G3 Series Mark II

Cooled CCD Cameras

User's Guide

moravian instruments

Version 1.3

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G3 cameras are not authorized for and should not be used within Life Support Systems without the specific written consent of the Moravian Instruments. Product warranty is limited to repair or replacement of defective components and does not cover injury or property or other consequential damages.

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Introduction

Thank you for choosing the Moravian Instruments camera. The cooled G3 series Mark II CCD cameras were developed for imaging under extremely low-light conditions in astronomy, microscopy and similar areas.

Design of this series inherits from earlier G3 Mark I cameras but brings some significant enhancements. G3 cameras employ precise electronics providing uniform frames and extremely low read noise limited only by CCD detector itself.

Modular mechanical construction allows various camera variants to be combined with rich set of accessories, including telescope adapters, off-axis guider adapters, internal or external filter wheels, Ethernet adapters, guiding cameras etc.

Rich software and driver support allows usage of G3 camera without necessity to invest into any 3rd party software package thanks to included free SIPS software package. However, ASCOM (for Windows) and INDI (for Linux) drivers, shipped with the camera, provide the way to integrate G3 camera with vast variety of camera control programs.

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 and runs modern 32 or 64-bit Windows operating system.
2. Is compatible with a PC standard and runs 32 or 64-bit Linux operating system.

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

3. Support for x64 based Apple Macintosh computers is also included.

   Only certain software packages are currently supported on Mac.

G3 cameras require at last one free USB 2.0 port to communicate with a host PC.

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 or seven additional USB ports. Make sure the USB hub is USB 2.0 high-speed compatible.

Alternatively, it is possible to use the “Gx Camera Ethernet Adapter” device. 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 WiFi adapter or other networking device to the communication path.

Please note while the USB standard allows usage of cable no longer than approx. 5 meters, the TCP/IP communication protocol used to connect the camera over the Ethernet adapter is routable, so the distance between camera setup and the host PC is virtually unlimited.

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 long exposures.

G3 Camera Overview

G3 camera head is designed to be easily used with a set of accessories to fulfil various observing needs. Camera head itself is manufactured in several variants.

First, there are variants differing in the cooling performance:

- Standard cooling
- Enhanced cooling (11 mm thicker due to increased heat sink)

Second, there are variants differing if filter wheel control:

- Camera with Internal filter wheel.
- Camera with control port for External filter wheel. This model allows attachment of several variants of external filter wheels with various number of filter positions and sizes.

Figure 1: G3 Camera Mark II without filter wheel (far left), with Internal filter wheel (left) and with attached "S" (right) and "L" (far right) External filter wheel

G3 camera model with Internal filter wheel accepts 5 filters for unmounted D50 mm filters or filters in standard 2" threaded cells.

There are three sizes of the External filter wheels, capable to accept various sizes of filters, available for the G3 cameras:

- Small “S” size wheel for 7 unmounted filters D50 mm or filters in 2” threaded cells.
- Small “M” size wheel for 7 unmounted filters D50 mm or filters in 2” threaded cells.
- Small “M” size wheel for 5 square filters 50×50 mm.
- Large “L” size wheel for 9 unmounted D50 mm or filters in 2” threaded cells.
- Large “L” size wheel for 7 square filters 50×50 mm.

Please note the camera head is designed to either accept Internal filter wheel or to be able to connect to the External filter wheel, but not both. If the Internal filter wheel variant is used, External filter wheel cannot be attached.

And third, there are two sizes of adjustable adapters, which can be used with G3 cameras:

- Small “S” adapters, compatible with G2 cameras, are used for e.g. M48×0.75 and M42×0.75 threaded adapters, Nikon bayonet adapter, 2” barrel adapter etc.
- Large “L” adapters, compatible with G4 cameras, intended for large diameter attachments between camera and telescope, e.g. M68×1 threaded adapter or G3-OAG, which is also equipped with M68×1 thread.

Adjustable adapters are mounted on adapter base when camera with internal filter wheel or camera without any filter wheel is used or directly on the external filter wheel front surface. This means both “S” and “L” adapter bases can be mounted on any camera, external but filter wheels are made for one particular adapter size only:

- “S” external filter wheels are compatible with “S” adapters
- “M” and “L” external filter wheels are compatible with “L” adapters

Note the “S” and “M” filter wheels are of very similar dimensions and hold the same number of the same filters. They differ in the adjustable adapter size only.

