600 Series User Guide

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Getting Started

Thank you for your purchase of a QSI Camera.

The QSI 600 Series family of cooled CCD cameras is designed to produce scientific - grade images with wide dynamic range, excellent linearity and low noise. Your QSI camera will provide years of service if properly treated and maintained. To get the most from your camera, we recommend that you read this User Guide thoroughly and follow the included precautions.

If you're in a hurry to try out your new camera and are familiar with the general operation of CCD cameras, this "Getting Started" section provides the basic information you will need to setup your camera and take your first image.

The QSI 600 Series Camera Family Showing Different Body Configurations

What's in the box

Your QSI 600 Series camera was shipped in a soft travel case with custom-cut foam to provide protection. Please take a few minutes to examine your camera to make sure that it has arrived in good condition, and that the case contains the items listed below. Note that additional items purchased at the time of order may be included as well.

- **Camera body**
- **Nosepiece** - 2” or 1 ¼” depending on configuration
- **Mounting adapter** - standard T-mount, or optional mounting adapter
- **Body cap** - matching body cap for mounting adapter
- **AC Power Adapter** - Universal AC power supply (100-240VAC, 50-60Hz) with detachable, region-specific AC power cord
- **USB Cable** - 10 ft. USB 2.0 cable
- **Guider Cable** - 10 ft. guider cable with modular connectors on each end
- **Tools** - tool kit for camera maintenance
- **Documentation envelope containing the following:**
    - Quick Start Guide
    - CD-ROM or USB flash stick containing the Installation program, the USB and camera drivers, and the Installation Guide and this User Guide in PDF format.
    - A licence and download link for Sequence Generator Pro.

Take a few minutes to familiarise yourself with the external connections and features of your camera

The image above shows the major external features of a typical QSI 600 Series camera with the 5-position internal colour filter wheel. The depth of the Camera Cover on your camera may differ depending on the internal options installed. 8-position CFW models have a larger front cover. See the “QSI 600 Series WSG User Guide Supplement” for additional details on WSG models with Integrated Guider Port.

Please note: The liquid heat exchanger is not available for the larger body cameras, such as the QSI 6162

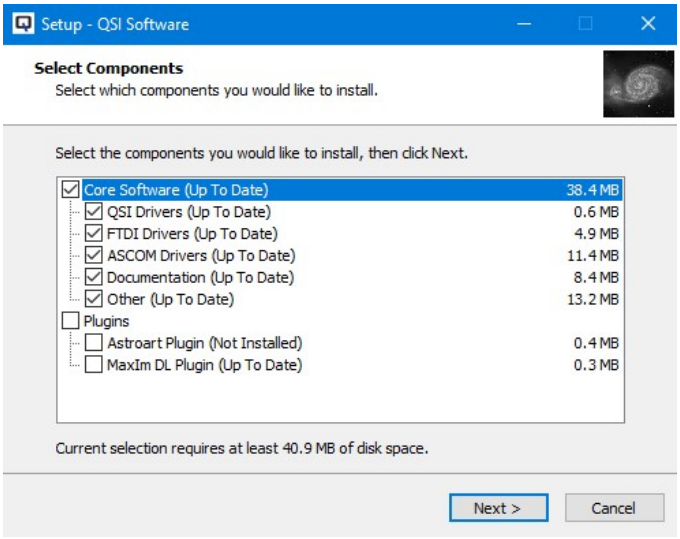
Install software and drivers

Note: For the most up to date version of the software and guides please go to https://qsimaging.com/drivers-software/

The QSI 600 series cameras include either a CD or a USB flash drive containing the drivers for the cameras plus plug-in's for Astroart and MaximDL.

Note: Do not connect your camera to your computer until instructed to do so during the camera installation process.

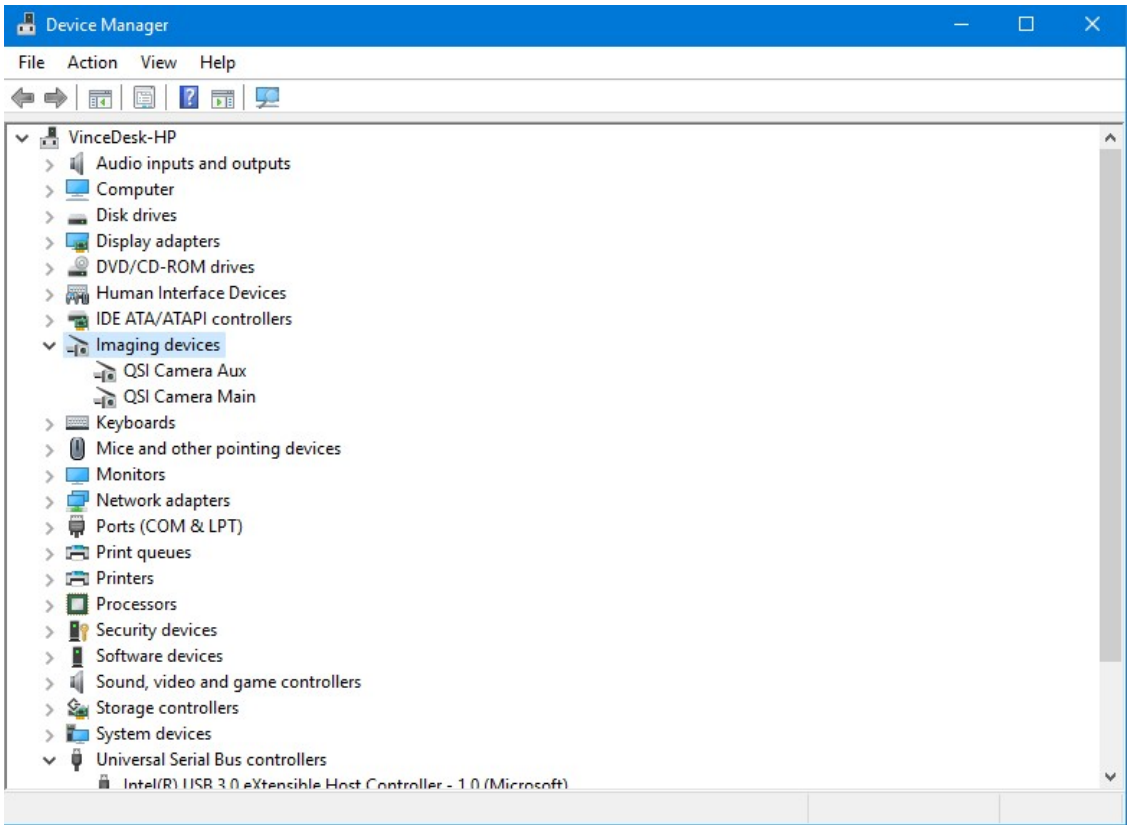
Either insert the supplied CD/flash drive or go to https://qsimaging.com/drivers-software/ to download the latest software. Navigate to the QSIinstaller.exe file and double click this file to launch it. After a confirmation window, you will be presented with the window below.



Select all the tick boxes that you require and select **Next**. Once the installer has completed you will be presented with the window below, select **Finish** and the installation is complete.

Plug in the camera.

Please plug in the power supply followed by the USB cable, your computer will now finish the installation and you should see two new devices in windows device manager as shown below.



Confirm installation and camera operation

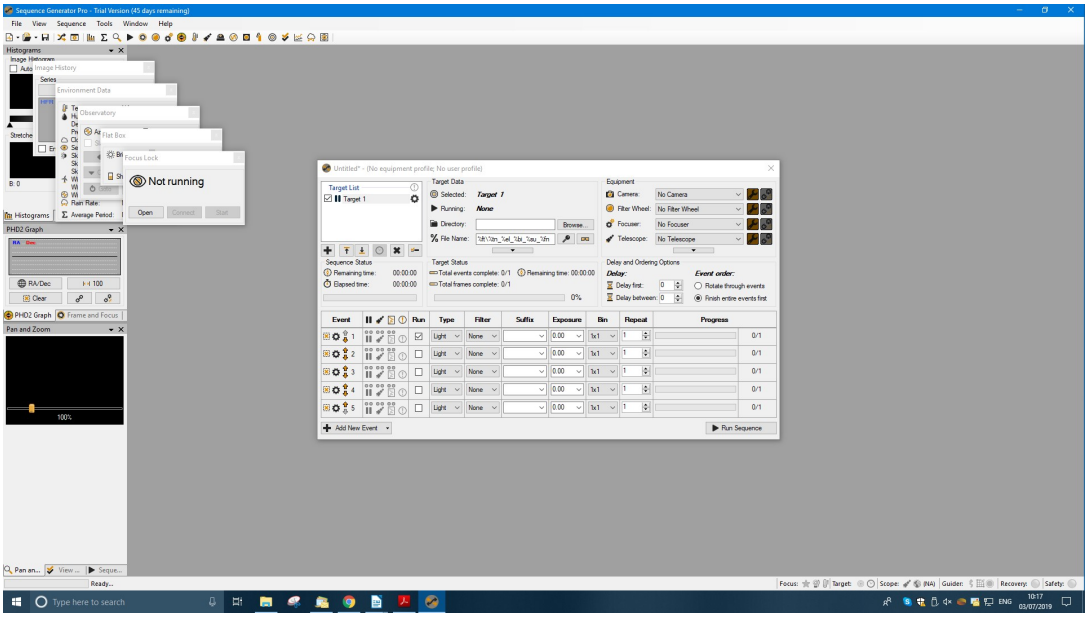
After the successful installation of the camera and the associated software is complete, you can quickly test your camera with SGP or the software application of choice. Please connect the power lead and the USB lead before turning the power on to the camera. Alternatively insert the power connector and wait for the camera to boot before plugging in the USB.

A basic guide to help you get started with SGP

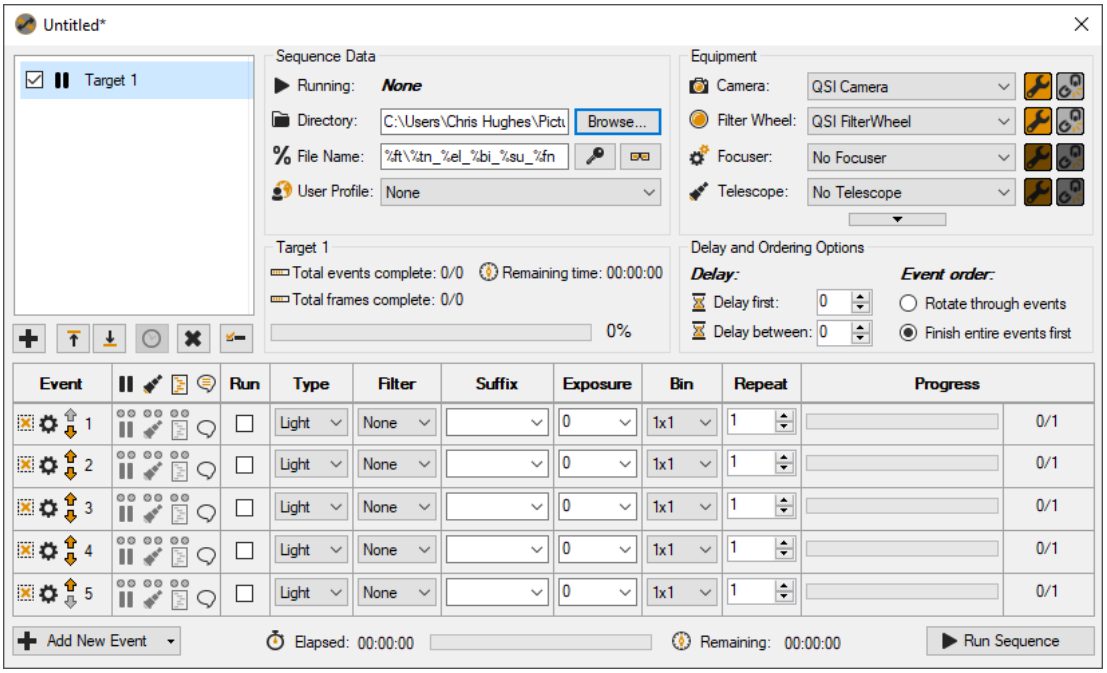
Note: This will also apply to any other control software when connecting through ASCOM.

Download Sequence Generator Pro from the link on the card included with your camera, register the software using the serial number included on the card.

Open SGP and you will be presented with the screen as shown below.

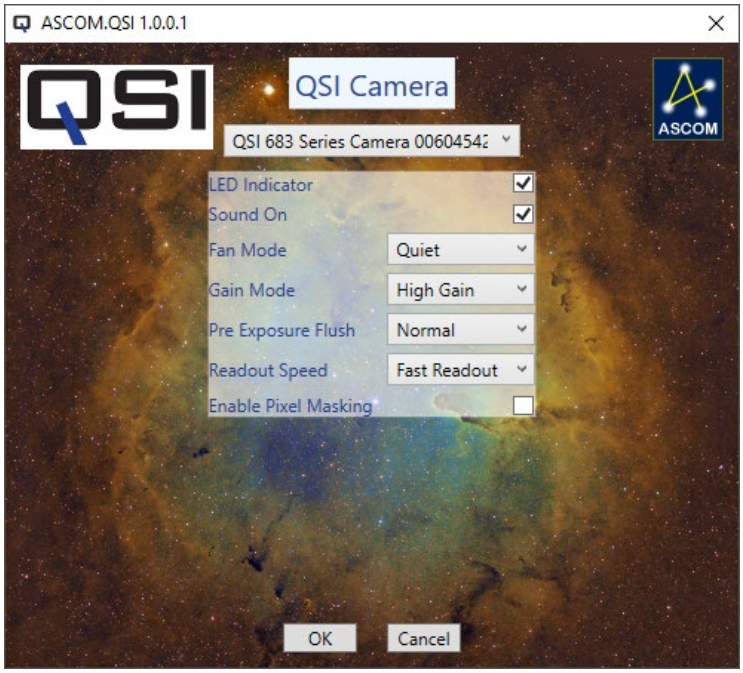


Select QSI Camera and QSI Filter Wheel as shown below and power your camera on if it isn't already on.

