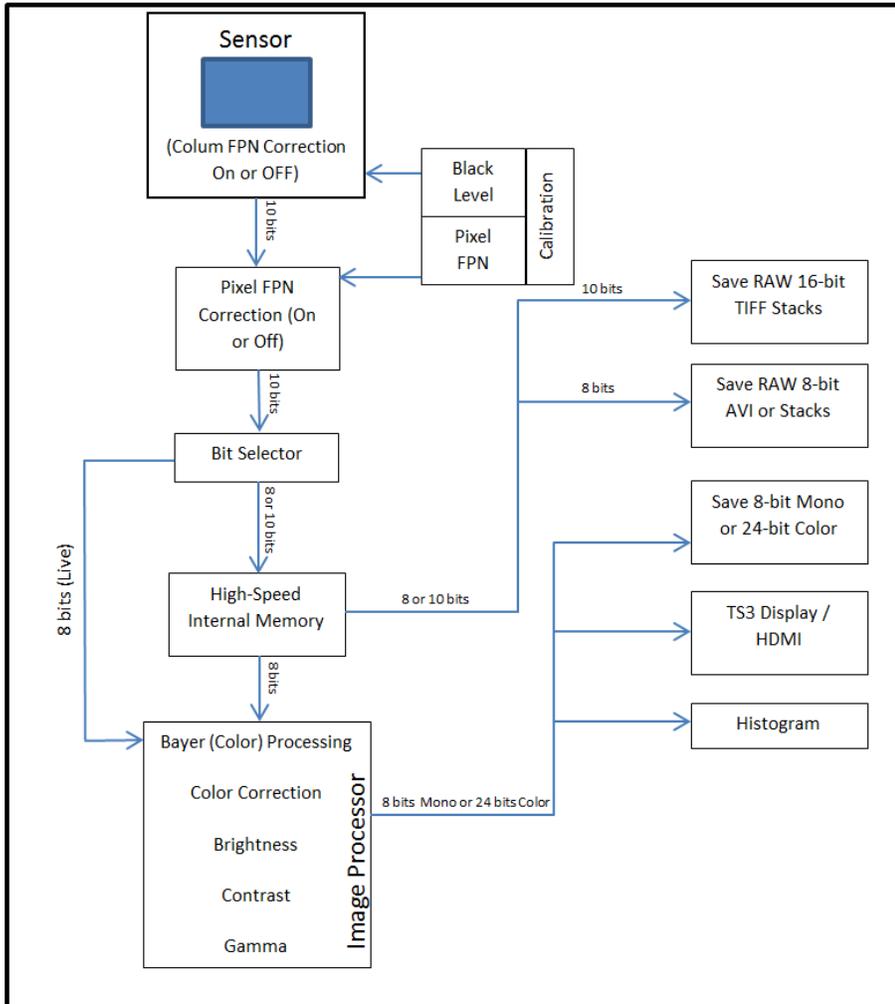
Record Rate (FPS)	60	125	250	500	1000	2000	4000
Playback Rates	5	5	5	5	5	5	5
	10	10	10	10	10	10	10
	15	15	15	15	15	15	15
	30	30	30	30	30	30	30
	60	60	60	60	60	60	60
		120	120	120	120	120	120
		125	125	250	500	1000	2000
				250	500	1000	2000

4-10 Image Processing

Image Processing Pipeline.

The TS3 image processing begins in the LUPA1300-2 sensor, where on-chip FPN corrections occur (if enabled) and the Black level is set using data collected during calibration. Pixel data, also collected during calibration is used for Pixel FPN correction (if enabled). (See “4-6 Black Level Calibration” on page 29.) The TS3 does more image processing, some of which can be controlled by the operator. To better understand how this works, please refer to Figure 41: Image Pipeline.

Figure 41: Image Pipeline



The 10-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 “4-4 Setting Bit Depth” on page 23.)

The path for all live images and the input to the histogram is: Sensor, to Bit Selector, to Image Processor, to Display / Histogram. It is always 8-bit.

The path for all RAW images is: Sensor, to Bit Selector, to Internal High-Speed Memory, to Save. It *never* goes through image processing.

- Images in the internal high-speed memory have *never* gone through the image processor. This means that, except for choosing 10-bit or 8-bit recording, the image processing settings have NO effect on the images captured in high-speed memory.

- Live images seen on the display ALWAYS go through the image processor.

User Control of Image Processor

- Bayer (Color) processing (color cameras only) is always done in order to display a live color image. The user may elect to save images that have not gone through Bayer colorization by choosing to download any of the RAW formats. (See 4-11 Saving Images to Mass Storage.)
- Color Correction is controlled via “White Balance” in the Display menu. You may choose from several color temperatures: Daylight (5500K), Tungsten (3400K), and Fluorescent (4100K) and Normal setting 1:1:1 (all channels at nominal gain).
- Brightness and Contrast are also controlled via the Display menu: users choose from five levels from -2 to +2, with 0 the default.
- Gamma: users choose from 0.2, 0.5, 1.0, 1.5 and 2, with 1.0 the default. Gamma is a non-linear control, often used to enhance a portion of the histogram more than another. Gamma controls are often used to brighten up darker portions of an image (using numbers <1.)

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.
5. If you have recorded 10-bit images, a menu item for Bit Depth will also be present in the Display Menu. If 8-bit images have been recorded, the bit selection has already been made, so this menu does not appear.

Figure 42: Image Processing Options

System	Record	Control	Display	Review
Brightness		0		
Contrast		0		
Gamma		1		
White Balance		Fluorescent (4100K)		

Note: There is no 10-bit option in Bit Depth in the Display menu. Making a selection from this menu only affects the Displayed image and any (non RAW)8-bit images saved to a mass storage device. It does not affect the 10-bit images recorded in the TS3's high-speed internal memory, or any RAW 16-bit TIFFS that are saved.

4-11 Saving Images to Mass Storage

Image sequences are saved either as AVI videos, in which one file contains all the frames of the sequence, or TIFF, JPEG, or BMP stacks, which are collections of files, one file per frame of imagery. The file save options change depending on whether or 8-bit or 10-bit image data has been written to internal high-speed memory:

Table 13: Image File Save Options

10-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)
BMP (8-bit M /24-bit C)	BMP (8-bit M/ 24-bit C) or RAW BMP (8-bit)
AVI (8-bit M /24-bit C)	AVI (8-bit M / 24-bit C) or RAW AVI (8-bit)
JPEG (8-bit M /24-bit C)	JPEG (8-bit M / 24-bit C)

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

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

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 actually 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 very 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 TS3:

1. Navigate to the Review Menu
2. Select Save. The Save dialog box will appear as in Figure 43: Save Dialog Boxes. The Start and Stop frames for the Save may be edited.

Figure 43: Save Dialog Boxes

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 38: Recording Progress: Triggered TS3.)

3. Selecting “Destination” will open a dialog box for selecting the mass storage device to save to.
4. Select “Format” to select the file type. Once you select a file type from the list, the OK button will turn blue. Press the left arrow to enable a RAW format, if available, depending on the bit-depth recorded. (See Table 13: Image File Save Options.)
5. The default file name format for the image stacks is Frame_000000.<TYPE>. If you would like the name to include the camera name, Select Use Name in the dialog. The resulting file name format for the example would become TS3-11_000000.<TYPE>.
6. 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 file name becomes 2011-10-11_000000.<TYPE>.
7. Both the Name and the Tag may be used, in which case the file name becomes TS3-11_2011-10-11_000000.<TYPE> in the example.
8. If AVI files are saved, the default file name is ts3_000000.AVI. The Use Name and Use Tag options are also valid for AVI files, in which case the resulting file names are TS3-11_000000.AVI, or 2011-10-11_000000.AVI, etc. If the file size exceeds the 4GB limit for 32bit file systems, the TS3 will make a second file for the remainder of the imagery. (MiDAS and other players will play the video as one.)

When the TS3 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 G: Contents of `Frame.txt` file.)
- `<filename>.cfg` files. This is a binary file used for MiDAS player so that it can properly play the image files as a movie.

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

5 Synchronizing Cameras

Note: Please refer to “Appendix D: Power and I/O Connections” on page 58 for electrical specifications. Do not experiment with these connections if you are unsure of compatibility with your source as they are very sensitive to over voltage and can be easily damaged.

5-1 Sync In

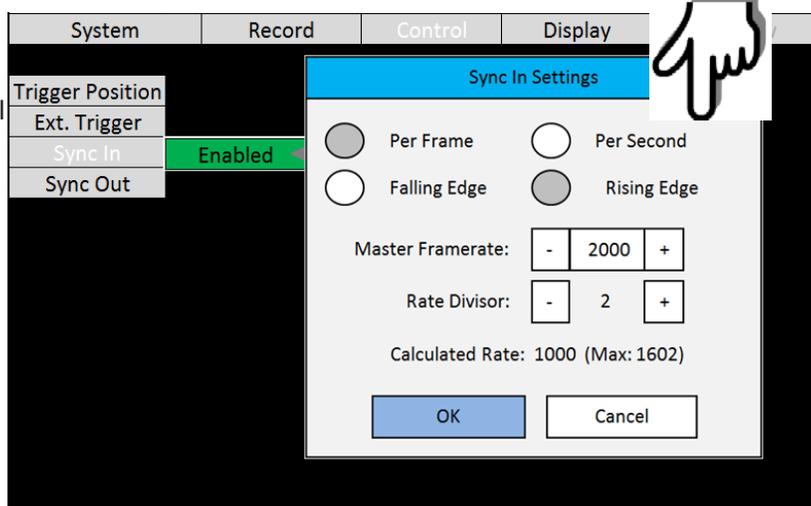
Per Frame:

The TS3 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 at a rate of one sync-pulse per frame or greater.

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. Change the state of the first button to “Enabled” (green), then click on the second button to open the Sync In Settings dialog.

Figure 44: Sync In Settings Dialog



The touchscreen feature is implemented for this dialog. If it is enabled, you will be able to enter data with your fingertip. (See “3-2 Using the Touchscreen” on page 13.)

4. Select Rising Edge or falling edge depending on your preference.
5. Select Per Frame. (Per Second Synchronization will be covered in the next section.)
6. Set the master framerate. This is the 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 integration timing.
7. Set the rate divisor. In the example shown in Figure 44: Sync In Settings Dialog, the desired framerate is 1000, while the Master Framerate is 2000, so a divisor of 2 is used.
8. Click on OK to accept the settings. The camera’s framerate will now be set at 1000 and all of the shutter settings are adjusted accordingly.