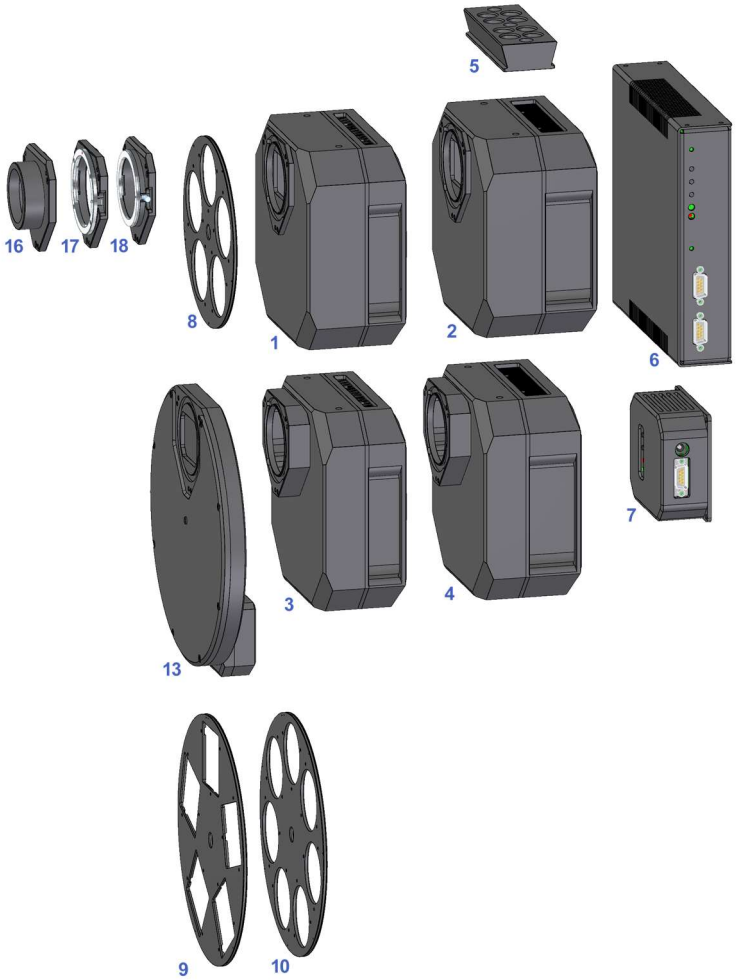


Figure 2: Schematic diagram of G3 camera with "S" size adapter system components

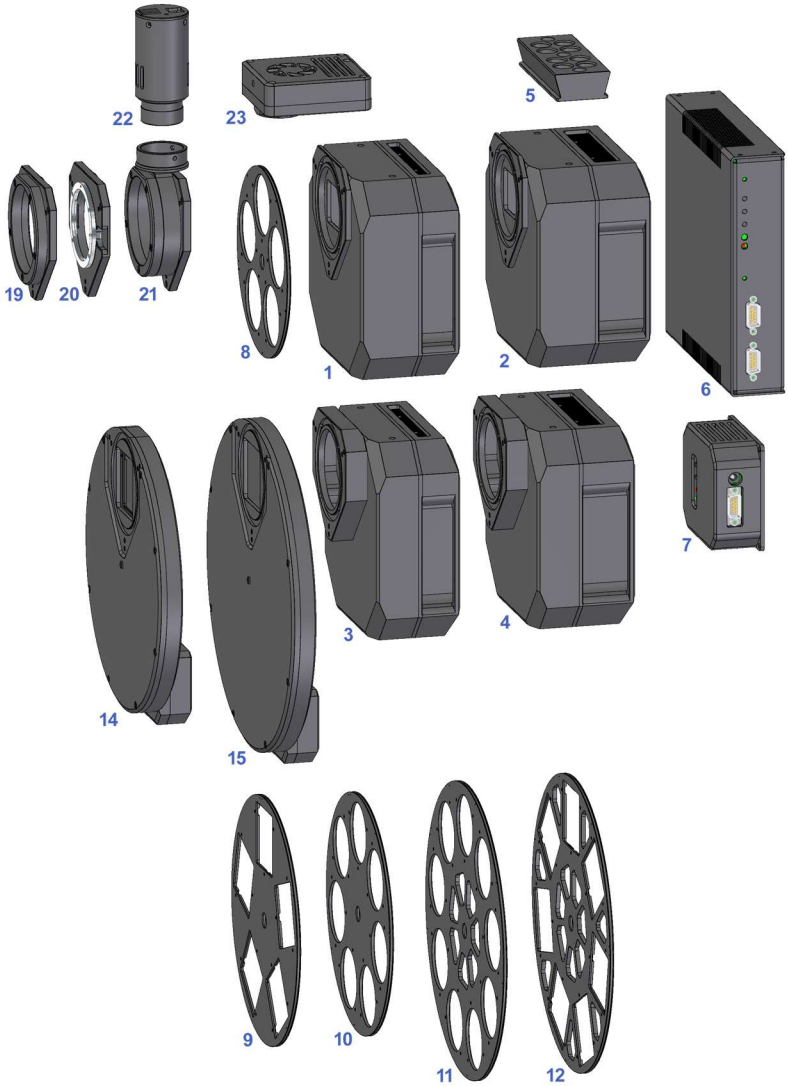


Figure 3: Schematic diagram of G3 camera with "L" size adapter system components

Components of G3 Camera system include:

1. G3 camera head with Internal Filter Wheel (5 positions)
2. G3 camera head with Internal Filter Wheel (5 positions) and Enhanced Cooling option
3. G3 camera head capable to control External Filter Wheel
4. G3 camera head capable to control External Filter Wheel and Enhanced Cooling option
5. 1.75” dovetail rail for G3 camera head
6. Gx Camera Ethernet Adapter (x86 CPU)
7. 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 unlimited distance.

8. 5-positions internal filter wheel for 2”/D50 mm filters
9. 5-positions filter wheel for “S” or “M” housing for 50×50 mm filters
10. 7-positions filter wheel for “S” or “M” housing for 2”/D50 mm filters
11. 9-positions filter wheel for “L” housing for 2”/D50 mm filters
12. 7-positions filter wheel for “L” housing for 50×50 mm filters
