G3 CCD Camera

User's Guide

moravian instruments

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Introduction

Thank you for choosing the Moravian Instruments CCD camera. G3 series of CCD cameras were developed for imaging under extremely low-light conditions in astronomy, microscopy and similar areas. Design of this series inherits from G2 cameras, with which they share precise electronics providing uniform frames without artifacts and extremely low read noise limited only by CCD detector itself. Also the robust construction, rich software support and easy manipulation are the same. However, G3 camera head is large enough to contain detector up to 24×36 mm.

G3 cameras can contain also filter wheel with 5 positions for 2 inch (50 mm) diameter filters.

G3 cameras can be equipped with external filter wheel, but it is not possible to combine internal and external wheels on single camera. G3 camera mus be made without internal filter wheel to be compatible with external filter wheels.

The G3 cameras are designed to work in cooperation with a host Personal Computer (PC). As opposite to digital still cameras, which are operated independently on the computer, the scientific slow-scan, cooled cameras usually require computer for operation control, image download, processing and storage etc. To operate the camera, you need a computer which:

1. Is compatible with a PC standard.
2. Runs a modern 32 or 64-bit Windows operating system.

   Drivers for 32-bit and 64-bit Linux systems are also provided, but camera control and image processing software, supplied with the camera, requires Windows operating system.

3. Provides at last one free USB port.

   G3 and G4 cameras are designed to operate with USB 2.0 high-speed (480 Mbps) hosts. Although they are fully backward compatible with USB 1.1 full-speed (12 Mbps) hosts, image download time can be somewhat longer if USB 1.1 connection is used.

A simple and cheap device called USB hub can expand number of available USB port. Typical USB hub occupies one computer USB port and offers four free ports. Make sure the USB hub is USB 2.0 high-speed compatible.

But keep on mind that if more USB devices connected to one hub need to communicate with a host PC, USB hub shares its single up link line to the host PC. Although G3 and G4 cameras can operate through a USB hub, it can negatively affect the camera performance, like download time etc. It is recommended to connect other USB devices through USB hub (e.g. the mouse) and to provide the camera a direct USB connection to the host PC.

4. Alternatively it is possible to use the Gx Camera Ethernet Adapter. This device can connect up to four Gx cameras of any type (not only G3, but also G0, G1, G2 and G4) and offers 1 Gbps and 10/100 Mbps Ethernet interface for direct connection to the host PC. Because the PC then uses TCP/IP protocol to communicate with the cameras, it is possible to insert e.g. WiFi bridge or other networking device to the communication path.

The G3 cameras need an external power supply to operate. It is not possible to run the camera from the power lines provided by the USB cable, which is common for webcams or very simple imagers. G3 cameras integrate highly efficient CCD chip cooling, shutter and possibly filter wheel, so their power requirements significantly exceed USB line power capabilities. On the other side separate power source eliminates problems with voltage drop on long USB cables or with drawing of laptop batteries etc.

Also note the camera must be connected to some optical system (e.g. the telescope) to capture images. The camera is designed for long exposures, necessary to acquire the light from faint objects. If you plan to use the camera with the telescope, make sure the whole telescope/mount setup is capable to track the target object smoothly during the exposure.

G3 Camera Overview

G3 camera head is designed to be easily used with a set of accessories to fulfill various observing needs. Camera head itself is manufactured in two different variants:

- Camera with internal filter wheel with 5 positions for 2” or D50 mm filters.
- Camera with control port for external filter wheel. This model allows attachment of an external filter wheels with with 7 positions for 2” or D50 mm filters.

The whole system comprises of various telescope adapters, which can be attached to all variants of camera heads – without filter wheel, with internal filter wheel or with external filter wheel.

Let us note that it is not possible to combine both internal and external filter wheels. The external filter wheel reuses the control electronics, which stays idle if the camera is not equipped with internal filter wheel. This solution eliminates separate power and control cables for the external filter wheel, as it is attached to the camera head. It also brings full software compatibility, as the software does not distinguishes internal and external filter wheels, only the number of available filters is different.

All telescope adapters, which preserve defined back focal distance (BFD – typically bayonet adapters for photographic lenses but also the OAG adapter), are designed for the external filter wheel BFD. If they are used on the camera with internal filter wheel or without a filter wheel at all, it is necessary to use spacers. Thin spacer compensates BFD difference between external and internal filter wheel and thick spacer adds the thickness of the external filter wheel housing to keep the BFD on camera without filter wheel.

