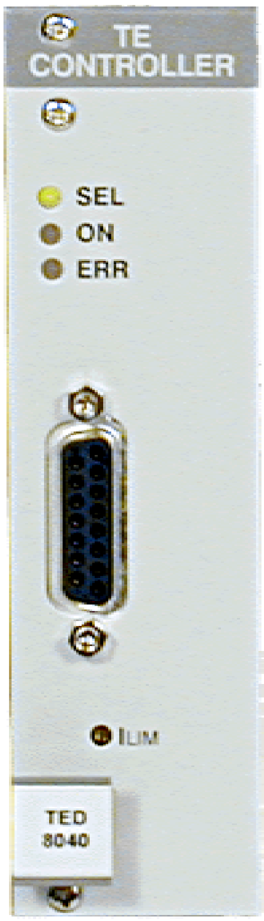
Operation Manual

Thorlabs Blueline™ Series

PRO8000 (-4) / PRO800

Temperature module TED8xxx



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We aim to develop and produce the best solution for your application in the field of optical measurement technique. To help us to come up to your expectations and develop our products permanently we need your ideas and suggestions. Therefore, please let us know about possible criticism or ideas. We and our international partners are looking forward to hearing from you.
In the displays shown by the PRO8 you may find the name PROFILE.
PROFILE was the name of the manufacturer before it was acquired by Thorlabs and renamed to Thorlabs GmbH.

Thorlabs GmbH

This part of the instruction manual contains every specific information on how to operate a temperature module TED8xxx. A general description is followed by explanations of how to operate the unit manually. You will also find every information about remote control via the IEEE 488 computer interface.

☝Attention☝

This manual contains "WARNINGS" and "ATTENTION" label in this form, to indicate dangers for persons or possible damage of equipment.

Please read these advises carefully!

NOTE

This manual also contains "NOTES" and "HINTS" written in this form.

1 General description of the temperature module TED8xxx

1.1 Safety

☝ Attention ☝

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly.

Before applying power to your PRO8000 (-4) / PRO800 system, make sure that the protective conductor of the 3 conductor mains power cord is correctly connected to the protective earth contact of the socket outlet!
Improper grounding can cause electric shock with damages to your health or even death!

Modules may only be installed or removed with the mainframe switched off.

All modules must be fixed with <u>all</u> screws provided for this purpose.

Modules of the 8000 series must only be operated in the mainframe PRO8000, PRO8000-4 or PRO800.

All modules must only be operated with duly shielded connection cables.

Only with written consent from Thorlabs may changes to single components be carried out or components not supplied by Thorlabs be used.

This precision device is only dispatchable if duly packed into the <u>complete</u> original packaging including the plastic form parts. If necessary, ask for a replacement package.

☝ Attention ☝

Semiconductor laser modules can deliver up to several 100mW of (maybe) invisible laser radiation!

When operated incorrectly, this can cause severe damage to your eyes and health!

Be sure to pay strict attention to the safety recommendations of the appropriate laser safety class!
This laser safety class is marked on your PRO8000 (-4) / PRO800 plug-in module or on your external laser source used.

☝ Attention ☝

Mobile telephones, handy phones or other radio transmitters are not to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to EN 50 082-1.

1.2 Warranty

Thorlabs GmbH warrants material and production of the TED8xxx modules for a period of 24 months starting with the date of shipment. During this warranty period *Thorlabs GmbH* will see to defaults by repair or by exchange if these are entitled to warranty.
For warranty repairs or service the unit must be sent back to *Thorlabs GmbH (Germany)* or to a place determined by *Thorlabs GmbH*. The customer will carry the shipping costs to *Thorlabs GmbH,* in case of warranty repairs *Thorlabs GmbH* will carry the shipping costs back to the customer.
If no warranty repair is applicable the customer also has to carry the costs for back shipment.
In case of shipment from outside EU duties, taxes etc. which should arise have to be carried by the customer.

Thorlabs GmbH warrants the hard- and software determined by *Thorlabs GmbH* for this unit to operate fault-free provided that they are handled according to our requirements. However, *Thorlabs GmbH* does not warrant a faulty free and uninterrupted operation of the unit, of the soft- or firmware for special applications nor this instruction manual to be error free. *Thorlabs GmbH* is not liable for consequential damages.

Restriction of warranty

The warranty mentioned before does not cover errors and defects being the result of improper treatment, software or interface not supplied by us, modification, misuse or operation outside the defined ambient conditions (refer to the PRO8000 (-4) / PRO800 mainframe operation manual) stated by us or unauthorized maintenance.

Further claims will not be consented to and will not be acknowledged. *Thorlabs GmbH* does explicitly not warrant the usability or the economical use for certain cases of application.

Thorlabs GmbH reserves the right to change this instruction manual or the technical data of the described unit at any time.

1.3 Features

1.3.1 Safety measures for the TEC element

To protect the connected TEC element the laser diode control system PRO8000 (-4) / PRO800 includes the following protection circuits:

- **Limit of the TEC current (hardware- and software limit) in all operating modes**
  Protection against thermal destruction.

- **Protection of the sensor**
  Protection against use of incorrect temperature sensors / protection against line interruption of the temperature sensor.

- **Contact protection of the TEC element (open circuit)**
  Protection against cable damage, bad contact or TEC element with too high resistance.
  The output remains switched on since a wrong TEC element is still cooling and can protect the laser diode.

- **Separate on/off function for each module**
  Protection against operating errors.

- **Control LED for TEC current on**
  Protection against accidental turning off the cooling.

- **Separate over-temperature protection for each module**
  Protection against thermal failure of the module.

- **Mains filter**
  Protection against line transients or interference’s.

- **Line failure protection**
  In case of power failure or line damage the temperature control and the laser must explicitly be switched on anew since it cannot be taken for granted that all components of the measurement set-up are still working faultlessly.

- **Key-operated power switch**
  Protection against unauthorized or accidental use.

- **LabVIEW®- and LabWindows/CVI®-driver**
  For the PRO8000 (-4) / PRO800 *Thorlabs GmbH* supplies LabVIEW®- and LabWindows/CVI®-drivers for MS Windows 32.

  Please refer to our homepage for latest driver updates.
  http://www.thorlabs.com

1.3.2 General functions

The temperature modules TED8xxx , TED8xxx-PT and TED8xxx-Kryo operate similar, however they differ regarding maximum current, accuracy and resolution.
➔ (Refer to chapter 1.4, "Technical data" on page 7)

All normal modules have an input for IC temperature sensors of the AD590/592 or LM335 series as well as an input for thermistors. With thermistors two resistance ranges can be used (maximum resistance 20kΩ or 200kΩ).
The TED8xxx-PT has an input for thermistors and PT-100 sensors.
The TED8xxx-Kryo only has an input for a PT-1000 sensor (2 temperature ranges).

All necessary value settings are done by the mainframe operating elements (keypad and rotational encoder) or via remote control by a computer. Only the TEC current limit (hardware limit) has to be set manually as "absolute limit".
In an automated test set-up for different laser diodes no manual settings are required.

The set values for the temperature or the thermistor resistance have 16 bits resolution. The limit value for the TEC current (software limit) is set with 12 bit. The read back of actual temperature and actual resistance has 16 bit resolution, the read back of TEC current, TEC voltage and the limit for the TEC current (hardware limit) 15 bit plus sign.

The P-, I- and D-share of the analog control loop are set with three independent 12 bit D/A converters.