In this example, the Max (frame rate) is 1602. The camera’s resolution was set at 800 x480. 1602 is the maximum frame rate for that resolution. If you wish to change your maximum frame rate, you must change the resolution in the Record/Settings menu.

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

Per Second:

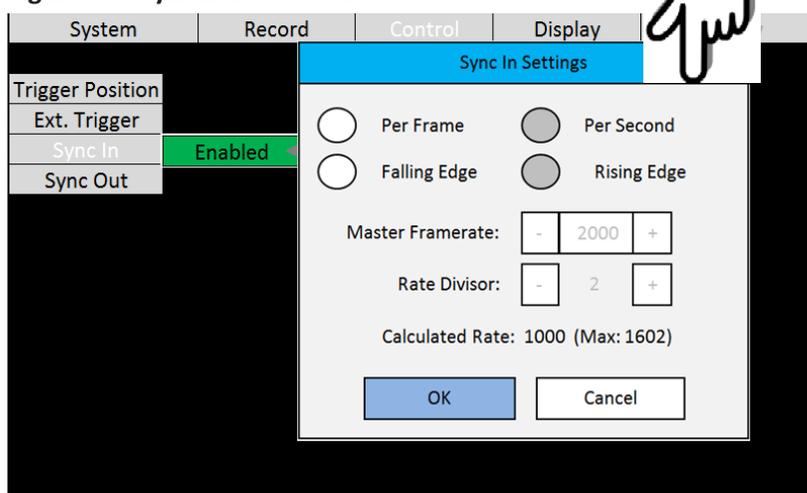
Many commonly available sync sources have a precision 1 Hz output. IRIG and GPS are two that are very often used with high-speed data capture.

The TS3 is able to 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 Framerate and Rate Divisor fields will gray-out.
3. 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 Setting Frame Rate and Resolution" on page 20.)

Figure 45: Sync In Per Second



5-2 Sync Out

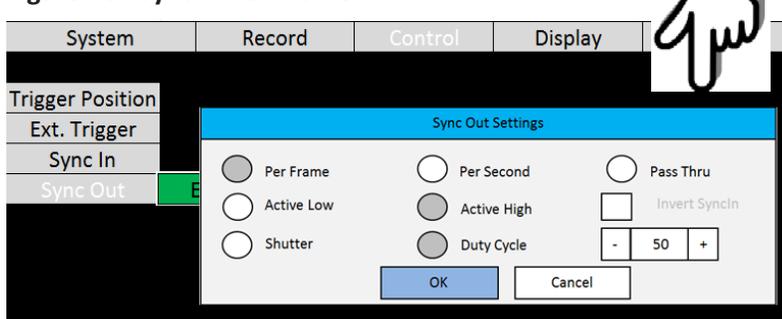
Per Frame

External devices such as additional cameras, strobe lights, and test instruments may be synchronized via Sync Out pulses from the TS3. 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), 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 with the beginning of frame integration, or **Active Low**, meaning the signal goes low with the beginning of frame integration. 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/framerate) for the active portion of the signal using the number box provided.

Figure 46: Sync In Per Frame



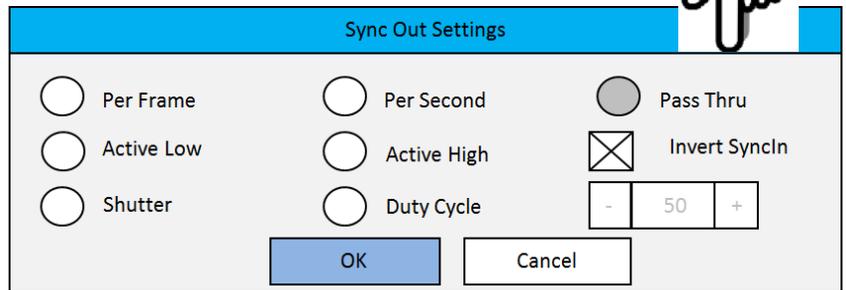
Per Second

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

Pass Thru

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

Figure 47: Sync Pass Thru



5-3 Master/Slave Setup

There are many possible configurations used to synchronize groups of cameras.

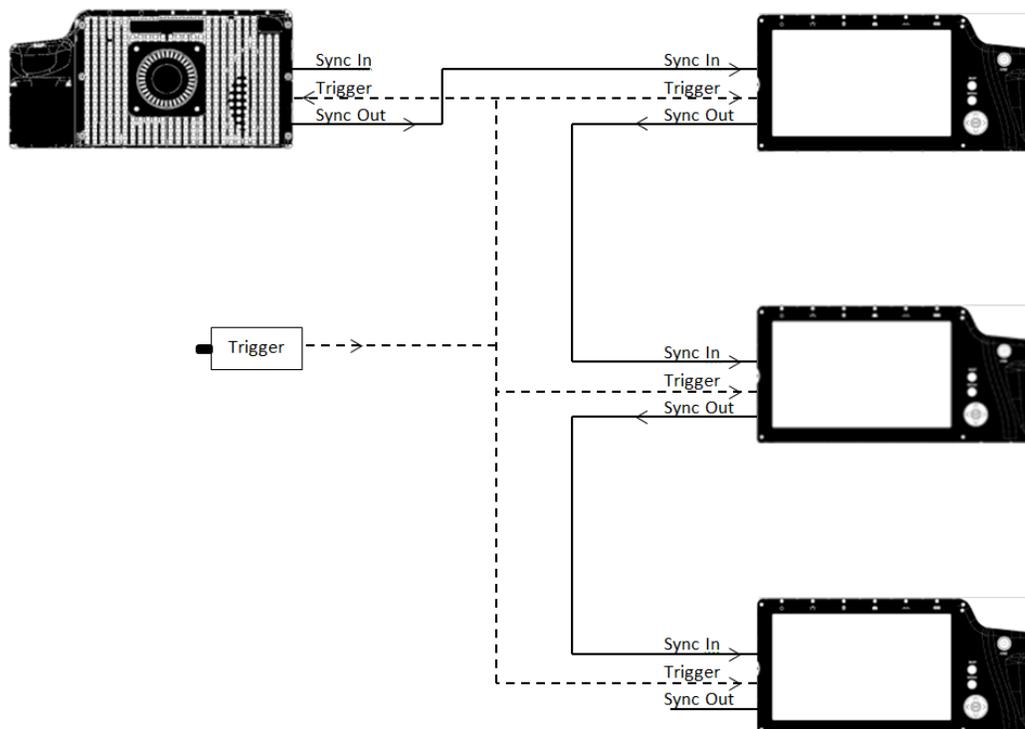
The Master/Slave configuration is often used when a group cameras is used to capture multiple synchronous views of an event that is not driven by a clock or PLC. For example, when studying animal or human kinetics, the subject (animal or human) is not supplying a sync signal for the camera system, so 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 are set to “Pass Thru.” Invert Sync In is **not** selected.
- Sync In for the Slave cameras Master Framerate is set the same as the Framerate of the Master camera.
- Choice of Shutter or Duty Cycle does not matter.

Figure 48: Master and Slave Cameras



- 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.

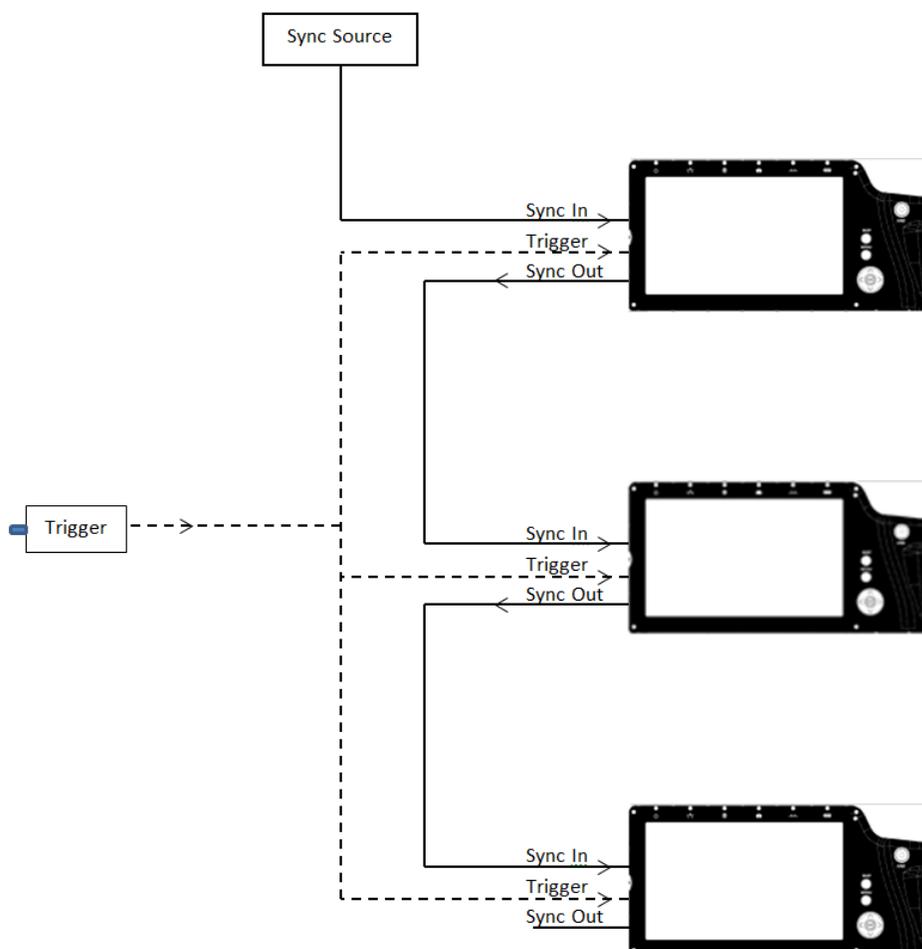
Parameters that affect post trigger recording time include: Trigger position, Resolution, Color vs Mono, Bit depth, base internal Memory (camera model), Framerate.

Variations on Master/Slave:

- Use a slower framerate 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.

5-4 External Source Sync

Figure 49: External Sync: Local Grouping



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 D: Power and I/O Connections” on page 58, for electrical specifications.