13. External Filter Wheel “S” size (7 or 5 positions)
14. External Filter Wheel “M” size (7 or 5 positions)
15. External Filter Wheel “L” size (9 or 7 positions)
16. M42×0.75 (T-thread) or M48×0.75 threaded adapters, 55 mm BFD
17. Canon EOS bayonet lens “S” size adapter
18. Nikon bayonet lens adapter
19. M68×1 threaded adapter, 47.5 mm BFD
20. Canon EOS bayonet lens “L” size adapter
21. Off-Axis Guider with M68×1 thread, 61.5 mm BFD
22. G0 guider camera
23. G1 guider camera

CCD Detectors and Camera Electronics

G3 Mark II series of CCD cameras are manufactured with two kinds of 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 through the whole dynamic range. FF CCD detectors used for astrophotography are equipped with ABG to eliminate disrupting blooming streaks within field of view.
  Cameras with Full Frame, non-ABG 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.

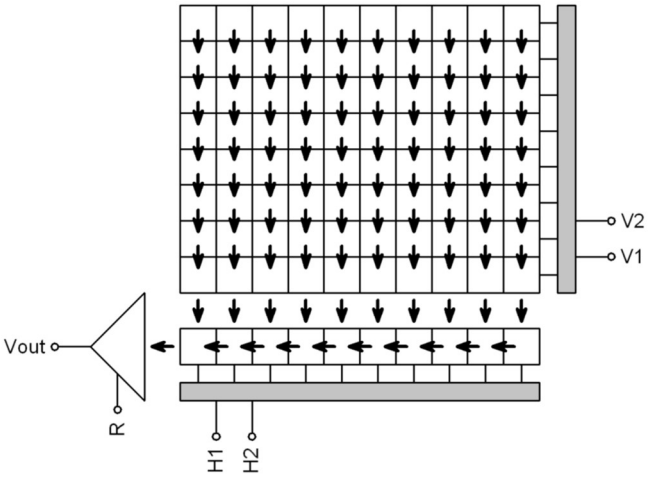


Figure 4: "Full Frame" CCD schematic diagram

- **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, G3 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.

