LDI-880 PRODUCT MANUAL

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Overview:

The LDI, LDC and TEC series laser diode drivers and TEC controllers are designed to precisely and reliably drive diode lasers and Peltier / TE cooler elements. They are available as benchtop units and as OEM units. All laser diode current sources have an integrated QCW pulse generator and can be run from QCW pulse to CW mode. External digital and analog modulation functionality is also included on all models. The standard RS232 interface can be used for configuration, operation and monitoring. A USB interface is optionally available on all models. Every unit passes a burn-in inspection, a full functional test and a final calibration prior to shipment.

Laser Diode Current Source Features:

- Full digital control, standard interface RS232 or USB
- Non volatile pre-configuration (EEPROM)
- Controllable internal and external fan supplies
- Hardware interlock
- Over-temperature and over-current protection
- Precise current controlled CW and pulsed laser operation modes
- Low power dissipation by active voltage control in CW mode
- Multiple laser diode safety features
- Internal and external modulation functions

TEC Controller Features:

- Thermosensor input for NTCs (standard 10 kΩ), PT100, PT1000 or others
- Polynomial and Steinhart-Hart sensor model
- PID temperature controller for TEC coolers
- Voltage, current and temperature limits
- Target temperature sequencer on request

Contents

1. Introduction

The LDI, LDC and TEC series precision laser diode drivers and TEC controllers offer the user full control of all configuration parameters through a front panel and/or through a serial interface. It is important to read this manual thoroughly before turning on the device for the first time. The operating instructions should be followed for safe operation and optimum performance of the laser diode.

In case of questions or problems, please contact Laser Lab Source in North America or OsTech in Europe.

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Please note that unauthorized opening of the device enclosure cancels the warranty. Please not break the calibration and warranty seal.

2. Technical Parameters

2.1 General Parameters FOR ALL MODELS

input voltage	DS01: 24 V DC ± 10% DS11: 110–220 V AC
ambient temperature	0 . . . 40 °C
humidity	< 95%
housing size	*width×height×depth (depth without connectors)*
o44 housing	105 mm × 44 mm × 160 mm (4.1 in × 1.7 in × 6.3 in)
o85 housing	105 mm × 85 mm × 160 mm (4.1 in × 3.3 in × 6.3 in)
t85 housing	105 mm × 85 mm × 200 mm (4.1 in × 3.3 in × 7.9 in)
t95 housing	119 mm × 95 mm × 235 mm (4.7 in × 3.7 in × 9.3 in)
t127 housing	200 mm × 127 mm × 277 mm (7.9 in × 5.0 in × 10.9 in)
t192 housing (19 inch, 2 HU)	483 mm × 89 mm × 266 mm (19 in × 3.5 in × 10.5 in)
t193 housing (19 inch, 3 HU)	483 mm × 133 mm × 266 mm (19 in × 5.25 in × 10.5 in)
remote control	PC serial interface RS232

2.2 (Model Specific) Laser Diode Current and Voltage

laser diode current	range	1.5 | 2.5 | 5 | 8 | 12 | 16 | 24 | 32 | 40 . . . 100 A
	resolution	$I_{\mathrm{max}}/4000$
	accuracy	±0.5 %
laser current limit	range	0 . . . I_{max}
	resolution	$I_{max}/4000$

	accuracy	±2 %
laser diode voltage	min.	1.2 V
	max.	3 | 6 | 9 | 12 | 15 | 18 | 24 | 48 V
current noise		1 % . . . 0.01 % of I_{max} rms
internal pulse mode		
pulse width	range	(model specific) 10 µs . . . 2^{32} µs (71 min)
pulse period	range	(pulse width + 100 µs) . . . 2^{32} µs (71 min)
time base	accuracy	±1 %
pulse to pulse	accuracy	30 µs
rise time	at 2.5 A I_{max}	< 2 µs
	at 4 A I_{max}	< 3 µs
	at 8 A I_{max}	< 10 µs
	at 12 A I_{max}	< 15 µs
	at 16 A I_{max}	< 18 µs
	> 16 A I_{max}	25–40 µs
	on request	< 1 µs . . . 3 µs
fall time		70 % . . . 100 % of T_{rise}
laser fan control		
voltage	range	1.2 V . . . 24 V (adjustable by software)
current	max.	300 mA