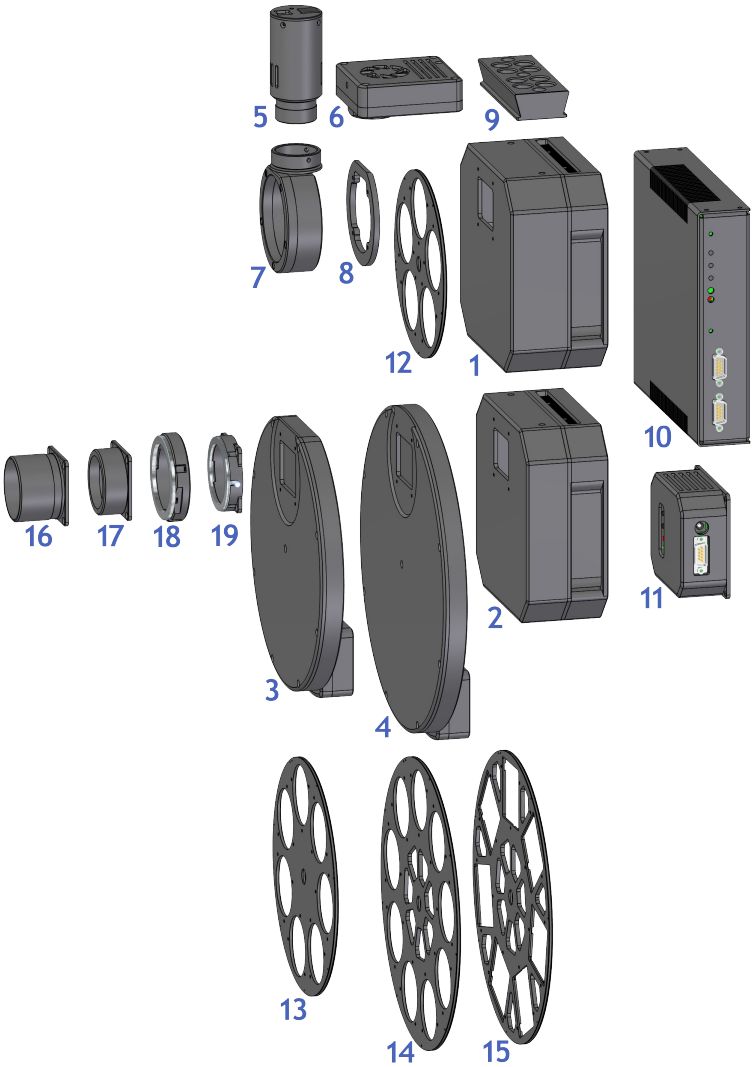


Illustration 1: Schematic diagram of the G3 camera system components

Components of G3 Camera system include:

1. G3 camera head with internal filter wheel
2. G3 camera head capable to control External Filter Wheel
3. External Filter Wheel “S” size (7 positions)
4. External Filter Wheel “L” size (9 or 7 positions)
5. G0 Guider camera
6. G1 Guider camera
7. Off-Axis Guider with M68×1 thread
8. Spacer compensating IFW and EFW back focal distance
9. 1.75” dovetail rail for G3 camera head
10. Gx Camera Ethernet Adapter (x86 CPU)
11. Gx Camera Ethernet Adapter (ARM CPU)

    Camera Ethernet Adapter allows connection of up to 4 Gx cameras of any type on the one side and 1 Gbps Ethernet on the other side. This adapter allows access to connected Gx cameras using routable TCP/IP protocol over practically unlimited distance.
12. 5-positions internal filter wheel for 2”/D50 mm filters
13. 7-positions external filter wheel “S” for 2”/D50 mm filters
14. 9-positions external filter wheel “L” for 2”/D50 mm filters
15. 7-positions external filter wheel “L” for 50×50 mm filters
16. 2-inch barrel adapter
17. T-thread (M42×0.75) adapter
18. Canon EOS bayonet adapter for Canon compatible lenses
19. Nikon bayonet adapter for Nikon compatible lenses

CCD and Camera Electronics

G3 series of CCD cameras are manufactured with two kinds of OnSemi (formerly Kodak) CCD detectors:

- **G3 cameras with OnSemi KAF Full Frame (FF) CCD architecture.** Almost all Full Frame CCD detector area is exposed to light. This is why these detectors provide very high quantum efficiency. FF CCD detectors, intended for research applications, are not equipped with so-called Anti Blooming Gate (ABG – a gate, which prohibits blooming of the charge to neighboring pixels when image is over-exposed) to ensure linear response to light. FF CCD detectors used for astrophotography are equipped with ABG to eliminate disrupting blooming streaks within field of view.

  Cameras with Full Frame detectors are suitable for scientific applications, where linear response is necessary for photometric applications in astronomy, microscopy etc. High quantum efficiency could be used also for narrow-band imaging, where overexposure is a rare exception, and for imaging of small objects without a bright star in the field of view.

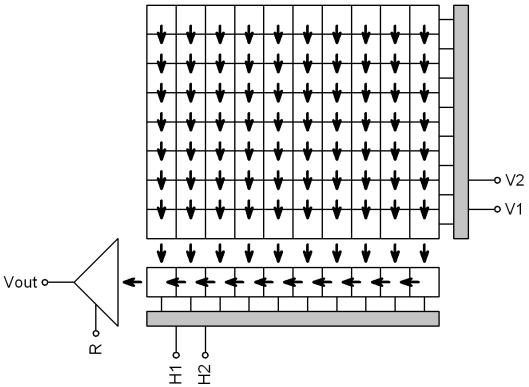


Illustration 2: "Full Frame" CCD schematic diagram

- **G3 cameras with OnSemi KAI Interline Transfer (IT) architecture.** There is a shielded column of pixels just beside each column of active pixels on these detectors. The shielded columns are called Vertical registers. One pulse moves charge from exposed pixels to shielded pixels on the end of each exposure. The the charge is moved from vertical registers to horizontal register and digitized in the same way like in the case of Full Frame detectors. This mechanism is also known as "electronic shuttering", because it allows very short exposures and also digitization of the image without mechanically shielding of the detector from incoming light.

  Also cameras with IT CCDs are equipped with mechanical shutter, because electronic shutter does not allow dark-frame exposures, necessary for proper image calibration etc.

  The price for electronic shutter if lower quantum efficiency (sensitivity) of IT detectors compared to FF ones. Also all IT detectors are equipped with ABG, so they can acquire images of very bright objects without charge blooming to neighboring pixels.

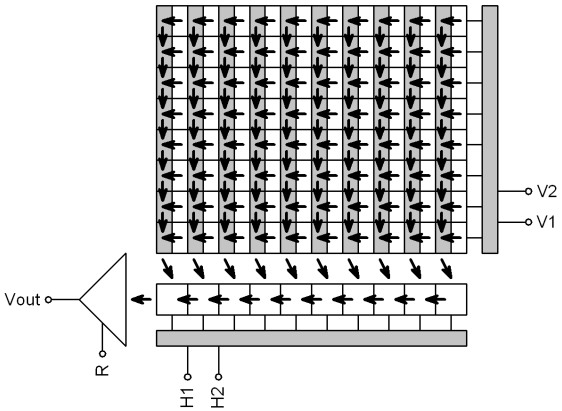
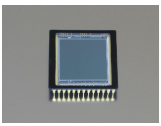
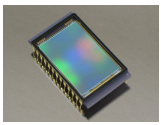
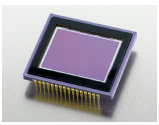
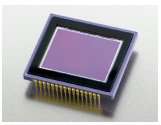
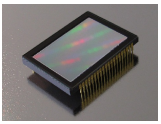
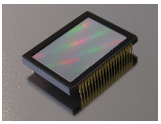


Illustration 3: "Interline Transfer" CCD schematic diagram

G3 camera models with FF CCD architecture:

Model	**G3-1000**	**G3-6300**	**G3-16200**	**G3-16200C**
CCD chip	KAF-1001E	KAF-6303E	KAF-16200	KAF-16200
Resolution	1024×1024	3072×2048	4540×3640	4540×3640
Pixel size	24×24 µm	9×9 µm	6×6 µm	6×6 µm
CCD area	24.6×24.6 mm	27.7×18.4 mm	27.2×21.8 mm	27.2×21.8 mm
ABG	No	No	Yes	Yes
Color mask	No	No	No	Yes
				

G3 camera models with IT CCD architecture:

Model	**G3-11000**	**G3-11000C**
CCD chip	KAI-11002	KAI-11002
Resolution	4032×2688	4032×2688
Pixel size	9×9 µm	9×9 µm
CCD area	36.3×24.2 mm	36.3×24.2 mm
ABG	Yes	Yes
Color mask	No	Yes
		

Cameras with “C” suffix contains CCD detector covered with so-called Bayer mask. Color filters of three basic colors (red, green, blue) cover all pixels, so every pixels detects only light of particular color.

These cameras are able to acquire color image in single exposure, without the necessity to change color filters. On the other side color mask brings lower sensitivity and limits the capability to perform exposures using narrow-band filters etc.

Because each pixel is covered by one of three basic color filters, it is necessary to compute (interpolate) remaining two colors for each pixel, which of course limits resolution of color image. Imaging using color detectors is described in the “Color images” chapter.

CCD Chip

Quantum efficiency (sensitivity) of CCD detectors used in G3 cameras depends on the particular camera model.

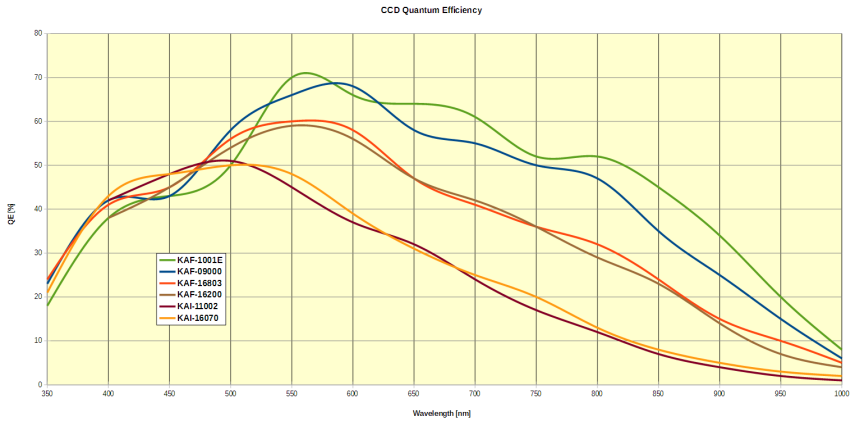


Illustration 4: Quantum efficiency of CCD detectors used in G3

Inherent dark current of these detectors is quite low compared to other CCD detectors, suitable for scientific applications, which results into very good signal/noise ratio.

Model G3-1000

G3-1000 model uses 1 MPx OnSemi KAF-1001E Class 1 or 2 CCD chip.

Resolution	1024×1024 pixels

Pixel size	24×24 µm
Imaging area	24.6×24.6 mm
Full well capacity	Approx. 220 000 e-
Output node capacity	Approx. 650 000 e-
Dark current	17 e-/s/pixel at 0°C
Dark signal doubling	5.5 °C

Model G3-6300

G3-6300 model uses 6 MPx OnSemi KAF-6303E Standard Class CCD chip.

Resolution	3072×2048 pixels
Pixel size	9×9 µm
Imaging area	27.7×18.4 mm
Full well capacity	Approx. 100 000 e-
Output node capacity	Approx. 220 000 e-
Dark current	1 e-/s/pixel at 0°C
Dark signal doubling	6.3 °C

Model G3-11000

G3-11000 uses 11 MPx CCD OnSemi KAI-11002 Class 1 or 2.

Resolution	4032×2688 pixels
Pixel size	9×9 µm
Imaging area	36,3×24,2 mm
Full well capacity	Approx. 60 000 e-
Dark current	12 e-/s/pixel at 0°C
Dark signal doubling	7 °C
ABG	>1000×

Model G3-11000C

G3-11000C uses 11 MPx CCD OnSemi KAI-11002 Class 1 or 2 with color (Bayer) mask.

Model G3-16200

G3-16200 uses 16 MPx CCD OnSemi KAF-16200.

Resolution	4540×3640 pixels
Pixel size	6×6 µm
Imaging area	27.2×21.8 mm
Full well capacity	approx. 41 000 e-
Dark current	0,08 e-/s/pixel at 0°C
Dark signal doubling	5.7 °C
ABG	2800×

Model G3-16200C

G3-16200C uses 16 MPx CCD OnSemi KAF-16200 with color (Bayer) mask.

Camera Electronics

16-bit A/D converter with correlated double sampling ensures high dynamic range and CCD chip-limited readout noise. Fast USB interface ensures image download time within seconds.

Maximum length of single USB cable is 5 m. This length can be extended to 10 m by using single USB hub or active USB extender cable. Up to 5 hubs or active extenders can be used in one connection.

Gx Camera Ethernet Adapter device allows connection of up to four Gx cameras of any type through Ethernet interface and TCP/IP network. Because TCP/IP protocol can be routed, the distance between camera and host PC can be virtually unlimited.

ADC resolution	16 bits
Sampling method	Correlated double sampling
Read modes	Preview
	Low-noise
Horizontal binning	1 to 4 pixels
Vertical binning	1 to 4 pixels

Sub-frame readout	Arbitrary sub-frame
Computer interface	USB 2.0 high-speed
	USB 1.1 full-speed compatible

Binning can be combined independently on both axes.

Image download time and system read noise depends on the CCD chip used in particular camera model.