This sync pulse may be used for a localized group of cameras, in which the cameras are connected as in “Figure 49: External Sync: Local Grouping” on page 41 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 50: External Sync: Distributed Grouping.

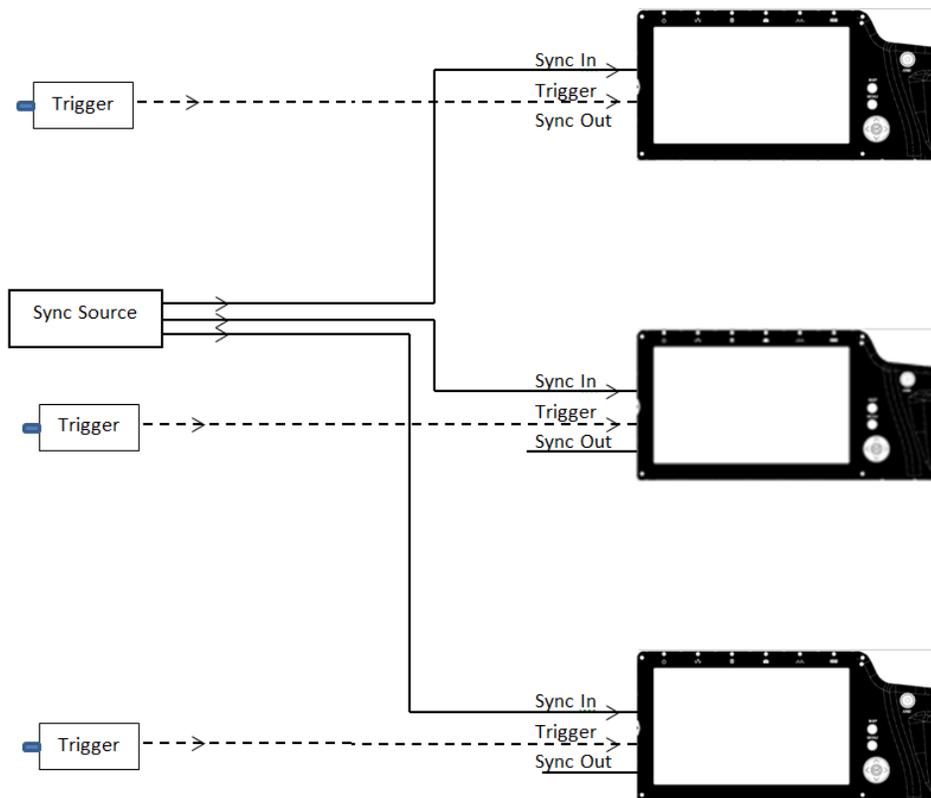
In the case of using a PLC or other local clock, you will need to know the polarity and frequency of the signal in order to set the cameras up. Optimum framerates can often be derived using the Rate Devisor function.

When using IRIG or GPS as an input, you will first need to derive a 1Hz signal from the source, 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 50: External Sync: Distributed Grouping



6 Using the Web App

6-1 Web App Overview

The Web Application is a utility built into the TS3 which makes control of the camera possible by any networked computer running an Internet Browser. No software needs to be loaded on the computer. It provides the user all the utility available through the buttons and touch screen of the TS3.

Enter the Web App by typing either the network-connected TS3's camera name or IP address into the address bar of an internet browser (See "3-5 Using the TS3 with a PC" on page 16 .

Figure 51: Address bar (Chrome)



The Application Window is comprised of:

- A Control Bar at the top, which includes Arm and Trigger buttons as well as the Battery Icon
- 6 Application Tabs, including the Camera Tab, Storage Settings Tab, Record Settings Tab, Record Control Tab, Display Settings Tab, and the Video Review Tab, which is present only when there is captured video available for Review.
- The Tabs Pane. When you click on a Tab it will open vertically along this pane. Tabs beneath the opened one will slide down the pane.
- The image area. This is where Live or Captured imagery appears.

In the figure below, TS3_12 is connected in Live Mode.

Notice that the Camera Name is displayed in brackets [] on the Camera Tab and that the camera's mode of operation (in this case "Live View" is listed there as well. The Trigger Button is absent because the camera has not yet been armed. The Review Tab is also absent as there is no video to review.

Figure 52: Application Window Camera Tab



6-2 Camera Tab

Clicking on the Camera Tab exposes its contents and shifts the other tabs down the Tabs Pane below it.

All tabs are always accessible, with the exception of the Review tab, which is only available in Review Mode (after video has been captured). Clicking on the Camera Tab a second time closes it. Opening another tab will also close the current one.

The Camera Tab always displays the Camera's current Mode of operation.

These modes include:

- Camera Live View, in which a live image is displayed in the Image Area.
- Camera Armed. This is the state of capturing pre-trigger frames.
- Camera Triggered. The camera is capturing post-trigger frames.
- Camera Video Review. The camera has finished recording. The captured video appears on the screen. Playback controls appear beneath the image window. (See "Web-App Review and Save" on page 49.)

You will also notice that when the camera is controlled via the Web App, the Mode script will say, "Waiting for Camera to Arm" or "Waiting for camera Trigger," etc. for a very short time until the app gets confirmation back from the camera that its state has changed.

If the computer loses communication with the camera, the Mode script will say "Camera Load Failure."

To change the camera name: highlight the camera name in the Edit Box and type in the new name. Press "tab" to accept.

The Camera Configuration may be loaded or saved via the Configuration Dialog. It may be reset using The "Reset to Factory Default..." button.

The Network Configuration of the camera may be viewed by clicking on the "Network Information" button.

Figure 53: Camera Tab

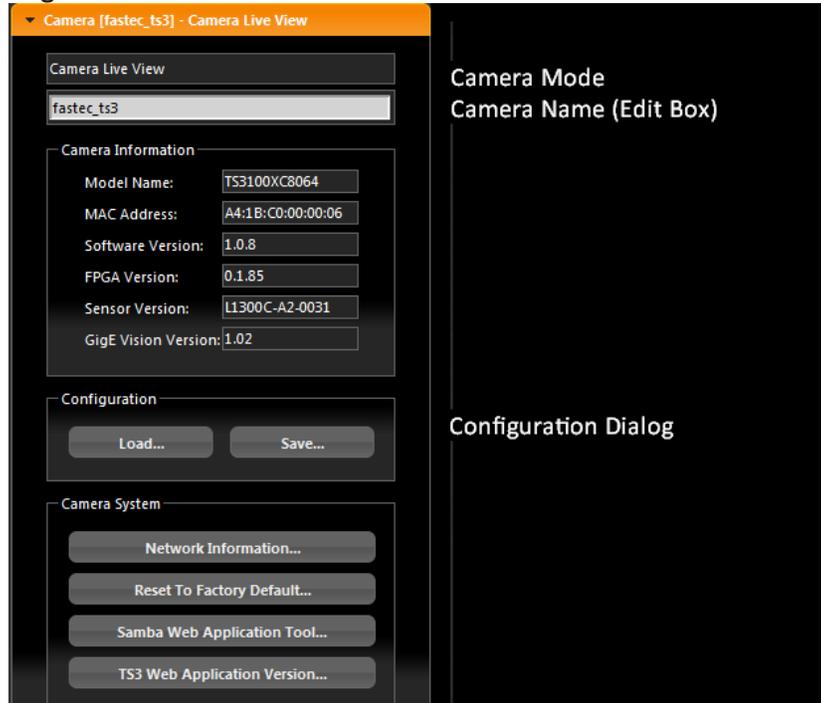
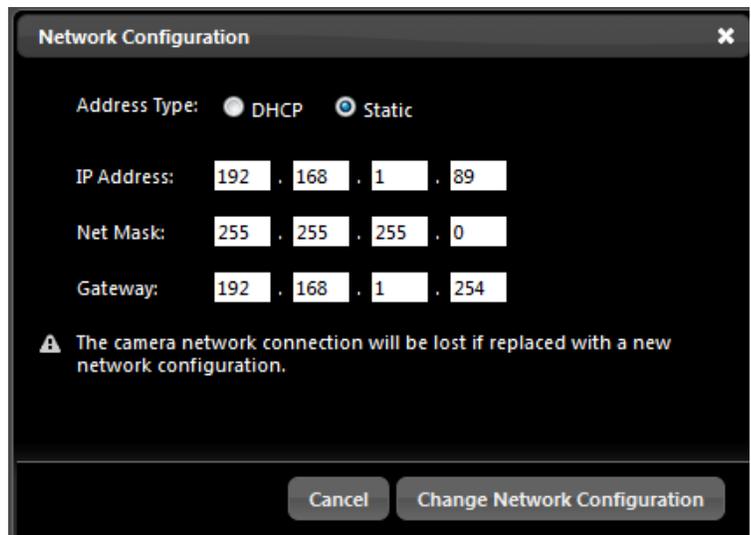


Figure 54: Network Configuration Dialog



6-3 Storage Settings Tab

The Storage Tab is used to Explore the memory storage devices connected to or installed in the camera as well as the Internal (high-speed) memory used for capturing video.

The ability to create multiple partitions in internal memory is not enabled at the time of this writing. When this feature is enabled, you will be able to choose the number of partitions and select the active partition using this dialog.

The upper portion of this tab is for Exploring the Storage Media. When exploring

1. Use the radio buttons to choose the storage device to manage-- SD Card (SDHC), SSD (internal drive), or USB Drive.
2. Click on Explore to open an Explore window for the device.
3. If you wish to explore another device from the explore window, click on "Parent Directory" to see the list of other devices.

The Explore window will look slightly different depending on the web browser and operating system you are using, but the content will be the same for all. (See Figure 56.)

Notice that in the example, we are looking at the directory of the SD Card: `.../media/sdcard`. Click on "hs_video/" to find the stored video files. Click on "dcim/" then "100fastc/" to find stored stills and video stacks.

To play a video, click on the file name and the video will open in the default media player. Large stored videos may play slowly when opened this way. You may wish to copy them to a computer drive first, and play them from there.

To open a still, click on the file name and the still will open in the explore window. To return to the last directory, right click in the window (but not on the image) and select "back."

