gRAY

Instruction Manual

for

gRAY Sensor Components

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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 sensor components supplied by greenTEG AG. This document is specifically applicable to gRAY B01-SC and gRAY B05-SC.

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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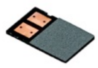
1. SHORT USER GUIDE

About the gRAY sensor components

The gRAY sensor components are the smallest and most basic detectors that greenTEG offers. With these detectors, the user has the most freedom in both electrical and thermal system design according to his/her needs.
All gRAY sensor components are thermopile detectors. Thermal detection of radiation power permits the detection of light across a broad wavelength spectrum (UV to MIR).
The gRAY sensor components are especially suitable for integration into limited space. Also, use as a sensing element in power meters is possible. As an option, the output signal can be amplified and normalized by a separate voltage amplifier unit, which facilitates the straightforward conversion from voltage to power.

B01-SC



B05-SC

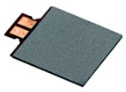


Figure 1: gRAY sensor components. Both mechanical and electrical integration can be freely chosen. The electrical connection is done through solder pads.

Prepare your measurement

- Mount the detector onto a post or other holder for mechanical stability. To ensure a sufficient cooling, it is recommended to mount the sensor onto a heat sink. You can either glue the sensor onto a heat sink or solder it onto a metal core PCB (more details on mounting option are given below).
- Connect the detector electrically by soldering wires to the solder pads of the detector or establishing a connection to the pads on your PCB.
- Procure a voltmeter as a read-out device.
- *Optional:* When used with a voltage amplifier, procure a voltage source for the amplifier supply voltage.

How to record the detector signal

Hook up the detector electrically by connecting the two wires to your voltmeter and record the analog voltage signal U while illuminating the detector.

⚠ 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 mV/W.

2. MOUNTING OF THE DETECTOR

In order to get meaningful measurement data, the gRAY detector has to be mounted with adequate mounting substances. Adequate mounting substances feature high thermal conductivity and low thickness. Three types of mounting substance are suitable: thermally conductive tape, thermally conductive glue and soldering.
greenTEG provides product recommendations for each of these three categories. The mounting substance should be chosen based on the measurement setup.

Thermally conductive tape

Thermally conductive tape should be used for experiments where quick sett-up is first priority and the thermal coupling is of secondary importance.
Clean the surface of interest, and apply the tape to the backside of the sensor. Mount the sensor onto the surface by applying gentle pressure to establish adhesion. Use a force below 2 kg/cm^2. Use some protective layer (e.g. thin polymer foil) for protection of the absorber coating when applying pressure.
Product recommendation: http://www.whayueb.com.tw/en/FCT-730_Glass.php#.VPhcbi5BFsk

Thermally conductive glue

Thermally conductive glue is suitable for applications where additional mechanical stability is required and a good thermal contact is important. It ensures a strong thermal coupling and adapts to surface inhomogeneities.
Clean the surface of your heat sink and spread a thin layer of thermal glue onto the backside of the sensor. Then press the sensor onto the surface and follow the curing instructions of the glue. Use a force below 2 kg/cm^2. Use some protective layer (e.g. thin polymer foil) for protection of the absorber coating when applying pressure.
Product recommendation: http://shop.greenteg.com/shop/accessories/gskin-25/

Soldering

To ensure both good thermal and electric contact, the sensor can be integrated as a SMD component onto a metal core PCB. The sensor comes with a Cu-package on the bottom side, which enables a reflow solder process.
Prepare a metal core PCB which contains the footprint of the sensor component (see drawing in section 7). For enhanced solderability, it is recommended to pre-tin the two solder pads of the detector before the reflow process. Spread a ca. 120 um thick layer of low temperature solder paste onto your predefined PCB footprints. Place the sensor component on top and cure the solder as described in the manual. The reflow temperature should not exceed 180 °C. Use some protective layer (e.g. thin polymer foil) for protection of the absorber coating when applying pressure. Remove the coating before placing the detector inside the oven.
Product recommendation: http://www.chipquik.com/datasheets/SMDLTLFP250T3.pdf

3. 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 of the environment causes additional background noise 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. Furthermore, the sensitivity Z of the sensor depends on the detector temperature (see Fig. 3). 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	Heat sink (e.g. aluminum block) of 25 cm^3
<5 W	Passive heat sink e.g. 5cm x 5cm x 2.5cm (thermal resistance <5 K/W)

3.1. 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 detector backside surface with ethanol or isopropanol and mount the detector on the thermal stabilizer as explained in section 2.