The built-in mains filter in the mainframe and the careful shielding of the transformer, the micro processor and the module itself provides an excellent suppression of noise and ripple.

1.4 Technical data

(All technical data are valid at 23 ± 5°C and 45 ±15% humidity)

1.4.1 Common data TED8xxx

AD590/LM335

Control range	-12.375 °C ... +90.000 °C
Calibration	2-point linearization
Measurement accuracy	0.1 °C
Measurement resolution	0.0015 °C
Accuracy	±0.1 °C
Setting resolution	0.025 °C
Temperature stability (typ.)	< 0.002 °C

Thermistor (calibrated and not calibrated, display in Ω)

Measurement current	100 µA/10 µA[1)]
Control range	5 Ω ... 20 kΩ / 50 Ω ... 200 kΩ[1)]
Resolution	0,3 Ω / 3 Ω [1)]
Setting accuracy	± 2.5 Ω / 25 Ω [1)]
Resistance stability	typ. < 0.5 Ω / 5 Ω[1)]

Thermistor (calibrated, display in °C)

Measurement current	100 µA/10 µA[1)]
Control range	temperature at 20 kΩ / 200 kΩ ... 150 °C[2)]
Resolution	[2)]
Setting accuracy	[2)]
Temperature stability	[2)]

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[1] depending on the selected range (20 kΩ / 200 kΩ)

[2] depending on thermistor data

Temperature-control-loop

	PID, analog
P-, I-, and D-share	to be set separately
Setting range	0.1 ... 100 %
Setting resolution	12 Bit

PT100 (Option)

Control range	-12.375 °C ... +90.000 °C
Measurement accuracy	± 0.3 °C
Measurement resolution	0.0015 °C
Accuracy	± 0.3 °C
Temperature stability	typ<. 0.005 °C

Temperatures

Operating temperature	0 … +40 °C
Storage temperature	-40 … +70 °C

Connector

	15 pin D-Sub (f)

1.4.2 Technical data TED8xxx-Kryo (option)

PT-1000 Sensor

Measurement current	1 mA / 400 µA[1)]
Control range	20 K... 310 K[1)]
Resolution	(20 … 155 K) 2 mK [1)]
Accuracy	2 K [1)], ±0.5 K [2)]
Temperature stability typ	(20 … 155 K) 0.005 K

[1)] depending on selected range (low / high)

[2)] after applying correction factors according to Figure 12

1.4.3 TED8020

Current output TEC element	
Control range	- 2 A ... + 2 A
Maximum output power	16 W
Compliance voltage	> 8 V
Measurement resolution I_{TE}	0.07 mA
Measurement accuracy I_{TE}	± 5 mA
Measurement resolution U_{TE}	0.3 mV
Measurement accuracy U_{TE}	± 20 mV
Noise and ripple	< 1 mA
Current limit	
Setting range	0 ... ≥ 2 A
Accuracy	± 20 mA
Resolution D/A Converter	0.5 mA
Width	1 slot
Weight	< 500 g

1.4.4 TED8040

Current output TEC element	
Control range	- 4 A ... + 4 A
Maximum output power	32 W
Compliance voltage	> 8 V
Measurement resolution I_{TE}	0.15 mA
Measurement accuracy I_{TE}	± 10 mA
Measurement resolution U_{TE}	0.3 mV
Measurement accuracy U_{TE}	± 20 mV
Noise and ripple	< 2 mA
Current limit	
Setting range	0 ... ≥ 4 A
Accuracy	± 40 mA
Setting accuracy (software)	1 mA
Width	1 slot
Weight	< 600 g

1.4.5 TED8080

Current output TEC element	
Control range	- 8 A ... + 8 A
Maximum output power	64 W
Compliance voltage	> 8 V
Measurement resolution I_{TE}	0.3 mA
Measurement accuracy I_{TE}	± 25mA
Measurement resolution U_{TE}	0.3 mV
Measurement accuracy U_{TE}	± 20 mV
Noise and ripple	< 4 mA

Current limit	
Setting range	0 ... ≥ 8 A
Accuracy	± 80 mA
Setting accuracy (software)	2 mA
Width	2 slots
Weight	< 700 g

1.5 Operating elements on front panel

1.5.1 The TED8xxx module

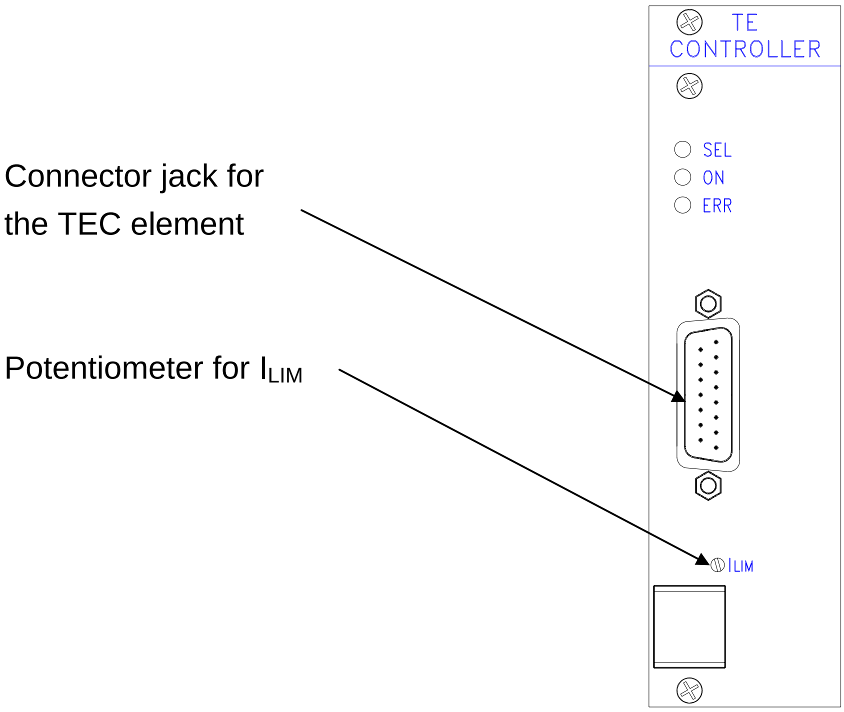


Figure 1 The front panel of the TED8xxx module

NOTE

This picture is valid for all temperature modules with one slot width.

The module TED8080 with 8 A TEC current is of double width.

