G2 Series Mark II

Cooled CCD Cameras

User's Guide

moravian instruments

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Introduction

Thank you for choosing the Moravian Instruments camera. The cooled G2 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 G2 Mark I cameras but brings some significant enhancements. G2 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 G2 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 G2 camera with vast variety of camera control programs.

The G2 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.

G2 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 G2, but also G0, G1, G3 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 G2 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. G2 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.

G2 Camera Overview

G2 camera head is designed to be easily used with a set of accessories to fulfil various observing needs. Camera head itself is manufactured in two different variants:

- 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: G2 Camera Mark II without filter wheel (left), with Internal filter wheel (middle) and with attached External filter wheel (right)

G2 camera model with Internal filter wheel accepts two sizes of filters:

- Filter wheel with 5 positions for unmounted D31 mm filters or filters in 1.25” threaded cells.
- Filter wheel with 6 positions for unmounted D26 mm (or 1”) filters.

There are two sizes of the External filter wheels, each capable to accept two sizes of filters, available for the G2 cameras:

- Extra small “XS” size wheel for 8 unmounted filters D31 mm or filters in 1.25” threaded cells.

- Extra small “XS” size wheel for 7 unmounted filters D36 mm.
- Small “S” size wheel for 12 unmounted filters D31 mm or filters in 1.25” threaded cells.
- Small “S” size wheel for 10 unmounted filters D36 mm.

Because G2 series of cameras can work with various sensors, not all filter wheel/filter variants can be used with every detector. For instance, G2-8300 camera works with CCD measuring 22.7 mm diagonally. Depending on the used optics f/ratio, 1” or even 1.25” filters can cause more or less significant vignetting when combined with such sensor.

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.

