PRICE $10.00

Operating Manual
STV
Video Camera and Autoguider

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Note: This equipment has been tested and found to comply with the limits for a Class B digital device pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the receiver and the equipment.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Also note that user must use shielded interface cables in order to maintain product within FCC compliance.

STV Manual
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Chapter 1. Introduction

The STV is a unique and versatile instrument. It is a highly sensitive, cooled, digital video camera with exceptional abilities including the ability to autoguide and image without the need of a computer. The STV will take and store digital images on board for download to a computer at a later time. This makes the STV ideally suited for field use.

STV Features

- TC237 CCD with 656 x 480 Pixels and various binning modes
- Single Stage Thermoelectric Cooling
- Integral Filter/Shutter Wheel with Open, Closed and Filter positions
- Video Output to Internal and External Video Monitors
- Advanced 2 line x 24 Character Alphanumeric Display
- Fast Frame Rates (up to 10 frames per second)
- Built In Track & Accumulate (SBIG patent 5,365,269)
- 2 MB Flash memory for saving 14 images
- Remote Operation with STV REMOTE Software
- Digital Signal Processor (DSP) Powered for Highest Performance
- Standard T-Thread Front End (with screw in 1.25" nose piece)
- Telescope Port for Stand Alone (No Computer Required) Auto Guiding
- RS-232 Port for Remote Control and Image Download
- Optional 2 position Focal Reducer for 2X and 3X Reduction
- Optional C-Mount and Tripod Mount Accessories
- Optional Mini 4" Focal Length Telescope Tube for eFinder Operation
- Optional built-in 5" LCD Video Screen

What Can You Do With An STV?

- Rapidly Focus the System at Video Rates with the *Focus Mode*
  - Adjust Focus Sensitivity with a Single Knob
- Take High Quality Images with *Image Mode*
  - Continuous
  - Snap shots
  - Track & Accumulate
  - Mosaics
  - Auto Grab
- Save Images to Flash Memory with the *File Ops Mode*
- Download Images to PC for Offline Viewing and Processing
- Measure Images with the *Display Mode*
  - Stellar Magnitudes
  - Stellar Separations
- Autoguide Your Telescope with the *Calibrate* and *Track Modes*
  - Measure Critical Seeing Parameters with the *Monitor Modes*
  - Telescope PEC
  - Optical System Quality
  - Atmospheric Seeing
  - Electronic Finder (eFinder)

System Requirements

The STV does not require a computer to operate. However, a computer can remotely control the STV and digital images may be downloaded to a computer over a standard serial port. Remote control and image transfers require that STV REMOTE software be installed on the host computer.

The minimum system requirements are:

IBM compatible PC running Windows 95/98
1.44MB floppy drive (for software installation)
256 color graphics display (or 16 bit color graphics for better image rendition)
Standard serial port (COM1 or COM2)

Recommended system requirements are:

True color (24 bit or 32 bit) graphics display for faster performance
External Video Monitor

System Overview

The STV is easy to use and you are encouraged to try all of its functions without fear of hurting the camera. It is impossible to damage the STV by pressing any of the buttons on the control panel. If you ever get lost in a menu and want to start over simply press the Interrupt button and begin again.

Most of the STV's functions are accessed in a similar way. In general, pressing a function button once takes you to the setup menu for that function and pressing the same function button again starts the particular function using the values you have entered in the setup menu. The STV will remember the setup items as you last entered them. If you are repeating a function and you do not want to make any changes in the setup items simply press the function button twice to initiate the function using the old setup values.

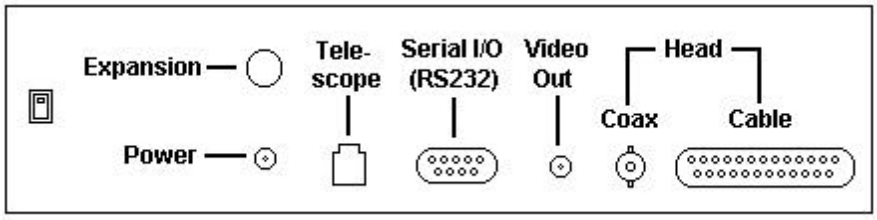
The control panel is laid out in such a manner as to make using the buttons as intuitive as possible. For instance, menu items are generally displayed on the left-hand side of the alphanumeric display. You can scroll through these items (parameters) by pressing the **Parameter** button located directly under the left-hand side of the alphanumeric display. In some cases you may also scroll through the menu items (parameters) by turning the rotary knob directly under the **Parameter** button. An example of this is setting the Date and Time. By repeatedly pressing the **Parameter** button you can scroll through the menu to select the items: Month, Day, Year, etc. For every menu item (parameter) there is a value shown on the right-hand side of the alphanumeric display. Using the Date as an example, after selecting from the menu item "Month," then you would chose a value for this item by repeatedly pressing the **Value** button or turning the rotary knob directly under the **Value** button. For the menu item "Month" the possible range of values is 1 to 12. If the current month is January, you would select a value of 1.

Chapter 2. Assembly

Assembly of your STV is simple and straightforward. All of the cable connections are clearly marked on the back of the STV chassis. It is recommended that power be connected last.

Important Safety Notes: ***Observe proper polarity if using 12VDC. Center pin is negative.*** The STV head can be damaged if you connect or disconnect it with the power turned on. Do not attempt to connect a head from an ST-237, ST-5C or any other camera in place of the STV head! Severe damage will result and your warranty will be void.

Cable Connections



1. The STV camera head has two cables that must be connected to the CPU box. Connect both the DB25 **Cable** and the smaller BNC **Coax** plug to the connectors indicated under **"Head"** on the back panel.

2. The **Video Out** plug on the back panel is for connecting the STV to an external video monitor or VCR using commonly available video cable. The connector is a standard RCA type jack. The external monitor must be equipped with a "Video In" connector.

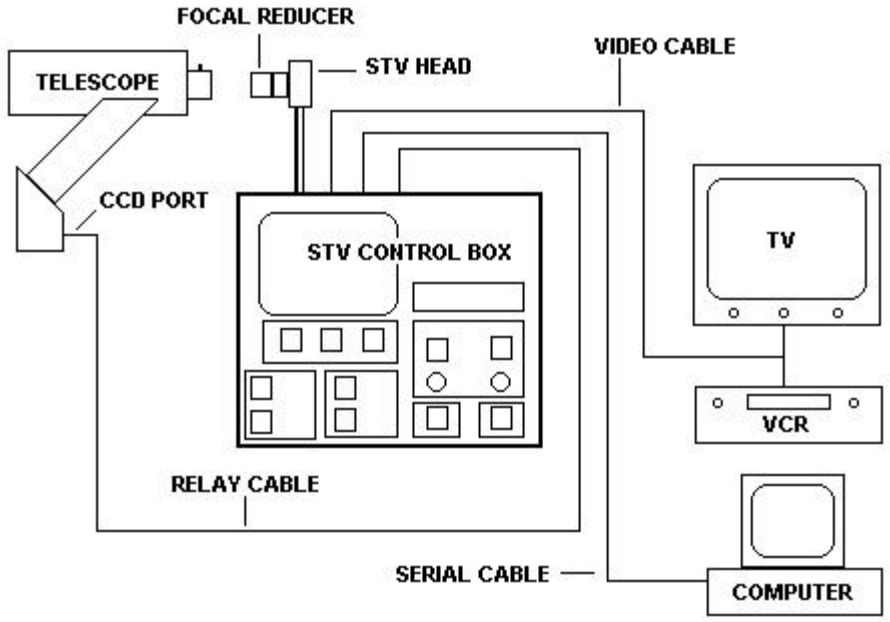
3. The DB9 **Serial I/O (RS232)** port is for connection to a standard serial port (COM1 OR COM2) on a PC using the supplied serial cable. While a computer is not necessary for the STV to function, you may remotely control the camera from the computer and you may also download digital images stored in the STV's internal memory to the computer. The Serial I/O may also be used for upgrading the STV firmware as updates become available.

4. The RJ11 **Telescope** jack is the autoguider output from the STV. The STV contains internal mechanical relays similar to the ST-4 making it suitable for any autoguiding application without the need of a relay adapter box. A telescope interface cable (TIC) is supplied with the STV that will plug directly into the "CCD" port on many common telescope mounts such as the LX200, Ultima, Losmandy and others. If your particular telescope drive does not accept the relay cable supplied, please refer to Appendix A, page 44, for the relay pinouts of the STV. This information may be used to construct a custom cable.

5. The **Power** plug is for receiving 12VDC to operate the STV ***(Note: center pin is negative and outside is positive***). You may use the supplied wall transformer or you may power the STV from a battery source. If you are powering the STV from a source other than the wall transformer please refer to Appendix A, page 43, for the required specifications.

6. The **Expansion** slot is not used at this time.

A number of external connections may be made to increase the versatility of the STV. Some or all of these external connections may be made at the same time. For instance, you may connect the STV to a remote computer and an external video monitor. If connected to a telescope, you can use the STV as a stand alone autoguider or you may control the guiding functions remotely from a PC or laptop while viewing the video signal on the external video monitor.

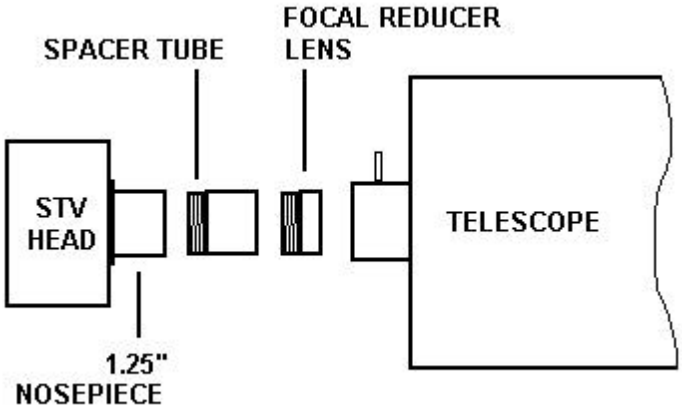


The connection to a telescope is for autoguiding only (e.g., not GOTO functions). For remote telescope GOTO control you will need a software package such as TheSky from Software Bisque. Typically remote telescope GOTO control is handled over the telescope's RS232 port. You should not confuse this with the RS232 port on the STV and attempt to connect the STV and telescope's RS232 ports. The STV (like all other autoguiders) connects to a telescope by way of a "CCD" port or an "Autoguider" port. In some cases (e.g., Losmandy) the connection is made using the same port as the telescope's hand controller. Please consult with your telescope's manual or the manufacturer for the proper autoguider input port for your telescope.

Most commercial telescopes manufactured recently have an RJ11 phone type jack available as an input port for autoguiders. If your telescope has a different plug for an autoguider, please refer to the Appendix A, page 44, of the manual for pin outs of the STV's telescope jack so that you can make your own relay cable. Also, note that on the LX200 series and some others, the autoguider port is labeled "CCD." Unfortunately some of these same telescopes also use an RJ11 type plug for serial communications to a computer for remote control. These auxiliary ports on the telescope look identical to the autoguider ports but they may be labeled RS232 or AUX instead of CCD. Meade ETX models and Celestron Nextstar models have RJ11 type jacks for RS232 communications only, not autoguider input. If you are unsure if your telescope supports an autoguider, please consult with the telescope manufacturer.

Focal Reducer Assembly

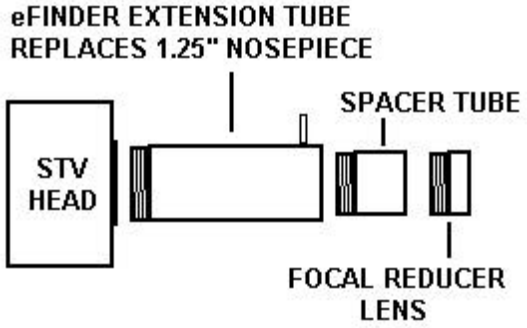
An optional custom focal reducer is a recommended accessory for the STV. This focal reducer also doubles as a wide field finder/autoguider lens. When used with the supplied spacer tube, this focal reducer will reduce an f/10 system to approximately f/3.75.



Focal ratio of parent system	F/14	F/10	F/6.3
Resulting focal ratio without spacer tube	F/8	F/5.95	F/3.75
Resulting focal ratio with spacer tube	F/5.25	F/3.75	Not recommended

eFinder Assembly

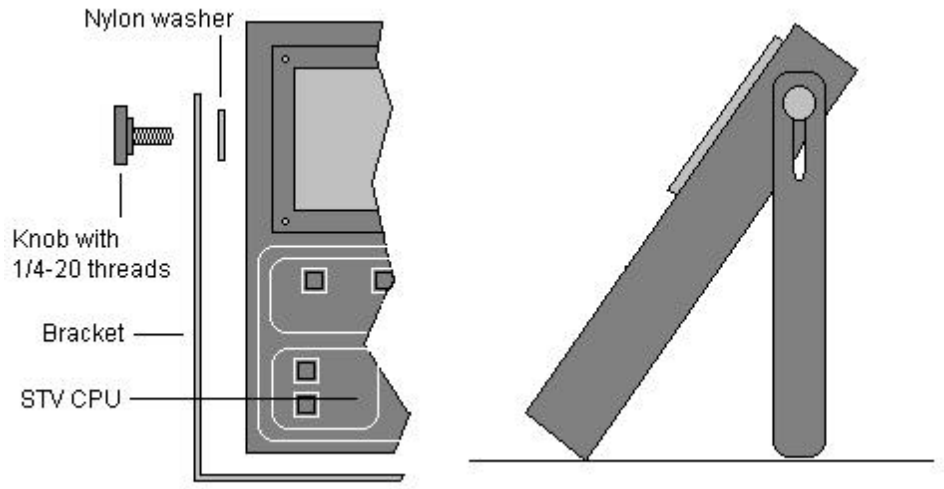
The focal reducer lens is also designed to work as an f/4 wide field lens of ~100 mm focal length when placed at a distance of about 4" from the CCD chip. In this configuration the STV works exceptionally well as an electronic finder ("eFinder") scope. A special tube assembly is provided



that will place the lens at approximately the correct distance. The extension tube has a set-screw at the objective end that allows for focus adjustment by sliding the lens in and out until best focus is achieved. The eFinder extension tube assembly replaces the nosepiece when using the lens as a wide field objective. In this configuration, the STV may also be used as a piggyback autoguider without the need of a separate guide scope. The tracking accuracy of the STV with the eFinder lens assembly is better than 1 arc second.

Other Accessories

The STV comes with a large "U" shaped bracket that can be used as carrying handle or a support for tilting or standing up the STV CPU box. You may find this helpful in placing the built-in 5" LCD video screen at the optimum viewing angle. The bracket is supplied with 2 nylon washers that should be inserted between the bracket and the case to protect the case from scratches. The bracket is attached to the case with two supplied 1/4-20 threaded knobs.



Recommended Accessories for the STV from SBIG:

- Custom Focal Reducer and eFinder Tube assembly.
- T-thread to C-thread adapter (for attaching video camera lens).
- CLA5 Camera lens adapter (for attaching a 35mm camera lens).
- Tripod foot (for attaching STV head directly to tripod or to piggy back mount).
- 12VDC power cord (with alligator clips and cigarette lighter adapter).
- Hard carrying case with custom cut foam for STV.
- CCDOPS for Windows 95/98/NT.

Other Recommended Accessories for the STV:

- External high resolution B&W video monitor
- Laptop or PC for remote control
- Marine deep cycle battery for extended field operation

Chapter 3. Quick Start

If you are one of those individuals who think that detailed instruction manuals are for everyone else, this section is for you!

Basic Imaging

1. Attach the camera head and other cables as indicated on the back panel of the control box, plug in the power cord from the wall transformer and turn on the STV. Set the Date/Time. Go to the Setup menu and set the telescope focal length and aperture.

2. Insert the STV head into a telescope or attach the eFinder lens supplied with the STV and point it at something in the sky that is not too bright (The moon may be too bright without the lunar filter item selected in the Setup menu).

3. Press the **Focus** button twice and adjust the exposure time with the rotary knobs until you can make out light and dark areas in an image. Focus the telescope or lens. Toggle the zoom mode by pressing the **Parameter** button. Toggle the frame size by pressing the **Value** button.

4. Press the **Image** button once and set an exposure time by using the left-hand rotary knob to select "Exposure" from the menu and use the right-hand rotary knob to pick the value in seconds. Press the **Image** button again to start taking images. Adjust the brightness and contrast with the rotary knobs.

5. Press the **Image** button again to go back to Image setup if you want to increase or decrease the exposure time. You can also go through the Setup menu to find the "Filter" item so you can try it on bright things like the moon.

6. When you see something you like - press the **Display** button. Adjust the Brightness and Contrast with the rotary knobs or press the **Parameter** button for Auto Contrast. If you want to save the image press the **File Ops** button and select SAVE from the menu. Press the **Value** button under the small arrow and you will see the SAVE submenu. For a quick reference to all the menu items in the STV see Appendix F, page 55.