1.5.2 The TED8080 module

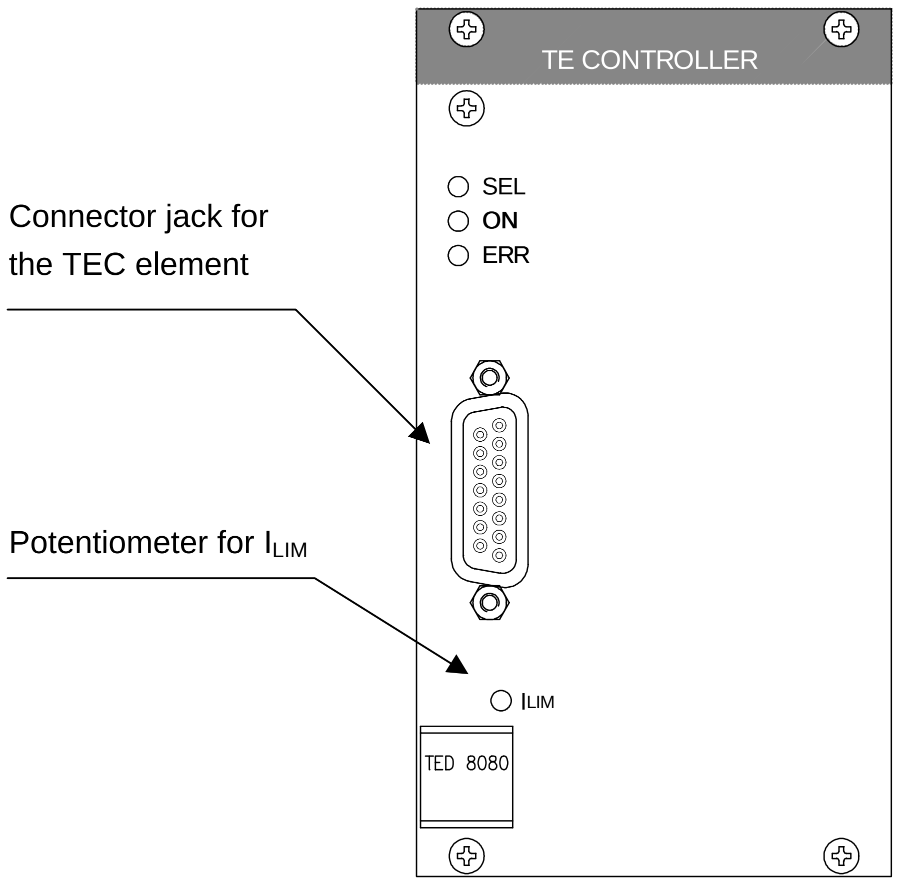


Figure 2 The front panel of the TED8080 module

1.6 Pre-settings

1.6.1 Setting the limit values

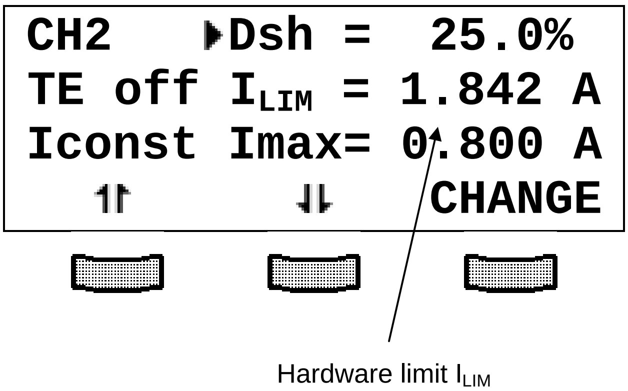
To protect the TEC element the maximum delivered current may be limited.
Two limit values will be possible: hardware limit and software limit.

Hardware limit I_{LIM}

The hardware limit I_{LIM} is set with the potentiometer I_{LIM} at the front of the module TED8xxx.

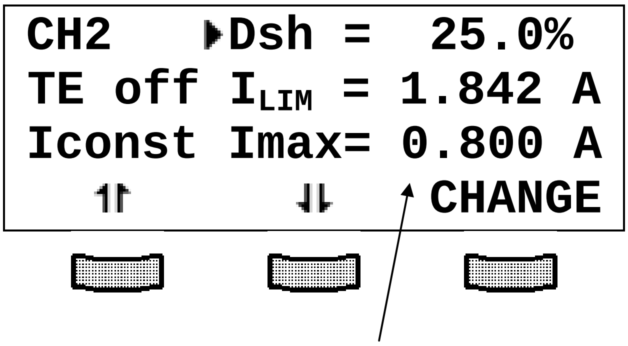
➔ (See section 1.5, "Operating elements on front panel" on page 11)

The value is displayed continually in the channel menu of the module so you can watch it during adjustment:



Software limit I_{MAX}

The software limit I_{MAX} is set or changed manually in the channel menu of the module or with a control computer via IEEE 488 interface.



Software limit I_{MAX}

The software limit I_{MAX} effects the current regulation of the module via D/A converters and yields exactly the same protective function as the hardware limit.

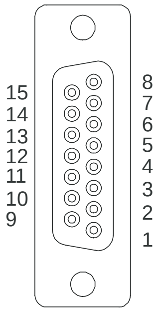
➔ (Refer to chapter 2.2.2, "Changing parameters" starting on page 31)

NOTE

The lower value of the two limits I_{MAX} and I_{LIM} will limit the TEC current.

1.7 Connecting components

1.7.1 Pin assignment TED8xxx

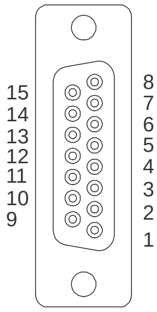


(female 15-pole D-SUB)

Figure 3 TED8xxx pin assignment

Pin	**Connector**
	TEC element
5,6,7	TEC element +
13,14,15	TEC element - (ground)
2	Voltage detector TEC element +
9	Voltage detector TEC element -
	Status display
1	Status-LED anode
8	Status-LED cathode (ground)
	Temperature sensor
3	Thermistor - (ground)
4	Thermistor +
10	AD590 -
11	AD590 +
12	leave open

1.7.2 Pin assignment TED8xxx-PT

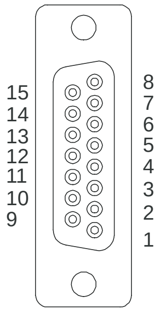


(female 15-pole D-SUB)

Figure 4 TED8xxx-PT pin assignment

Pin	**Connector**
	TEC element
5,6,7	TEC element +
13,14,15	TEC element - (ground)
2	Voltage detector TEC element +
9	Voltage detector TEC element -
	Status display
1	Status-LED anode
8	Status-LED cathode (ground)
	Temperature sensor
3	PT-100 current source - (ground)
4	PT-100 current source +
10	Voltage measurement input -
11	Voltage measurement input +
12	leave open

1.7.3 Pin assignment TED8xxx-Kryo



(female 15-pole D-SUB)

Figure 5 TED8xxx pin assignment

Pin	Connector
	Heater element
5,6,7	Heater element +
13,14,15	Heater element - (ground)
2	Voltage detector heater element +
9	Voltage detector heater element -
	Status display
1	Status-LED anode
8	Status-LED cathode (ground)
	Temperature sensor
3	PT-1000 current source - (ground)
4	PT-1000 current source +
10	Voltage measurement input -
11	Voltage measurement input +
12	leave open

We recommend to use separate lines drilled in pairs (twisted pair) in a common shield for TEC current and temperature sensor. The shield has to be connected to ground (pin 13,14,15).

1.7.4 Connecting a thermistor

The thermistor is connected between pin 3 and pin 4.

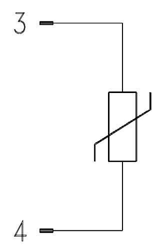


Figure 6 Connecting a thermistor

1.7.5 Connecting an AD590

The IC-temperature sensor AD590 is connected between pin 10 (-) and pin 11 (+).

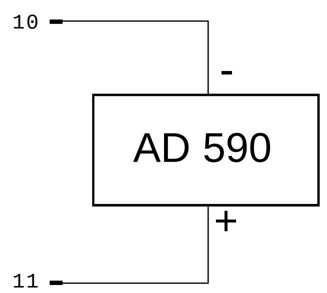


Figure 7 Connecting an AD590

1.7.6 Connecting an LM335

The IC-temperature sensor LM335 is connected between pin 10, pin 11 (+) and pin 8 (-).

