gRAY

Instruction Manual

for

gRAY Housed Detectors

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CONTENT

Preface

All gRAY laser power detectors are of high quality. To maximize benefit from their outstanding performance, some precautions must be taken during storage, assembly and packaging. Therefore, please read the following instructions carefully.

Applicability

This document is applicable to all gRAY housed detectors supplied by greenTEG AG. This document is specifically applicable to gRAY C05-HC, gRAY C10-HC, gRAY C50-HW and C100-HW.

Precautions

⚠ gRAY laser power detectors have long lifetimes when used under normal operating conditions. greenTEG will repair or replace at its discretion, any gRAY detector which proves to be defective within a one year period or purchase, except in the case of product misuse. Any unauthorized alteration or repair of the product is not covered. greenTEG is not liable for consequential damages of any kind.

⚠ The user must avoid any misuse that could cause damage to the detector. Misuse includes, but is not limited to, laser exposure outside greenTEG's published specifications, high voltage exposure outside greenTEG's specifications, physical damage due to improper handling and exposure to harsh environments. Harsh environments include, but are not limited to, excessive temperature, vibration, humidity, chemicals or surface contaminants, exposure to flame, solvents or water, and connection to improper electrical voltage.

⚠ greenTEG products are not authorized for use as critical components in life support devices/systems or in any military application without the express written approval of a board member at greenTEG.

For support regarding any of the above points, please contact us at:

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1. SHORT USER GUIDE

About the gRAY housed detectors

The gRAY housed detectors are specifically designed to fulfill the needs of OEM manufacturers. Their robust design allows long lifetime and the full mechanical and electronic integration enables easy system integration.
All housed detectors contain a gRAY Type C detector module, which is a thermopile detector. Thermal detection of radiation power permits the detection of light throughout a broad wavelength spectrum (UV to MIR).
gRAY housed detectors are ideal for measuring CW lasers up to 50 W. The output signal is an amplified and normalized analog voltage, facilitating the straightforward conversion from voltage to power.

C05-HC and C10-HC

C50-HW and C100-HW

Figure 1:
gRAY housed detectors. All detectors are electrically and thermally integrated for simpler handling. The C50-HW and C100-HW have connectors for a water cooling circuit.

Prepare your measurement

- Mount the detector onto a post or other holder. To ensure sufficient cooling, an additional heat sink is recommended for the detector C10-HC.
- Procure a voltmeter as a read-out device.
- Procure a voltage source for the amplifier supply voltage.

How to record the detector signal

Contact the detector electrically by connecting the wires as follows:

Red wire:	DC voltage supply 12-24 V
Black wire:	Ground (shared between voltage supply and signal out)
White wire:	Detector signal out (0-10V)

Provide the amplifier with the supply voltage and record the analog voltage signal U with your read-out device while the detector is illuminated.

⚠ Never apply a power density higher than 1.5 kW/cm^2 to the detector coating as this will damage the absorber!

How to calculate the incident power

The power of the laser incident to the detector surface is proportional to the voltage output of the detector. Its unit is W, and it is calculated using the following formula:

$$\Phi = U / Z \qquad [W]$$

where U is the detector output voltage, in V; and
Z is the radiant sensitivity of the detector, in V/W.

2. THERMAL INTEGRATION OF THE DETECTOR

This section describes the recommended mounting methods for the gRAY detectors. When measuring with a thermal detector, any thermal influence from the environment will cause background signals besides the actual radiation signal. If the sensor temperature is considerably higher than the room temperature, conductive heat flow occurs, inducing an additional signal at the sensor. Further, the sensitivity Z of the sensor depends on the detector temperature (see Fig. 2). The change of Z needs to be taken into account when converting the output voltage into power.

Therefore, in order to obtain reliable results, heating of the detector module needs to be avoided. This is achieved by providing passive or active cooling to keep the module temperature close to room temperature and stable throughout the measurement.

The method of thermal stabilization depends on the incident power expected during the measurement. Use the following table as guideline for selecting the thermal stabilizer.