Basic Autoguiding

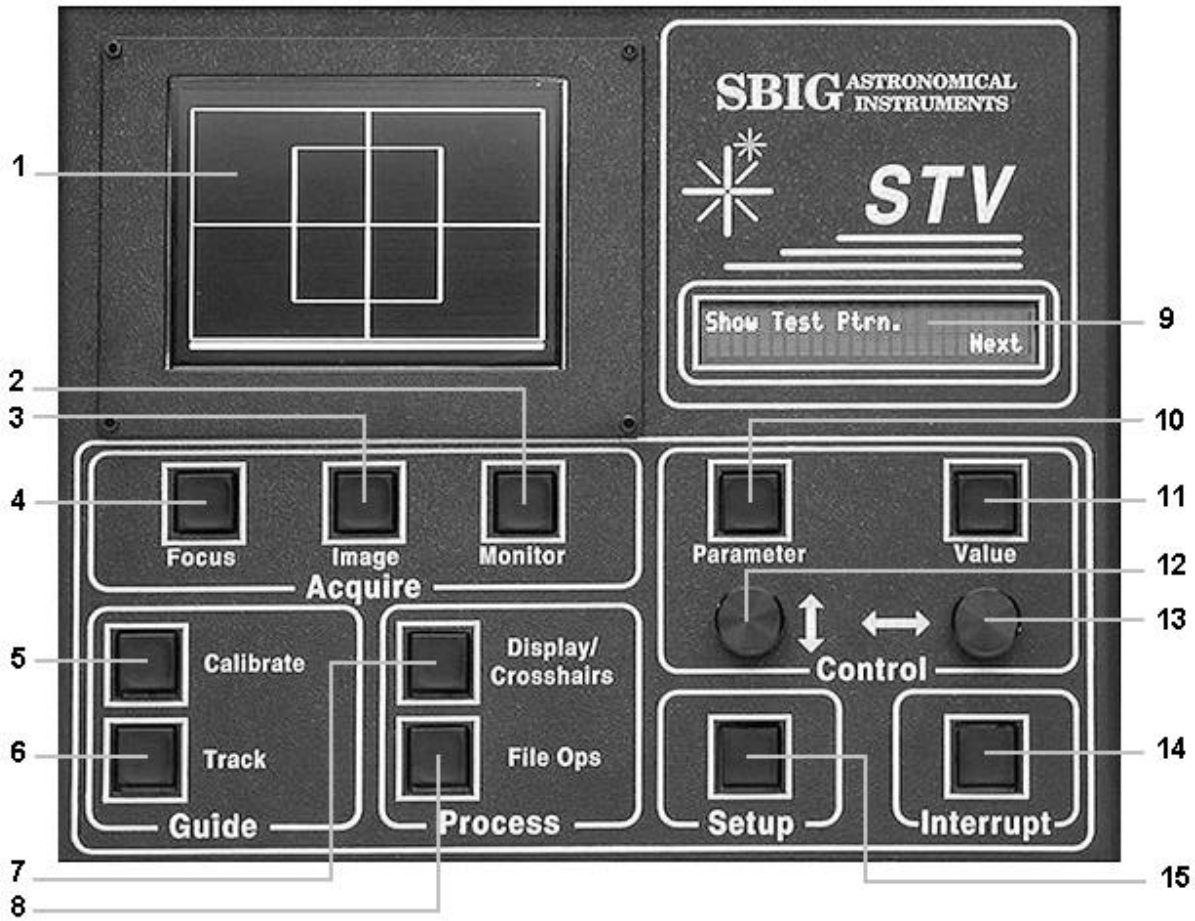
1. Do Basic Imaging steps 1-3. Make sure you have properly entered the focal length in the Setup menu. The STV uses this information to choose the calibration time. Mount the STV head piggyback on your telescope with the eFinder lens assembly attached. Connect the relay cable to your drive and press the **Calibrate** button - use auto mode.

2. After calibration is done, press the **Guide** button.

3. Repeat above or press any button you like to see what happens until you decide to read the rest of the manual! Have fun!

Chapter 4. Control Panel

The control panel of the STV labels each of the function buttons as shown in the figure below. The upper left quadrant of the control box holds the optional built-in 5" LCD video screen (shown here with the test pattern activated). The upper right quadrant of the control box under the SBIG logo contains a 2 line by 24 character vacuum florescent alphanumeric display. The lower left and lower right quadrants contain the control buttons used to activate and toggle through the STV menu functions.



Control Panel Functions

A brief description of the STV control panel buttons and displays is outlined below. For a more detailed description of each function please refer to Chapter 5 of the manual.

1. Optional built-in 5" LCD video screen. An external TV or VCR may be used instead of or in addition to the built-in video screen. The video screen area contains information as well as the video image. The diagram on **page 10** shows the layout and identification of the STV's video output.

2. Monitor button. Press once to activate the Monitor Setup Menu. Press again to enter one of the five Monitor modes: eFinder, Optics, Drive (slow), Drive (fast) and Seeing. See **page 21** for details.

3. Image button. Press once to activate the Image Setup Menu. Press again to enter Image mode. In the Image Setup Menu you may select various Image modes such as Continuous, Snap, Track & Accumulate, etc. See **page 18** for details.

4. Focus button. Press once to activate the Focus Setup Menu. Press again to enter Focus mode. See **page 17** for details.

5. Calibrate button. Press once to activate the Calibration Setup Menu (auto or full menu). Press again to activate a calibration sequence before autoguiding. The STV automatically calculates the exposure time and grabs an image. The STV automatically estimates the amount of move to make and then moves in each of 4 directions and measures the results. If enough stars are seen in the original image, the STV will mark up to eight bright stars. If the STV cannot find 8 stars in the original frame, it will mark as many as it can detect. After each move, the STV will check to see if a majority of the stars marked on the previous frame are present. If so, it will continue to calibrate until done. The process takes a couple of minutes. See **page 32** for details.

6. Track button. Press to start autoguiding after a successful calibration sequence. See **page 34** for details.

7. Display / Crosshairs button. Press once to activate the Display / Crosshairs Mode anytime there is an image on the video screen. Entering Display Mode freezes the video image and places a scale bar at the bottom of the video screen. The rotary knobs will adjust the brightness and contrast of the frozen image. Press the Value button to activate and toggle the cross hairs. When the cross hairs are active the rotary knobs are used to adjust the position of the cross hairs on the image for measuring stellar magnitudes and angular separation. See **page 26** for details.

8. File Ops button. Press once to enter the File Operations menu where you can Save, Recall and Erase images as well as download images to a remote computer. See **page 27** for details.

9. Alphanumeric display. This 2 line x 24 character vacuum fluorescent display provides menu and other information during operation of the STV. The information changes depending on the mode you select. See the particular mode section for details.

10. Parameter button. Performs several different functions depending on the mode. Typically it is used to toggle through items in setup menus or to change the zoom level in image mode. See the individual mode section for details.

11. Value button. Performs several different functions depending on the mode. Typically it is used to select a value for a menu item or to toggle the frame size in image mode. See the individual mode section for details.

12. Left (up-down) rotary control knob. Performs several different functions depending on the mode. It often mirrors the Parameter button for scrolling through menu items (e.g., selecting the item "Exposure" in the Image Setup menu). Changes the Brightness in image mode. See the individual mode section for details.

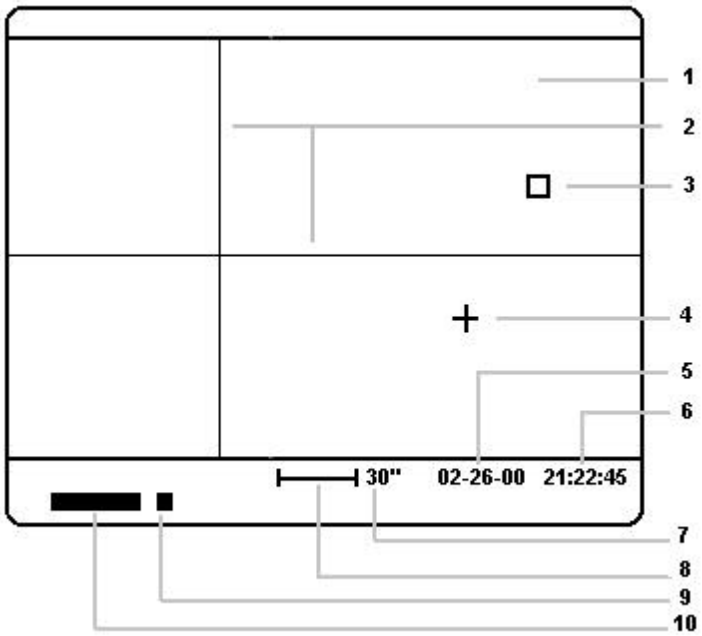
13. Right (left-right) rotary control knob. Performs several different functions depending on the mode. It often mirrors the Value button for scrolling through values to be assigned to menu items (e.g., selecting "10 seconds" as the exposure time in Image Setup menu). Changes the contrast in image mode. See the individual mode section for details.

14. Interrupt button. Press once anytime to stop whatever is in progress and freeze the image. The alphanumeric display reverts to the same display as on power up. Press Interrupt again to blank the video screen. Holding down Interrupt while turning on power to the STV prepares the camera to receive a firmware update via the RS232 port. See **page 36** for details.

15. Setup button. Press once to activate the STV set up menu. Use the Parameter and Value buttons or the rotary knobs to scroll through the setup menu items and the values assigned to each item. See **page 14** for details.

Video Screen Appearance

The video output of the STV often contains data as well as the video picture. For instance, if the Date / Time function is set to "on" in the setup menu then the information will automatically be displayed under the video image whenever the STV is in Image mode. The information displayed on the video screen changes depending on the mode you select (next page):



1. Video image area (see page 12).

2. Adjustable Crosshairs.

3. Small box marks area of image you select with crosshairs as the background when making stellar magnitude measurements or separation measurements.

4. Small cross marks the first star or location you select when making stellar magnitude measurements or separation measurements.

5. Date displayed below image area in Image Mode and Idle Mode.

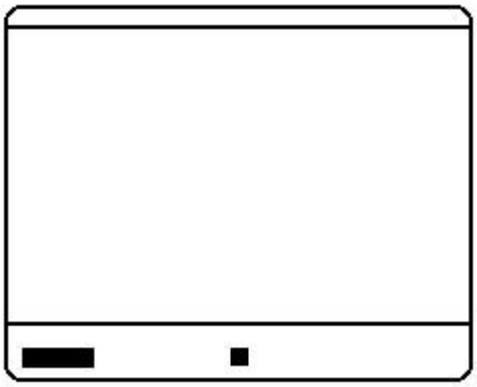
6. Time displayed below image area in Image Mode.

7. Value in arc seconds or arc minutes of image scale bar displayed in eFinder mode and Display mode.

8. Image scale bar displayed in eFinder mode and Display mode. Scale is based on focal length entered in set up menu and the zoom level currently displayed.

9. Moving cursor travels across bottom of screen from left to right taking one step after each exposure in Focus, Image and Monitor modes.

10. "Gas gauge" indicator showing progress of single exposures of 3 seconds or longer. For shorter exposures this indicator remains solid.



Focus Mode:

Only the exposure indicators are displayed in focus mode.

The "gas gauge" indicator remains solid and the small cursor moves to indicate continuous exposures in progress. The longest exposure possible in Focus mode is 2.5 seconds with the zoom level set to Normal (see Tech Note below).

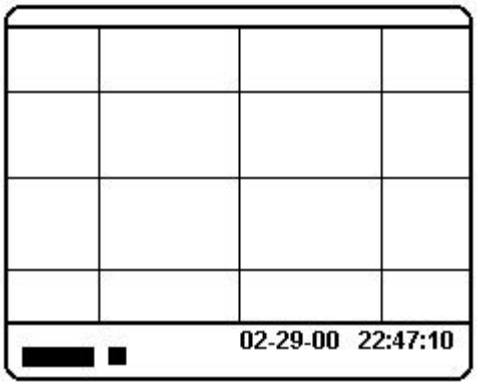
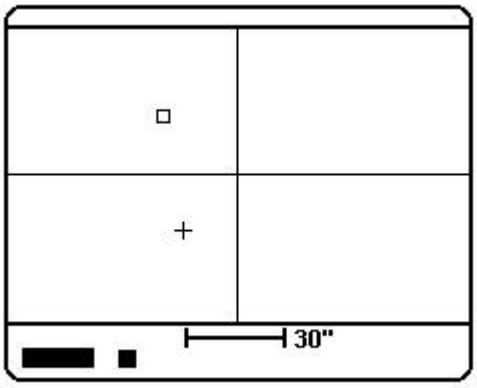


Image Mode:

The date and time are displayed in addition to the exposure indicators. The grid may be turned on or off in the set up menu (default is off).

The "gas gauge" indicator shows exposures in progress for exposures of 3 seconds or longer. The small cursor moves one step from left to right after each exposure. Exposure times from .001 to 600 seconds are possible in Image mode.

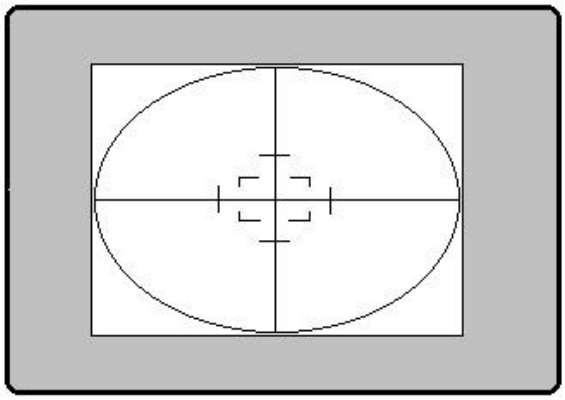


Display / Crosshairs / eFinder Mode:

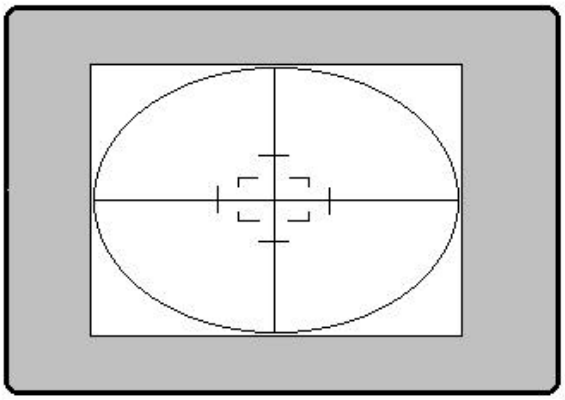
In Display mode the video image and the exposure indicators are frozen. The adjustable crosshairs may be turned on or off. The small box marks the location you select as the background and the small crosshair marks the location you select as the first star for stellar magnitude and separation measurements.

In eFinder mode the video screen looks the same as crosshairs mode with adjustable crosshairs except that the image is continuously updating. The exposure indicators operate as they do in Image mode

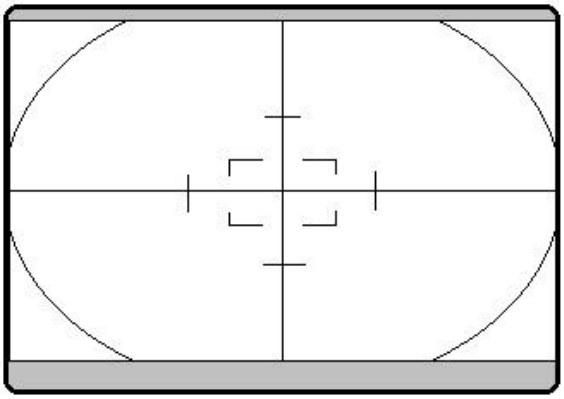
TECH NOTE - Exposure Times and Zoom Level: The STV has three electronic zoom levels: Normal, Zoom and Wide. When the zoom level is set to Normal, the central 640x400 pixels of the CCD are binned 2x2. When the zoom level is set to Zoom, the central 320x200 pixels are displayed unbinned (1x1). When the zoom level is set to Wide, the entire array of 656x480 pixels is binned 3x3. Binning pixels increases the sensitivity as a function of the area of the pixel. What this means is that if the exposure time seems about right when you have the zoom level set to Normal, and you then switch the zoom level to Zoom or Wide, the sensitivity changes as well. To compensate for this fact, the STV automatically adjust the exposure times when you switch between zoom levels to equalize the sensitivity. This keeps the image brightness on the video screen about the same when you toggle between zoom levels. Throughout this manual where reference is made to exposure times, operation in Normal mode is assumed. For instance, in Focus mode the maximum exposure time allowed is 2.5 seconds with the zoom set to Normal. However, if you set the zoom level to Wide the maximum time is 2.2 seconds (.88X Normal) and if you set the zoom level to zoom the maximum time is 5.0 seconds (2X Normal).



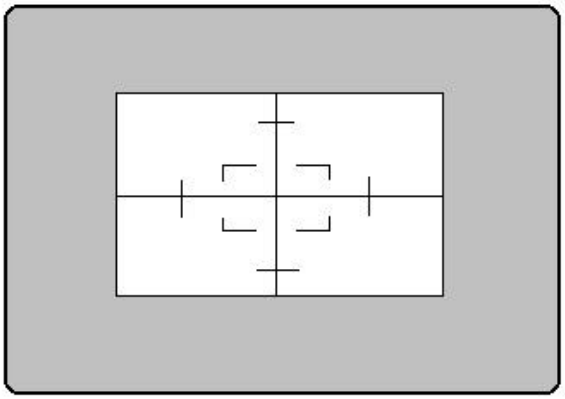
Wide + Full: The entire 656x480 pixels are binned 3x3 and displayed in a window in the center of the video screen. This gives the widest field of view and is the most sensitive mode. Best for imaging large dim objects



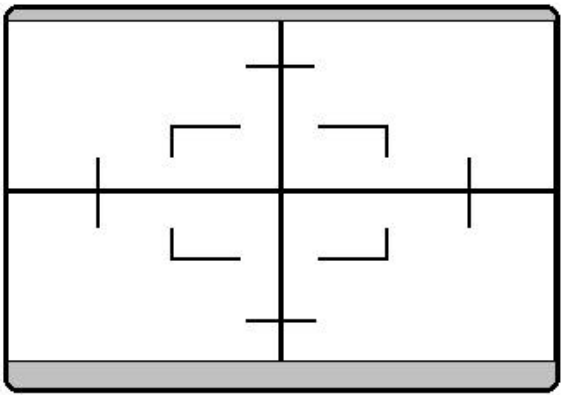
Wide + Partial (focus only): Same as Wide + Full except every other line is displayed every other frame. This increases the update rate by approximately 2X. Best for finding and centering dim objects.



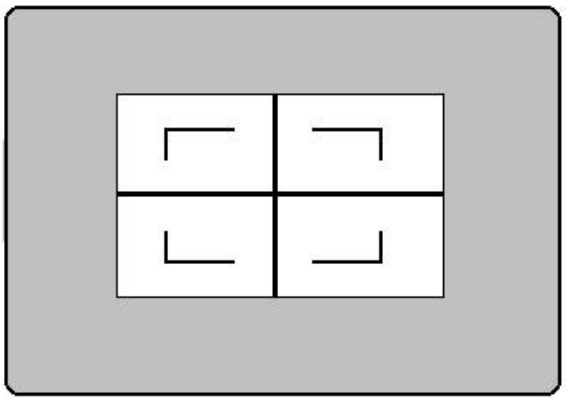
Normal + Full: The central 640x400 pixels are binned 2x2 and displayed to fill the video screen horizontally. Good balance of sensitivity and resolution. Good mode for galaxies.



Normal + Partial (focus only): Same as Normal + Full except only the central 60% of the image is displayed. This increases the update rate by about 2X.



Zoom + Full: The central 320x200 pixels are displayed unbinned (1x1) to fill the video screen horizontally. This mode has the lowest sensitivity and highest resolution. Best for moon and planets.



Zoom + Partial (focus only): Same as Zoom + Full except only the central 60% of the image is displayed. This increases the update rate by about 2X. Best mode for critical focusing.

Chapter 5. Operation

This Chapter describes the operation of the STV in detail.