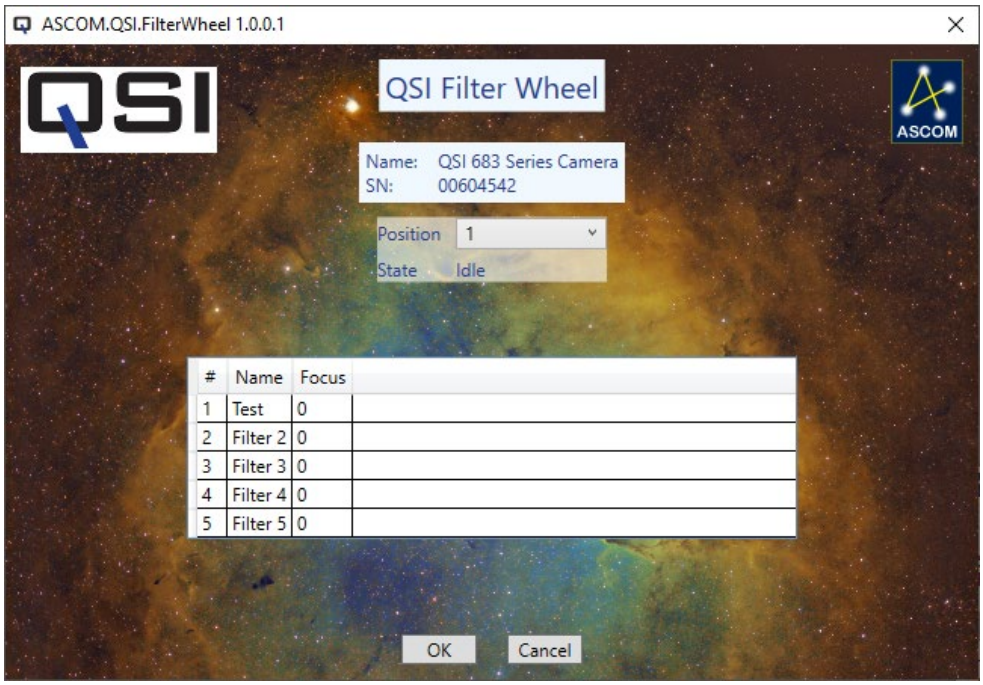


Select the settings icon. You will be presented with the screen below.

Once the camera has been correctly identified it will be named as the connected camera in the pull-down box. Please select the camera and click on OK.



Once your camera has booted up successfully select “connect” and the camera will connect to the software.After the camera has been set up in ASCOM you will then need to set up the filter wheel. Click on the setting button as above and you will be presented with the screen below once the filter wheel has been located.



Please click on OK and connect the filter wheel in SGP

Select a save path in the directory box, and ensure there is a tick in the “Run” box on the first line of the sequencer, set the exposure time and run the sequence. This will then take your first image.

Sequence Generator Pro is a fully featured image acquisition software with may advance features, to take full advantage of all of its many functions please see the Main Sequence Software website for tutorials and helpful video files http://mainsequencesoftware.com/Support

Your downloaded images will be in a standard 16 bit FITS image format, this format can be read by all astronomical processing software for processing and calibration of your images.

SECTION 2

CAMERA FEATURES AND OPERATION

Camera attachment options

The camera can be attached to your telescope or lens in a variety of ways. The image above shows the industry standard T-Adapter with an attached 2" nosepiece. An optional 1.25" nosepiece is also available. The T-Adapter is compatible with a wide variety of standard accessories. A larger diameter 2.156" adapter is available for WSG models.

An optional C-Adapter adapter is also available. The C-Adapter replaces the T-Adapter and is compatible with many standard lenses, lens mounting accessories and other equipment such as microscopes.

Note: The T-Adapter has industry standard 42mm diameter x 0.75 mm pitch threads. The C-Adapter has industry standard 1" x 32TPI threads. Always make certain that any device you attempt to thread into either adapter has proper matching threads. Some optical components have threads that look like they might work, but have slightly different dimensions. **Never force thread anything into the adaptors.**

Attach the camera to your telescope

The picture below shows a QSI 500 Series camera with 2" nosepiece being fitted to the 2" focusing tube of a refracting telescope. Always use the largest nosepiece that your telescope will allow to minimize any vignetting of your image.

With the correct diameter nosepiece firmly screwed in to the front of the camera, carefully guide the nosepiece into the eyepiece adapter on your telescope. Tighten any retaining screw or screws to ensure the camera is stable and will not slip or move when the orientation of the telescope changes.

Electrical connections

The image at the left is a close- up of the bottom of the camera body. All electrical connections to the camera are made through the three connectors located on this connector panel. The panel is recessed into the camera body to protect the connectors when no cables are attached.

DC power connector

The camera is ordinarily powered by the included AC power adapter which plugs into the middle connector on the bottom of the camera. The AC power adapter accepts any input voltage from 90v to 240v and 50-60 Hz. It is supplied with a region-specific AC power cord.

Shortly after power is applied to the camera, the Camera Status Indicator on the back of the camera will start glowing yellow indicating that the camera is starting up. The camera will make a small “chirp” sound and then a few seconds later will make a “chirp” sound indicating that the camera successfully completed its initialization steps. The Camera Status Indicator will begin flashing green if the camera is not connected via the USB cable. The Camera Status Indicator will glow solid green once the camera is connected to the computer via the USB cable. See the **Status and Notification** discussion later in this Section for additional detail.

Note: Power up initialisation can take up to 6 seconds. It is not possible to connect to the camera from an image application during this time. Any attempt to do so will cause an error message to be displayed by your imaging application.

Note: The camera is designed to operate on stable, regulated 12 V DC power and Consumes less than 2 amps at full power. Dc power inputs above or below 12V will decrease the maximum cooling capability of the camera by increasing power dissipation or lowering cooling efficiency. If the input voltage is below 11V or above 14V the camera will report and error until the voltage is returned to the specified range. See Status and Notification below.

Caution: Applying an input voltage over 16V or under 10V may permanently damage your camera and will void the camera warranty

Note: The camera power connector uses a standard 2.1 mm coaxial DC power connector with centre positive connector. The outside diameter is 5.5 mm and the length is 10 mm.

Caution: Because of the wide range of potential power sources (especially with field operations that can employ batteries, generators, DC inverters etc.) there is a real possibility of damaging your camera and other equipment by creating unexpected ground loops and different ground reference potentials between your equipment.

It is highly recommended that the included AC adaptor be used to power the camera at all times, if a power source other than the included is used it is your responsibility to insure it is suitable. Avoid sharing the camera DC power source with other devices that can produce excessive noise (old technology dew heaters, etc.) and possible ground loops that could interfere with the reliable operation, or even damage your equipment.

If you choose to use a power source other than the included AC adapter and are uncertain about meeting these requirements, please

USB connector

The cameras USB interface is compatible with USB 2.0 and 1.1. The inclu ded USB 2.0 cable plugs into the USB port on the camera connector panel. The other side connects to any standard USB port on your computer. All camera control commands and resulting images are passed over the USB cable.

Note: Do not connect your camera to your computer unless you have successfully installed the camera software and drivers.

After the camera power-up initialization is complete, and the cameras USB cable is connected to your computer, the computer will make a Plug-N-Play sound indicating that a device was connected to the computer. This means that your camera is ready and is listening for commands to be sent over the USB connection.

Note: QSI 600 series cameras do not draw power from the USB bus.

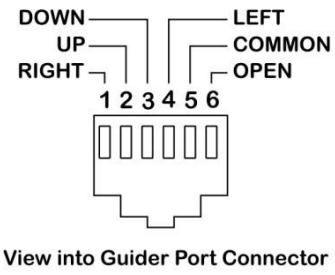
Powered hubs are not necessary for operation.

Guider Control Port

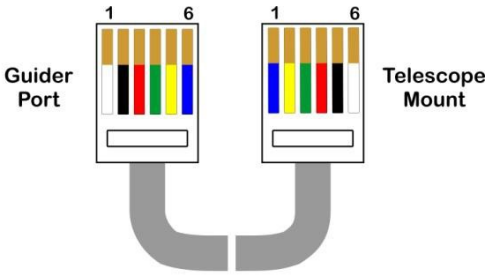
All QSI 600 Series cameras have a Guider Control Port that can be used in conjunction with CCD imaging software to guide your telescope mount for long- duration astro-imaging. Ordinarily, the Port is only operational if the camera is being used as the Guider camera, or if you're using the QSI camera as your main imaging camera and have configured your software to send guider correction signals through the "Main Relays".

The Guider Port employs an RJ-25, 6-conductor modular connector. The interface scheme is compatible with most modern telescope mounts. Typically, a 6P6C (6 position, 6 conductor) telephone-style cable is required for connecting the camera to the mounts guider input. This type of cable is commonly available at retailers such as Radio Shack. A 10 ft. version of this cable is supplied with 600 Series cameras.

The image below summarizes how the Guider Port and compatible cable are wired:



View into Guider Port Connector



RJ-25 6P6C 'Telephone' Style Cable
Wire Colors are Typical

Note: The Guider Port outputs employ optically isolated solid-state switches that mimic the traditional behaviour of the older technology mechanical relays. The optical isolation prevents potentially interfering or damaging ground loops between the camera and the mount.

This newer approach is completable with most modern telescope mounts that employ logic inputs pulled to VCC with a suitable load resistor.

Caution: Do not apply more than 50v or 50 mA to the guider port pins. The ‘Common’ input must be at ground or zero volt potential relative to the control input of your mount. Contact QSI if you are uncertain about your mount’s electrical characteristics.

Cooling the Camera

Cooling the CCD is essential for successful long exposure imaging. Cooling the sensor dramatically reduces the dark current and resulting thermal noise in an image and makes long exposures practical. See the discussion in the CCD Imagin g Overview Section on dark current and noise.

QSI 600 Series cameras use a very efficient thermo-electric cooler (TEC) which relies on the Peltier Effect to cool the CCD. When power is applied to a TEC, one side of the device gets cold and other side gets hot, essentially pumping heat from the cold side to the hot side. All QSI 600 Series cameras employ a two-stage TEC to increase the differential cooling effect.

The more power applied to the TEC, the greater the differential cooling and the colder the CCD can get. The heat pumped from the CCD, as well as the power dissipated by the TEC, creates a significant amount of excess heat that must be removed from the camera. QSI 600 Series cameras employ two different methods for removing this heat.

Standard air cooling

The back of a QSI 600 Series camera acts as a large heatsink with cooling fins machined directly into the body. Two automatically controlled cooling fans force air through these fins. The movement of air through the cooling fins greatly increases the amount of heat removed from the camera.

Keep in mind that the lowest temperature that the CCD can be cooled is limited by the ambient air temperature and the speed of the cooling fans. Achieving very low temperatures is easy when imaging outdoors during cooler weather. If it is particularly cold you may not even need to turn the fans on. If the weather is warm and humid you may not be able to cool the CCD to the desired temperature. See the specifications for your camera to determine the maximum cooling differential you can expect under typical conditions.

Liquid-assisted cooling

Forced air cooling is usually all that is needed to reach desired levels of cooling. However, in warm weather, indoors, or other particularly demanding situations, additional cooling can be achieved with the optional Liquid Heat Exchanger, or LHX. The LHX utilizes recirculating water for more efficient removal of heat from the camera. All things being equal, the LHX can provide an additional 7ºC to 10ºC of CCD cooling. It attaches to the rear of the camera body as illustrated in the image to the right. The LHX includes a thin thermal pad. Place the thermal pad between the LHX and the camera body. Hold the LHX and pad in place with the provided screws.

Water flows through the two hoses, coloured blue in this picture.
Self-sealing quick-disconnect couplings are used to attach the hoses to the LHX so that the hoses can be removed easily without leakage of the recirculating water.

There are numerous ways of supplying recirculating water for the camera. One of the simpler and more common methods for astro-photography is to place a small submersible pump into a 5 gallon plastic pail full of cool water. The temperature of this amount of water will rise by only a few degrees after a full night of imaging. For additional details on the Liquid Heat Exchanger, see the **Accessories** section below.

Note: The fans can usually be turned off when using the LHX. In fact, the fans may actually decreases the cooling ability if the air is warmer than the liquid. The cameras with the larger style body (ie.QSI-6162) do not support the LHX unit.

Caution: It is generally advised that only water be used in the LHX. Coolants such as ethylene glycol and some solvents may damage the seals and gaskets.

How Much Cooling Is Enough?

Good results can be obtained with the CCD cooled to -10ºC when taking modest length exposures. This is easy to achieve with forced air cooling on a QSI 600 Series camera when the ambient air is at 25ºC (77ºF) or lower. For most CCDs used in QSI 600 Series cameras, dark current is reduced by half for every ≈6ºC drop in the temperature of the CCD. Cooling from 26C to -10ºC results in a 64-fold decrease in CCD dark current. For more demanding imaging and longer exposures, lower temperatures are desirable. Cooling the CCD another 12ºC to -22ºC lowers the dark current further to just 0.4% of the dark current at 26C. Cooling below -30ºC results in a diminishing improvement as the noise from the dark current is outweighed by the intrinsic read noise of the CCD itself. The camera will actively prevent the CCD from being cooled below -40ºC.

Note: Refer to the specification sheets at the end of this guide for the exact cooling specification for your particular camera model. Keep in mind that ambient temperature changes, air movements, and even relative humidity can affect the temperature that the camera can reach and maintain.

Note: The cooler is not designed to raise the temperature of the CCD above the temperature of the camera body, i.e. it cannot heat the CCD. If the ambient temperature is – 10 degC the cooler cannot bring the CCD temperature up to 0 degC.

When using forced-air cooling the body of the camera and the window of the CCD chamber can be up to 12ºC warmer than the surrounding ambient air temperature. By definition, the camera will be above the dew point (or frost point) and condensation will not form. When using the LHX there is the opportunity to drive the enclosure of the camera and the CCD chamber window significantly below ambient temperature if the recirculating water is colder that the surrounding environment. If the relative humidity is high enough, this action could drop the camera below the dew/frost point and condensation will form.

Caution: Do not allow excessive dew or frost to collect in or on the camera. Exercise the normal precautions that you would with any precision optical or electronic device. Never use the LHX to drive the camera temperature so low that liquid water forms on or in the camera. Under certain conditions excessive moisture can impair or damage the optical coatings and the electronics.