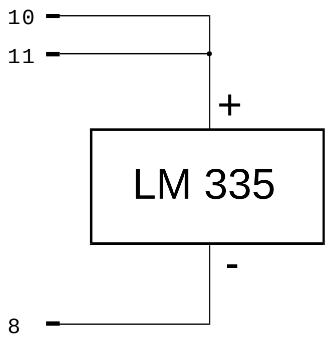


Figure 8 Connecting an LM335

1.7.7 Connecting a PT-100 or PT-1000 sensor (option PT or Kryo)

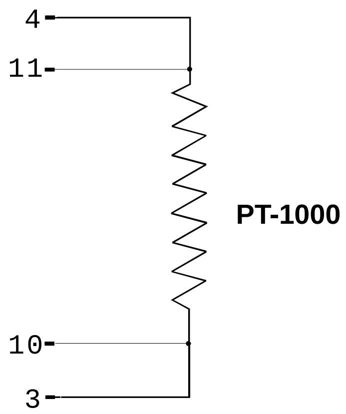


Figure 9 Connecting a PT-100 or PT-1000 sensor (option PT or Kryo)

Pin 3 and 4 of the D-Sub-Connector are the current source, Pin 10 and 11 are the voltage-measurement input-pins for the 4-wire measurement setup.

One connector of the sensor has to be connected to pin 4 and 11 while the other connector goes to pin 3 and 10.
Pin 3 is connected to common ground via a 10 Ω resistor.

What in case of a faulty sensor

The measurement input (Pin 10 and 11) is connected internally to the output of the current source (Pin 3 and 4) via a 1 kΩ resistance.

Therefore the following behavior can be expected with a faulty sensor:

- No sensor connected
  Error message „no sensor“, the display shows the upper range limit for actual resistance or actual temperature. The output cannot be activated.

- Pin 10 and / or Pin 11 are not connected.
  The resistance measurement is done as 2-wire measurement, the resistances of cable and connectors are included in the measurement.
  The temperature control works at normal conditions.
- Pin 3 and / or Pin 4 are not connected
  The resistance measurement is done as 2-wire measurement, the resistances of cable and connectors are included in the measurement.
  The temperature control works at normal conditions.

1.7.8 Connecting TEC elements with voltage detector

The TEC element is connected between pins 5,6,7 (plus pole) and pins 13,14,15 (minus pole). For a 4-point measurement of the TEC voltage connect the TEC element to pin 2 and 9 to measure the voltage directly at the TEC element.

Pin 2 and pin 9 may also be connected directly to the plug at the temperature module (i.e. pin 2 with pin 5,6,7 and Pin 9 with pin 13,14,15), but this may lead to a measurement error due to a voltage drop in the lines to the TEC element. The indicated voltage will then be slightly higher.

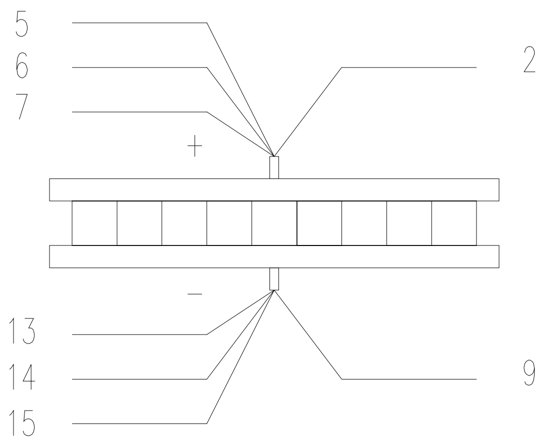


Figure 10 4-pole measurement of TEC voltage

☝ Attention☝

An reverse poled TEC element may lead to thermal runaway and destruction of the connected components.

➔ Refer to section 1.7.9, ”Polarity check of the TEC element” starting on page 22)

1.7.9 Polarity check of the TEC element

Pre-settings

- Connect TEC element and temperature sensor. The sensor must be in good thermal contact to the active surface of the TEC element.
- Switch on the PRO8000 (-4) / PRO800 system.
- Select the TED8xxx module.
- Select the correct type of sensor
- Set the correct value for I_{MAX}

Polarity check of the TEC element

- Observe T_{ACT} (or R_{ACT}) and switch on the module by pressing the key ”ON/OFF”.

➔ If T_{ACT} (or R_{ACT}) runs away from T_{SET} (or R_{SET}), the TEC element is reverse poled. Change polarity and repeat the procedure.

➔ If T_{ACT} (or R_{ACT}) is oscillating around the value T_{SET} (or R_{SET}) the TEC element is connected correctly, but the P-, I- and D-share values of the control loop are still incorrect.

➔ (Refer to chapter 1.8.2, "PID adjustment" starting on page 24)

➔ If T_{ACT} (or R_{ACT}) is settling properly to the value T_{SET} (or R_{SET}) the TEC element has been connected correctly, the values for the P-, I- and D-share of the control loop might still be improved.

1.7.10 Connecting the status display

To display the operating status a standard LED may be used between pin 1 and pin 8. The LED will light up if the current output is switched on.

1.8 Optimization of temperature control

1.8.1 Principle set-up and function

When diode laser systems are tempered mainly the following components are involved:

- The laser diode to be tempered
- A temperature sensor (thermistor / AD590 / LM335)
- A heat source or heat sink (air or water / cooling element)
- A heat conductor connecting the laser diode to the source/sink (copper, aluminum)
- A "propulsion" to lead the flow of temperature (TEC element)

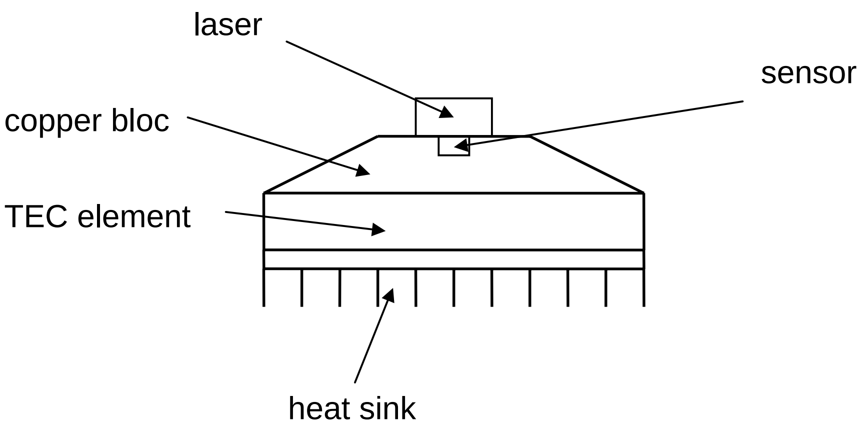


Figure 11 Principle set-up of laser temperature control

<u>Influences on the real temperature control loop</u>

1: Offset and gain errors of the sensor allow only an estimate of the laser temperature.
The sensor is never fixed directly to the laser chip to measure its “real” temperature. The inhomogeneous temperature in the copper bloc will influence the measurement. Even within the laser chip you will find a temperature gradient.
Possible optimization: calibration of sensor

2. If the internal power dissipation in the laser changes (e.g. the laser current is changed) also the temperature gradient between laser and sensor will change. This results in a measurement error depending on the mechanical set-up laser/sensor. Slow changes of the ambient temperature, however, will be compensated well by the control loop since the retroaction of the air on the laser diode can be neglected.
   Possible solution: optimized thermal design

3. The transient response by setting a new temperature is limited since the heat transport in the copper bloc is relatively slow. Furthermore, the temperature slope in the copper must stabilize anew. The sensor must settle to the laser temperature - it also has a non negligible heat capacity.
   Possible optimization: careful adjustment of PID parameters

1.8.2 PID adjustment

Temperature control loops are comparatively slow with control oscillations in the Hertz range.