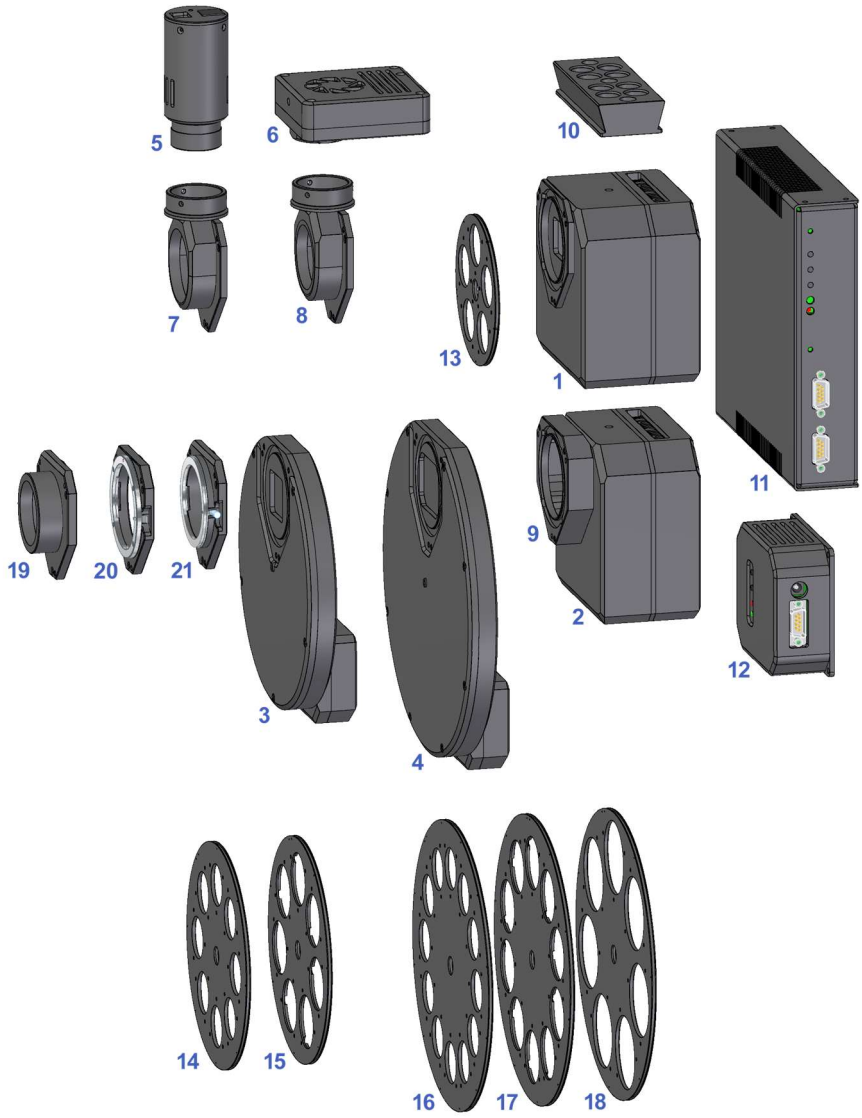


Figure 2: Schematic diagram of G2 camera system components

Components of G2 Camera system include:

1. G2 camera head with Internal Filter Wheel (5 or 6 positions)
2. G2 camera head capable to control External Filter Wheel
3. External Filter Wheel “XS” size (7 or 8 positions)
4. External Filter Wheel “S” size (10 or 12 positions)
5. G0 guider camera
6. G1 guider camera

   G0 and G1 cameras are completely independent devices with their own USB connection to the host PC. They can be used either on G2 OAG or on standalone guiding telescope.

   Both G0 and G1 camera can share the Gx Camera Ethernet Adapter with up to 3 other Gx cameras to be accessed over network.

7. Off-Axis Guider with M48×0.75 thread
8. Off-Axis Guider with M42×0.75 thread (T2)
9. Thick adapter base, compensating EFW thickness to achieve proper back focal distance for cameras without filter wheel
10. 1.75” dovetail rail for G2 camera head
11. Gx Camera Ethernet Adapter (x86 CPU)
12. 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.

13. 5-positions internal filter wheel for 1.25”/D31 mm filters
14. 8-positions external filter wheel “XS” for 1.25”/D31 mm filters
15. 7-positions external filter wheel “XS” for D36 mm filters
16. 12-positions external filter wheel “S” for 1.25”/D31 mm filters
17. 10-positions external filter wheel “S” for D36 mm filters
18. 7-positions external filter wheel “S” for 2”/D50 mm filters
19. M42×0.75 (T-thread) or M48×0.75 threaded adapters, 55 mm BFD
20. Canon EOS bayonet lens adapter
21. Nikon bayonet lens adapter

CCD Detectors and Camera Electronics

G2 Mark II series of CCD cameras are manufactured with two kinds of CCD detectors:

- **G2 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.

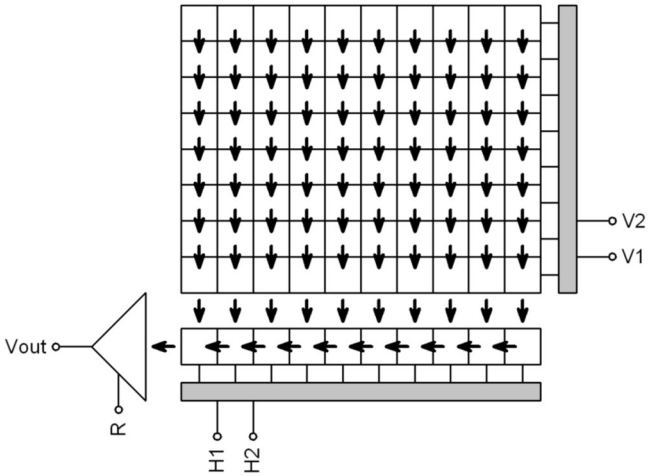


Figure 3: "Full Frame" CCD schematic diagram

- **G2 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, G2 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.

