Temperature Controller Module for Peltier-cooled Detector Arrays

PELTIER-tc

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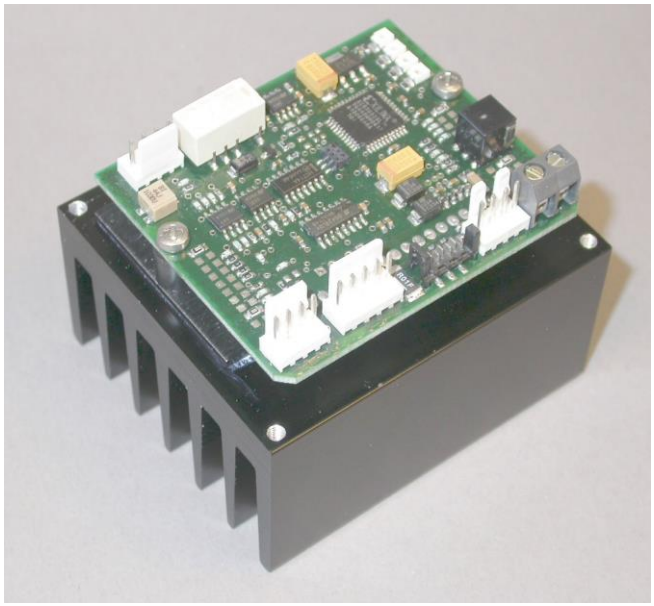


Functional Properties

- Temperature controller module for Peltier-cooled photodiode arrays with thermistor
- For 1-, 2- and 3-stage Peltier elements
- Analog, bipolar PI-type controller
- Possible cooling stability: better than ± 10 mK
- Maximum cooling current: 3 A
- Operating voltage range +5 V to +12 V
- Adjustable current limit
- Thermistor current 10 µA or 100 µA
- Adjustment of the setpoint temperature with
  - four fixed-value resistors,
  - a potentiometer or
  - an analog input voltage alternatively
- Monitor outputs (analog voltage) for
  - Setpoint temperature
  - Actual temperature
  - Cooler current
- Digital output ‚temperature o.k.'
- Temperature error indication by
  - LED
  - Digital output signal
  - Two relay contact pairs
- Connection terminals for two temperature sensors (thermistors) for current shutdown at excess heatsink temperature of the Peltier element and /or the controller electronics, alternatively for remote on/off switching
- Connection terminals for two fans
- Modular mechanical design with heatsink mounting

Functional Description

The temperature controller module PELTIER-tc was designed specifically for cooling detector arrays used in optical spectroscopy. Operating as a linear controller, possible crosstalk of the cooling current to the detector output signal is minimized.

Functionally, the PI-control adjusts the current across the Peltier element to reach a sensor temperature equal to the preset setpoint temperature. If the difference between monitor and setpoint voltage is below 10 mV, the digital output ‚temperature o.k.' is activated and the relay contacts are closed.

With user-supplied thermistors connected to the board, the Peltier current output may be disabled automatically if excess temperature of one of the heatsinks attached to the sensor or the controller electronics is detected.

Installation Steps

To put the module in operation, please follow the steps described below. All details for each step are contained in particular sections of this document. These steps are required unless the temperature controller module has been preconfigured to your particular sensor by tec5.

- Determine key operation parameters of configuration (required: Peltier current limit, operating voltage, thermistor current, setpoint temperature).
  Note:
  The sections „Peltier Current Limit" and „Safe Operating Area" contain important information for selection of the operating voltage and the current limit. If not applied properly, these settings may damage the photodiode array or the temperature controller module.
- Check the factory settings of your module and modify it to implement the selected key parameters. All modifications have to be performed by qualified electronics personnel in a static-discharge protected environment, obeying the typical handling precautions for electronics equipment.
- Connect the equipment according to your system configuration, connect a voltage meter to pin 5 (signal 'current_mon') and pin 3 (GND) of CON101. Connect CON300 to a (switched-off) power supply providing the selected operating voltage and the Peltier current limit plus a margin of 0.3 A.
- Watching the voltage meter, turn on the power supply. If the initial monitored Peltier current exceeds the selected current limit, immediately turn the power supply off and check the settings.

