Data sheet

PSx1
TEC Driver

OsTech GmbH i.G.

Overview

The peltier source PSx1 temperature controller series is a high precision safe and cost effective solution for driving thermo electric coolers. This series supports a consistent interface to control TECs at a broad range of different voltages and currents. The driver's microcontroller based digital control unit offers a lot of options in the standard and can be fast and effective be customised. Standard interface is the RS232 port, analog control is also possible.

You can set arbitrary limits for currents, voltages and temperatures. The temperature controllers realise a PID control loop. Differnt types of temperature sensors like RTDs (PT100), NTCs or silicon sensors can be used. Every device has passed our 24 h full power burn in and several safety tests for proving static discharge and transient protection.

Features

- fully digital control, standard interface RS232
- non volatile preconfiguration (EEPROM)
- controllable internal and external fan supplys
- hardware interlock for all modules
- temperature protection
- thermosensor input for NTCs (standard 10 kΩ), PT100, PT1000 or others
- Polynomial and Steinhart-Hart sensor model
- up to 4 PID temperature controllers for TEC coolers
- voltage, current and temperature limits
- target temperature sequencer on request

Parameters

supply:	xS01 default 24 V DC, on request 8 . . . 32 V DC xS11 100..230 V AC
size:	depending on power and max. currents, f.e.: o44 oem version up to 300W 44 mm × 105 mm × 160 mm t8511 tabletop version up to 200W 85 mm × 105 mm × 220 mm
max. current in A:	±1 | ±2 | ±4 | ±6 | ±8| ±10| ±12| ±16
max. voltage in V:	4 | 8 | 14 | 18
current limit:	$0 \ldots I_{max}$
current resolution:	$I_{max}/4000$
temperature accuracy:	< 10..100 mK

Contents

1 Introduction

Thank you for your interest in our laser-diode and temperature controllers. Our devices are high-quality advanced products and we do our best so that you will enjoy the work with it.

Please read this operation manual carefully before switching on the device and pay attention to the safety instructions given here. In order to obtain optimum performance from your driver module follow the installation and operating instructions. In case of questions or problems, please contact our service staff.

Please note that unauthorized opening of the device cancels the two year warranty. Don't break the calibration seal!

Our advanced laser power supply is microprocessor controlled with many safety features for reliable operation of the laser diode. The serial interface of the power supply allows external computer-controlled operation for elaborate experiments.

2 Technical parameters

2.1 General parameters

input voltage	24 V DC $\pm$ 10%
power in	$\leq 1.25 \cdot P_{out}$
max. current	4 | 8 | 12 A
fuse value	6.3 | 10 | 12 A
ambient temperature	0 . . . 40 °C
humidity	< 95%
housing size (H×W×D) (depth without connectors)	85 mm × 105 mm × 200 mm 3.4 in × 4.2 in × 7.8 in
mass	1.4 kg
remote control	PC serial interface RS232

2.2 Peltier module

peltier current	range	±1.5 | ±2.5 | ±4 | ±8 | ±12 | ±16 A
	accuracy	$\pm I_{max}/4000$
peltier voltage	max.	4 | 8 | 14 | 18 V
temperature controller	range	−25 °C . . . 150 °C, larger on request
	accuracy	< 10 mK
temperature limits	range	−25 °C . . . 150 °C
default lower limit		5 °C
default upper limit		35 °C

3 Keypad and display menus

3.1 Keypad

▲	UP	▪ increases the digit under the cursor
▼	DOWN	▪ decreases the digit under the cursor
◀	LEFT	▪ moves to the previous input field
▶	RIGHT	▪ moves to the next input field
●	OK or Enter	▪ starts input field actions
		▪ toggles checkboxes
		▪ enters changed value
		▪ pressing it twice on unchanged digits moves the cursor position

3.2 Display menus

This section describes the menus on the front display which let you control the device. Figures of menus in this section use the following legend:

____	input field for numeric values
....	output field for numeric values
[_]	input field check box
[.]	output field check box
->	input field action
▶	next menu

The menus are shown in figure 3.1. The abbreviations have the following meanings:

LTON/OFF	laser temperature control ON/OFF
CTON/OFF	crystal temperature control ON/OFF
LTT/CTT	laser temperature target
LTA/CTA	laser temperature actual

LTCL/CTCL	laser temperature current limit
LTCA/CTCA	laser temperature current actual
LTVA/CTVA	laser temperature voltage actual
LTLU/CTLU	laser temperature limit upper
LTLL/CTLL	laser temperature limit lower
SetDef.->	sets defaults for PID coefficients
k, Tn, Tv	PID controller coefficients
GX On Start	external device control on startup, setting it causes the driver to switch to external mode after 5 seconds
GDefaults	sets global defaults
GXControl	external device control over RS232
Pilot Laser	activates the pilot laser if laser is on
GF	external fan voltage
GFD	default external fan voltage

```
Laser-Temp.  Menu                ▶
LTON/OFF:   [_]  SetDef.->
LTT:   _____  °C  LTLU: _____  °C
LTA:    ....  °C  LTLL: _____  °C
LTCL: _____   mA  k:    _____
LTCA: _____   mA  Tn:   _____
LTVA: _____    V  Tv:   _____
```

