

T-compensated Laser Power Detector (I²C)

FEATURES

- Absolute power sensing of laser beams
- Highly sensitive thermopile sensor
- **Temperature compensated signal**
- Sensitive to all wavelengths from UV to MIR
- Compact and robust design for system integration
- **Serial digital I²C interface**
- Onboard ROM



gRAY detectors

Product Name	gRAY detectors combined with digital electronics
Detector Type	Thermopile
Spectral Range [μm]	0.19 – 15
Aperture [mm]	Depending on sensor model ¹
Max. Power [W]	Depending on sensor model ¹
Minimum Detectable Power [mW]	Depending on sensor model ¹
Max. Average Power Density [kW/cm ²]	1.5
Rise Time (0-95%) [ms]	Depending on sensor model ¹
Linearity with Power [±%]	0.5
Calibrated Temperature Range Min/Max [°C]	25 / 50
Operating Temperature Range Min/Max [°C] ²	15 / 65
Cooling Method	Depending on sensor model ¹
Voltage Input [V]	5 - 24
Conversion Rate (recommended)	10 Hz
Electrical Connection	4 wired cable
Outer Dimensions [mm x mm x mm]	Depending on sensor model ¹
Fixture	Depending on sensor model ¹

¹ Please check the respective data sheet for details.

² Sensor accuracy might be slightly reduced if operated outside the calibrated temperature range.

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1. FUNCTIONAL DESCRIPTION

The gRAY laser power detector with digital output can be used to determine the power of a laser beam. It uses a highly sensitive thermopile sensor to quantify the amount of thermal energy emitted by the laser. The sensors data then gets digitalized, conditioned and deployed via a serial I²C interface.

The digital output consists of a 15 bit value for the power ranging from [0; 1). The value is continuously written to the output register during power on.

Please note that it is necessary to add pull-up resistors to the I²C bus lines to allow communication.

For a sensor supporting SPI or other serial protocols, please contact greenTEG.

2. ELECTRICAL PARAMETERS

Parameter	Min	Typical	Max	Unit
Supply:				
Supply Voltage VDD	5		24	V
Supply Current	2	4	10	mA
Digital - I²C:				
Bus Voltage	4.6 (3.3 ^[1])		5.5	V
SDA pin load capacitance			400	pF
Pull-up resistors (external) ^[2]	1		10	kΩ
SCL pin clock frequency			400	kHz
Device address		0x78 ^[3]		

¹ bus voltage between 3.3 and 4.6 V may lead to unreliable operation

² pull-up resistors must be added to SDA and SCL for proper operation

³ other device addresses can be provided upon request.

3. PROTOCOL DESCRIPTION

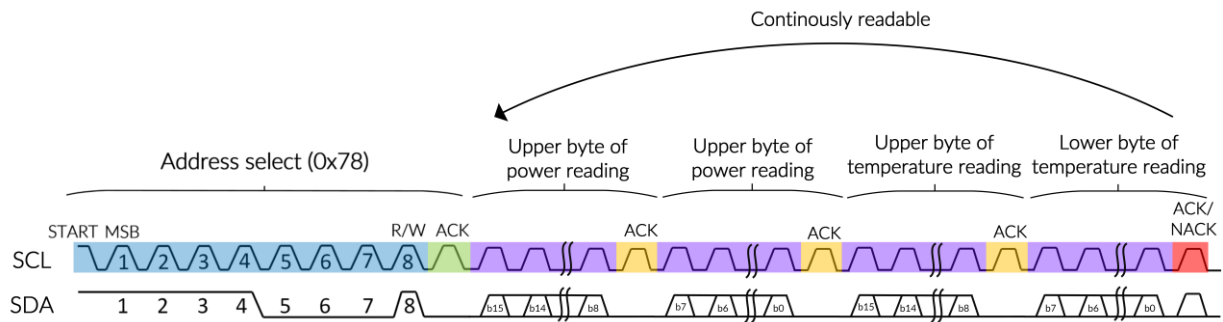
Communication with the system is done via the two wire serial I²C protocol. The device acts as an I²C slave having the hexadecimal 7 bit address **0x78**. Data has to be transmitted **MSB first**. For 16 bit data words the highest byte is transmitted first (**big endian**).

Please note that it is only possible to read from the device. So the R/W bit is always 1.

Each byte transmitted has to be acknowledged by the receiving entity. To achieve this, the master has to generate an additional acknowledgement clock pulse on the SCL line. The receiver will then pull down the SDA line. If the data is not acknowledged by the receiver, the sender will stop transmitting. The transmission has to be restarted in that case.

Since the device is continuously deploying new values to the interface, it is possible to read data in a continuous loop (without ever invoking a STOP condition).

For more information about the I²C protocol please review [UM10204 I2C-bus specification and user manual](#) by NXP.