Incident power on detector	Thermal stabilizer (example)
<1 W	gRAY housing is sufficient
<5 W	Passive heat sink e.g. 5cm x 5cm x 2.5cm (thermal resistance <5 K/W)
<20 W	Passive heat sink e.g. 10cm x 10cm x 4cm (thermal resistance <2.5 K/W)
<50 W	Water cooling

2.1. Mounting the detector on a heat sink

1. If an element of the laser system, where the detector will be integrated into, has features or thermal resistance as stated in the table above, you can mount the detector directly onto it.
   Please note that these values are guidelines – other important factors as the room temperature or air convection need to be taken into account for each system individually.
2. Ensure that the surface of the stabilizer is flat, dry, and free of dust and grease. Clean the backside of the detector with ethanol or isopropanol.

   ⚠ Do not use acids or bases for cleaning the detector!

   When mounting the detector onto a heat sink, it is recommended to apply a heat conductive paste between the detector and the heat sink to ensure a good thermal coupling. Air gaps are thermally insulating and greatly reduce the cooling efficiency of the heat sink.

2.2. Active cooling with water

1. Use polymer pressure tubes (e.g. PE) to connect your cooling circuit to the two water fitting plugs.
2. In order to avoid residues, a water filter is recommended in the cooling circuit.

   ⚠ Only use pure water and no glycol or similar products to avoid corrosion!

1. The water temperature must be maintained at temperatures between 15 and 25 °C to ensure accurate measurement results based on the calibration at 20 °C. Temperature changes on the time scale of minutes can be misinterpreted as power fluctuations and need to be avoided.
2. Maintain a constant water flow rate of 1.5 l/min. This can be controlled by a valve or pump settings. Notice that a higher flow rate might cause noise on the output signal of the detector.

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3. DATA ANALYSIS

This section contains the basic analysis methods needed to interpret data from the gRAY laser power detectors.

3.1. Laser power measurement

The power of the laser incident to the detector surface is proportional to the voltage output of the detector. Its unit is W, and it is calculated using the following formula:

$$\Phi = U / Z \qquad [W]$$

where U is the detector output voltage, in V; and
Z is the radiant sensitivity of the detector, in V/W.

The value of Z is provided as a calibration constant with the detector. For the gRAY housed detectors, the values are:

C05-HC:	Z = 2 V/W
C10-HC:	Z = 1 V/W
C50-HW:	Z = 0.2 V/W
C100-HW:	Z = 0.1 V/W

3.2. Temperature corrected sensitivity

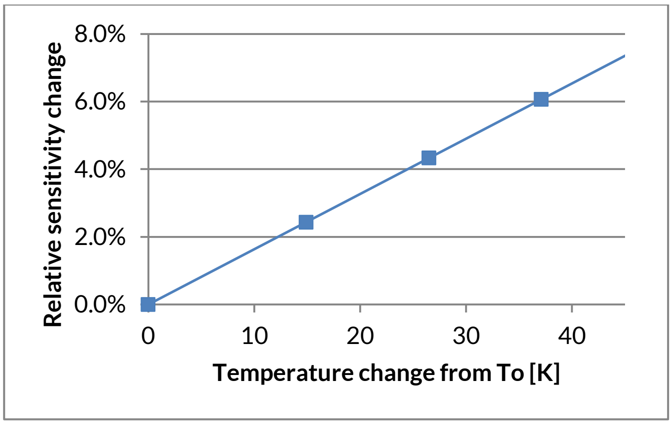


Figure 2:
Dependence of sensitivity Z on detector temperature T. Plotted is the relative change of Z as a function of the temperature difference to the calibration temperature To=20 °C.

The sensitivity of the gRAY laser power detectors depends on the operation temperature. The temperature-corrected sensitivity of the detector is calculated using the following formula:

$$Z = Zo + (T - To) \cdot Zc \qquad [mV/W]$$

where Zo is the radiant sensitivity at calibration temperature and calibration wavelength, in V/W;
Zc is the linear correction factor for the radiant sensitivity, in (V/W)/°C;
To is the calibration temperature (typically 20 °C), in °C; and
T is the heat sink temperature level, in °C.

Values Zo, Zc, and To are detector specific calibration values. T can be measured with a thermocouple mounted onto the heat sink; preferably close to the sensor.

