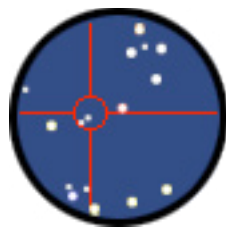


Equinox Image

SBIG Control Manual



Microprojects
Equinox Image 1.3
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Copyright

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Microprojects does not assume any liability arising out of the application or use of Equinox Image software or any product described herein.

Registration

Once Equinox image is installed on your Mac you have 30 days to try it out. All the features of Equinox Image are available during this trial period. After 30 days you will not be able to run Equinox Image until you register.

Please support Mac shareware. *This is not a free program.*
If you use Equinox Image please register.

Contacting Microprojects

email: support@microprojects.ca
web: www.microprojects.ca
users group: http://groups.yahoo.com/group/mpj-equinox

Introduction

This manual describes the SBIG camera control features and image processing functions of Equinox Image. It is assumed that you are familiar with your SBIG camera. The planetarium and telescope control program Equinox 6 can be used in conjunction with Equinox Image, but it is not a requirement.

Getting that perfect deep sky image with crisp detail, accurate color and round stars is not easy. You need experience, patience, good equipment and stable skies. However, the learning experience on that road to the perfect image is rewarding and hopefully Equinox Image will help you get there.

This Manual

This manual does not document the obvious, but many of the SBIG control features in Equinox Image do need some explanation. It is designed so that you can look up just the information you are looking for. It is recommended, however, that you read through this manual before using your SBIG camera with Equinox Image.

If you want to print this manual it is recommended that you use Apple's Preview application.

Initial Installation

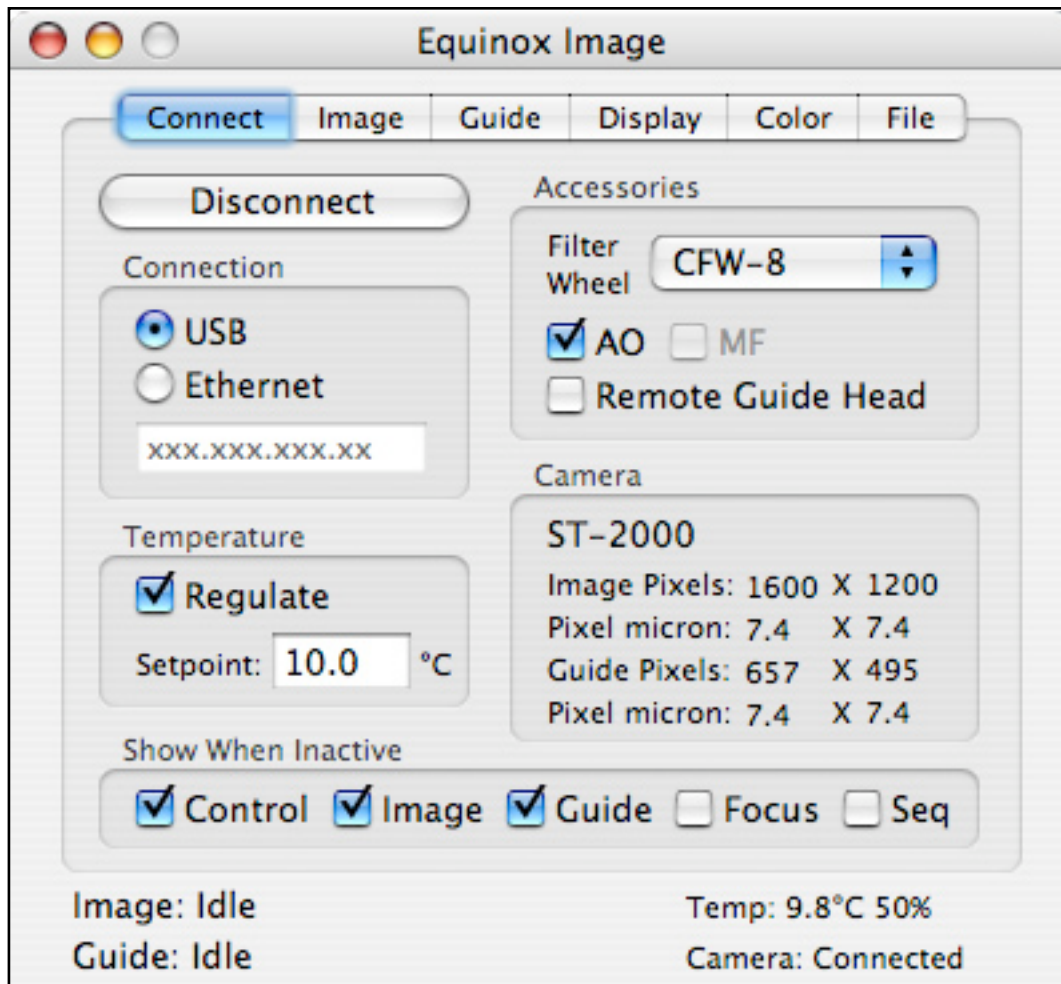
The Equinox Image installer will install the application, folders and this manual in a new Equinox Image folder. Your Applications folder is the default location for Equinox Image but you can put this folder anywhere you wish.

The SBIG driver (.kext) and framework files must be installed on your Macintosh before you launch Equinox Image. *Equinox Image can not run until the SBIG driver is installed.* These files have a separate installer supplied by SBIG. You can download the SBIG driver installer at:

- <ftp://ftp.sbig.com/pub/devsw/SBIGDriverInstallerUniv.dmg>

Connect Tab

From the Connect tab you can establish what accessory devices you are using, the type of connection to your camera, temperature setpoint and other basic information.



Accessories

If you are using a filter wheel you must select your model from the Filter Wheel popup menu. If you are not using a filter wheel or have a color camera, select None. If you have a CFW-6A you have to calibrate it so each filter position is centered. Under the Edit menu you can call up a calibration panel that allows you to adjust each filter position.

You can change the names of the filters in your filter wheel from the Filter Names item in the Files Menu. The default order of the filters is the SBIG factory order - *it is recommended that you do not change this order.*

Check the AO box if you are using an AO-7, AO-8 or AOL device. If you have an AO attached but do not wish to use it do not check this box. Check the MF box if you have an SBIG Motor Focus focuser and wish to use it.

If your camera has a remote guide head, and you wish to use it, check the Remote Guide Head box after you are connected to your camera. If you have a remote guide head but do not wish to use it, do not check this box. If your camera does not support a remote guide head this box will not be enabled.

If you have a single chip SBIG camera a Guide box will appear once you are connected. If you wish to use your camera for autoguiding rather than imaging, check this box.

Connection

Select your camera connection type (USB or Ethernet) from the connection radio buttons. If you have multiple USB cameras connected Equinox Image will select the first one it finds. If you select Ethernet the ip address text box will be enabled. Enter your camera's ethernet ip address in this box.

After you power up your camera wait at least 30 seconds before you hit the Connect button, otherwise the connection can stall. If this happens you may have to Force Quit Equinox Image or even reboot your Mac.

Temperature

Enter your target temperature (setpoint) and check the Regulate box to start SBIG cooling. You should enter a temperature that the SBIG can maintain without using 100% of its power. The camera's current temperature and power consumption (%) is shown in the "Temp:" status line at the bottom right of the Equinox Image window.

If you want to ramp down the power before you disconnect and turn off your camera you can uncheck the Regulate checkbox. A progress wheel will spin until the ramp down is complete.

Show When Inactive

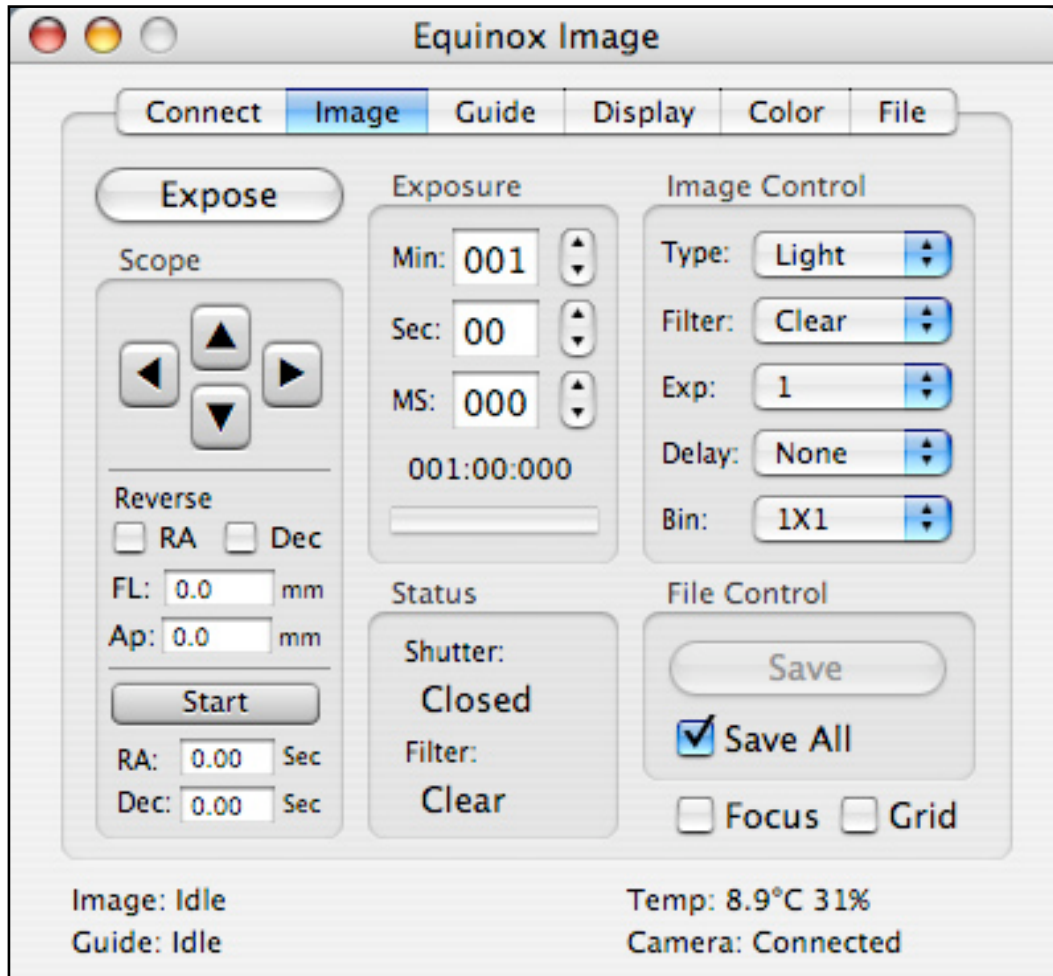
These boxes represent the Equinox Image window (Control), the image and guide windows, the Optec, RoboFocus or JMI control panel and the Sequence panel. If you have other applications that you run along with Equinox Image these preferences allow you select windows that will remain visible when Equinox Image is not the active application. *Note: Inactive is Apple's term when an application is not the active or "front" application. Equinox Image is still running when inactive!*

Camera

Your camera name and pixel information is displayed in this area after you connect to your camera.

Image Tab

The Image tab is where you control your camera's image exposure, filter selection, binning, and other information. From this tab you can also control your scope through the autoguide connection between your camera and mount.



Exposure

Enter your desired image exposure time from the controls in this area. **If you enter values in the text boxes you must hit the return key to register your entry.** The current exposure time is displayed under the entry boxes. The bar graph will indicate the current exposure time taken during an exposure as well as the download progress after the exposure completes. During an exposure the Expose button allows you to stop the exposure. If no exposure time has been entered the minimum exposure time that your camera allows will be used.

Image Control

From this area you can select what type of an image to take, what filter to use, the number of exposures, the delay time between exposures and the camera binning.

The exposure type “Light” means to take an image without subtracting a dark frame. “D&L” means to take a dark frame, then a light frame and subtract the dark frame from the light frame. Once this is done all additional exposures will use the same dark frame until something is changed about the exposure (exposure time, binning, etc.). “DD&L” will take a dark frame for display only - saved images will not have the dark frame subtracted. “Dark” means take a dark frame (the shutter is closed during the exposure). This dark frame can be subtracted from your images at a later time. “Bias” is a specialized dark frame used in some scientific applications. It is essentially a zero exposure time dark frame.

