

gRAY

Instruction Manual

for

gRAY Mounted Detectors



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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 mounted detectors supplied by greenTEG AG. This document is specifically applicable to gRAY B01-SMC, gRAY B05-SMC, gRAY B05-MC and gRAY C50-MC.

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

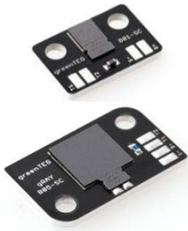
About the gRAY mounted detectors

The gRAY mounted detectors are specifically designed to be integrated into systems where space is limited and electronic signal processing is handled remotely. Their mechanical integration allows for easy mounting onto a mechanical support, which may act as heat sink simultaneously.

All mounted detectors contain gRAY thermopile detectors. Thermal detection of radiation power permits the detection of light across a broad wavelength spectrum (UV to MIR).

gRAY mounted detectors are ideal for integration into power meters or laser systems for industrial or medical applications. As an option, the output signal can be amplified and normalized by a voltage amplifier unit, facilitating the straightforward conversion from voltage to power.

B01-SMC & B05-SMC



B05-MC



C50-MC

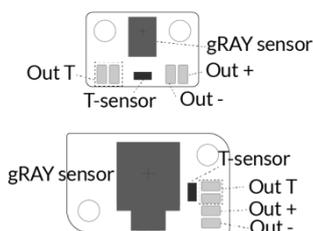


Figure 1: gRAY mounted detectors. The detectors are mechanically integrated for simpler handling. The electrical connection is done through solder pads.

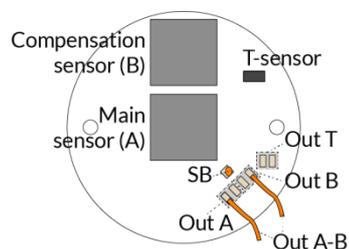
Prepare your measurement

- Connect the detector electrically by soldering wires to the solder pads of the detector (see Fig. 2). For detector B05-MC, the signals of the two sensors can either be read-out individually or differentially. For the differential signal, a solder bridge needs to be formed on the board at position SB in Fig. 2.
- Mount the detector onto a post or similar holder. To ensure sufficient cooling, an additional heat sink is recommended for both detectors.
- Procure a voltmeter as a read-out device.
- *Optional:* When used with temperature sensors, a suitable read-out device needs to be procured.
- *Optional:* When used with a voltage amplifier, procure a voltage source for the amplifier supply voltage.

B01-SMC & B05-SMC



B05-MC



C50-MC

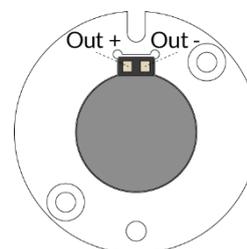


Figure 2: Schematics of gRAY mounted detectors. The respective solder pads are indicated for the two detector models.

How to record the detector signal

Contact the detector electrically by connecting the two wires to your voltmeter and record the analog voltage signal U 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:

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

where U is the detector output voltage, in V; and
Z is the radiant sensitivity of the detector, in mV/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 different 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. 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)
<20 W	Passive heat sink e.g. 10cm x 10cm x 4cm (thermal resistance <2.5 K/W)
<50 W	Water cooling through supplied cooling circuit

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 surface with ethanol or isopropanol and use the screw holes to tighten the detector on the thermal stabilizer.

⚠ 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 good thermal coupling. Air gaps are thermally insulating and



greatly distort the cooling efficiency of the heat sink.

2.2. Active cooling with water

1. Use any water/liquid cooling circuit of your liking and mount the detector onto it as described in Section 2.1.
2. The water/liquid 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.
3. Maintain a constant water/liquid flow rate. This can be controlled by a valve or the pump settings. Notice that flow rates that fluctuate or are too high may cause noise on the output signal of the detector.