2.2.1 Security Shut-Down Conditions

- Interlock open
- Internal supply failure
- Abnormal transients
- Open circuit / no laser connected
- Internal overtemperature
- Beyond max. power dissipation

2.3 (Model Specific) TEC Controller

peltier current	range	±1.5 | ±2.5 | ±4 | ±8 | ±10 | ±12 | ±16 A
	accuracy	$\pm I_{max}/4000$
peltier voltage	max.	4 | 8 | 14 | 18 | 24 | 48 V
temperature controller	range	−25 °C . . . 150 °C, larger on request
	accuracy	typical: < 10 mK
		max.: < 100 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, unsaved changes are discarded
▶	RIGHT	▪ moves to the next input field, unsaved changes are discarded
●	OK or Enter	▪ triggers actions ▪ toggles checkboxes ▪ saves a changed value ▪ moves the cursor position if pressed on an unchanged or already saved value

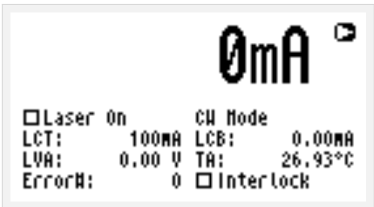
3.2 Display Menus

After power-on, the main menu is shown on the display. Some fields can be used to change settings of the device, others only show the current values. You can switch to the next menu with the arrow in the upper right corner. The laser menu is next. Then follow the TEC menus. The last menu is the device menu for general settings.

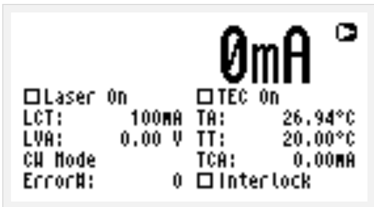
3.2.1 Main Menu

The main menu gives an overview over the current state and allows you to control basic settings. The layout of the main menu depends on the model. It is shown in figure 3 .1. The large number show the present laser current in laser drivers and the current temperature in TEC controllers. The following fields may be available in the main menu:

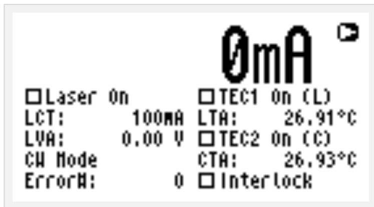
`Laser On`	switch the laser on and off, can only be changed if the device has no separate laser switch
`LCT`	laser current target
`LVA`	laser voltage actual
`LCB`	laser current bias (for modulation)
`CW Mode, ... Mod.`	modulation mode
`TEC On`	switch the TEC controller on and off
`TT, LTT, CTT`	target temperature
`TA, LTA, CTA`	temperature actual
`TCA, LTCA, CTCA`	TEC current actual
`TVA`	TEC voltage actual
`TCL`	TEC current limit
`Error#`	error number (0 = no error)
`Interlock`	if the interlock is closed



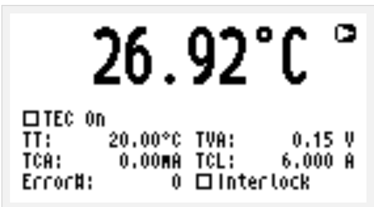
(a) Laser driver without TEC controller.



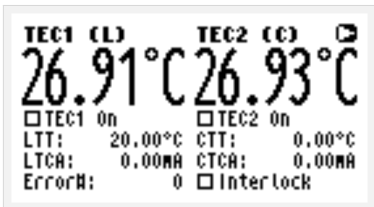
(b) Laser driver with one TEC controller.



(c) Laser driver with two TEC controllers.



(d) Controller for one TEC.



(e) Controller for two TECs.