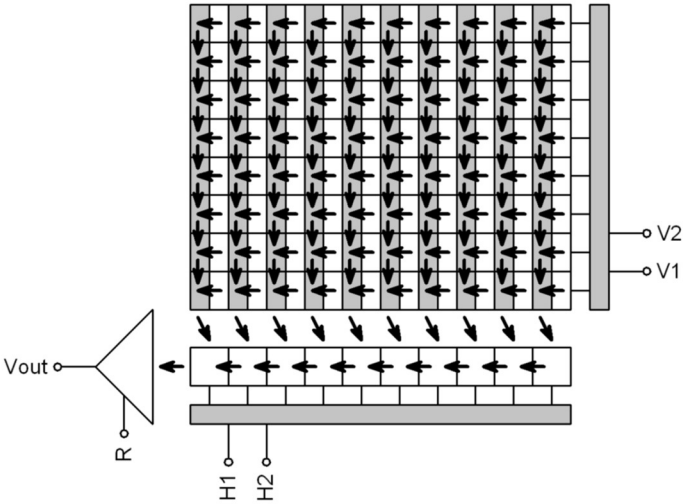
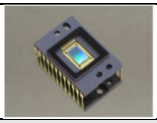
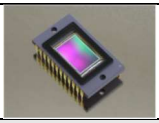
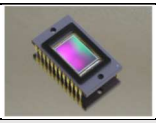
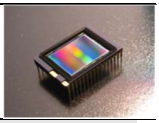


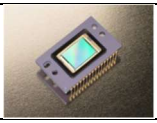
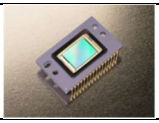
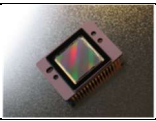
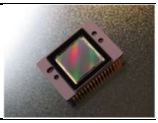
Figure 4: “Interline Transfer” CCD schematic diagram

G2 camera Mark II models with Full Frame CCD detectors:

Model	G2-0400	G2-1600	G2-3200	G2-8300
CCD sensor	KAF-0402ME	KAF-1603ME	KAF-3200ME	KAF-8300
Resolution	768 × 512	1536 × 1024	2184 × 1472	3358 × 2536
Pixel size	9 × 9 µm	9 × 9 µm	6.8 × 6.8 µm	5.4 × 5.4 µm
Sensor size	6.9 × 4.6	13.8 × 9.2	14.9 × 10.0	18.1 × 13.7
ABG	No	No	No	Yes
Color mask	No	No	No	No*
				

* G2-8300 camera is available in the G2-8300C version with color CCD detector (with Bayer mask), capable of single-shot color images.

G2 camera models with Interline Transfer CCD detectors:

Model	G2-2000	G2-2000C	G2-4000	G2-4000C
CCD sensor	KAI-2020	KAI-2020	KAI-4022	KAI-4022
Resolution	1604 × 1204	1604 × 1204	2056 × 2062	2056 × 2062
Pixel size	7.4 × 7.4 µm	7.4 × 7.4 µm	7.4 × 7.4 µm	7.4 × 7.4 µm
Sensor size	11.9 × 8.9	11.9 × 8.9	15.2 × 15.2	15.2 × 15.2
ABG	Yes	Yes	Yes	Yes
Color mask	No	Yes	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 G2 cameras depends on the particular camera model.

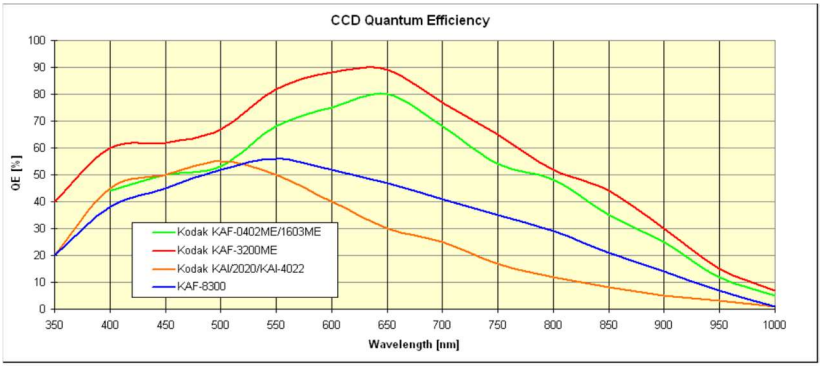


Figure 5: Quantum efficiency of OnSemi CCD detectors used in G2 cameras

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.