The PID adjustment will optimize the dynamic behavior. With the TED8xxx the three parameters P, I and D can be set independently from 0.1% to 100%.

Example of a PID adjustment

(Pre-conditions: All limit values have been set correctly, all polarities are correct, all set and relevant calibration values are entered, ambient temperature is about 20°C)

- Switch off the I-share.

- Set the P-, I- and D-share to 1%.

➔ (refer to section 2.2.9 ,"Setting the P-, I- and D-share of the control loop" on page 38)

- Switch on the output and observe the temperature.

P-share

- Change repeatedly between set temperatures of 18 °C and 22 °C while observing the settling behavior of the actual temperature.
  Increase the P-share gradually. Higher values will increase the settling speed, to high values make the system oscillate.
  The P-share has been set correctly when the actual temperature remains stable near the set temperature after only 2-3 overshoots.

D-share

- Change repeatedly between set temperatures of 18 °C and 22 °C while observing again the settling behavior of the actual temperature.
  Increase the D-share gradually. Higher values will decrease the amplitude of the overshoots.
  The D-share is set correctly when the actual temperature remains stable near the set temperature after a minimum of overshoots.

I-share

- Turn on the I-share again.

- Again change repeatedly between set temperatures of 18 °C and 22 °C.
  Increase the I-share gradually. Higher values will accelerate the settling to the set temperature.
  The I-share is set correctly when the actual temperature reaches the set temperature in shortest time without overshoots.

2 Operating the TED8xxx

➔ Before switching on the TEC current please refer to chapter 1.6, "Pre-settings" on page 13

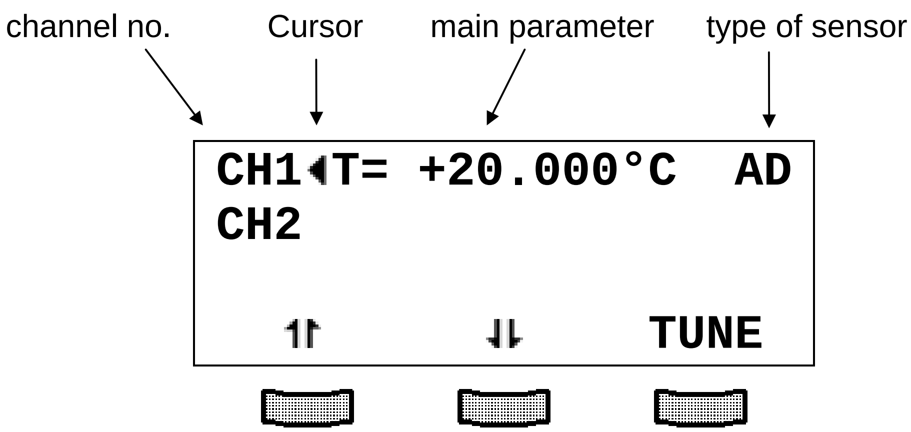
NOTE

With modules of the TED8xxx series all settings are executed at once. It is not necessary to confirm the set values.

2.1 Functions in the main menu

2.1.1 Display

The main menu shows the channel number, the main operating parameter and the type of sensor of the TED8xxx module.



With the module switched OFF the main parameter is the set temperature.

With the module switched ON (LED “ON” lights up on the front of the module) the main parameter is the actual temperature.

NOTE

Even with a thermistor as temperature sensor the "temperature" is shown in °C. If the thermistor is not calibrated, the displayed temperature may be absolutely wrong.

2.1.2 Selecting a module

Select a module for further input by setting the cursor to the channel number of the desired module with the softkeys ⇈ or ⇊ .

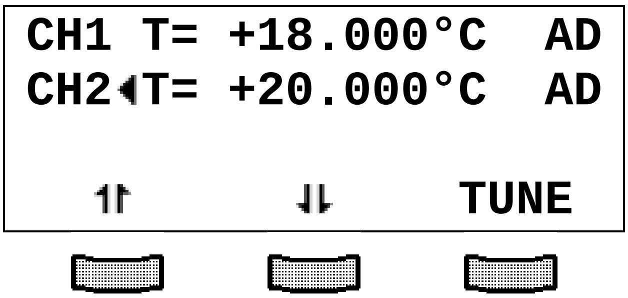
CH4◂

Pressing [CHANNEL] will lead to the channel menu

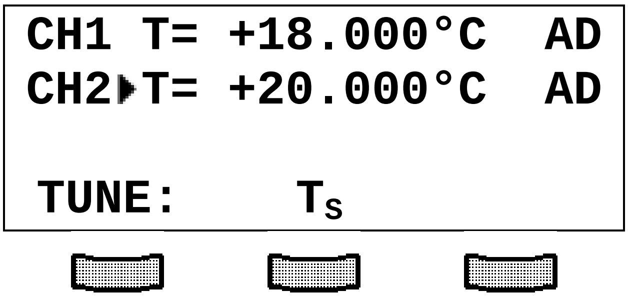
➔ (Refer to chapter 2.2, "Functions in the channel menu" starting on page 29)

2.1.3 Setting the temperature

To change the set temperature in the main menu the corresponding module is selected with the cursor (here: CH2):



Pressing the key **(TUNE)** will turn the cursor to the right:



The temperature can be adjusted by means of the tuning knob.
Press ESC to make the new settings valid.

NOTE

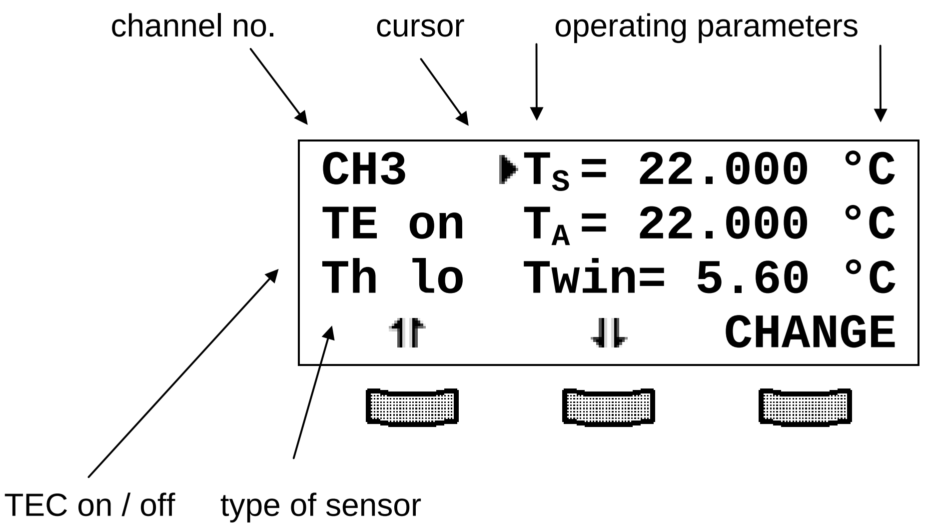
If the TEC current is switched ON, the actual temperature is displayed. In this case the set temperature can still be changed but is not displayed.