(a) Laser temperature menu

```
Laser-Temp.  Menu                ▶
CTON/OFF:   [_]  SetDef.->
CTT:   _____  °C  CTLU: _____  °C
CTA:    ....  °C  CTLL: _____  °C
CTCL: _____   mA  k:    _____
CTCA: _____   mA  Tn:   _____
CTVA: _____    V  Tv:   _____
```

(b) Crystal temperature menu

```
Device Menu                  ▶
GX On Start:  [_]
GDefaults->
GXControl->
Pilot Laser:  [_]
GF:  _____      V
GFD: _____      V
```

(c) Device menu

Figure 3.1: Menus

4 Hardware setup preparations

- Make sure that the power supply unit is disconnected from main. Use an approved personal grounding bracelet for ESD protection of the laser during the following step.
- Connect your laser to the driver at the laser & peltier interface at the rear side of the driver unit. Remove the shortage clip from the laser (during off state the laser output of the driver unit is internaly shortened).
- Connect the power supply unit to main.
- Make sure that the interlock connector is closed.
- Make sure that the emergency button (the large red button at the front side) is unbolted.
- Make sure that an appropriate temperature sensor for the laser is connected, the driver needs also a temperature signal for LasSrc devices.

Please note laser safety regulations! Turn the key switch on. The laser cooling fan will start, if an external fan is operated by the driver. Attention: don't press any keys on the keyboard while `Device Init` message is displayed. After turning on the device CW mode is entered by default.

5 Temperature controller and sensors

5.1 PID controller parameters

The temperature controller in devices with TEC support has a PID structure with the common formulas:

$$G_c(s) = k_p \left(1 + \frac{1}{T_n s} + T_v s\right)$$
$$u(t) = k_p \left(e(t) + \frac{1}{T_n} \int e(t) dt + T_v \frac{de(t)}{dt}\right)$$

k_p	– proportional gain	– LTCCK
$T_n = T_i$	– integral time	– LTCCN
$T_v = T_d$	– derivative time	– LTCCV

The values of these three variable parameters have to be found. After Ziegler-Nichols for example you can calculate

$$k_p = 1.2 \cdot \frac{T}{L}$$
$$T_n = 2 \cdot L$$
$$T_v = 0.5 \cdot L$$

Here, T is the base time constant and L is the delay time, both derivated from a step response. Note that the so found parameters differ slightly from the theoretical values. In practice typical value ranges for a TEC circuit are:

LTCCK:	1...5
LTCCN:	5...50
LTCCV:	0.2...2

If you don't know anything about the TEC circuit, you may set LTCCK = 1, LTCCN = 2 and LTCCV = 0.1. Then increase LTCCK slowly by 1 as long as the circuit stays stable. When it becomes unstable halve the LTCCK value. Here the controller nearly runs as P controller. After this try to find the value for LTCCN in the same way. However,

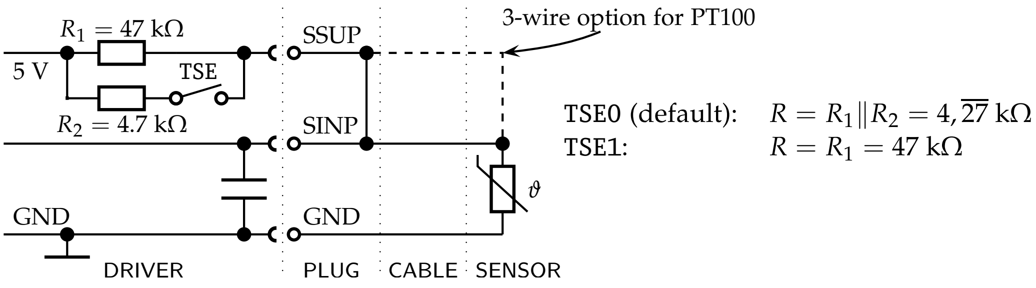

Figure 5.1: schematic for connecting a temperature sensor

you may increase it by bigger steps. Now the controller behaves like a PI controller. Finally, you may increase LTCCV by steps of 0.3 until you find an optimum value for response time and overshooting.

Note that you have to stop and start the temperature controller after changing those values to make sure that the controller is initialized with the new values.