Figure 2 shows the temperature dependence of the sensitivity Z. Typically, the housed gRAY detectors show a highly linear increase of Z by 0.175 % per K.

3.3. Wavelength corrected sensitivity

The coating on the detector surface determines the percentage of incoming light that is absorbed. The gRAY absorber coating is an inorganic absorber designed for high damage threshold and broad band absorption characteristics.

All gRAY detectors are calibrated at 1064 nm. If a different measurement wavelength is used, the sensitivity should be corrected according to the wavelength specific absorption coefficient. The absorption spectrum is plotted in Figure 3 as absolute data. Figure 4 shows the same data but normalized to the absorption value at 1064 nm.

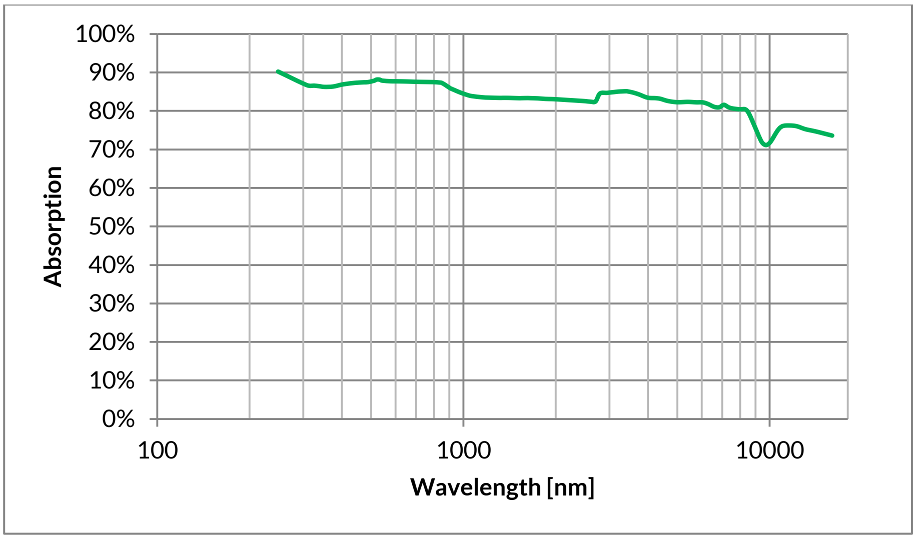


Figure 3: Absorption spectrum of gRAY broad band absorber coating.

In order to obtain the exact value for Z at a specific wavelength, the provided calibration value for Zo needs to be corrected by the respective correction factor C. The latter can be read from Figure 4.

As an example, the sensitivity of the C05-HC is Zo = 2 V/W at 1064 nm. If the measurement is carried out at 10.6 um, the following correction needs to be carried out:

$Z = Zo \cdot C = 2\ V/W \cdot 89.3\% = 1.79\ V/W.$

If you need exact values for a specific wavelength, contact us.

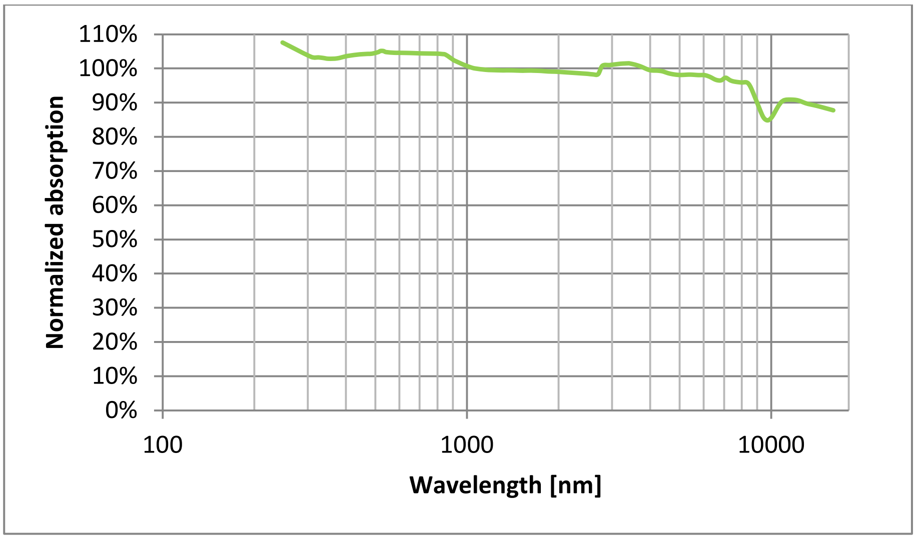


Figure 4:
Absorption spectrum of gRAY broad band absorber normalized to absorption value at the calibration wavelength of 1064 nm.