Controlling the Cooler

The operation of the cooler is managed from your CCD imaging application. When power is first applied to your camera the cooler is in an inactive state. It must be actively turned on. When the Cooler On button is clicked, the camera immediately starts cooling the CCD at full power. The cooler will stay at full power until it has cooled the CCD to within a few degrees of the set point temperature. The camera will then start adjusting the power applied to the cooler as it approaches the set point temperature. The displayed CCD temperature may slightly over-shoot the set point temperature as the regulation servo locks. It can take a couple more minutes for the temperature servo to achieve a solid lock. After lock is achieved, the camera will keep the CCD temperature within 0.1ºC of the set point.

Note: Depending on the ambient temperature and cooler set point, the time to reach the set point temperature can take as long as 15 minutes. Once the CCD temperature has stabilized at the set point value, it is recommended to allow the entire camera an additional 5 to 10 minutes to reach thermal equilibrium.

Note: Best regulation is achieved when the power to the cooler is kept below 85%. This gives the camera some headroom to compensate for variations in the ambient temperature. If the camera cannot reach the desired temperature, it will keep trying by running the cooler at 100% power indefinitely. If the desired temperature hasn't been reached within 15 – 20 minutes, or the power level is above 85%, we recommend selecting a higher set point temperature.

Caution: Be careful not to block free air movement around the camera, or any airflow through the fans and cooling fins on the rear of the camera.

Internal Colour Filter Wheel

A five or eight–position colour filter wheel is available for some QSI 600 Series cameras. The filter wheel is designed to hold five or eight standard 1.25" mounted filters or un-mounted 31mm filters. In the case of the QSI-6162 the filter wheel is designed to hold five or eight 2" mounted filters or 50.8 mm un-mounted filters. The following image shows a 5-position filter wheel with filter positions 1-4 occupied by red, green, blue and luminance filters respectively.

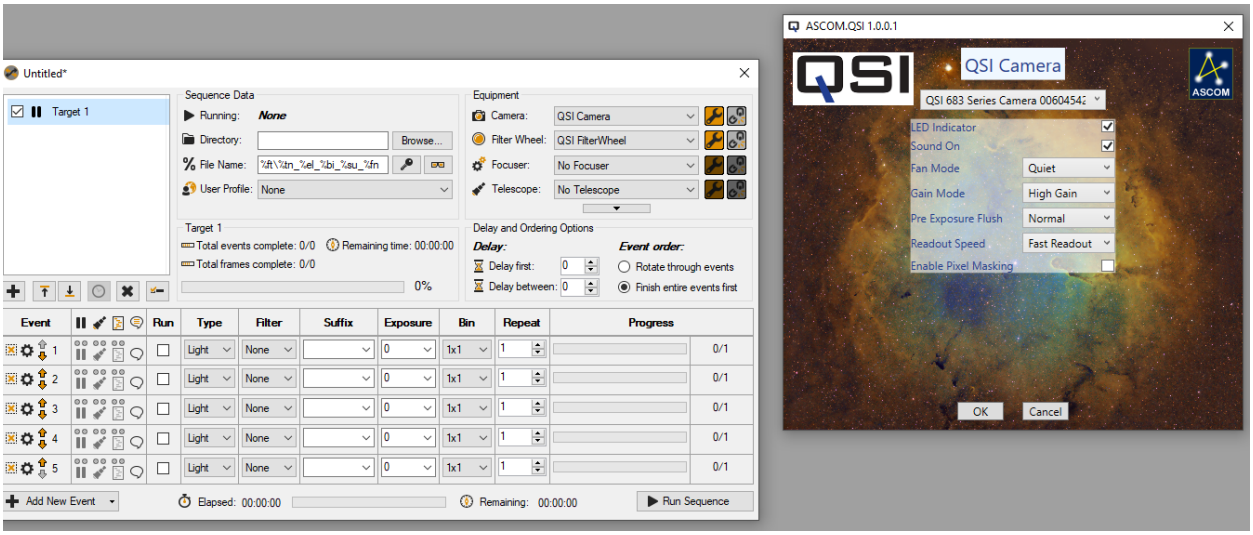
The filter wheel is designed to be removed and replaced easily. After detaching the camera cover, the filter wheel can be removed by loosening the single shoulder screw in the middle of the filter wheel. This allows the user to have additional filter wheels populated with different combinations of filters and interchange them quickly while operating in the field.

See the **Care and Maintenance** section for details.

Advanced Setup Options

The QSI Configuration dialog box is used to view or change camera settings that are seldom modified. Bring up the Camera Control dialog box and click the Setup tab. The camera must be disconnected to proceed further. If necessary, click the Disconnect button.

Open SGP and click on the spanner icon next to the camera select box which is top right in the SGP profile box. This will bring up the ASCOM QSI setting box.



If the Camera Model list box does not indicate your QSI camera please select it from the USB Interface drop-down box. From here you can control things such as the LEDs, Sound on and off, fan mode, gain, Pre-exposure flush, Optimisation, the filter wheel setup and Enabling pixel masking.

Note: The very first time a QSI camera is connected to the computer It will set the relevant options shown above to default values based on the configuration of the specific camera. From that point forward, the settings are maintained in the Windows Registry. All subsequent changes are made to these Registry settings. This allows the computer to always know your last selections for each camera and restore them the next time you begin imaging. Also, a camera's settings are remembered uniquely when being used as a main camera and when being used as a guide camera.

Only those settings that are relevant to a particular camera model and software package are enabled. Options that dont apply are greyed -out.

Camera Selection

USB Interface

Select the specific QSI camera that you wish to control from those listed in the USB Interface list box. Cameras are tracked by their serial number. That is the number located in parenthesis, and will match the number engraved on the camera nameplate / desiccant cover.

If a camera has previously been assigned to another role, it will not appear in the list. For example, if a camera is currently assigned as the Main camera, it will not appear as an option in the Guider selection list box.

Note: If only one camera is connected to the computer, the computer will always select that camera by default. You do not need to make a selection here. If two or more cameras are available and they match the serial numbers of the last camera(s) used for the Main and / or Guide camera, the computer will automatically reconnect them in the same roles

The only time you will need to actively make a selection is when you have two or more cameras available and you want to:

1) Change the camera roles or

2) Select a new camera that has never been connected to this computer before.

Ethernet Interface This function is disabled on QSI 600 series cameras

Status Indicators

LED Indicator On - Uncheck to disable the Status Indicator LED on the back of the camera. Only normal status indications are disabled.

Visual indication of errors cannot be disabled.

Sound on - Uncheck to disable the Audible Beeper. Sounds associated with camera initialization and error notification cannot be disabled.

Fan mode - Can be set to Off, Quiet or Full-Speed. Quiet is the default setting and is sufficient in most situations.

If Off is selected the fans are disabled unless the camera temperature begins to exceed a predefined safe level. At that point the fans are turned on and run at full speed until the camera temperature is reduced to a safe level. ***Turning the fans off is only recommended when there is an alternate source of cooling such as an external fan or the when using the Liquid Heat Exchanger.***

When in Quiet mode the camera runs the fans at reduced speed for quieter operation. If more cooling is required to maintain the set point temperature, the fan speed is increased as needed to maintain the desired temperature.

Full-Speed mode runs the fans at full speed.

Imaging Options

Camera Gain Default setting is “High”. This setting can only be changed on camera models that support switchable gain. With supported cameras, gain can be set to “High,” “Low” or “Auto”. “High” gain is recommended for 1x1 binning. “Low” gain is recommended for binning higher than 1x1 in order to utilize the full dynamic range of the CCD. “Auto” sets the gain automatically to “High” for 1x1 binning and “Low” for binning other than 1x1. Note: Some camera control applications may offer additional methods of controlling the Camera Gain setting. See below.

Shutter Priority - Settings are “Mechanical” or “Electronic”. This setting can only be changed on cameras with interline transfer CCDs . In “Mechanical” priority the shutter is closed after each exposure. In “Electronic” priority the mechanical shutter is left open unless the camera is exposing a dark or bias frame. Electronic priority provides the highest possible frame rate when taking short exposures.

Anti-Blooming - Default setting is “Off”. This can only be set to On with cameras that have CCDs with anti-blooming protection that can be controlled or adjusted electronically.

Pre-Exposure Flush - This number determines how aggressively the pixels in the CCD are flushed between exposures. The default value is “normal”. It can be lowered to decrease the time between exposures or increased if you want to ensure that the CCD retains less stray charge between exposures.

When using full-frame CCDs such as in the QSI 616 and 632, the Flush options correspond to 0, 1, 2, 4, and 8 flush cycles respectively. With interline transfer CCDs a variety of flushing techniques are used by the different Flush options to provide increasingly aggressive flushing of stray charge before beginning an exposure.

Show D/L Progress Check this box to enable reporting progress while an image is being downloaded from the camera. The default setting is “Off”. If Show D/L Progress is enabled it will modestly increase the download time.

Optimization - Some QSI camera models (e.g. QSI 600 Series cameras) support multiple read modes. Select “Image Quality” for the highest image quality or “Readout Speed” for the fastest possible downloads. Default is “Image Quality”.

Note: Some camera control applications may offer additional methods of controlling the Readout Mode Optimization setting.

Other Options

Cooling Control, Filter Wheel and Camera Gain will only be enabled in the Advanced Dialog Box when using Software packages that do not offer direct control of these features from within the application. If the options are greyed out you should change these settings using the features built into the application. Refer to the User Guide for your camera control application for details.

Some camera control applications such as Maxim DL provide options for changing the Camera Gain and Readout Mode Optimization from the Camera Control Window and AutoSave dialog box. This allows those settings to be changed as part of an automated sequence.

Gain offers three options

1. High Gain - High Gain is optimized for 1x1 binning.

2. Low Gain - Low Gain is optimized for binning higher than 1x1.

3. Auto - Auto selects “High” gain for images with 1x1 binning and “Low” gain for images with binning higher than 1x1.

In the example below Gain is set to “Auto” for the Light frames in sequence positions 1 through 4, to “High Gain” for the bin 1x1 Dark frame in position 5 and to “Low Gain” for the bin 2x2 Dark frame in position 6. In most situations Gain can be set to “Auto.”

Readout Mode Optimization offers three options:

4. Use Adv Dialog Use the Optimization setting from the Advanced Dialog box.

5. Image Quality Set Optimization to Image Quality – lowest noise.

6. Fast Readout Set Optimization to Readout Speed – fastest downloads.

Cooling control - For camera control applications that do not provide a way to enable cooling or control the set point temperature, cooling can be turned on by clicking the checkbox next to “Cooler On.” The desired temperature can then be set in the text box in degrees Celsius.

Filter wheel - For camera control applications that do not provide a way to setup and/or control the filter wheel, click the “Setup…” button to assign names to the filter positions of your camera.

Enable pixel masking

Enable Pixel Masking is an advanced function that does not need to be used under most normal circumstances. Click the “Enable Pixel Masking” checkbox to expose a table of pixel X, Y values (see dialog box below) Enter the X,Y coordinates of a pixel that you wish to be “masked” or ignored.

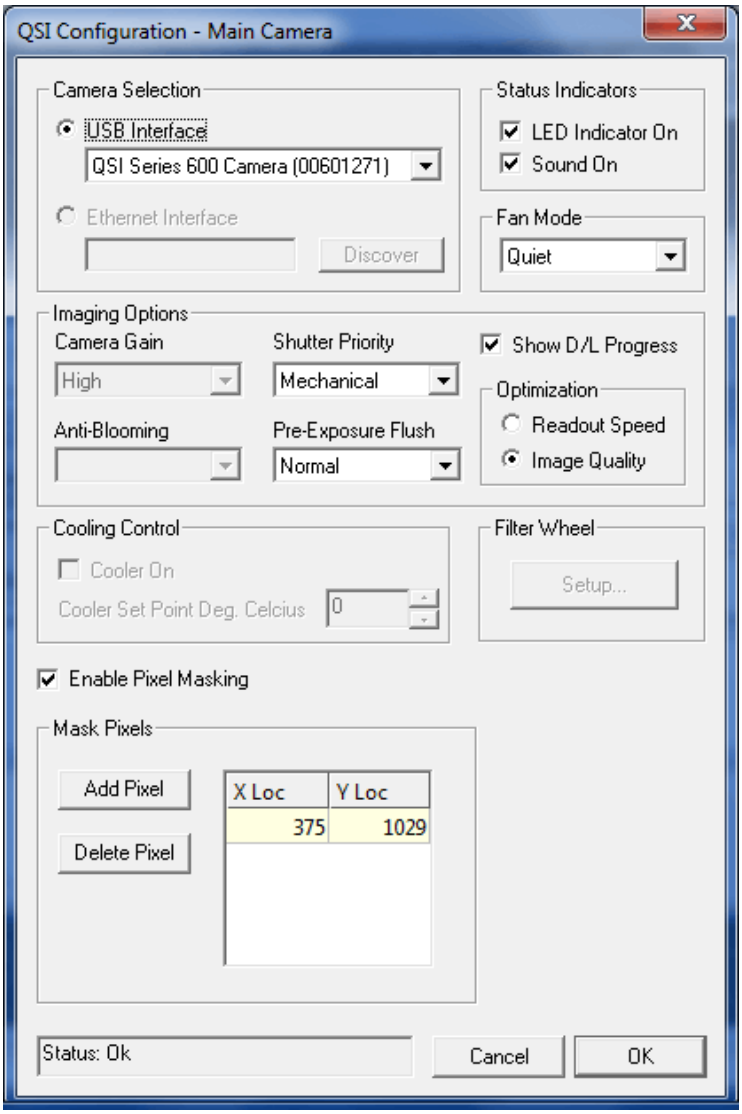
When a pixel value is “masked” its original value is replaced with a constant, typically 200. It can be used to replace the value of excessively bright or dark pixels with a known value. This function can sometimes be handy, for instance, when using guiding or focusing software the automatically selects the brightest pixel in the image. If the brightest pixel is a hot pixel rather than a star, then masking the pixel will allow the software to function correctly.

Some camera control applications offer more sophisticated methods of interpolating missing values from the values of surrounding pixels. See your software’s User Guide for additional details.

Click “Add Pixel” to add another entry in the Mask Pixels table. If a pixel entry is selected, the new entry will be entered above the current entry. If no pixel is selected, a new entry will be added at the end of the table.

Select a pixel X or Y value and click “Delete Pixel” to delete that pixel value from the Mask Pixels table.