5.2 Temperature sensor

The temperature sensor is connected over three pins of the laser & peltier interface: GND, SINP and SSUP. The schematic in figure 5.1 shows the internal part of the driver on the left hand side and a typical NTC thermistor connected to it on the right hand side.

As you can see there the temperature is calculated by measuring the voltage over a simple voltage divider. After a 24 bit AD conversion the temperature T is calculated from the measured voltage V using the following third-order polynomial:

$$T(V) = c_3 \cdot V^3 + c_2 \cdot V^2 + c_1 \cdot V + c_0 \qquad \text{(TSM0)}$$

The default coefficients c_0, c_1, c_2 and c_3 of this polynomial correspond to an NTC with 10 kΩ at 25 °C which is a wide spread standard. You may adjust these coefficients to a different sensor by the commands LTSC [0 . . . 3] for the laser TEC or CTSC [0 . . . 3] for the crystal TEC. As also described in figure 5.1 LTSE/CTSE can be used to chose the series resistor R.

Additionally, the driver can be set to calculate the temperature using the Steinhart-Hart equation:

$$T(R_{\text{NTC}}) = \frac{1}{c_1 + c_2 \cdot \ln(R_{\text{NTC}}) + c_3 \cdot (\ln(R_{\text{NTC}}))^3} + c_0 \qquad \text{(TSM1)}$$

The model switching is done with the TSM command. Here TSM0 causes the polynomial model to be used and TSM1 switches to the Steinhart-Hart equation.

The coefficients for some common sensors are given in the table below. Here x has to be replaced by L or C depending on whether you want to set the parameters for the laser or the crystal TEC.

The settings for a PT100 or PT1000 sensor can be calculated from its resistance using the following formulas:

$$R_0 = 100\ \Omega \qquad \text{(at 0 °C)}$$
$$R(T) = R_0 \cdot (1 + A \cdot T - B \cdot T^2) \qquad (T\text{: temperature in °C})$$

As B is commonly neglected you can calculate them using

$$R(T) = R_0 \cdot (1 + A \cdot T)$$

and using the divider network wich leads to the coefficients shown in the following table.

	xTSC0	xTSC1	xTSC2	xTSC3	xTSE
polynomial model (xTSM0)					
NTC 10 kΩ B3980	135.83	−63.2256	15.3332	−1.80043	0
NTC 10 kΩ B3450	156.089	−74.4317	17.5466	−1.99111	0
PT100 TK3850	−266.475	2330.44	0	0	0
PT1000 TK3850	−327.084	344.924	0	0	0
PT1000 TK3850	−265.862	2552.28	0	0	1
AD590 (1 µA/K)	−897.065	−234.043	0	0	0
Steinhart-Hart equation (xTSM1)					
NTC 10 kΩ B3980	−273.15	$1.0832 \cdot 10^{-3}$	$2.4141 \cdot 10^{-4}$	$6.505 \cdot 10^{-8}$	0
NTC 10 kΩ B3450	−273.15	$1.1293 \cdot 10^{-3}$	$2.3411 \cdot 10^{-4}$	$8.7755 \cdot 10^{-8}$	0

The settings for the AD590 (1 µA/K) sensor can be calculated using

$$U(T) = U_{\text{ref}} - (4272.72 \cdot 10^{-6} \cdot T) \qquad (T\text{: temperature in °C})$$

For tolerances of real sensors you may need to calibrate the setup point of your sensor by adding the difference between the real temperature and the shown temperature to the absolute part LTSC0. If you need assistance in connecting your sensors or you want to assemble any other sensor to the driver we would be pleased to assist you in finding the appropriate coefficients.

6 Remote control

All OsTech modules may be controlled over a serial interface. The transfer parameters of the serial interface are fixed to 9600 baud 8N1.

6.1 Standard mode

In *standard mode* you can send commands and parameters to the device in text format and the device answers in the same way. The answer of the device always contains comments and the parameters and values are given back. This mode is optimal for working at a PC using any terminal program.

After sending a character you will receive an echo of your input, i. e. all sent characters return immediately. All characters are changed to upper case. All inputs have to be finished by CR to process the input; CR is also returned. If a command returns a value, the answer is also finished by CR. No linefeed LF is added after the CR, but most terminals are able to generate this automatically. You may invalidate any sequence by sending Esc. Single characters may be deleted from the buffer by backspace ⟵. Between commands and their parameters you can insert as many spaces as you want (no space is also okay). But note that the whole command line must not be longer than 15 characters.

sent command:	`LCT2.33` CR	every character is returned
received answer:	`Laser Current Target: 2.33 A` CR	verbose answer

6.2 Reduced mode

The *reduced mode* works similarly to the standard mode. The difference is that you merely receive the values and numbers without any comment or unit.

sent command:	`LCT2.33` CR	every character is returned
received answer:	`2.33` CR	short answer

For a single command this mode can be reached by simply adding the prefix `R`. So `LCT2.33` would become `RLCT2.33`. To switch to this mode permanently use the command `GMS32768`. The command `GMC32768` switches back to standard mode.

