SWIR InGaAs Camera

Shortwave Infra-Red Sensitive Fast Digital Imager

USER MANUAL

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1. UNPACKING

You should receive:

For the basic camera:

- GEV SWIR camera head
- Power supply with integral power cable
- This manual

For a system:

Items 1-3 above, plus any of the following according to the details of your order:

- Software (e.g. GEV installer, PS Viewer software, DLL files, LabVIEW drivers, etc.)
- Memory stick or DVD containing drivers and the PSL_camera_files directory of configuration data
- Trigger cable
- Network cable
- Water chiller/recirculator and water pipes

Additional items may be supplied as ordered, and should be checked against the delivery note to ensure all items are present.

Please check that all items are in good condition. If not please notify the carriers immediately.

2. OVERVIEW

The SWIR GEV InGaAs camera is a 640 x 512 format cooled shortwave infrared sensitive camera. The camera features a unique image sensor based on Indium Gallium Arsenide technology to provide sensitivity in the 950 nm to 1700 nm waveband. Over this spectral range the sensor has a very high quantum efficiency, of typically greater than 70%, with a peak quantum efficiency of approximately 80% at 1000 nm.

The camera features digitisation of the sensor signal to 14 bits, at 17.9 MHz pixel frequency. This leads to a maximum frame rate, at short integration periods, of over 160 frames per second.

The camera provides a full range of in-PC corrections to process the raw image from the sensor to remove non-uniformities. In each of the three gain modes, the supplied DLL and end user PC software will carry out offset, flatfield, darkcurrent, and defective pixel correction in order to produce a highly uniform calibrated image free of sensor non-uniformities. The darkcurrent correction compensates for variations in integration time, leading to a very low darkcurrent output image under a range of operating conditions.

The camera uses a Gigabit Ethernet (GigE) interface for both image data transmission to the PC and camera control. The interface is GigE Vision compliant (GEV), which provides very reliable high bandwidth image streaming abilities to allow smooth camera operation even at high frame rates. The control is achieved via the RS232 protocol within the GEV interface. Power for the camera is derived from a separate power supply unit. Power (line supply voltage 115V or 230V AC) is fed in via a fused IEC socket on the rear panel

The camera has a standard “C-mount” lens fitting for compatibility with a wide range of lenses and microscope adaptors.

The sensor in this camera is cooled by a single stage thermoelectric peltier cooler with secondary water cooling. This cooling reduces the build-up of thermally generated dark current in the sensor, and allows the camera to integrate with extended integration time to provide very high sensitivity for faint signals. Water cooling provides a very efficient way of removing the heat generated and pumped by the peltier and allows the sensor to be cooled to typically -50°C for minimum darkcurrent and to allow very long exposures.

3. CONNECTING THE SYSTEM TOGETHER

Water Connections

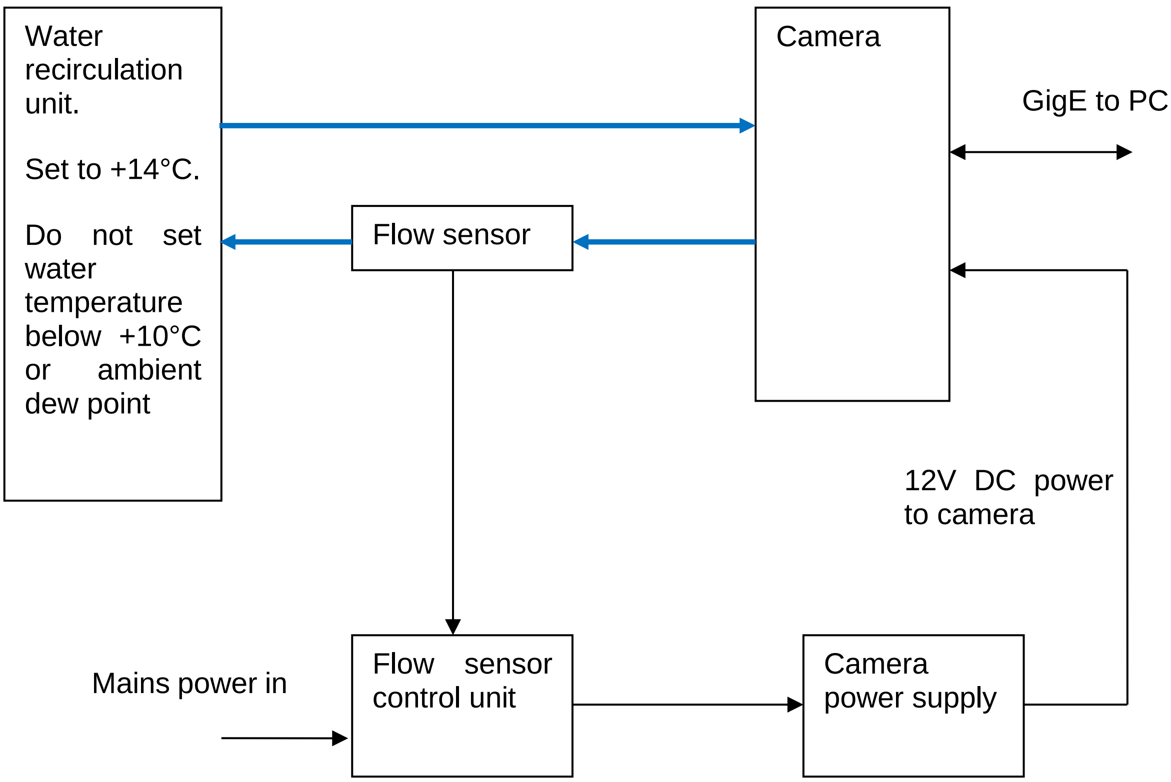
IMPORTANT: Always ensure that cooling water is flowing before power is applied to the camera.