Note: Pixel values are stored by the camera serial number in the registry of the connected computer. If you have multiple QSI, separate “Mask Pixel” tables will be automatically maintained for each camera.



Advanced dialog box showing the “Mask Pixel” table.

The current camera status is shown in the text field to the left of the OK and Cancel buttons.

Click the OK button to save your changes or the Cancel button to abort them. This will return you to the Setup QSI Universal window. Click OK again and youll be returned to the Setup tab in the Camera Control window.

Status and notification

QSI 600 Series cameras utilize a variety of methods to inform the operator of the cameras operation, status and other events. A built-in LED Status Indicator and audible Beeper provide notification at the camera. In the event of a serious internal error, the camera will also pass a descriptive error code back to the controlling application which then reports it to the user.

Camera status indication

There is a small tri-state LED indicator on the camera back just above the connector panel. The LED indicates the current status of the camera and any operation that is underway.

The LED can display green, yellow or red and flash at various rates.

Camera operational state indication

Green solid - In Idle state, not Busy. Ready to accept commands.

Green flashing - USB cable not connected. Not ready to accept commands. This only indicates that the USB cable is not physically connected between the camera and computer or hub.

Yellow solid - Busy with internal operation. Not ready to accept commands. This state is seen while the camera is performing power-up initialization, moving the filter wheel or shutter, or when uploading an image to the computer

Yellow flashing - Upgrading firmware. The indicator will flash rapidly while downloading the camera firmware and then more slowly as it is validated.

Red slow flashing - Exposing an image. Flashes once every 4 seconds. The camera can still respond to commands (such as abort image or read CCD temperature) while in this state.

Note: The Status Indicator can be disabled for the normal camera states described above. This may be desirable during long exposures where the light from the Status indicator may be reflected into the telescope. See Advanced Setup dialog.

Camera error indication

Camera error conditions are indicated by a more elaborate sequence of Red and Yellow flashes of the Status Indicator. Errors are classified as Soft errors or Hard errors. Soft errors are those that the camera can mitigate, but typically need operator action to resolve. Soft errors always begin with one Red flash followed by a number of Yellow flashes.

Camera soft error state indication

Flash Red: 1

Flash Yellow:1

The camera is over-temperature. Camera has exceeded the 40°C maximum recommended operating temperature for the internal electronics and enclosure. This sequence will repeat every four seconds as long as the camera remains “over- temperature”.

Flash Red: 1

Flash Yellow: 2

The CCD is under-temperature. The CCD has exceeded the -40°C minimum recommended operating temperature. This sequence will repeat every four seconds as long as the CCD remains “under-temperature”.

Flash Red: 1

Flash Yellow: 3

The camera DC supply voltage is below the 11V minimum recommended operating level. This sequence will repeat every four seconds until the supply voltage is raised above this threshold.

Flash Red: 1

Flash Yellow: 4

The camera DC supply voltage is above the 14V maximum recommended operating level. This sequence will repeat every four seconds until the supply voltage is lowered below this threshold.

Flash Red: 1

Flash Yellow: 5

The filter wheel has encountered a problem and is no longer operational. The camera will still function, but will no longer attempt to move the filter wheel. The filter wheel may be in any position. Power to the camera must be turned off and on to reinitialize the filter wheel.

Flash Red: 1

Flash Yellow: 6

The shutter has encountered a problem and is no longer operational. The camera will still function, but will no longer attempt to operate the shutter. The shutter may be in any state. Power to the camera must be turned off and on to reinitialize the shutter.

Hard errors occur when the USB communication channel to the computer malfunctions or the camera has an unrecoverable internal error. The power to the camera must be turned off and on to reinitialize the camera and USB connection to the computer. This class of error is generally caused by problems with the USB connection between the camera and computer or software and firmware version incompatibility. Hard errors always begin with two Red flashes followed by a number of Yellow flashes.

Camera hard error state indication

Flash Red: 2

Flash Yellow: N

The number of yellow flashes of the Status Indicator specifies the nature of the camera Hard Error. This code indicates the technical nature of the problem.

Note: Neither class of error indications can be disabled with the Advanced Diolog box. If you encounter any of these errors, make a record of the code flashing by the Status Indicator. This information will be useful if you need to contact QSI Customer Services.

Audible beeper

There is a small beeper located inside the camera that is used to provide notification of various events. Shortly after power is applied to the camera, the Beeper will make a short “chirp” sound indicating that the camera is entering the Initialization mode. Once the camera is fully operational the Beeper will make a “chirp-chirp” sound. At this point the camera is ready to communicate over the USB connection to the computer.

The Beeper is also sounded in sequence with the Status Indicator when any sort of error occurs. A long beep is sounded whenever the Status Indicator is displaying Red and a short beep when displaying yellow. This audible alert is intended to alert the operator in case the Status Indicator is not noticed or not visible.

Note: The Beeper disable function in the Advanced Dialog box does not apply to power-on initialization or error notifications. These events are always accompanied by the corresponding audible beeper sounds.

Imaging application messages

The imaging applications may display messages in response to activities performed with the camera. Many of these messages have straightforward text descriptions of the event. Others messages may include only a numeric code. If you get a message indicating an error, record the text message or numeric code in the event that you need to contact QSI Customer Support.

SECTION 3

CCD Imaging Overview

This section is intended only as a brief overview of CCDs and CCD Imaging. If you are new to CCD imaging there are a number of excellent books and lots of information on the internet that you can use to gain a deeper understanding of the issues and techniques. The subject matter is discussed in the context of astronomical imaging, but the basic principles apply to any application.

How CCDs work

Charge Coupled Devices (CCD) work by converting photons into electrons which are then stored in individual pixels. A CCD is organized in a two-dimensional array of pixels. The CCDs used in the QSI 600 Series cameras at the time of printing range from roughly 400,000 pixels (768W x 512H) to 16 million pixels (4499 W x 3599 H).

Each pixel can hold some maximum number of electrons. CCDs currently used in the QSI 600 Series can hold from 25,500 to as many as 100,000 electrons depending on the specific model of CCD. While integrating (exposing) an image, photons strike individual pixels and are converted to electrons and stored in each pixel well. The effectiveness of this process is referred to as Quantum Efficiency (QE). The number of electrons stored in each pixel “well” is proportional to the number of photons that struck that pixel. This linear response is one of the key traits that make CCDs exceptionally well suited to astronomical imaging. A subject that is twice as bright will build up twice as many electrons in the CCD. After an exposure is complete, the electrons in each pixel are shifted out of the CCD and converted to a number, indicating how dark or light each particular pixel was. Those brightness values for each pixel are then stored in the image file, typically a FITS file for astronomical imaging.

Types of CCDs

CCDs are available in a variety of designs and technologies. QSI cameras currently employ two different types of CCDs, Full Frame and Interline Transfer, with numerous optional features.

Full-frame CCDs

Full-Frame CCDs generally provide the highest sensitivity and the widest linear response range of these two types of CCDs. These characteristics make full-frame CCDs ideally suited to astronomical imaging. Full-frame CCDs must employ a mechanical shutter to prevent light from falling on the CCD surface while the image is being shifted out of the CCD.

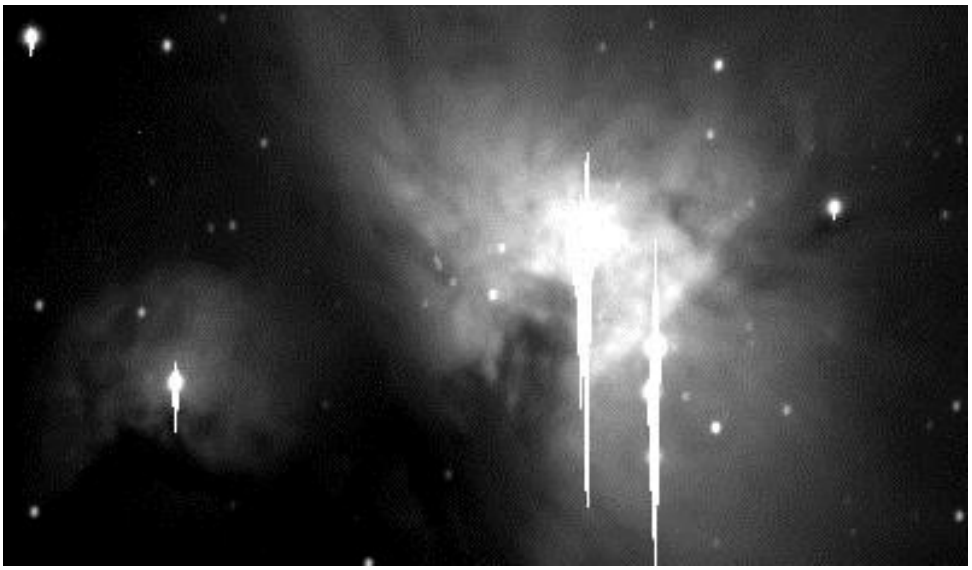
Interline transfer CCDs

Interline transfer CCDs work somewhat differently. In an interline transfer CCD, next to every column of pixels is a specialized storage column that is covered by a mask to prevent light from hitting the storage pixels underneath. When an exposure is complete, the entire image is shifted in a single operation into this masked storage column. The pixels which are now under the mask stop building additional charge and are shifted out of the CCD in the same fashion as

a full-frame CCD. Interline transfer CCDs give up some sensitivity because a sizeable portion of the potential light gathering surface of the CCD is occupied by the masked storage columns. The key benefit of interline transfer CCDs is that the shifting of the image into the masked storage column acts like a very precise electronic shutter allowing short, accurate exposures.

Anti-blooming CCDs

CCDs are subject to an electronic artefact called “blooming” that results in bright vertical streaks leading from bright objects.



The 60-second image above shows a portion of M42, the great nebula in Orion. The stars that make up the centre of the nebula are much brighter than the surrounding nebula. Taking an exposure long enough to show detail in the nebula causes the bright stars to bloom. Note that some of the other brighter stars around the image also show varying amounts of blooming.

Blooming occurs when taking images of bright objects because when a pixel reaches its full well capacity, say 100,000 electrons, the electrons literally overflow into adjoining pixels eventually causing them to fill and overflow as well. In a severely bloomed image, the bright blooming trail can lead all the way to the edge of the image. Data under a “bloom” is lost although there are a variety of processing techniques that can be used to hide pixel blooms in a final processed image.

Anti-blooming is a feature available on many full-frame and most interline transfer CCDs. Anti-blooming technology limits the number of electrons that can accumulate in a pixel by draining off excess electrons before they exceed the capacity of the pixel. This can increase the dynamic rage of the CCD by as much as 300 times or more. This increase in dynamic range greatly reduces the difficulty of imaging bright objects.

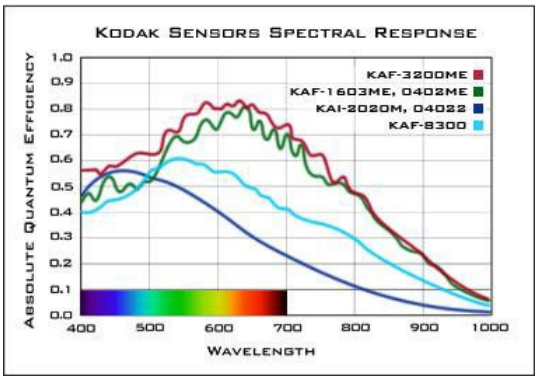
Anti-blooming CCDs make astrophotography more convenient, but with trade-offs in quantum efficiency (QE) and linearity. Anti-blooming protection requires additional circuitry on the surface of the CCD, reducing the physical size and consequently the light gathering area of each pixel. Anti-blooming CCDs also have a non-linear response to light. This non- linearity becomes significant as a pixel fills beyond 50%. The closer a pixel gets to full-well capacity, the greater the rate of electron drainage in order to prevent blooming. This generally isn't a problem if your goal is producing great-looking pictures of the night sky, but anti-blooming CCDs are generally not appropriate for photometric and other scientific use where accurately recording the relative brightness of objects is important.

Microlenses

CCDs only record the light that hits the photosensitive portion of the CCD. Most CCDs are "front illuminated" meaning that the light strikes the top surface of the integrated circuit forming the CCD. A portion of the surface of the CCD is covered with the electronic circuits that make a CCD work. Light striking a part of the CCD covered by a circuit will not get recorded by the CCD.

The surface of some CCDs is covered with microlenses which focus more of the light striking the surface of the CCD onto the photosensitive area away from the circuits.

The amount of the CCD surface covered in circuits is one factor in determining the quantum efficiency (QE) of the CCD. QE is a measure of how efficiently the CCD converts photons striking the CCD into electrons stored in any given pixel. QE varies by type of CCD and by the wavelength of light. Adding microlenses to a front-illuminated CCD will raise the quantum efficiency of the CCD. Typical peak QE values for the CCDs used in QSI 600 Series cameras range from 35% to over 80%. Microlens models tend to have the highest QE, while anti-blooming gate models tend to have the lowest QE. Here is a graph showing the QE of the CCDs available in QSI 600 Series cameras at the time of printing.



Note that the non-anti-blooming, full frame KAF-3200 and KAF-1603 have the highest QE, peaking toward the red end of the spectrum around 650nm. The anti-blooming, interline transfer KAI-2020 and KAI-04022 have the lowest QE, peaking toward the blue end of the visible spectrum around 450nm.

Single-shot colour CCDs

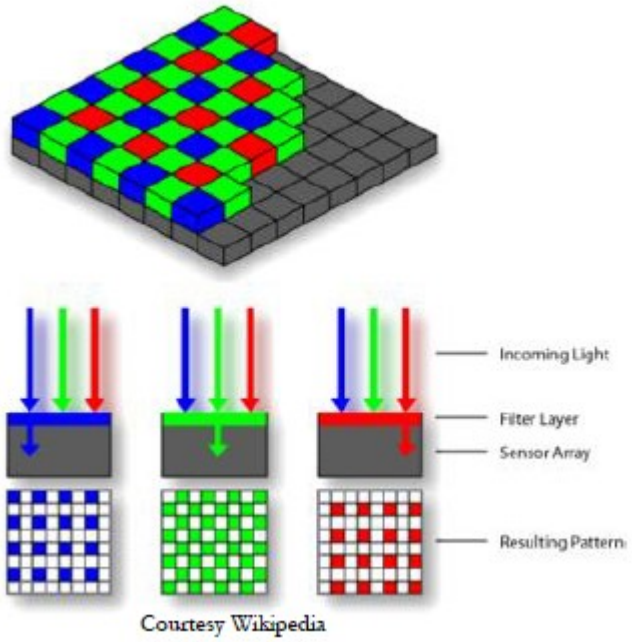
CCDs are inherently monochrome devices with varying response to different frequencies of light. That varying response can be seen in the quantum efficiency graph above. Colour images are normally produced with CCD cameras by taking three (or more) images through red, green and blue filters. The resulting images are then combined using computer image processing programs into a final colour image.