3. DATA ANALYSIS

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

3.1. 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:

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

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

Alternatively, the value of Z can be provided as a calibration constant with the detector. For gRAY mounted detectors, typical values are:

B05-MC:	Z = 100 mV/W
C50-MC:	Z = 0.5 mV/W

3.2. Temperature corrected sensitivity

The sensitivity of the gRAY laser power detectors depend on the temperature level at which they are used. The temperature-corrected sensitivity of the detector is calculated using the following formula:

$$Z = Z_0 + (T - T_0) \cdot Z_c \quad [mV/W]$$

where Z₀ is the radiant sensitivity at calibration temperature and calibration wavelength, in mV/W;
Z_c is the linear correction factor for the radiant sensitivity, in (mV/W)/°C;
T₀ is the calibration temperature (typically 20 °C), in °C; and
T is the heat sink temperature level, in °C.

Values Z₀, Z_c, and T₀ are detector specific calibration values. T can either be measured with the integrated T-Sensor (B05-MC) or a thermocouple mounted onto the aluminum plate on which the sensor is mounted (C50-MC).

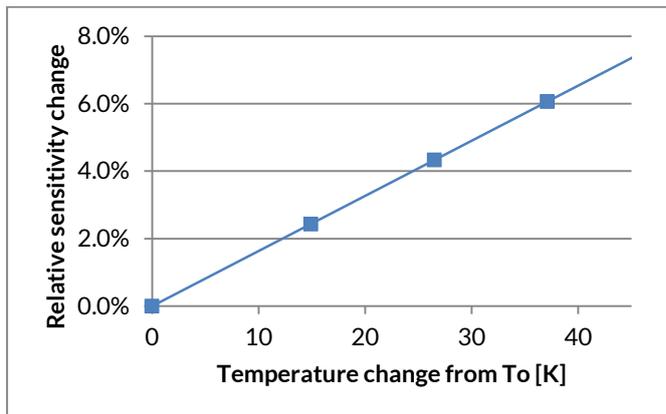


Figure 3: Dependence of sensitivity Z on detector temperature T. Plotted is the relative change of Z as a function of the temperature difference to the calibration temperature $T_0=20\text{ }^\circ\text{C}$.

Figure 3 shows the temperature dependence of the sensitivity Z for the type C detector. Typically, the type C gRAY detectors show a highly linear increase of Z by 0.175 % per K. The type B detectors show a linear dependence with an increase of 0.125 % 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. 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.

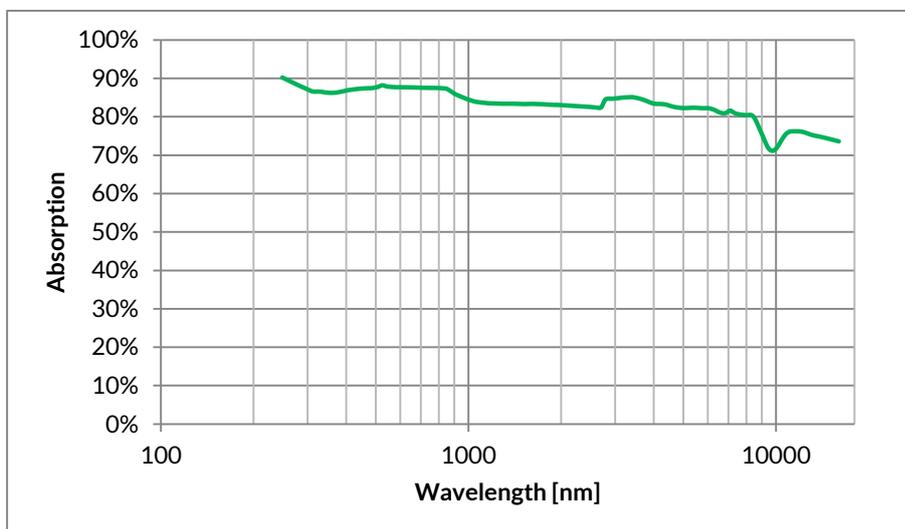


Figure 4: Absorption spectrum of gRAY broad band absorber coating.