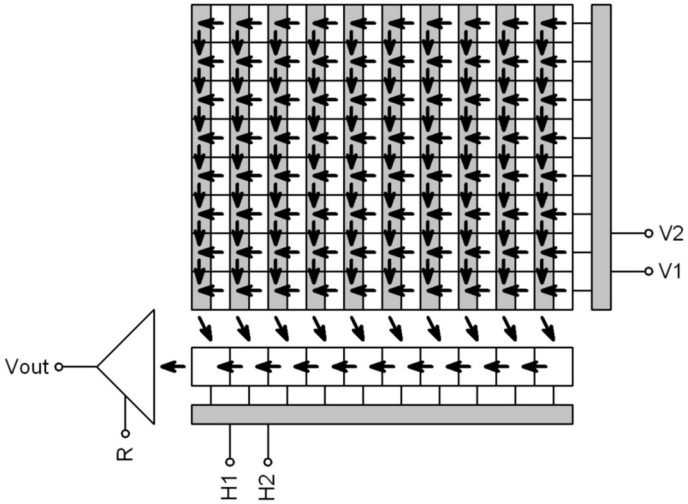
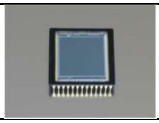
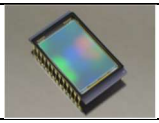
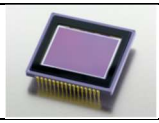
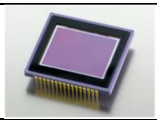
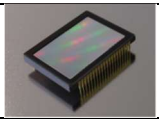
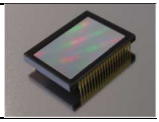


Figure 5: “Interline Transfer” CCD schematic diagram

G3 camera Mark II models with Full Frame CCD detectors:

Model	G3-1000	G3-6300	G3-16200	G3-16200C
CCD sensor	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
Sensor size	24.6 × 24.6	27.7 × 18.4	27.2 × 21.8	27.2 × 21.8
ABG	No	No	Yes	Yes
Color mask	No	No	No	Yes
				

G3 camera models with Interline Transfer CCD detectors:

Model	G3-11000	G3-11000C
CCD sensor	KAI-11002	KAI-11002
Resolution	4032 × 2688	4032 × 2688
Pixel size	9 × 9 µm	9 × 9 µm
Sensor size	36.3 × 24.2	36.3 × 24.2
ABG	Yes	Yes
Color mask	No	Yes
		

Cameras with “C” suffix contain CCD detector covered with so-called Bayer mask. Color filters of three basic colors (red, green, blue) cover all pixels, so every pixel 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 sensor

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

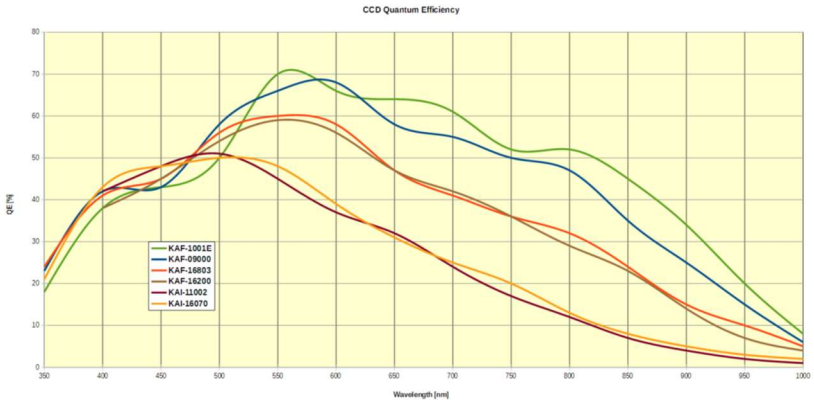


Figure 6: Quantum efficiency of OnSemi CCD detectors used in G3 cameras

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 CCD OnSemi KAF-1001E.

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 CCD OnSemi KAF-6303E.

Resolution	3072 × 2048 pixels
Pixel size	9 × 9 µm

Imaging area	27.6 × 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 model uses 11 MPx CCD OnSemi KAI-11000.

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	7.0 °C
ABG	>1000×

Model G3-11000C

G3-11000 model uses 11 MPx CCD OnSemi KAI-11000 with color (Bayer) mask.

Model G3-16200

G3-16200 model 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

G3-16200V model 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 approx. 5 m. This length can be extended to 10 m or 15 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 as well as on the camera read mode.

- **Preview** read mode provides system read noise approx. 1 or 2 e^- above CCD chip read noise.
- **Low Noise** read mode is somewhat slower, but ensures system read noise roughly equal to the manufacturer-specified chip read noise.