Power Up

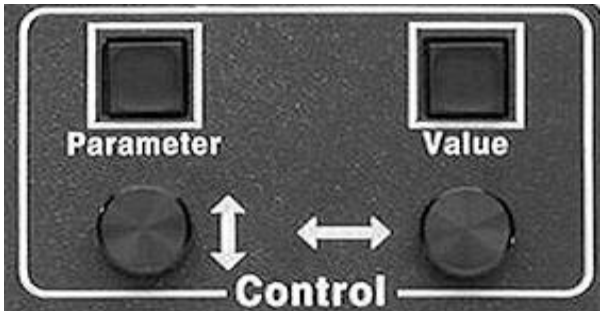
When you first turn on the power to the STV, the camera will initialize, flash the ROM version and then you will see a display similar to this:

```
Filter=Open   Please set
+12.2c ♦  70%  Date/Time
```

The diamond shaped symbol will blink at first indicating that (a) the TE cooler is active and (b) the STV is seeking the optimum operating temperature. The STV will automatically set an optimum operating temperature according to the ambient temperature. Once the temperature of the CCD has stabilized the diamond symbol will stop blinking.

The information format on the display above is divided into a left and right section. Generally this corresponds to menu items and values that are adjusted by pressing the **Parameter** and **Value** buttons immediately below the display or by scrolling through the menus with the rotary knobs located just below the **Parameter** and **Value** buttons. Setting the date and time demonstrates the relationship of the buttons and knobs just below the display to the information and menu items shown on the display. In the display shown immediately above, the left section of the display shows the position of the internal filter wheel, the CCD temperature and the percent of power the TE cooler is drawing in order to or maintain the temperature of the CCD. You can override this automatic temperature setting in the main SETUP menu if you wish. On the right of the display you are prompted to set the current date and time. The STV will remember the date and time the STV was last used but it does not have an internal battery operated clock so you must set this each time you power up. You can ignore the date and time setup and the STV will function normally but your images will not have a correct date and time stamp on them. You can set or change the date and time whenever you like by pressing the SETUP button and entering the setup menu. To set the current date and time after power up hit the **Value** button under the words "Please set Date/Time" and you will enter the DATE/TIME SETUP menu similar to this:

```
DATE/TIME SETUP
Month                 1
```



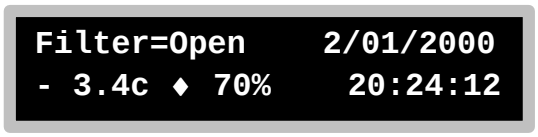
Date / Time Setup Tips:

Use the left (**Parameter**) button or the left control knob to scroll up and down through the menu items: Month, Day, Year, Hour, Minute, Second. Use the right (**Value**) button or control knob to scroll left and right through the values for each of the menu items.

When you have entered all the current information down to the second the display will prompt you to **Sync Time Do It!** At this point you can press the **Value** button to sync the time to the nearest second based on a reference source such as WWV, the Phone Company or an external clock.

When you have entered all of the date and time information you will see the following display:

Hit the **Value** button to synchronize the time to an external source. The STV will set its clock and after a second or two show a display similar to this:



You will note that this is similar to the display appearance at power up but now the date and time are shown and the temperature of the CCD will probably be lower than when you first turned on the power.

Setup

You can enter the SETUP menu at any time by pressing the Setup button on the STV control panel. The Setup menu contains a number of items in addition to the date and time. The STV will remember some of the items the next time you power up the camera but the date and time information will be saved only as of the time the camera was turned off. This is why there is also a separate prompt to enter the date and time at power up. The items contained in the Setup menu are as follows:

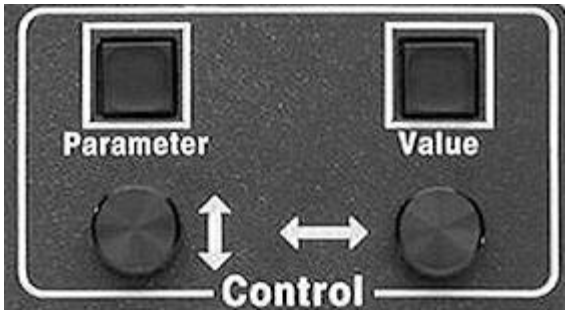
MAIN MENU	**VALUES**
Date/Time	Set month, day, year, hour, minute, second
CCD Temperature	Set temperature to a given value greater than -50 (degrees C).
Grid	On / Off (displays a grid overlay in image mode for manual guiding)
Night Vision	On / Off (turns the video image predominantly red)
Filter	Yes / No (rotates an internal filter over the CCD for ~20x attenuation of light)
Units	Inches / cm
Focal Length	Enter your scope's focal length (0.01 to 600)
Aperture Diameter	Enter your scope's aperture diameter (0.01 to 600)
Telescope	Refractor / Reflector (a Schmidt-Cassegrain is a reflector)
Magnitude Corr.	Enter correction factor for calibration of magnitudes (+5.0 to -5.0)
Site	Enter site ID number from 1 to 255 for inclusion in the image header
Beep	On / Off
Adjust Filter	Adjust the threshold value for the filter wheel opto sensor
Video	► [takes you to the VIDEO SETUP MENU]

VIDEO MENU	**VALUES**
Mode	NTSC / Internal PAL / External PAL / Off (set video format or turn it off)
Date/Time	On / Off (turns the date/time display on the video screen on or off)
Test Pattern	► [displays a test pattern for adjustment of an external video display]
Gray Scale	► [displays a gray scale for adjustment of an external video display]

In the same way that you set the Date/Time when you powered up the STV, once you have pressed the **Setup** button, you can scroll through the setup menu items by pressing the **Parameter** button or by turning the rotary know directly under the **Parameter** button. Likewise you may select or change the value for any given men item by pressing the **Value** button or by turning the rotary knob directly under the **Value** button.

For illustration let us assume you wish to use the Night Vision Mode for the video display. You press the **Setup** button to enter the setup mode and then scroll through the menu items using the **Parameter** button or the rotary knob directly under the **Parameter** button until you see the following display:

```
STV SETUP
Night Vision          Off
```



You would then press the **Value** button under the word "Off" or turn the rotary knob directly under the **Value** button until the display reads:

```
STV SETUP
Night Vision          On
```

Notice that repeatedly pressing the **Value** button or turning the rotary knob directly under the **Value** button toggles the Night Vision mode On and Off. There is no additional step required to "save" the setup values because the STV automatically saves the last value entered until you change it. When you have set a particular value in the setup mode, you may simply exit the setup mode by pressing any other button on the STV control panel.

Use the same procedure to select and set any item in the Setup menu:

Date / Time: Set or change the date and time. You are also prompted to enter this information at power up of the STV (the STV does not have an internal battery operated clock so the date and time information must be entered whenever you power up the STV CPU). The STV will remember the last date and time you used the STV so it is usually only necessary to update the day and time when setting up for an imaging session. If you leave this information blank, the STV will operate normally but the date and time information will not be displayed on the video screen and there will be no date or time of observation recorded in the headers of saved images. It is not necessary to set the date or time when using the STV as an autoguider only.

CCD Temperature: The STV will automatically pick an operating temperature when you power up the CPU. The STV will attempt to run at the lowest temperature it can achieve using 70% power to the TEC (thermoelectric cooler). If the head warms up during the imaging session and the TE cooler power

approaches 100% you should re-set the temperature to a higher number so that the % figure remains about 70 to 80. If the night cools off you can set the temperature to a lower number.

Grid: When set to "on" the STV will overlay a grid on the video image when the STV is in Image Mode. The grid is three vertical and three horizontal lines, making 9 intersections on the video screen. These 9 intersections make handy cross hairs for manual guiding. Default setting is "off."

Night Vision: When set to "on" the video image is colored red. Default setting is "off."

Filter: There is an internal filter wheel in the STV head containing a green filter. When this menu item is set to "on" the filter is rotated into place over the CCD. The green filter is useful for imaging the moon as it attenuates the light by about 20X. You should set this to item to "on" if you are imaging the moon and the image is saturated at the shortest exposure time. The filter is also useful for making more accurate measurements of stellar magnitudes because it passes light in the middle of the visual spectrum. The filter position is indicated on the alphanumeric display at power up. Also, since the filter greatly attenuates the light reaching the CCD, a reminder is displayed if you attempt to take images longer than 2 seconds with the filter in place. Default setting is "open." [Note: Filter glass causes a slight shift of focus. If you focus first and then set the Filter to "On" you should re-focus the camera].

Units: Set this to "inches" or "centimeters" at your discretion. When you enter values for Focal Length and Aperture this item dictates whether the Focal Length and Aperture values are in inches or centimeters. Default setting is "inches."

Focal Length: Enter the focal length of your telescope in inches or centimeters (depending on the "Units" selected in the previous menu item). The focal length of your telescope is calculated by multiplying the diameter of the aperture by the f/ratio. For example, an 8" f/10 telescope usually refers to a telescope that has an aperture of 8" and a focal ratio of 10. In this example the focal length is 8" x 10 = 80". Note that a 6" f/8 telescope and an 8" f/6 telescope both have the same focal length (48 inches).

Aperture Diameter: Enter the diameter of your telescope's primary objective (lens or mirror).

Telescope: Select either reflector or refractor. Many catadioptric telescopes (Schmidt-Cassegrain, Maksotov, etc.) have elements of both a refractor and a reflector. If your telescope uses a mirror anywhere in the optical path, chose "reflector."

Magnitude Correction: Enter a correction factor (+5.0 to -5.0) to be added or subtracted when making magnitude measurements. Use this item to fine tune the STV to your optical system. For example, if you calibrate on a star with a known visual magnitude of 10.7 and the STV reports it as 10.2 then you would set this item to +0.5.

Site: Enter a site identification number from 1 to 255. This is an arbitrary number for your reference only. If you routinely observe from more than one location and you wish to record a site ID, this number will be saved in the image header so that in you can identify where you were when you took the image.

Beep: Turns on and off the tone heard when pressing keys on the control box. Default setting is "on."

Adjust Filter: Adjust the threshold for the shutter sensor. See Appendix E, page 54 for details.

Video: Selects the Video Sub-Menu:

Mode: Select NTSC, Internal PAL or External PAL. NTSC is the standard video mode for the US and Japan. PAL is commonly used throughout Europe. Internal PAL refers to the built-in video screen and External PAL refers to an external video monitor. Default setting is "NTSC."

Date/Time: Set to "off" if you do not want the Date and Time to be displayed on the video screen. Default setting is "on."

Test Pattern: Displays a geometric test pattern for adjustment of an external video screen.

Gray Scale: Displays a gray scale for adjustment of an external video screen.

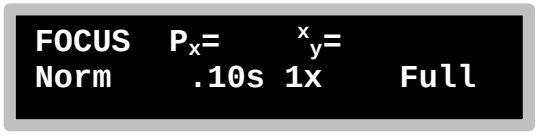
Having set the date and time and other setup items you are now ready to start capturing images. The first thing you need to do is focus the camera. Enter the Focus mode by pressing the **Focus** button once. You will see a focus setup display similar to the following:

You can adjust the initial sensitivity by pressing the **Value** button or turning the rotary knob directly under the **Value** button. Select a sensitivity value between 1 and 16 and press the **Focus** button again. Now you will see a display similar to this:

The **focus display** shows the following information:

FOCUS = you are in focus mode
Norm = zoom level is normal (Normal, Zoom, Wide) [1]
.10 s = exposure time is .10 seconds (1ms to 2.5 seconds) [1]
1x = the camera gain is set to 1x (1x, 2x, 4x, 8x, 16x)
Full = the image size is full (Full or Partial)

In focus mode, both of the rotary knobs perform the same function: to increase or decrease the exposure time and gain of the camera. The range of exposure times is 1 millisecond to 2.5 seconds with a zoom setting of Normal.[1] The gain is increased or decreased only when the exposure time is at .25 seconds. Try turning either of the rotary knobs and watch the resulting change in exposure times and sensitivity. Also note that when you have increased the exposure time to .25 seconds and the gain to 4x the display adds some additional information:



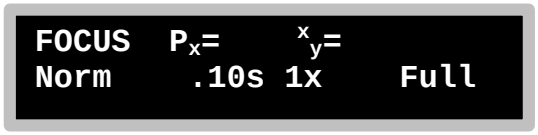
P_x = peak value of brightest pixel on the CCD (maximum 1023 with zoom set to Normal)[2]
x_y = X and Y coordinates of the brightest pixel on the CCD (e.g., 154, 265)

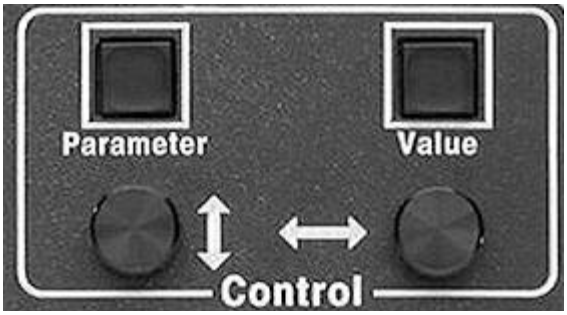
Because it takes some processing time to display this additional information, it is not displayed at exposure times shorter than .25 seconds in order to keep the video screen updates as rapid as possible for visual focusing. However, this information is particularly helpful when using the STV as a stand alone autoguider without any video display. In this case, when the video screen is set to "Off" in the Video Setup menu, the peak value and location of the brightest pixel are displayed at all exposure times.

---

1. In order to maintain a similar level of sensitivity when switching between zoom modes, the exposure time is automatically adjusted to compensate for the different modes. See Tech Note, page 11 for details.

2. In Focus mode, the maximum counts with zoom level set to "Wide" is 767, and with zoom level set to "Zoom" is 1023.





Focusing Tips:

Note the location of the words "Norm" and "Full" on the display and in relation to the buttons below the display.

Pressing the **Parameter** button will toggle the Zoom mode: Norm, Zoom, Wide.

Pressing the **Value** button will toggle the image size on the video screen: Full or Partial.

These functions may be invoked in any combination to select, for instance, a video image that is Zoom and Partial or one that is Wide and Full (See **page 12**). Selecting Zoom and Partial will increase the update rate and give the highest resolution. This will make visual focusing easier.

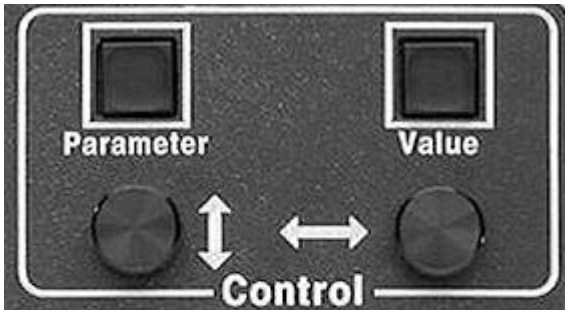
Image

Pressing the Image button once takes you to the Image Setup menu. You will see a display similar to this:

You can toggle through the Image Setup menu items by pressing the Parameter button or by turning the rotary dial under the Parameter button. For each menu item on the left-hand side of the display a range of values may be selected on the right-hand side of the display by pressing the Value button or by turning the rotary dial under the Value button. The Image Setup items are as follows:

Image Setup Items	**Function**
Exposure:	Set exposure from 0.001 to 600 seconds
Gain:	Set gain 1X or 2X
Zoom:	Set the zoom level to Zoom, Normal or Wide (See Tech Note page 11)
Dark Subtract:	Select Yes or No
Mode:	
Continuous:	Continuously takes and displays images
Snap:	Takes a single image
Track & Accum:	Takes a Track & Accumulate Image
Mosaic (Lg):	Automatically takes a series of 6 cropped images and makes a mosaic
Mosaic (Sm):	Automatically takes a series of 40 cropped images and makes a mosaic
Best Sharp:	Updates image only when it is sharper than the sharpest already seen
Best Peak:	Updates image only when a peak value is higher than the highest already seen
Auto Grab:	Takes and saves a series of full frame mages
Auto Grab Interval:	Sets the interval the STV pauses between exposures during auto grab

After setting or changing any Image Setup item, press the Image button again to begin capturing images. If you want to go directly to **Image Capture** mode without changing any Image Setup item, simply press the Image button twice and the STV will initiate image mode. You will see a display similar to this:



In Image Capture Mode (unlike focus mode) the rotary knobs do not change the exposure time of the image. Rather, the exposure time is selected in the Image Setup Menu and the rotary knobs control the brightness and contrast of the image. The display shows small circular arrows prompting you to adjust the Brightness and Contrast to suit your monitor. Pressing the Parameter button in Image Mode will toggle through the zoom levels. Pressing the Value button has no effect in Image Mode.

Each of the Image Setup Menu Items and Values are explained in detail below:

Exposure: Set the exposure time from 0.001 seconds to 600 seconds.

Gain: Set the gain of the camera 1x or 2x. In general, use 1x for bright objects like the moon and use 2x for dim objects like galaxies.

Zoom: Set the initial zoom level to Zoom, Normal or Wide. The zoom mode can also be toggled between Zoom, Normal or Wide by hitting the Parameter button during continuous updates while in Image mode without having to return to the setup menu. Changing the zoom level will automatically adjust the exposure time to compensate for the difference in sensitivity (See Tech Note on page 11).

Dark Subtract: Yes or No. If set to No the STV does not take a dark frame. When taking short exposures (e.g., less than one or two seconds) it will speed up the video rate if you do not take a dark frame. For longer exposures, a dark frame is recommended. When set to Yes, the STV automatically takes a dark frame by rotating the internal shutter to the closed position and taking an image. The STV will then automatically subtract the dark frame from each subsequent light frame that is of the same exposure time and zoom setting. Changing the exposure time or zoom setting will cause the STV to automatically take a new dark frame.

Mode: Continuous, Snap, Track&Accum, Mosaic (Lg), Mosaic (Sm), Best Sharp, Best Peak, Auto Grab:

Continuous*:* The STV will continuously take and display images. The actual frame rate is somewhat slower than normal video and (depending on the mode and exposure time you select) you will notice the frames updating on the video monitor. Using a short exposure time, no dark subtract, zoom mode will give the fastest video updates for focusing and planetary observations.

Snap: The STV will take a single image.

Track&Accum (Track & Accumulate - US Patent 5,365,269): The STV will automatically take, register and co-add a series of images. You see the image density and brightness build up on the video monitor in real time as each subsequent image is added to the accumulated composite of all the previous images. This mode is a useful alternative to guiding because the STV will register each new frame on a common reference star of your selection in the original frame. Small shifts caused by telescope drive errors are compensated for by this process and the resulting Track & Accumulate image is nearly as good as a long single guided exposure.

When you take a Track & Accumulate series, the STV automatically closes the shutter and takes a dark frame at the beginning of the sequence. This dark frame is stored in the STV's internal memory and it will be subtracted from each subsequent light frame in the sequence. After the dark frame is captured, the shutter rotates to the open position and the first light frame is captured. The first light frame is displayed and the brightest star is highlighted with a shrinking box. The display will look similar to this:

It is usually OK to use the guide star that is automatically selected by the STV. However if the brightest star happens to be near the edge of the image or very near another star you should manually select a bright star that is located away from the edge of the frame so that it is not lost during the sequence. You can select a different guide star by moving the highlighted box around the image using the STV's rotary knobs. When you are ready to start the sequence, select "Next" by pressing the **Value** button on the STV control panel.