Status

In this area the current state of the shutter is displayed (Open, Closed, Moving) and the currently selected filter. The filter status also indicates when the filter wheel is moving and any error conditions.

File Control

Save All means that every exposure taken will be saved to disk. If you do not select this box you can use the Save button to save any image after it has been taken. You can save images as TIFF or FITS files - see the File tab for more information.

Focus and Grid

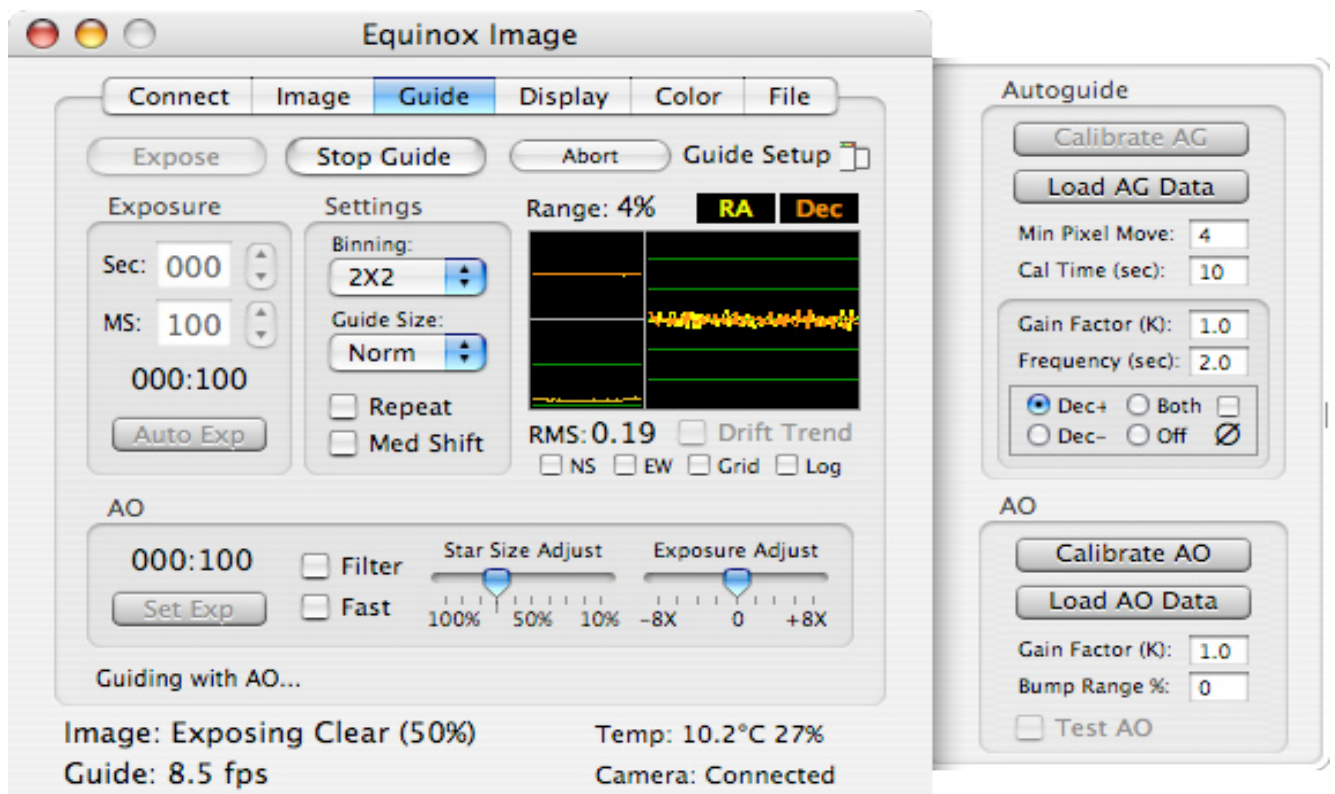
The Focus box will cause repeated exposures to be taken until you stop them. These images are not saved. Use this function to manually focus your camera. When the Focus box is checked you can drag an outline in the image. Only this area will be exposed and focusing will be faster. It is recommended that you use the D&L or DD&L image type whenever focusing. *If you hold down the option key and then select the Focus checkbox the focus image will be enlarged 4X.* The Grid box will draw a center grid on the image. This can help center objects and aid in collimation.

Scope

The scope controls allow you to move your scope through the autoguide connection between your camera and your mount. These controls are a convenient way to center an object or locate a guide star without having to use the scope’s hand controller or another scope control program. You can reverse the control action in RA and Dec. The focal length (FL) and Aperture (Ap) of your scope should be entered. These values are used for several calculations in Equinox Image. You can also move your scope in RA and Dec by fixed amounts of time. Enter the drive time and then hit the Start button. Experienced users often know the drive time between favourite objects and this control can be used for that purpose.

Guide Tab

The Guide tab controls the guide chip exposure and has all the controls for auto-guiding, AO guiding and calibration.



Exposure

You can enter a guide chip exposure in this area (remember to hit return after you enter a time). The Expose button will start (or abort) a guide image exposure and will return the image to full size if needed. Click on a guide star to form the small guide image. Clicking in the small guide image will also return the image to full size. The Start Guide button starts (or stops) autoguiding and the Exp Image button allows you to start an image exposure without going to the Image tab. Once you have clicked on the guide star you can run the Auto Exp function. This will take a series of exposures, analyze the images, and set the exposure time to the shortest exposure possible while still allowing a good star position to be calculated. You can then manually increase this value if you find you get better autoguiding with a slightly longer exposure.

Settings

Autoguiding uses the connection between your camera and the scope's autoguide port. Unlike the AO this type of control physically moves the scope. The update rate for autoguide corrections is determined by the frequency value entered in the Autoguide calibration side drawer. You can enter a frequency from 0.1 second (as fast as possible) to 60 seconds. This frequency sets the delay time from the end of one relay closure to the start of the next relay closure. One or two seconds is usually best.



Usually the binning on the guide chip is set at 2X2 to gain maximum star brightness without much loss of resolution. If you have a very bright guide star you could try 1X1 but you will get better results by using a shorter exposure time instead.

The Guide Size determines how large an image is downloaded during guiding. Normal is adequate for most situations, including AO guiding. However, if the guide star is bouncing around close to the edge of the guide window (strong winds) the Large size may be needed. If you are guiding with the AO and you have very stable skies, the Small setting may give you faster corrections.

The Repeat checkbox will cause exposures to be repeatedly taken. This can be used to help center the guide star in the image prior to calibration. The Median Shift function offsets the guide center for up to 25 images in an image sequence. Once aligned each image in the sequence is offset slightly so that hot pixels do not line up. The median stack function can then eliminate the hot pixels. This is sometimes called image dithering.

Trend

The Trend area is divided into three separate trends. The large area trends RA and Dec errors. Each horizontal line represents one pixel. This trend can be used to adjust the guide settings to maximize guiding accuracy. This trend also has a Drift Trend box which allows you to see in what RA and Dec direction your scope will drift when no corrections are applied. This is important information (see the calibration section below).

The top left trend displays the X and Y range of the AO. If you do not have an AO this trend is inactive. You can use this trend to manual recenter the guide star if the AO gets close to its range limit and you can also monitor the automatic AO “bump” controls.

The bottom left trend is a running Root Mean Square (RMS) error calculation. The value is in pixel error. You want this value as low as possible as it is a good indicator of how round your stars will appear in the final image. During an image exposure the average RMS error is calculated and displayed in the image window title. This value is also stored in the FITS header.

You can flip the guide image North/South and East/West with the N/S and E/W checkboxes to match your optics. The Grid checkbox displays a center grid. Log stretches the image to display faint detail but is not normally used when guiding.

Autoguide Calibration

Calibration controls are in a side drawer, displayed by clicking on the Guide Setup button in the top right corner of the tab. Hold down the option key when you click on this button if you want the side drawer to remain open from all tabs. *Your camera must be rotated to the position you want before you calibrate - if you rotate the camera after calibration you will have to calibrate again.* Calibration assumes your scope is mounted equatorially - Alt/Az mounted scopes can not be calibrated.

The first step to autoguide calibration is to center a bright star (3rd or 4th magnitude and close to the object you want to image) in the guide image and use a short exposure time. No other bright star should be close enough to get into the image as the calibration moves the scope. Make sure the scope speed is set to Guide or the slowest setting and then hit the Calibrate AG button. The scope will be moved in the RA Plus direction (left) first, then in the Dec Plus (up) direction. The star image will not update while the scope is moving. If all goes well you will have a successful calibration.

Chances are, however, that your first attempt to calibrate your scope will not be successful. If the star marker ever “misses” the star you should stop the calibration and start over. The guide star should move about 1/4 of the frame during calibration. If it does not then you can increase the Cal Time setting - this drives the scope for a longer time. If the star should move out of the frame then you can reduce this time.

The calibration tries to detect backlash. This is when the scope is told to move but it doesn't because the drive gears are not in contact. Usually you have much more Dec backlash than you do RA backlash. The Min Pixel Move value sets how many pixels the guide star has to move to indicate the mount is out of backlash. Wind and other factors can move the image even when the scope is in backlash, so this value can not be zero. On the other hand this value should be lower than what the scope drive will move the star in one second. If the calibration cleared the backlash message before the mount really started to move, increase this value.

Once all these factors are taken into account you should be able to get a good calibration. Once that happens the calibration data is written to disk. If you need to re-establish the calibration and nothing has changed, you can load the last saved data with the Load AG Data button. With a good calibration the Gain value should be left at 1.0.
Option: calibrate twice and the average calibration data will be used.

Guide Direction

The guide direction buttons allow you to control how Dec correction values are applied during guiding. Because of Dec backlash you do not want to drive the Dec correction in both directions, otherwise you will get stuck in backlash and your guiding will not work. Of course if your mount has no Dec backlash you can select Both, but that is unlikely. The Off selection turns off all autoguiding. If your mount can not autoguide in both the RA and Dec directions simultaneously check the \emptyset checkbox.

In order to know which button to select (Dec+ or Dec-) you need to know what direction your scope will drift when no corrections are applied. That is what the Drift Trend box is for. The drift trend works whether you have calibrated or not, but if you have not calibrated the camera should not be rotated. Check the Drift Trend box and see which Dec direction the trend moves. Normally up is Dec+, down is Dec- but your optics may reverse this. You want to check the box (Dec+ or Dec-) that indicates the opposite direction - in other words you want to apply Dec corrections to oppose the normal drift but you do not want to apply corrections in the direction the scope will drift anyway. Once this direction is determined, check the appropriate Dec+ or Dec- box and stop the drift trend. Click on the guide star in the guide image and you can start autoguiding with the Start Guide button.

Autoguide Notes

Most mounts can autoguide with an RMS error between one or two pixels if everything is set up perfectly. Here are some notes on what you can do to get the best autoguiding performance from your mount.

- Your scope must have an equatorial mount. Alt/Az mounts can not autoguide.
- Calibrate before you run the Drift Tend.
- You really should run the Drift Trend.
- Based on the drift trend, you must select Dec+ or Dec- to oppose that Dec drift. A selection of Both will never autoguide.
- You must have a good RA axis balance.
- You must have a good Dec axis balance - but not perfect! If your scope drifts up the Dec- selection will drive the scope down to oppose it. A slightly heavy back end balance will help keep the Dec gears in contact. If your scope drifts down the Dec+ selection will drive the scope up, so a slightly heavy front end is best.
- Never ever use your mount's anti-backlash feature.
- Run your mount's RA PEC function.
- If you need to alter EI's gain your calibration is no good.
- Calibrate on a star with nearly the same Dec as your guide star and if it is bright enough calibrate on your guide star.
- If you change your camera angle you have to calibrate again.
- You need to set the mount's speed to Guide or its slowest speed. Calibrate and autoguide at this speed. However, if you have a very wide field of view or your camera's pixels are very large you might need to increase this speed.
- Before you calibrate take up the Dec backlash with the mount's hand controller in the Dec+ direction.
- Before you start guiding manually take up the Dec backlash with the mount's hand controller - in the direction you have selected (Dec+ or Dec-).
- If you have an AO device you still need to calibrate the autoguide.
- Do not use the Log display feature when guiding.
- If you calibrate twice the average calibration values will be used and autoguiding will be more accurate.