Model G3-1000

Gain	3 e^-/ADU (1×1 binning)
	5 e^-/ADU (other binnings)

System read noise	12 e^- RMS (Low noise)
	15 e^- RMS (Preview)
Download time	0.67 s (Low noise)
	0.48 s (Preview)

Model G3-6300

Gain	1.5 e^-/ADU (1×1 binning)
	2.0 e^-/ADU (other binnings)
System read noise	10 e^- RMS (Low noise)
	12 e^- RMS (Preview)
Download time	3.84 s (Low noise)
	2.78 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^- RMS (Low noise)
	13 e^- RMS (Preview)
Download time	5.67 s (Low noise)
	3.84 s (Preview)

Model G3-16200

Gain	0.6 e^-/ADU (1×1 binning)
	1.0 e^-/ADU (other binnings)
System read noise	10 e^- RMS (Low noise)
	11 e^- RMS (Preview)
Download time	9.61 s (Low noise)
	6.77 s (Preview)

Stated read noise is measured on particular CCD sensor, evaluated during camera design. Actual read noise of different sensors varies within sensor manufacturing batch and also among various manufacturing batches. The camera read noise is determined by the sensor itself and the camera manufacturer cannot affect it.

Cooling and power supply

Regulated thermoelectric cooling is capable to cool down the CCD chip from 45 to 50 °C below ambient temperature, depending on the camera type. The Peltier hot side is cooled by 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.

G4 cameras are available in two variants, differing in the cooling performance:

- **Standard cooling** cameras achieve regulated temperature difference up to 45 °C below environment temperature.
- **Enhanced cooling** cameras can regulate temperature up to 50 °C below 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.

Figure 7: Standard cooling camera (left) and Enhanced cooling model (right) with thicker back shell containing larger heat sink

The camera head contains two temperature sensors – the first sensor measures directly the temperature of the CCD chip. The second one measures the temperature inside the camera shell.

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.

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.

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.

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

Figure 8: 12 V DC/5 A power supply adapter for G3 camera

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.

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.

G3 camera measures its input voltage and provides it to the control software. Input voltage is displayed in the Cooling tab of the CCD Camera control tool in the SIPS. This feature is important especially if you power the camera from batteries.

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. Enhanced cooling increases camera depth by 11 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. Another connector allows control of optional external filter wheel. Integrated mechanical shutter allows streak-free image readout, as well as automatic dark frame exposures, which are necessary for unattended, robotic setups.

Internal mechanical shutter	Yes, blade shutter
Shortest exposure time	0.2 s
Longest exposure time	Limited by chip saturation only
Standard cooling head dimensions	154×154×65 mm (without filters)
	154×154×77.5 mm (internal wheel)
Enhanced cooling head dimensions	154×154×76 mm (without filters)
	154×154×88.5 mm (internal wheel)
Back focal distance	33.5 mm (base of adjustable adapters)
Standard cooling weight	1.6 kg (without filter wheel)
	1.9 kg (with Internal filter wheel)
	2.5 kg (with “S” External filter wheel)
	2.5 kg (with “M” External filter wheel)
	2.8 kg (with “L” External filter wheel)
Enhanced cooling weight	1.8 kg (without filter wheel)
	2.1 kg (with Internal filter wheel)
	2.7 kg (with “S” External filter wheel)
	2.7 kg (with “M” External filter wheel)
	3.0 kg (with “L” External filter wheel)

Back focus distance is measured from the sensor to the base on which adjustable adapters are mounted. Various adapters then provide back focal distance specific for the particular adapter type (e.g. Canon EOS bayonet adapter back focal distance is 44 mm).

Stated back focal distance already calculates with glass permanently placed in the optical path (e.g. optical window covering the CCD cold chamber).