As each light frame is captured during the Track & Accumulate sequence, the STV will co-add the frame to the accumulated image seen on the video monitor. You will see the composite image build up after each exposure. When you are satisfied with the density of the image press the Display button to stop the process and examine the result. You can also save the image by pressing the File Ops button and selecting Save from the File Ops Menu.

Mosaic (Lg): The STV takes a series of 6 images, each cropped to the central 104 x 98 pixels and arranges the result is a mosaic of a single frame of two rows and three columns. Mosaic is useful for taking planetary shots where a wide field of view is not so important and momentary changes in seeing are difficult to anticipate. By automatically taking a series of exposures your chances of capturing one or more during a moment of best seeing are increased and you may later crop the mosaic to keep the best of the lot. There must be at least one empty memory slot available to take a mosaic image. The time each image is taken is saved in a text file for reference.

Mosaic (Sm): The same as Mosaic (Lg) mode except that the STV takes a series of 40 images, each cropped to the central 40 by 40 pixels and arranges the result in a mosaic on a single frame of five rows and eight columns. The time each image is taken is saved in a text file for reference. In either Mosaic mode, unless you stop it, the STV will keep making mosaics until all the available memory slots are full. (See also Auto Grab Interval for setting the interval between exposures).

Best Sharp: The video frame is bifurcated and begins with the same image displayed on both sides. The image on the left half of the video frame is updated continuously but the image on the right half of the video frame is updated only when subsequent images are sharper than the one stored in temporary memory. The central 100 x 100 pixels are used to determine the FOM. This mode works best on planets. In Best Sharp (and Best Peak) mode you will see a display similar to this:

FOM stands for "Figure of Merit" and is a relative number assigned by the STV. The FOM is only used for comparing the current image to the last image for sharpness.

Best Peak: Same as best sharp except the image on the right half of the video display is updated only when subsequent images have a peak pixel value higher than the last highest value. This mode works exceptionally well on double stars. The entire image is scanned for the highest peak value.

Auto Grab: The STV automatically takes and saves a series of full frame images. See Auto Grab Interval, below.

Auto Grab Interval
This sets the time delay between exposures taken during an Auto Grab or Mosaic modes. This interval may be set from 0.1 seconds to 60 seconds.

Monitor

As with Focus and Image modes, pressing the Monitor button once takes you to the Monitor Setup Menu where you select the monitor mode you wish to use. Pressing the Monitor button again initiates the monitor mode you have selected. There are five monitor modes:

Monitor Setup Menu Item	Function
eFinder	The STV operates as an electronic finder with adjustable cross hairs
Optical Quality	Compares your optical system to a theoretically perfect system
Drive Monitor Fast	Graphs your drive's periodic error (RA and DEC) sampling every .2 seconds
Drive Monitor Slow	Graphs your drive's periodic error (RA and DEC) sampling every 2 seconds
Seeing Monitor	Measures atmospheric seeing independent of drive errors and optical quality

When you first press the Monitor button you should see the eFinder Setup display. If you see another monitor mode displayed you can cycle through the five monitor modes by pressing the Parameter button or turning the rotary knob under the Parameter button until you have selected the monitor mode you want. The STV will remember the last mode selected.

eFinder

If you select the eFinder mode you should see a display similar to this:

The small arrow pointing to the right on a display indicates a submenu is available by pressing the Value button under the arrow. In this case, pressing the Value button takes you to the eFinder Setup Menu. You should see a display similar to this:

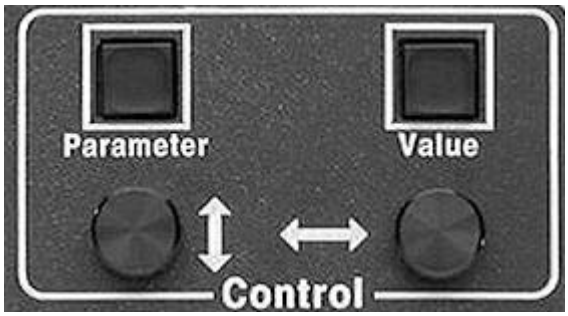
Press the Parameter button or turn the rotary knob under the Parameter button to scroll through the eFinder SETUP menu items:

eFinder SETUP

Menu Item	**Value**
Exposure	0.001 to 600 seconds
Zoom	Zoom, Normal, Wide
Flip	Horizontal, Vertical, Both, None

Exposure and Zoom functions are the same as Image mode. The Flip feature allows you to adjust the orientation of the image on your video monitor to match your main optical system or printed finder charts.

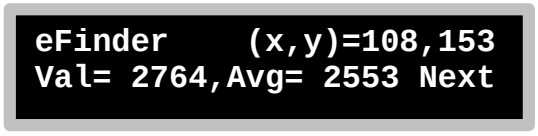
When the eFinder SETUP items are set the way you want them, press the Monitor button again. You will see a display similar to this:



eFinder TIP

When mounted on a telescope, the eFinder becomes an electronic finderscope with a field of view of 2.7 by 2.0 degrees. This image scale makes comparison of the displayed image with a star chart very easy. The combination is sensitive enough to show any star in Uranimetria with a 3 second exposure. The eFinder mode is different from Imaging mode in that crosshairs are projected onto the scene. The crosshairs are moveable, allowing one to center an object through the main telescope, and then position the crosshairs on it, boresighting the two assemblies.

At this point you can use the rotary knobs to adjust the brightness and contrast of the Finder image. Press the Parameter button to set the zoom level (Zoom, Normal, Wide). When the zoom, contrast and brightness are set the way you like them press the Value button to set the cross hairs. When the cross hairs are first turned on the display changes to show the cross hair position and the pixel value under the intersection as well as the average pixel value for an 11x 11 box of pixels centered on the crosshairs. The display will look similar to this:



Use the rotary knobs to adjust the position of the cross hairs as you would adjust the cross hairs of any finder scope. When the cross hairs are positioned where you want them, press the Value button under the word “Next” on the display and the STV will automatically update the video image using the settings you have selected. The display will revert to the previous eFinder display, similar to this:

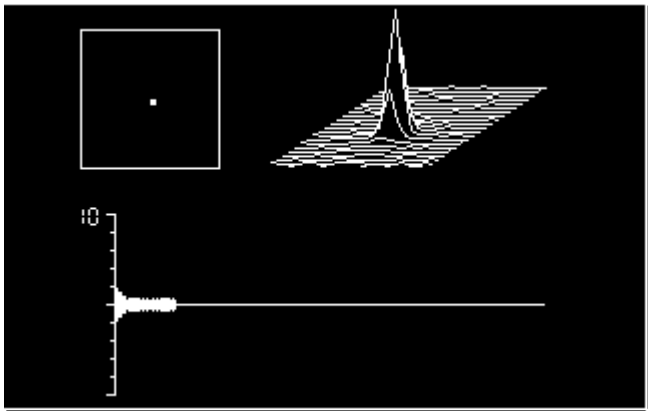
The video screen will show the cross hairs superimposed on the image and the image will update continuously. If you wish, you can change the zoom setting or the cross hair position by pressing the Parameter button or the Value button respectively. If you need to change the exposure time or any other parameter in the eFinder Setup Menu press the Monitor button to return to the eFinder Setup Menu, change the item(s) as needed and press the Monitor button again to return to resume the eFinder mode. For further description of the eFinder refer to Appendix C, page 48.

Optical Quality

If you select the Optical Quality mode from the Monitor Setup Menu you will see a display similar to the following:

```
MONITOR SETUP
OPTICAL QLTY      Do It!
```

Press the **Value** button and the STV captures a star image, displays it in a small box on the video screen above a graph and begins measuring the optical quality of your system. Selection of the star and exposure times is automatically calculated by the STV. A graph of the results is displayed on the video screen similar to the sample below:



OPTICAL QUALITY MONITOR TIPS

Perform this measurement only on nights of exceptional seeing. Chose a relatively bright star high in the sky. The Optical Quality mode measures optical image quality independent of seeing and drive problems. The way it does this is by taking many very short exposures and reporting the "best" stellar widths it measures. The assumption is that drive errors are insignificant over short times, and seeing occasionally allows one to see the full performance of the optical system. This last assumption is only valid on a good night. See **Appendix C, page 49**, for details.

When the graphic information is on the video screen you can toggle on the 3 dimensional graph of the star profile by hitting the **Value** button again. Displaying the 3D graph will slow the update rate. As the graph is updating, the alphanumeric display provides the quantitative data:

```
OPTICAL QLTY.   Exp=50ms
FWHM= 2.6^s  Strehl= 72%
```

In this example the STV is using an exposure time of 50 milliseconds, the FWHM (Full Width Half Maximum) of the star image is 2.6 arcseconds and the Strehl ratio of the optical system compared to a theoretically perfect system is 72% *(Reminder: You must accurately set your telescope's focal length and aperture diameter in the Setup Menu before using this function)* .

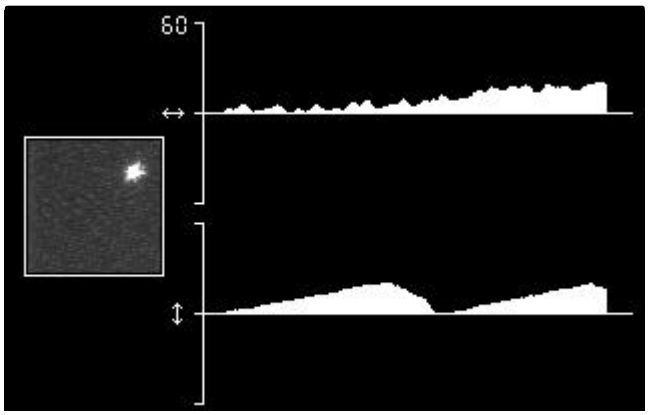
For an explanation of the theory and calculations behind the Optical Quality Monitor mode see Appendix C, page 49.

Drive (fast) and Drive (slow)

When you select the Drive Monitor mode, the display will appear similar to the following:

```
MONITOR SETUP
DRIVE (fast)      Do It!
```

Select Drive (fast) or Drive (slow) by toggling the **Parameter** button or turning the rotary knob directly under the **Parameter** button. When ready, press the **Value** button to start the Drive monitor function you have selected. The STV will automatically adjust the exposure time to capture star images by taking sample exposures and measuring the results. When the best exposure time is calculated, the STV will capture an image and select the brightest star in the frame. A shrinking box will briefly highlight the selected star. At the fast rate, the star's centroid is determined every 200 milliseconds. The fast rate is best for measuring high frequency drive or mount vibrations. At the slow rate the star's centroid is determined every 2 seconds. The slow rate is best for measuring the drive's periodic error. The video screen will show a graph similar to the screen shot below:



DRIVE MONITOR TIPS

When the guide star is selected the STV assigns a brightness value to the star. If the brightness falls to a low level the message "Dim" will appear on the top line of the alphanumeric display in place of the Exposure time. If the star saturates the CCD, the message "Bright" will appear. If the guide star is lost or moves too close to the edge of the CCD, the message "Off CCD" will appear. **See Appendix C, page 50,** for details.

The alphanumeric display will report the following information:

```
DRIVE (fast)    Exp=50ms
RMS xy= 2.1, 1.9  arcsec
```

The graph shows the position of the star with time. In fast mode the STV reports the exposure time and the RMS (root mean square) variation in X and Y over the last 16 points. In slow mode the STV reports the peak to peak variation since you began the measurement.

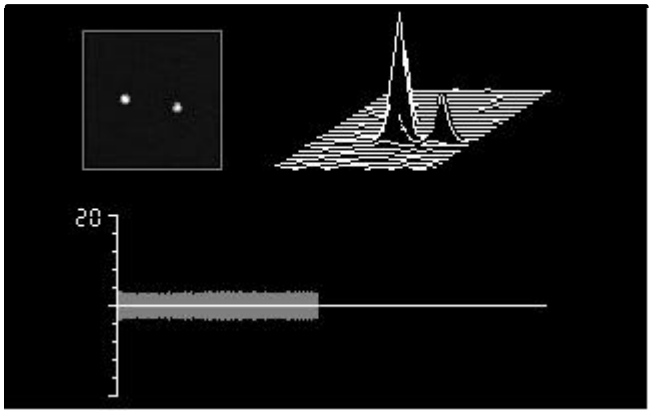
For a more explanation of the theory and calculations behind the Drive Accuracy Monitor mode see Appendix C, page 50.

Seeing (DIMM)

The Seeing Monitor mode uses a Differential Image Motion Monitor (DIMM) technique to measure your seeing conditions independent of your system's optical quality and drive errors. In order to use the Seeing Monitor mode you must make a two-hole aperture mask for your telescope and follow the other special instructions found in Appendix C, page 51. When you have properly set up your telescope for this measurement, select the Seeing Monitor mode. The display will show:

```
MONITOR SETUP
SEEING (DIMM)     Do It!
```

Enter the seeing monitor mode by hitting the Value button. The software will automatically find the stars, adjust the exposure, and start collecting data. It can be quite impressive seeing how the two images move relative to each other! A graph will appear on the video screen similar to the following:



SEEING MONITOR TIPS:

Once the graph of the error vs. time is on the video screen you can toggle on the three dimensional stellar profile graph by hitting the Value button. When the 3-D graph is active the video update rate is slowed. Hitting the Value button again pauses the 3-D graph and increases the video update rate.

A proper two-hole mask is required to take seeing measurements. Place the mask over the aperture so that the out of focus star images are oriented approximately horizontal on the video display. See **Appendix C, page 51** for details.

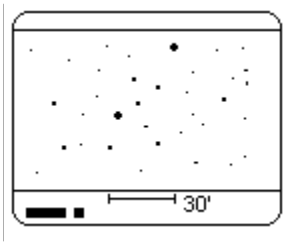
Once the graph is displayed on the video screen you can toggle on the 3-D stellar profile graph by pressing the **Value** button. When the 3-D graph is added to the display the video update rate is slower. Pressing the **Value** button again pauses the 3-D graph and speeds up the video update rate. The software will report the seeing as the Full Width Half Maximum in arcseconds of a long exposure stellar image (> 5 to 10 seconds). It uses the RMS relative motion of 32 images to calculate the result, so the result does not appear for a short time after the mode is entered. The alphanumeric display will appear similar to the sample below with the exposure time selected by the STV, the separation of the two star images in arc seconds and the FWHM in arc seconds calculated by the DIMM technique:

```
SEEING (DIMM)   Exp=96ms
Sep=1.33^s   FWHM= 3.2^s
```

For more information about the Seeing Monitor mode theory and calculations please refer to Appendix C, page 51.

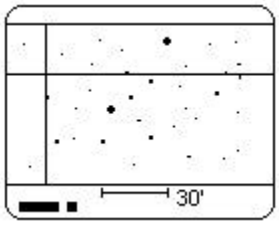
Display / Crosshairs

Press the **Display/Crosshairs** button anytime there is an image on the video screen to stop the video image from updating and to enter the Display/Crosshairs mode. The video screen will add a scale bar under the image and the alphanumeric display will indicate you are in Display mode :



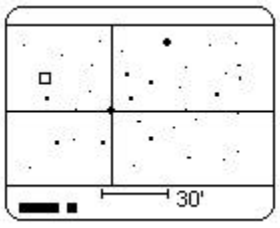

```
DISPLAY     Adjust Image
 Auto Cont.        Next
```

Hit the **Parameter** button to have the STV adjust the contrast of the image automatically, or use the rotary knobs to manually adjust the brightness and contrast. Hit the **Value** button to bring up a set of adjustable crosshairs superimposed on the video screen:




```
DISPLAY      Select Back
Val= 414, Avg= 426  Next
```

The alphanumeric display prompts you to select an area of the image for the background measurement. Use the rotary knobs to move the crosshairs to an area of the image that is relatively dark and devoid of stars. As you move the crosshairs you will notice that the values change on the alphanumeric display. "Val" is the value (or brightness) of the pixel located directly under the crosshair. "Avg" is the average pixel value for an 11 x 11 pixel box centered on the crosshair. When you have positioned the crosshairs to a background location, press the **Value** button again. You will see a small box mark the location you selected for the background and the alphanumeric display changes:

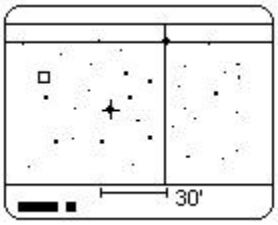



```
DISPLAY     Select Pos.1
Mag=+ 4.05          Next
```

```
DISPLAY        Val= 1728
Mag=+ 4.05          Next
```

The alphanumeric display now displays the calculated magnitude of any object you place under the crosshairs. You are prompted to select the first position for a separation measurement. As soon as you begin to move the crosshairs the alphanumeric changes to also show the peak value of the pixel directly under the crosshair. This is helpful in centering the crosshair accurately on a star image that may cover several pixels and make sure that the star is not saturated. Use the rotary knobs to position the crosshairs over the first of two stars you wish to measure. When you have located the

first star, press the **Value** button once more and you will see a small cross mark the star you selected. The alphanumeric display will prompt you to select the second star position:




```
DISPLAY     Select Pos.2
Sep=XX'XX",Ang=XXXº Next
```

```
DISPLAY       Mag=+ X.XX
Sep=XX' X",Ang=XXXº Next
```

As soon as you begin to move the crosshairs the alphanumeric display changes to indicate the angular separation relative to the first star as well as the magnitude of the position under the crosshairs.

It should be noted that before you can obtain accurate magnitude and separation measurements you must properly enter your telescope's focal length and aperture in the Setup menu. This focal length and aperture information is stored in the image at the time the image is captured. Display Mode uses the information found in the image to report measurements so this data must be accurately entered in the Setup menu before you capture the image.

If, based on known reference stars, you find that you consistently get magnitude measurements that are somewhat too high or too low, you may make adjustments to the magnitude readings by entering a magnitude correction factor in the Setup menu. If you find that the measured separations are off, measure a wide, known double and adjust the focal length to get the correct answer. If you save an image from the Crosshairs mode, only the image data (not the crosshairs or markers) are saved. However, you can **Recall** (Pg. 28) any image in memory image and invoke the crosshairs to perform the same measurements using the steps outlined above.