The accuracy of autoguiding, and guiding with an AO device, is also very dependant on how well Equinox Image can calculate the guide star's position. This effects both the calibration and the guiding.

Two things effect the "centroid" calculation - guide star exposure and the dark frame. With most SBIG cameras the fastest exposure possible is 120 ms when the shutter is used. There is no limit on how fast the exposure can be during an image exposure (when the shutter is open). For most guide stars a much longer exposure is required so this is not a consideration. However, the dark frames are. Equinox Image tries to take accurate dark frames for both situations but it is possible that on occasion the dark frame does not match the exposure time. If the guiding shows a large and distinct oscillation this is probably the cause. *You can force Equinox Image to retake the dark frames when the little guide window is visible and you are not guiding buy holding down the option key and hitting the Expose button.*

AO-7/8/L Controls

If you have an AO-7, AO-8 or AOL the Guide tab has several controls to adjust AO guiding as well as AO calibration controls in the side drawer.

AO Calibration

Before you can guide with the AO you must calibrate it. Center a reasonably bright star in the guide image, set an exposure time and hit the Calibrate AO button in the side drawer. As long as the star marker does not “miss” the star the calibration will be successful. The calibration data will be written to disk and can be reloaded with the Load AO Data button. This data can be reused any time you need to re-establish the calibration, but it can not be used if the optics have been altered. *Option: calibrate twice and the average calibration data will be used.*

AO Guiding

The AO area has exposure and adjustment controls. You must click on the guide star in the guide image before you can use these controls. The Set Exp button will set the AO guiding exposure to the exposure time entered in the Exposure area. The Auto Exp button will determine the shortest exposure time possible while still being able to calculate a good star position. This will give you the fastest possible guide frequency but it may not be the best exposure for accurate guiding.

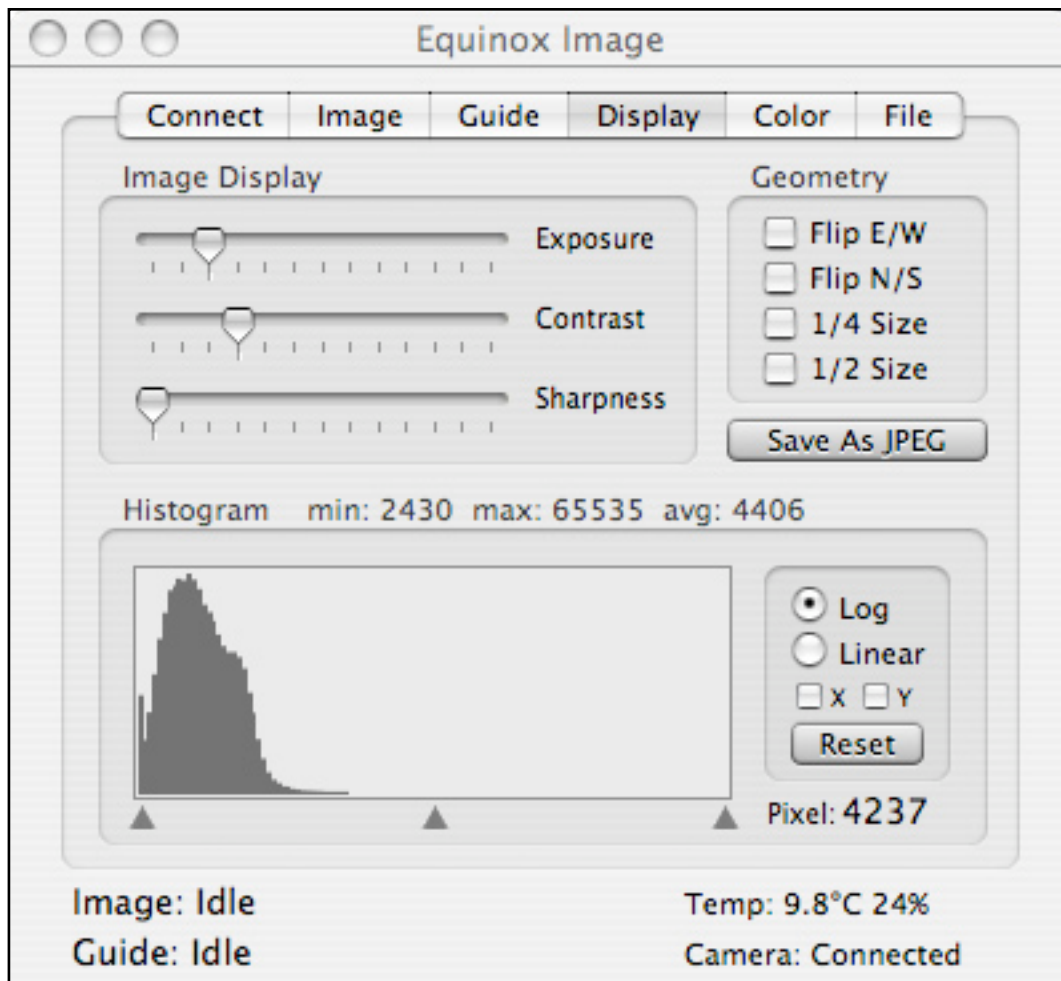
Once the exposure time has been set and the AO has been calibrated you can use the Test AO button in the side drawer. This simulates the conditions when an image exposure is being taken. Watch the trend and RMS values. Move the Exposure Adjust slider control to the point where the smallest error trend and RMS value appears. This is probably the best exposure time, although not necessarily at the fastest frequency possible. You can also try different Star Size Adjust settings. This control alters what percentage of the star image is used to determine its position. The smaller the value the more the star position will be centered on the brightest pixel in the star image. This may not produce the “roundest” star images however - watch the RMS value.

If you have a bright guide star you can check the Fast checkbox to increase the guide frequency. This will have little or no effect with longer exposure times. The Filter checkbox applies a slight filtering action to the guide star position error. This may help remove the random errors that can be generated when the exposure is too short.

The Bump Range % value determines at what point the scope is moved to recenter the guide star (autoguide calibration is required). You don't want the AO to get too far past 50% of range for best guiding, but on the other hand you don't want to keep needlessly “bumping” the scope. The guiding frequency has to be fast enough to keep the star within the guide image while the scope is being moved, otherwise the guide star will be lost. Watch the Range trend to see when a bump occurs (you will hear a beep) and if it was successful. If the guide star was lost enter a lower percent value. You can also enter a bump percent of zero and Equinox Image will bump the scope at the maximum range possible while making sure that the guide star will not be lost.

Display Tab

The controls in the Display tab allow you to see the faint detail in your image so that you can evaluate your exposure settings.



The controls in the Display tab give you several different ways to manipulate the image. *Note that none of these controls change the raw image saved to disk.* You can alter the effective exposure, contrast and sharpness with slider controls, flip the image and reduce the size (so you can see the entire image within the window). If you select both the 1/4 and 1/2 boxes the image will actually be scaled up 2X.

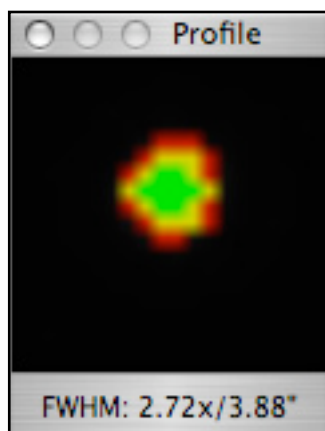
The Histogram displays the density spread of the image. You can adjust the low, mid and high densities with the triangle controls under the histogram. You can also see a log stretch or linear representation of the image. The log setting can help see faint detail that the other controls may miss. The Reset button sets all the controls back to default values.

The X and Y checkboxes display a graph of a spectrogram image. The X shows a single row and the Y shows a single column. Click in the image window and move the cursor over the spectrograms to view the graph. The graph can also be used to check for uneven field illumination (vignetting). Graph data can be logged (⌘-P) into the Misc folder.

Above the histogram the minimum, maximum and average pixel densities are displayed (0 to 65535). If you move the cursor over the image the pixel density under the cursor will be displayed in the Pixel area to the right of the histogram. These values can be very useful to help you determine what exposure changes the image may require.

The Save As JPEG button will save an image that incorporates all the changes you have made from this tab. However, this is not a substitute for a true image processing application (which Equinox Image is not). The saved JPEG is an 8-bit grey scale image and can not be read back into Equinox Image.

Star Profile



If you option + click on a star in the image a Star Profile panel will be displayed. This panel will analyze the star shape and represents various densities in different colors. The green central area is the full width half maximum (FWHM) area, literally the area of the star that is measured from half the star density range to its maximum value. The green shape should be round. An oval shape indicates poor guiding or a collimation problem with your scope. If the green area is not reasonably round your stars will not look round in the final image.

The yellow area represents the star density from the “toe” of the profile (9% above background) to the FWHM value. You want this area to be as narrow as possible. A star with a wide yellow profile will probably look “fuzzy” in the final image and may indicate a poor focus or bad seeing. Images taken when the humidity is high often show wide yellow star profiles.

The red area represents the star density from 3% above the background to 9%. Again, this should be narrow for sharp looking stars but unless the final image is severely stretched this area may not be noticeable.

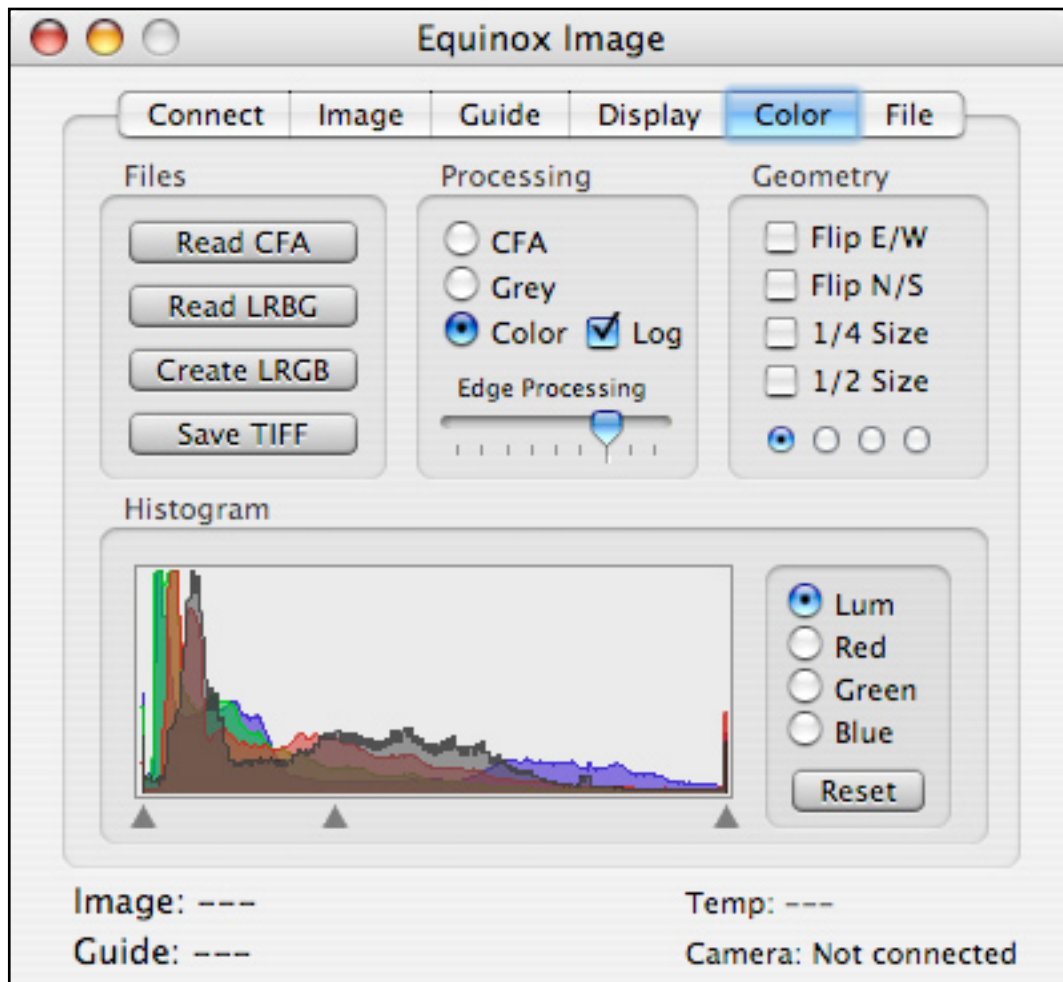
At the bottom of the profile the FWHM value is displayed in pixels (2.72x) and arc-sec (3.88”). In order for the arcsec value to be calculated Equinox Image must know information about your scope and camera. If Equinox 6 is running at the time the image was taken this information is read from Equinox 6 and stored in the FITS header. Otherwise the scope information entered from the Image tab is used. If you are saving your images as TIFF files this information is not saved and the FWHM value will be calculated in pixels only.