Camera with Internal Filter Wheel

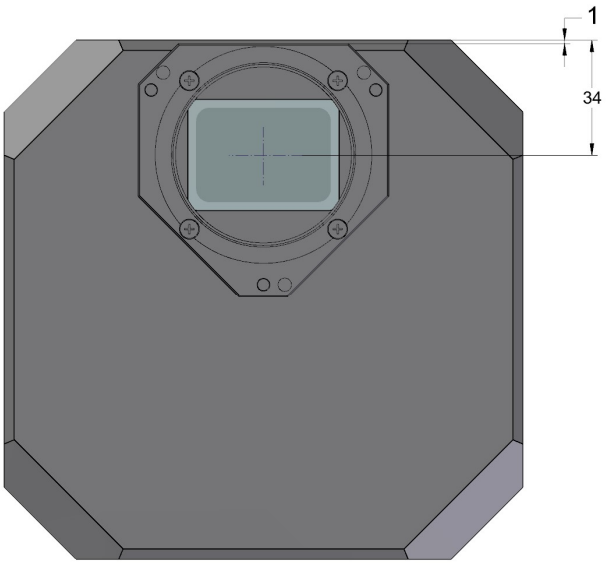


Figure 9: G3 camera head front view dimensions

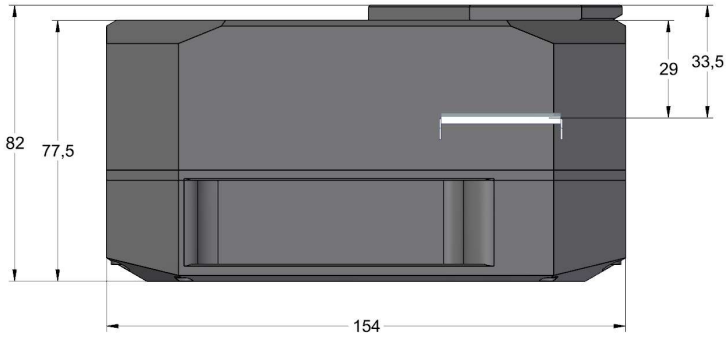


Figure 10: G3 camera head with Internal Filter Wheel side view dimensions

Figure 11: G3 camera head with External filter wheel bottom view dimensions

Enhanced cooling variant

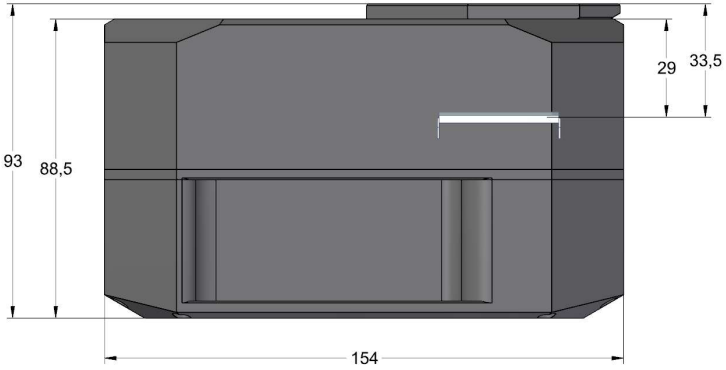


Figure 12: G3 camera head with Internal Filter Wheel and Enhanced cooling side view dimensions

Camera with “S” External Filter Wheel

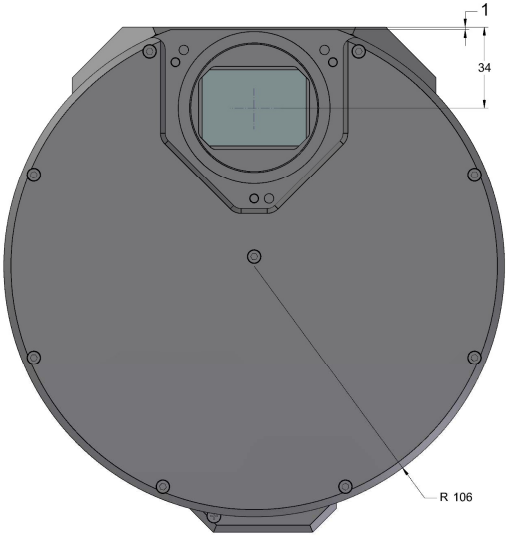


Figure 13: G3 camera head with External filter wheel front view dimensions

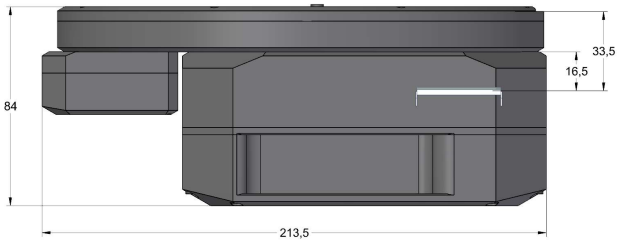


Figure 14: G3 camera head with External filter wheel side view dimensions

Figure 15: G3 camera head with External filter wheel bottom view dimensions

The “L” sized External Filter Wheel diameter is greater (see External Filter Wheel User's Guide), but the back focal distance of all external filter wheels is identical.