To copy a video or still to a computer drive:

1. Right click on the file you wish to open. A context menu will open with a list of actions. The list varies depending on the browser you are using.
2. If using Chrome, Firefox, or Safari, select "save link as..." or, if using Windows Internet Explorer, select "save target as..." This will open a dialog box allowing you to navigate to the drive and directory you wish to save the file to.

Note: Only one file may be copied at a time. No files may be either deleted or moved via the Web App. In order to copy groups of files and directories (file stacks, etc.) open the camera in a separate Explore window. (See "3-5 Using the TS3 with a PC" on page 16

Figure 55: Storage Settings Tab

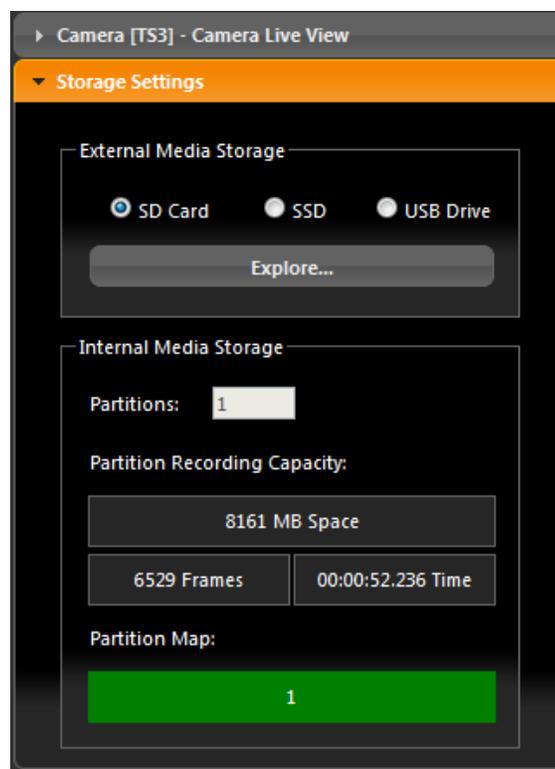
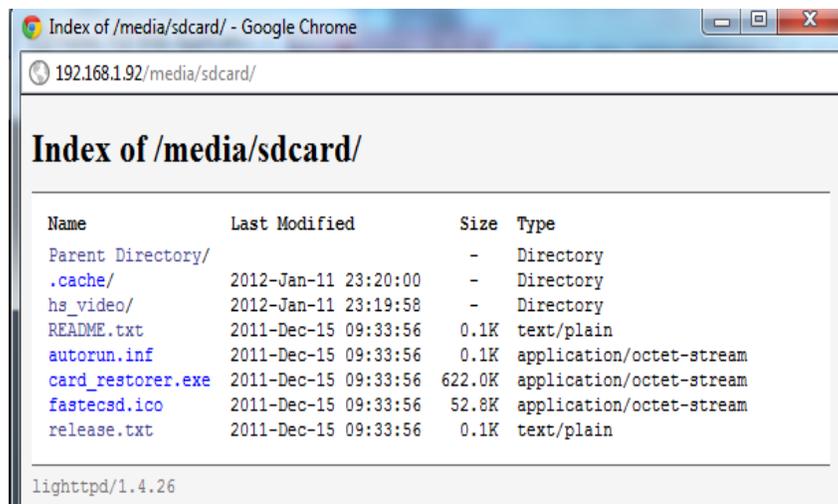


Figure 56: Explore Window



6-4 Record Settings

The Record Settings Tab is analogous to the Record Menu on the TS3 camera GUI. It contains the controls for setting ROI (Region of Interest), record Rate and Time (Frame Rate and Record Time), Shutter Speed, and Bit Depth, and FPN Control.

Setting ROI:

1. If you wish to use one of the standard aspect ratios: 4:3, 5:4, or 16:9, click on the Frame Aspect Ratio bar and make your selection from those choices. If wish to select a custom aspect ratio, select that choice from the same pull down menu.
2. If you are using anything but a "Custom" for aspect ratio, you can adjust either width or height and the other will adjust automatically. You can either use the sliders or the edit boxes to make your selection. If you use the edit box, hit the "Tab" key on your computer keyboard or click outside the box to complete your entry.
3. Select the "Autoset" box if you wish the camera ROI set automatically for the largest resolution possible at the selected frame rate.
4. Select the "Center" box to center the ROI to the optical center. If this is unchecked, you may set the ROI offset using the Offset X and Y edit boxes (See "Figure 25: Advanced Record Settings" on page 21).

Setting the Frame Rate:

Either move the Frame Rate slider or edit the associated text box to change the frame rate.

The frame rate is limited by the resolution. There is a Max framerate number next to the edit box letting you know what the maximum frame rate is for the current resolution. Clicking on the "Autoset" button will set the frame rate to that maximum number possible with the current resolution setting.

Setting the Shutter Speed:

Set the shutter speed by moving the slider.

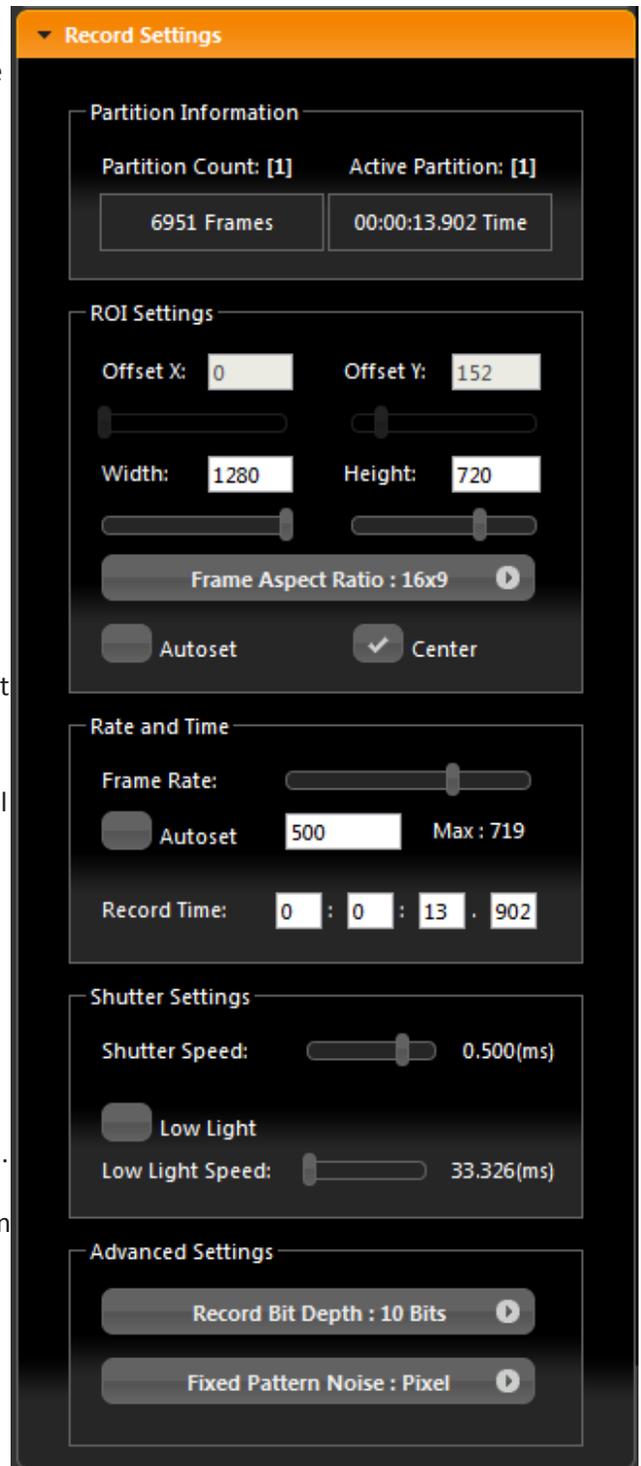
The minimum shutter speed (maximum sensor integration time) is limited by the frame rate. It is .006ms less than 1 frame time or $1/(\text{frame rate} - .006\text{ms})$. The maximum shutter speed (minimum sensor integration time) is always .002ms.

Low Light: (See "4-3 Low Light Mode" on page 23.)

The Low light feature lets you use shutter speeds up to 33.326ms for framing an focusing the camera prior to image capture. (During image capture the shutter speed will revert to its normal setting.)

Click on the Low Light check box to enable it. Use the slider to set the shutter speed.

Figure 57: Record Settings Tab



The Record Settings Tab, Advanced Settings box has one drop down menu for Record Bit Depth and another for Fixed Pattern Noise.

Select Bit Depth for Recording:

(See “4-4 Setting Bit Depth” on page 23.)

Note that if 10 bits are selected for the recording, the recording time will be shorter, but you will have the added flexibility of selecting which 8 bits to view in Review or Save. (The bit selection drop down menu will appear in the Display Settings Tab.

Select FPN Setting:

FPN selection (Disabled / Column FPN / Pixel FPN) can be done from the Web-Application via the Advanced Settings menu, but Calibration must be done from the camera. It is important to calibrate the camera frequently. (See “4-6 Black Level Calibration” on page 29.)