If you are focusing with a section of the image (you have dragged a focus rectangle) you can option+click in the focus image and the star profile will be updated with each new image. This can be helpful in determining your best focus.

The FWHM calculation is accurate only if the exposure type is D&L or DD&L.

Color Tab

If you have a color camera this tab is where you can manipulate the exposed image for viewing. You can also create color images here from LRGB grey scale images.



Files

This area has buttons for reading and writing files in various formats. If you have a color camera the exposed images are saved as a 16-bit grey scale Bayer pattern, also known as a color filter array (CFA).

The Read CFA button allows you to read in color camera images that were saved to disk. Once read in these files can be manipulated with the controls in this tab and saved in various formats.

The Create LRGB button will convert the CFA image to four 16-bit grey scale images representing the luminance, red, green and blue color channels. This is the format that most image processing applications require. You can also read in LRGB files that were created with a grey scale camera and filter wheel with the Read LRGB button. You can also save the manipulated image as a color TIFF file.

Processing

The CFA radio button is the default mode and displays the image in its “raw” format. A CFA image looks “grainy” - this is normal. Grey displays the image in grey but converts the CFA pattern to a smooth scale. Color displays the image in color. When you are displaying the image in CFA or grey scale you can use the histogram controls in the Display tab. When you are displaying the image in color you can use the color histogram controls in the Color tab. The Log checkbox will apply a log expansion to the luminance channel.

The Edge Processing slider control alters the CFA to color processing with an algorithm developed by Robert Geddes at MIT. This algorithm enhances edge sharpness. The default slider position will probably give you the best results but you can experiment with different settings. At the Max position artifacts may become visible. At the Min setting a conventional linear demosaic algorithm is used.

Histogram

The histogram area allows you to manipulate each color channel separately and analyse the color components of an image. The Reset button sets all histogram settings back to the default values.

Geometry

Here you can flip the image and alter the scale. The flip settings are saved with the Save TIFF button but the scale values are for viewing only. The four radio buttons at the bottom of this area control how the Bayer pattern is interpreted. These buttons do not effect how a color image is saved, only how the pattern is processed. For images taken with Equinox Image use the first button. However, color images taken with another application may interpret the bayer pattern differently. If the color preview looks “grainy” with these images try a different selection.

Notes About Color Cameras

Equinox Image saves exposed color camera images as 16-bit CFA files (TIFF or FITS). This allows dark frames (also saved in CFA format) to be subtracted. If all the images do not need to be aligned you can stack CFA images (the log stack is not recommended because it can alter the color balance). Otherwise you need to create LRGB images and align and stack those.

CFA images can not be used to process a flat field. You can, however, take your flat field image, select the Grey mode and Save Grey. The grey scale image is saved as a 16-bit grey scale image (not as a CFA image) and then it can be used as the flat field image when processing CFA images.

From the Color tab you can read in the final dark subtracted, aligned and stacked files and make as many color changes as you like. You can save the result as LRGB grey scale files or as a single 16-bit color TIFF image.

File Tab

From this tab you can process your exposed images in a variety of ways, establish file names and folders and convert files between FITS and TIFF formats.

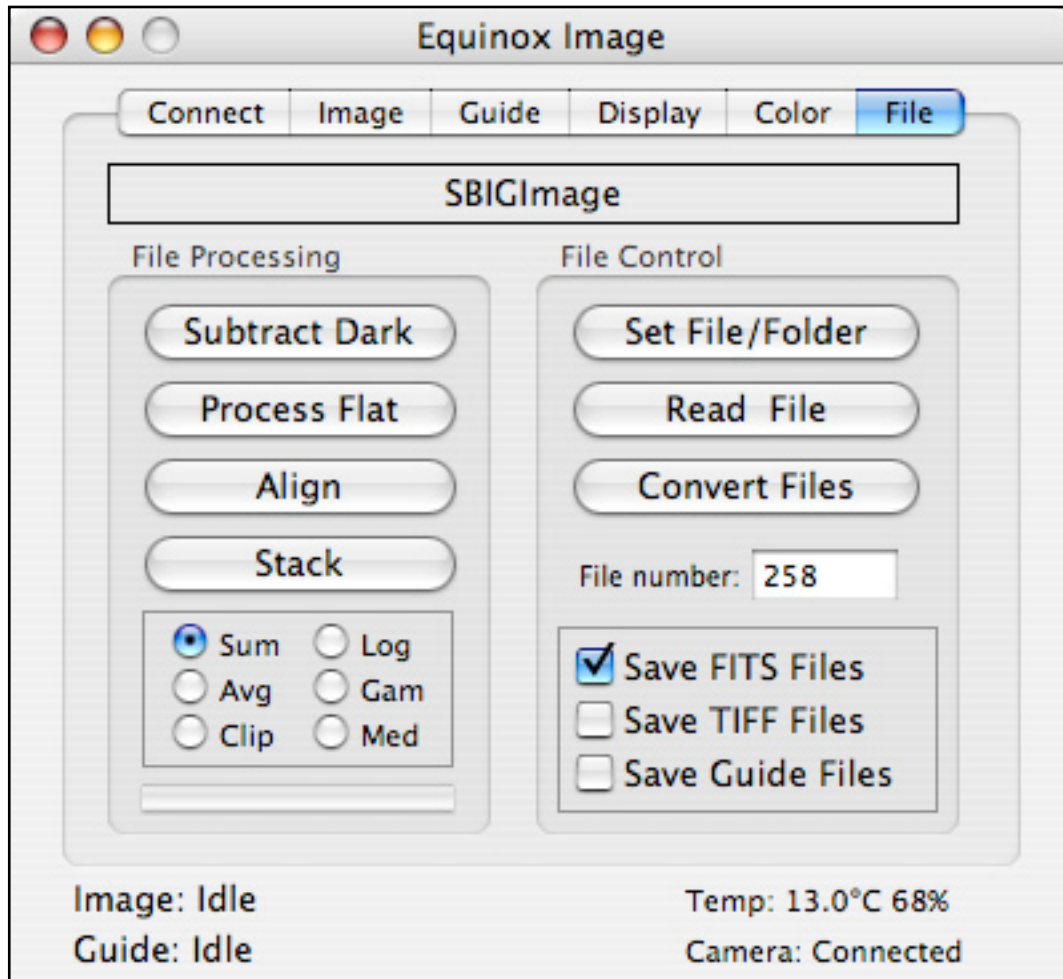


Image Processing Order

The order of image processing is important. You must dark subtract all the images first if they were not D&L type images. Then do flat field processing if you have a flat field image. Alignment of all the images to a single master image is next. Align luminance, red, green and blue images to the master (which can be any image in the sequence). Once all that is done you can then stack all the luminance images, all the red, green and blue images. The last step is to read in the LRGB images in the Color tab and form your color image. If you are using an image processing application you will do your color processing there.

File Processing

If your images were not taken as D&L type (dark subtracted at the time of exposure) you can subtract dark frames with the Subtract Dark button. You can subtract a dark frame from multiple images. Just be sure the dark frame you select matches the images for exposure time, temperature and binning.

The Process Flat button will process a flat field image with multiple images. Taking a good flat field image is not simple but there are many good web sites that explain the procedure.

Aligning images can be complicated. If images are aligned automatically the results are rarely as good as a visual alignment and rotating images is usually not possible. Equinox Image does not do automatic alignment. Instead a special alignment window has been created that allows you to visually align your images (see the next section in this manual). It may not be as fast, but the results are worth the extra effort.

Stacking images improves the signal to noise ratio (S/N) and keeps stars small. The purpose of stacking is generally not to increase image density. You will want to take several (or many) images and stack them. Before you stack images each image must be dark subtracted, possibly flat field processed, and finally aligned. You stack luminance, red, green and blue images separately, but they must be all aligned the same.

There are many ways to stack images. Each method has its advantages and disadvantages. Sum simply adds up each pixel value in all the images to produce a final image. In this case image density is increased (along with an improved S/N ratio) but stars and hot areas in the image can saturate. Bright stars can increase in size and lose detail and color.

An average stack (Avg) produces a final image where each pixel is the average of all the stacked images. This improves the S/N ratio but hot or dark pixels in any image will degrade the improvement. The clip stack improves on the average stack by eliminating the brightest and darkest value from the stack for each pixel before calculating the average value. This is usually the best choice for improved S/N ratio but the clip stack should have at least five images in the stack.

Log stacking is designed to emphasize the faint detail without saturating the bright star images. It is a sum type stack, but it adds a logarithmic value of each pixel. The log curve is very steep so even the darkest areas (and background noise) of the image may be emphasized and the S/N ratio improvement will not match that of a sum or average stack. The gamma log stack (Gam) is a log stack but a gamma function is applied which reduces the severity of the log curve. These log stacks may improve images of globular clusters but are not recommended for galaxy and nebula images.

The Median (Med) stack uses the median value of each pixel from all of the images. Median stacks require at least three images and more processing time but often produce cleaner, more defined images. The S/N ratio is not improved as much as with an average stack but it does completely eliminate hot or dark pixels. The Median Shift function can be used when exposing images to improve the results of median stacks.

File Control

Set File/Folder allows you to establish a file name prefix and a default folder. The folder name is up to you, but choose something that organizes your images. You may name folders by the date or by the object name, for example. If you do not create a new folder the default folder is the Images folder inside the Equinox Image folder.

Equinox Image uses a file naming convention that identifies information about how the image was exposed and what processing has been done on it.

You might end up with a file name like: NGC6853.Light(60S-20X1)Red.248.fits The NGC6853 is your prefix. Then comes the type of Image (Light, Dark, Bias). Inside the () is the exposure time in seconds (60S means 60 seconds), the temperature (-20 is -20 deg C) and the binning (X1 is 1X1). Next comes the filter used. If you used a color camera it will say CFA. The file number is an incrementing value that assures a unique file name. Finally the file format extension (.fits or .tiff) is added.

If you have done some processing on the file additional letters may be added to the file name, A for aligned, S for stacked, etc. If you used the D&L image type (automatic dark subtraction) a D will be appended to the file number.

The file number starts at 1 and increments every time you save an image. You can, however, set the number to a specific value with the File Number entry, or reset it to zero from a File menu item. A different file number may be calculated to prevent an existing file from being over written.

The Read File button allows you to read in a specific image for processing or viewing. If you want to read a color file (CFA) that was not saved by Equinox Image you must use the Read CFA button in the Color tab instead.

The Convert Files button allows you to make multiple file selections and then Equinox Image converts each one from FITS to TIFF or TIFF to FITS. You can mix FITS and TIFF files in your selection and each file will be converted to its alternate format.