- Monitor the Peltier current and possibly change the gain factor using SW100 to improve the control loop behavior.

Loop Gain

The module is based on an analog PI-control with bipolar output and fixed I-portion using a time constant of 0.5 seconds. The P-portion (or gain) is selectable as fixed value of 33 (JP111) or adjustable in steps using the hex-switch SW100 in the range between 5.7 and 60.1 (with JP111: 1-2).

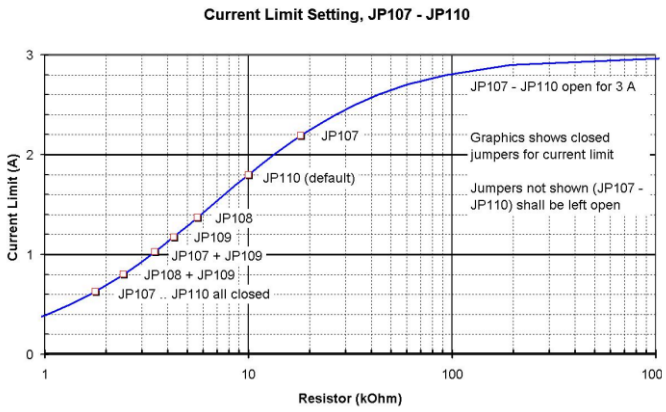
The optimum gain adjustment assures stable control loop operation at the shortest possible response time. For a number of photodiode arrays used in spectroscopy, recommended parameter values are available from tec5. For gain adjustment, the monitor signals for the Peltier current and the actual sensor temperature may be connected to an oscilloscope to examine the control loop behavior.

Hex-Switch-Setting	Gain Factor	Hex-Switch-Setting	Gain Factor
0	5.7	8	46.5
1	11.3	9	48.3
2	19.8	10	51.3
3	23.8	11	52.8
4	30.8	12	55.6
5	33.9	13	56.9
6	38.7	14	59.0
7	41.1	15	60.1

Peltier Current Limit

The maximum current across the Peltier element is adjustable by jumpers JP107 – JP110. This setting is critical for the lifetime of the photodiode array and it is of vital importance to observe the ratings for the Peltier element and the contents of the section „Safe Operating Area“ later in this document.

The figure below gives an overview of possible current limit settings. Additional limit values may be adjusted by using JP110 (only) and replacing the resistor R136 according to the graph. This is recommended only for users experienced in electronics assembly. Use a surface-mount resistor with 0603 footprint.

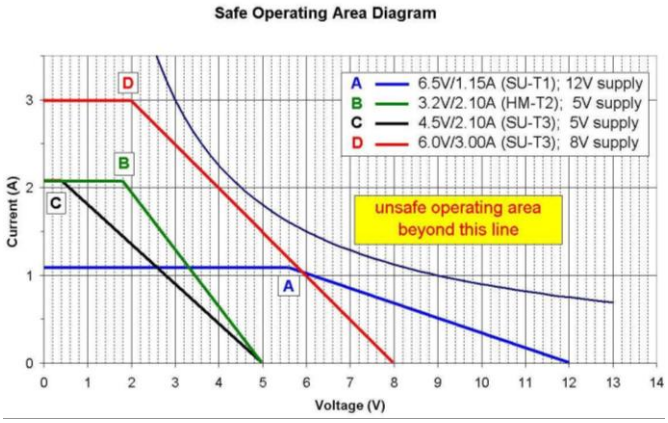


Safe Operating Area (SOA)

In addition to the maximum current specified for the Peltier element in use, limits for the safe operating area (SOA) have to be considered when configuring the controller module's operating parameters. This is important to avoid excess power dissipation of the control electronics.

Caution: Operation outside the SOA will damage the controller module!