Model G3-1000

Gain	3 e-/ADU (1×1 binning)
	5 e-/ADU (other binnings)
System read noise	12 e- (Low noise)
	15 e- (Preview)
Full frame download	1.6 s (Low noise)
	1.3 s (Preview)

Model G3-6300

Gain	1.5 e-/ADU (1×1 binning)
	2.3 e-/ADU (other binnings)
System read noise	10 e- (Low noise)
	12 e- (Preview)
Full frame download	9.4 s (Low noise)
	7.3 s (Preview)

Model G3-11000

Gain	0.8 e-/ADU (1×1 binning)
	1.6 e-/ADU (other binnings)
System read noise	11,5 e- (Low noise)
	13 e- (Preview)
Full frame download	14.9 s (Low noise)
	11.2 s (Preview)

Model G3-16200

Gain	0.6 e-/ADU (1×1 binning)
	1.0 e-/ADU (other binnings)
System read noise	10 e- (Low noise)
	11 e- (Preview)
Full frame download	24.5 s (Low noise)
	18.8 s (Preview)

Cooling and power supply

Regulated two-stage thermoelectric cooling is capable to cool the CCD chip from 45 to 50 °C below ambient temperature, depending on the camera type. The Peltier hot side is cooled by a fans. The CCD chip temperature is regulated with ±0.1 °C precision. High temperature drop and precision regulation ensure very low dark current for long exposures and allow proper image calibration.

G3 cameras are available in two variants, differing in the cooling performance:

- **Standard** cooling cameras achieve temperature difference up to 45 °C Under environment temperature.
- **Enhanced** cooling cameras can regulate temperature up to 50 °C under environment temperature. Compared to standard variant, enhanced cooling cameras are somewhat bulkier due to bigger heat sink, slightly heavier and somewhat noisier because of more powerful fans.

The camera head contains two temperature sensors – the first sensor measures directly the temperature of the CCD chip. The second one measures the temperature of the air cooling the Peltier hot side.

The cooling performance depends on the environmental conditions and also on the power supply. If the power supply voltage drops below 12 V, the maximum temperature drop is lower.

CCD chip cooling	Thermoelectric (Peltier modules)
Standard cooling ΔT	48 °C below ambient maximum
	45 °C below ambient typical
Enhanced cooling ΔT	53 °C below ambient maximum
	50 °C below ambient typical
Regulation precision	±0.1 °C
Hot side cooling	Forced air cooling (two fans)
	Optional liquid coolant heat exchanger

Maximum temperature difference between CCD and ambient air may be reached when the cooling runs at 100% power. However, temperature cannot be regulated in such case, camera has no room for lowering the CCD temperature when the ambient temperature rises. Typical temperature drop can be achieved with cooling running at approx. 85% power, which provides enough room for regulation.

Illustration 5: Comparison of the standard (left) and enhanced (right) cooling cameras

Power Supply

The 12 V DC power supply enables camera operation from arbitrary power source including batteries, wall adapters etc. Universal 100-240 V AC/50-60 Hz, 60 W “brick” adapter is supplied with the camera. Although the camera power consumption does not exceed 55 W, the 60 W power supply ensures noise-free operation.

Camera head supply	12 V DC
Camera head power consumption	15 W without cooling
	52 W maximum cooling
Power connector	5.5/2.5 mm, center +
Adapter input voltage	100-240 V AC/50-60 Hz
Adapter output voltage	12 V DC/5 A
Adapter maximum power	60 W

1. Power consumption is measured on the AC side of the supplied 12 V AC/DC power supply. Camera consumes less energy from 12 V power supply than state here.
2. The camera contains its own power supplies inside, so it can be powered by unregulated 12 V DC power source – the input voltage can be anywhere between 10 and 14 V. However, some parameters (like cooling efficiency) can degrade if the supply drops below 12 V.
3. G3 camera measures its input voltage and provides it to the control software. Input voltage is displayed in the Cooling tab of the Imaging Camera control tool in the SIPS. This feature is important especially if you power the camera from batteries.

Illustration 6: 12 V DC/5 A power supply adapter for G3 and G4 CCD Camera

Warning:

The power connector on the camera head uses center-plus pin. Although all modern power supplies use this configuration, always make sure the polarity is correct if you use own power source.

Mechanical Specifications

Compact and robust camera head measures only 154×154×65 mm (approx. 6×6×2.6 inches) for the model with standard cooling without internal filter wheel. Enhanced cooling increases camera depth by 11 mm and internal filter wheel adds another 12.5 mm. The head is CNC-machined from high-quality aluminum and black anodized. The head itself contains USB-B (device) connector and 12 V DC power plug, no other parts (CPU box, USB interface, etc.), except a “brick” power supply, are necessary. Integrated mechanical shutter allows streak-free image readout, as well as automatic dark frame exposures, which are necessary for unattended, robotic setups. Integrated filter wheel contains 5 positions for standard 2-inch filter cells with M48×0.75 thread. There are three M3 threaded holes around each filter position, which allow fixing of filters without cells (only a glass) up to 51 mm diameter.

Mechanical shutter	Yes, blade shutter
Shortest exposure time	0.2 s
Longest exposure time	Limited by chip saturation only
Internal filter wheel (optional)	5 positions 2" threaded filter cells or glass filters up to 51 mm diameter
Standard cooling head dimensions	154×154×65 mm (G3 without filter wheel)
	154×154×77.5 mm (G3 with internal filter wheel)
Enhanced cooling head dimensions	154×154×76 mm (G3-EC without filter wheel)
	154×154×88.5 mm (G3-EC with internal filter wheel)
Back focal distance	16,5 mm (G3 without filter wheel)
	29 mm (G3 with internal filter wheel)
	33.5 mm (G3 with external filter wheel)
Standard cooling head weight	1.6 kg (G3 without filter wheel)
	1.9 kg (G3 with internal filter wheel)
	2.5 kg (G3 with “S” external filter wheel)

Enhanced cooling head weight	1.8 kg (G3-EC without filter wheel)
	2.1 kg (G3-EC with internal filter wheel)
	2.7 kg (G3-EC with “S” external filter wheel)