Figure 3.1: Main menu layout depending on the modules in the device

3.2.2 Laser Menu

The laser menu is shown in figure 3.2. This is where the user can change laser current settings. The following fields are included:

LCL	laser current limit
LVC	compliance voltage ($\geq$ LVA)
LVA	laser voltage actual
LCB	laser current bias (for modulation)
LCLM	limit for average laser current (for modulation)
LTM	laser temperature maximum, laser stops above this temperature
Error#	error number ($0 =$ no error)
CW Mode	no modulation
LMAX	external analog modulation
LMDX	external digital modulation
LMDI	internal digital modulation
LMW	laser modulation width
LMP	laser modulation period
PC	pulse count (= LMDIC command) ▪ PC = 1: single pulse ▪ PC = 2: burst of 2 pulses . . . ▪ PC = 0: continuous pulses
LG	gate option

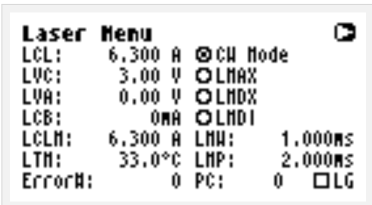


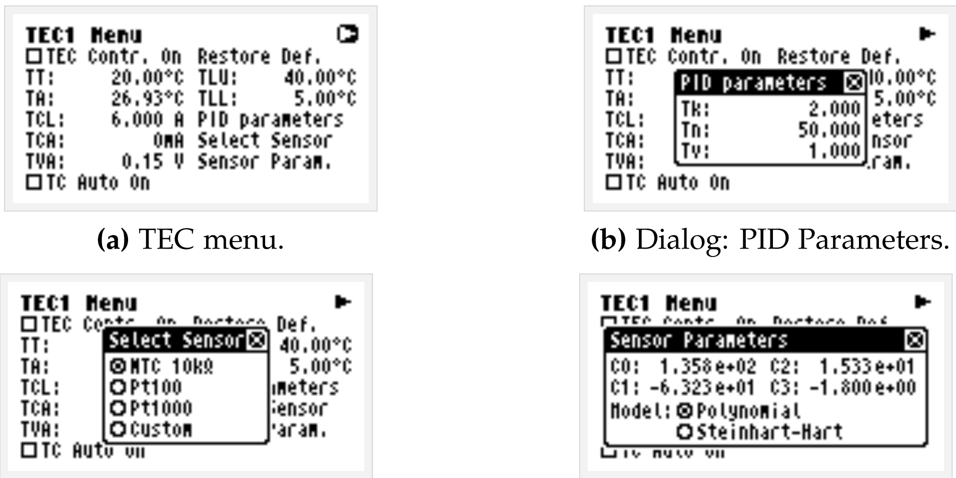
Figure 3.2: Laser menu

3.2.3 TEC Menu

The TEC menu is shown in figure 3.3a. This is where the user can change TEC controller settings. The following fields are included:

TEC Contr. On	switch the TEC controller on and off
TT	target temperature
TA	temperature actual
TCL	TEC current limit
TCA	TEC current actual

`TVA`	TEC voltage actual
`TC Auto On`	TEC controller is automatically activated when the temperature is whithin limits
`Restore Def.`	restores the default settings for the TEC controller
`TLU`	upper temperature limit
`TLL`	lower temperature limit
`PID parameters`	set the PID coefficents (see figure 3.3b)
`Select Sensor`	select one of some predefined temperature sensor settings (see figure 3.3c)
`Sensor Param.`	manually set the temperature sensor settings (see figure 3.3d)



(a) TEC menu.

(b) Dialog: PID Parameters.

(c) Dialog: Select Sensor.

(d) Dialog: Sensor Parameters.

Figure 3.3: TEC Menu and dialogs in it.

3.2.4 Device Menu

The device menu is shown in figure 3.4. This is where the user can change general settings and find out the type and serial number of your device. You find the following fields in this menu:

`External Control on Start`	Switch to external control automatically after power-on. You get the chance to abort this.
`Switch to External Control`	You can control the device over the RS232 interface after activating this.
`Pilot laser`	Switch the pilot laser on and off.
`Intensity`	pilot laser intensity (0. . . 16)

GFD	default fan voltage
Restore Default Settings	Reset all settings in the device to their default values.
Service	Show type, serial number and software version of the device.

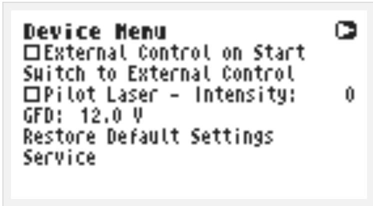


Figure 3.4: Device menu.