Enhanced cooling with External filter wheel variant

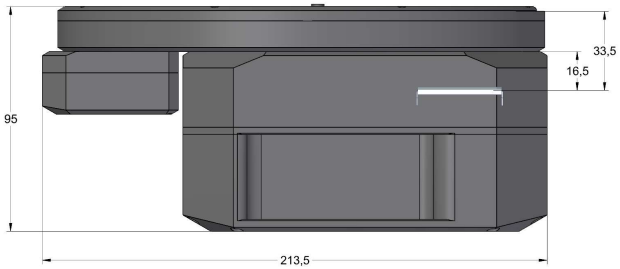


Figure 16: G3 camera head with Enhanced cooling and External filter wheel side view dimensions

Optional accessories

Various accessories are offered with G3 Mark II cameras to enhance functionality and help camera integration into imaging setups.

Telescope adapters

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

G3 Mark II cameras are offered with two sizes of adjustable adapter base:

- Small “S” adapters (also used with G2 cameras)
- Large “L” adapters (also used with G4 cameras)

Figure 17: Comparison of the "S" size external filter wheel with "S" adapter (left) and "M" size external filter wheel with "L" adapter (right)

Adjustable adapters are mounted on adapter base when camera with internal filter wheel or camera without any filter wheel is used or directly on the external filter wheel front surface. This means both “S” and “L” adapter bases can be mounted on any camera, external but filter wheels are made for one particular adapter size only:

- “S” external filter wheels are compatible with “S” adapters

- “M” and “L” external filter wheels are compatible with “L” adapters

Small “S” size adapters:

- **2-inch barrel** – adapter for standard 2" focusers.
- **T-thread short** – M42×0.75 inner thread adapter.
- **T-thread with 55 mm BFD** – M42×0.75 inner thread adapter, preserves 55 mm back focal distance.
- **M48×0.75 short** – adapter with inner thread M48×0.75.
- **M48×0.75 with 55 mm BFD** – adapter with inner thread M48×0.75, preserves 55 mm back focal distance.
- **Canon EOS bayonet** – standard Canon EOS lens adapter (“S” size”). Adapter preserves 44 mm back focal distance.
- **Nikon F bayonet** – standard Nikon F lens adapter, preserves 46.5 mm back focal distance.

Large “L” size adapters:

- **M68×1** – adapter with M68×1 **inner thread**.
- **Canon EOS bayonet** – standard Canon EOS lens adapter (“L” size”). Adapter preserves 44 mm back focal distance.

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.

G3-OAG is manufactured with M68×1 thread with the back focal distance 61.5 mm.

If the OAG is used on camera without filter wheel, thicker adapter base must be used to keep the Back focal distance and to allow the guiding camera to reach focus.

Note the G3-OAG is manufactured for “L” size adapter base, so it is compatible with “M” and “L” external filter wheels only.

While G2-OAG (with M48×0.75 or M42×0.75 inner thread) for “S” size adapter base can be technically mounted to “S” size external filter wheel, the mirror is so close to optical axis, that it partially shields sensors used in G3 cameras and G2-OAG cannot be used.

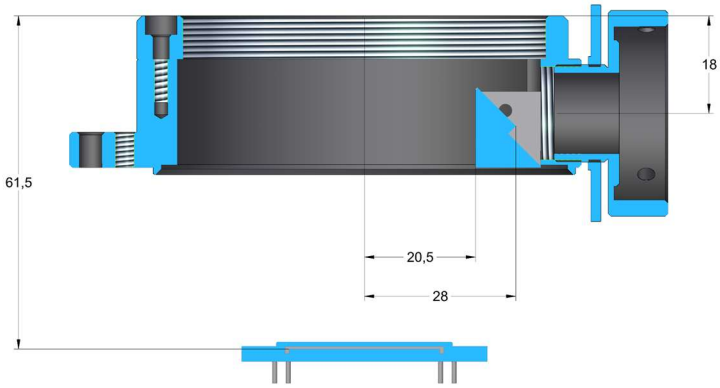


Figure 18: Position of the OAG reflection mirror relative to optical axis

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.

Figure 19: OAG on G3 camera with Internal filter wheel, attached to thin adapter base

Attaching camera head to telescope mount

G3 camera heads are equipped with two “tripod” thread (0.25”) on the top side. 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.

Figure 20: 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.

Figure 21: G3 Mark II camera color variants

Gx Camera Ethernet Adapter

Gx 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.

Figure 22: The Gx Camera Ethernet Adapter with two connected cameras

Adjusting of the telescope adapter

All telescope/lens adapters of the Gš Mark II series of cameras can be slightly tilted. This feature is introduced to compensate for possible misalignments in perpendicularity of the telescope optical axis and sensor plane.