Camera head dimensions

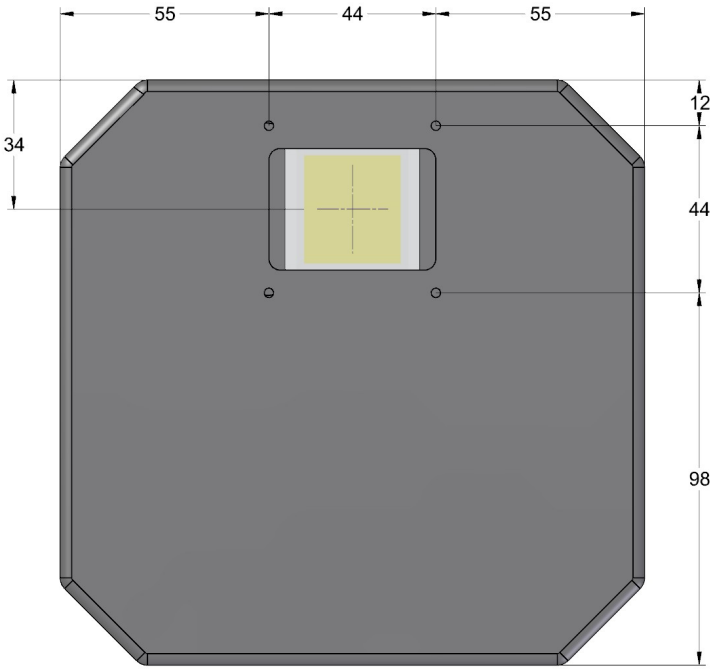


Illustration 7: G3 camera front view (both standard and enhanced cooling)

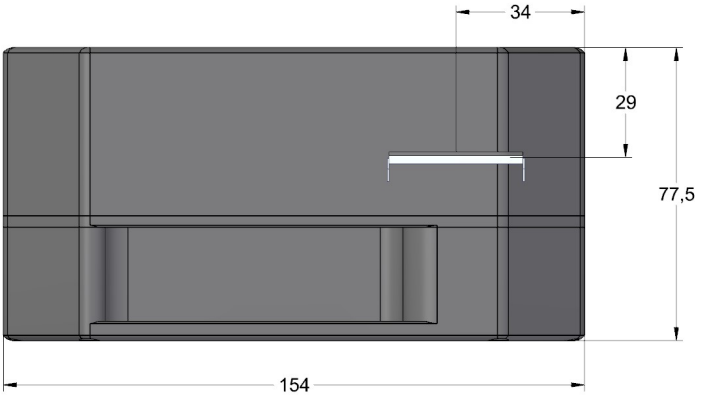


Illustration 8: G3 camera with standard cooling and internal filter wheel side view

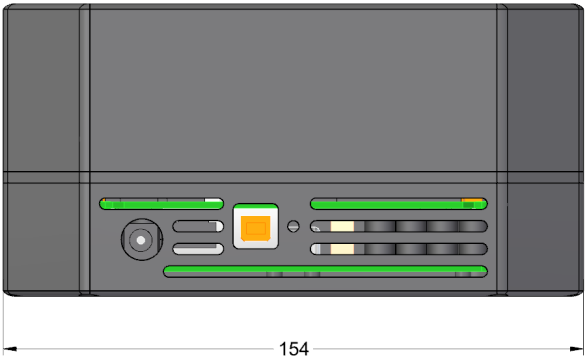


Illustration 9: G3 camera with standard cooling and internal filter wheel bottom view

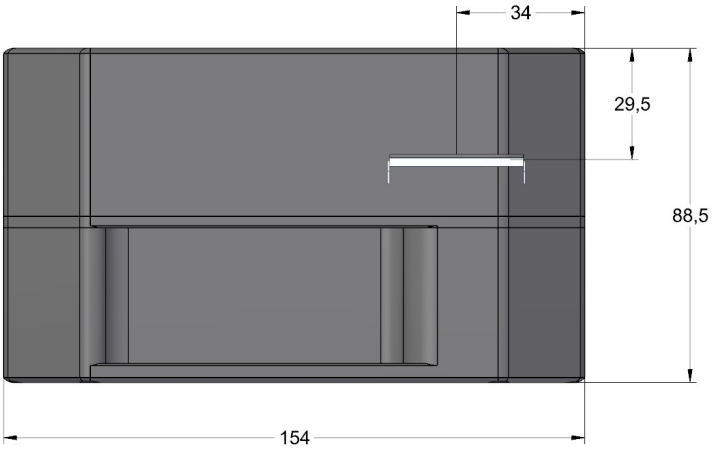


Illustration 10: G3 camera with enhanced cooling and internal filter wheel side view

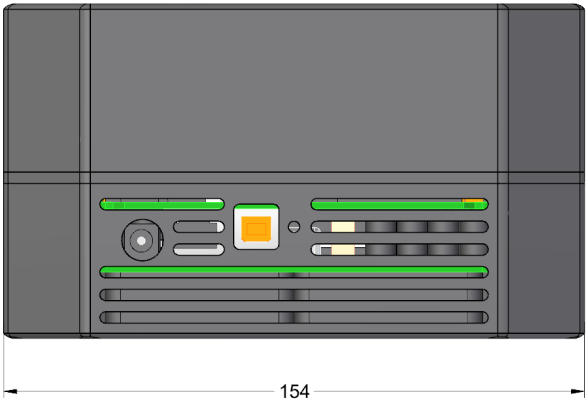


Illustration 11: G3 camera with enhanced cooling and internal filter wheel bottom view