4. Hardware Set-Up Preparation

These steps must be followed:

- Make sure that the power supply is disconnected from your main power supply.
- Use an approved personal grounding bracelet or other means for ESD protection during the assembly of the laser or other electronics.
- Connect your laser to the proper connectors of the driver unit.
- Remove the shorting clip from the laser. While turned off, the laser output of the driver unit is internally shorted.
- Connect the power supply unit to the proper supply voltage.
- Make sure that the interlock connector is closed.
- Make sure that the emergency button (the large red button on the front) is unbolted / pulled out.
- Make sure that an appropriate temperature sensor for the laser is connected. **The laser driver needs a temperature signal to active the drive current.**
- Please note laser safety regulations!
- Turn the key switch on.

5. Laser Diode Current

5.1 Preparations

First the laser current limit and the laser compliance voltage must be configured. To adjust the laser current limit using the display:

- go to the `Laser Menu` by pressing [◀] and [●]
- go to the LCL input field by pressing [▶] to adjust the laser current limit
- to move the cursor position press [●] several times
- to increase/decrease the digit press [▲]/ [▼] as often as necessary
- after adjusting the value press [●] to enter the new value

After the step above, the user should adjust the laser compliance voltage (LVC input field) to an expected voltage drop slightly above the laser's rating.

These values can also be set by using the RS232 interface (see chapter 7). To do this use the commands LCL and LVC.

5.2 CW Mode

The mode of operation can be selected in the laser menu. The CW mode is active by default when all of the modulation modes (LMDI, LMDX and LMAX) are unchecked.

5.2.1 Switching on the Laser Diode

Go to the main menu and adjust the laser current target in the LCT input field. The selected value must be under the laser current limit and the maximum operating current of your laser module. Enable the LON/OFF input field to switch on current to the laser. The LED on the front panel will start blinking and the actual current will be displayed. Disabling it switches off the laser and causes the red LED on the front panel to stop blinking. The actual current 0.00 A will be displayed. Pressing the emergency button on the front panel interrupts the power supply immediately. Unbolt it by twisting.

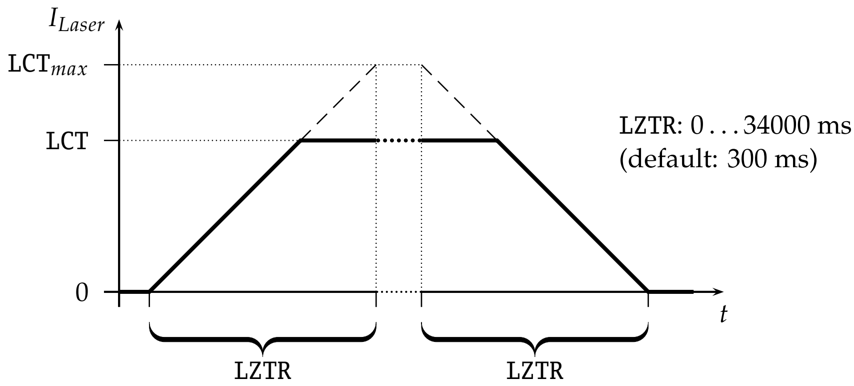


Figure 5.1: Laser current on-off ramp in CW mode. The ramp is active at any change of laser current.

When using the RS232 interface the command LR may be used to switch the laser on. The command LS switches the laser off.

5.2.2 Current Ramp to Laser Current Set-Point

In CW mode the ramp on laser run and stop is activated by default. However, this function is not available over the display menus. To use this feature, you need to control the driver over an RS232 interface. With e. g. LZTR2000 you can set the time to reach the maximum current set-point for you laser diode. The slope of the ramp will be $LCT_{max}/2000$ ms in this example. During the laser stop ramp, you can turn off the laser immediately by sending LS command again. You can disable the ramp with LZTR0. The default value for LZTR is 300 ms. Figure 5.1 shows how LZTR works. For a list of other commands see chapter 9.

5.2.3 Laser APC Power Control Mode

The power control mode is only available in CW mode and consists of two independent parts:

- The photo-current control loop
- The laser power coefficients which do a translation from a power value into a value for the photo-current

To initiate the APC power control you must first prepare the laser for proper operation in CW mode (see section 5.1). Don't forget to adjust the laser current limit.