2.2 Functions in the channel menu

The channel menu is reached from the main menu by pressing CHANNEL.
Hit again CHANNEL or ESC to return to main menu.

2.2.1 Display

In the channel menu all parameters of the selected module are shown:



Only three parameters can be shown at a time, so there is a scroll function. All parameters are sorted in a virtual list, which can be run through with the cursor:

T_S = 22.000 °C
T_A = 22.000 °C
Twin= 5.60 °C
Ite =-0.799 A
Ute =-1.950 V
Psh = 20.0%
Ish = 20.0%
Ishare = off
Dsh = 20.0%
I_{LIM} = 1.999 A
Imax= 0.800 A

further lines follow if "Thermistor, Pt100, Kryo or AD590" is chosen (see next page)

Thermistor	Pt100	Kryo	AD590
Thermistor	**PT100**	**low range**	**AD590**
Th.range=low	**Rs=100.00 Ω**	**Rs=300.00 Ω**	
Exponential	**Ra=100.25 Ω**	**Ra=298.45 Ω**	
R_S = 9.1234 kΩ	**Rwin=10.50 Ω**	**Rwin=10.50 Ω**	
R_A = 9.1234 kΩ			
Rwin=6.1234kΩ			
R0= 10.000 kΩ			
B = 3900.0			
T0= 25.000 °C			
C1= 1.1234E-3			
C2= 2.1234E-4			
C3= 3.1234E-6			

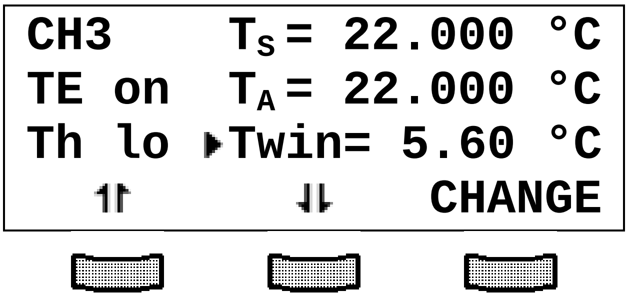
The field "type of sensor" shows:

AD590	If the sensor is an AD590 or LM 335 or equ.
Th lo	If the sensor is a thermistor (20 kΩ max)
Th hi	If the sensor is a thermistor (200 kΩ max)
PT100	If the sensor is a PT100 (PT100-option)
Kry hi	If the sensor is a PT-1000 (200-500 Ω; Kryo-module)
Kry lo	If the sensor is a PT-1000 (480-1200 Ω; Kryo-module)

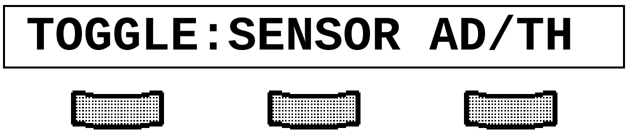
2.2.2 Changing parameters

To set or change a numerical set parameter in the channel menu the respective line is selected with the cursor:

Example: Twin is to be changed:



After pressing the key (**CHANGE**), you can change the selected parameter with the tuning knob. If the selected parameter is a switch parameter (i.e. the type of the sensor) the function of the softkeys will change:



Pressing the right softkey will toggle the sensor type.

Pressing ESC will terminate the procedure.

NOTE

Some parameters can not be changed, as they are measurement values (i.e. the TEC voltage) or may not be changed with the TEC switched on. In these cases access is denied indicated by a long beep.

2.2.3 Selecting the type of the sensor

The sensor type can be selected in the TED8xxx modules by selecting the line "Thermistor" respectively "AD590".

AD590	**=**	AD590 and LM335 families
Thermistor	**=**	Thermistor. The corresponding range has to be selected

The modules with Pt-100 option let you choose between

Thermistor	= Thermistor. The corresponding range has to be selected
PT100	= Pt-100. No further selection.

As for the TED8xxx-Kryo you can not choose between different sensors. The Pt-1000 sensor is predefined. You can only choose between two temperature (resistance) ranges, (see section 2.2.5, “Selecting the range of the Pt-1000 (Kryo-option) ” on page 33).

Select the desired type and press ESC.

The channel menu displays in the second line the options:

AD590
PT100
Th lo
Th hi
Kry lo or
Kry hi

➔ (Refer to chapter 2.2.2, "Changing parameters" starting on page 31)

2.2.4 Selecting the range of a thermistor

The range of the thermistor can be selected up to 20 kΩ or 200 kΩ

Th.range=low **=** 20 kΩ range
Th.range=high **=** 200 kΩ range

Select the desired range and press 

.

2.2.5 Selecting the range of the Pt-1000 (Kryo-option)

In menu-line “range“ the temperature-range can be selected.
The setting “low range“ operates from 76 K to about 148 K, the “high range“ from 143 K to about 325 K.

The display changes between:

Low range and
High range

2.2.6 Calibrating the thermistor

2.2.6.1 Select the calculation method

If the relation between thermistor resistance and corresponding thermistor temperature is known all inputs and outputs can be calibrated in °C.

Two methods to calculate the resistance from temperature are implemented:

- The exponential method
- The Steinhart-Hart method

In the channel menu you can choose between those two methods and enter the corresponding parameters:

Select the line

`Steinh.-Hart`

resp.

`Exponential`

The right softkey toggles between the two methods.
Select the desired type and press ESC to make setting valid.

2.2.6.2 Exponential method

The dependency of resistance on temperature of an NTC-thermistor and vice versa is described by the formula:

$$R(T) = R^0 * e^{B_{val}(\frac{1}{T} - \frac{1}{T_0})} \Leftrightarrow T(R) = \frac{B_{val} * T_0}{T_0 * \ln(\frac{R}{R_0}) + B_{val}}$$

(temperatures in Kelvin)

with: R_0: Thermistor nominal resistance at temperature T_0
T_0: Nominal temperature (typ. 298.15 K = 25°C)
B_{val}: Energy constant

Refer to the data sheet of the thermistor.

To change the three parameters select them one by one and change them to the desired value.

Pressing 

will make every setting valid.

➔ (Refer to chapter 2.2.2, "Changing parameters" starting on page 31)

2.2.6.3 Steinhart-Hart method

A further way of representing the relation between temperature and thermistor resistance is the method according to Steinhart-Hart

$$1/T = C1 + C2 * \ln(R) + C3 * (\ln(R))^3$$

with the three parameters C_1, C_2 and C_3.

To change the three parameters select them one by one and set them to the desired value.

Pressing ESC will terminate each input.

2.2.7 Calibration of the Pt-1000 sensor (Kryo option)

The Pt-1000 sensor itself is factory calibrated and does not need any further calibration. The calculation of the temperature by means of the sensor-resistance is done according to DIN IEC 751. At very low temperatures however (below 200K), there are small differences between the DIN IEC 751 model and the real sensor resistance / temperature.

The following graphics shows the corrections which have to be applied by the customer to the displayed temperature values to obtain physically correct temperatures.