Single-shot colour CCDs, like those found in almost all general use digital cameras, are made by placing red, green and blue filters over adjacent pixels in the CCD. The image processing program then has to separate the three different colour images and recombine them into a single colour image.

Single-shot colour CCDs use a “Bayer filter” with alternating red, green and blue pixels covering adjacent pixels in a checker board pattern as shown in the image to the right.

50% of the pixels are covered in a green filter, 25% are covered in a blue filter and 25% are covered in a red filter. This arrangement is used because the human eye is most sensitive to green light. The green pixels correspond to luminance and record the greatest detail while the red and blue filters record chrominance.

After the raw image is read from the CCD, an algorithm to take away the mosaic must be applied to the image to produce a complete set of red, green and blue images by interpolating the missing pixel values. This is exactly what normal digital cameras do, but it’s all hidden inside the camera’s electronics. You only see the final processed image. With a CCD camera, the raw image is read into the camera control program and then processed on your computer. This has the advantage that you can directly manipulate the raw image to, for instance, vary the colour balance.



Courtesy Wikipedia

Single-shot colour models offer the easiest way to take colour images of the night sky. The trade-off is reduced QE and detail because of the mosaic removal and pixel interpolation.

Signal versus noise

For an astronomer, “signal” is the photons coming from the stars in the night sky. In an ideal world, there would be steady stream of photons from every bright object and every photon striking a pixel would be converted into exactly one electron in the CCD. Then the number of electrons would be precisely counted and converted to a number telling the photographer exactly how much light struck each pixel. Unfortunately, the process of converting light to pixel values in a CCD image is governed by some fundamental physical laws and other factors that introduce “noise” into an image. Noise is unwanted variations in pixel values that make the image a less than exact representation of the original scene.

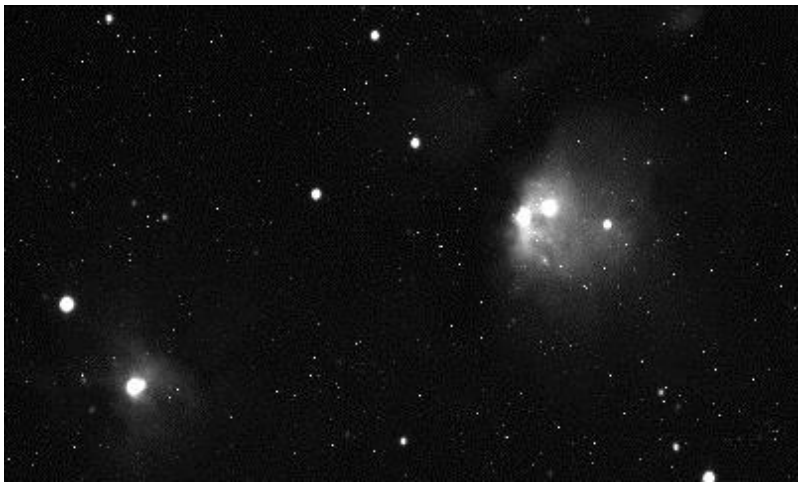
Noise in CCD images can manifest itself in multiple ways, including “graininess” in darker background areas, “hot” pixels, faint horizontal or vertical lines that become visible in low signal areas of the image, blotchy gradients between darker and lighter regions in a nebula, a gradient

from dark to light from one corner or side of an image to the other, and especially as low contrast images — the result of a reduced signal to noise ratio. Achieving high dynamic range, low noise images from a cooled CCD camera requires a basic understanding of how CCDs work and the different sources of noise that can reduce the quality of your images.

Reducing noise in CCD images

CCD imagers have developed a standard set of calibration techniques to reduce or eliminate different types of noise from CCD images. Calibrating CCD images requires taking some special kinds of exposures that are then applied to the “light frames” taken of the night sky. The calibration frames are called Dark Frames, Flat Fields and Bias Frames. CCD camera control software help gather these extra frames. After the frames are gathered, you will need processing software that allows you to calibrate your images either automatically or manually.

All the calibration frames should be collected during each imaging session with the CCD at the same temperature used for the light frames. This will ensure the best possible calibration of the final images. Many CCD imagers plan their night of observing to begin taking the calibration frames as dawn approaches. That way, you don’t waste precious dark time

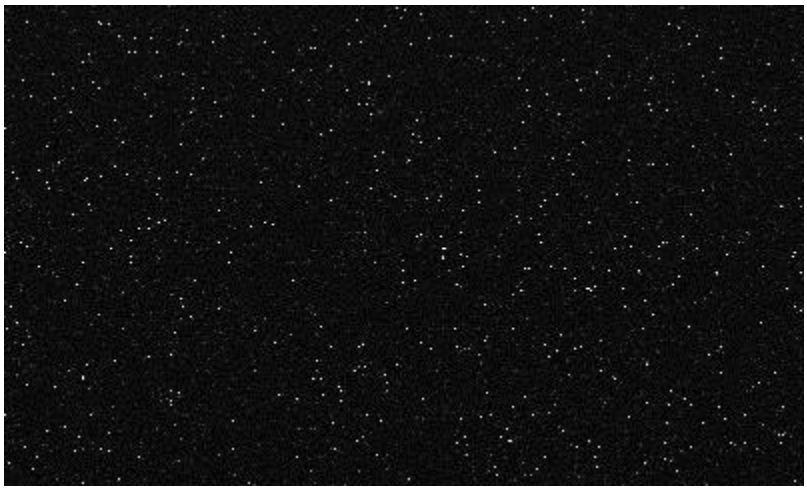


The image above is a single raw 6-minute image of the diffuse nebula M78 in Orion. Some bright stars are clearly visible along with some nebulosity but there are also scattered bright spots around the image caused by “hot” pixels.

Dark frames

Dark frames are used to subtract the build-up of dark current from a CCD image. Dark current is caused by heat. Similar to how CCDs convert the energy from a photon into a stored electron, CCDs also convert the energy from heat into stored electrons. CCDs build up “dark current” whether the CCD is being exposed to light or not. The rate that dark current builds up is dependent on the temperature of the CCD and can be dramatically reduced by cooling the CCD. Dark current builds up more slowly as the temperature of the CCD is reduced.

Most pixels on a CCD build up dark current at a constant rate but that rate will vary slightly from pixel to pixel. A subset of the pixels in a CCD will build up dark current at a dramatically different rate from the average. These pixels are called “hot pixels” or “dark pixels”. Hot pixels and dark pixels are both the result of slight imperfections introduced into the silicon substrate of the CCD during the manufacturing process. Hot pixels are very easy to see in a raw CCD image as a series of bright dots placed randomly around the image.



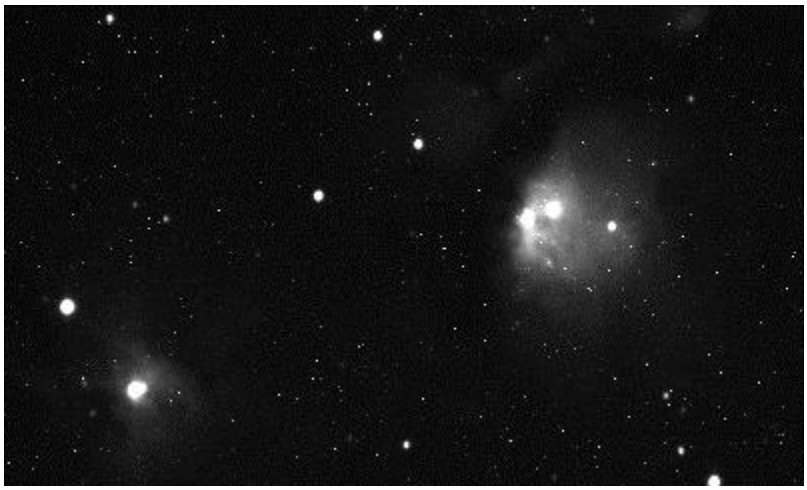
6- minute Dark Frame

Above is a 6-minute dark frame taken during the same imaging session with the above image of M78. Notice the brighter pixels scattered randomly around the image.

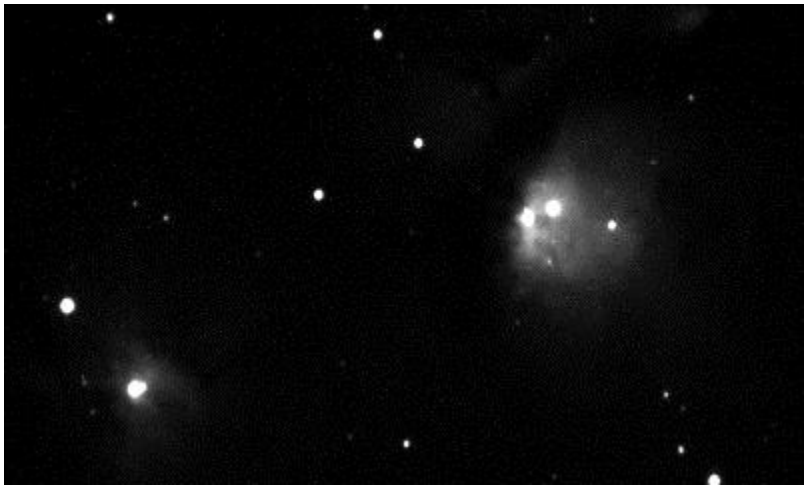
Most imaging software will automatically scales the visible range of pixels to match the underlying data. In the dark frame shown above the average pixel value is just 203 out of a possible 16-bit dynamic range of 0-65,535. Seeing an automatically scaled dark frame or bias frame can be a bit disconcerting for a new imager. Fear not, this “noise” will be almost completely eliminated by subtracting a dark frame from your images.

Dark frames are subtracted from a light frame to remove the dark current from the image. This subtraction removes the slight differences in dark current build-up from pixel to pixel along with the larger variations caused by hot or dark pixels.

In general you’ll want to take at least 5 dark frames at each exposure used for your light frames. You’ll get even better results with 9 or more dark frames. If all your light frames were taken with 5-minute exposures, you’ll need to collect a set of 5-minute dark frames. If you took both 5-minute and 10-minute light frames, you’ll need a set of 5-minute dark frames and a set of 10 minute dark frames. There is a way to reduce the number of dark frames you collect by using a set of bias frames but, in general, you’ll achieve the best results taking dark frames with the same exposure as your light frames.



Original image



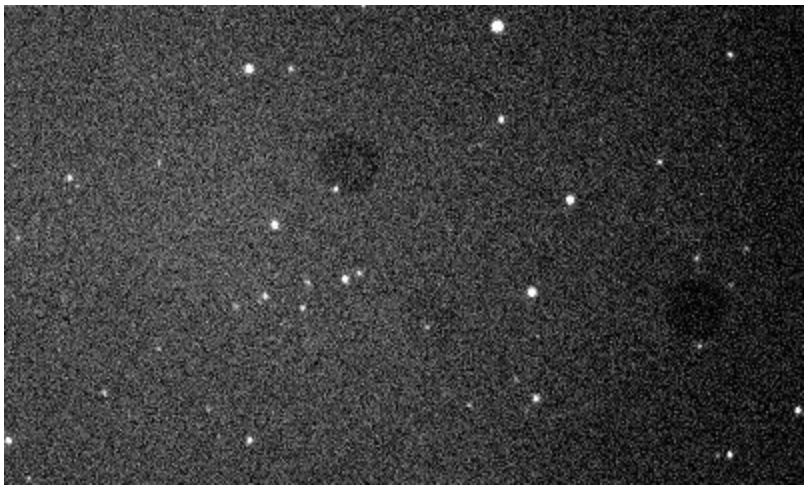
Original image minus dark frame

Look at the two images above. The top image is the original image as it came out of the camera. The bottom image has had the average of 5 dark frames subtracted from it. Note that the bright pixels have been virtually eliminated leaving a smooth black sky background.

Flat fields

Flat fields are used to correct for any irregularities in your optical system, such as vignetting or dust motes, and to adjust for any pixel non-uniformity inherent in the CCD. Pixels in a CCD all respond slightly differently to light, typically within 1% to 2% across a CCD.

All optical systems have a “signature” which gets recorded on the CCD. This unique signature is caused by how light travels through the telescope illuminating the CCD and how each pixel responds to that illumination.



The image above has been manipulated to highlight the effect of dust motes on a filter or CCD cover glass. Note the 3 darker circles. Because dust will tend to stay in one place over a night of imaging, the variation in pixel values caused by the dust can be easily eliminated by properly applying a Flat Field.

A flat field is created by taking an image of an evenly illuminated subject. There are four common ways to create flat fields.

Lightbox flats – Using a lightbox is usually the easiest way to create good flat fields. There are a few commercial lightbox solutions, but many astronomers make their own. You can find plans in The New CCD Astronomy and The Handbook of Astronomical Image Processing as well as online. Search for “Telescope light box”.

Twilight flats – There is a brief time after the sun sets or just before it rises when the sky is appropriate for creating flat frames. Too early and the sky is too bright. Too late and stars will begin to show up in the image.

Dome flats – If your telescope is in an observatory, you can take dome flats. A dome flat is created by aiming your telescope at a white card placed somewhere on the inside of the dome.

Sky flats –Taking sky flats requires taking dozens or hundreds of images with the telescope pointed at the sky with tracking turned off. All the images are combined into a master flat to remove the effect of any stars moving through the field. Sky flats require more time than the other three options so few amateurs take sky flats. We recommend reading the section on Sky Flats in the Handbook of Astronomical Image Processing for additional details on this technique.

Good flat fields require an exposure time such that the pixel wells are filled to approximately half their full capacity. With a QSI 600 Series camera you should strive to achieve average pixel values between 20,000 and 30,000 out of a total of roughly 65,000. You should experiment with exposure times to yield that result. Pixel values are commonly called “ADUs”, short for Analog to Digital Units.