Figure 58: Record Settings Tab--Advanced Settings

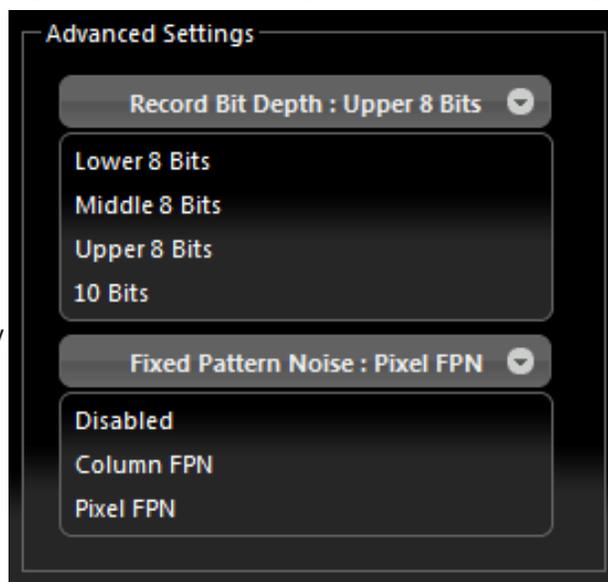
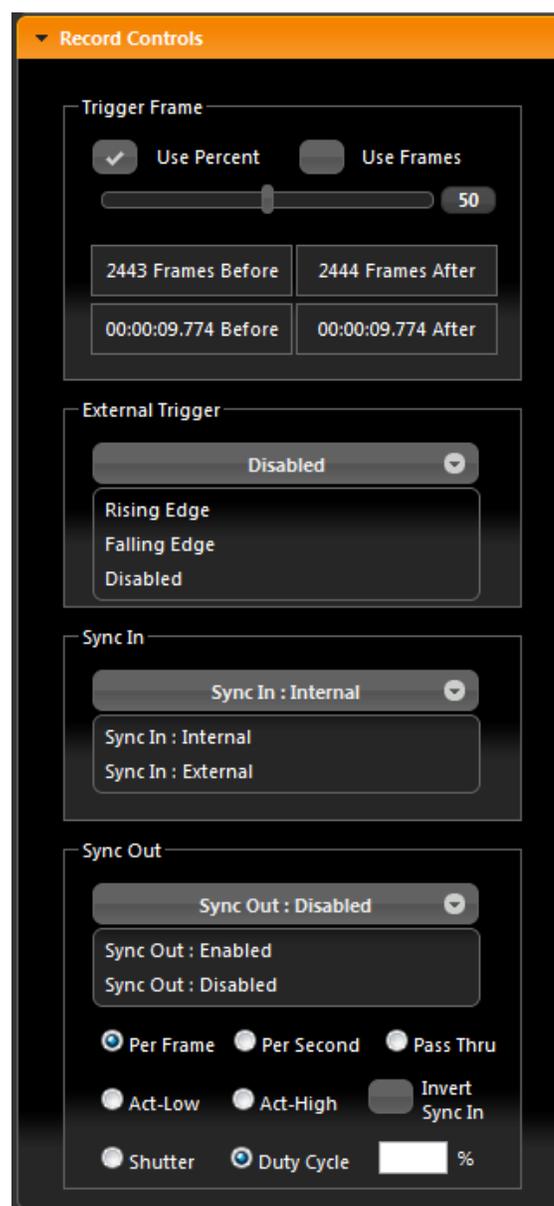


Figure 59: Record Controls Tab



6-5 Record Controls

The Record Controls Tab of the Web-App is shown in Figure 59 with the External Trigger, Sync In and Sync Out pull down menus open.

Setting the Trigger Position:

The trigger position is set via slider. There is much finer control of the trigger position using the Web-App than can be had on the camera GUI.

External Trigger:

Please refer to “Appendix D: Power and I/O Connections” on page 58 for specification for all electrical connections, including External Trigger, Sync In and Sync Out.

Select Rising Edge, or Falling Edge to enable the External Trigger. Use Falling Edge for a simple switch closure.

Sync In and Sync Out:

NOTE: If Sync in is enabled you will not see any Live or captured imagery unless there is a valid Sync In signal.

All of the options for camera synchronization are selectable on this menu.

Please refer to “5 Synchronizing Cameras” on page 38 for detailed descriptions of the options.

6-6 Display Settings Tab

Figure 60: Display Settings Tab, is shown with the /Bit Depth and White Balance selection boxes open.

Settings in this tab control displayed images, both Live and in Review, and all saved images except the RAW formats.

The Display **Bit Depth** selection box will only be present when the camera has been placed in 10-bit mode in the Record Settings Tab. (See Figure 58: Record Settings Tab--Advanced Settings.) For more detail on bit selection see “4-4 Setting Bit Depth” on page 23.

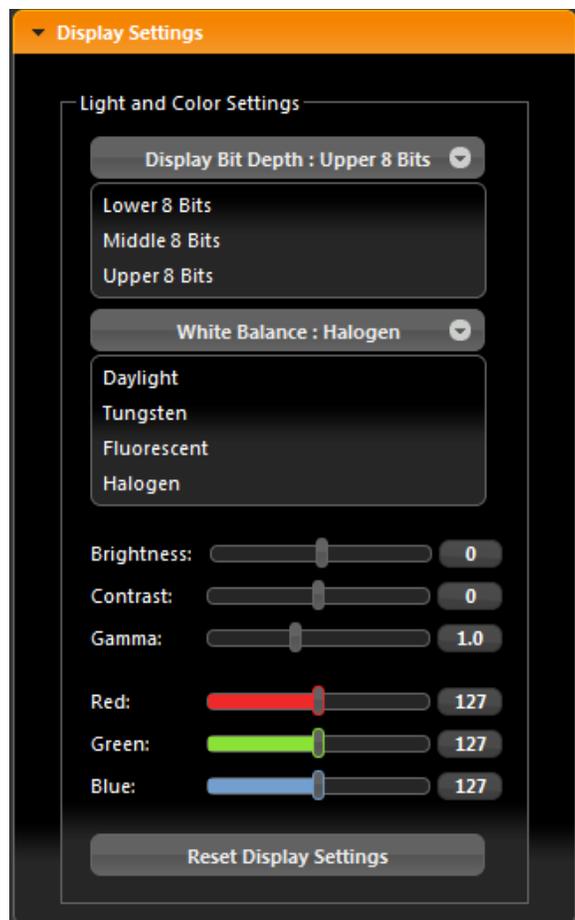
Select **White Balance** preset according to the available light.

The sliders used for **Brightness, Contrast, and Gamma** you control over the same range as with the presets in the camera, but it is a much finer control.

The color sliders give you control over the RGB gains. It is advisable to use the color sliders with a grey card to get good color balance:

1. Frame the camera image on a neutral gray object. (A cray card, piece of white paper, white wall etc.)
2. Turn on the histogram on the camera display.
3. Adjust the light or F-stop so that the histogram shows most pixel values in mid range. You will see a separate peak for Red, Green, and Blue. Green will likely be highest.
4. Adjust the gains for Blue and Red up so that the peaks match the Green.

Figure 60: Display Settings Tab



6-7 Arm, Trigger, Live, and Review Buttons

Use the Arm, Trigger, Live, and Review Buttons above the image window to control the state of the camera:

Figure 61: Arm, Trigger, Live and Review Buttons

When the camera is in Live mode with no captured images in its buffer, the **Arm** and **Live** buttons will be enabled (bright) and the Trigger and Review buttons will be disabled (grayed).



Click on the **Arm** button whenever it is enabled and to go into Record mode. This will arm the camera, recording the pre-trigger frames.



The Arm button will now turn Brown and change to “Armed.” The Trigger button will become enabled. Clicking on the **Armed** (brown) button, will de-arm the camera (after a warning message), just like pressing the mechanical Arm button on the camera while the camera is recording.



Clicking on the **Trigger** button (or using the external hardware trigger, if enabled) will cause the camera to record the post-trigger frames, thereby completing the recording. When the recording is

complete the captured video is automatically opened in Review mode.

The **Live** button returns you to Live mode. If the camera is currently recording, there will be a warning message that proceeding will result in loss of unsaved video. If the camera is in Review mode, pressing the Live button will bring up an information box telling you that you are leaving Review and entering Live mode, but that captured video will remain in the camera until it is re-armed.

When in **Review** Mode, the Live and Review buttons act as a toggle between Live and Review. The current recording is not deleted until the camera is Armed or powered down.

6-8 Review Tab

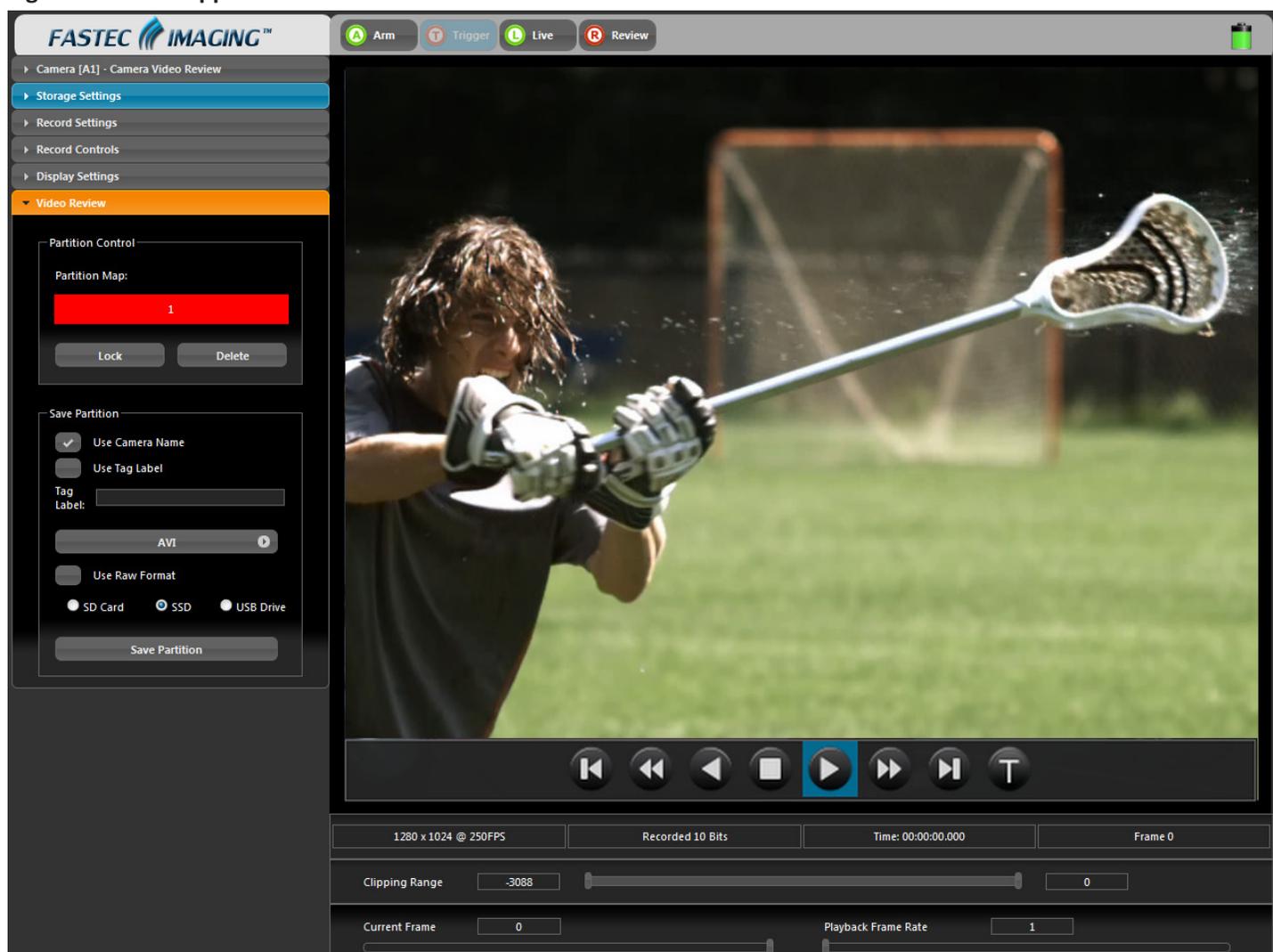
When in Review Mode, the Review Tab will open and the Playback controls will appear beneath the Image window.