The camera can be cooled either from the mains water supply, or from a recirculation chiller unit. The water should be connected to flow through the camera first, then through the flow sensor unit provided. If using a chiller, a water temperature of +14°C is strongly recommended to avoid the need for antifreeze and to avoid issues with condensation on pipes. Camera corrections are optimised for a water temperature of +14°C.

Photonic Science recommends a flow rate of a minimum of litre per minute for the cooling water, or a pressure of at least 0.5 bar.

A water flow sensor unit is provided, integrated with the camera body. This should be connected in line with the water supply to the camera, as shown in the following diagram, such that the water flows in the direction indicated by the arrow on the flow sensor. The sensor is connected to a control unit that should be connected in line with the IEC lead that powers the camera power supply, see the diagram below. When water is flowing, the green LED will light on the control unit, and mains electricity will be supplied to the camera's power supply. If the water is turned off or drops to an insufficient flow rate, a red LED will light, and the mains power to the camera power supply will be cut.

MAKE SURE THAT COOLING WATER IS FLOWING BEFORE ATTEMPTING TO RUN THE CAMERA, OTHERWISE THE CAMERA WILL NOT OPERATE. When the camera is running and connected to its PC the GigE socket on the rear will light and flash.



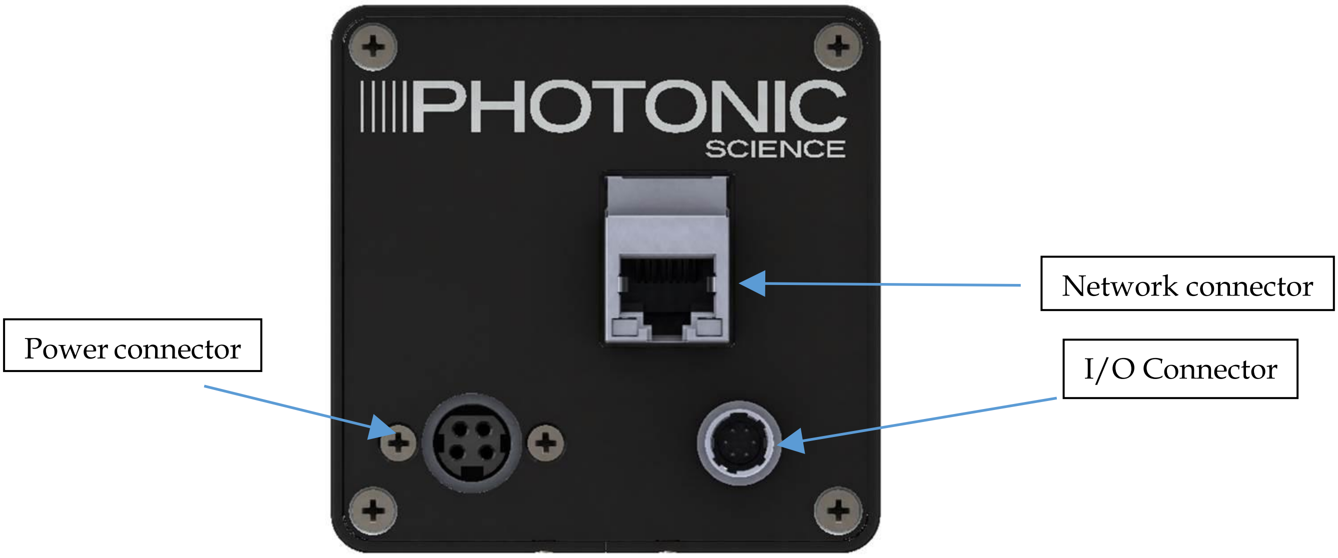
Electrical Connections

Connect the camera head to the power supply with the multiway cable provided as shown above in the water connection schematic.