6.3 Binary mode

In *binary mode* no comments are returned and values are sent binary coded (MSB first) with a checksum following. This mode is optimal if you want to control the device automatically by a master computer. The checksum is computed by adding every single byte of a word or float value to the fixed value 0x55 (ignoring the overflow). For e. g. a float value whose four bytes are all 0x00 (= 0.0) the checksum is 0x55. If all bytes are 0x01 then the checksum would be 0x59 and so on.

sent command:	`LCT2.33` CR	every character is returned
received answer:	*MSB . . . LSB, checksum*	binary coded answer

There are four data types with the following return structure:

- float — 4 bytes + checksum
- short or word — 2 bytes + checksum
- string — 0. . . 255 bytes + 0x00
- boolean — 1 byte:
  - 0xAA for *run* or *on*
  - 0x55 for *stop* or *off*

The device always starts in standard mode. Binary mode is initialized by setting a bit in the general mode variable of the device as follows:

sent command:	`GMS8` CR	set bit 0x08 of mode variable

To return to standard mode this bit has to be cleared:

sent command:	`GMC8` CR	clear bit 0x08 of mode variable

6.4 Software

At `http://www.ostech.de` you may download the terminal program *OSTERM* and sample routines in the C language to interact with OsTech devices. Please find also LabVIEW™ VIs and runtime versions for remote control on our homepage.

7 Command reference

7.1 TEC commands (xT)

In these commands x has to be replaced by a letter or a digit to select the TEC. The first TEC (laser) corresponds to 1 or L. Use 2 or C to select the second TEC (crystal). If applicable, 3 and 4 can be used to select the third and fourth TEC.

cmd	type	min	max	default	unit	description
xTC	bool	S	R	S		temperature controller stop/run
xTA	float	— *no parameter* —			°C	actual temperature
xTT	float	−20	60	20	°C	temperature target
xTLU	float	−20	60	40	°C	upper temperature limit
xTLL	float	−20	60	0	°C	lower temperature Limit
xTCA	float	— *no parameter* —				actual current
xTCL	float	$-I_{P_{max}}$	$I_{P_{max}}$	$I_{P_{max}}$	mA	current limit
xTVA	float	— *no parameter* —			V	actual voltage
xTCCK	float	0	256	2		PID parameter: gain factor
xTCCN	float	0	256	60	s	PID parameter: reset time
xTCCV	float	0	256	1	s	PID parameter: rate time
xTSCn	float			NTC B3980		sensor coefficients, $n = 0 \dots 3$
xTSE	word	0	1	0		resistor for temperature sensor ▪ 0: $4,\overline{27}$ kΩ ▪ 1: 47 kΩ
xTSM	word	0	1	0		sensor approximation model ▪ 0: polynomial model ▪ 1: Steinhart-Hart equation

7.2 General commands

cmd	type	min	max	default	unit	description
GD	bool		— *no parameter* —			set defaults
GF	float	1.2	24	5	V	fan voltage (max. 300 mA)
GFD	float	1.2	24	5	V	default fan voltage
GX	bool	S	R	S		external control stop/run
GT	float		— *no parameter* —		°C	device temperature (head)
GVS	word		— *no parameter* —			software version
GVN	word		— *no parameter* —			serial number

7.2.1 Status command

cmd	type	min	max	default	unit	description
GS	word		— *no parameter* —			get status

The status bits have the following meanings:

0x0001	interlock OK		
0x0004	driver supply OK	0x0400	LT sensor OK
0x0008	driver temperature OK	0x0800	CT sensor OK
0x0010	LTLU not OK		
0x0020	LTLL not OK	0x2000	LTM not OK
0x0040	CTLU not OK	0x4000	LC ON
0x0080	CTLL not OK	0x8000	LC error

7.2.2 Mode commands

cmd	type	min	max	default	unit	description
GM	word		— *no parameter* —			get mode
GMC	word					clear mode bit(s)
GMS	word					set mode bit(s)
GMT	word					toggle mode bit(s)

The mode bits have the following meanings:

0x0001	laser current ON	0x0100	first TEC (laser) ON
0x0002	input echo OFF	0x0200	second TEC (crystal) ON
		0x0400	pilot laser ON
0x0008	binary mode	0x0800	laser current control (LCC) OFF

0x0010	laser voltage control OFF	0x1000	use external interface after startup
0x0020	LMDI ON	0x2000	LMDX OFF
0x0040	LMDX ON	0x4000	gate option
0x0080	LMAX ON	0x8000	reduced mode