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

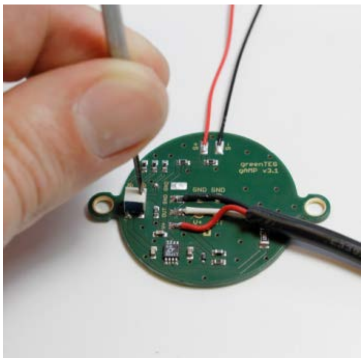
4. USE WITH gRAY AMPLIFIER (AMP 2050)

We optionally supply a voltage amplifier with our gRAY detectors. Depending on the power range you intend to read-out, the basic gain will be adjusted by us. Fine tuning needs to be done inside your system, when the calibration is carried out.

Figure 2 shows, how the amplifier is wired. The two wires on the top of the image are the connections to the detector (red: Out +, black: Out -).
The read-out requires three wires for the voltage supply of the amplifier and the amplified signal. Solder the wires to the pads in the center of the circuit board (see Fig. 2). The color code is 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 illuminating the detector.



It is convenient to adjust the amplifier gain to such a value, that the conversion from voltage to power gets straightforward e.g. 1 V/W. You therefore might want to adjust the amplifier gain accordingly while illuminating the detector with a known power. Turn the screw of the trimmer until the desired conversion factor is reached.

For robust integration into your system, you can mount the amplifier with two screws. Use the two holes at the sides of the amplifier.

Figure 2: gRAY AMP 2050 with electrical connections. By turning the screw of the trimmer, the amplifier gain can be adjusted.

5. DATA ANALYSIS

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

5.1. Laser 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 mV/W.

The value of Z should be determined with a reference sensor after mechanical integration. For the gRAY sensor components, typical values are:

B01-SC: Z = 100 mV/W
B05-SC: Z = 100 mV/W

5.2. Temperature corrected sensitivity

The sensitivity of the gRAY laser power detectors depends on the temperature level at which they are used. 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 mV/W;
Zc is the linear correction factor for the radiant sensitivity, in (mV/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 aluminum plate on which the sensor is mounted.

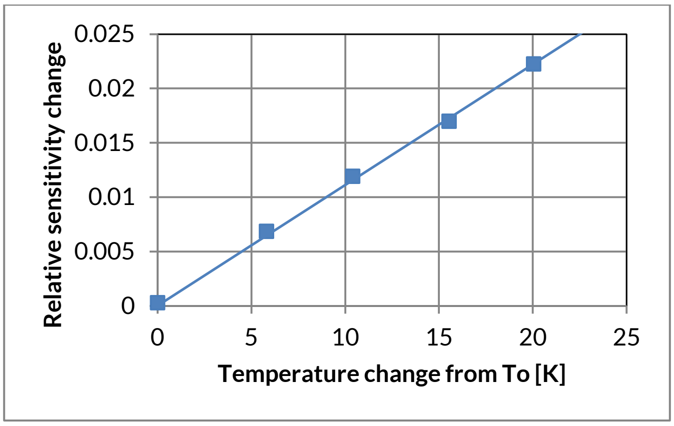


Figure 3: Dependence of sensitivity Z on detector temperature T. Plotted is the relative change of Z as a function of the temperature difference to the calibration temperature To=20 °C.

Figure 3 shows the temperature dependence of the sensitivity Z for a sensor component. Typically, the gRAY sensor components show a highly linear increase of Z by 0.125 % per K.

5.3. 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. Although the spectral absorption is designed to be flat throughout the wavelength range from UV to MIR, a small variation of absorptivity cannot be excluded completely.
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 4 as absolute data. Figure 5 shows the same data but normalized to the absorption value at 1064 nm.