For Gigabit Ethernet cameras, install the network card in a free expansion slot and connect the camera to the PC with the Cat 5E network cable. Power on the camera before the PC. Follow the instructions in the Quickstart guide.

Turn on the camera by connecting the power supply to the mains. Start the PS Viewer imaging software, and follow the software manual or Quickstart guide.

Diagram 1: Rear Panel



I/O connector:

6 way HR10 panel mounted plug type **HR10-7R-6P(73)**

Mating connector for cable **HR10-7J-6S(73)**

6 way HR10 panel plug	Name
1	GND
2	5V TTL hardware trigger input
3	Do not connect
4	5V TTL exposing output
5	Do not connect
6	Do not connect

When not in use, or when in long-term storage, the camera should be kept in the appropriate environment away from extremes of temperature and humidity and not in any corrosive or hazardous conditions.

4. OPERATION

The operation of the camera is controlled entirely via software. The only manual function is to turn on the camera via the power supply.

If you have purchased only the camera hardware and are writing your own driver, then refer to the DLL and header file (supplied free of charge upon request).

Integration Period

The integration or exposure period of the sensor is user-selectable via software over a very large range. The integration period is defined by a 14 bit number (range 1 to 16384) together with a unit (microseconds, milliseconds, or seconds). Very fine control of integration period is therefore available to the user.

Sensor Gain

The camera offers three settings of sensor gain (high, mid and low) selectable via software. This gain is applied as part of the SWIR sensor's readout circuit and therefore offers better signal to noise performance than any gain applied subsequently. High gain is approximately 40x the low gain setting. High gain provides the lowest readout noise in electrons (approximately 35 electrons RMS) and should be used when the lowest amplitude signals are to be imaged. Low gain provides a very high full well capacity (typically 1.3 million electrons) and so is ideal for imaging very large or bright signals which would saturate the other gain modes. Mid gain mode is often the recommended mode to use, as it provides low noise (approximately 55 electrons RMS) with high full well capacity (100k electrons) and so provides a high dynamic range mode with high sensitivity.

Sub-area Operation

The camera supports the readout of a user-defined sub-area of the SWIR image sensor. This results in only the image data for this rectangular sub-area being transferred to the PC.

The time taken to read out the sensor will be reduced, roughly in proportion to the number of pixels in the final image. With short exposures this allows the camera to operate at higher frame rates. For example, in free running mode with no PC corrections, with full area 640x512 selected a maximum frame rate of 170 frames/second can be achieved. Reducing the sub area to 320 x 256 increases the frame rate to 600 frames/ second.

Trigger Control

This camera operates in software trigger, hardware trigger, and free running modes.

Software Trigger Mode

In software trigger mode, a software-generated trigger command is sent via the GigE interface to the camera head. In response to this trigger, the camera immediately starts integrating, for the duration that had been previously set in software. At the end of the integration period, the sensor reads out the integrated image. Once this readout period is over, the sensor is ready to receive a new trigger again. In between software triggers, the sensor is not integrating: it is “cleaning”, or dumping any acquired signal, in readiness for the receipt of the next trigger. The sensor is operated in Integrate-then-Read (ITR) mode when software triggered, which means that integration and readout are not overlapped, which leads to highest image quality.

Hardware Trigger Mode

In hardware trigger mode the camera accepts a 5V TTL trigger to allow image capture to be synchronised with an external event. On receipt of the trigger, the camera begins a new integration whose duration is set by the previously sent software command. In hardware trigger mode a new trigger may be received and accepted by the camera while the previous image is still being read out from the sensor. This allows, for example, the camera to be triggered at 100 Hz with a software–set integration period of just under 10ms. The sensor is operated in Integrate-then-Read (ITR) mode when software triggered, but this can become Integrate-while-Read (IWR) if the trigger period is shortened to be less than the integration period plus the readout period (approximately 6ms for the sensor full area). Reduced image quality (typically a horizontal timing line artefact) can occur when the sensor is operated IWR.

Free Running Mode

In free running mode the camera is continuously outputting images via the GigE interface, using the current software-set exposure. The sensor starts integrating immediately after transfer of the previous image. Even though the camera is continuously producing images in this mode, note that these will be displayed only if the acquisition system has been set up to continuously acquire and display them. (This is achieved in PS Viewer, for example, by selecting “Preview”, or the RAM sequence capture mode).

In free running mode with exposure times less than the readout time (which is approximately 6ms for full area operation), the camera’s frame rate will be at a fixed maximum of approximately 170 frames/second. As the exposure time is increased, the camera’s frame rate will reduce as the reciprocal of the exposure time (to give e.g. 100 frames/second at 10ms exposure time).

The sensor is operated in Integrate-while-Read (IWR) mode when in freerunning mode. To avoid timing line artefacts, operate with an integration period of longer than the readout period (approximately 6ms for the sensor full area).