Note: While in Review, the image may be adjusted using the controls in the Display Settings Tab. See “6-6 Display Settings Tab” on page 48.

The Play buttons, which only appear when the mouse cursor is brought over them, have the same functions as on the camera GUI (see “Table 14: Playback Control” on page 33), except that the Cut-In and Cut-Out points are entered by editing the Clipping Range boxes or by adjusting the slider between them. The clipping range is then used, as it is on the camera GUI for both playback and while saving to mass storage.

You may jump to the beginning of the clip (|<); to the end (>|) or to the Trigger frame (T). You may

Figure 62: Web-App Review and Save



also move to any frame by editing the Current Frame box, or by moving the slider beneath it.

The Playback Frame Rate may box may be edited directly or controlled via slider. The Playback Rate governs the speed at which the clip is played back both forward and reverse.

The skip forward >> and reverse << buttons skip at 1/10th the Playback Frame Rate. If you set the Playback Rate at 30, the >> and << buttons will skip forward or back 3 frames; if you set it to 300, they will skip 30, etc.

Video clips may be saved to mass storage devices attached to or installed in the camera (SD Card, SSD, or USB Drive).

To save a video clip:

1. Adjust the Clipping Range (edit the boxes or move the sliders) to include the portion of the clip you wish to save.
2. Use the “Use Camera Name” and/or “Use Tag Label” check boxes and the Tag Label edit box to set up the file name prefix you wish to use.
3. Click on the File Type bar (labeled “AVI” in Figure 63: Video Review Tab) to select the file type.
4. Select or deselect “Use Raw Format.” This checkbox will be active or grayed depending on the bit depth recorded and the file type selected.

Please refer to “4-11 Saving Images to Mass Storage” on page 35 for more details.

5. Select the destination drive using the “SD Card,” “SSD,” and “USB Drive” radio buttons.
6. Click on “Save Partition.”

A Progress Bar will appear beneath the image window showing the download status. When finished, an information window as in Figure 64: Download Information Box will appear.

Figure 63: Video Review Tab

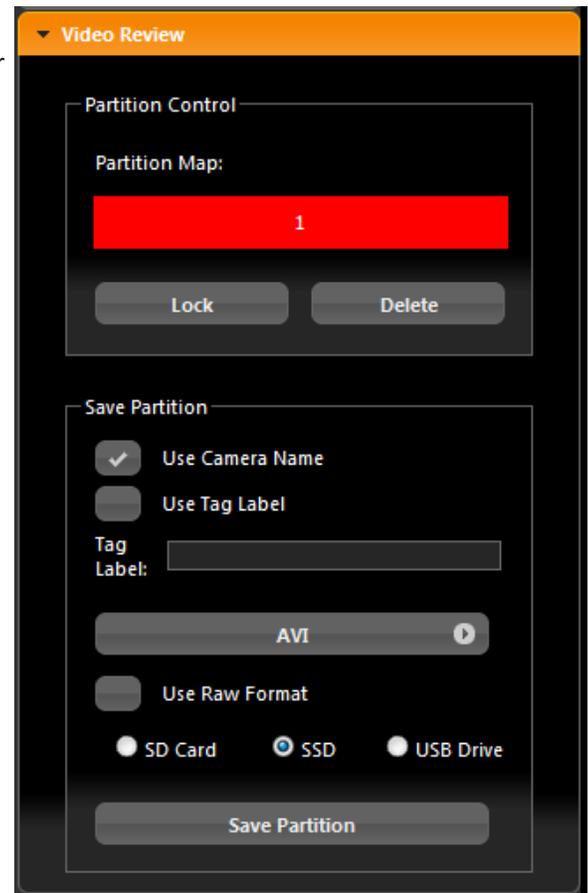
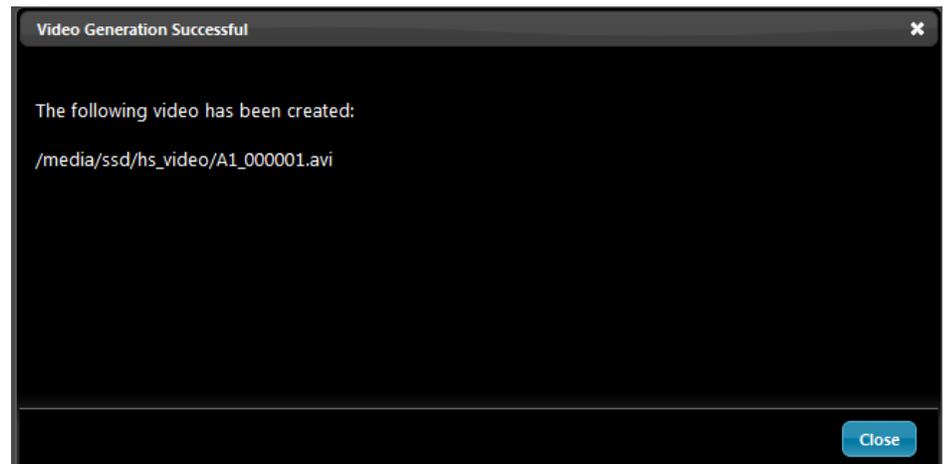


Figure 64: Download Information Box



Appendix A: Definition of terms

Arm	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 vertical line 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 file type for electronic video. AVI files may include certain types of image/video data (compressed or un-compressed), audio data, and metadata.
Backlight	The Backlight is the illumination used to light the LCD display on the camera.
Battery Status LED	Battery Status LED States:
Bit Depth	Images captured by the TS3 sensor are read in binary form. Each pixel is given a binary 10-bit value from 0000000000 to 1111111111, or, in decimal form, from 0 to 1023. 0 is black, 1023 is white—all numbers in between are shades of gray from very dark to very bright. The camera operator has the option of recording all ten bits (1024 shades) or 8 bits (256 shades). If the operator chooses to record 8-bit data, they must choose which 8 bits of the ten to record. They may wish to record the Lower 8 bits, which will greatly enhance the dark areas of the image, tend to saturate the bright areas, and will expose more noise; or the Middle 8 bits, which will somewhat enhance the dark areas wash out the brighter areas, and expose some noise; or the High 8 bits, which will be the cleanest image, but with the least definition in the darker areas.
BMP Stack	BitMaP (BMP) files contain un-compressed image data. Each file contains one image. A BMP Stack is a collection of images. The BMP Stack produced by the TS3 is a collection of frames, written as BMP files representing a captured video sequence.
Brightness	Linear image control that boosts all pixel values without disturbing the slope of the 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 dependant on digital video recording, i.e. automobile crash testing, military testing, etc.
Color Temperature	The Color Temperature of an ideal black body is defined as its surface temperature in kelvins (K). The Color Temperature of a light source is an assigned value that closely approximates what a human would perceive as a match between that light source and an ideal black body at that Temperature (K). High color temperatures are seen bluish, while lower color temperatures 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.
Custom Camera Control Application	Camera control software compatible with the TS3.

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.
Dialog	A Dialog is a box that requires user input such as the selection of an option, or the entering of a number or text.
Download	Electronically moving 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 all image processing including colorization, white balance, brightness, contrast, and gamma, are all bypassed.
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	Gamma encoding of images is required to compensate for properties of human vision - to maximize the use of the bits or bandwidth relative to how humans perceive light and color.[1] Human vision under common illumination conditions (not pitch black or blindingly bright) follows an approximate gamma or power function. If images are not gamma encoded, they allocate too many bits or too much bandwidth to highlights that humans cannot differentiate, and too few bits/bandwidth to shadow values that humans are sensitive to and would require more bits/bandwidth to maintain the same visual quality-
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 shut down.
JPEG Stack	Joint Photographic Expert Group (JPEG) file format is a highly compressed file format, capable of reducing image files to a fraction of the size of a BMP or lossless TIFF. The image quality of JPEGs is excellent, although there may be some discernible noise in the displayed image, often referred to as JPEG artifacts.
Menu	Once an item in the Menu Bar is selected, the corresponding Menu appears below.
Menu Bar	The Menu Bar is the bar across the top of the camera display that lists the Menu Items.
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.
Record Bar	When the camera is Armed and it commences capturing images, the Record Bar presents a graphic indication of the progress of filling the buffer.
Refresh Rate	Rate at which image data is re-painted on the display. 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, or stepping through every 10th frame. 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. If 10 bit images have been saved, the user may also select which 8 bits to display. 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 hard drive that is located inside the camera. This is a non-volatile mass storage device retains its data when the camera is powered down.
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 much more flexible format than the BMP, in that it may use one of several compression schemes, may be used to store multiple images (multi-page TIFF), and may include metadata in the form of Tags. Developers may apply for their own block of private Tags. The TIFF is the only file format used in the TS3 that is compatible with 10-bit images. The TIFF Stack produced by the TS3 is a collection of frames, written as BMP files representing a captured video sequence.
Trigger	The trigger is a signal sent to the camera either via the trigger switch on the camera or from an external source applied to the camera's trigger input connector. When an armed camera receives a trigger, it will capture and write a prescribed number of frames into camera memory, then stop capturing images. If the TS3 receives a Trigger while in Live Mode, it will take a still image.
Update Rate	The rate at which the TS3 or a PC can process a new frame of video and send it to the display.
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, the camera appears as a mass storage device to the PC, much like plugging a thumb drive into a PC's USB port. The camera is automatically a slave to the 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 Specifications

System Design	Stand alone, battery powered, portable with multiple PC I/O ports
Sensor	CMOS sensor
Resolution	1280 x 1024 pixel maximum
Pixel Size	14 μm square
Light Sensitivity	3,200 ISO monochrome, 1,600 ISO color
Record Rate	500 fps at 1280 x 1024, up to 20,000 fps at reduced resolution
Shutter	Global electronic shutter from 2 μsec to 1 second
Image Memory	4GB standard
Removable Storage	SDHC up to 16GB
Multi-Sequence Mode	1, 2, 4, 8 or 16 individual recording partitions
File Formats	BMP, TIFF, JPG, AVI, RAW
Lens Mount	C-Mount or F-Mount
Built-in Monitor	Ultra bright, 178mm diagonal (7"), WVGA LCD
Ports	USB(2), SD, GigE
PC Interface	PC or Mac compatible via Gigabit Ethernet or USB 2.0
Control Software	MAC, Windows or Linux OS compatible
Trigger	Contact Closure or LVTTTL
Sync	External sync inputs via BNC
Video Out	HDMI
Construction	Machined Aluminum Housing
Power	Rechargeable Battery Pack – 3 hours, or 10-26 VDC external power supply
Power Consumption	7.5 Watts maximum
Operating Environment	+5°C to +40°C
Size and Weight	228mm W x 114mm H x 89mm D. 1.8 Kg.