You’ll need to take enough flat fields to average out the noise and then take a series of dark frames (called flat-darks) using the same exposure you used for your flat fields. Just as with light frames, the flat-darks are subtracted from the flat fields to remove any contribution from

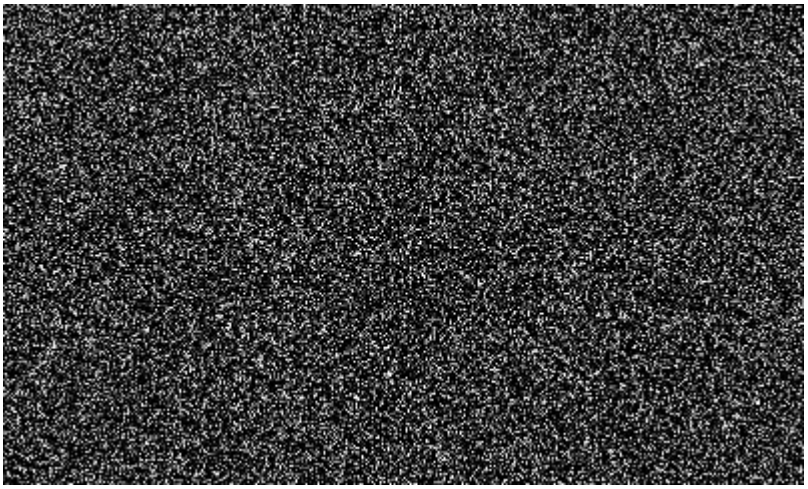
dark current. Taking 16 flat fields and 16 flat-darks will yield excellent results. Luckily because flat fields tend to use fairly short exposures, you can often take a full series of flat fields and flat-darks in just a few minutes.

The resulting master Flat Field is used to scale the pixel values in the light frame, eliminating the effects of pixel non-uniformity, optical vignetting and dust on the optical surfaces.

Bias frames

A Bias Frame is a zero-length (dark) exposure intended to measure just the difference between the pixels plus any additional noise added during the process of reading the image from the CCD and converting it into a digital image file. Because the CCD pixels are emptied immediately before the image is read from the CCD, only a small amount of dark current has had a chance to build up, but that rate of accumulation varies slightly for every pixel. Also, reading an image from a CCD is not instantaneous. Pixels near the bottom of the CCD are read later than pixels closer to the top of the CCD so pixels toward the bottom tend to have slightly higher pixel values than pixels closer to the top.

One common use of bias frames is for scaling dark frames. By subtracting a bias frame from a dark frame, you end up with a “thermal frame.” A thermal frame contains pixel values showing just the effect of dark current. Because dark current in any given pixel accumulates at a constant rate, a thermal frame allows you to predict with reasonable accuracy how much dark current there would be for different length exposures. However, given the opportunity, you’re generally better off taking dark frames that match the exposure times of your light frames.



Here is an example bias frame. Note again that this image has been automatically stretched to show variations in the pixel values. Your software does this automatically when you view an image file. All the pixel values in the original image fall between 181 and 221 out of a possible range of 0-65,535, meaning that the unstretched image would appear almost perfectly and uniformly black.

Bias frames can also be used to analyse the read noise in a CCD camera.

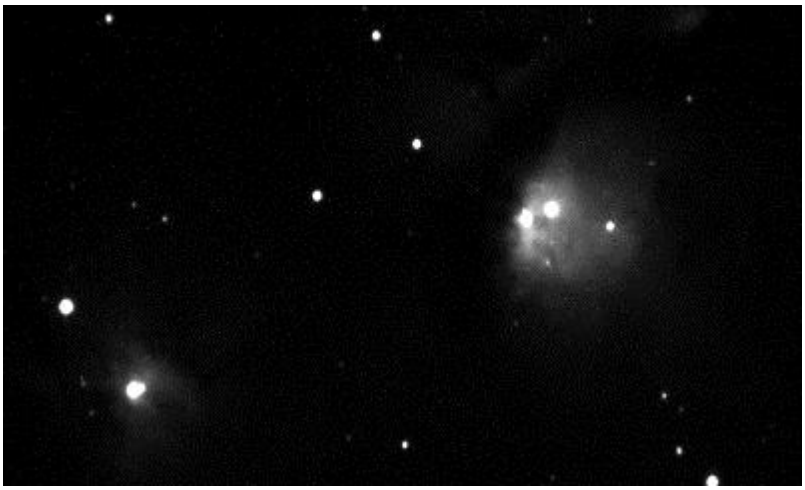
Taking bias frames is easy and takes only a couple of minutes. When you’re taking your dark

frames and flat fields, also take a series of at least 16 bias frames. That completes your full set of calibration frames.

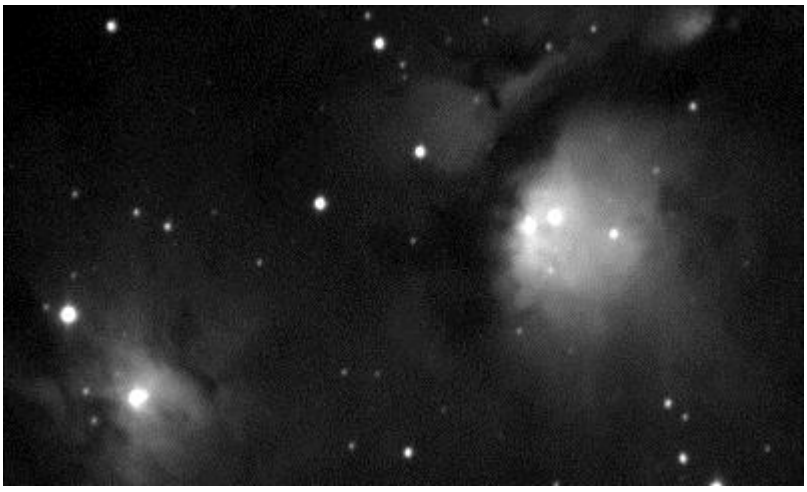
Stacking images

After calibrating each of your raw images with dark frames, flat fields and bias frames, combining or “stacking” multiple sub-exposures can be used to further reduce the noise in your images. Stacking multiple images with a pixel-by-pixel average or median combine tends to increase the signal to noise ratio (SNR) of the combined image. This is because random variations in pixel values tend to cancel each other out when multiple images are combined, resulting in a smooth background, while non-random pixels, the bright objects in the night sky you’re trying to take a picture of, reinforce each other getting you closer to a true representation of the patch of sky you’re imaging.

The benefits of stacking images can be clearly seen by comparing an individual frame to a pixel-by-pixel average of multiple frames.



Individual dark-subtracted image of M78



Average combine of 9 dark-subtracted images of M78

Averaging 9 separate images increases the signal to noise ratio of the final image, allowing the faint nebulosity in M78 to become visible and smoothing the black sky background.

Adding more frames would further improve the results although you do end up in a situation of diminishing returns. Combining 18 frames will not yield a final image twice as good as combining 9 frames.

Also note that in some cases, doing a “median combine” rather than an “average combine” may yield better results. A median combine is recommended if several of the individual frames have unique anomalies such as bright pixels caused by cosmic rays, satellites, airplanes, etc. With at least 5 images, a median combine completely eliminates extreme pixel values that occur in individual frames.

Colour images

Unless you’re using a single-shot colour camera such as the QSI 683c, producing colour images requires taking separate exposures through different coloured filters and then electronically combining the separate colour channels. The most common method used by amateur astronomers for colour imaging is called LRGB, where separate colour images are taken through red, green and blue filters and combined with a set of “luminance” images taken through a luminance filter. The luminance filter is required because CCDs are generally responsive to frequencies of light that can’t be seen by the human eye. The luminance filter blocks the infrared (IR) and ultraviolet (UV) frequencies that fall outside the range of human vision.

The luminance filter transmits most of the visible light coming from the object. Because the individual frames taken through the red, green and blue filters block roughly ⅔ of the total visible light, the luminance image will often reveal subtle details not apparent in the individual colour frames. This actually works out quite well since the human eye is much more sensitive to changes in brightness than it is to changes in colour. Combining a colour- balanced RGB image with a luminance image will yield an LRBG image that the human eye would perceive as being very close to the true colours of the object with more fine detail than is present in the RGB image on its own.

Your processing software can be used with your QSI 600 Series camera to collect and catalogue the various filtered images that you’ll need to create LRGB images. As with any images, you’ll want to collect multiple frames through each filter and then calibrate and combine them in order to reduce the major sources of noise. After calibration, you’ll have a master luminance image plus master red, green and blue images. Those master colour frames are combined into your final image. In addition to the colour image tools in your software you can do further processing of your images in Adobe Photoshop or similar photo manipulation programs to yield impressive final results.

SECTION 4

Accessories

T-mount adapter

The T-mount adapter plate attaches to the front of the camera body. It comes standard on all QSI 500 Series cameras. The T-mount adapter is threaded with standard T-mount threads, 42mm diameter by 0.75mm pitch.

2” nosepiece

The 2” nosepiece screws into the T-mount adapter plate. The 2” nosepiece allows the camera to be mounted in any 2” eyepiece adapter. The 2” nosepiece is threaded to accept a standard mounted 48mm filter.

1 ¼” nosepiece

The 1 ¼” nosepiece is optional and screws into the T-mount adapter plate. The 1 ¼” nosepiece allows the camera to be mounted in any 1 ¼” eyepiece adapter. The 1 ¼” nosepiece is threaded to accept a standard 1 ¼” filter.

C-mount adapter

The C-mount adapter replaces the standard T-mount adapter on the camera faceplate. The C-mount adapter is threaded with standard C-mount threads, 1” x 32tpi. There are two different versions of the C-mount adapter plate which provide the correct focal depth for slim and mid-sized QSI 600 Series cameras. You must use the correct version of the C-mount adapter plate for your body style in order to achieve focus at infinity. A C-mount adapter will mount to full-sized 600 Series WS model cameras but standard C-mount lenses will not achieve focus at infinity.

SLR lens adapter

SLR lens adapters are available for the following lens mounts:

▪ Canon EF (EOS)

▪ Nikon F

The SLR lens adapter provides the correct focal distance for specified lenses when threaded to the standard T-mount adapter on full-size “ws” model cameras. Standard extension tubes or T-mount extenders should be used to achieve the correct focal distance with slim or mid-size bodies. Mid-size bodies will require a 0.5” extension tube. Slim bodies require a 0.825” extension tube.

Liquid heat exchanger

The liquid heat exchanger (LHX) provides additional cooling of the CCD beyond what can be achieved using the standard air cooling. The liquid heat exchanger attaches to the back of the QSI 500/600 Series camera (excluding the QSI-6162) using four screws. Refer to the camera specifications to determine the temperature differential that can typically be maintained when using the LHX.

Recirculating pump

The recirculating pump is used to pump water through the liquid heat exchanger.

Colour filter wheel

Cameras with an internal colour filter wheel include one filter wheel and an optional set of LRGB filters. Additional 5 or 8-position colour filter wheels can be ordered to hold 1.25”/2” mounted or 31/50.8 mm un-mounted filters. With additional colour filter wheels you can load a second set of filters, such as narrowband filters or photometric filters, and easily replace the entire filter wheel. See the Care & Maintenance section below for instructions on removing and installing the colour filter wheel.

See the WSG User Guide Supplement for details on accessories specific to WSG models.

See the Accessories page on the QSI web site for complete details on available accessories: https://qsimaging.com/products/

SECTION 5

Care and Maintenance

Cleaning the exterior

The QSI 600 Series cameras are machined from high quality 6061 aluminium with a very durable anodized finish that resists most scratches and fingerprints. Use a soft cloth to remove dirt or spots from the exterior surface of the camera.

Installing or removing colour filters

Always remove the colour filter wheel when installing or removing filters. To change filters or replace the colour filter wheel the front cover of the camera must be removed. Place the camera face up on a stable surface. Using the included Allen wrench, carefully remove the screws holding the camera cover to the camera body. Lift the cover straight up to expose the colour filter wheel.

Remove the colour filter wheel by unscrewing the screw in the centre of the filter wheel. Carefully lift out the colour filter wheel.

The standard colour filter wheel is designed to hold 1.25” mounted, 31 mm un-mounted filters or in the case of the 6162, 2” mounted or 50.8 mm un-mounted. Any filter can be screwed into any of the available positions.

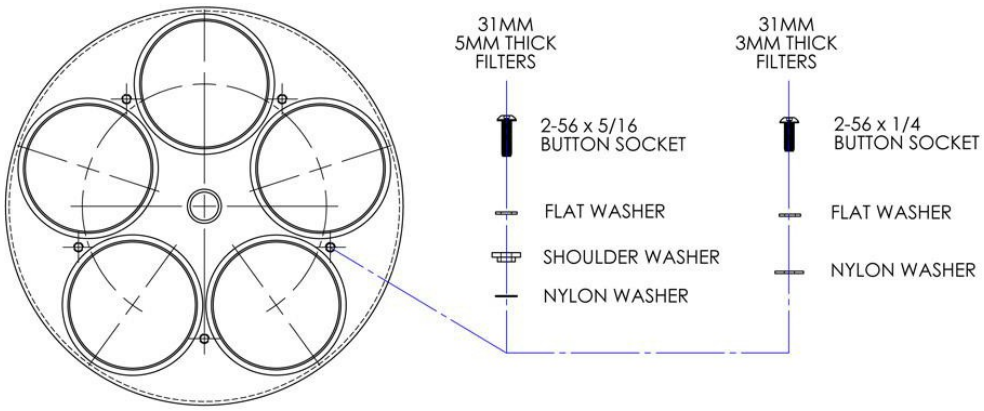
To replace the colour filter wheel a slight pressure must be applied with the outside O-ring against the capstan motor that drives the colour filter wheel. Carefully line up the centre screw and press the filter wheel O-ring gently against the capstan motor. Lining up a filter or empty filter position over the shutter opening can help to achieve the proper alignment.

Screw in the centre screw until it is quite snug. 5 inch-pounds or more of force if you have a torque wrench. Stainless steel screws naturally "lock" with anodized aluminium. The screw is tight enough when you can hear the screw "break free" when it is loosened.