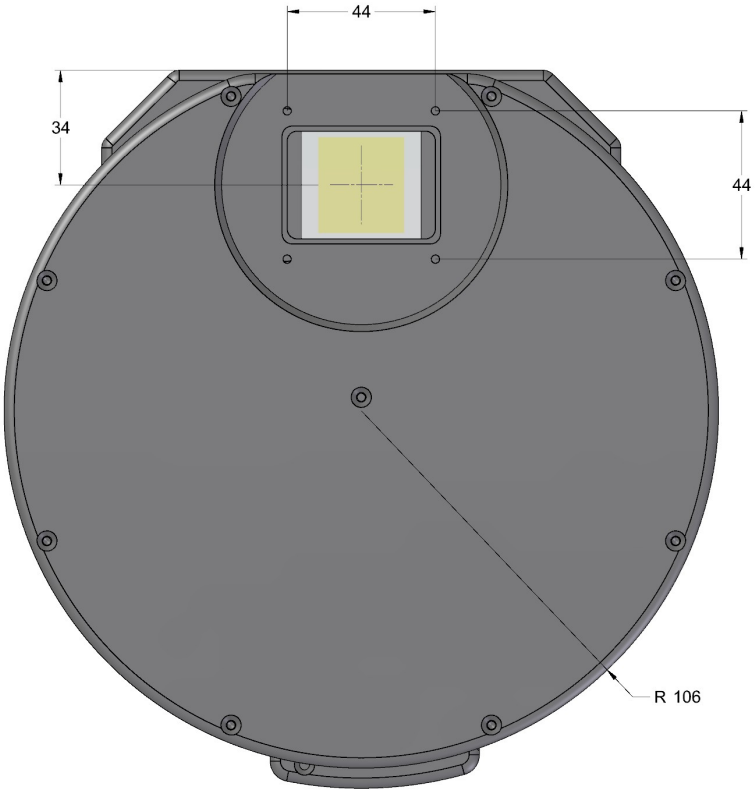


Illustration 12: G3 camera front view (both standard and enhanced cooling) with "S" size external filter wheel

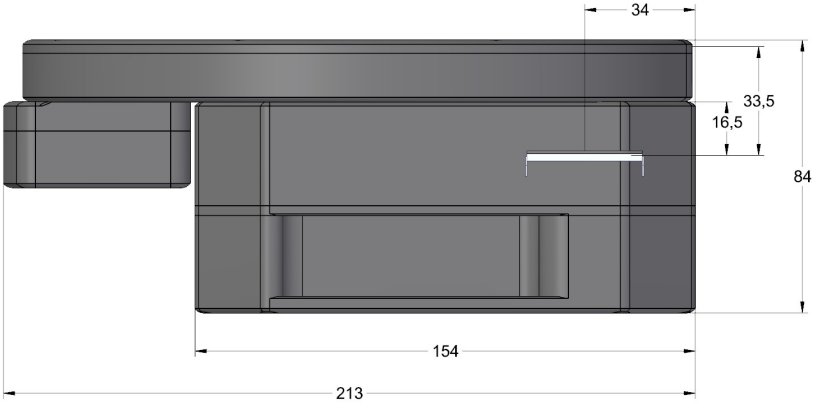


Illustration 13: G3 camera with standard cooling and "S" size external filter wheel side view

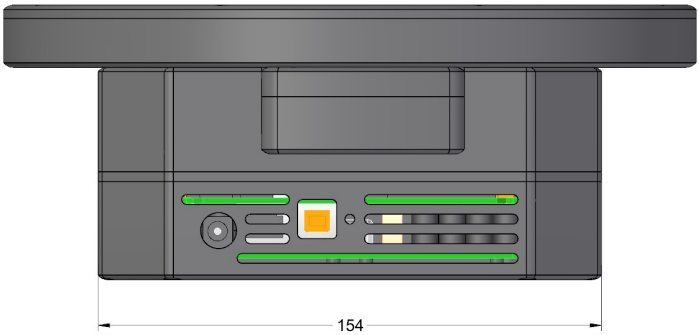


Illustration 14: G3 camera with standard cooling and "S" size external filter wheel bottom view

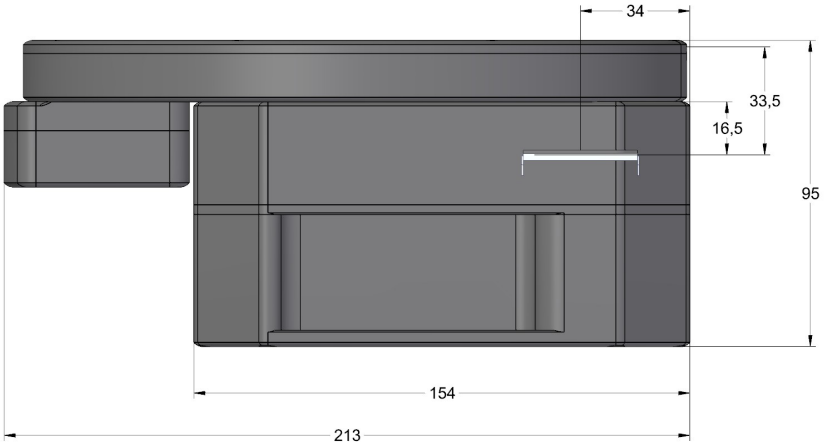


Illustration 15: G3 camera with enhanced cooling and "S" size external filter wheel side view

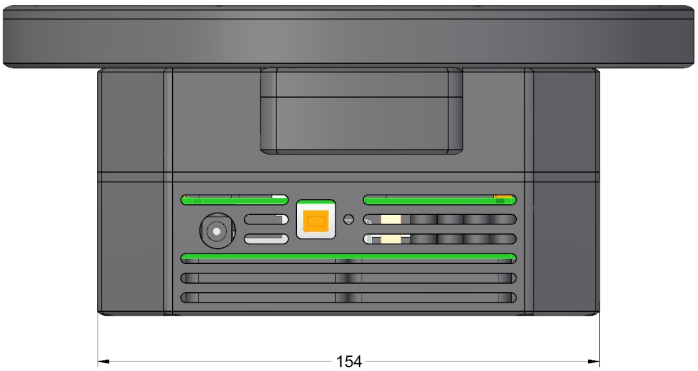


Illustration 16: G3 camera with enhanced cooling and "S" size external filter wheel bottom view

Telescope adapters

Various telescope and lens adapters for the G3 cameras are offered. Users can choose any adapter according to their needs and another adapters can be ordered separately.

It is possible to choose among various telescope/lens adapters:

2" barrel adapter		Adapter for 2" focusers.
T-thread short		M42×0.75 mm inner thread, 7.5 mm thick.
T-thread with 55 mm BFD		M42×0.75 mm inner thread, preserves 55 mm back focal distance.
M48×0.75 thread short		Adapter with inner thread M48×0.75, 7.5mm thick
M48×0.75 thread with 55 mm BFD		Adapter with inner thread M48×0.75, preserves 55 mm back focal distance.
Pentax (Praktica) lens adapter		M42×1 mm inner thread, preserves 45.5 mm back focal distance.