5. IN-PC IMAGE CORRECTIONS

The provided software provides a comprehensive range of image corrections to enhance the raw image quality from the sensor. The corrections available are as follows:

Offset correction: Enabling this function sets the camera pedestal (image amplitude at short exposure time in darkness) to a value of 5000 in each gain mode. This reduces fixed pattern structure in the image due to pixel to pixel offset variations. In this camera type enabling offset correction also enables linearity correction and flatfield correction. This function is an “all-in-one” multipoint correction that both removes non-uniformities in darkness and removes the pixel to pixel responsivity variations when illuminated, to result in a uniform image when viewing a uniform scene.

Dark current subtraction: enabling this feature causes the thermally generated dark current signal within the sensor to be subtracted from the image, resulting in a reduction in fixed graininess on longer exposure images. At a controlled sensor temperature of -50°C the dark current in the sensor will be significant in exposures over approximately 100ms, and so dark current correction is vital to remove the fixed grain offset that would otherwise be superimposed on the captured image.

Flat field correction: This function is integrated in the offset correction, and so it is not necessary to enable this correction when offset correction is enabled.

Bright pixel correction: enabling this feature causes those pixels that are identified in an internally stored defective pixel map to be replaced by an average of their neighbours.

6. MAXIMISING IMAGE QUALITY

The GEV SWIR camera is capable of producing very high quality images. To obtain the best quality, we recommend the following:

1. **Ensure that the image does not saturate**

If the image is allowed to saturate, through the use of long integration period and/or high light intensity, then the image pixel values may distort. To avoid these effects, always operate with a maximum signal level less than approximately 60000 digital numbers (ADU), or select a lower gain mode.

2. **Operate with in-camera post-processing corrections turned on**

The post processing corrections provided within the camera will improve image quality and should always be enabled. Select Offset, Bright Pixel, and Darkcurrent corrections. See 7 below for more details.

3. **Operate in Integrate-then-Read mode rather than Integrate-while-Read**

In software triggered mode the sensor is always operated in Integrate-then-Read mode, which provides highest performance. The in-camera corrections are optimised for the ITR modes. In the other trigger modes the sensor is operated in either Integrate-while-Read mode or Integrate-then-Read, depending on integration time. IWR mode can result in image artefacts such a timing line, and pedestal and image texture changes with integration time. For best image quality, choose the integration period in your selected mode so as to avoid IWR mode. The trigger mode section earlier in this manual describes the way to do this.

4. **Also use additional background subtraction in external software if necessary**

In some conditions (very low signal levels, very long exposures, IWR mode) image quality may be enhanced by applying background subtraction to the acquired images, in addition to the in-camera post-processing corrections of Offset, Flat Field, Bright Pixel, and Darkcurrent. If running the camera with the PSEL DLL or PS Viewer software then the features and functions are provided to acquire background images and then automatically subtract these from future acquisitions.

5. **Operate in mid or high gain modes**

The in-PC corrections are optimised for long exposures (up to approx. 2 seconds in high gain mode and up to 10 seconds in mid gain mode. We recommend mid gain mode for most applications as it combines both low noise and high dynamic range.

6. **Operate with a water temperature of +14°C**

In-PC corrections have been optimised for a water temperature of +14°C. This is especially important when very long exposure times (up to ten seconds) are being used.

7. SPECIFICATION

(See camera test data sheet for camera specific performance)

Pixel Resolution: 640 x 512

Input Pixel Size: 15 microns square

Spectral Response: 950 nm to 1700 nm

Peak quantum efficiency: Approximately 80% at 1000 nm

Typical quantum efficiency: > 70%, 950 nm to 1700 nm

Grey Scale Resolution: 16384 grey levels (14 bits)

Pixel frequency: 18 MHz

Sensor: 3 gain modes, approximately 50:1 range

Exposure Time: User selectable from < 25 µs to ten seconds

Readout Philosophy: Correlated double sampling with fast 14-bit A/D converter

In-PC corrections: offset, flatfield, linearity, darkcurrent, defective pixel

Sensor temperature: approximately -50°C +14°C water

Control: Gigabit Ethernet Vision

Lens/Microscope fitting; C-mount

Power Requirements: 110 or 230V ac 50/60Hz less than 50W

Weight: <1 kg

Operating Environment: Temperature - Storage: < 50 °C

Operation: 0 to +50°C

Humidity - 0-80% RH non-condensing

Revision status

Revision number	Date	Changed by	Approved by	Status	Details
Issue 1	10.6.20	SJY	SJY	Super-ceded	Latest V2 WC version, water cooled, PC corrections, based on V3 WC 20200421 Issue 1
Issue 2	2.7.21	SJY	SJY	Current	Updated power connector