Installing or removing 31/50.8mm colour filters

Some QSI 600 Series colour filter wheels are configured to hold unmounted 31/50.8 mm filters. Filter wheels capable of holding 31/50.8 mm unmounted filters have a screw hole between each filter position.

Note the retaining screws in the image above between each filter position which hold the unmounted filters in place.

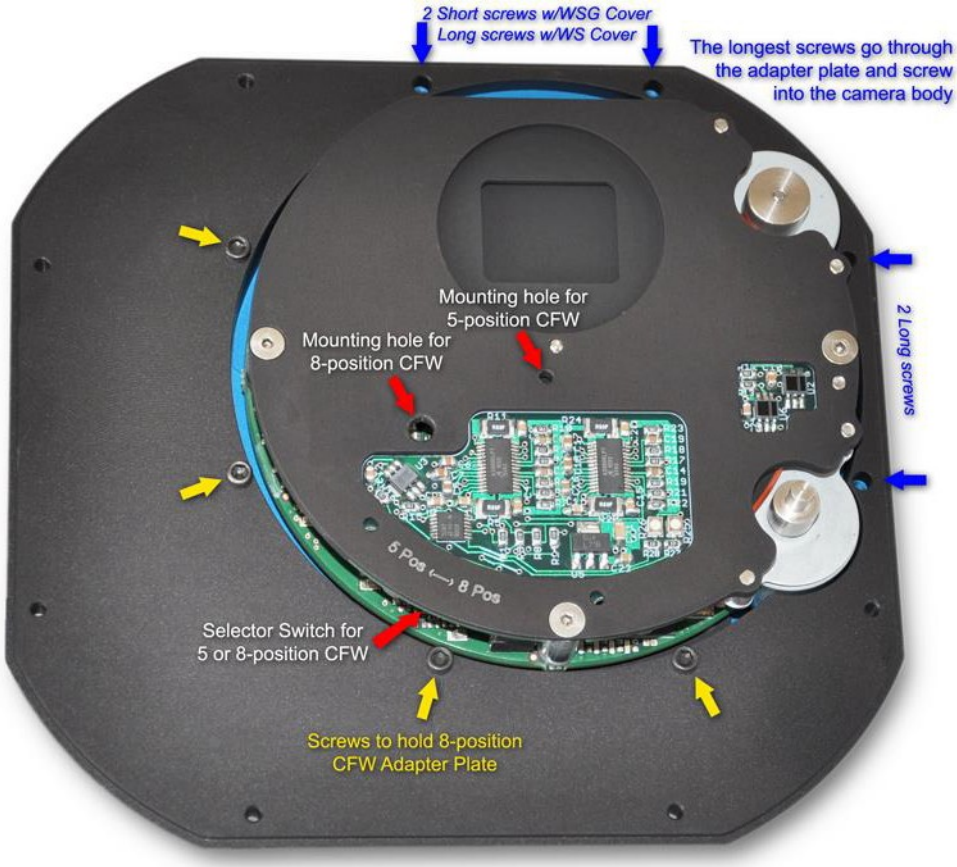


Different retaining screw/washer combinations are used to hold different thickness filters. Filters up to 3mm thick (e.g. Astrodon, Astronomik) use the configuration shown above to the right. 5mm thick IDAS filters use the configuration to the left.

Note: A thin spacer or O-ring may be required to be placed under unmounted filters that are less than 3.5 mm thick in order to raise the top surface of the filter above the top of the filter wheel recess so that the retaining screw can hold the filter firmly in place.

Installing the 8-position colour filter wheel

Always remove the colour filter wheel when installing or removing filters. To change filters or replace the colour filter wheel the front cover of the camera must be removed. Place the camera face up on a stable surface. Using the included Allen wrench, carefully remove the screws holding the camera cover to the camera body. Note that 2 or 4 of the screws holding the 8-position cover to the body are longer than the rest. The longer screws go through the 8-position CFW Adapter Plate and screw directly into the QSI 600 Series body, shown with blue arrows below. Lift the cover straight up to expose the colour filter wheel.



Remove the colour filter wheel by unscrewing the screw in the centre of the filter wheel. Carefully lift out the colour filter wheel. To replace the colour filter wheel a slight pressure must be applied with the outside O-ring against the capstan motor that drives the colour filter wheel. Carefully line up the centre screw for the 8-position CFW (shown above) and press the filter wheel O-ring gently against the capstan motor. Lining up a filter or empty filter position over the shutter opening can help to achieve the proper alignment.

Screw in the centre screw until it is quite snug. 5 inch-pounds or more of force if you have a torque wrench. Stainless steel screws naturally "lock" with anodized aluminium. The screw is tight enough when you can hear the screw "break free" when it is loosened.

Cleaning the colour filters

As with any precision optical surface, the optical coatings or glass of colour filters can be permanently damaged by improper cleaning procedures. For best results follow the cleaning instructions that came with your filters.

It is best to clean the filters infrequently and use the least intrusive of the methods below to remove any dust or fingerprints.

1. Blow any dust off the filter with clean, dry compressed air.

2. Gently wipe off any remaining dust with a lens brush or microfiber cloth.

3. Remove the filter and clean it with gentle soap and water and then dry it gently using a 100% cotton cloth.

Cleaning the CCD cover glass

As with any precision optical surface, the optical coatings or glass of CCD cover glass can be permanently damaged by improper cleaning procedures. You are often better off not trying to clean the CCD cover glass. The effects of small amounts of dust can be removed from your images with proper calibration techniques.

If you must clean the CCD cover glass.

1. First try blowing off any dust off the filter with compressed air.

2. If that doesn't work gently wipe off any remaining dust with a lens brush or microfiber cloth.

Note: The CCD cover glass cannot be removed.

Recharging the desiccant

The environmental chamber enclosing the CCD is filled with UHP argon during manufacturing to increase cooling capability and prevent the formation of frost on the CCD cover glass. This ultra dry and clean noble gas will generally remain in the environmental chamber for about 3 years.

Warning: Depending on specific use patterns and environmental conditions around the camera, it is possible that moisture could build up in the chamber in less than 3 years. Proper maintenance of the environmental chamber is critical to the operation of the camera. If water vapour or ice forms inside the environmental chamber when cooling below the dew point, it is critical that the camera be turned off immediately and the instructions below followed to restore the camera to proper operating condition.

You can restore many of the benefits of the original UHP argon by recharging the microsieve desiccant in the desiccant chamber. The desiccant removes the moisture present in the environmental chamber and stores it behind a submicron gas permeable membrane. Over time the desiccant will lose its ability to remove additional moisture and you may begin to see frost or dew forming on the CCD cover glass when operating the CCD at low temperatures or in high humidity environments.

To recharge the desiccant, unplug the camera and allow sufficient time for the CCD to reach room temperature. Place the camera, with the desiccant chamber cover upright, on a stable surface. Loosen the four screws holding the desiccant cover and lift it from the camera.

Lift the brass desiccant canister from the camera. Preheat an oven to 500 degrees Fahrenheit. Place the desiccant canister in the 500°F oven for 4 to 5 hours. This will drive out the accumulated water molecules, recharging the desiccant.

Remove the desiccant canister from the oven and let it cool. As soon as the canister leaves the oven it will begin absorbing moisture.

To minimize the impact on the effectiveness of the desiccant, the canister should be returned to the camera as soon as it has cooled to nearly room temperature. Place it back in the desiccant chamber with the fine grid face down toward the inside of the camera. Screw the nameplate back down to the camera making sure that the O-ring surrounding the nameplate is carefully seated against inside of the environmental chamber.

Note: Your camera can also be returned to QSI to have the environmental chamber purged and refilled with argon gas and the desiccant recharged. Argon has better thermal insulating properties than air and provides the best results but the camera will work extremely well in most conditions with just air in the chamber and an active desiccant plug. For the QSI-6162 camera please contact QSI support for the environmental chamber maintenance instructions

Please contact QSI support for further details.

Technical support

Most technical support questions can be answered 24 hours a day using the support section of our web site at https://qsimaging.com/support/technical-support/# . There you will find online help and instruction manuals, technical articles and a searchable knowledge base with answers to common questions. If you can't find the answer to your question on our web site please contact QSI technical support at shown below. Email is preferred.

Internet: https://qsimaging.com/support/technical-support/#

Email: support@qsimaging.com

Phone: +441603 740397

Appendix A

600 Series Specifications

General camera specifications (I, s, ws models)

Feature	QSI 600i	QSI 600s	QSI 600 ws
Electronic Shutter (Interline transfer CCDs only)	100µsec to 240 minutes	100µsec to 240 minutes	100µsec to 240 minutes
Mechanical Shutter		0.03 seconds to 240 minutes	0.03 seconds to 240 minutes
Internal Colour Filter Wheel	No	No	Yes - 5 Position, 1.25" std filters
Camera Body Configuration	Slim Cover	Medium Cover	Full Cover
Dimensions	W4.45”x H4.45” x D1.68” (add 0.23" for T-Mount)	W4.45”x H4.45” x D2.00” (add 0.23" for T-Mount)	W4.45” x H4.45” x D2.50” (add 0.23" for T-Mount)
Weight, without Nosepiece	26 oz. / 740g	34 oz. / 950g	40 oz. / 1120g
Optical Back Focus (without Filters in path)	0.61" w/ T-mount adapter 0.68" w/ C-mount adapter 0.39" w/o mounting adapter	0.90" w/ T-mount adapter 0.68" w/ C-mount adapter 0.68" w/o mounting adapter	1.40" with T-mount adapter 1.18" with C-mount adapter 1.18" w/o mounting adapter

Thermoelectric CCD Cooling	Temperature regulation +/- 0.1 degC, @0 degC to -40 degC CCD temperature.
***In free air, Fans at full speed**	Typically 45 degC below ambient air with 85% cooling power
***With Opt Liquid Cooling (adds 0.75” to camera depth)**	Typically 52 degC below circulating liquid with 85% cooling power
Cooling Fan Control	Intelligent, user configurable

Status and Notification.	User configurable multicolour LED status indicator and multifunctional audible beeper. Over temperature and high/low voltage alarms
Power consumption.	12v, 2A (24 watts) at max cooling, max fans and filter moving (25 AC watts with included 90-240V AC power supply) 2.1 mm I.d DC power connector, o.d 5.5 mm, length 10 mm, centre positive
Operating Environment.	Temperature: 20 degC to 30 degC, Humidity: 10% to 90% non-condensing
Computer Connectivity	600 series – USB 2.0 High Speed (USB1.1 compatible)
Other ports	Optically isolated 4 channel control port for telescope guiding (or other application specific control in some configurations)

T Mounting Adaptor	Standard adapter – T-Thread, 42mm x 0.75mm		
C Mounting Adaptor **(1” x 32TPI)**	Optional, C mount lens focus compatible (17.5mm back focus)	Optional, C mount lens focus compatible (17.5mm back focus)	Optional, for non-lens adaptors and accessories (standard C mount lens doesnt reach focus)
Nosepiece	Standard, T Adapter to 2” nosepiece. Optional, T Adapter to 1.25” nosepiece		

General camera specifications (wsg, ws-8, wsg-8 models)

Feature	QSI 600 WSG	QSI 600 ws-8	QSI 600 wsg-8
Electronic Shutter (Interline transfer CCDs only)	100µsec to 240 minutes	100µsec to 240 minutes	100µsec to 240 minutes
Mechanical Shutter	0.03 seconds to 240 minutes	0.03 seconds to 240 minutes	0.03 seconds to 240 minutes
Internal Colour Filter Wheel	Yes – 5 position, 1.25” std filters	Yes – 8 position, 1.25” std filters	Yes – 8 position, 1.25” std filters
Camera Body Configuration	WSG Cover	Medium 8-position Cover	WSG 8-position Cover
Dimensions	W4.45”x H4.45” x D3.08”(add 0.23" for T-Mount) (+0.35” for 2.156” Adaptor)	W5.86”x H5.56” x D2.5”(add 0.23" for T-Mount)	W5.86” x H5.56” x D2.50”(add 0.23" for T-Mount) (+0.35” for 2.156” Adaptor)
Weight, without Nosepiece	46 oz. / 1300g	51 oz. / 1450g	56 oz. / 1600g
Optical Back Focus (without Filters in path)	1.98" w/ T-mount adapter 2.11" w/ 2.156”- adapter 1.76" no adapter	1.40" w/ T-mount adapter 1.18" w/ C-mount adapter 01.18" w/o adapter	1.98" with T-mount adapter 2.11" with C-mount adapter 1.76" no adapter

Thermoelectric CCD Cooling	Temperature regulation +/- 0.1 degC, @0 degC to -40 degC CCD temperature.
***In free air, Fans at full speed**	Typically 45 degC below ambient air with 85% cooling power
***With Opt Liquid Cooling (adds 0.75" to camera depth)**	Typically 52 degC below circulating liquid with 85% cooling power
Cooling Fan Control	Intelligent, user configurable
Status and Notification.	User configurable multicolour LED status indicator and multifunctional audible beeper. Over temperature and high/low voltage alarms
Power consumption.	12v, 2A (24 watts) at max cooling, max fans and filter moving (25 AC watts with included 90-240V AC power supply) 2.1 mm I.d DC power connector, o.d 5.5 mm, length 10 mm, centre positive
Operating Environment.	Temperature: 20 degC to 30 degC, Humidity: 10% to 90% non-condensing
Computer Connectivity	600 series – USB 2.0 High Speed (USB1.1 compatible)
Other ports	Optically isolated 4 channel control port for telescope guiding (or other application specific control in some configurations)

T Mounting Adaptor	Standard adapter – T-Thread, 42mm x 0.75mm		
2.156" Adaptor **(2.156" x 24TPI)**	Optional, with WSG models provides 1.8"of clear aperture to fully illuminate the pick off prism	N/A	Optional, with WSG models provides 1.8"of clear aperture to fully illuminate the pick off prism
Nosepiece	Standard, T Adapter to 2" nosepiece. Optional, T Adapter to 1.25" nosepiece Optional, 2.156" Adapter to 2" nosepiece WSG models only)		