Before turning the laser diode on you must connect the photo-sensor between the PDC (cathode) and the GND (anode) pins at the laser connector. After this you should test whether the sensor is working. For this step, run the laser and check with the LPCA command (laser photo-current actual). The default maximum photo current is 700 µA, but can be increased on request. Enter your target photo-current with the LPCT command. Initialize the photo-current control mode by the command LPCCR (laser photo current control run). Now you can run and stop the laser by LR and LS. As soon as you start the laser the driver begins continuously to track and control the photo current. The second step is to adjust the power coefficients so that you can use power values in Watts. For this, do as follows:

- adjust the LPT value (laser power target), it should have a typical or a maximum value
- run the laser in normal CW mode and set the current to the point that the laser emits exact the target laser power. An external power meter is necessary for this. Now execute the LPF command to fix the actual photo-current value to this laser power.

You can now you can get the laser power by the command LPA, set the power target by the LPT command, run the power control mode by the LPCCR command. Start and stop the laser by LR and LS.

5.3 Gate Option

There is a gate option which can be used in CW mode as well as in internal digital modulation mode. You may switch on and off the internally generated laser current by the modulation input. Optionally, a separate gate pin may be used. In this case the gate option is also available in the external modulation modes. The gate option is activated by the command LGR and deactivated by LGS. Additionally, the LMDXNR command can be used to negate the modulation input.

5.4 Modulation Modes

The modulation modes can be selected in the laser menu. Changing modulation modes turns off the laser. You may start the laser again the main menu.

Please note that the preparations—as described in section 5.1—have to be done first. In modulation modes the measured currents and voltages displayed in the main

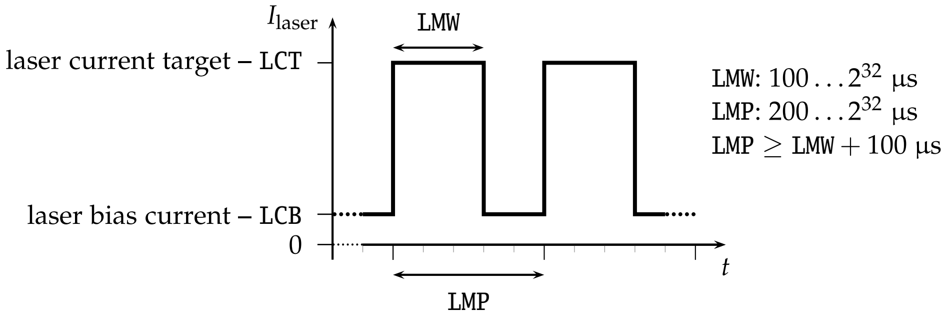


Figure 5.2: continuous pulse mode

menu **show the mean values** not the peak values. These measured values may differ from the adjusted ones caused by the low speed of the AD converter. Don't care about this. The real values are within the limits as described above.

5.4.1 Internal digital modulation mode

The driver is able to modulate the laser current by internally generated pulses. This internal modulation mode may be activated by checking the `LMDI` input field in the laser menu or entering the `LMDIR` command.

Continuous pulse mode

Unless configured otherwise, pulses are generated continuously as you can see in figure 5.2. You have to enter the pulse width (duration) and pulse period in µs. Take care of the right proportions of these values. The pulse width is in the range of 100 µs . . . 4×10^9 µs and may be changed by the `LMW` command. The pulse period (`LMP` command) is in the range of (`LMW` + 100 µs) . . . 4×10^9 µs, so it is always at least 100 µs larger than the pulse width.

Newer devices are not subject to these limitations. Here, `LMW` and `LMP` can be set freely in steps of 1 µs.

You can run and stop the laser by the commands `LR` and `LS`.