Appendix C: TS3 Record / Resolution Tables

4:3 Resolutions

Resolution		"Frame Rate"	2GB Capacity		4GB Capacity		8GB Capacity	
H.	V.	Rate	Time (Sec.)	Frames	Time (Sec.)	Frames	Time (Sec.)	Frames
320	240	60	464.1	27,848	928.3	55,696	1857.4	111,392
320	240	125	222.8	27,848	445.6	55,696	891.5	111,392
320	240	250	111.4	27,848	222.8	55,696	445.8	111,392
320	240	500	55.7	27,848	111.4	55,696	222.9	111,392
320	240	1000	27.8	27,848	55.7	55,696	111.4	111,392
320	240	1250	22.3	27,848	44.6	55,696	89.2	111,392
320	240	2000	13.9	27,848	27.8	55,696	55.7	111,392
320	240	4000	7.0	27,848	13.9	55,696	27.9	111,392
640	480	60	116.1	6,964	232.1	13,928	464.5	27,856
640	480	125	55.7	6,964	111.4	13,928	223.0	27,856
640	480	250	27.9	6,964	55.7	13,928	111.5	27,856
640	480	500	13.9	6,964	27.9	13,928	55.7	27,856
640	480	1000	7.0	6,964	13.9	13,928	27.9	27,856
640	480	1250	5.6	6,964	11.1	13,928	22.3	27,856
800	600	60	74.3	4,457	148.6	8,914	297.3	17,828
800	600	125	35.7	4,457	71.3	8,914	142.7	17,828
800	600	250	17.8	4,457	35.7	8,914	71.3	17,828
800	600	500	8.9	4,457	17.8	8,914	35.7	17,828
800	600	1000	4.5	4,457	8.9	8,914	17.8	17,828
800	600	1250	3.6	4,457	7.1	8,914	14.3	17,828
1280	1024	60			54.4	3,265	108.9	6,529
1280	1024	125			26.1	3,265	52.2	6529
1280	1024	250			13.1	3,265	26.1	6,529
1280	1024	500			6.5	3,265	13.0	6529

16:9 Resolutions

Resolution		"Frame Rate"	2GB Capacity		4GB Capacity		8GB Capacity	
H.	V.	Rate	Time (Sec.)	Frames	Time (Sec.)	Frames	Time (Sec.)	Frames
320	200	60	556.5	33,392	1113.1	66,785	2228.7	133,659
320	200	125	267.1	33,392	534.3	66,785	1068.6	133,569
320	200	250	133.6	33,392	267.1	66,785	534.6	133,659
320	200	500	66.8	33,392	133.6	66,785	267.3	133,659
320	200	1000	33.4	33,392	66.8	66,785	133.7	133,659
320	200	1250	26.7	33,392	53.4	66,785	106.9	133,569
320	200	2000	16.7	33,392	33.4	66,785	66.8	133,659
320	200	4000	8.3	33,392	16.7	66,785	33.4	133,659
800	480	60	92.9	5,572	185.7	11,143	371.4	22,285
800	480	125	44.6	5,572	89.1	11,143	178.3	22,285
800	480	250	22.3	5,572	44.6	11,143	89.1	22,285
800	480	500	11.1	5,572	22.3	11,143	44.6	22,285
800	480	1000	5.6	5,572	11.1	11,143	22.3	22,285
800	480	1250	4.5	5,572	8.9	11,143	17.8	22,285
1024	600	60	58.0	3,482	116.1	6,965	232.2	13,929
1024	600	125	27.9	3,482	55.7	6,965	111.4	13,929
1024	600	250	13.9	3,482	27.9	6,965	55.7	13,929
1024	600	500	7.0	3,482	13.9	6,965	27.9	13,929
1024	600	1000	3.5	3,482	7.0	6,965	13.9	13,929
1024	600	1250	2.8	3,482	5.6	6,965	11.1	13,929
1280	720	60			77.4	4,643	154.8	9,286
1280	720	125			37.1	4,643	74.3	9,286
1280	720	250			18.6	4,643	37.1	9,286
1280	720	500			9.3	4,643	18.6	9,286

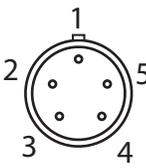
1:1 Resolutions

Resolution		"Frame Rate"	2GB Capacity		4GB Capacity		8GB Capacity	
H.	V.	Rate	Time (Sec.)	Frames	Time (Sec.)	Frames	Time (Sec.)	Frames
256	256	60	543.9	32,632	1087.7	65,264	2176.5	130,528
256	256	125	261.1	32,632	522.1	65,264	1044.2	130,528
256	256	250	130.5	32,632	261.1	65,264	522.1	130,528
256	256	500	65.3	32,632	130.5	65,264	261.1	130,528
256	256	1000	32.6	32,632	65.3	65,264	130.5	130,528
256	256	1250	26.1	32,632	52.2	65,264	104.4	130,528
256	256	2000	16.3	32,632	32.6	65,264	65.3	130,528
256	256	4000	8.2	32,632	16.3	65,264	32.6	130,528
512	512	60	136.0	8,161	272.0	16,321	544.3	32,643
512	512	125	25.3	3,161	50.6	6,321	261.1	32,643
512	512	250	32.6	8,161	65.3	16,321	130.6	32,643
512	512	500	6.3	3,161	12.6	6,321	65.3	32,643
512	512	1000	8.2	8,161	16.3	16,321	32.6	32,643
512	512	1250	6.5	8,161	5.1	6,321	26.1	32,643
1024	1024	60	34.0	2,040	68.0	4,080	136.1	8,161
1024	1024	125	16.3	2,040	32.6	4,080	65.3	8,161
1024	1024	250	8.2	2,040	16.3	4,080	32.6	8,161
1024	1024	500	4.1	2,040	8.2	4,080	16.3	8,161
1024	1024	1000	2.0	2,040	4.1	4,080	8.2	8,161
1024	1024	1250	1.6	2,040	3.3	4,080	6.5	8,161
1280	256	60	108.8	6,529	217.6	13,057	435.5	26,115
1280	256	125	52.2	6,529	104.5	13,057	208.9	26,115
1280	256	250	26.1	6,529	52.2	13,057	104.5	26,115
1280	256	500	13.1	6,529	26.1	13,057	52.2	26,115
1280	256	1000	6.5	6,529	13.1	13,057	26.1	26,115
1280	256	1250	5.2	6,529	10.4	13,057	20.9	26,115
1280	256	2000	3.3	6,529	6.5	13,057	13.1	26,115

Appendix D: Power and I/O Connections

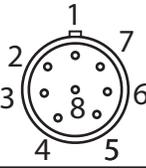
Power Connections For the TS3

Table 16: 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	

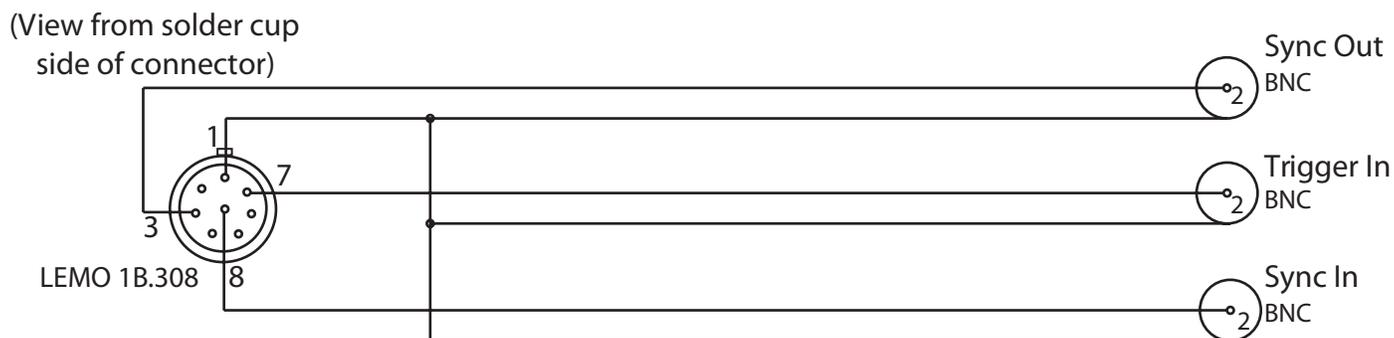
I/O Connections: Sync and Trigger

Table 17: 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 Reserved	
5	LVTTTL Reserved	
6	LVTTTL Reserved	
7	LVTTTL Trigger In	
8	LVTTTL Sync In	