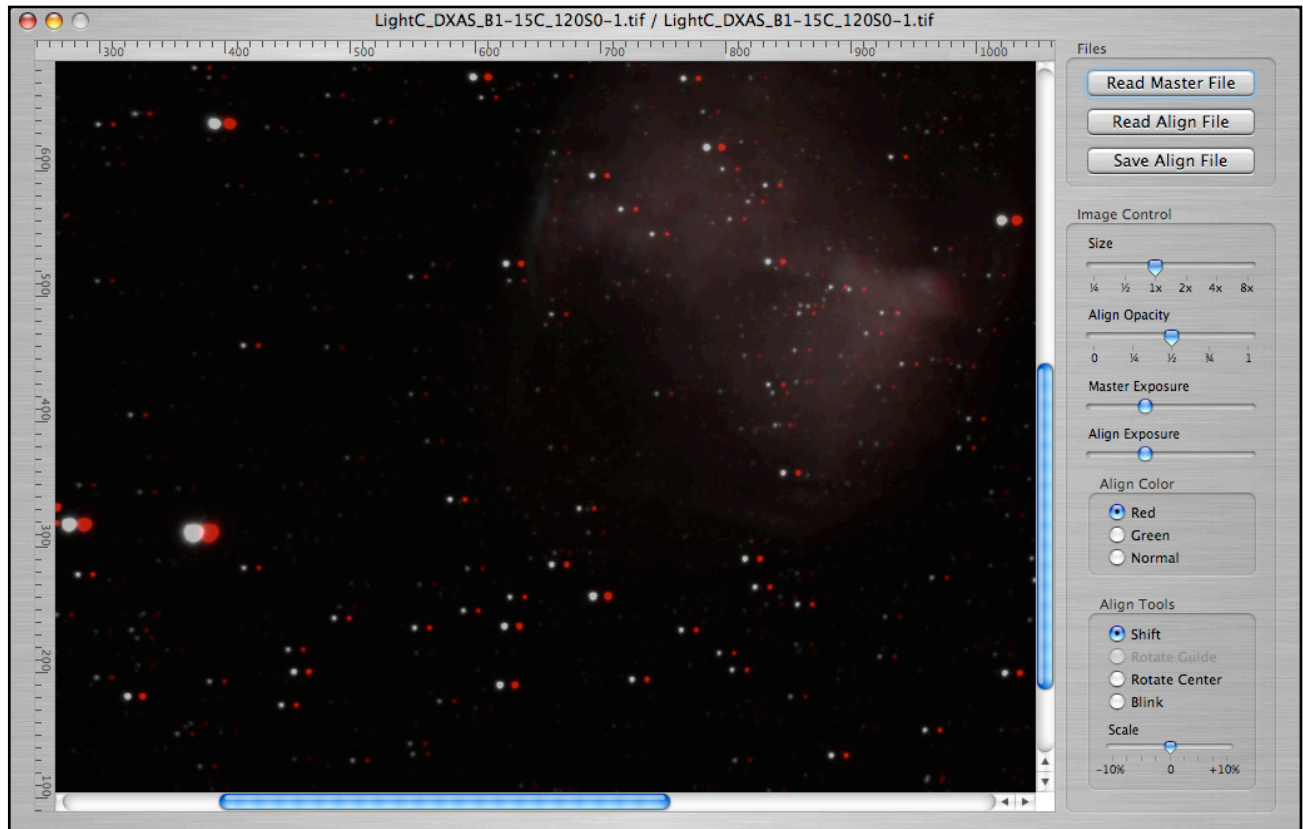
You can save your images as TIFF files, FITS files or both by checking the appropriate boxes. The preferred format is FITS for several reasons. FITS files can store additional information in header records. You can even add your own custom records from the File menu. Camera information, like the binning, pixel size and guide star location is stored in the header so the alignment window can do rotations.

If you want to save guide chip (internal or RGH) images you can select the Save Guide Files checkbox. All guide images will be saved when they are downloaded (as long as you are not guiding).

Telescope and object location (RA and Dec) information is stored if Equinox 6 is running during the exposures. If you do not have Equinox 6 running the scope information entered from the Image tab is stored, but no object location data is recorded.

Alignment Window

When you hit the Align button in the File tab an alignment window will open. From this window you can visually align your images.



The first thing to do is read in a master file with the Read Master File button. This will be the image that all the other images will be aligned to. Then read in your first alignment image with the Read Align File button. Once you are finished with the alignment save it with the Save Align File button - an "A" will be appended to the file name. You can then read in the next image to align. All the original images will not be altered.

It is a common practice to take the red, green and blue images with more binning than the luminance images. If you have done this those images will be scaled up to match the master image using a Lanczos5 filter and saved in the correct size.

Image Control

You can alter the image size to magnify an area or reduce the size to see the entire image. When you magnify the images you can align to sub-pixel accuracy.

The Align Opacity determines how much of the underlying master image "shows through". Both the master and align images can be exposure adjusted. Use these controls to make the alignment operation as visually accurate as possible - the star images should match in size. The overlaid align image can be in red, green or normal.

Align Tools

You have shift and rotate alignment tools. Most images will require shift alignment but may not need a rotate alignment and rarely need a scale adjustment.

You can shift the align image by selecting the Shift tool and dragging the mouse. Once you have a rough alignment you can then magnify the image and do a fine adjustment with the arrow keys. The higher the magnification the more sub-pixel resolution you have. It is best to align on stars, not faint nebula or galaxy images. Once you have a good alignment move around the entire image to make sure the alignment is valid for all areas of the image.

If you find that some portions of the image are aligned while others are not you may need to do a rotate alignment. If you saved your images as FITS files each image knows where the guide star was located. You need this information because images rotate over time around the guide star - which is not within the image! If you have saved your images as TIFF, this information is not available and you can not do a guide rotation.

It is best to go to the bottom of the image and do the rotational alignment there. The portion of the image that is furthest away from the guide star will show the most displacement. Again, use the arrow keys under magnification for sub-pixel accuracy.

Under some circumstances you may have a slight rotation around the center of the image. Equatorial mounts that are not aligned well can cause this. Choose the Rotate Center tool and the center of rotation will be the mid point of the image.

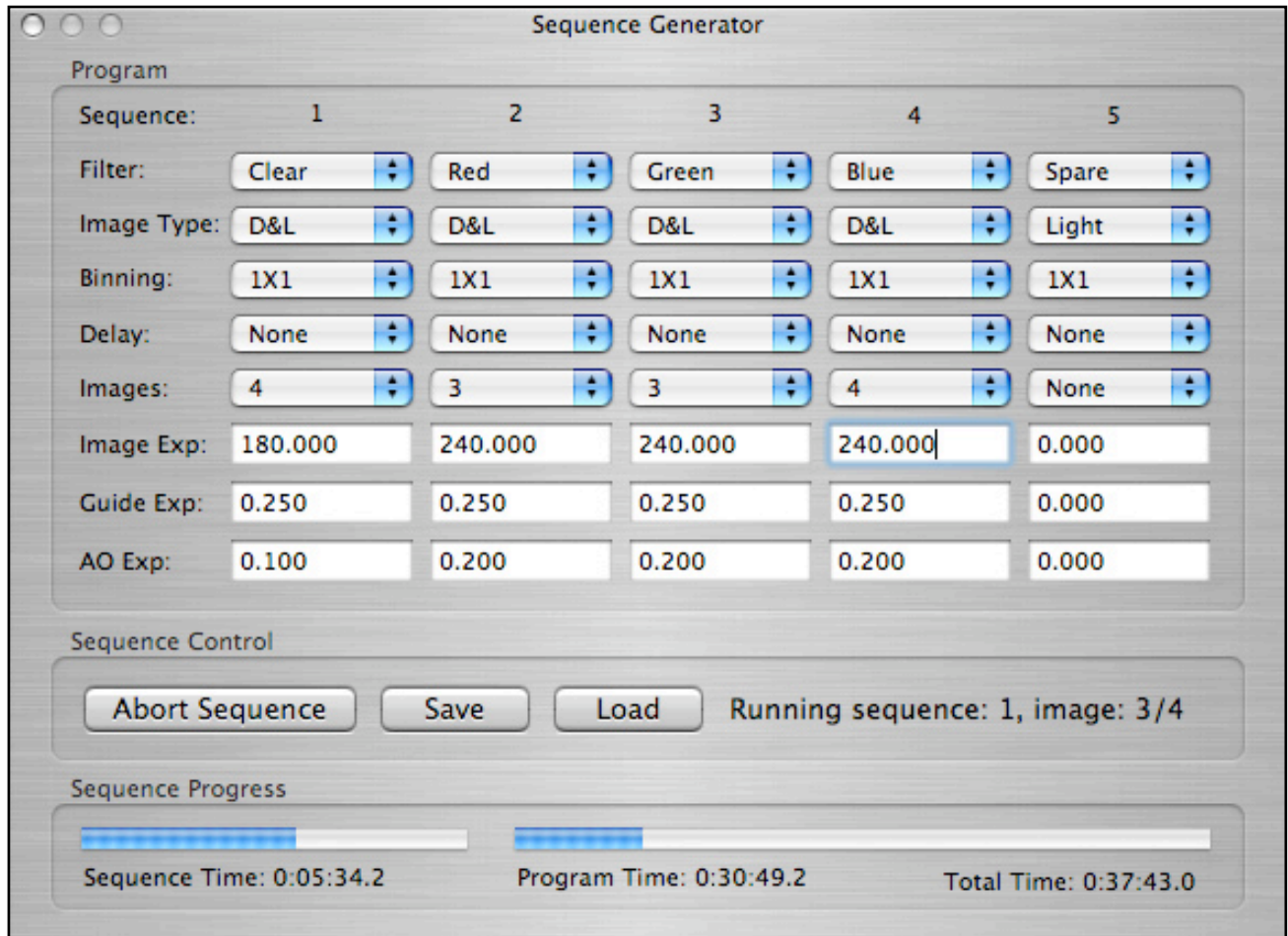
If, over time, the focus changed between exposures that can alter the effective focal length of the scope and also the size of the image. This is usually a minor effect but you can correct for this with the scale slider control.

Once you have the image aligned as accurately as possible, save the file with the Save Align File button. Read in the next image to align and repeat.

The Alignment window Blink tool can be used for supernova and comet searches. Read in the two images you want to compare (Master and Align). Set the color to normal and adjust the Align exposure until the two images match (do not use the align opacity). If the images do not line up use the alignment tools to align them and then select the Blink tool. The display will alternate between the two images. Any star that has gone supernova will blink and any object that has moved will jump back and forth. You can adjust the blink rate with the slider control.

Sequence Generator

The Sequence Generator is displayed from the View menu. This panel allows you to program a sequence of exposures, filter changes and other options.



You can define up to five sequences, each designed to expose images through a different filter. All the normal exposure settings are available, including exposure type, binning and exposure times (entered as seconds). The Delay setting sets the time to wait between exposures, allowing for autoguide stabilization.

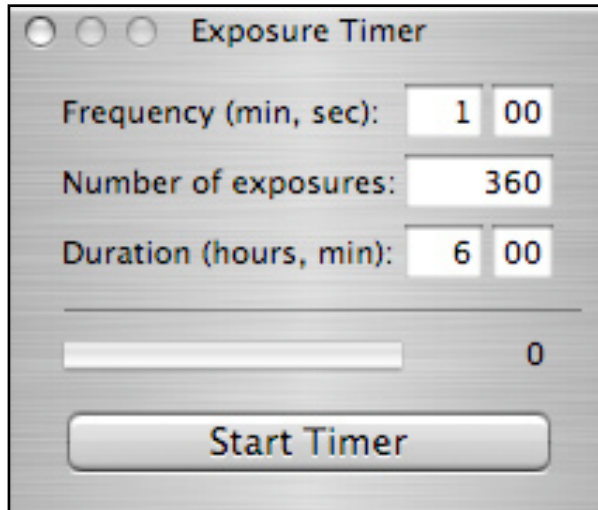
There are two guide exposure times, one for autoguiding and one for the AO if you are using an AO. These guide times should be determined before you start the program. This is very important and will take some effort and experimenting with the guide star you are using.

Once all the sequence information is entered you can save the data in a file with the Save button. You can also load a previously saved program with the Load button.

Before you start the sequence you must initiate autoguiding from the Guide tab. Then hit the Start Sequence button. An estimated total time for the entire program will be calculated and displayed in the Total Time text. As the program runs the remaining time for both the current sequence and the entire program will be displayed, along with progress bars. *Make sure you have Save All checked in the Image tab.*

Exposure Timer

The Exposure Timer allows you to take quick images of the same section of the sky at regular intervals over an extended period of time. You access the Exposure Timer panel from the View menu.



Before you start the timer you must enter all the exposure settings from the Image tab. Make sure you have Save All selected. Define a file name preference and location for the image files from the File tab. If you are autoguiding that must be started before starting the timer.

You can enter a frequency in minutes and seconds. Register your entries with the return key. The frequency can not be faster than the image exposure time plus the download and file write times. A new image will be taken at the entered frequency with about a 1/4 second accuracy.

You can enter the total number of exposures to take or how long you want to run the timer (hours and minutes). If you enter the number of exposures the duration will be calculated. If you enter a duration the number of exposures will be calculated.