In order to obtain the exact value for Z at a specific wavelength, the provided calibration value for Z_0 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 $Z_0 = 2\text{ V/W}$ at 1064 nm. If the measurement is carried out at 10.6 μm , the following correction needs to be carried out:

$$Z = Z_0 \cdot C = 2\text{ V/W} \cdot 89.3\% = 1.79\text{ V/W}.$$

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

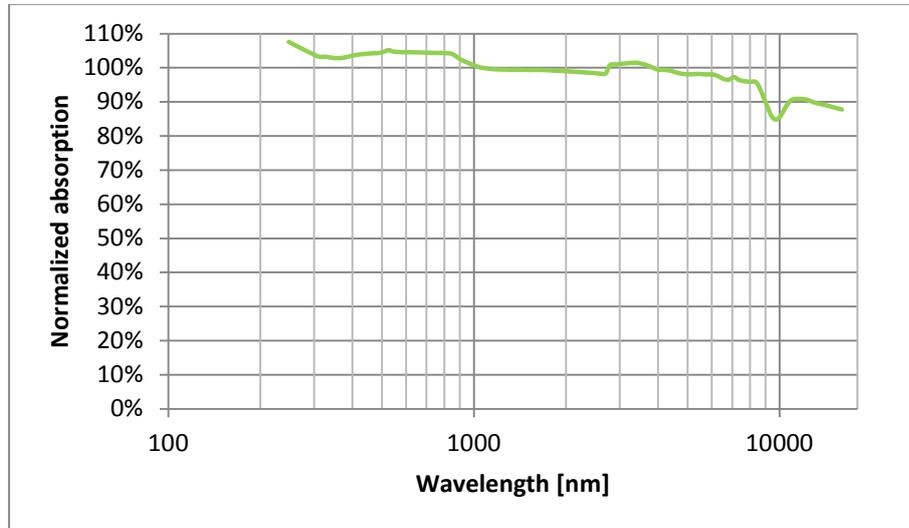


Figure 5: Absorption spectrum of gRAY broad band absorber normalized to absorption value at the calibration wavelength of 1064 nm.

4. USE WITH gRAY AMPLIFIER (AMP 2040, AMP 2050 or AMP 2060)

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.

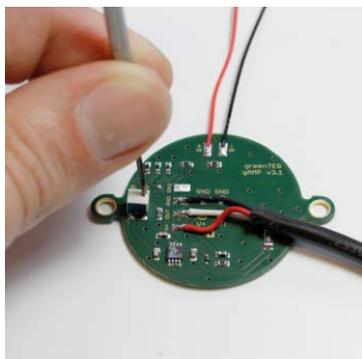
Figure 6 shows, how the amplifier is wired. The two wires on the top of the image are the connections to the detector (red: Out +, black: Out -).

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. 5). 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 6: gRAY AMP with electrical connections. By turning the screw of the trimmer, the amplifier gain can be adjusted.



5. MAINTENANCE OF THE DETECTOR

5.1. 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.

5.2. 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).

5.3. 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.

6. GENERAL CONSIDERATIONS

6.1. Electromagnetic interference

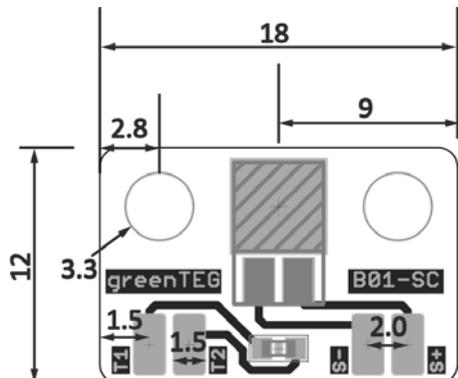
Due to the low electrical resistance of the detector and its aluminum packaging, electromagnetic interference is usually not of concern. If electromagnetic interference is observed within an application, the typical countermeasures (e.g. shielded cables, proper grounding) should be taken.