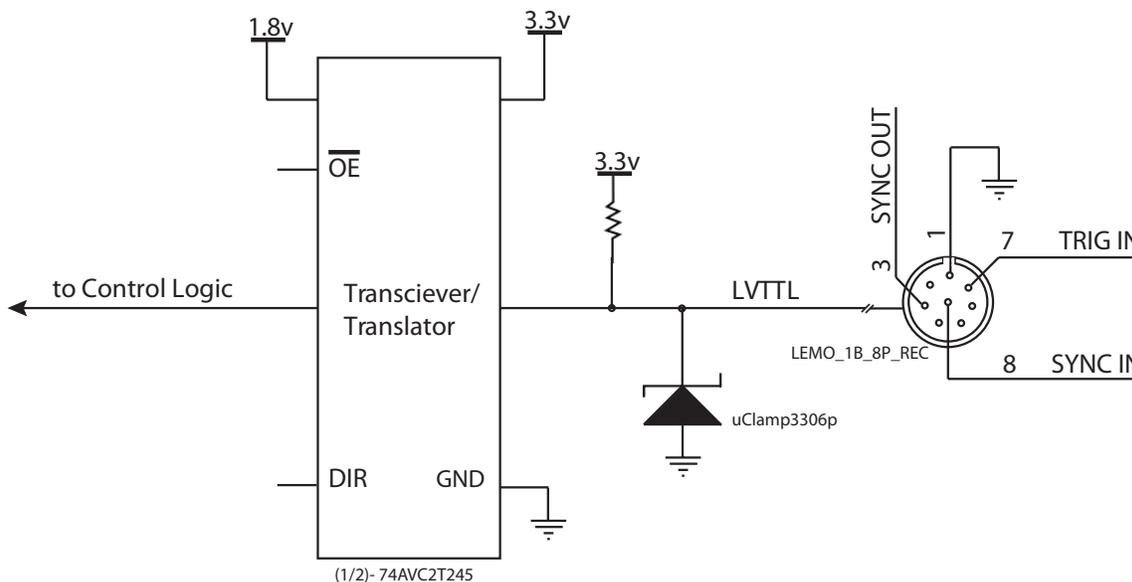
The TS3 is shipped with a Sync I/O cable for connecting external Trigger, Sync Out, and Sync In signals. The cable has a LEMO connector for the TS3 end and BNC connectors for the three signals.

Figure 65: Sync I/O Cable Drawing



For simplicity, the schematic below represents one I/O signal.
 The μ Clamp is for ESD protection.

Figure 66: Sync I/O Camera Interface Schematic



The TS3 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 TS3.

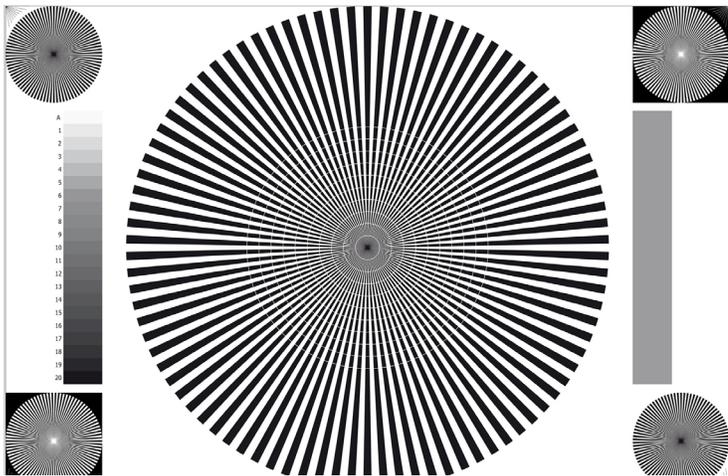
There is an I/O conditioning accessory available from Fastec that accepts signals up to 24v. The conditioner uses opto-isolators to protect the camera from over-voltage.

Appendix E: Adjusting Back Focus

Symptoms of incorrect Back Focus Adjustment:

- Zoom lenses loose 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.

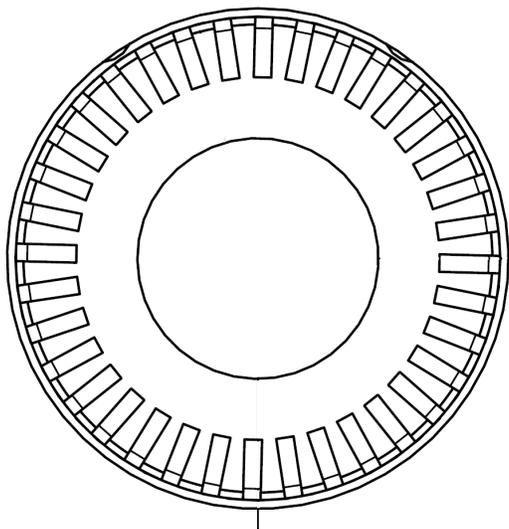
Figure 67: Focus Chart



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 focus chart can be very helpful. In a pinch, you can print one yourself. An 8 1/2 x 11" or A-Size Seimens Star chart will work for the example here.
- A 3/32" hex allen wrench for the C-mount lock screws. (See "TS3 Top View" on page 4 and "TS3 Bottom View" on page 5.)

Figure 68: C_Mount



Adjustment procedure:

1. Connect the TS3 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 $f/1.95$ lens.
3. Decide on a distance. . For this discussion we will use 5', or 1.5m.
4. Set your target 5' / 1.5m from the target. The proper way to measure is from the image plane to the target. The image plane would be about 17.5 mm behind the face of the C-mount. Set the target as flat and square to the camera as possible. Usually, taping it to a wall is the easiest.
5. Get plenty of flat white light on the target.
6. Set the TS3 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. Make a reference mark on the C-mount adapter to mark your starting point. This can be done with a little dab of white out, or a small piece of tape.
8. Frame and focus the camera on the focus target.
9. Set the lens aperture wide open.

10. Adjust the illumination and/or the exposure setting to get the right exposure, avoiding saturation. (Keep the lens set at its largest aperture. It is important to use the shallowest depth of focus possible.)
11. Look at the witness mark on the lens. It should be pointing to 5'/1.5m. If it is not, continue on with the adjustment.
12. Set the lens to the 5'/1.5m witness mark.
13. If the focus got noticeably worse, go on with the adjustment.
14. Loosen the two C-Mount Lock screws (see Figure 3: TS3 Top View and Figure 5: TS3 Bottom View). The C-Mount is threaded onto the TS3 Optical Block. Loosening the screws enable turning the C-Mount for adjustment.
15. Turn the C-mount adapter a short distance one direction, then back to where it was, then the other direction. You will quickly learn which way to turn it to get better results.

Note: The C-mount has 3/32 threads on it. It also has a scalloped pattern on its edge comprising 36 indentations. Rotating the mount the distance of one of these indentations is equivalent to adjusting the back focus distance a .022mm or a little less than .001." It is a good goal to adjust the back focus to within a couple of these indentations, or less than .05mm / .002."

16. 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.

Setting For Infinity:

If you will be using the TS3 exclusively for close by objects and are satisfied that the back focus is correct, you may skip this part. If, however, you will be using the camera for activities where it will be imaging far away objects, you will want to confirm that it can focus at infinity.

Figure 69: Navitar 50mm f/95 Lens

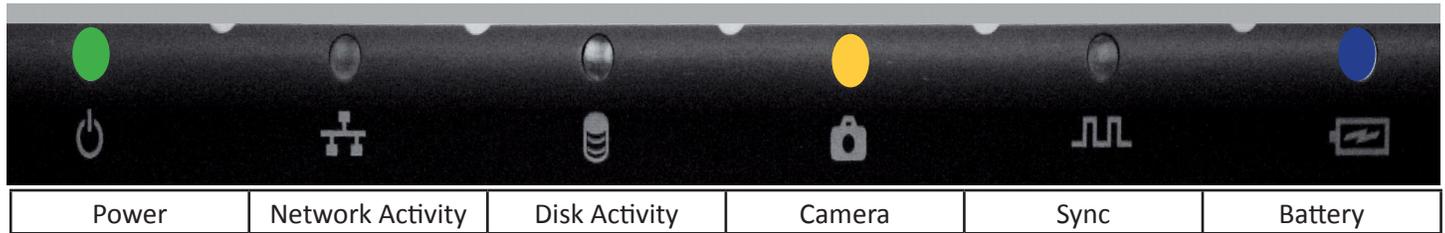


To do this you will need to find a place where you can set the camera up that has a good view of objects at various distances.

17. Check the location of the reference mark made on the lens in #7, above.
18. Look at the last witness mark on the lens before infinity. Find an object in your field of view that is approximately the distance indicated by that last witness mark. For example on the Navitar 50mm f/.95 lens, the last witness mark before infinity is 10m. So you would find an object approximately 10m away and focus on it.
19. Is the lens now set close to the 10m witness mark? Continue finding targets farther and farther away to get a feel for how far the lens can focus to.

If the best focus for very far objects is at or a tiny bit before the infinity stop, the lens is OK. If you find that the best focus for the farthest objects is not close to the infinity stop, or you find that you just cannot focus on far away objects, repeat #14 through #16 above.

Appendix F: Camera Status LEDs



Power LED:  Solid Green whenever the TS3 is powered up.

Network Activity LED:  Fast blinking Amber whenever the TS3 is sending or receiving on the network.

Disk Activity LED  Fast blinking Amber whenever the TS3 SDD or SDHC are accessed.

Camera LED

-  Solid Green whenever in Live mode (operating, but not recording).
-  Blinking Amber slowly (1 Hz) when the TS3 is Armed (recording, not triggered).
-  Blinking Amber quickly (2 Hz) when the TS3 is Triggered.
-  Solid Amber when in Review mode (playing back recorded images).
-  Off when battery is charging

Battery LED

-  Blue when no battery is present
-  Solid Green when in operation and battery charge is above 15%.
-  Solid Amber when in operation and battery charge is above 5%, below 15%
-  Blinking Red when in operation and battery charge is below 5%
-  Blinking Green when charging above 15%
-  Blinking Amber when charging above 5%, below 15%
-  Blinking Red when charging below 5%

Appendix G: Contents of Frame.txt file

```
[Image]
roi_x=0
roi_y=0
width=1280
height=1024
bit_mode=upper 8
frame_count=345
trigger_frame=344
time_stamp=Thu Oct 6 12:27:48 2011
[Camera]
make=FASTEC
model=TS3
fpga_rev=0x00010040
software_version=000.001.002
mac_address=a4:1b:c0:00:00:17
camera_name=TS3-c
sensor_type=C31L
[Record]fps=500
shutter_speed=2000
multi_slope=0:0
trigger_settings=0
sync_in=0x0
sync_out=0x0
[Normalization]
red_balance=256
blue_balance=256
green_balance=256
brightness=100
contrast=100
gamma=100
sensor_gain=0
red_gain=1
green_gain=1
blue_gain=1
red_matrix=[256,0]
blue_matrix=[0,0]
green_matrix=[0,256]
```