Single pulse mode, n-pulses mode

This mode—which is illustrated in figure 5.3—is useful if you want to generate only a single pulse or a certain number of pulses. To activate it first select the internal digital modulation mode as stated above. Then enter the command `LMDIC` *n* where *n* is the number of pulses you want to be generated. After entering the `LR` command

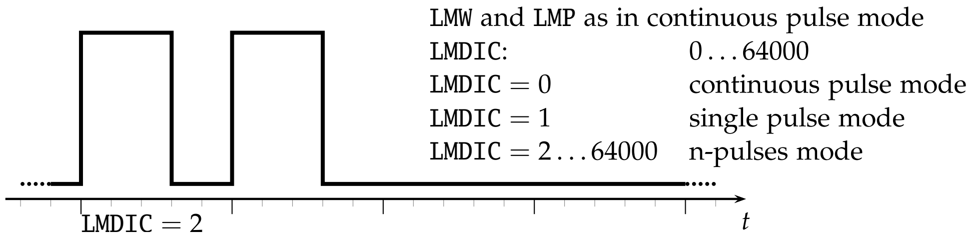


Figure 5.3: single pulse mode, n-pulses mode

the number of pulses will be generated. Afterwards, the driver enters the *OFF state* automatically. You don't need to enter `LS`.

Assigning 0 to `LMDIC` switches to the continuous pulse mode described above.

External trigger mode

To switch to this mode activate the gate option in single pulse mode/n-pulses mode. The gate option (see section 5.3) has a different meaning in this mode. Activating it enables you to trigger the beginning of the generated pulses externally. If `LGR` is activated and `LR` was entered the driver generates the defined number of pulses as soon as a low-high transition at the modulation input occurs.

5.4.2 External Digital Modulation

The external digital modulation mode may be activated by entering the `LMDX` command. If this mode is active and the laser is run (`LR`) then the laser is activated by a TTL high-level at the modulation input and vice versa. The command `LMDXNR` negates this logic so that the laser will be activated by TTL low-level. This mode is similar to the CW mode with the gate option activated. However, in this mode you can set a laser bias current (`LCB`).

5.4.3 External Analog Modulation

The external analog modulation mode is selected by entering the `LMAX` command. In this mode the laser current can be controlled by the voltage at the AMOD input where 4 V corresponds to I_{max}. The compliance voltage (`LVC`) has to be set before and the laser has to be run by `LR`.

The input has an internal terminating resistor of 10 kΩ. If you want to connect e.g. a 10 V signal, you should use a 15 kΩ resistor in series externally.

5.5 Pilot Laser Control

These laser diode drivers support an internal pilot laser. One pin on the laser & peltier connector is reserved for this purpose. In *ON state* a voltage between 4.0 and 5.0 V is applied. The maximum output current is 150 mA. In *OFF state* the output is near 0 V level. With PLR and PLS you can turn the pilot laser *ON* and *OFF*. With the command PP *n* you may set the pulse width modulation value with a base frequency of 62 Hz. The modulation parameter *n* can take values between 0 and 16. The meaning of those values is as follows:

$n = 0$	pilot laser OFF
$n = 1$	duty cycle 6.25 % - ON duration 16 ms
$n = 2$	duty cycle 12.5 % - ON duration 32 ms
...	...
$n = 16$	pilot laser ON

6. TEC Controller and Temperature Sensors

As some models may have more than one TEC controller, the temperature sensor or TEC controller is selected by a prefix, in this chapter written as x. So, x has to be replaced by a digit (or letter) to select the temperature sensor or TEC. The first temperature sensor or TEC corresponds to `1`, the second to `2`, the third to `3` and so on. As the first temperature sensor or TEC is usually used for a laser and the second for a crystal, a deprecated option for selecting them is the use of the letters `L` and `C`, respectively.

6.1 PID Controller Parameters

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

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

k_p	– proportional gain	– x`TCCK`
$T_n = T_i$	– integral time	– x`TCCN`
$T_v = T_d$	– derivative time	– x`TCCV`

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:

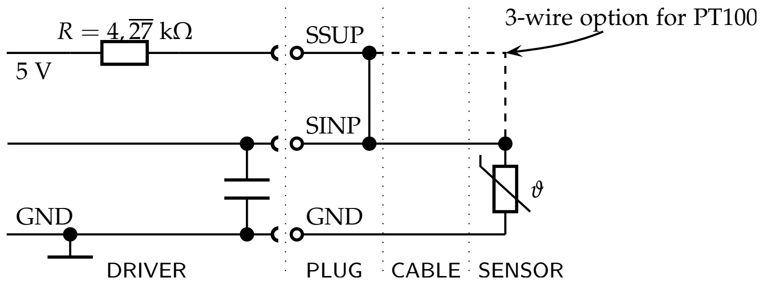


Figure 6.1: schematic for connecting a temperature sensor

$$
\begin{aligned}
x\text{TCCK}: &\quad 0.2\ldots5\\
x\text{TCCN}: &\quad 5\ldots50\\
x\text{TCCV}: &\quad 0.2\ldots2
\end{aligned}
$$