Figure 23: Releasing of the "pushing" screw

The Mark II camera telescope adapters are attached using three "pulling" screws. As the adapter tilt is adjustable, another three "pushing" screws are intended to fix the adapter after some pulling screw is released to adjust the tilt.

Warning:

Both pulling and pushing screws, used on the G3 camera adapter, are fine-pitch M4×0.5 thread screws, not standard M4 thread ones. Always

use only screws supplied with the adapter, using of normal M4 screws damages the adapter.

Because the necessity to adjust two screws (one pushing, one pulling) at once is inconvenient, the adapter tilting mechanism is also equipped with ring-shaped spring, which pushes the adapter out of the camera body. This means the pushing screws can be released and still slight releasing of the pulling screw means the distance between the adapter and the camera body increases. The spring is designed to be strong enough to push the camera head from the adapter (fixed on the telescope) regardless of the camera orientation.

When all three pulling screws are fully tightened, releasing of just one or two of these screws does not allow adapter to move, or at last only very slightly thanks to deformation of the adapter body. If the adapter has to be adjusted, it is necessary to slightly release all three pulling screws, which makes room for tilt adjustment.

Figure 24: Adjusting of the "pulling" screw

Only after the proper tilt is reached, the pushing screws should be slightly tightened to fix the adapter in the desired angle relative to camera head. This ensures long-time stability of the adjusted adapter.

Adjustable telescope/lens adapters are attached slightly differently depending if the adapter is attached directly to the camera head (e.g. when camera is equipped with internal filter wheel) or to the External filter wheel case.

- If the External filter wheel is used, the adapted base is not necessary, as the Mark II External filter wheel front plate is already designed to hold the spring and it also contains threads to fix respective adapters.
- G4 Mark II adapters are not mounted directly on the camera head. Instead a tilting adapter base, holding the circular spring, is always used.

Figure 25: Off Axis Guider adapter on the adapter base, attached to the G3 camera without External filter wheel (left) and directly on the External filter wheel (right)

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 connected with the insulated cooled CCD chamber itself.

> **Warning:**
>
> High level of moisture inside the CCD cold chamber can cause camera malfunction or even damage to the CCD sensor. 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 desiccant. 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 absorbed water – 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.

Figure 26: Silica-gel container is accessible from the camera back side

Exchanging the silica-gel

G3 Mark II cameras employ the same desiccant container like the larger G4 cameras. The whole container can be unscrewed, so it is possible to exchange silica-gel without the necessity to remove the camera from the telescope.

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.

Figure 27: Desiccant is held inside container by perforated cap

Note:

New containers have a thin O-ring close to the threaded edge of the container. This O-ring plays no role in sealing the CCD cold chamber itself. It is intended only to hold possible dust particles from entering the front half of the camera head with the CCD chamber optical window, shutter and possibly internal filter wheel. While the O-ring material should sustain the high temperature during silica-gel baking, it is possible to remove it and put it back again prior to threading the contained back to the camera.

This design also allows usage of some optional parts:

- Threaded hermetic cap, which allows sealing of the dried container when it is not immediately attached to the camera head.
- 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 sealing cap as well as the tool-less container are not supplied with the camera, they are supplied only as optional accessory.

Figure 28: Optional cap, standard and tool-less container variants for both standard cooling and enhanced cooling (prolonged) cameras

Desiccant containers for Standard cooling and Enhanced cooling cameras

The difference between Standard and Enhanced cooling cameras is the thickness of the camera back shell, containing heat sink. Naturally, the silica-gel container of Enhanced cooling variants must be longer. Otherwise the containers are the same and the longer variant can be used with standard cooling cameras, it then only extends from the camera back.

Changing Filters

It is necessary to open the camera head to change filters or the whole filter wheel.

Opening the camera head

To open the head, unscrew the eight bolts holding camera head together.

Figure 29: Filters can be exchanged after removing of the camera front cover

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!

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

All adapters of the Mark II cameras are attached using three “pulling” screws. As the adapter tilt is adjustable, another three “pushing” screws are intended to fix the adapter in place.

If the adapter has to be replaced for another one, it is necessary to unscrew the three pulling screws. The adapter then can be removed and replaced with another one.

Figure 30: Replacing of the adjustable telescope adapter

Warning:

Both pulling and pushing screws, used on the G4 camera adapter, are fine-pitch M4×0.5 thread screws, not standard M4 thread ones. Always use only screws supplied with the adapter, using of normal M4 screws damages the adapter.

Always make sure to carefully locate the ring-shaped spring prior to attaching the adapter.

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.