4. MAINTENANCE OF THE DETECTOR

4.1. Cleaning the detector

Cleaning is only necessary before mounting the detector onto a heat sink. Clean the detector backside surface with ethanol or isopropanol. Once the detector is mounted, no further cleaning is necessary. Never touch the absorber surface and do not bring it in contact with any chemical agents.

4.2. Storage

Store the unused gRAY laser power detectors at ambient temperatures in a clean and dry place. In order to protect the absorber surface, put it back into the shipping package (wrap the detector in the polymer foam).

4.3. Recalibration

greenTEG recommends a yearly recalibration to ensure accurate measurement results. This calibration can be carried out at greenTEG or at any certified calibration institute.

5. GENERAL CONSIDERATIONS

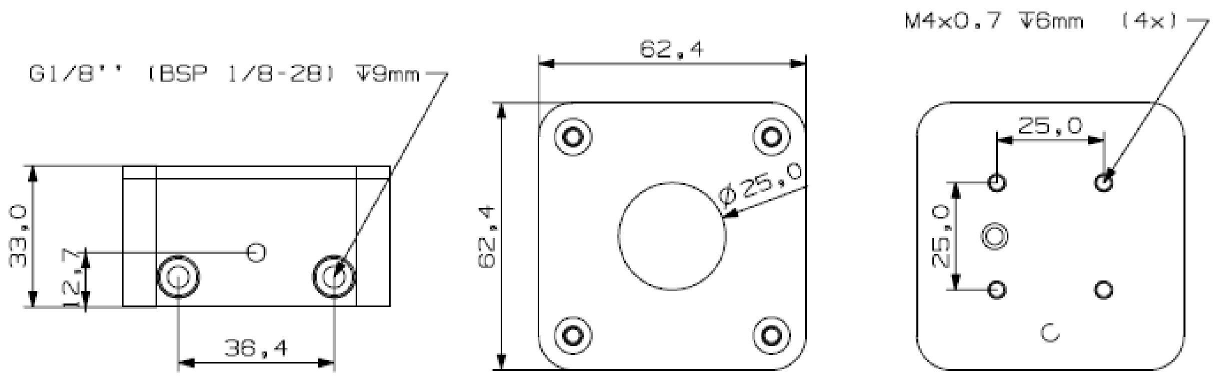
5.1. Electromagnetic interference

Due to the low electrical resistance of the detector and its aluminum packaging, electromagnetic interference is usually not of concern. If electromagnetic interference is observed within an application, the typical countermeasures (e.g. shielded cables, proper grounding) should be taken.

5.2. Application in temperatures outside of the operating temperature range

The operation temperature range of the gRAY laser power detectors is stated in the respective data sheets. Outside of this range, thermal effects might be non-linear and too large to be compensated for.

6. TECHNICAL DRAWINGS



LIST OF SYMBOLS

Name	Symbol	Unit
Laser power	Φ	W
Detector output voltage (measured)	U	V
Temperature corrected radiant sensitivity	Z	V/W
Radiant sensitivity at calibration temperature	Zo	V/W
Temperature correction factor for radiant sensitivity	Zc	(V/W)/°C
Spectral correction factor for radiant sensitivity	C	%
Absolute thermal resistance	K	K/W
Electrical resistance	R	Ohm
Temperature of the cold side	Tc	°C
Calibration temperature	To	°C
Detector temperature	T	°C
Detector area	A	m^2
Detector thickness	d	µm

Disclaimer

The above given restrictions, recommendations, materials, etc. do not cover all possible cases and items. This document is not to be considered to be complete and it is subject to change without prior notice.

Revision History

Date	Revision	Changes
09. March 2015	1.0	Initial revision
15. June 2015	1.1	Adaptation to C100-HW