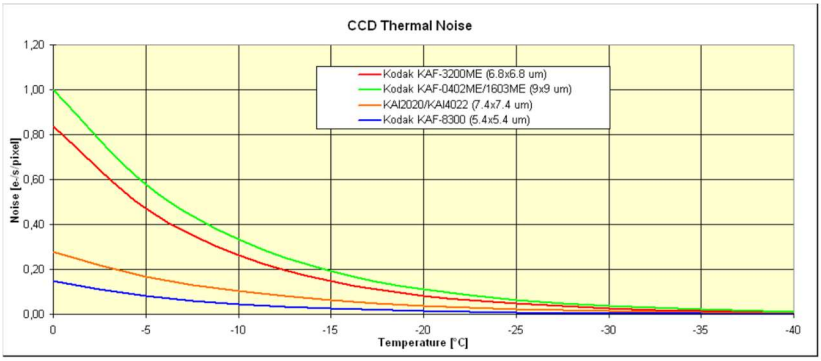


Figure 6: Dark current of some OnSemi CCD detectors, used in G2 cameras

Model G2-0400

G2-0400 model uses 0.4 MPx CCD OnSemi KAF-0402ME.

Resolution	768 × 512 pixels
Pixel size	9 × 9 µm
Imaging area	6.9 × 4.6 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 G2-1600

G2-1600 model uses 1.6 MPx CCD OnSemi KAF-1603ME.

Resolution	1536 × 1024 pixels
Pixel size	9 × 9 µm
Imaging area	13.8 × 9.2 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 G2-3200

G2-3200 model uses 3.2 MPx CCD OnSemi KAF-3200ME.

Resolution	2184 × 1472 pixels
Pixel size	6.8 × 6.8 µm
Imaging area	14.9 × 10.0 mm
Full well capacity	Approx. 55 000 e^-
Output node capacity	Approx. 110 000 e^-
Dark current	0.8 e-/s/pixel at 0°C
Dark signal doubling	6.0 °C

Model G2-8300

G2-8300 model uses 8 MPx CCD OnSemi KAF-8300.

Resolution	3358 × 2536 pixels
Pixel size	5.4 × 5.4 µm
Imaging area	18.1 × 13.7 mm
Full well capacity	Approx. 25 000 e^-

Output node capacity	Approx. 55 000 e^-
Dark current	0.15 e-/s/pixel at 0°C
Dark signal doubling	5.8 °C

KAF-8300 CCD detector with color (Bayer) mask can be used in the G2-8300C camera.

Model G2-2000

G2-2000 model uses 2 MPx CCD MPx OnSemi KAI-2020.

Resolution	1604 × 1204 pixels
Pixel size	7.4 × 7.4 µm
Imaging area	11.9 × 8.9 mm
Full well capacity	Approx. 40 000 e^-
Output node capacity	Approx. 80 000 e^-
Dark current	0.3 e-/s/pixel at 0°C
Dark signal doubling	7.0 °C

KAI-2020 CCD detector with color (Bayer) mask can be used in the G2-2000C camera.

Model G2-4000

G2-4000 model uses 4 MPx CCD MPx OnSemi KAI-4022.

Resolution	2056 × 2062 pixels
Pixel size	7.4 × 7.4 µm
Imaging area	15.2 × 15.2 mm
Full well capacity	Approx. 40 000 e^-
Output node capacity	Approx. 80 000 e^-
Dark current	0.3 e-/s/pixel at 0°C
Dark signal doubling	7.0 °C

KAI-4022 CCD detector with color (Bayer) mask can be used in the G2-4000C camera.