Model 616 CCD Specifications

Feature	Standard	Optional
CCD Manufacturer & Model	Kodak KAF-1603ME	Kodak KAF-1603E
CCD Architecture	Full Frame	Full Frame
Blue Enhanced	Yes	Yes
Microlens	Yes	No
Anti- blooming	No	No
Imager Size (W x H)	6.91 mm x4.6 mm	6.91 mm x4.6 mm
Pixel Array (W x H)	1552x1032 total pixels, 1536x1024 active (visible)	1552x1032 total pixels, 1536x1024 active (visible)
Pixel size	9um x 9um	9um x 9um
	Typical Values	
Pixel Full Well Depth	100,000 electrons	100,000 electrons
Quantum Efficiency	Peak: 77% 400nm: 45%	Peak: 65% 400nm: 30%
Pixel Dark Current	<1.0 electron per second at 0 degC; <1.0 electron per second at -25 degC	
Dark current doubling	6.3 degC	6.3 degC
Intrinsic read noise	15 electrons RMS	15 electrons RMS
Dynamic Range	76db	76db
Charge transfer efficiency	>0.99999	>0.99999

Model 632 CCD Specifications

Feature	Standard	Optional
CCD Manufacturer & Model	Kodak KAF-3200ME	Kodak KAF-3200E
CCD Architecture	Full Frame	Full Frame
Blue Enhanced	Yes	Yes
Microlens	Yes	No
Anti- blooming	No	No
Imager Size (W x H)	14.85mm x 10.26mm	14.85mm x 10.26mm
Pixel Array (W x H)	2254x1510 total pixels, 2184x1472 active (visible)	2254x1510 total pixels, 2184x1472 active (visible)
Pixel size	6.8µm x 6.8µm	6.8µm x 6.8µm
	Typical Values	
Pixel Full Well Depth	55,000 electrons	55,000 electrons
Quantum Efficiency	Peak: 82% 400nm: 55%	Peak: 65% 400nm: 30%
Pixel Dark Current	<1.0 electron per second at 0 degC; <1.0 electron per second at -25 degC	
Dark current doubling	6 degC	6 degC
Intrinsic read noise	7 electrons RMS	7 electrons RMS
Dynamic Range	77db	77db
Charge transfer efficiency	>0.99999	>0.99999

Model 640 CCD Specifications

Feature	Standard	Optional
CCD Manufacturer & Model	Kodak KAI-04022	Kodak KAI-04022
CCD Architecture	Interline Transfer	Interline Transfer
Microlens	Yes	Yes
Anti- blooming	Yes – 300x suppression	Yes – 300x suppression
Colour Filters	No	Yes - Internal RGB on CCD; Bayer colour filter mask
Imager Size (W x H)	15.15mm x 15.15mm	15.15mm x 15.15mm
Pixel Array (W x H)	2112x2072 total pixels, 2048x2048 active (visible)	2112x2072 total pixels, 2048x2048 active (visible)
Pixel size	7.4µm x 7.4µm	7.4µm x 7.4µm
	Typical Values	
Pixel Full Well Depth	40,000 electrons	40,000 electrons
Absolute Quantum Efficiency	Peak: 55% 400nm: 45%	Blue Peak: 45%, Green Peak: 42%, Red Peak: 35%
Pixel Dark Current	<1.0 electron per second at 0 degC; <1.0 electron per second at -25 degC	
Intrinsic read noise	<8 electrons RMS	<8 electrons RMS
Dynamic Range	74db	74db
Charge transfer efficiency	>0.99999	>0.99999

Model 683 CCD Specifications

Feature	Standard	Optional
CCD Manufacturer & Model	Kodak KAF-8300	Kodak KAF-8300 (Colour)
CCD Architecture	Full Frame	Full Frame
Microlens	Yes (Optional non-microlens version available)	Yes (Optional non-microlens version available)
Anti- blooming	Yes – 1000x suppression	Yes – 1000x suppression
Colour Filters	No	Yes - Internal RGB on CCD; Bayer colour filter mask
Imager Size (W x H)	17.96mm x 13.52mm	17.96mm x 13.52mm
Pixel Array (W x H)	3348x2574 total pixels, 3326x2504 active (visible)	3348x2574 total pixels, 3326x2504 active (visible)
Pixel size	5.4µm x 5.4µm	5.4µm x 5.4µm
	Typical Values	
Pixel Full Well Depth	25,500 electrons	25,500 electrons
Absolute Quantum Efficiency	Absolute Quantum Efficiency Peak: 56% 400nm: 38%	Blue Peak: 33%, Green Peak: 41%, Red Peak: 33%
Pixel Dark Current	<0.02 electron per second at 0 degC;	
Intrinsic read noise	<8 electrons RMS	<8 electrons RMS
Dynamic Range	70db	70db
Charge transfer efficiency	>0.999995	>0.999995

Model 660 CCD Specifications

Feature	Standard	Optional
CCD Manufacturer & Model	Sony ICX694	Sony ICX694 (Colour)
CCD Architecture	Interline Transfer – Exview HAD CCD II	Interline Transfer – Exview HAD CCD II
Microlens	Yes	Yes
Anti- blooming	Yes – 800x suppression	Yes – 800x suppression
Colour Filters	No	Yes - Internal RGB on CCD; Bayer colour filter mask
Imager Size (W x H)	12.48mm x 9.98mm	12.48mm x 9.98mm
Pixel Array (W x H)	2758 x 2208 active (6.1 megapixels)	2758 x 2208 active (6.1 megapixels)
Pixel size	4.54µm x 4.54µm	4.54µm x 4.54µm
	Typical Values	
Absolute Quantum Efficiency	Peak: ≈75% at 560nm	Blue: ≈46%, Green: ≈62%, Red: ≈66%
Pixel Dark Current	<0.002 electrons per second at -10°C	
Intrinsic read noise	<7 electrons RMS (typically 5 e- RMS)	<7 electrons RMS (typically 5 e- RMS)
Dynamic Range	69db	69db

Model 690 CCD Specifications

Feature	Standard	Optional
CCD Manufacturer & Model	Sony ICX814	Sony ICX814 (Colour)
CCD Architecture	Interline Transfer – Exview HAD CCD II	Interline Transfer – Exview HAD CCD II
Microlens	Yes	Yes
Anti- blooming	Yes – 800x suppression	Yes – 800x suppression
Colour Filters	No	Yes - Internal RGB on CCD; Bayer colour filter mask
Imager Size (W x H)	12.48mm x 9.98mm	12.48mm x 9.98mm
Pixel Array (W x H)	3388 x 2712 active (9.19 megapixels)	3388 x 2712 active (9.19 megapixels)
Pixel size	3.69µm x 3.69µm	3.69µm x 3.69µm
	Typical Values	
Absolute Quantum Efficiency	Peak: ≈75% at 560nm	Blue: ≈46%, Green: ≈62%, Red: ≈66%
Pixel Dark Current	<0.002 electrons per second at -10°C	
Intrinsic read noise	<7 electrons RMS (typically 5 e- RMS)	<7 electrons RMS (typically 5 e- RMS)
Dynamic Range	68db	68db

Model 6162 CCD Specifications

Feature	Standard	Optional
CCD Manufacturer & Model	Kodak KAF-16200	
CCD Architecture	Full Frame	
Microlens	Yes	
Anti- blooming	Yes – 2800x suppression	
Colour Filters	No	
Imager Size (W x H)	27 mm x 21.8 mm	
Pixel Array (W x H)	4499 x3599 active	
Pixel size	6 µm x 6µm	
	Typical Values	
Pixel Full Well Depth	40,000 electrons	
Absolute Quantum Efficiency	Peak: 56%	
Pixel Dark Current	<0.25 electron per second at 0 degC;	
Intrinsic read noise	<8 electrons RMS	
Dynamic Range	69db	
Charge transfer efficiency	>0.999995	

Appendix B – Warranty

QSI Warranty Policy

The limited warranty set forth below is provided by Quantum Scientific Imaging, Inc. for QSI Scientific Cameras when purchased directly from QSI or an authorized QSI dealer within the dealers authorized territory. This limited warranty also covers the following accessories if they were included with your original purchase: carrying case, AC power adapter, AC cable, and USB cable.

Your QSI Scientific Camera is warranted against defects in materials or workmanship for a period of one (1) year from the date of original purchase, or longer in some regions as required by law. QSI will, at its option, repair or replace any camera that is proven to be defective during the warranty period.

This limited warranty covers all defects encountered in normal use of the QSI Scientific Camera, and does not apply in the following cases:

(a) Loss of or damage to the QSI Scientific Camera due to abuse, mishandling, improper packaging by you, alteration, accident, electrical current fluctuations, failure to follow operating, maintenance or environmental instructions prescribed in QSIs users manual or services performed by someone other than QSI, or an authorized QSI Scientific Camera Service Provider. Without limiting the foregoing, water damage, sand/corrosion damage, dropping the camera, scratches, abrasions or damage to the body, internal parts or circuit boards, or the imaging sensor will be presumed to have resulted from misuse, abuse or failure to operate the QSI Scientific Camera as set forth in the operating instructions.

(b) Use of parts or supplies (other than those sold by QSI) that cause damage to the QSI Scientific Camera or cause abnormally frequent service calls or service problems.

(c) If the camera body has been opened and any parts inside have been altered or damaged, except for those parts that are expressly intended for user modification or maintenance as described in the QSI Scientific Camera User Guide. QSI Scientific Cameras have internal parts that should not be touched or modified by the user. UNLESS SPECIFICALLY DIRECTED TO REMOVE THE CAMERA COVER, SUCH AS FOR CHANGING FILTERS, WE STRONGLY RECOMMEND THAT YOU DO NOT OPEN YOUR QSI SCIENTIFIC CAMERA BODY. QSI IS NOT RESPONSIBLE FOR DAMAGE CAUSED BY MISUSE, ABUSE OR FAILURE TO OPERATE THE QSI SCIENTIFIC CAMERA AS SET FORTH IN THE OPERATING INSTRUCTIONS.

(d) If the QSI Scientific Camera has had its serial number or dating altered or removed.

Manufacturer Warranties

Kodak/Truesense provides a separate warranty that their CCDs will perform in normal use in accordance to device specifications for a period of one year from date of shipment to the customer. This warranty does not cover failure due to the following mechanical and electrical causes after receipt of the device by the customer: Damage from mechanical (scratches or breakage), electrical (ESD), or other misuse of the device (electrical, storage temperature, etc.) beyond the stated maximum ratings in the device specifications.

Shipping Costs

The customer is responsible for all costs in shipping to QSI. For a period of one (1) year after the date of purchase, QSI will pay reasonable shipping costs when returning a product to the customer after a warranty repair covered by the original factory warranty. All replacement/repaired products are shipped via UPS Ground unless a rush is requested.

The cost of such a shipping upgrade is to be paid by the customer prior to shipment. The customer is responsible for return shipping costs on all maintenance services, even those included under an Extended Warranty Agreement. Customer is responsible for any additional taxes, duties or other fees associated with international shipments.

NO IMPLIED WARRANTY, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, APPLIES TO THE QSI SCIENTIFIC CAMERA AFTER THE APPLICABLE PERIOD OF THE EXPRESS LIMITED WARRANTY STATED ABOVE, AND NO OTHER EXPRESS WARRANTY OR GUARANTY, EXCEPT AS MENTIONED ABOVE, GIVEN BY ANY PERSON OR ENTITY WITH RESPECT TO THE QSI SCIENTIFIC CAMERA SHALL BIND QUANTUM SCIENTIFIC IMAGING, INC. (SOME STATES AND PROVINCES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATION MAY NOT APPLY TO YOU.) QUANTUM SCIENTIFIC IMAGING SHALL NOT BE LIABLE FOR LOSS OF REVENUES OR PROFITS, INCONVENIENCE, EXPENSE FOR SUBSTITUTE EQUIPMENT OR SERVICE, STORAGE CHARGES, LOSS OR CORRUPTION OF DATA, OR ANY OTHER SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES CAUSED BY THE USE OR MISUSE OF, OR INABILITY TO USE, THE QSI SCIENTIFIC CAMERA, REGARDLESS OF THE LEGAL THEORY ON WHICH THE CLAIM IS BASED, AND EVEN IF QUANTUM SCIENTIFIC IMAGING HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. IN NO EVENT SHALL RECOVERY OF ANY KIND AGAINST QUANTUM SCIENTIFIC IMAGING BE GREATER IN AMOUNT THAN THE PURCHASE PRICE OF THE QSI SCIENTIFIC CAMERA SOLD BY QUANTUM SCIENTIFIC IMAGING AND CAUSING THE ALLEGED DAMAGE. WITHOUT LIMITING THE FOREGOING, YOU ASSUME ALL RISK AND LIABILITY FOR LOSS, DAMAGE OR INJURY TO YOU AND YOUR PROPERTY AND TO OTHERS AND THEIR PROPERTY ARISING OUT OF USE OR MISUSE OF, OR INABILITY TO USE, THE QSI SCIENTIFIC CAMERA NOT CAUSED DIRECTLY BY THE NEGLIGENCE OF QUANTUM SCIENTIFIC IMAGING. (SOME STATES AND PROVINCES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE EXCLUSION OR LIMITATION MAY NOT APPLY TO YOU.) THIS LIMITED WARRANTY SHALL NOT EXTEND TO ANYONE OTHER THAN THE ORIGINAL PURCHASER OF THE QSI SCIENTIFIC CAMERA, OR THE PERSON FOR WHOM IT WAS PURCHASED AS A GIFT, AND STATES YOUR EXCLUSIVE REMEDY.

Appendix C – Notices

If you have questions about this product, you can write to:

Quantum Scientific Imaging. Customer Service at Unit 8 Lodge Farm Barns, New Road, Bawburgh, Norwich, UK, NR9 3LZ or via the QSI website at www.qsimaging.com.

QSI 600/RS Series Tested to comply

with FCC standards FCC Part 15 Class A

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC

Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Modifications not expressly approved by the manufacturer could void the users authority to operate the equipment under FCC rules.

EC Declaration of Conformity

The QSI 600/RS Series conforms with the essential requirements of the EMC directive 2004/108/EC, based on the following specifications applied:

EU harmonized Standards EN/KN55022 Class A Emissions EN61326-1: 2006, KN22 Emissions EN61326-1:2006, KN24 Immunity

FCC part 15.b Class A

and therefore complies with the essential requirements and provisions of the MEC Directive.

The Declaration of Conformity is kept at the following address: Quantum Scientific Imaging.

Unit 8 Lodge Farm Barns, New Road, Bawbrugh, Norwich NR9 3LZ

Phone Number: +44(0)1603 740397
www.QSImaging.com