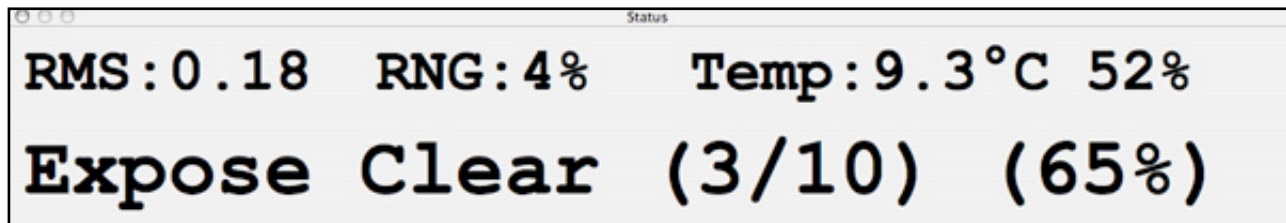
Once you start the timer the progress bar will indicate how far along the timer has progressed. To the right of the bar the total number of images taken so far will be listed.

If you want to change the frequency or the number of exposures to take you must stop the timer first. Enter the new values and then start the timer again. When all the exposures have been taken the timer will stop.

If you want the panel to remain visible when Equinox Image is inactive you can select the Seq checkbox in the Connect tab.

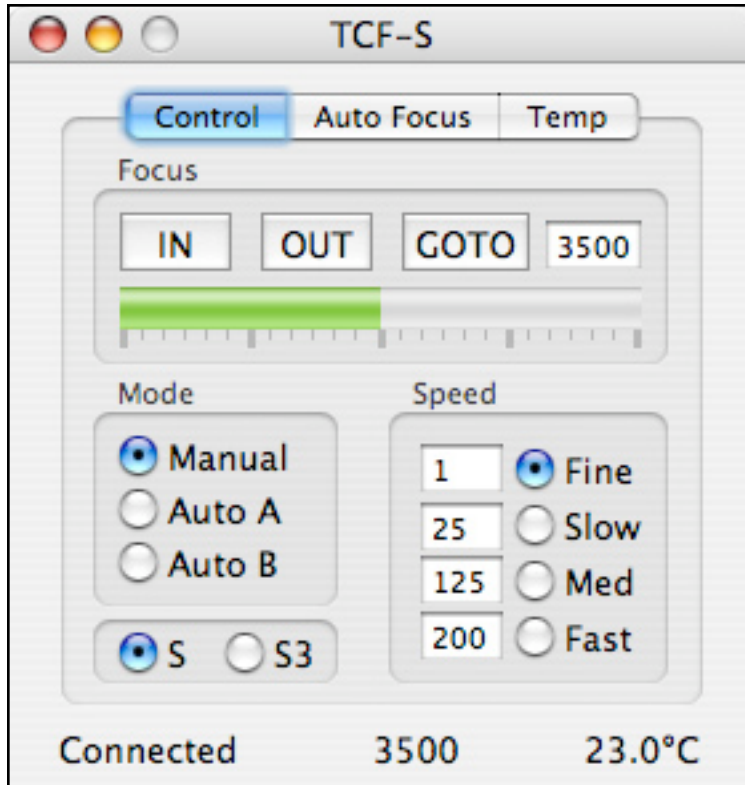
Status Panel

The Status Panel is a large window that displays the current RMS error, AO range or relay time, the chip temperature and power rating and the image exposure status. This panel allows you to monitor this information from a distance away from the computer. You access the Status Panel from the View menu.



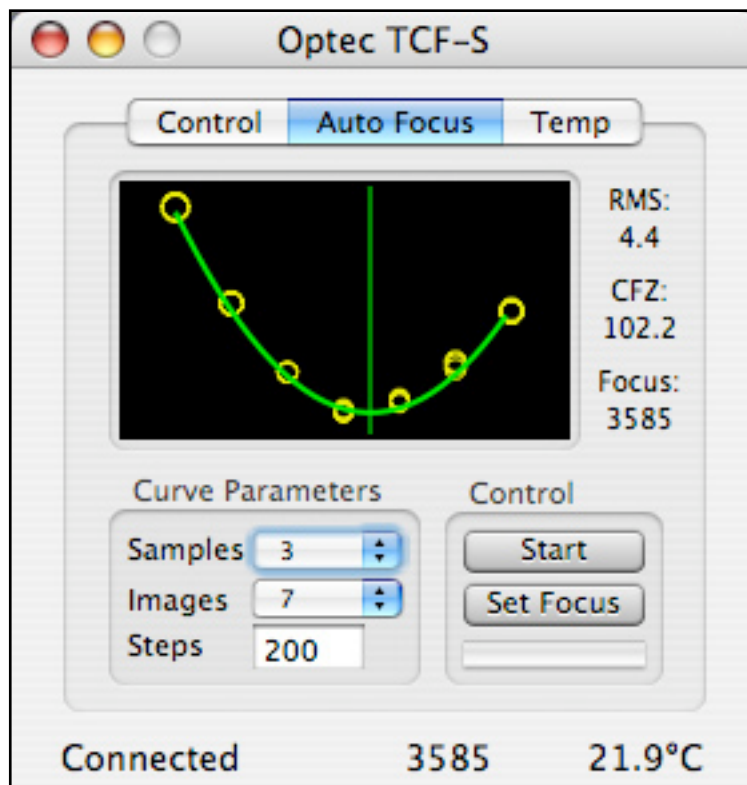
Optec Focuser

Connect to the Optec TCF focuser from the Focuser menu. The focuser is cabled to your Mac by means of a USB/Serial adaptor and the Optec PC serial port converter and cable. Select your focuser model (S or S3) from the Control tab.



From the control tab you can move the focuser in and out at various speeds or set it to a particular position. You can also set the focuser to the A or B temperature compensation modes. The current position and temperature are always displayed at the bottom of the window. The GOTO command and Auto Focus apply backlash compensation. You can also click on the progress bar to GOTO a new position.

From the Auto Focus tab you can calculate the best focus position. First, focus as accurately as you can manually. With color cameras you must set the binning to 1X1. Once you have a reasonably good focus in the image, click on a star. You should choose the star and exposure such that the star will not saturate at the best focus and the star is not near any other bright stars.



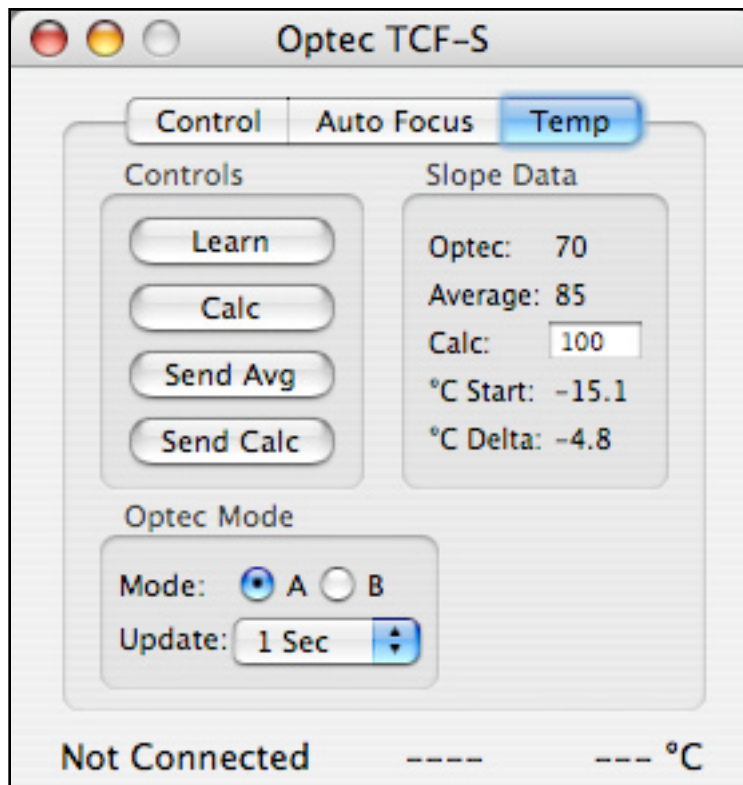
The Samples menu sets how many images to take at each focus position. The Images menu sets how many different focus positions to use and the Steps value sets how many focuser steps to move between images.

To start the auto focus process hit the Start button. This will move the focuser inward by half the total movement range. Images will be taken and the focuser will be moved until all the images have been recorded. The graph should show a curve similar to the example here. If you do not end up with a curve you may have to start the sequence over again from a different starting focus position. The Steps value should be large enough to clearly record variations in focus.

Once the exposure sequence is complete a curve fit routine will run and the best focus position will be calculated. Hit the Set Focus button to move the focuser to this position.

A sigma 2 level RMS error value will be calculated. As long as the error value is within the critical focus zone (CFZ in steps) for your telescope, you are at best focus. You may want to try different Samples, Images and Steps settings to get the lowest RMS error possible.

Note: The auto focus functions have to take control of the SBIG camera, so you can not be autoguiding or using the camera for other purposes while auto focusing.



The Temp tab allows you to monitor and control the Optec temperature compensation functions. You need to establish your best focus first. Select either mode A or B, an update rate and then hit the Learn button. After your scope cools by several degrees you can run the auto focus routine again and then hit the Calc button to calculate the slope data. Each time you do this an average slope value is calculated. You can also enter a slope value manually if you know what it should be. You can send either the current calculation or the average value to the Optec focuser with the Send buttons.

Once you have a good slope value and have sent it to the focuser you can turn on automatic temperature compensation by selecting the mode (A or B) from the Control tab. Do NOT use the mode switch on the Optec hand controller.

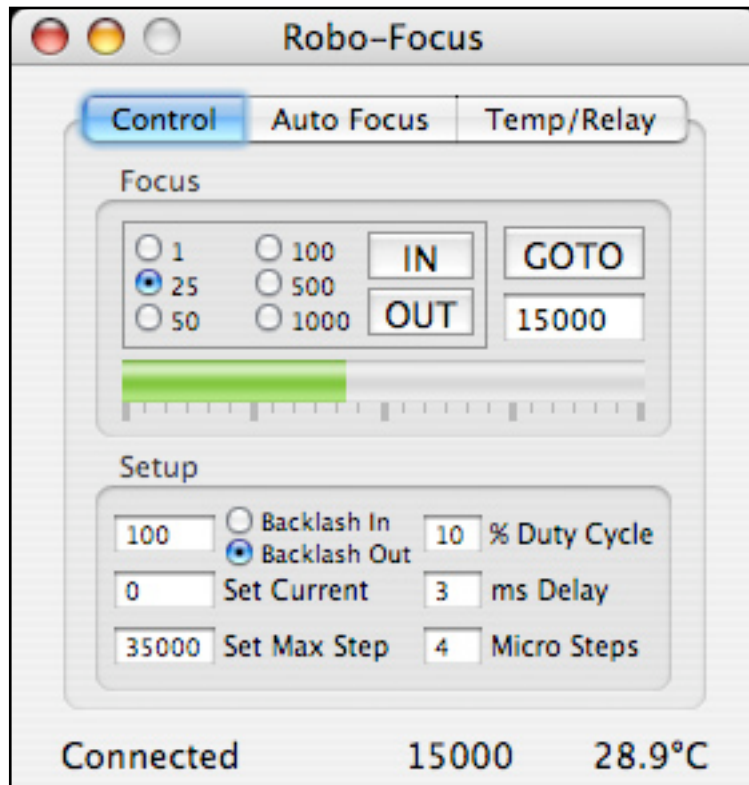
However, if you disconnect from the focuser you can use the mode switch on the Optec hand controller instead.

You can close the Optec panel with the panel's close button or with the Panel menu item. The Optec are still running. The Panel menu item will display the Optec panel again. The Optec menu item will disconnect the Optec focuser.

Be sure to select Manual from the Control tab before you disconnect from the Optec or want to use the focuser's hand controller.