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 G2-0400

Gain	1.5 e^-/ADU (1×1 binning)
	2.0 e^-/ADU (other binnings)
System read noise	13 e^- RMS (Low noise)
	15 e^- RMS (Preview)
Download time	0.25 s (Low noise)
	0.16 s (Preview)

Model G2-1600

Gain	1.5 e^-/ADU (1×1 binning)
	2.0 e^-/ADU (other binnings)
System read noise	13 e^- RMS (Low noise)
	15 e^- RMS (Preview)
Download time	0.95 s (Low noise)
	0.67 s (Preview)

Model G2-3200

Gain	0.8 e^-/ADU (1×1 binning)
	1.3 e^-/ADU (other binnings)
System read noise	7 e^- RMS (Low noise)
	9 e^- RMS (Preview)
Download time	1.95 s (Low noise)
	1.39 s (Preview)

Model G2-8300

Gain	0.4 e^-/ADU (1×1 binning)
	0.8 e^-/ADU (other binnings)
System read noise	8 e^- RMS (Low noise)
	9 e^- RMS (Preview)
Download time	4.95 s (Low noise)
	3.48 s (Preview)

Model G2-2000

Gain	0.5 e^-/ADU (1×1 binning)
	0.8 e^-/ADU (other binnings)
System read noise	7 e^- RMS (Low noise)
	9 e^- RMS (Preview)
Download time	1.06 s (Low noise)
	0.73 s (Preview)

Model G2-4000

Gain	0.5 e^-/ADU (1×1 binning)
	0.8 e^-/ADU (other binnings)
System read noise	7 e^- RMS (Low noise)
	9 e^- RMS (Preview)

Download time	2.30 s (Low noise)
	1.56 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 the CCD chip up to 50 °C below ambient temperature. The Peltier hot side is cooled by fan. 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.

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.

Figure 7: Back side of the G2 Mark II camera head contains vents for a fan, cooling Peltir 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)
Maximal cooling ΔT	>50 °C below ambient
Regulated cooling ΔT	48 °C below ambient (85% cooling)
Regulation precision	±0.1 °C
Hot side cooling	Forced air cooling (fan)

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
	40 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

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.

G2 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.

Figure 8: 12 V DC/5 A power supply adapter for G2 camera

Mechanical Specifications

Compact and robust camera head measures only 114×114×65 mm (approx. 4.5×4.5×2.6 inches). 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. Integrated mechanical shutter allows streak-free image readout, as well as automatic dark frame exposures, which are necessary for unattended, robotic setups.

Figure 9: Bottom side with connectors of the camera without filter wheel (left) and with internal filter wheel (right)

Camera head with integrated Internal filter wheel is 77.5 mm thick. Filter wheel offers 5 positions for standard 1.25-inch threaded filter cells. A variant of filter wheel with 6 positions for unmounted D26 mm filters is also available.

Internal mechanical shutter	Yes, blade shutter
Shortest exposure time	0.1 s
Longest exposure time	Limited by chip saturation only
Internal filter wheel	5 positions for 1.25” threaded cells or for D31 mm unmounted filters
	6 positions for D26 mm unmounted filters
Head dimensions	114×114×77.5 mm (Internal filter wheel)
	114×114×65 mm (without filter wheel)

Back focal distance	33.5 mm (base of adjustable adapters)
Camera head weight	1.15 kg (with Internal filter wheel)
	1.00 kg (without filter wheel)
	1.70 kg (with “XS” External filter wheel)
	1.95 kg (with “S” External filter wheel)

Filter wheel with 6 positions can cause vignetting (shielding of the detector corners) if large CCD detector is used.

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. M48 threaded adapter back focal distance is 55 mm).

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

When the adjustable adapter base, intended for camera with Internal Filter Wheel, is mounted on camera without filter wheel, the resulting back focal distance is only 21 mm.