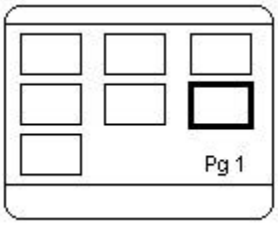
File Ops

Press the **File Ops** button to enter the File Operations menu. Once in the File Ops mode, repeatedly pressing the Parameter button or turning the rotary knob directly under the Parameter button will toggle through the following File Ops menu items:

File Ops Menu Item	**Function**
Save	Save an image in the STV's internal flash memory
Recall	Recall an image from the STV's internal flash memory
Download	Download the image currently displayed to a computer
Download All	Download all the images in the STV's memory to a computer
Slide Show	Displays each image in memory in slide show fashion
Erase One	Erase one image from the STV's internal flash memory
Erase All	Erase all images from the STV's internal flash memory
Baud Rate	Sets the baud rate for the serial connection to the PC
Test Comm	Tests the communication with the PC

Save

From the **File Ops Setup** menu, turn the rotary knobs or toggle the **Parameter** button until the Save command is displayed. Select Save by hitting the **Value** button. The STV will bring up a page of image thumbnails or empty slots on the video screen.



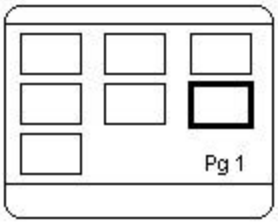
Turn the rotary knobs to move the highlight box from slot to slot and then press the **Value** button again to save an image in the selected slot. There may be more than one page of image thumbnails and if you continue to move the highlight box after it reaches the first or last image on the video screen, the next page available will be displayed.

As you turn either rotary knob the highlight box will scroll through all of the memory slots and you will see thumbnails of the saved images on the video screen. If a slot contains an image the date and time the image was taken will appear on the alphanumeric display. If a slot is empty the word "Empty" appears on the display.

When you have selected a slot, press the Value button and the image will be saved in that slot. If the slot you select already contains an image the new image will overwrite the old image.

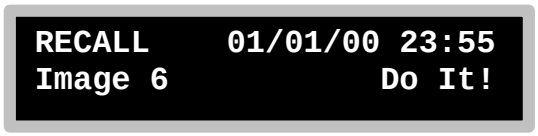
Recall

From the **File Ops Setup** menu, turn the rotary knobs or toggle the **Parameter** button until the **Recall** command is displayed. Select **Recall** by hitting the **Value** button. The STV will bring up a page of image thumbnails or empty slots on the video screen.



Turn the rotary knobs to move the highlight box from slot to slot and then press the **Value** button again to recall an image in the selected slot. There may be more than one page of image thumbnails and if you continue to move the highlight box after it reaches the first or last image on the video screen, the next page available will be displayed.

As you turn either rotary knob the highlight box will scroll through all of the memory slots and you will see thumbnails of the saved images on the video screen. If a slot contains an image the date and time the image was taken will appear on the alphanumeric display. If a slot is empty the word "Empty" appears on the display.



When you have selected an image, press the **Value** button and the image will be recalled to the video screen and displayed full size.

Download

From the **File Ops Setup** menu, turn the rotary knobs or toggle the **Parameter** button until the **Download** command is displayed. The alphanumeric display will show:

Hit the Value button to download the image currently displayed on the STV to your PC. *Note: In order to download images to your PC you must be running STV REMOTE software on your PC. For complete instructions please refer to Chapter 6, page 37.*

Download All

From the **File Ops Setup** menu, turn the rotary knobs or toggle the **Parameter** button until the **Download All** command is displayed. The alphanumeric display will show:

Select **Download All** by hitting the **Value** button. The STV will download all of the images in its internal memory to your PC. *Note: In order to download images to your PC you must be running STV REMOTE software on your PC. For complete instructions please refer to Chapter 6, page 37.*

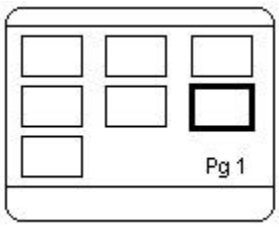
Slide Show

From the **File Ops Setup** menu, turn the rotary knobs or toggle the **Parameter** button until the **Slide Show** command is displayed. Select **Slide Show** by hitting the **Value** button. The alphanumeric display will show the following:

You may select **Auto** or **Next**. If you select **Auto** by pressing the **Parameter** button, the STV will automatically display each image in its memory with a short pause after each image is displayed. If you select **Next** by pressing the **Value** button, the STV will display each image in its memory, however it will pause after each image until you hit the Value button again.

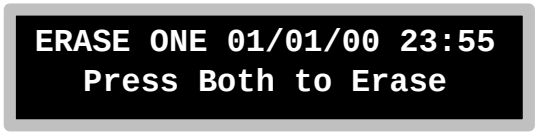
Erase One

From the **File Ops Setup** menu, turn the rotary knobs or toggle the **Parameter** button until the **Erase One** command is displayed. Select Erase One by hitting the **Value** button. The STV will bring up a page of image thumbnails or empty slots on the video screen.



Turn the rotary knobs to move the highlight box from slot to slot and then press the **Value** button again to select an image to erase. There may be more than one page of image thumbnails and if you continue to move the highlight box after it reaches the first or last image on the video screen, the next page available will be displayed.

As you turn either rotary knob the highlight box will scroll through all of the memory slots and you will see thumbnails of the saved images on the video screen. If a slot is empty the word "Empty" appears on the display. If a slot contains an image, the date and time the image was taken will appear on the alphanumeric display. When you have selected the image to erase, press the Value button and the STV will prompt you to press both the Parameter button and the Value button at the same time.



This extra step helps prevent the accidental deletion of an image.

Erase All

From the **File Ops Setup** menu, turn the rotary knobs or toggle the **Parameter** button until the **ERASE ALL** command is displayed. Select **ERASE ALL** by hitting the **Value** button.

The STV will prompt you to press both the **Parameter** button and the **Value** button at the same time to erase all the images in the STV's internal memory.

Baud Rate

From the **File Ops Setup** menu, turn the rotary knobs or toggle the **Parameter** button until the **BAUD RATE** command is displayed. Toggle a baud rate by pressing the **Value** button or by turning the rotary knob under the Value button. The range is 115.2K to 9600.

This is the baud rate at which the STV will communicate with your remote computer over the serial link. It does not affect the STV's operations in stand alone mode. The STV will attempt to establish a link at the baud rate you have selected, so you should try it at the highest rate to begin with. However, if you experience difficulty maintaining a reliable link (particularly if you are using a long serial cable), then try adjusting the baud rate to a lower setting.

Test Comm

From the **File Ops Setup** menu, turn the rotary knobs or toggle the **Parameter** button until the **TEST COMM** command is displayed. If you experience communication problems with a remote computer you can use this command to test the RS232 port on the STV and the connection to your remote computer. You will need to run a simple terminal program on the remote computer to perform this test.

Hit the **Value** button to test the RS232 port on the STV and the alphanumeric display will show:

At this point anything you type on the computer keyboard should be echoed back from the STV to the remote terminal window.

Calibrate

Calibration is a prerequisite for autoguiding. It is the process whereby the STV learns how much and in what direction it should move your telescope to correct for the drift of a guide star that it is tracking. You must complete a successful calibration before you can use the Track function. When you press the Calibration button you are presented with the Calibrate Setup menu. You have two options: Auto and Full-Menu. If you are a beginner, the Auto mode is recommended. If you have experience using an autoguider like the ST-4 then you may be more comfortable setting some of the calibration items manually. The Calibrate Setup menu contains the following items:

Calibrate Setup Menu Items	**Function**
Mode	Select Auto or Full-Menu.
Move	Moves the telescope in four directions so you can test your relay cable
View Results	Displays the results of the calibration process for each move it made
Full-Menu	
Exposure	Select an exposure time (0.001 to x seconds)
Calibrate Time	Select the amount of time the STV will move in each direction (0.1 to 60 sec)
Relays	Select the relays the STV will use (1234 or 12 or 34)

Mode

Auto: If you select Auto, the STV will do all the work:

Press the **Calibrate** button again and the STV will take an exposure, measure the brightness of the stars in the image, adjust the exposure time as necessary and finally mark up to eight stars in the image to follow through the calibration process. The STV will remember the relative brightness and positions of the calibration stars it marks and it will automatically set the calibration time. After each move the STV will check to see if at least a majority of the stars it marked in the previous step are still present in the image. If the STV does not see a majority of the stars it marked on the previous move it will display the error message: "Star Field." This helps assure that the calibration process does not move the telescope so far that the reference star moves off the CCD. The calibration time the STV selects is determined by the focal length of your telescope, so it is important that you set this item accurately in the Setup menu (Page 16). Since the STV will select the brightest stars in the field in auto mode, you should be careful not to position a star on the CCD that is too bright for calibrating. Very bright or saturated stars can sometimes get recognized incorrectly as multiple stars.

Full Menu: If you select Full-Menu, the process is the same except you may set the exposure time, calibration time and select the relays instead of letting the STV set these items:

Exposure: Set an exposure time from 0.001 seconds to 600 seconds

Cal. Time: Set a calibration time from 0.1 seconds to 60 seconds. This is the amount of time the STV will close each relay to move the telescope for the purpose of calibrating the drive speeds. This time

should be long enough to see a star move at least 10 to 20 pixels but not so long that the star moves off the CCD.

Relays: Select 1234, 12 or 34. 1234 means that all four relays are exercised. 12 means that just relays 1 and 2 are exercised. 34 means that just relays 3 and 4 are exercised.

When you have set the items in the Full Menu, press the **Calibrate** button again to start the calibration process. The STV take an image and report the number of stars it is using for calibration and initial position of the brightest star:

```
CALIBRATE        Stars 8
Initial:  Star x,y 219, 78
```

As the STV moves the telescope the alphanumeric display provides the following information:

```
CALIBRATE        Mv=10.0
Relay 1:  Star x,y 150, 84
```

In this example, the calibrate move time is 10.0 seconds, relay 1 has completed its move and the new location for the brightest star is pixel x=150, y=84.

If the STV does not detect motion in one direction (or too little motion) it will abort the calibration process and give message: "Error: No Move."

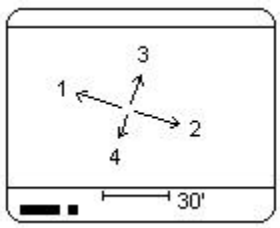
Move

Use the **Move** function simply to test the relays and the relay cable connection to your telescope. When you select Move and tell the STV to "Do It!" the STV will present you with Relay 1: and prompt you to "Do It!" You can toggle through each of the four relays by pressing the Parameter button or by turning the up-down rotary knob. Press the Value button when ready to move a relay. The STV will close the relay for 5 seconds and indicate that it is MOVING. You should be able to see the motion of the telescope using a high power eyepiece.

View Results

After a successful calibration, the relative speed and direction of the motion detected for each relay is indicated in a graphic display on the video screen. The alphanumeric display will also report that the calibration passed. In the graphic display the orientation of the arrow indicates the direction of the move and the length of the arrow indicates the relative speed:

```
CALIBRATE        Passed!
Relay 1: 4.91, 279° Next
```



In this example the STV reports that when Relay 1 was activated the measured speed was 4.91 arcseconds per second in the compass direction of 279 degrees as seen on the video screen (straight up as seen on the video screen is 0 degrees, straight down is 180 degrees, etc.,). You can toggle through the factors for each relay by hitting the **Value** button. *Note: the STV calculates the correction rate in arcseconds per second based on the focal length you have entered in the Setup menu. If you change the focal length of your system you must recalibrate.*

If, instead of "Passed!" the alphanumeric display contains the message "Angles?" or "Speeds?" then the calibration is suspect and you are prompted to check the angels of motion or the speeds of the drives to determine if there is a problem. Unlike earlier autoguiders, The STV will calibrate with the camera head in any orientation, even if the X and Y directions are oriented at a 45 degree angle to the mechanical axis of your telescope. However, it assumes that the angles it will see for RA and DEC motion will be approximately at 90 degrees relative to one another. It also assumes that the drive speeds in different directions do not differ by more than a factor of about 4X. You can override these assumptions by using the Full-Menu mode.

Track

After you have successfully completed the calibration process the STV is ready to autoguide. Hit the **Track** button to enter the Track Setup mode. Like Calibration mode, you have two setup options: Auto and Full-Menu. The Track Setup menu contains the following items:

Track Setup Menu Items	**Function**
Mode	Select Auto or Full-Menu.
Relay Tone	Toggles on/off a tone given by the STV when a relay is activated
Full-Menu	
Exposure	Select an exposure time (0.001 to 600 seconds)
Guide to	Select a star, Last position or Cursor
Aggress. X	Sets the aggressiveness of corrections in the X axis
Aggress. Y	Sets the aggressiveness of corrections in the Y axis

Mode

If you select **Auto**, the STV will do all the work. It will take an exposure, measure the brightness of the stars in the image, adjust the exposure time as necessary, select a guide star, set the Aggressiveness factor to 1 and start autoguiding.

If you select **Full-Menu**, you may set the exposure time, select a guide star or pixel location, and set the aggressiveness for corrections in each axis:

Exposure: Set an exposure time from 0.001 seconds to 600 seconds

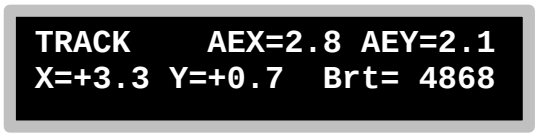
Guide to: **Sel. Star:** (Select a Star) If you chose "Select Star" then you may move a highlight box around the video screen to select any guide star in the field of view.
Last Pos: (Last Position) If you chose "Last Position" then the STV will move the current guide star to the location of the previous guide star position before it starts autoguiding.
Cursor: If you chose "Cursor" then the STV will move the current guide star to the cursor location that you position on the video screen before it starts to autoguide.

Aggress. (X): Sets the "Aggressiveness" of the STV in making corrections in the X axis. Select a value from 0 to 2.0. The default value is an aggressiveness of 1 which means that the STV will make the exact move it calculates it needs to make to return the guide star back at its initial position. An aggressiveness of 0.5 means that the STV will make half of the move it thinks it needs to make for every correction and an aggressiveness of 2 means that it will make twice the move it thinks it needs to make. Use this feature to fine tune the STV's guiding accuracy. Selecting a number lower than 1.0, for instance, will help reduce oscillation or over correction. If you set this number to 0 the STV will not make any corrections in that axis.

Aggress. (Y): Same Aggress. (X), but applies to corrections in the Y axis.

In Auto mode the Aggressiveness is always set to 1. In Full-Menu mode, the aggressiveness for X an Y may be independently changed using the left and right rotary knobs respectively while the STV is autoguiding.

When you start to track, the alphanumeric display will show the following information:

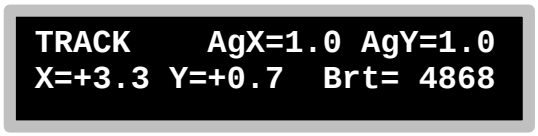


Track: You are in Track mode
AEX: Average error in X in arcseconds (running average over the last 16 moves)
AEY: Average error in Y in arcseconds (running average over the last 16 moves)
X: Instantaneous error in X in arc seconds
Y: Instantaneous error in Y in arc seconds
Brt: The relative brightness of the guide star

If the brightness of the guide star falls below 50% of its initial value, the STV will give a warning beep and display the message "DIM" on the top line of the alphanumeric display.

The STV will continue to autoguide, however, for as long as it can detect the guide star. If the guide star is saturating the CCD the STV will give a warning beep and display the message "Bright." If the guide star is lost or moves too close to the edge of the CCD the STV will give a warning beep and display the message "Off CCD."

If you are in full-Menu mode, as soon as you turn either of the rotary knobs, the AEX and AEY data are replaced with the Aggressiveness setting:



In this way you can adjust the aggressiveness and immediately see the effect in the guiding errors reported by the STV as it continues to track. As you change the aggressiveness values, you can see the effect on the instantaneous errors in X and Y. After 16 corrections, the average error data (AEX and AEY) will return in place of the Aggressiveness values.

If you are using auto mode, the rotary knobs have no effect and the aggressiveness remains set at 1.0 during autoguiding.

Tech Note: When the STV is tracking, after each exposure it will send the calculated centroid position of the guide star over the RS232 port. If you run a simple terminal program on your remote computer you can capture the data in ASCII format for analysis.

Relay Tone

This simply turns on or off a tone that is given out by the STV whenever a relay is activated. This audible reference can be handy when you are letting the STV autoguide without having to watch it. The length of the tone is proportionate to the error. Short tones = good guiding. Long tones = poor guiding.

Interrupt

Pressing the Interrupt button will stop any function in progress and toggle through the following steps:

Press **Interrupt** once to freeze any image on the video screen and return the alphanumeric display to the default status: Filter position, date, time and CCD temperature.

Press **Interrupt** again to blank the video screen.

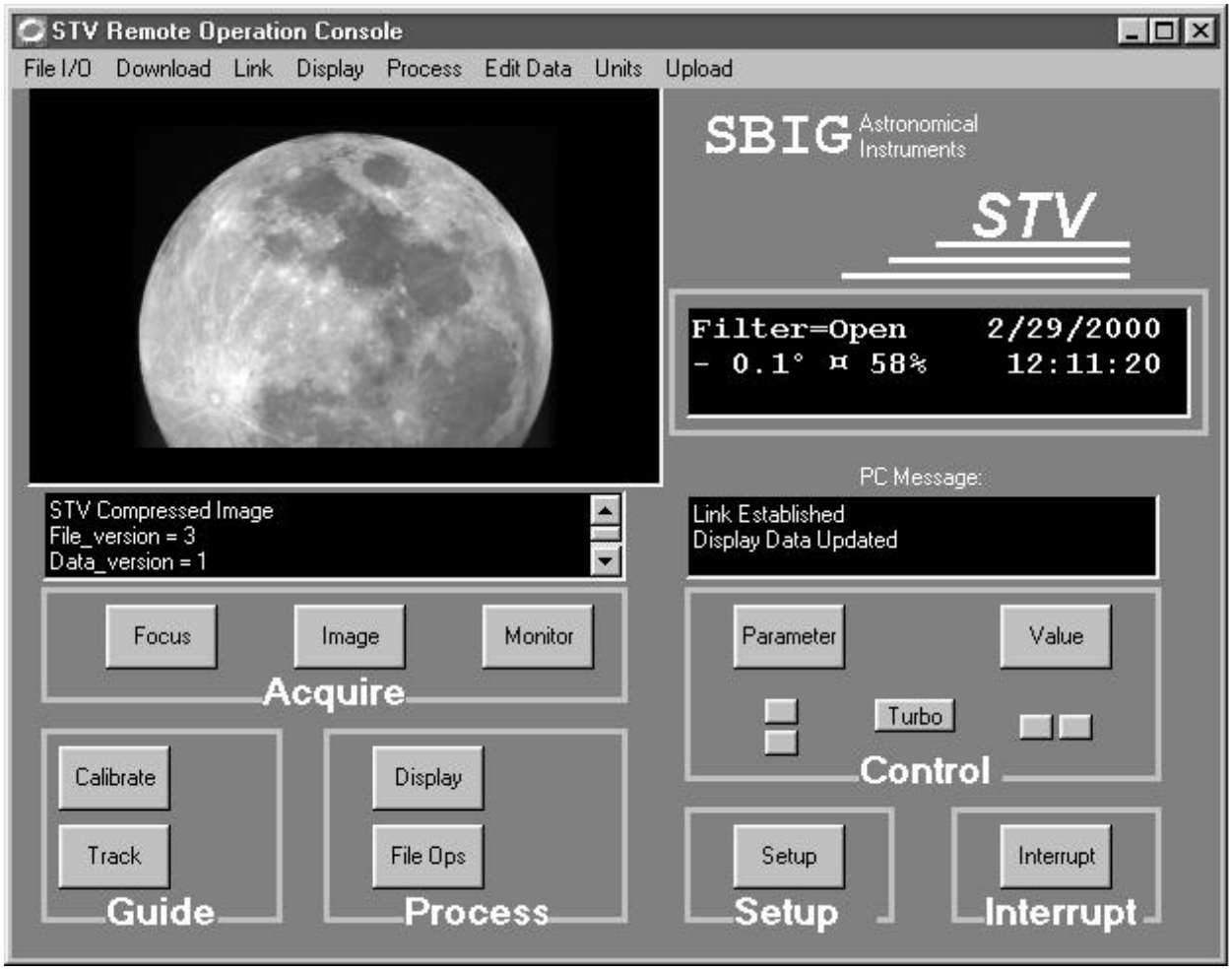
Press **Interrupt** again to redisplay the video image.