M68×1 thread adapter		Adapter with inner thread M68×1.
Canon EOS lens adapter		Standard Canon EOS bayonet adapter.
Canon EOS clip lens adapter		Canon EOS bayonet adapter with the possibility to insert “clip” filter. Can be used on cameras with internal filter wheel only.
Nikon F lens adapter		Standard Nikon F bayonet adapter.
3” Wynne adapter		Adapter for 3” coma-corrector ASA Wynne.
3” Paracorr BIG adapter		Adapter for 3” coma-corrector TeleVue Paracorr BIG, intended for G3-OAG.
3” Paracorr BIG adapter		Adapter for 3” coma-corrector TeleVue Paracorr BIG, intended for attaching to EFW with M68×1.

T-thread (M42×0.75) adapter or M42×1 adapter cause vignetting when used with cameras equipped with large sensors. Also common coma correctors (often equipped with T-thread) cause vignetting with this large chip. G3 cameras with 24×36 mm CCD require using of M68×1 adapter.

If the mounting standard defines also back focal distance (distance from adapter front plane to detector), the particular adapter is constructed to preserve defined distance (for instance T-thread defines back focal distance to 55 mm, but certain distance is defined also for Pentax (Praktica) thread, for Canon EOS and Nikon bayonets etc.).

Adapters are attached to the camera body using four M3 (3 mm metric) screws. These threaded holes are placed on the corners of 44 mm square. Custom adapters can be made upon request.

Off-Axis Guider Adapter (OAG)

G3 camera can be optionally equipped with Off-Axis Guider Adapter. This adapter contains flat mirror, tilted by 45° to the optical axis. This mirror reflects part of the incoming light into guider camera port. The mirror is located far enough from the optical axis not to block light coming to the main camera sensor, so the optics must be capable to create large enough field of view to illuminate the tilted mirror.

Because of the above described reasons the G3-OAG is manufactured with M68×1 threaded adapter. G3-OAG is compatible with external filter wheels. Adapter back focal distance is 61.5 mm.

If the OAG has to be used on camera with internal filter wheel, it is necessary to insert a spacer between OAG and camera head compensating BFD difference. Similar, but thicker spacer must be used when OAG is mounted to camera without filter wheel at all.

OAG guider port is compatible with G0 and G1 cameras. It is necessary to replace the CS/1.25” adapter with short, 10 mm variant in the case of G1 cameras. Because G1 cameras follow CS-mount standard, (BFD 12.5 mm), any camera following this standard with 10 mm long 1.25” adapter should work properly with the G3-OAG.

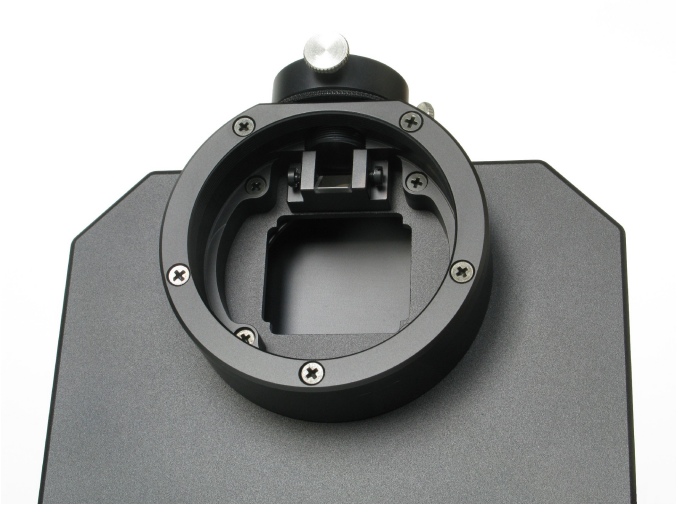


Illustration 17: G3-OAG on the camera head

Attaching camera head to telescope mount

G3 cameras are equipped with two “tripod” 0.250-20UNC threads on the top side of the camera head. This thread can be used to attach 1.75 inch “dovetail bar” (Vixen standard). It is then possible to attach the camera head, e.g. equipped with photographic lens, directly to various telescope mounts supporting this standard.

Illustration 18: 1.75" bar for standard telescope mounts

Camera head color variants

Camera head is available in several color variants of the center plate. Visit manufacturer's web pages for current offering.

Illustration 19: G3 camera color variants

Camera Maintenance

The G3 camera is a precision optical and mechanical instrument, so it should be handled with care. Camera should be protected from moisture and dust. Always cover the telescope adapter when the camera is removed from the telescope or put the whole camera into protective plastic bag.

Desiccant exchange

The G3 camera cooling is designed to be resistant to humidity inside the CCD chamber. When the temperature decreases, the copper cold finger crosses freezing point earlier than the CCD chip itself, so the water vapor inside the CCD chamber freezes on the cold finger surface first. Although this mechanism works very reliably in majority of cases, it has some limitations, especially when the humidity level inside the CCD chamber is high or the chip is cooled to very low temperatures.

This is why a cylindrical container, filled with silica-gel desiccant, is placed inside the camera head. This cylindrical chamber is attached to the insulated cooled CCD chamber itself.

Warning:

High level of moisture in the CCD chip chamber can cause camera malfunction or even damage to the CCD chip. Even if the frost does not create on the detector when the CCD is cooled below freezing point, the moisture can be still present. It is necessary to keep the CCD chamber interior dry by the regular exchange of the silica-gel. The frequency of necessary silica-gel exchanges depends on the camera usage. If the camera is used regularly, it is necessary to dry the CCD chamber every few months.

It is possible dry the wet silica-gel by baking it in the oven (not the microwave one!) to dry it again. Dry the silica-gel for at last one or two hours at temperature between 120 and 140 °C.

The silica-gel used in G3 cameras changes its color according to amount of water absorbed – it is bright yellow or orange when it is dry and turns to

transparent without any color hue when it becomes wet. It is recommended to shorten replacement interval if the silica-gel is completely transparent upon replacement. If it is still yellow-orange, it is possible to prolong the replacement interval.