Camera with Internal Filter Wheel

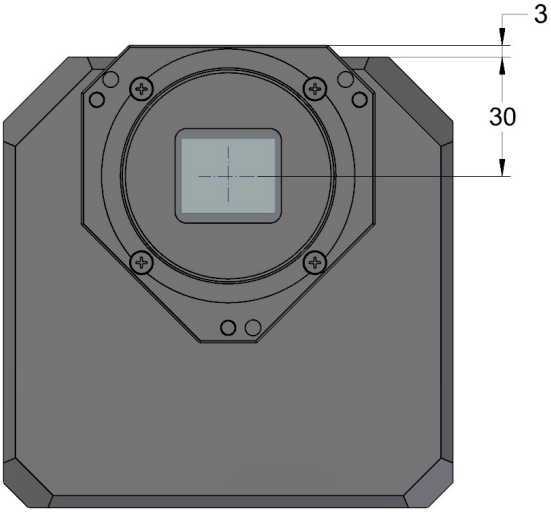


Figure 10: G2 camera head front view dimensions

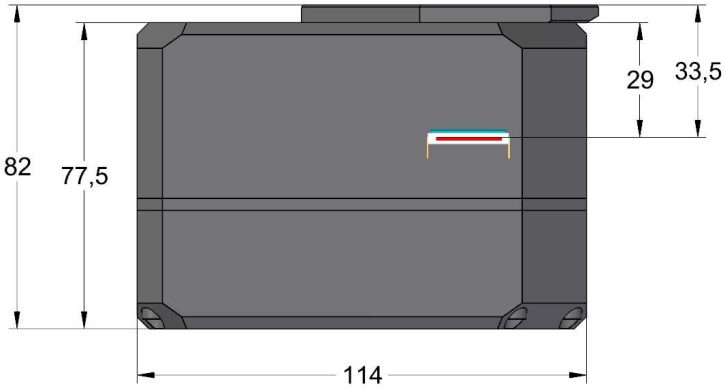


Figure 11: G2 camera head with Internal Filter Wheel side view dimensions

Figure 12: G2 camera head bottom view dimensions

Camera with “XS” External Filter Wheel

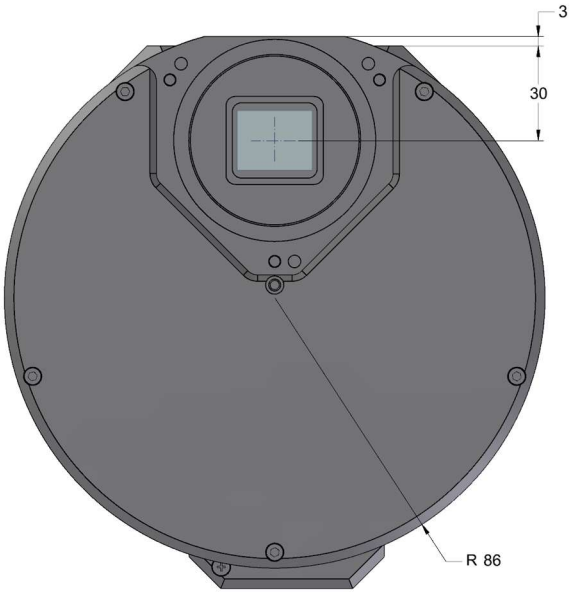


Figure 13: G2 camera head with External filter wheel front view dimensions

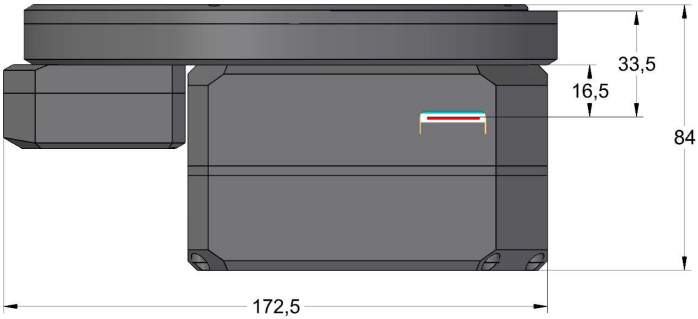


Figure 14: G2 camera head with External filter wheel side view dimensions

Figure 15: G2 camera head with External filter wheel bottom view dimensions

The “S” 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.