If you hold down the Interrupt button while turning on the STV power switch the STV will report that it is ready to receive a firmware update over the RS232 port.

If you hold down the Interrupt + Parameter buttons the STV will set all menu parameters to their default values.

Chapter 6. Remote Operation

A PC may remotely control the STV. To transfer images to a PC or to remotely control the STV a serial cable must be connected between the Serial I/O (RS232) port on the STV and COM1 or COM2 serial port on a PC. The PC must be running the STV REMOTE software under Windows 95/98. This section describes the software installation procedure and operation.



Software Installation

Start Windows 95/98. After Windows has started and you see your Windows desktop, insert Disk #1 into Drive A (or the appropriate 1.44 MB floppy drive on your computer). From your Windows Start Menu, select Run. When you get the pop up dialog box, type in A:\setup.exe (or substitute the appropriate drive letter for your floppy drive). Click OK. Follow the setup instructions that appear on the screen. The installation process will create a menu item on your Program Menu labeled STV. After a successful installation you can run the STV REMOTE program by clicking on the STV icon from your Program Menu. You should see a screen similar to the one above.

STV Remote Console Layout

When you run STV REMOTE software you will see a virtual copy of the STV control panel on your computer screen similar to the sample screen shot on the pervious page. Updates or modifications to the software will undoubtedly occur in the future so your screen may appear slightly different from the sample screen shot in the manual. For the most part, any function that you can perform by pressing buttons on the STV control panel can also be performed by clicking on the corresponding button on your computer screen. However, there are some differences:

1. The STV REMOTE console has two additional windows for display of data, one for display of image header information and one for display of PC messages and crosshair information.

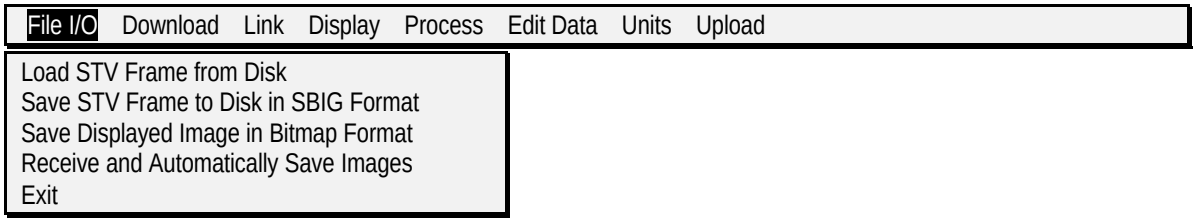
2. The STV REMOTE console has a Turbo button that can be toggled to increase the rate at which the virtual rotary buttons make the crosshairs move on the video screen.

3. The STV REMOTE console has a menu bar across the top of the panel with pull down menus. These pull down menus and commands are described in detail in the next section of the manual.

4. The STV REMOTE console will display digital images downloaded from the STV as well as STV images previously saved to a disk on your computer. However, the STV REMOTE console does not display a live video image. In order to view the video image as you control the STV from a remote computer you must run a video cable from the STV control box to a video monitor near your computer.

STV Remote Console Menus

The STV REMOTE console contains several simple pull down menus for handling images from the STV and for remotely controlling the camera. This section describes each menu item:



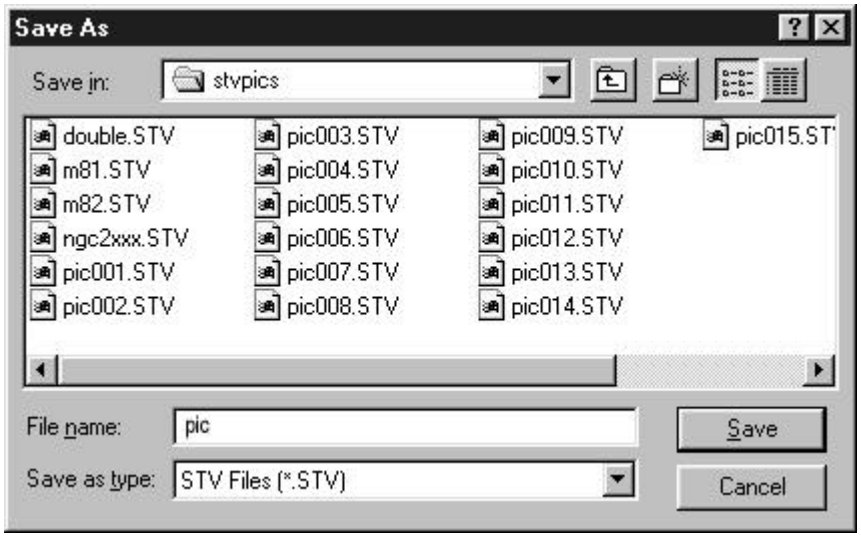
Load STV Frame from Disk:
Use this command to view an STV image that has already been saved on your computer's hard drive or a floppy disk

Save STV Frame to Disk in SBIG Format:
Use this command to save the image that is currently displayed on the STV REMOTE console screen to your computer's hard drive or floppy disk. The image will be saved in SBIG compressed format. Saving all of your images in SBIG format is recommended because this will preserve the image bit depth (up to 16 bits) and will also preserve the header information. STV compressed image files are approximately 66 Kbytes. SBIG image compression utilizes a routine that does not degrade the image data but saves disk space. The latest versions of CCDOPS for DOS and CCDOPS for Windows 95/98/NT will also read

STV image files. You can therefore use CCDOPS to save the original STV images in 8 or 16 bit TIFF, FITS or several other common image file formats.

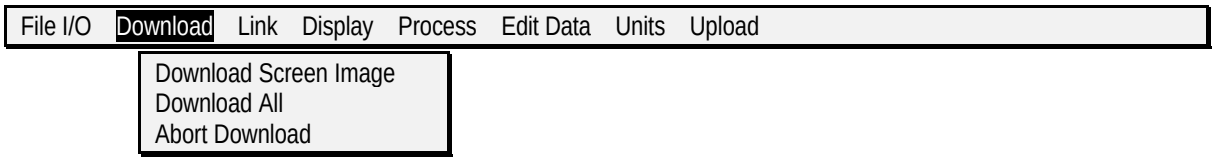
Save Displayed Image in bitmap Format:
Use this command to save an image that in bitmap format. It is important to adjust the contrast of the image before saving in bitmap format because bitmap image files are only 8 bits while the original STV files are a minimum of 10 bits and may be up to 16 bits (depending on the binning mode and whether you used Track & Accumulate). STV bitmap image files are approximately 192 Kbytes. Although bitmap image files are only 8 bits and take up more disk space, this option is included because many third party image processing software programs will read *.bmp files. It is recommended that you always save the original images in SBIG format as this will preserve the header information that is automatically saved with the image. Then, if you wish to export an image to another program for processing, save the image again under another name in bitmap format or use CCDOPS to save the image in any of several other formats. This way your original image data will be preserved as an archive in the event that your image processing efforts accidentally destroys or corrupts the image you are working on.

Receive and Automatically Save Images:
This command sets up the PC to receive images from the STV. This command must be invoked before you can automatically transfer images from the STV to the unattended remote computer. The program will prompt you to enter a file name:



Once you have entered a file name and clicked the "Save" button on the dialog box, all image files received from the STV will use the file name you selected plus an appended number sequence. For example if you type the file name "moon" the images received thereafter will automatically be named moon001.stv, moon002.stv, etc.

Exit:
Exits and closes the STV REMOTE program.

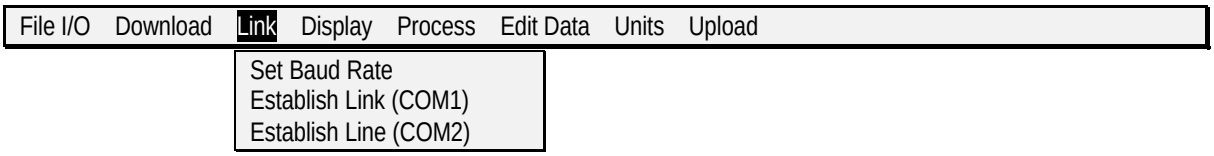


Download Screen Image: Use this command to download the image that is currently displayed on the STV's video screen. The image that is currently on the STV's video screen may be a new image that you just captured or it may be any image that you have RECALLED from the STV's internal flash memory. This command will cause the STV to transfer the image via the serial port to your computer

where it will be displayed on the STV REMOTE console screen. It will not automatically be erased from the STV's flash memory, nor will it be automatically saved on your computer. You must use one of the save commands if you wish to keep the image on a disk on your remote computer.

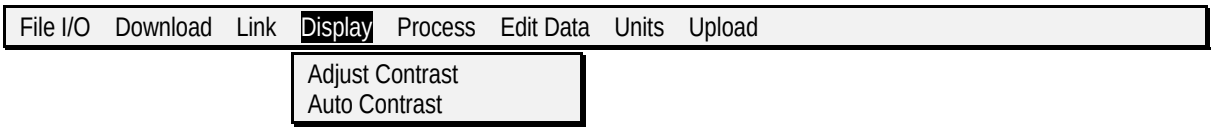
Download All: Use this command to initiate a complete transfer of all the images in the STV's memory. The result is the same as using the DOWNLOAD ALL command from the STV File Ops menu. A dialog box will appear prompting you to enter a file name. The files will be transferred, saved and named using the same naming convention as the Receive and Automatically Save Images command**.**

Abort Downalod: Stops a download in progress.

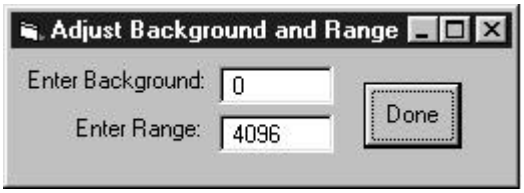


Set Baud Rate: Chose the fastest baud rate that gives reliable communication with your PC. If you find you have trouble maintaining a link at the highest rate, particularly if you are using a long serial cable, try manually selecting a lower setting.

Establish Link (COM1 or COM2): STV REMOTE will only work over your computer's COM1 or COM2 port.

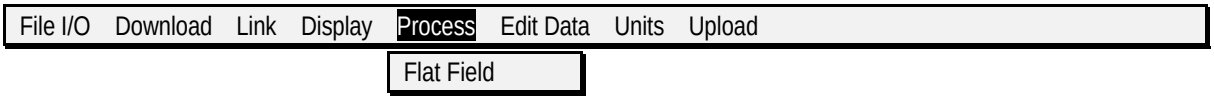


Adjust Contrast: When an image is displayed on the STV REMOTE screen, use this command to manually adjust the contrast (background and range). When you select this menu item you will get a pop up dialog box similar to the example below:



Use this dialog box to enter or change background and range settings of the displayed image. It may be easier to use the Auto Contrast command (below) the first time the image is displayed and then manually adjust the values assigned by the program in order to bring out different details.

Auto Contrast: Select this item to have the STV REMOTE program automatically set the contrast (background and range) of the image displayed. Thereafter you can manually adjust these values by using the Adjust Contrast command.



Flat Field: Use this command when an image is displayed that needs a flat field correction applied to it. *This assumes that you have taken a good flat field image and saved it with a unique name that you can easily identify as a flat field image (See Appendix D, page 53)*.

Follow these steps to make a flat field correction to an STV image:

1. Select the light image you wish to correct and display it on the STV REMOTE console screen.

2. Once the light image is displayed, select the Flat Field command from the Process menu.

3. You will be presented with a dialog box for selection of the flat field image you wish to use. Select the flat field image from your list of saved images.

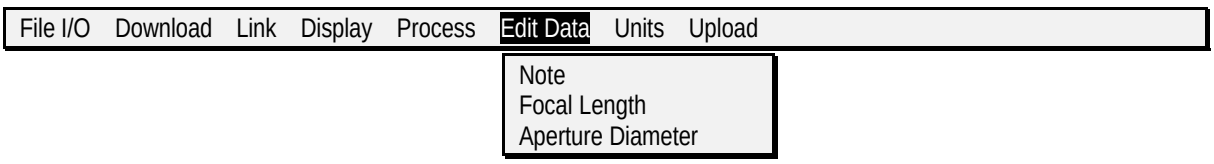
4. When you select the flat field image, it will replace the light image on the STV REMOTE console screen momentarily. After a moment, then the light image will automatically be process and the results will be displayed.

5. If you are satisfied with the results of the flat field correction, you must save the image to preserve the processing you have just done.

Flat Field Tips:

If you find that flat field corrections are necessary due to vignetting effects, CCD sensitivity variations, or for more accurate measurements of star magnitudes, try either taking an image of the twilight sky near the horizon or take an image of a blank wall or neutral grey card. When a sensitive detector such as the TC-237 in the STV is used at fast f/ratios, a circular brightening of the sky background sometimes appears near the center of the image. This is an effect often caused by a focal reducer that can be eliminated with a good flat field.

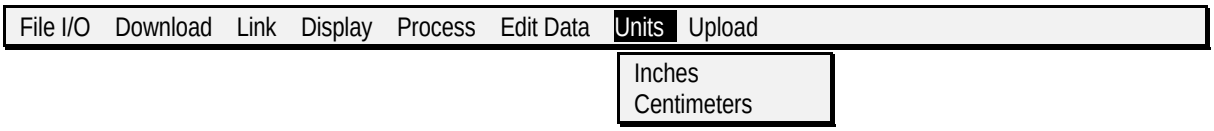
Finding areas of the sky devoid of stars is very difficult after twilight. Therefore, you should take flat field images of the night sky after sunset, but not long before you can see any stars. Remember that the STV will see stars before you do. If this is not possible, take an image of a featureless wall or card held in front of the telescope. However, if using this method be sure that the card is evenly illuminated. **Appendix D, page 53**, describes how to do this. You will know if the flat field is good if the sky background in your images has little variation across the frame after flat fielding, displayed using high contrast. A good flat field image can only be obtained with the camera in exactly the same position in the telescope as the light image you are correcting. If you remove the camera after taking a light image and try to reposition it to take a flat field image, the flat field image may not give very good results.



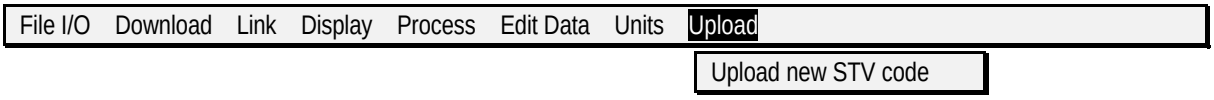
Note: This item allows you at add a note to the image file currently displayed.

Focal Length: Set or change the Focal Length parameter in the image file currently displayed.

Aperture Diameter: Set or change the Aperture Area parameter in the image file currently displayed



Units: Set or change the units (Inches or Centimeters) used to describe the focal length and aperture measurements.



Upload new STV code: Use this command to upload a new firmware version over the RS232 port. Typically, as SBIG releases a new version of the code, you will download a file from the SBIG web site or obtain a file on a disk. The new code will be a file named EXECXXX.BIN (or something similar) where XXX is the new version number. Then, when you have the new file saved on your PC's hard drive you will:

1. Hold down the Interrupt button on the STV while turning on the power switch.

2. Wait until the STV displays the message: "Send Flash Upgrade".

3. From the STV REMOTE software console running on your PC, select this menu item: "Upload new STV code".

4. Wait while the STV receives the new code.

5. The display will show a "gas gauge" indicating the progress of the programming.

6. When the upgrade is complete, the STV will automatically reset and go into idle mode (the default mode when you turn on the power switch).

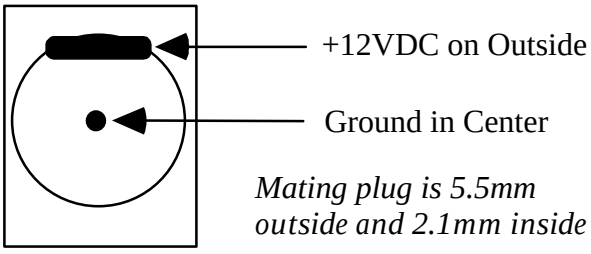
Appendix A - STV Specifications

Camera Specifications

Video Output:	NTSC Standard - 525 horizontal lines with 720 pixels / line PAL Standard available as a menu option
Image Modes:	Normal = 640 x 400 binned 2x2 Wide = 656 x 480 binned 3x3 Zoom = 320 x 200 binned 1x1
Image bit depth:	10 bits for 1x1 binning mode Up to 16 bits for other binning modes and Track and Accumulate images
Exposure times:	0.001 to 600 seconds
Cooling:	Single stage thermoelectric -25 degrees C from ambient
Power Requirements:	12VDC, 2 amps
Head Weight:	16oz (0.4kg)
Head Dimensions:	3.25 x 1.75 inches (8.3 x 4.4 cm)
CPU Weight:	4lb (1.8kg) with LCD, 3.2lb (1.4kg) without LCD
CPU Dimensions:	11.6 x 9.4 x 2.6 inches (29.5 x 23.7 x 6.7 cm)

Battery Operation

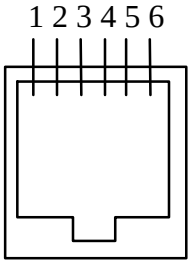
The STV will run from any 12VDC source such as a car battery. The pin configuration for the STV power plug is shown in the diagram below.