The photo detector array manufacturer provides current-voltage characteristics for the Peltier element. The position of the inflection point of the load characteristics line (A – D in the figure below) is determined from the adjusted controller current limit and from the difference between supply voltage and the voltage drop of the Peltier element at the limited current. The resulting difference is the length of the horizontal part of the characteristics line, also corresponding to the voltage drop at the temperature controller hybrid integrated circuit. The intersection point of the load characteristics line and the x-axis is the supply voltage of the temperature controller module.
For safe operation, both parts of the load characteristics line must be completely within the safe operating area of the controller hybrid integrated circuit, below the curve limiting the SOA drawn in the graphics below. Further details concerning SOA considerations can be found in the data sheet of the hybrid integrated circuit HTC-3000, issued by Wavelength Electronics.
The graphics below also contains typical parameter settings for single stage (characteristics line A) and two-stage (characteristics line B) Peltier elements. If optimum cooling potential is required for the application, the supply voltage of the module may be varied, as shown for example in characteristics line D. The maximum available cooling power corresponds to the area of the rectangle defined by the inclined part of the load characteristics with vertical and horizontal boundary lines, it amounts to 18 W in the example of the load line D.



If, resulting from parameter considerations, a part of the load characteristics line resulting from the envisaged maximum current and the selected supply voltage for the module extends into the unsafe operating area, a different set of operating parameters must be defined before putting the module in operation. In this case, either the operating voltage or the current limit must be reduced to obtain safe operation.

Temperature Setpoint

In the table below, the available possibilities for adjusting the setpoint are listed. Each of them is activated by closing the corresponding solder jumper. Generally, the

setpoint voltage corresponds to the thermistor resistance at the setpoint temperature multiplied by the selected thermistor current, i.e. 10 µA or 100 µA as described in detail is section “Temperature Sensor Current”.

Source	Jumper	Setpoint Voltage
Internal fixed voltage	JP105	0.13 V
Internal fixed voltage	JP104	0.16 V
Internal fixed voltage	JP103	0.33 V
Internal fixed voltage	JP102	0.49 V
Internal voltage, adjustable using potentiometer PO100	JP101	0.085 ... 0.940 V
External voltage from analog input CON101 / SP_Extern	JP106	Equals input voltage SP_Extern

Temperature Sensor Current

When choosing the sensing current for the thermistor, the specification of the maximum power dissipation of the thermistor has to be met at the selected setpoint temperature. Two settings are available for the thermistor current source.

Note:
Note that changing the thermistor current results in different control loop gain. In most cases, a readjustment of the gain factor using the HEX-switch SW100 is required to obtain optimum control loop performance.

Jumper	Thermistor Current
JP_100 1-2	10 µA (default)
JP_100 1-3	100 µA

Display-LEDs

LED1	Supply voltage applied
LED2	Temperature reached (same as Digital Out 2)
LED3	Temperature shutdown thermistor 1 / CON400
LED4	Temperature shutdown thermistor 2 / CON401

Connections

Supply Voltage Input

CON300: 2-pin screw terminal type WECO S94/95

Pin	Signal	Comment
1	+Ub	Supply voltage +Ub
2	GND	Ground

Temperature Sensors for Heat Sink Monitoring

The Peltier current is shut down at a thermistor resistance below 6.2 kOhm (thermistor 1) or 4.7 kOhm (thermistor 2) approx.. Using thermistors with 10 kOhm at 25°C will e.g. result in an over-temperature shutdown at approximately 30°C (TERM1) and 40°C (TERM2). Alternatively, a closing switch for remote shutdown of the temperature control may be connected to each terminal in place of the thermistor.

CON400, CON401: Solder terminals

Connector / Pin	Signal	Comment
CON400 / Pin 1	TERM1	Thermistor 1 (Peltier)
CON400 / Pin 2	GND	Ground
CON401 / Pin 1	TERM2	Thermistor 2 (Controller)
CON401 / Pin 2	GND	Ground

Fans

Important: When connecting fans, the operating voltage of the fans must be equal to the operating voltage selected for the temperature controller module.