Camera without filter wheel

If the camera model, intended for usage with External filter wheel, is used without filter wheel at all, two types of adjustable adapter bases can be used.

When a “thin” adapter base, intended for camera with Internal filter wheel, is used, the back focal distance is only 21 mm.

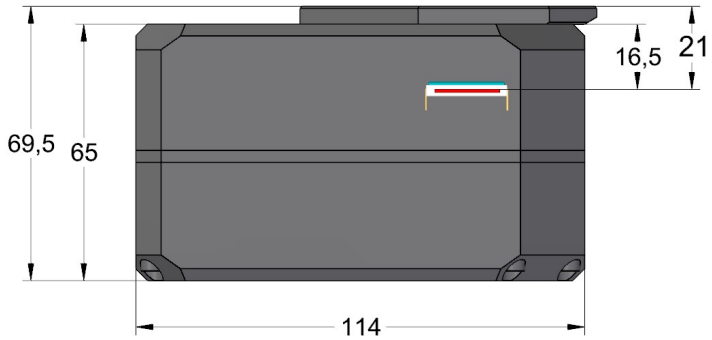


Figure 16: Camera without filter wheel with "thin" adapter base

“Thick” adapter base has the same thickness like the External filter wheel. This means all adapters, attached to this thick base, keep the same 33.5 mm back focal distance like the camera with External filter wheel attached or camera with Internal filter wheel and “thin” adapter base.

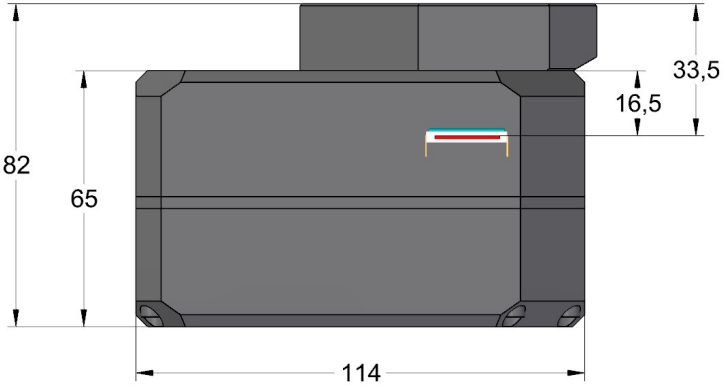


Figure 17: Camera without filter wheel with "thick" adapter base

Optional accessories

Various accessories are offered with G2 Mark II cameras to enhance functionality and help camera integration into imaging setups.

Telescope adapters

Various telescope and lens adapters for the G2 Mark II cameras are offered. Users can choose any adapter according to their needs and other adapters can be ordered separately.

- **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, preserves 44 mm back focal distance.
- **Nikon F bayonet** – standard Nikon F lens adapter, preserves 46.5 mm back focal distance.

Mark II adapters are attached either directly to the External filter wheel front plate or to the adjustable adapter base mounted on the camera head.

Off-Axis Guider Adapter (OAG)

G2 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.

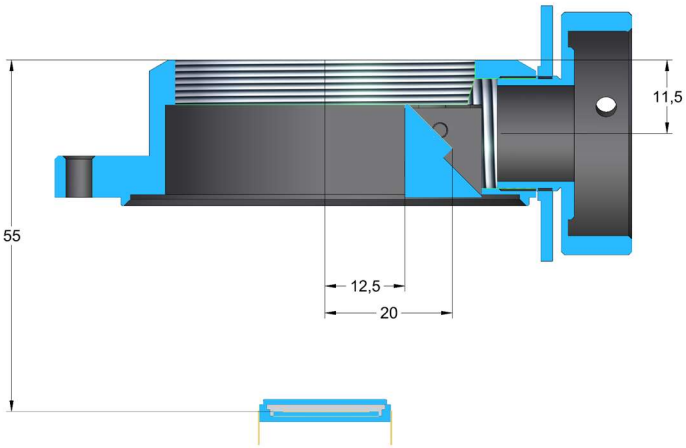


Figure 18: Position of the OAG reflection mirror relative to optical axis

G2-OAG is manufactured in two variants, one with M42×0.75 thread (T-thread) and another with M48×0.75 thread. Both variants are designed to be compatible with external filter wheels and to preserve 55 mm distance from the sensor.