Caution: The STV will draw approximately 2 amps of current, which can drain a car batter to low levels over the course of an evening. It may be wise to use a separate battery to run the STV if you intend to image for any significant length of time, particularly if you are also running an external monitor and/or telescope mount from the same battery. Deep discharge marine batteries are recommended.

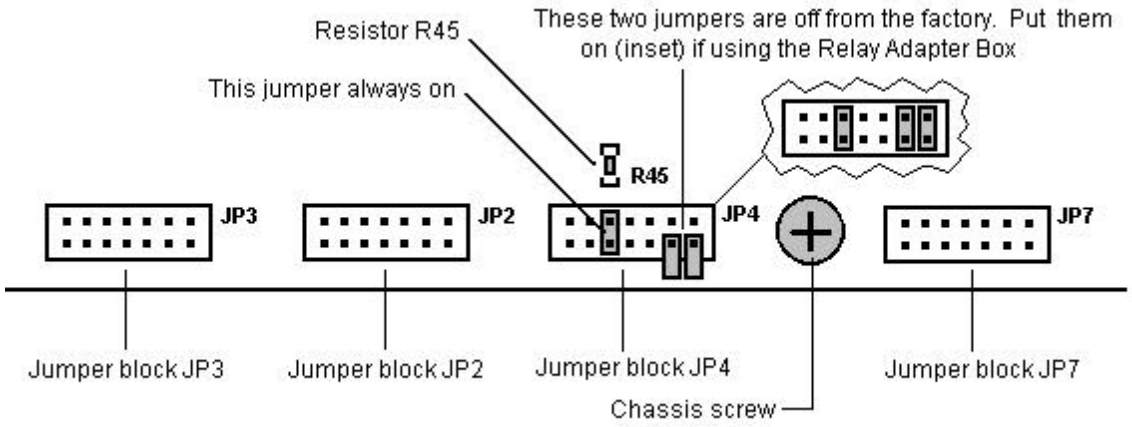
Telescope Port

The autoguider output from the STV is via the Telescope port on the back of the STV chassis. The pinouts for the Telescope port are shown below. Please note that you cannot use an off-the-shelf telephone cable to make the connection between this port and your telescope. The connectors on a telephone cable are reversed relative to the connectors on a relay cable.



1 = +RA (Right)
2 = +DEC (Up)
3 = -DEC (Down)
4 = -RA (Left)
5 = Common
6 = No Connect

The relays in the STV are mechanical, however, they are normally open relays only. If you require a special interface that uses relays that are normally closed you must use a Relay Adapter Box available from SBIG. Use of the Relay adapter box requires setting two jumpers on the STV CPU board. The diagram below shows how the jumpers are set at the factory. The inset shows how they should be set for use with the Relay Adapter box. See also Appendix B, page 45, if you have any difficulty locating jumper block 4 on the CPU board (Note that the orientation of the diagram below is rotated 180 degrees relative to the larger diagram in Appendix B).



RS232 Connector / Cable

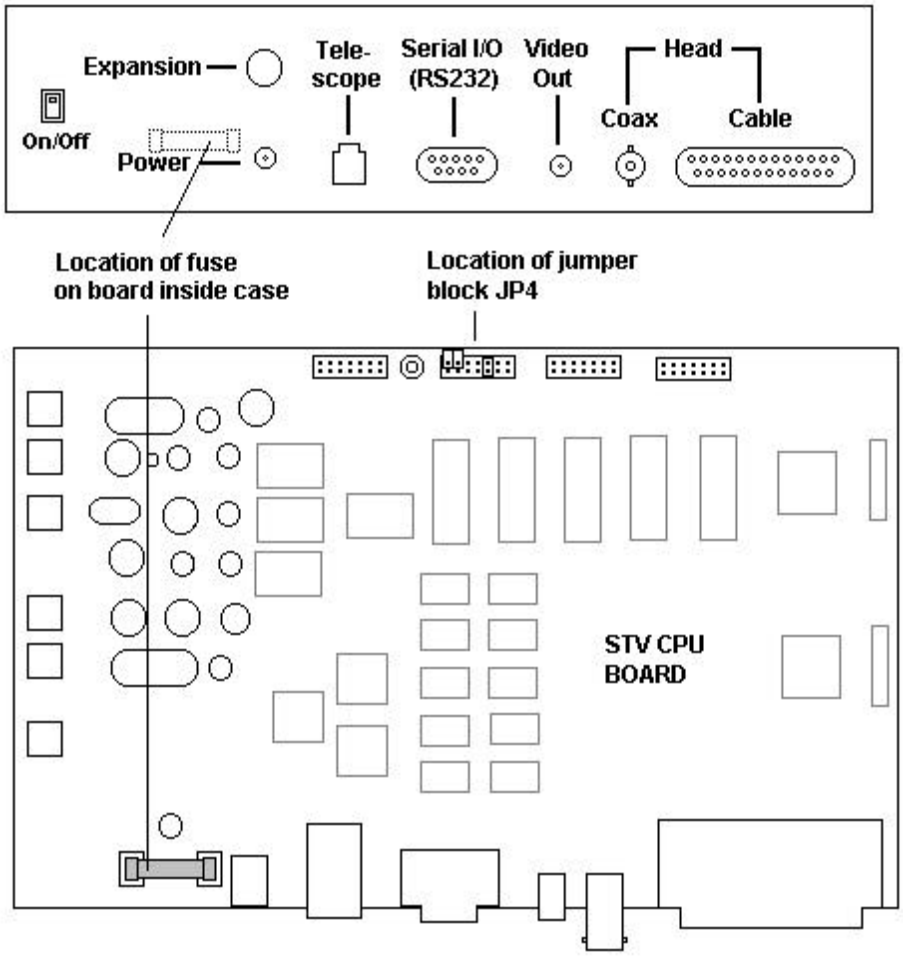
If you intend to remotely control the STV from a distance greater than a few feet, you will need to purchase or make a custom serial cable. The pin configuration for the RS232 port on the STV is as follows:

STV Pin	Function	PC/XT (25 pin D)	AT (9 pin D)
2	Transmit data from STV	3	2
3	Receive data to STV	2	3
5	Ground	7	5

Appendix B Maintenance

Replacing the Fuse

The STV has a 3 amp 3AG fuse mounted on the main circuit board inside the case. If, for any reason, you have to replace the fuse you will need to open the CPU box. Unplug the power to the CPU box. Remove the 12 screws that attach the CPU cover to its base. The keypad board and display boards are attached to the inside of the cover and the main CPU board is attached to the base. There are several cables connecting the CPU board to the keypad and displays. Be careful not to damage these cables when opening the case. The fuse is located on the main CPU board next to the power input plug as indicated on the accompanying diagrams. The top diagram shows the fuse location in relation to the back panel of the chassis. The lower diagram shows the fuse location on the CPU board.



Disassembling / Reassembling the Optical Head

In order to gain access to the CCD for cleaning or desiccant removal, please follow these instructions or return to the manufacturer for service.

1. Remove the four screws holding the front cover onto the camera and set the cover aside.
2. Remove the shutter/filter wheel from the camera by pulling it straight up out of the camera, lifting it off the axle.
3. Remove the three hex-head screws that hold the inner housing into the camera. The inner housing covers the CCD, making a hermetic chamber for the CCD and desiccant. Lift the inner housing and set it and the O-Ring aside.

At this point you have access to the CCD and all the windows in the system as well as the desiccant pack. To reassemble the camera please do the following:

1. Make sure the desiccant packet is in place below the CCD so that it may be captured by the inner housing. You may find it necessary to take the two outer corners of the desiccant and turn them inwards, making the rectangular packet somewhat conform to the round outline of the inner housing.
2. Seat the O-Ring in the groove in the bottom of the inner housing and gently place the inner housing down into the camera. Place careful attention to not pinching the desiccant packet under the seat of the inner housing. The proper orientation of the inner housing is with the window over the CCD.
3. Tighten each of the three hex-head screws one-half turn at a time until the inner housing is seated completely and flatly into the camera.
4. Place the shutter/filter wheel back into the camera with the side containing the small reference marks and the larger bushing towards the CCD. You will have to slightly deform the O-Ring that surrounds the wheel against the shaft of the motor and be careful not to pinch or tear it.
5. Replace the front cover, noting that there is only one orientation that will fit as the four mounting screws are at irregular angles.

Cleaning the Optical Window

The design of the STV allows for cleaning of the CCD. The optical heads are not evacuated and are quite easy to open and clean. Follow the instruction in the section above to gain access to the CCD and clean it using one of the following 3 methods:

1. To remove dust from the windows, a can of dust remover can be used but be careful to hold the can in the proper orientation. If you tilt the cans too far from upright a stream of cold liquid (the propellant) will issue forth rather than the burst of air.
2. In lieu of canned air, a small, soft, camel hair brush can be used to wipe dust from the windows.

3. Finally, for hard to remove particles or water spots, use a Q-Tip lightly dampened in Isopropyl Alcohol to clean the windows.

   Note: The key to cleaning optical surfaces is successive cleanings with a fresh Q-tip each time.

Replacing the Desiccant

This section describes the replacement procedure for the desiccant used in your camera. The desiccant absorbs moisture in the CCD chamber, lowering the dew point below the operating temperature of the cooled CCD, thus preventing the formation of frost. The desiccant is contained in a small rectangular package inside the CCD chamber. In normal operation the useful life of the desiccant is over a year. If the CCD chamber is opened often, the desiccant should be replaced when frosting is noticed.

Follow the instructions in the section above to gain access to the CCD chamber and desiccant packet. Discard the old packet and replace it with a fresh one. Note that the desiccant material in the packet can be regenerated by baking it in an oven at 400 degrees Fahrenheit for four hours *but you'll have to remove the desiccant from the packet first* . Otherwise the packet will melt. In a pinch you could snip the end of the packet off, pour out the desiccant beads, bake them out, pour them back into the packet and reseal the packet with scotch tape.

Appendix C Monitor Modes

The STV has five separate modes under the Monitor selection: e-Finder, Optical Quality, Drive accuracy (fast), Drive accuracy (slow) and Seeing. This appendix contains advanced information regarding each of those modes.

eFinder

The eFinder is a recommended optional accessory for the STV. It consists of a focal reducer and a 3 inch (7.6 cm) long extension tube that together form a 100 mm focal length F/4 telescope that can be screwed into the STV. When mounted on a telescope, the combination forms an electronic finderscope with a field of view of 2.7 by 2.0 degrees. This image scale makes comparison of the displayed image with a star chart very easy. The combination is sensitive enough to show any star in Uranimetria with a 3 second exposure. The eFinder mode is different from Imaging mode in that crosshairs are projected onto the scene. The crosshairs are moveable, allowing one to center an object through the main telescope, and then position the crosshairs on it, boresighting the two assemblies.

Assembling the e-Finder Components and Attaching to the Telescope

Attach the short extension tube (0.8 inch (2 cm)) to the focal reducer by screwing them together. They screw together with the joint being away from the lens. Next, slide the focal reducer assembly into the 3 inch (7.6 cm) finderscope tube. Use the thumbscrews to position the assembly about midway in the tube. Screw the resulting finderscope assembly into the front of the STV. Attach the tripod foot to the STV. Using a camera mount accessory (not supplied) for piggybacking a camera onto your telescope, attach the STV-Finderscope assembly to the telescope in such a way that when the telescope moves in RA the star image moves parallel to the long axis of the CCD. Usually right on top of the tube is the right position, or on the left or right side.

Focusing and Aligning Telescope to STV

Point the telescope and STV at a bright star. Find the bright star in the telescope eyepiece and center it. Adjust the STV mount to position the bright star near the center of the field. This may require shimming the telescope bracket in one direction. When close, tighten the screw down. Avoid any bracket arrangement that has O-rings or any cork or rubber cushioning. Metal-to-metal contact at all points is best for a solid connection, with three well spaced points making contact.

When the STV-Finderscope is secured, select the e-Finder mode and adjust the crosshairs to align to the star. Within the e-Finder mode you can change the exposure, flip the image either horizontally or vertically to line up with the star chart, or change the zoom. The crosshairs stay on the star as the zoom is changed, so if your star is close to the edge you may lose the crosshairs (and star) when going to high resolution zoom.

Application Hints

The e-finder mode is very handy for finding an obscure galaxy. Even though the galaxy will probably not show up in the e-Finder image, one can tell where it is relative to nearby stars and place it under the crosshairs. The finderscope can also be used to guide images in TRACK mode –

the STV guiding accuracy is about +/- 1 arcsecond even with a short 100 mm lens. Differential deflection between the STV-Finderscope assembly and the main telescope will probably limit your exposure to 5 to 10 minutes, but this is fine for CCD imaging or short film exposures. For longer exposures some sort of off-axis guider is recommended.

Optical Quality

When one first reviews the STV's Optical Quality, Drive accuracy (fast or slow) and Seeing monitor modes, one's first impression will probably be "Why is this so complicated?" What we have tried to do is provide a monitor mode for each of these parameters that affects long exposure imaging that separates out the effect of the other parameters. For example, if one get elongated stars on a film image, it could be bad optics, bad tracking, or bad seeing. Bad seeing can produce elongated stars since the drive is usually much more responsive in RA than in DEC, and chases the star image back and forth. The STV monitor modes allow one to determine what the problem is.

The Optical Quality mode measures optical image quality independent of seeing and drive problems. The way it does this is by taking many very short exposures and reporting the "best" stellar widths it measures. The assumption is that drive errors are insignificant over short times, and seeing occasionally allows one to see the full performance of the optical system. This last assumption is only valid on a good night.

The optical quality is measured from the ratio of the peak brightness in an image to the total number of counts in the stellar spot. Two measures of optical quality are calculated, the Full Width Half Maximum (FWHM) in arc seconds and the Strehl ratio. The FWHM is a well known measure of image quality in CCD imaging. If the star is magnified to where it extends over many pixels, and the peak number of counts on one pixel are 100 then the FWHM is the number of arcseconds between the pixels that have 50 counts of signal. Each point on the graph that builds up on the screen is the peak FWHM over the last 16 looks.

The other measure, the Strehl ratio, is the ratio between the signal found on one pixel to what it would be if diffraction limited unobscured optics were used. This measure compares your image quality to theoretical.

Making the Measurement

To measure optical quality, use a focal length of at least 100 inches (2.5 meters), more if you have a large aperture and a very good night. A barlow lens works well for extending the focal length if your system is shorter than this. Be sure to set the proper focal length and aperture in the Setup menu. Focus the image on the CCD as best as you can, and then enter the optical quality monitor mode. Use the filter built into the STV if you are worried about chromatic aberration. Avoid trusting the numbers with short focal lengths since the sampling of the stellar image with the CCD pixels is too coarse.

The mathematics behind the displayed values

The calculation of optical quality uses the following procedure. The formulae assume an Airy disk (theoretical) shaped energy distribution, even if the star is bloated up several times this size.

1. Measure peak star brightness
2. Measure total counts in star image relative to background (box is 66 x 66 pixels)
3. Find the ratio (peak/total counts)
4. Using Table 1, determine the pixel width relative to the Airy Disk that matches the ratio calculated in step 3
5. Since the pixel width is 7.4 microns, calculate the effective "Airy disk" diameter in microns
6. The FWHM is 0.422 times the diameter of the "Airy disk" in arcseconds

To calculate the Strehl ratio a similar procedure is used.

1. Based on system data in Setup menu, calculate theoretical unobscured Airy disk diameter (= 2.44 * 0.6 microns * F number)
2. Calculate ratio of pixel width (7.4 microns) to Airy disk
3. Using Table 1, calculate how much energy should have been on one pixel
4. The Strehl ratio = 100* measured fraction/ calculated fraction that should have been on one pixel

Table 1: Fraction of counts on a single pixel

Airy Disk Calculation Alan Holmes 12/16/99 Size of Pixel Width (Relative to Airy disk)	Numerically Calculated Fraction of energy on one pixel	Curve Fit Fraction = 5.2 *BW^2
0.05	0.013	0.013
0.15	0.115	0.117
0.25	0.290	0.325
0.35	0.494	
0.45	0.682	
0.55	0.825	
0.65	0.921	
0.75	0.970	
0.85	0.985	
0.95	0.992	

Note: one can test the algorithms and results by using a small aperture on a good night.

Drive Accuracy (fast or slow):

The Drive accuracy monitor mode shows the RMS accuracy of the drive at two different sampling rates. At the fast rate, the centroid of the stellar position is determined every 100 milliseconds. At the slow rate, it is determined every 2 seconds. The graph shows the position of the star with time. The rms number reported on the numeric display is the rms variation in X and Y over the last 16 points. It is difficult to separate seeing-induced stellar motion from drive errors at the fast rate. However, if one has an equatorial mount, the seeing errors will be identical in RA and DEC

directions, while high speed drive errors will be greatest in the RA direction. Comparing the two graphs will reveal if your drive has any high speed "rumble" due to motor speed irregularities or grit in the gears. The slow rate is excellent for determining the residual error of your drive after periodic error correction (PEC) training. The scale on each graph is in arcseconds. In fast mode the rms error is reported and in slow mode the peak-to-peak variation is reported.

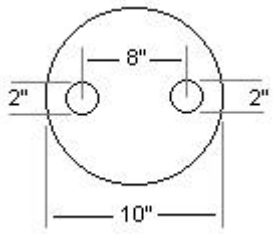
Seeing Monitor:

Astronomical "seeing" is a well known quantity that can be hard to quantify. It is usually expressed in arcseconds, and is a measure of how close of a double star can be resolved on that night. It is typically determined by an amateur either visually or by measuring the diameter of a star on a CCD image or photographic plate. The latter measurement is not good for diagnostic purposes since the optical quality and the drive accuracy both affect the long exposure FWHM of a stellar image. Professional astronomers determine the seeing by placing a two hole mask over the telescope aperture, putting the optics slightly out of focus to create two close, but distinct star images, and measuring the motion of one image relative to the other. This is called the Differential Image Motion Monitor (DIMM) technique, and is the one implemented here by SBIG. Professional astronomers use an 8 inch or 10 inch aperture telescope for the measurement, so many amateurs have the right equipment.

This technique can be a bit hard to understand. It is as if you had two telescopes, side by side, 8 inches apart. On most nights the seeing is poorly correlated even over this short separation. If one had a perfect drive, the jiggle of one star image about its average position is mathematically related to the seeing. If the two images are essentially uncorrelated, then the relative motion of one star image to the other is 1.4 times the motion of a single image to the average location. This relative separation, though, is insensitive to drive errors since the images move together.