Robo-Focus Focuser

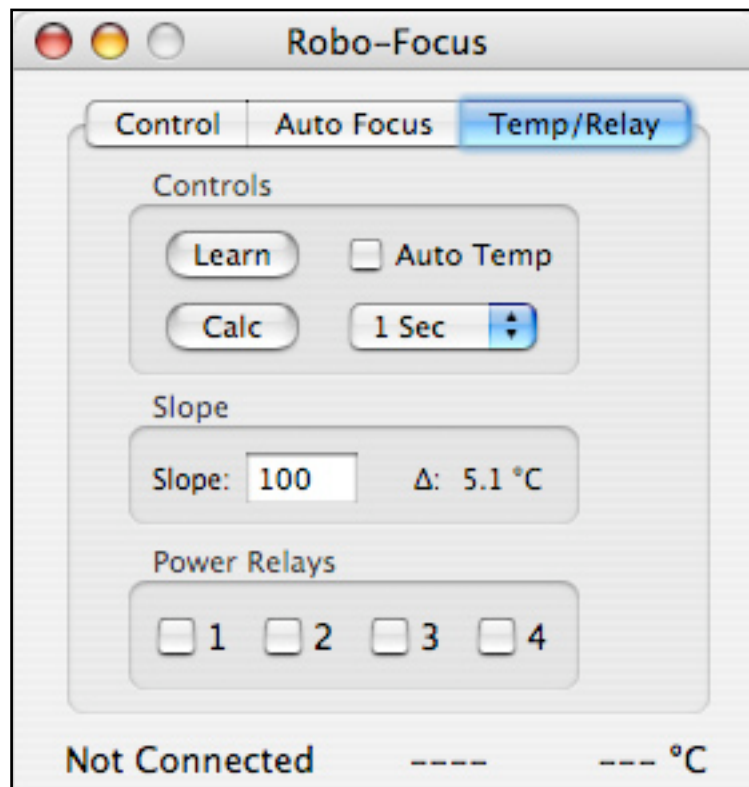
Connect to the Robo-Focus focuser from the Focuser menu. The focuser is connected to your Mac by means of a USB/Serial adaptor and the RS-232 connecting cable.



From the Control tab you can click on the IN and OUT buttons (click on/click off) or the indicator bar to move the focuser. The GOTO button will move the focuser to the entered position. The indicator bar shows the relative position of the focuser from 0 to the Max Step value. *Note: backlash is not applied with the In/Out buttons.*

The Robo-Focus configuration settings are displayed in the Setup box. When you enter new values they will be stored in the Robo-Focus. See the Robo-Focus manual for information about these values.

The Auto Focus controls operate in an identical way to the Optec focuser. See the Optec focuser section in this manual for instructions.

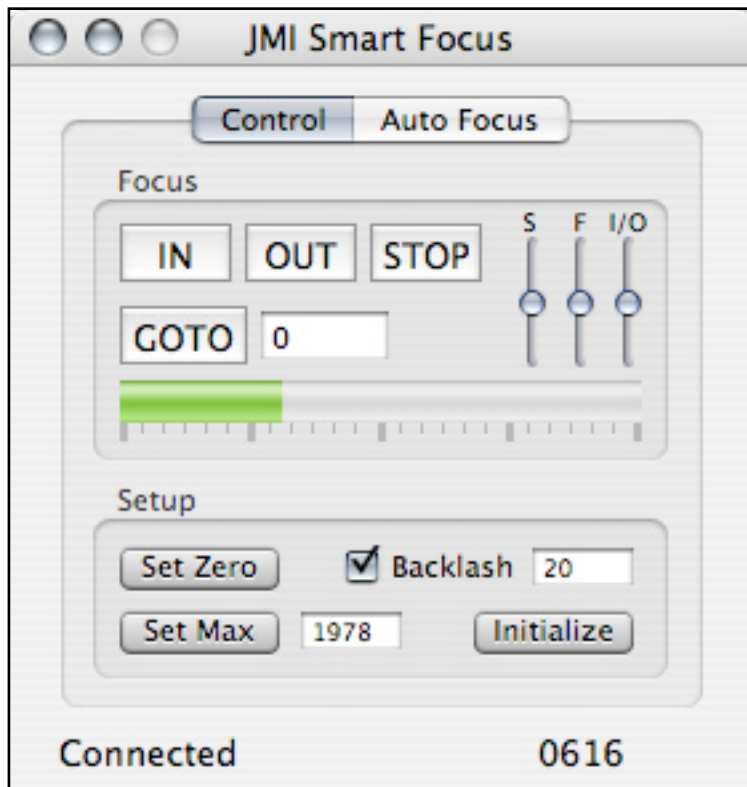


From the Temp/Relay tab you can establish automatic temperature compensation and control the Remote Power Module if you have one.

To enable automatic temperature compensation you need to establish your best focus first. Hit the Learn button and the current focus position and temperature will be saved. After the temperature has dropped several degrees refocus and then hit the Calc button. The temperature compensation slope value will be calculated. Choose an update rate and check the Auto Temp box to start automatic temperature compensation. The slope value will be saved and unless you change scopes or optics you will not have to run the Learn sequence again.

JMI Smart Focus

Connect to the JMI Smart Focus from the Focuser menu. The focuser is connected to your Mac by means of a USB/Serial adaptor and the RS-232 connecting cable.



From the Control tab you can click on the IN and OUT buttons to start focuser movement, enter a value and hit the Goto button or click on the indicator bar to move the focuser. Hit the Stop button during movement and the focuser will stop (without backlash). The IN and OUT buttons do not apply backlash. The indicator bar shows the relative position of the focuser from 0 to the Maximum value.

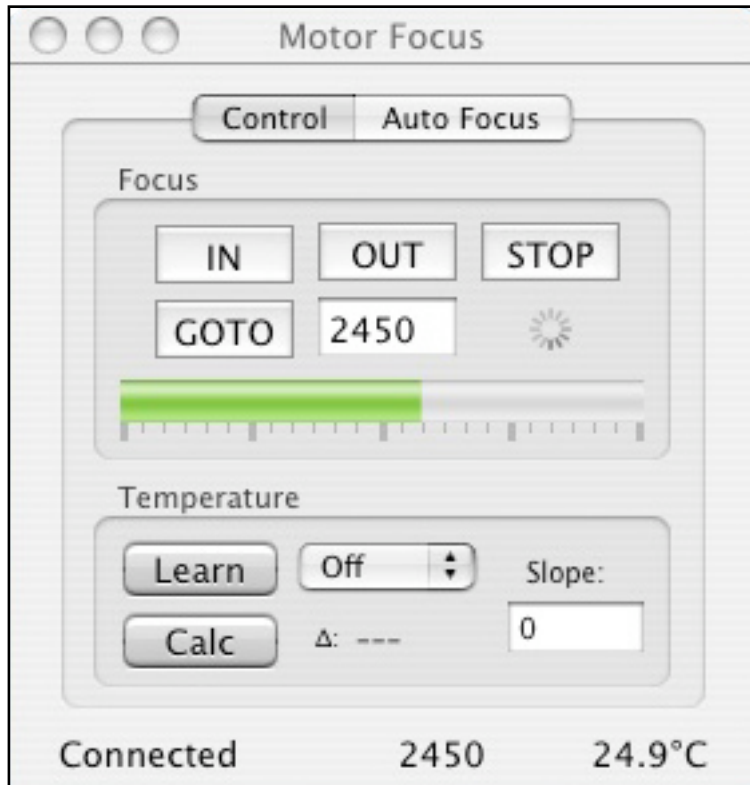
The three slider controls allow you to adjust the focuser speed. The slow (S) slider adjusts the speed when a goto movement is close to the target position. The fast (F) slider adjusts the speed when a goto movement is far from the target position. The IN/OUT (I/O) slider adjusts the speed when the IN or OUT buttons are selected.

The Setup area has controls to establish the zero point, maximum value and backlash amount. *Read the JMI manual before you hit the Initialize button.* It is very important to establish the correct zero point and maximum value before you operate the focuser, and this must be done at least once or Equinox 6 will not be able to accurately move the focuser.

The Auto Focus controls operate in an identical way to the Optec focuser. See the Optec focuser section in this manual for instructions. The JMI Smart Focus does not have temperature compensation.

SBIG Motor Focus

If you have the Motor Focus connected to your camera the MF checkbox in the Connect tab will be enabled. Check the MF box if you want to use the Motor Focus. The Motor Focus menu item in the Focus menu will display the control panel.



You can move the focuser position In, Out or to a specific step value with the Goto button and the text entry field. The Stop button will stop any current movement of the focuser. You can also click on the position indicator bar to move the focuser to that position. A step value of 0 is the center position, with minus values In and positive values Out from the center.

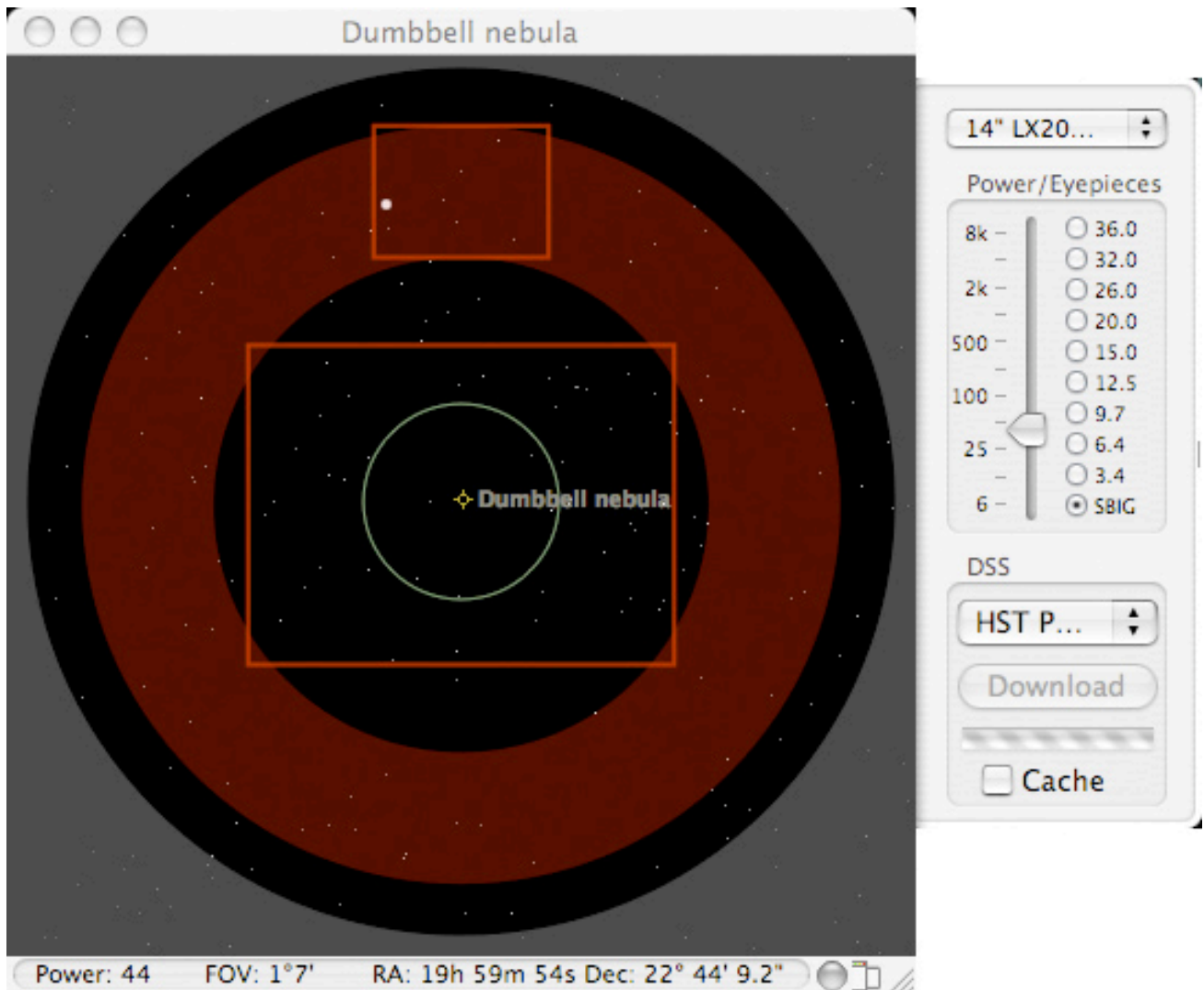
To enable automatic temperature compensation you need to establish your best focus first. Hit the Learn button and the current focus position and temperature will be saved. After the temperature has dropped several degrees refocus and then hit the Calc button. The temperature compensation slope value will be calculated (steps/degree). Choose an update rate from the rate popup menu to start automatic tem-

perature compensation. The slope value will be saved and unless you change scopes or optics you will not have to run the Learn sequence again. You can also manually enter a new slope value at any time.

The Auto Focus controls operate in an identical way to the Optec focuser. See the Optec focuser section in this manual for instructions. However, if you want to use the full range of the Motor Focus you can enter a Steps value of 0.