If the OAG has to be used on camera with internal filter wheel, the OAG is mounted to adapter base like any other adapter. Resulting Back focal distance remains the same.

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.

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 G2-OAG.

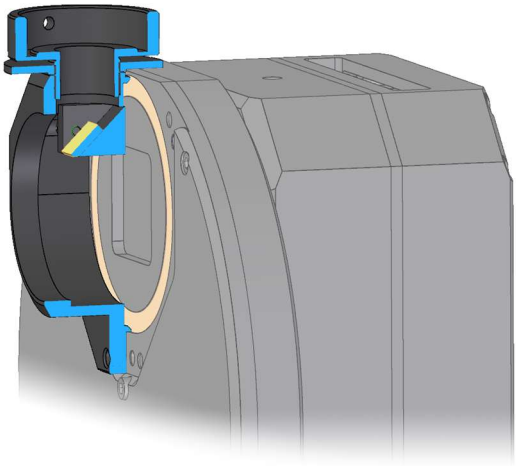


Figure 19: G2-OAG sectional rendering illustrating reflecting mirror

Attaching camera head to telescope mount

G2 camera heads are equipped with “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: G2 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 G2 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 G2 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.

- G2 Mark II adapters are not mounted directly on the camera head. Instead a tilting adapter base, holding the circular spring, is always used.
- 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.

Figure 25: Mark II External filter wheels are already designed to for adjustable telescope adapters

Camera Maintenance

The G2 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 G2 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 G2 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.

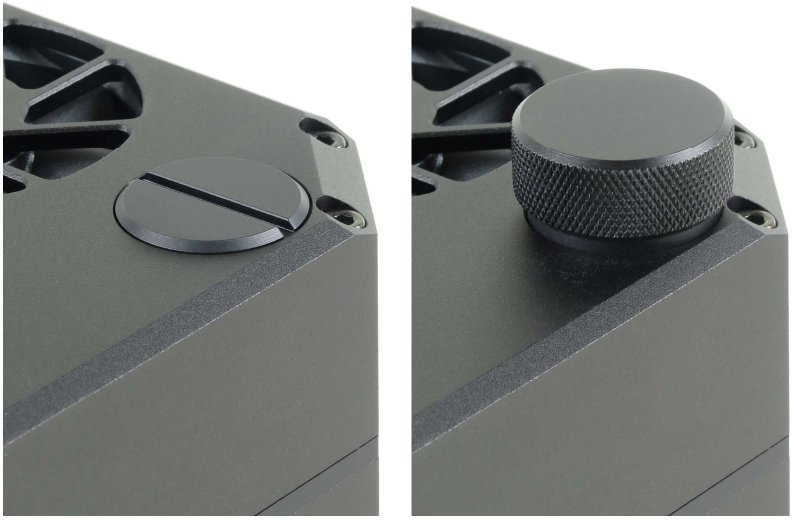


Figure 26: Silica-gel container is accessible from the camera back side

Exchanging the silica-gel

G2 Mark II cameras employ the same desiccant container like the larger G3 and 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 container and the tool-less variant of the container

Changing Filters

It is necessary to open the camera head to change filters or the whole filter wheel. To open the head, unscrew the six bolts holding camera head together.

Opening the camera head

The blade shutter rotates 180° between individual snapshots. Camera cover could be opened only when the shutter is fully closed (covers the CCD). If for instance the camera is unplugged from power adapter while exposing, the shutter remains open. Camera cannot be opened in such case.

Warning:

Shutter can be damaged while removing the camera cover if not in proper position.

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!

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

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.

Warning:

Both pulling and pushing screws, used on the G2 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.

Figure 30: Removing of the adjustable telescope 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.