Making the Measurement

First of all, make a cardboard mask with two circular holes 80% of the diameter of your aperture apart, each 20% of the size of your aperture. For example, the drawing below shows how a mask would be made for a telescope with a 10" aperture:



To do the measurement, find a bright star near the zenith and image it with the STV. Place the mask over the aperture and defocus the telescope until you have two spots cleanly separated, but not so defocused that the star images get too blurry. Orient the mask or the camera so the stars are separated horizontally on the CCD. Next, enter the seeing monitor mode. The software will automatically find the stars, adjust the exposure, and start collecting data. It can be quite impressive seeing how the two images move relative to each other!

The software will report the seeing as the Full Width Half Maximum in arcseconds of a long exposure stellar image (> 5 to 10 seconds). It uses the rms relative motion of 32 images to calculate the result, so the result does not appear for a short time after the mode is entered. As more statistics are gathered the measurements improve.

Conditions under which an accurate measurement is achieved

An accurate seeing measurement with the DIMM technique as we have implemented it requires a bright star high in the sky, and low wind speeds. The short exposure is required to not attenuate the stellar motion. For example, if each exposure was several seconds long on a turbulent, windy night, the stellar image centroids would move very little – the movement all takes place at shorter time scales. The STV uses exposures from 2 milliseconds up to 100 milliseconds. If the wind speed is below 4 miles per hour the measurement should be good always. With a bright star, wind speeds up to 30 mph should be tolerable. On the occasional night when the star is a boiling fuzzball, the technique does not work well.

The mathematics behind the displayed values

Mathematically, this calculation makes the optical quality calculation look simple. The long exposure FWHM in arc seconds is given by:

$$FWHM = 0.98 * Lambda /(4.85x10^{-6}* R_0)$$

Where lambda = wavelength in cm (0.00006)
R_0 = Atmospheric Cell Size in cm

R_0 is the transverse phase coherence length (the Fried parameter), a well known quantity – most books describe it as being on the order of 3 to 4 inches (7.5 to 10 cm). It is related to the rms differential image motion by:

$$R_0 = \{rms^2/[\ 2* Lambda^2*(0.179*d^{-1/3} – 0.0968*r^{-1/3})]\ \}^{-3/5}$$

Where d = diameter of individual aperture in cm
R = separation of apertures in cm
rms = standard deviation of spot separation in cm

The equation and methodology has been tested by numerous investigators and found to give accurate results.

Determining Long Exposure Image Quality

With great optics and an excellent mount, the FWHM of a long exposure image will be the value determined by our seeing monitor. Typically some blurring is contributed by each source. The aggregate FWHM is given by:

$$FWHM\ (Aggregate) = [\ FWHM^2(optics) + FWHM^2(fast\ drive\ error) + FWHM^2(seeing)]^{1/2}$$

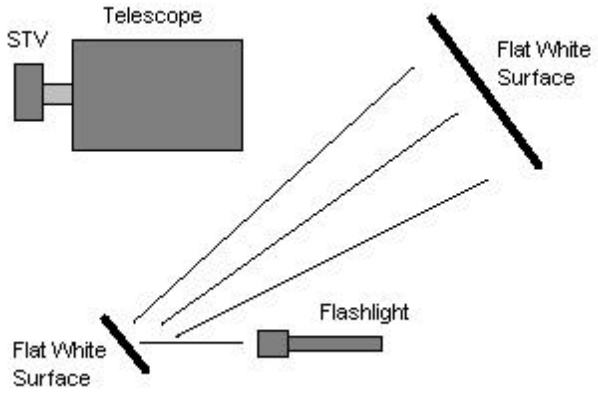
This result is approximate since the measurements of optical quality and drive error are always compromised by seeing.

Appendix D - Capturing a Good Flat Field

This appendix describes how to take a good flat field image. A good flat field is essential for displaying features little brighter than the sky background. The flat field corrects for pixel non-uniformity, vignetting, dust spots (affectionately called dust doughnuts), and stray light variations. If the flat field is not good it usually shows up as a variation in sky brightness from one side of the frame to the other.

The first consideration in capturing a flat field is to use the telescope-CCD camera combination in exactly the same configuration used to collect the image. This means you probably have to capture the flat field at the telescope. Do not rotate the camera head between image and flat field, since the vignetting is usually slightly off center. Do not be tempted to build a little LED into the telescope or camera for doing flat fields; it doesn't work at all. The dust debris shadows would be different.

Arrange a light source such as a flashlight, two white cards, the telescope and CCD camera as shown below:



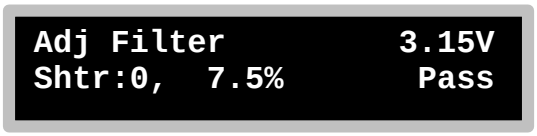
The key aspects of this geometry are that reflection off two diffuse surfaces is used, and the large flat surface is square to the illumination from the small flat surface. When we do this, the first surface is typically a white T-shirt worn by the operator! Take care that no apparent shadows are cast onto the larger flat white surface and that no other source of direct light (LED's from computers, etc.) is illuminating the large white surface. Use an exposure that yields an average light level equal to about half of full scale.

Appendix E - Adjusting the Filter Wheel

The STV has an internal shutter wheel containing a green ("lunar") filter. This filter is handy for taking images of bright objects like the moon because it attenuates the light by about 20X. It is also helpful for removing chromatic aberration from camera lens or telescopes that do not have good color correction because it passes a limited band of light centered on the green. It is also useful for more accurate visual magnitude measurements because it approximates the passband of the V filter commonly used in photometry.

The STV knows the position of the filter by sensing markings on the perimeter of the wheel. In order for accurate alignment of the filter position the sensor may require adjustment from time to time. This section describes the process for the user to make this adjustment.

Press the **Setup** button and from the **Setup Menu**, turn the rotary knobs or toggle the **Parameter** button until the **Adj Filter** command is displayed. Select **Adj Filter** by hitting the **Value** button. The alphanumeric display will show the following data:



In this example the following information is displayed:

Adj filter	You are in the Adjust Filter mode
3.15V	The sensor voltage is 3.15 volts (range is 0 to 5 volts)
Shtr:1, 7.5%	Shutter (Filter wheel) is moving, 1 and 0 are displayed alternately as the sensor sees the marks. The position is within 7.5% (acceptable range is 2.5% to 15% and 7.5% +/- 2.5% is nominal)
Pass	The shutter wheel is working correctly and does not need adjustment (pass or fail)

If the alphanumeric display reads "**Fail**" instead of "**Pass**" then you should make the following adjustment: Turn the right hand rotary knob to adjust the voltage value up or down until the shutter position ("**Shtr**") falls within the acceptable range of 2.5% to 15%. Try to get it as close to 7.5% as you can.

Appendix F Menus

- [**Power On**]
  - Set Date / Time

- [**Set Up**]
  - Date / Time
  - CCD Temp
  - Grid
  - Night Vision
  - Filter
  - Units
  - Focal Len.
  - Aperture Diam.
  - Telescope
  - Mag. Corr.
  - Site
  - Beep
  - Adj Filter
  - Video
    - Mode
      - NTSC
      - Int PAL
      - Ext PAL
      - Off
    - Date / Time
    - TEST PTRN
    - GRAY SCALE

- [**Focus**]
  - Sensitivity
  - Zoom
    - Zoom
    - Normal
    - Wide
  - Subframe
    - Full
    - Partial

- [**Image**]
  - Image Setup
    - Exposure
    - Gain
    - Zoom
    - Dark Sub.
    - Mode
      - Continuous
      - Snap
      - Track & Accumulate
      - Mosaic (Sm)
      - Mosaic (Lg)
      - Best Sharp
      - Best Peak
      - Auto Grab
    - Auto Grab Interval

- [**Monitor**]
  - eFinder
    - Exposure
    - Zoom
    - Flip
  - Optical Quality
  - Drive (fast)
  - Drive (slow)
  - Seeing (DIMM)

- [**Display/ Crosshairs**]
  - Auto contrast
  - Adjust Image
  - Select Back.
  - Select Pos. 1
  - Select Pos. 2

- [**File Ops**]
  - Save
  - Recall
  - Download
  - Download All
  - Slide Show
  - Erase One
  - Erase All
  - Baud Rate
  - Test Comm

- [**Calibrate**]
  - Mode
    - Auto
    - Full Menu
      - Exposure
      - Calibrate Time
      - Relays
  - Move
  - View Results

- [**Track**]
  - Mode
    - Auto
    - Full Menu
      - Exposure
      - Guide to
      - Selected star
        - Last position
      - Cursor
      - Aggressiveness (X)
      - Aggressiveness (Y)
    - Relay Tone

Appendix G Glossary

Antiblooming Gate - When a CCD pixel has reached its full well capacity, electrons can effectively spill over into an adjoining pixel. This is referred to as blooming. The Antiblooming gate can be used to help stop or at least reduce blooming when the brighter parts of the image saturate.

Astrometry - Astrometry is the study of stellar positions with respect to a given coordinate system.

Autoguider - All SBIG CCD cameras have auto guiding or "Star Tracker" functions. This is accomplished by using the telescope drive motors to force a guide star to stay precisely centered on a single pixel of the CCD array. The camera has four relays to control the drive corrector system of the telescope. The CCD camera head is installed at the guide scope or off axis guider in place of a guiding eyepiece.

CCD - The CCD (Charged Coupled Device) is a flat, two dimensional array of very small light detectors referred to as pixels. Each pixel acts like a bucket for electrons. The electrons are created by photons (light) absorbed in the pixel. During an exposure, each pixel fills up with electrons in proportion to the amount of light entering the pixel. After the exposure is complete, the electron charge buildup in each pixel is measured. When a pixel is displayed at the computer screen, its displayed brightness is proportional to the number of electrons that had accumulated in the pixel during the exposure.

Dark Frame - The user will need to routinely create image files called Dark Frames. A Dark Frame is an image taken completely in the dark. Dark Frames are subtracted from normal exposures (light frames) to eliminate fixed pattern and dark current noise from the image. Dark Frames must be of the same integration time and temperature as the light frame being processed or numerous hot and cold occur.

Dark Noise - Dark Noise or Dark Current is the result of thermally generated electrons building up in the CCD pixels during an exposure. The number of electrons due to Dark Noise is related to just two parameters; integration time and temperature of the CCD. The longer the integration time, the greater the dark current buildup. Conversely, the lower the operating temperature, the lower the dark current. This is why the CCD is cooled for long integration times. Dark noise is a mostly repeatable noise source, therefore it can be subtracted from the image by taking a "Dark Frame" exposure and subtracting it from the light image. This can usually be done with very little loss of dynamic range.

Double Correlated Sampling - Double Correlated Sampling (DCS) is employed to lower the digitization errors due to residual charge in the readout capacitors. This feature results in lower readout noise.

FITS Image File Format - The FITS image file format (which stands for Flexible Image Transport System) is a common format supported by professional astronomical image processing programs such as IRAF and PC Vista. CCDOPS can save image files in this format but can not read them.

Flat Field - A Flat Field is a image with a uniform distribution of light entering the telescope. An image taken this way is called a flat field image and is used with CCDOPS to correct images for vignetting.

Focal Reducer - A Focal Reducer reduces the effective focal length of an optical system. It consists of a lens mounted in a cell and is usually placed in front of an eyepiece or camera. With the relatively small size of CCDs compared to film, focal reducers are often used in CCD imaging.

Frame Transfer CCDs - Frame Transfer CCDs are CCDs that have a metal mask over some portion (usually half) of the pixel array. The unmasked portion is used to collect the image. After the exposure is complete, the CCD can very quickly shift the image from the unmasked portion of the CCD to the masked portion, thus protecting the image from light which may still be impinging on the CCD. This acts as an electronic shutter.

Full Well Capacity - Full Well Capacity refers to the maximum number of electrons a CCD pixel can hold. This number is usually directly proportional to the area of the pixel.

Light Frame - The Light Frame is the image of an object before a Dark Frame has been subtracted.

Photometry - Photometry is the study of stellar magnitudes at a given wavelength or bandpass.

Photons/ADU - This is an indication of the camera's gain in converting incoming light into image counts. This value is used with programs such as Hidden Image. For any image you take the Photons/ADU is shown in the Parameters command from the Image menu.

Pixel Size - The smallest resolution element of a CCD camera is the CCD pixel. The pixel size for your camera is 7.4 microns square (7.4 by 7.4 microns

Quantum Efficiency - Quantum Efficiency refers to the fractional number of electrons formed in the CCD pixel for a given number of photons. Quantum Efficiency is usually plotted as a function of wavelength.

Readout Noise - Readout noise is associated with errors generated by the actual interrogation and readout of each of the CCD pixels at the end of an exposure. This is the result of fixed pattern noise in the CCD, residual charge in the readout capacitors and to a small extent the noise from the A/D converter and preamplifier.

Readout Streaking - When a bright object is imaged using a short exposure time, readout streaking can occur. Readout streaking can look similar to blooming except it extends across the entire image passing through the bright object. This is a result of image shift at the beginning and again at the end of an exposure due to frame transfer. The readout streaking is usually very faint with respect to the overall image and can sometimes be eliminated from the display image by slightly raising the background level.

Resolution Mode - The resolution of a CCD camera is determined by pixel size. Pixel size can be increased by combining or binning more than one pixel and displaying it as one pixel. Doing so decreases the effective resolution but speeds up the download time of the image. Maximum resolution is determined by the smallest size of the individual CCD pixel.

Saturation - Saturation refers to the full well capacity of a CCD pixel as well as the maximum counts available in the A/D converter. The pixel is saturated when the number of electrons accumulated in the pixel reaches its full well capacity. The A/D is saturated when the input voltage exceeds the maximum.

Sky Background - The sky background illumination or brightness is the number of counts in the image in areas free of stars or nebulosity and is due to city lights and sky glow. High levels of sky background can increase the noise in images just like dark current. For some deep sky objects, filters can be used to reduce the sky background level.

Seeing - Seeing refers to the steadiness and the transparency of the atmosphere during an observing session.

TE Cooler - The TE Cooler is a Thermo-Electric cooling device used to cool the CCD down to operating temperature. The CCD is mounted to the TE Cooler which is mounted to a heat sink, usually the camera head housing.

TIFF Image File Format - The TIFF image file format (which stands for Tagged Interchange File Format) was developed jointly by Microsoft and Aldus Corporations to allow easy interchange of graphics images between programs in areas such as presentation and desktop publishing. CCDOPS can save image files in this format but it can not read them.

Track and Accumulate - The Track and Accumulate function is an patented feature of CCDOPS that allows the user to automatically co-register and co-add (including dark frame subtraction) a series of images of an object. These exposures can be taken unguided as long as the "Snapshot time" does not exceed the length of time before tracking errors of your clock drive become apparent. This allows you to image and track without guiding or the need to connect the CCD Relay port to your drive motors.

Vignetting - Vignetting is obstruction of the light paths by parts of the instrument. It results in an uneven illumination of the image plane. The effects of vignetting can be corrected using flat field images.

Appendix H Questions and Answers

This section contains answers to some of the more common questions we hear in the Technical Support department.

Q. *How often do I need to refocus?* A. When there has been a big temperature change (3 °F) or when you have moved to a vastly different position of the sky with an SCT, you should consider refocusing.

Q. *Can I use a camera lens with the camera?* A. Yes, SBIG sells an adapter for the camera that allows you to use C-mount or other lenses with the camera.

Q. *Can I operate the camera off of a car battery?* A. Yes you can. You'll probably want to use a deep cycle marine battery and you'll have to purchase a cable. Please refer to Appendix A. page 43.

Q. *How cold should the CCD get?* A. You should be able to work around 25 degrees Celsius below ambient.

Q. *How long of a cable can I use between the PC and the CPU?* A. You should be able to use cables up to 100 feet in length but it will vary from PC to PC. Please refer to Appendix A, page 44.

Q. *Where can I get a longer cable?* A. Go to your nearest computer store and ask for a 9 pin male to female extension cable.

Q. *I see dark spots in my images, what causes them?* A. If the dark spots are a single pixel they are typically caused by hot pixels in the CCD saturating and can be removed with the Remove Cool Pixels command in CCDOPS. If they're several pixels wide you should suspect dust on the window and that effect can be removed with flat fielding your images or clean the window with an "air duster".

Q. *My images have dark tendrils in the corners. What can I do?* A. These are caused by the CCD frosting and you need to replace the desiccant as described in Appendix B, page 47.

Q. *Is there other software available for the camera?* A. The STV comes with STV REMOTE software which is designed to control the camera from a remote computer. However, CCDOPS software will also read STV images and you can perform several image processing routines with CCDOPS as well as save STV images in a variety of formats. CCDOPS for DOS is available for free from the SBIG web site. CCDOPS for Windows 95/98/NT can be purchased from SBIG.

Q. *What do I do if my images have elongated stars?* A. If using Track and Accumulate you are probably using a snapshot time that is too long. If the snapshot time is longer than the amount of time your drive can track unguided with acceptable guiding errors, you will see elongated stars in your final images. If your snapshot times are getting down to 30 seconds or less you should improve your drive.

If you are using your camera as an autoguider for film photography and are noticing unacceptable guiding errors, please check the following:

1. Can you move the telescope using the Move command? This is an indicator as to whether or not you are properly connected to your drive system via the relay cable from the CPU.
2. Be sure that your calibration is good and that the STV saw motion in all four directions during the calibration process.
3. Check for flexure between the CCD camera head and your system. Check for flexure between the guide scope or off-axis guider and your telescope system. This is a very common source of guiding errors. A very small movement of the CCD head with respect to the guide scope during an exposure can cause unacceptable streaking.

4. If your mount is stable, try longer exposure times while tracking to average out the atmospheric effects.

Q. *What do I do if my CCD frosts?* A. If your camera starts to frost after a year of use it's time to replace the desiccant as described in Appendix B, page 47.

Q. *The moon is too bright, what do I do?* A. Try using the built-in lunar filter (Select Filter "On" in the Setup menu) and use a very short exposure. If the moon still saturates try using an aperture mask to cut down the light entering the telescope or or insert a neutral density (or any dark filter) in the STV's nose piece.

Q. *Why are my images grainy looking and not smooth?* A. The grainy look is from low signal to noise. A longer integration time will increase signal and reduce graininess. A focal reducer will also help. Try doubling exposure times. This works up to a point where you begin picking up sky background (light pollution) which limits maximum practical integration times. Also make sure your cooler is running at 70% capacity or more.

Q. *What are the advantages of shorter focal lengths and faster F# telescopes?* A. Shorter focal lengths increase the field of view, allowing you to image larger objects. Faster F# telescopes increase the field of view *and* shorten the exposure times. Do not underestimate the benefits of focal reducing your f/10 SCT systems!

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