6.2. Application in temperatures outside of the operating temperature range

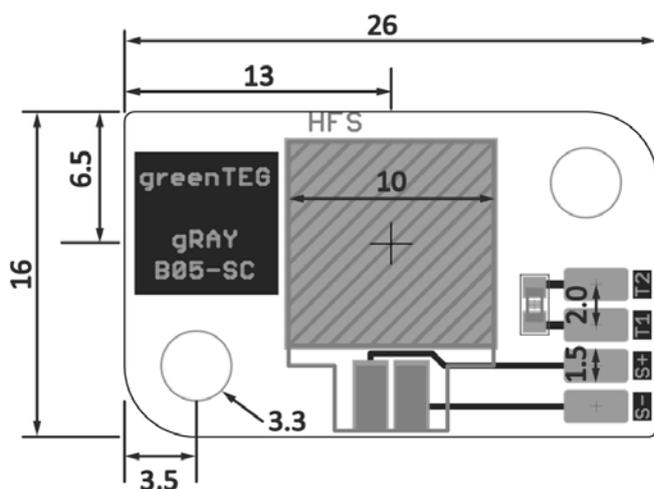
The operation temperature range of the gRAY laser power detectors is stated in the respective data sheets. Outside of this range, thermal effects might be non-linear and too large to be compensated for.

7. TECHINAL DRAWINGS

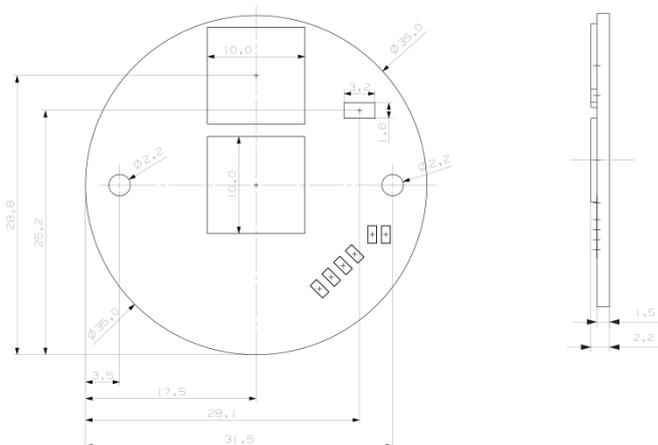
7.1. B01-SMC



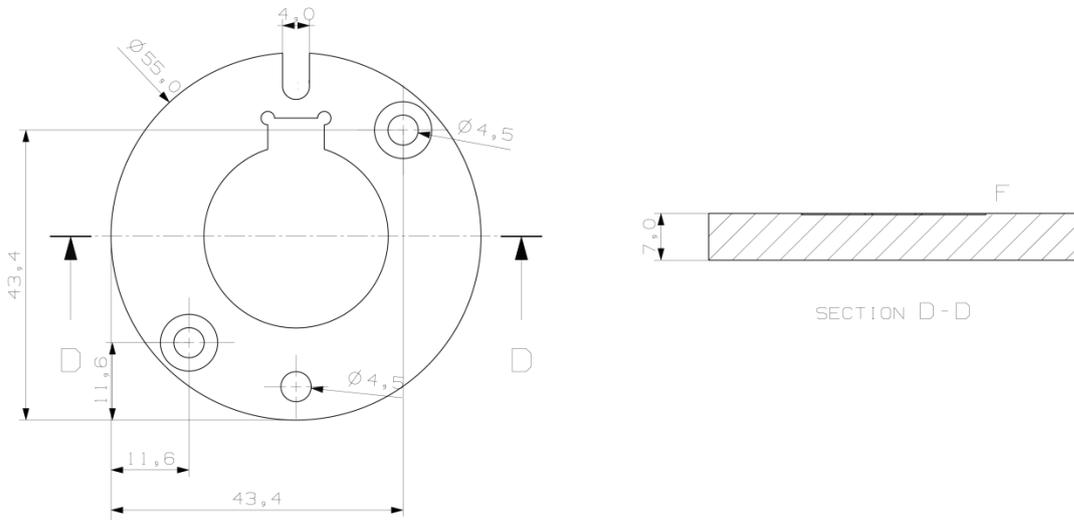
7.2. B05-SMC



7.3. B05-MC



7.4. C50-MC



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	Z ₀	mV/W
Temperature correction factor for radiant sensitivity	Z _c	(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	T _c	°C
Calibration temperature	T ₀	°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