CON301, CON302: 2 pin connectors type KK-6410-2

Connector / Pin	Signal	Comment
CON301 / Pin 1	+Ub	Fan1 / +Ub
CON301 / Pin 2	GND	Fan1 / Ground
CON302 / Pin 1	+Ub	Fan2 / +Ub
CON302 / Pin 2	GND	Fan2 / Ground

Relay Terminals

Two break contacts with a current capability of 0.5 A each are available e.g. to shut down potentially endangered sensors or other equipment. The relay contacts are closed if the sensor temperature is equal to the setpoint temperature, i.e. if the control loop is in normal function. According to this, a delay occurs after switching on the temperature controller module before the sensor reaches the setpoint temperature and the relay contacts are closed.

CON202: 4-pin connector type KK-6410-4

Pin	Signal	Comment
1	SW11	Break contact 1
2	SW12	Break contact 1 ret.
3	SW21	Break contact 2
4	SW22	Break contact 2 ret.

Digital I/O (3.3V levels)

The digital port connector provides an input to deactivate the cooling and two monitoring outputs for control loop operation.

CON200: 4-pin connector type KK-6410-4

Pin	Signal	Direction	Comment
1	OFF	Input	Control on/off (on=open) (off=high (>2V))
2	DO1	Output	High = temperature o.k.
3	DO2	Output	High = temperature error
4	GND	Output	Ground

Analog I/O / Monitoring

The analog port connector allows to connect an analog voltage corresponding to the temperature setpoint. If used, a well-filtered, clean DC voltage must be applied for correct operation of the cooling control. Three voltage outputs are available to monitor the actual sensor temperature, the setpoint temperature and the cooling current using a voltage meter or an oscilloscope.

CON101: 5 pin connector type KK-6410-5

Pin	Signal	Direction	Comment
1	SP_Extern	Input	External setpoint (0..1 V)
2	ACT_T_Mon	Output	Sensor temperature (0..1 V)
3	GND	Ground	Ground
4	SET_T_Mon	Outpout	Setpoint Voltage (0..1 V)
5	Current_Mon	Output	Cooling Current (1 V/A)

Sensor Connector

CON100 connects the temperature controller module to the tec5 preamplifier board carrying the photodiode array. The interconnection cable establishes the con-

nections both to the array's Peltier element and to the built-in temperature sensor (thermistor).

CON100: 6-pin connector type MICS6

Pin	Signal	Direction	Comment
1	TEC+	Output	Cooling current for Peltier element (*)
2	TEC+	Output	
3	TEC-	Output	Cooling current for Peltier element return (*)
4	TEC-	Output	
5	Sensor+	Input	Temperature sensor + (*)
6	Sensor-	Input	Temperature sensor – (*)

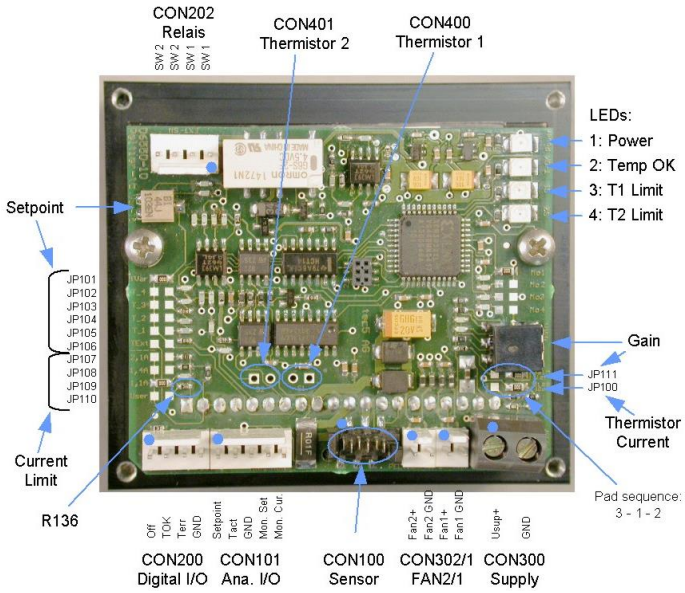
(*) Original signal HTC-3000

Important:

Never connect any of the lines of the sensor connector to ground. Both, the attached Peltier element and the thermistor must be floating. Any deviation from this requirement leads to destruction of the module and voids warranty.