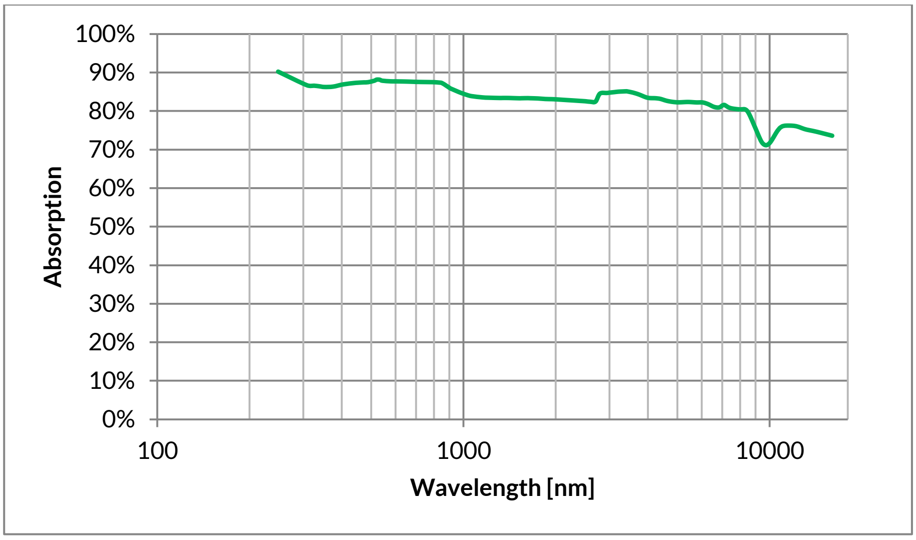


Figure 4: Absorption spectrum of gRAY broad band absorber coating.

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 5.
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.

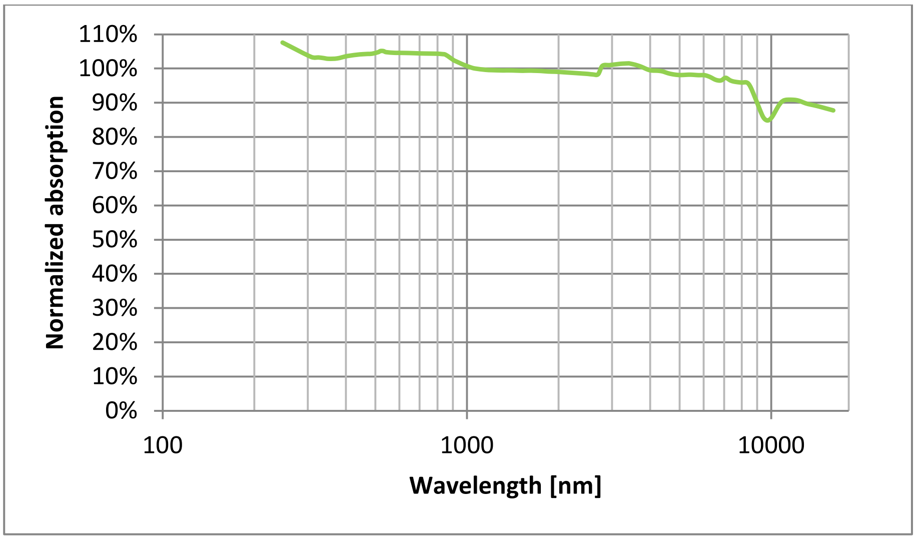


Figure 5: Absorption spectrum of gRAY broad band absorber normalized to absorption value at the calibration wavelength of 1064 nm.

6. MAINTENANCE OF THE DETECTOR

6.1. 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.

6.2. 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).

7. GENERAL CONSIDERATIONS

7.1. Electromagnetic interference

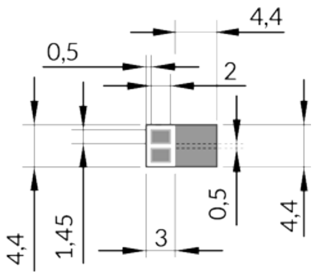
Due to the low electrical resistance of the detector and its aluminum packaging, electromagnetic interference is usually not of concern. If electromagnetic interference is observed within an application, the typical countermeasures (e.g. shielded cables, proper grounding) should be taken.

7.2. Application in temperatures outside of the operating temperature range

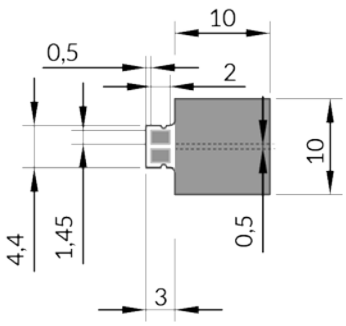
The operation temperature range of the gRAY laser power detectors is stated in the respective data sheets. Outside of this range, thermal effects might be non-linear and too large to be compensated for.

8. TECHINAL DRAWINGS

8.1. B01-SC



8.2. B05-SC



LIST OF SYMBOLS

Name	Symbol	Unit
Laser power	Φ	W
Detector output voltage (measured)	U	V
Temperature corrected radiant sensitivity	Z	mV/W
Radiant sensitivity at calibration temperature	Zo	mV/W
Temperature correction factor for radiant sensitivity	Zc	(mV/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