Note:

The silica-gel ability to absorb moisture depends on the ambient temperature. If the camera is located in the environment with below freezing point temperatures, drying of the CCD cold chamber can take up to several days.

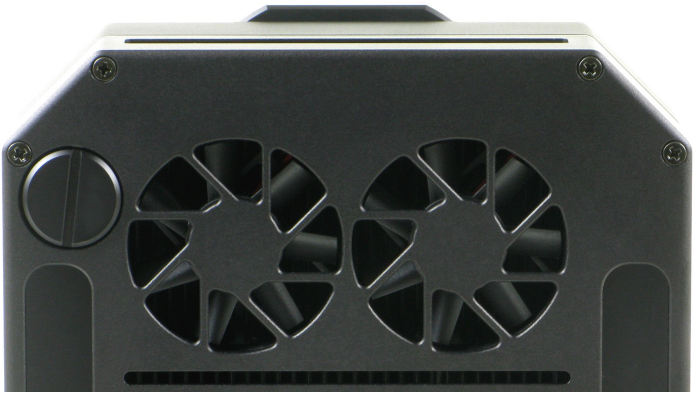


Illustration 20: Silica-gel container is accessible from the camera back side

Changing the silica-gel

The desiccant container design depends on the camera revision:

- G3 cameras revision 1 have the container accessible from the back side of the camera head. The slotted desiccant chamber cap can be unscrewed e.g. by a coin. Pour out wet silica-gel and fill the chamber with a dry one. The desiccant chamber can be filled with a hot silica-gel without a danger of damaging of the container.

  The desiccant container can be left open without the fear from contamination of CCD chamber interior by dust. There is a very faint stainless steel grid between the CCD chamber and the desiccant container, so dust particles cannot enter the chamber itself. It is even

recommended to keep the desiccant container cap off for a couple of hours when the camera is in the room with low humidity. This helps drying the CCD chamber interior and prolongs the silica-gel exchange interval.

- G3 revision 2 cameras cameras supplied in 2016 and later are equipped with a redesigned desiccant containers. New containers are no longer a fixed part of the camera body with only a removable cap, but the whole container can be unscrewed. The main advantage of this design is the ability to exchange silica-gel without the necessity to remove the camera from the telescope, which was necessary to be able to pour-out the silica-gel and then to pour it in.

  Silica-gel is held inside the container with a perforated cap. This cap is also screwed into the container body, so it is easy to exchange the silica-gel inside the container after it is worn out or damaged e.g. by too high temperature etc.

  The container itself does not contain any sealing (the sealing remains attached to the CCD cold chamber inside the camera head), it consists of aluminum parts only. So it is possible to heat the whole container to desired temperature without risking of the temperature-induced sealing damage.

  This design also allows usage of some optional parts. First it is a threaded hermetic cap, which allows sealing of the dried container when it is not immediately attached to the camera head. And the second one is an alternate (somewhat longer) desiccant container, modified to be able to be screw in and tightened (as well as released and screwed out) without any tool.

  The sealed cap as well as the tool-less container are not supplied with the camera, the are supplied only as optional accessory.

- The G3 cameras with Enhanced Cooling are equipped with a bigger heat sink and thus also thicker back shell. This requires usage of the longer desiccant containers. Both container variants (the standard one and also the tool-less variant) are supplied in two lengths. Shortened containers for standard cameras and longer ones for Enhanced Cooling cameras.

Illustration 21: Optional cap, containers with a slot and containers for tool-less manipulation, versions for the standard and Enhanced Cooling cameras

Changing Filters

It is necessary to open the camera head to change filters or the whole filter wheel of the G3 camera. Opening the head is quite simple – it is just necessary to unscrew she eight bolts, which holds the camera head together.

Warning:

The blade shutter rotates 180° between individual snapshots. Camera cover could be opened only when the shutter is closed. If for instance the camera is unplugged from power adapter while exposing and the shutter remains open, it can be damaged while removing the camera cover.

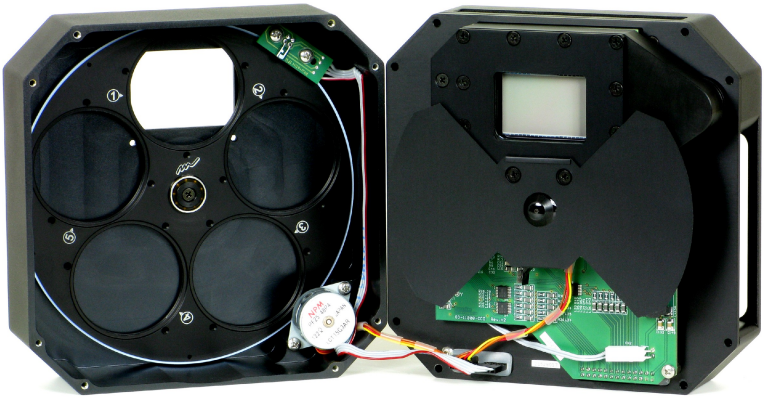


Illustration 22: Filters can be changed after opening the camera case front shell

After removing the screws carefully turn the camera head by the telescope adapter upward. Gently pull the front part of the case. Notice there are two cables, connecting the filter wheel motor and the filter position optical bar, plugged into the electronics board. It is not necessary to unplug these cables to change filters, but if you unplug them, take care to connect them again in the proper orientation!

Filter numbering is always engraved into the wheel, as illustrated on the image below.

Illustration 23: Filter positions in the G3 filter wheel

Changing the Whole Filter Wheel

The whole filter wheel can be changed at once. It is necessary to remove the front part of the camera case the same way as in the case of changing filters.

The filter wheel can be removed when you unscrew the bolt on the center of the front part of camera case. Take care not to damage the horseshoe-shaped optical bar when replacing the filter wheel.

Changing the Telescope Adapter

The camera head contains bolt square. The telescope adapter is attached by four bolts. If you want to change the adapter, simply unscrew these bolts and replace the adapter with the new one.

Power Supply Fuse

The power supply inside the camera is protected against connecting of inverted-polarity power plug or against connecting of too-high DC voltage (above 15 V) by a fuse. If such event happens and the cooling fans on the back side of the camera do not work when the camera is connected to proper power supply, return the camera to the service center for repair.