If you don't know anything about the TEC circuit, you may set *x*TCCK = 0.2, *x*TCCN = 2 and *x*TCCV = 0.1. Then increase *x*TCCK slowly by 1 as long as the circuit stays stable. When it becomes unstable, half the *x*TCCK value. Here the controller is operating primarily as "P" proportional controller. After this try to find the value for *x*TCCN in the same way. However, you may increase it by larger steps. At this point, the controller behaves like a "PI" controller. Finally, you may increase *x*TCCV by steps of 0.3 until you find an optimum value for response time and eliminate overshooting.
Note that you must stop and restart the temperature controller after changing those values to make sure that the controller is initialized with the new values.

6.2 Temperature Sensor

The temperature sensor is connected over three pins of the laser & peltier interface: GND, SINP and SSUP. The schematic in figure 6.1 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. In newer models, the SSUP and SINP are connected internally. Only the pins SINP and GND are available externally.

The temperature is calculated by measuring the voltage using a voltage divider. After a 24 bit AD conversion the temperature T is calculated from the measured voltage V. For this purpose the Steinhart-Hart equation is used by default.

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

The 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 *x*TSC [0 . . . 3].

Additionally, the driver can be set to calculate the temperature using the following third-order polynomial:

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

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

The coefficients for some common sensors are given in the table below.

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:

	*x*TSC0	*x*TSC1	*x*TSC2	*x*TSC3
polynomial model (xTSM0)				
NTC 10 kΩ B3980	135.83	−63.2256	15.3332	−1.80043
NTC 10 kΩ B3450	156.089	−74.4317	17.5466	−1.99111
PT100 TK3850	−266.475	2330.44	0	0
PT1000 TK3850	−327.084	344.924	0	0
AD590 (1 µA/K)	−897.065	−234.043	0	0
Steinhart-Hart equation (xTSM1)				
NTC 10 kΩ B3980	−273.15	$1.0832 \cdot 10^{-3}$	$2.4141 \cdot 10^{-4}$	$6.505 \cdot 10^{-8}$
NTC 10 kΩ B3450	−273.15	$1.1293 \cdot 10^{-3}$	$2.3411 \cdot 10^{-4}$	$8.7755 \cdot 10^{-8}$

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 xTSC0.

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.

7. Remote Control

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

7.1 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 on 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 14 characters.

sent command:	`LCT222.3` CR	every character is returned
received answer:	`Laser Current Target: 222.3 mA` CR	verbose answer

7.2 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:	`LCT222.3` CR	every character is returned
received answer:	`222.3` CR	short answer

For a single command this mode can be reached by simply adding the prefix `R`. So `LCT222.3` would become `RLCT222.3`. To switch to this mode permanently use the command `GMS32768`. The command `GMC32768` switches back to standard mode.

7.3 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.

sent command:	`LCT222.3` 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

7.4 Software

At `http://www.ostech.de` you may download software to interact with OsTech devices.

- the terminal program *OSTERM*
- LabVIEW™ VIs, including a runtime version

Sample routines in C and C++ are also available on request.

8. Error Codes

When an error occurs, the driver generates an error code. The error code can be determined by the GE command. Furthermore, the error is shown on the display. A list of error codes and their causes follows:

error code	cause
0	no error
1	interlock open
2	laser compliance voltage not acceptable or no laser connected
3	internal supply voltage not acceptable
4	laser temperature sensor open
5	crystal temperature sensor open
6	laser temperature exceeds upper limit
7	laser temperature lower than lower limit
8	laser short-circuit or no laser connected
9	device temperature (GT) too high
10	laser temperature exceeds maximum laser temperature (LTM)
11	crystal temperature exceeds upper limit
12	crystal temperature lower than lower limit
16	laser current greater than maximum current limit (LCLM)
17	current error
18	total power limit exceeded