Equinox 6

Equinox Image and Equinox 6 can talk to each other if both are running at the same time. Equinox 6 can supply scope information to Equinox Image and Equinox Image can supply SBIG camera information to Equinox 6.



Equinox 6 can display an SBIG outline in the Scope View window if it knows what camera is being used. Eyepiece 10 is reserved for SBIG outline use in this case. The SBIG outline can be used to help locate guide stars, centering faint objects and determining what camera angle is required to put a guide star into the guide chip image. The guide chip outline will rotate to the current camera angle if the autoguide calibration has been done.

You can also use this feature when you are not connected to your camera. When you first connect the camera information is saved as a preference. Equinox 6 can access this information when Equinox Image is running even if it is not connected to a camera.

Eyepiece 10 can be used to adjust the SBIG outline to exactly match your images. Start by setting the eyepiece power and FOV to 50. Then compare an actual image taken with your camera to the SV image. Adjust the eyepiece power to scale the SV image to match your actual image. If you have a focal reducer this adjustment will be large. If not the adjustment should be smaller.

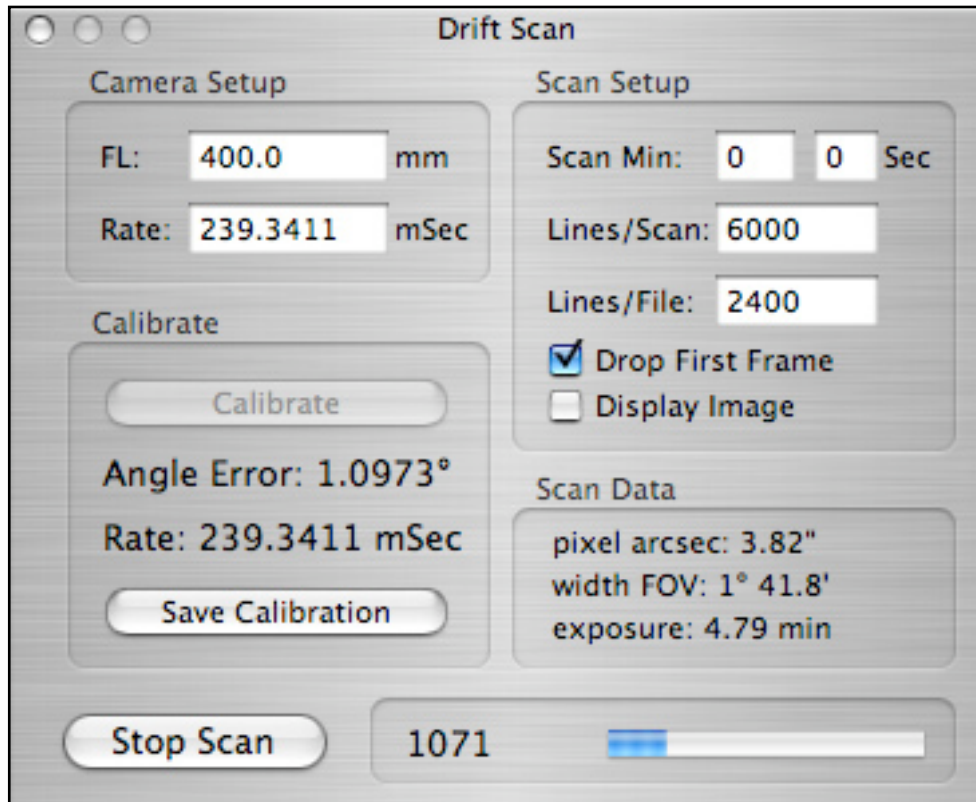
By running Equinox 6 and Equinox Image together during an imaging session you have access to all the scope control features of Equinox 6 with all the camera controls of Equinox Image. However, if you want to do advance planning and guide star selection check out AstroImageBrowser (<http://homepage.mac.com/astrod/Sites/software/astroimagebrowser/aib.html>).

While Equinox 6 can get camera information from Equinox Image to use in the Scope View window, Equinox Image can access the current scope information and object location from Equinox 6. This information is saved in the FITS header of all the images you save. Not only do you get this information recorded with the images but the FWHM calculation can use this information to give you accurate arcsec values - even when you read in the file later on.

You do not have to do anything to initiate this cross application communication. If both applications are running the data is passed between them automatically whenever needed.

Drift Scan

Drift Scanning or Time Delayed Integration (TDI) is an imaging method that keeps the camera fixed and lets the sky drift across the CCD at sidereal rate (RA scanning) or tracks the sky at sidereal rate and drives the scope's Dec at some rate (Dec scanning). This allows you to take huge images of the sky with long exposure times. If you are unfamiliar with TDI techniques you should read the available literature before you try this with Equinox Image.



Equipment

You need a dual processor Mac for best results. While drift scanning your Mac should be dedicated to the task and not running any other applications. Color cameras can not be used for drift scanning and interline cameras (ST-2000XM) are not suitable because of their dark current levels. The use of a focal reducer is not recommended.

Camera Setup

Enter your scope's focal length in the FL text entry box. You must hit the return key to register your entry. If you know the required scan rate you can enter it in the Rate text box. The Calibration operation will calculate the required scan rate and is the preferred method to determine this value if it is not known exactly.

Calibration

Drift scanning requires the image CCD to be aligned precisely. The rows must be pointing north/south for RA scanning or east/west for Dec scanning. This allows the stars to drift up through the CCD on the same column. The calibrate function allows you to align your camera and also calculate the correct scan rate. The scan rate is the time it takes a star to move from one CCD row to the next. For RA scanning the closer you are to a Dec of 0° the better the results.

The calibration function uses the image focus capabilities of Equinox Image. First, align your camera as accurately as you can in the correct orientation. If you are RA scanning make sure your mount is not tracking. If you are Dec scanning make sure your scope is tracking and start the Dec drive.

From the Image tab take a normal image exposure with a fast exposure time (you only want to image the bright stars in the field), Select the Focus checkbox and drag a tall, narrow focus rectangle in the image with a bright star near the bottom. The idea is that you want the bright star to drift straight up. Hit the Expose button to start the focus operation. If a brighter star should drift into the focus area you will have to stop the calibration and start over.

Once the focus exposures are being taken open the Drift Scan panel (from the View menu) and hit the Calibrate button. The position of the bright star will be calculated and used as the start point. As the star drifts up in the focus image the angle will be calculated. You need to align the camera so that the angle error is zero or very close to zero.

Of course, each time you change the camera orientation you will probably have to stop the focus, take a new image and start the calibration over. Once you get the camera accurately aligned let the calibration run for awhile. This will give you a more accurate rate calculation. When you have a good camera alignment and rate calculation stop the calibration and save the calibration values. The save button also saves all the setup data as preferences. You are now ready to start the drift scan exposure.

Scan Setup

You can enter the desired scan time in minutes and seconds or the total number of lines to scan but not both. If you enter zero time and zero lines the scan will run until you manually stop it. At the start of a scan the first frame does not receive a consistent exposure time so normally the Drop First Frame checkbox is selected. When selected the first frame of image data is not written to the file and the scan timer is started at the beginning of the second frame.

The Lines/File entry allows you to specify the maximum number of lines per file. If you enter 0 just one file will be created with the entire scanned image. Otherwise the current file will be closed and a new file opened every time the Lines/File number of lines have been scanned, including 25 lines of overlap.

Select the Display Image checkbox and a 1/4 size image will be displayed. Use this to make sure you are recording a good image but it is recommended that you turn this off once you have verified the scan as it uses a lot of CPU processing time.

Scan Update box

The numerical readout in the update box displays the total number of image lines (CCD rows) that have been downloaded. The progress bar indicates the percent of completion of the scan. If no scan time or lines/scan have been entered, or if the first frame is being downloaded and dropped, the progress bar is indeterminate and animated.

Information box

Pixel arcsec is the field of view of each pixel (height) as determined by the pixel size and the scope's focal length. The width field of view (FOV) is the width of the image in arc degrees and minutes. The exposure value is the time it takes for one complete frame to be exposed in minutes. This is the time it takes for a star to drift up through the entire height of the CCD.

File

When you start a scan a FITS file will be created with the file name preface and location that you have specified from the File tab. Once the first frame is past (if you have selected to drop it) scan data is written to the file. When the scan is stopped, either manually, when the time runs out or when the lines/scan have been recorded, the file is closed. A new scan will open a new file. Note that these files can be very large so make sure you have selected a disk that has sufficient capacity.

If you have specified a Lines/File value each additional file will have the same file name but the file number will be incremented by one.

Dark Frame / Flat Field

Usually a dark frame is not required for drift scan images - hot pixels are averaged out over the entire height of the CCD. However, if you have a bad column it can show up as a streak along the entire length of the image. Equinox Image can minimize this, but not completely eliminate it. You need to take a normal dark frame at the frame exposure time and temperature of your scan. Then use the normal Subtract Dark function from the File tab. Equinox image will figure out that the image is a drift scan and subtract the appropriate amount from each column pixel in the image. You can also process the scanned images with the appropriate flat field image.

Dec Scan Automation

You can automate Dec scanning with AppleScript and Equinox 6. This functionality is primarily used if you have a permanent setup and need to do identical scans extending over many nights.

You need to set up your scope with the Dec guide speed established (this may be difficult with some mounts), the exact scan rate determined and the camera aligned. Once this is done an AppleScript can automate multiple Dec scans with several different setup values and different start locations in the sky.

The Dec scanning parameters are established in one or more text files which must be located in the Misc folder. Use the sample file as a guide.

```
SCANRA = 135.0 // RA in deg. enter -1.0 for no scope action
SCANDEC = -10.0 // Dec in deg.
SCOPEDLY= 60.0 // scope move time in seconds
SCANRATE= 0.048694 // seconds. enter 0.0 to use default
SCANMIN = 0 // enter 0 for scan line
SCANSEC = 0 // enter 0 for scan line
SCANLINE= 9000 // total lines/scan. enter 0 for scan time
SCANFILE= 2400 // lines per file
SCANDROP= YES // drop first frame. enter YES or NO
SCANIMAG= NO // display image. enter YES or NO
SCANDEC+= UP // dec scanning. enter UP. DN, or NA
```

The SCANDEC+ parameter tells the scope which direction to move in Dec. The actual control used is the Equinox Image scope control function, so the control is driven by the autoguide port connection in the SBIG camera. The SCANRA and SCANDEC parameters are sent to Equinox 6 so the goto command is via the serial scope connection. The sequence is:

- 1) goto the RA and Dec (via Equinox 6 with SCOPEDLY seconds delay)
- 2) drive the Dec control (Up or Down via autoguide port) while taking the scan
- 3) once the scan is complete move the scope back to the start RA and Dec
- 4) then repeat.

You can establish many different parameter files and from the AppleScript select the ones to use.

There are many ways to design an automation AppleScript. The following sample starts both Equinox 6 (*you must have version 6.5.0+*) and Equinox Image. It then tells Equinox Image to connect to the camera and Equinox 6 to connect to scope number 1. After a minute (return 60) it then takes three scans using setup file 1, three scans using setup file 2, and then shuts everything down. To use an Idle handler like this sample the AppleScript should be saved as a “Stay Open” application.

```

property mycount : 0
set mycount to 0
run application "Equinox 6"
run application "Equinox Image"
on idle
    set mycount to mycount + 1
    if mycount = 1 then
        tell application "Equinox Image"
            set drift Cmd to "CONNECT"
        end tell
        tell application "Equinox 6"
            set scope Connect to 1
        end tell
        return 60
    else if mycount < 5 then
        tell application "Equinox Image"
            set drift Cmd to "ScanSetup1.txt"
        end tell
    else if mycount < 8 then
        tell application "Equinox Image"
            set drift Cmd to "ScanSetup2.txt"
        end tell
    else
        tell application "Equinox Image"
            set drift Cmd to "STOP"
        end tell
        tell application "Equinox Image"
            quit
        end tell
        tell application "Equinox 6"
            quit
        end tell
        quit
    end if
    return 300
end idle

```

When designing your AppleScript you have to be very careful about the timing. You do not want to start a new scan before the previous one has finished or start driving the scope to a new location in the middle of a scan. It will probably take several attempts and a few bad scans before you get everything timed just right and working the way you want.