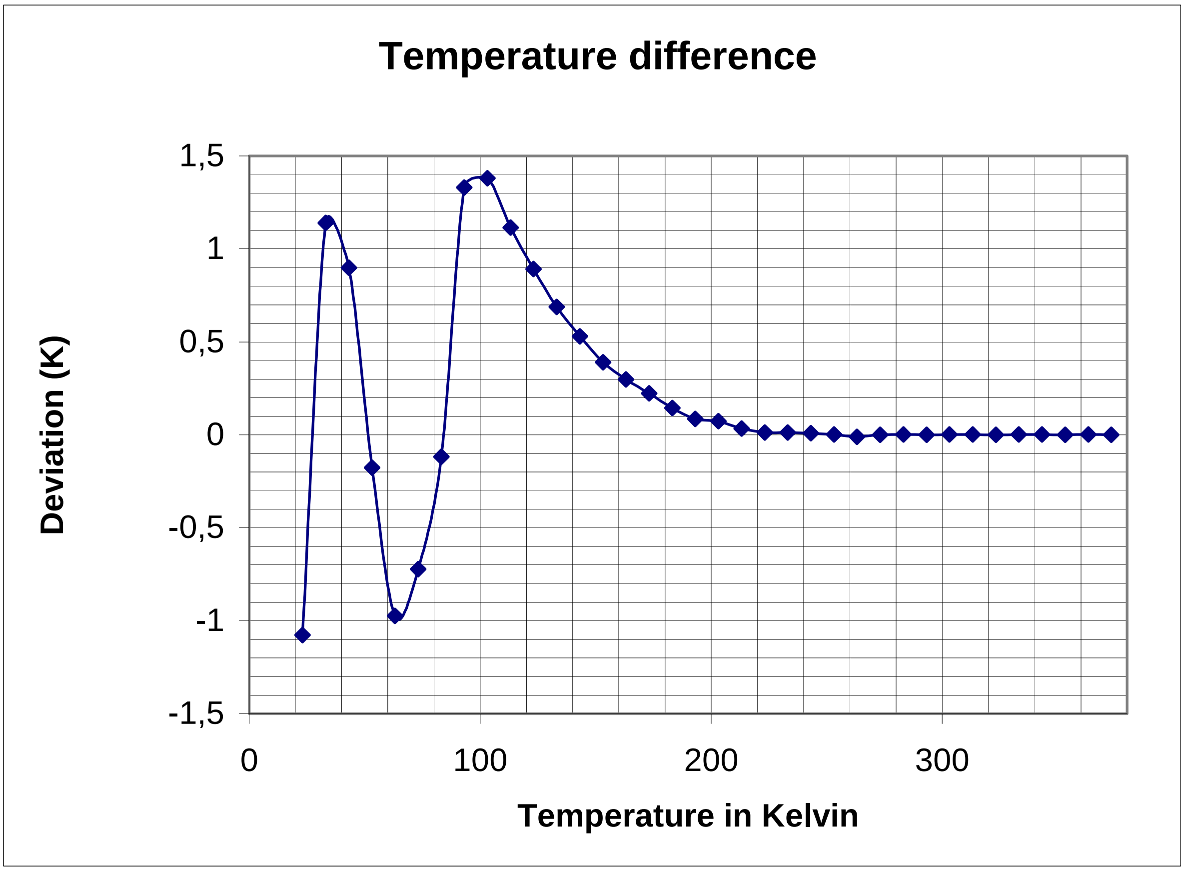


Figure 12 PT1000 temperature correction at low temperatures

$$\text{Deviation} = T_{sensor} - T_{Display}$$

Example: Desired temperature 100K, Figure 12 gives a deviation of +1.4K =>

$$T_{SET} = T_{display} = T_{sensor} - \text{Deviation} = 98.6\text{K}$$

2.2.8 Setting a temperature window

A temperature window can be defined to operate laser diodes in a well defined temperature region. This function can be used especially with an external control computer. In local mode the “ERR” led will light up, if the temperature leaves the window.

To set the window select the parameter **`Twin`** and adjust the desired value.

Pressing [ESC] will make the new settings valid.

NOTE

Please remind that if you use the TED8xxx module in conjunction with a LDC8xxx laser diode controller, the LDC may be switched off automatically if you change the temperature window because the laser temperature may be outside the new window.

2.2.9 Setting the P-, I- and D-share of the control loop

The temperature control behavior of the TED8xxx can be adapted optimally to the individual laser set-up by optimizing the parameters P-, I- and D-share of the control loop.
They can be set separately in values from 0.1% to 100%:

`Psh` = P-share
`Ish` = I-share
`Dsh` = D-share

To change the three parameters select them one by one and set them to the desired value.

Press [ESC] to make the new value valid.

For adjustment of the parameters it is sometimes necessary to switch off the I-share completely. There is a separate switch parameter for this purpose:

`Ishare = ON/OFF`

You can toggle the function with the right softkey.
Press 

to end input.

2.3 Switching on and off

First select the TED module in the main menu (the LED “SEL” must light)
➔ (Refer to chapter 2.1.2, "Selecting a module" on page 27)

☝ Attention ☝

Before switching on a temperature module TED8xxx first set the TEC limit current I_{LIM} (hardware limit) for the applied TEC element with a screwdriver.

The corresponding potentiometer is marked I_{LIM} and is situated at the front panel of the current module.

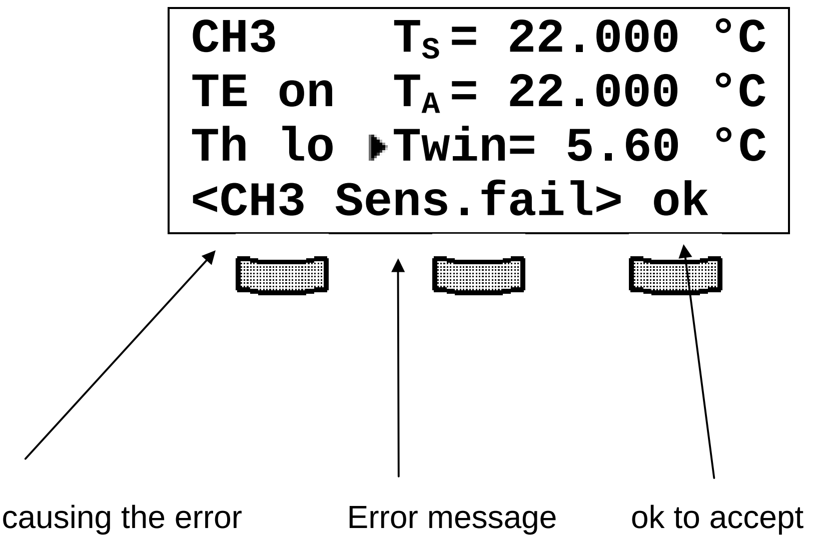
➔ (Refer to chapter 1.6.1, "Setting the limit values" starting on page 13)

Pressing the key ON/OFF will switch the module on or off not regarding the menu you are in as long as the module is selected. The LED “ON” at the respective module will light up when switched on.

2.4 Error messages

Error messages are shown in the bottom line of the display not regarding, if you are in the main menu or in the channel menu.

If an error occurs, the display shows for example:



Possible error messages for a TED8xxx module are:

Sens.fail	Wiring to the sensor has opened during operation
No Sensor	No or wrong sensor connected when trying to switch on
OPEN	Wiring to the Peltiér has opened during operation
OTP	Module is too hot. Operation is possible again after cooling down
TEMP PROT	Temperature has left the window (e.g. the laser has been switched off).
NOT IF TEC ON	Some parameters may not be changed with the temperature controller switched on.
OVERTEMP	The module is too hot and can not be switched on. Wait some time for cooling down.

If the error occurs during operation it is written in brackets:

<CH3 Sens.fail>

If the error occurs when switching on the module it is written in cursor arrows:

▶CH3 No Sensor◀

If an error occurs, it has to be acknowledged by pressing "**OK**" . Until acknowledgement further operation is locked.