9 Command References

9.1 Laser Commands (L)

cmd	type	min	max	default	unit	description
L	bool	S	R	S		laser stop/run
LTM	float	−99	200	35	°C	laser temperature maximum
LG	bool	S	R	S		gate option

9.1.1 Laser Current Commands (LC)

cmd	type	min	max	default	unit	description
LCL	float	0	$I_{max} + 5\%$	$I_{max} + 5\%$	mA	current limit
LCT	float	0	I_{max}	0	mA	current target
LCA	float		— *no parameter* —		mA	actual current
LCB	float	0	I_{max}	0	mA	base or bias current

9.1.2 Laser Coltage Commands (LV)

cmd	type	min	max	default	unit	description
LVA	float		— *no parameter* —		V	actual laser voltage
LVC	float	1.3	6	3	V	compliance voltage

9.1.3 Laser Photo-Current (LPC) and Power (LP) Commands

cmd	type	min	max	default	unit	description
LPCA	float		— *no parameter* —		µA	laser photo current actual
LPCT	float	0	20	0	µA	laser photo current target
LPCC	bool	S	R	S		laser photo current control
LPA	float		— *no parameter* —		W	laser power actual
LPT	float	0		0	W	laser power target
LPF	bool		— *no parameter* —			laser power fix procedure

9.1.4 Laser Modulation Commands (LM)

cmd	type	min	max	default	unit	description
LMDI	bool	S	R	S		internal digital modulation
LMDX	bool	S	R	S		external digital modulation
LMAX	bool	S	R	S		external analog modulation
LMW	float	100	1000000	1000	µs	pulse width
LMP	float	LMW + 100	600000000	2000	µs	pulse period
LMDIC	word	0	65534	0		number of pulses
LMDIO	word	0	65534	0		number of suppressed pulses
LMDXN	bool	R	S	S		negate modulation input

9.1.5 Laser Sequencer Commands (LZ)

The LZTR command is available in every laser driver:

cmd	type	min	max	default	unit	description
LZTR	float	300	34000	300	ms	ramp time (refers to I_{max})

The following commands are optionally available on request:

cmd	type	min	max	default	unit	description
LZR	bool		— *no parameter* —		ms	sequencer run (stop with LS)
LZP	word				ms	sequencer point select
LZPT	word				ms	subsequence time (duration)
LZPC	float				ms	subsequence current (end)

9.1.6 Pilot Laser Commands (P)

cmd	type	min	max	default	unit	description
PL	bool	S	R	S		pilot laser stop/run
PP	word	0	16	0		pilot laser modulation

9.2 Temperature Sensor and TEC Commands (xT)

In these commands x has to be replaced by a digit (or letter) to select the temperature sensor or TEC. The first temperature sensor or TEC corresponds to 1, the second to 2, the third to 3 and so on.

As the first temperature sensor or TEC is usually used for a laser and the second for a crystal, a deprecated option for selecting them is the use of the letters L and C, respectively.

9.2.1 Temperature Sensor Commands

In new firmware versions the sensor commands are also available with prefix nS instead of xT where n corresponds to the number of the temperature sensor.

cmd	type	min	max	default	unit	description
xTA	float		— *no parameter* —		°C	actual temperature
xTLU	float	−99	200	40	°C	upper temperature limit
xTLL	float	−99	200	0	°C	lower temperature Limit
xTSCk	float			NTC B3980		sensor coefficients, $k = 0 \ldots 3$
xTSM	word	0	1	0		sensor approximation model ▪ 0: polynomial model ▪ 1: Steinhart-Hart equation

9.2.2 TEC Commands

cmd	type	min	max	default	unit	description
xTC	bool	S	R	S		temperature controller stop/run
xTT	float	−99	200	20	°C	temperature target
xTCA	float		— *no parameter* —			actual current
xTCL	float	0	$I_{P_{max}}$	$I_{P_{max}}$	mA	current limit
xTVA	float		— *no parameter* —		V	actual voltage
xTCCK	float	0	255	2		PID parameter: gain factor
xTCCN	float	0	255	60	s	PID parameter: reset time
xTCCV	float	0	99	1	s	PID parameter: rate time

9.3 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)

cmd	type	min	max	default	unit	description
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

9.3.1 Status Commands

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

9.3.2 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

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