Connection Diagram

The following graphics shows the positions of the connectors and of the miscellaneous controls / settings on the printed circuit board. All details contained in the various sections of this data sheet must be carefully read and obeyed before making connections and putting the module in operation.



Suggested Parameter Set for Carl Zeiss PGS-Sensors

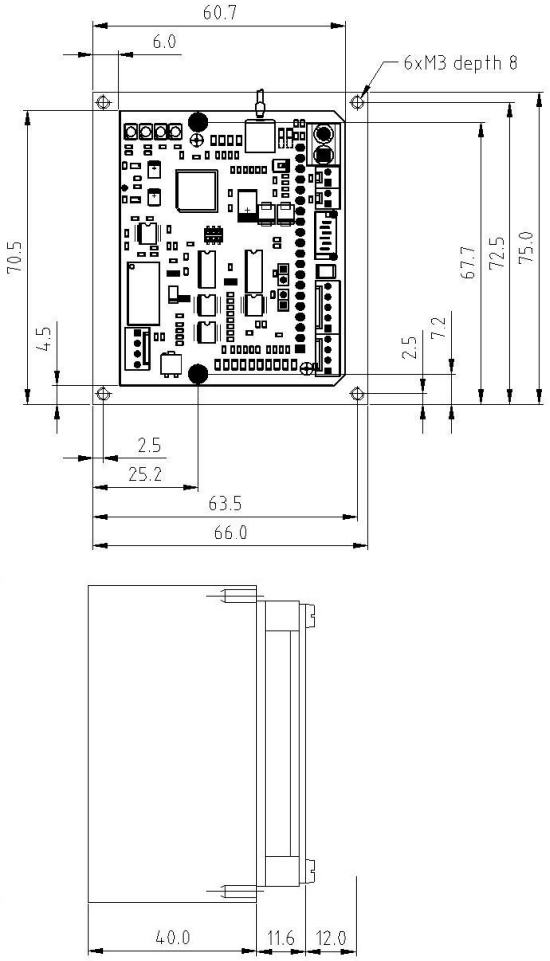
	PGS 1,7 µ 256/512 Pix Hamamatsu	PGS 2,2 µ 256 Pixel Hamamatsu
Setpoint temperature	+10 °C	-10 °C
Setpoint resistance	9.5 k	21 k
Thermistor current	10 µA	10 µA
Setpoint voltage	95 mV	210 mV
Max. Peltier voltage	4 V	3 V
Supply voltage	5 V	5 V (max 7 V)
Current limit	1,1 A	2,1 A
Gain	30	6
Gain switch setting	4	0

Environmental Conditions

- Operating temperature: 0 °C ... +50 °C
- Storage temperature: -40 °C ... +50 °C
- Humidity (@25°C, non-condensing): 10 % ... 90 %

Mechanical Design

The dimensions of the temperature controller module and the positions of the mounting holes are shown in the drawing below.



User Information

General

The information in this data sheet has been checked carefully. However, no responsibility is assumed for inaccuracies. tec5 reserves the right to make changes to any portion of this document without notice.

Each product is tested carefully before being shipped. If, however, problems should occur while initial operation or during later operation, please first check your specific settings and correct installation (connectors).

Warranty

The warranty period for this product is 12 months. The warranty begins on the day of delivery. Within the warranty period, tec5 will repair free of charge any faulty functioning of the product resulting from faulty design or defective material. All other claims are excluded, in particular consequential damage.

Handling

The electronics is partly constructed in CMOS technology and is thus sensitive against electrostatic discharge. Take appropriate precautions whenever handling the component. Please switch off the power before connecting or disconnecting the product.