3.1 I²C TIMING

Parameter	Min	Typical	Max	Unit
SCL clock frequency			400	kHz
Bus free time between start and stop condition	1.3			μs
Hold time start condition	0.6			μs
Setup time repeated start condition	0.6			μs
High period SCL/SDA	0.6			μs
Low period SCL/SDA	1.3			μs
Data hold time	0			μs
Data setup time	0.1			μs
Rise time SCL/SDA			0.3	μs
Fall time SCL/SDA			0.3	μs
Setup time stop condition	0.6			μs
Noise interception SDA/SCL			50	ns

3.2 ERROR CODES

If an error occurs, the device enters a diagnostic mode. When the MSB of the 16 bit measurement register is high the sensor is signaling an error. In this case, the reading is an error code. Errors usually happen due to misconfiguration, exceeding of the range of measurement or a damaged sensor. In any case please contact greenTEG for help with your specific error code.

In case of a measurement error the device has to be reset by power cycling.

4. CABLE PINOUT

The sensor is connected using a 4 wire cable.

The supply voltage needs to be applied between the red cable (VDD) and the black cable (GND).

The communication is then achieved via the yellow cable (SCL) and the white cable (SDA).



5. CALIBRATION AND MEASUREMENT

The sensor is factory calibrated for the temperature range between 25°C and 50 °C. A thermal sensor inside the power meter is used to compensate the effects of heating on the sensor.

The scales for both measurands are linear.

5.1 POWER OUTPUT VALUE MAPPING

The power output register has a dynamic range of 15 bit (0 - 32767 counts).

The detector will output a value of 1638 counts at zero laser power (5% of the maximum output range of 32767 counts). The "negative" power range (between 0 and 1637 counts) is enabled in order to allow a proper background subtraction when measuring low laser powers. Negative power readings may occur when the sensor is substantially warmer than the surrounding air, causing a net energy flow from the sensor to the environment.

In the following, the example of a detector calibrated for 50 W maximum laser power is discussed. The conversion for other power ranges is done analogously.

When applying the nominal laser power (50 Watt) the measured value will reach 31129 counts (5% of the maximum output range of 32767 counts). In case of slightly higher power than the maximum of 50 W, the last 5 % percent of the scale can be used to determine the laser power before an overflow occurs.

The laser power regarding to sensor reading can be determined using the following equation:

Calibrated Constants

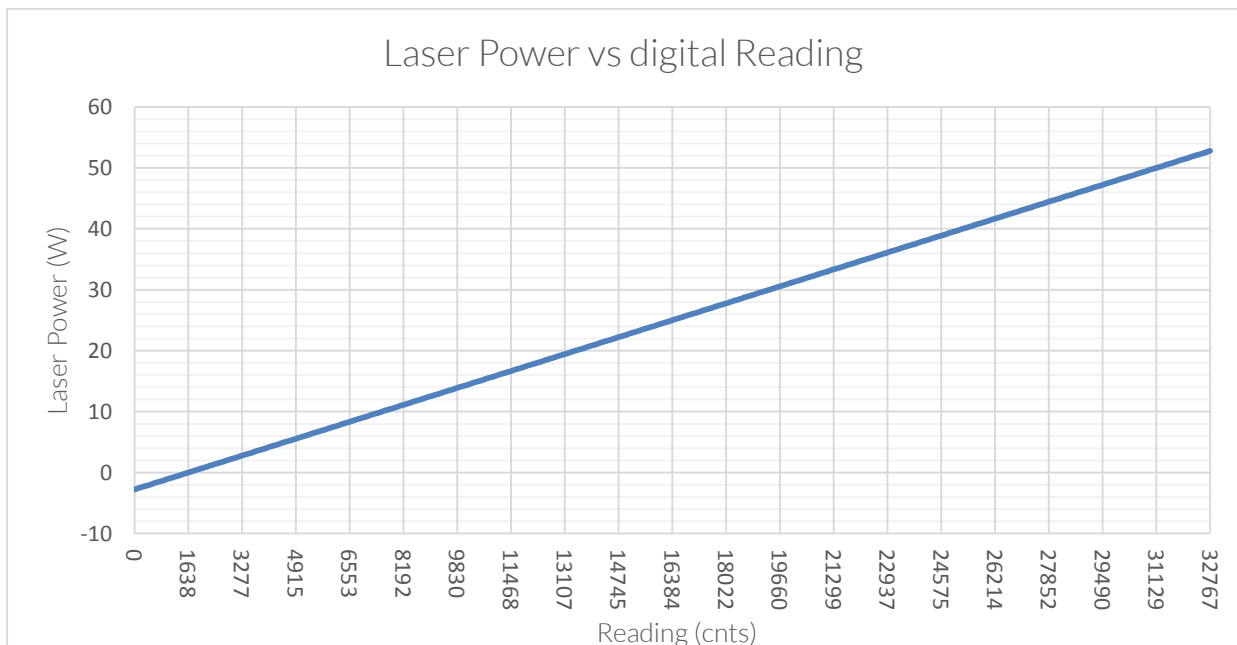
$$m = \frac{55.556}{(2^{15} - 1)} = 0.0016955$$

$$n = -2.778$$

Laser Power

$$P_{laser}(W) = m \cdot cnts + n$$

Where *cnts* is the 15 bit value read from the sensor.



Output in counts (Percent of output range)	0 (0%)	1638 (5%)	31129 (95%)	32767 (100%)
Laser Power [W]	-2.778	0.000 ¹	50.000 ²	52.778

¹ Value rounded up; exact value corresponds to -0.001 W

² Value rounded down; exact value corresponds to 50.001 W

5.2 TEMPERATURE OUTPUT VALUE MAPPING

The temperature reading is accurate in the range between 15°C and 65°C. It has been calibrated to a value of 6553 at 25 °C. The value at a temperature of 50 °C is 22937.

The temperature corresponding to a specific sensor reading can be determined using the following equation:

Calibrated Constants

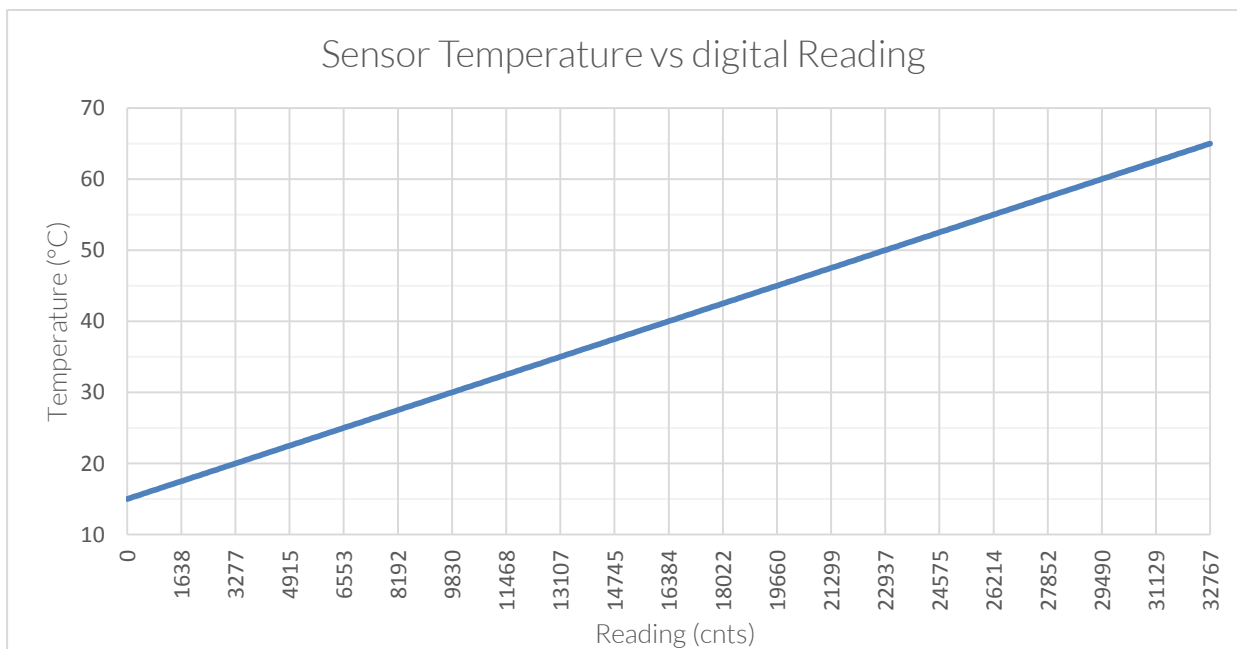
$$m = \frac{50}{(2^{15} - 1)}$$

$$n = 15$$

Temperature

$$T_{\text{sensor}}(^{\circ}\text{C}) = m \cdot \text{cnts} + n$$

Where *cnts* is the 15 bit temperature value read from the sensor.



Output in counts (Percent of output range)	0 (0%)	6553 (20%)	16384 (50%)	22937 (70%)	32767 (100%)
Temperature [°C]	15	25	40	50	65

6. ONBOARD ROM

To store important data like the calibration parameters mentioned in chapters 5.1 and 5.2 the device contains an onboard memory where these coefficients as well as additional information is stored permanently. The ROM shares the I²C bus with the sensor signal conditioner. Communication is initiated using the hexadecimal 7 bit address **0x50**. The ROM has a size of 256 Byte where the current memory address can be set by writing it to the device (1 byte). After that the user can continuously read the memory starting from that specific memory address. The ROM automatically increments the address after each byte read and sets it back to zero when overflowing **0xFF**.

The structure of the memory is shown in the following table. Only the first 40 bytes of the memory are used to store information. Multibyte data is stored in **big-endian** order.

ROM Address (HEX)	Data	Format	Description	Example value
00 to 03	4 bytes	IEEE 754 Float (32 bit)	m:	
04 to 07	4 bytes	IEEE 754 Float (32 bit)		
08 to 0B	4 bytes	IEEE 754 Float (32 bit)		
0C to 0F	4 bytes	IEEE 754 Float (32 bit)		
10 to 1F	16 bytes	16 byte ASCII String	Sensor name	"001072 A1"
20 to 23	4 bytes	32 bit Unix Timestamp	Calibration Date	
24 to 27	4 bytes	Unsigned 32 bit integer	Nominal power rating in mW	0x0000C350

7. ADDITIONAL INFORMATION

- [UM10204 I2C-bus specification and user manual](#)