3 Communicating with a control computer

3.1 General notes on remote control

The description of the mainframe of the PRO8000 (-4) / PRO800 includes all instructions of how to prepare and execute the programming of the system via IEEE 488 computer interface.

Special operation features of a TED8xxx temperature module are described here.

➔ (Refer to chapter 2, "Operating the TED8xxx" starting on page 26)

NOTE

All analog values are read and written in SI units, i.e. A (not mA), W (not mW) etc. Letters may be written in small or capital letters.

☝ Attention ☝

Before programming a temperature module first set the limit value of the TEC current I_{LIM} (hardware limit) for the used TEC element with a screwdriver.

The corresponding potentiometer is marked I_{LIM} and is situated at the front panel of the TED8xxx module.

The value I_{LIM} is continuously measured by the PRO8000 (-4) / PRO800 and can be checked in the sub-menu of the TED8xxx during setting.

➔ (Refer to chapter 1.6.1, "Setting the limit values" starting on page 13)

3.1.1 Nomenclature

Program messages (PC ⇒ PRO8000 (-4)) are written in inverted commas: **"*IDN?"**

Response messages (PRO8000 (-4) ⇒ PC) are written in brackets: [**:SLOT 1**]

There is a decimal point: **1.234**

Parameters are separated by comma: **"PLOT 2,0"**

Commands are separated by semicolon: **"*IDN?;*STB?"**

3.1.2 Data format

According to the IEEE 488.2 specifications all data variables are divided into 4 different data formats:

Character response data (<CRD>)

Is a single character or a string. Examples:

A or ABGRS or A125TG or A1.23456A

➔ (Refer to IEE488.2 (8.7.1))

Numeric response data Type 1 (<NR1>)

Is a numerical value with sign in integer notation. Examples:

1 or +1 or -22 or 14356789432

➔ (Refer to IEE488.2 (8.7.2))

Numeric response data Type 2 (<NR2>)

Is a numerical value with or without sign in floating point notation without exponent. Examples:

`1.1 or  +1.1 or -22.1 or 14356.789432`

➔ (Refer to IEE488.2 (8.7.3))

Numeric response data Type 3 (<NR3>)

Is a numerical value with or without sign in floating point notation with exponent with sign . Examples:

`1.1E+1 or  +1.1E-1 or -22.1E+1 or 143.56789432E+306`

(Refer to IEE488.2 (8.7.4))

3.2 commands

3.2.1 Select the module slot

":SLOT <NR1>"	Selects a slot for further programming <Nr1>=1…8 (PRO8000), 1…2 (PRO800)
":SLOT?"	Queries the selected slot **[:SLOT <NR1><LF>]**

3.2.2 Thermistor calibration (exponential method)

(Not for TED8xxx with Kryo-option!)

Programming:

":CALTB:SET <NR3>"	Program the energy constant B_{val}
":CALTR:SET <NR3>"	Program the nominal resistance R_0
":CALTT:SET <NR3>"	Program the nominal temperature T_0

Reading:

":CALTB:SET?"	Reading the energy constant B_{val} **[:CALTB:SET <NR3><LF>]**
":CALTR:SET?"	Reading the nominal resistance R_0 **[:CALTR:SET <NR3><LF>]**
":CALTT:SET?"	Reading the nominal temperature T_0 **[:CALTT:SET <NR3><LF>]**
":CALTB:MIN?"	Reading the minimum B_{val} allowed **[:CALTB:MIN <NR3><LF>]**
":CALTR:MIN?"	Reading the minimum R_0 allowed **[:CALTR:MIN <NR3><LF>]**
":CALTT:MIN?"	Reading the minimum T_0 allowed **[:CALTT:MIN <NR3><LF>]**

":CALTB:MAX?"	Reading the maximum B_{val} allowed **[:CALTB:MAX <NR3><LF>]**
":CALTR:MAX?"	Reading the maximum R_0 allowed **[:CALTR:MAX <NR3><LF>]**
":CALTT:MAX?"	Reading the maximum T_0 allowed **[:CALTT:MAX <NR3><LF>]**

➔ Refer to section 2.2.6, “Calibrating the thermistor” on page 34)

NOTE

The selection on how the sensor calibration is done (exponential method or Steinhart-Hart method) is done by the order in which you transmit the coefficients.

If the last transmitted calibration command belongs to the exponential method (see above), then the calculation is also done with the exponential method.

If the last command was a Steinhart-Hart parameter, then this method is chosen.

3.2.3 Thermistor calibration (Steinhart-Hart method)

(Not for TED8xxx with Kryo-option!)

Programming:

":CALTC1:SET <NR3>"	Set the Steinhart-Hart coefficient C1
":CALTC2:SET <NR3>"	Set the Steinhart-Hart coefficient C2
":CALTC3:SET <NR3>"	Set the Steinhart-Hart coefficient C3

Reading:

":CALTC1:SET?"	Read the Steinhart-Hart coefficient C1 **[:CALTC1:SET <NR3><LF>]**
":CALTC2:SET?"	Read the Steinhart-Hart coefficient C2 **[:CALTC2:SET <NR3><LF>]**
":CALTC3:SET?"	Read the Steinhart-Hart coefficient C3 **[:CALTC3:SET <NR3><LF>]**
":CALTC1:MIN?"	Read the minimum C1 allowed **[:CALTC1:MIN <NR3><LF>]**
":CALTC2:MIN?"	Read the minimum C2 allowed **[:CALTC2:MIN <NR3><LF>]**
":CALTC3:MIN?"	Read the minimum C3 allowed **[:CALTC3:MIN <NR3><LF>]**
":CALTC1:MAX?"	Read the maximum C1 allowed **[:CALTC1:MAX <NR3><LF>]**
":CALTC2:MAX?"	Read the maximum C2 allowed **[:CALTC2:MAX <NR3><LF>]**
":CALTC3:MAX?"	Read the maximum C3 allowed **[:CALTC3:MAX <NR3><LF>]**

➔ (Refer to chapter 2.2.6.3, "Steinhart-Hart method" on page 36)

➔ For selection between both methods, see the note on the previous page!

3.2.4 Switching the I-share on and off (INTEG)

Programming:

":INTEG ON"	Switching the I-share on
":INTEG OFF"	Switching the I-share off

Reading:

":INTEG?"	Read status of the I-share **[:INTEG ON<LF>]** **[:INTEG OFF<LF>]**

3.2.5 Reading the TEC current (ITE)

Programming:

":ITE:MEAS <NR1>"	Program ITE to be measurement value for "ELCH[1)]" on position <NR1> (1...8) in the output string.

Reading:

":ITE:ACT?"	Read the actual TEC (or heater) current **[:ITE:ACT <NR3><LF>]**
":ITE:MIN_R?"	Read the minimum TEC current for Ite –ADC = 0000 **[:ITE:MIN_R <NR3><LF>]**
":ITE:MAX_R?"	Read the maximum TEC current for Ite –ADC = FFFF **[:ITE:MAX_R <NR3><LF>]**
":ITE:MEAS?"	Read the position of the TEC current as measurement value in the "ELCH" output string (**1....8**, **0** if not selected) **[:ITE:MEAS <NR1><LF>]**

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[1] Electrical CHaracterization

3.2.6 Programming the TEC current software-limit (LIMT)

Programming:

":LIMT:SET <NR3>"	Program the TEC software current -limit

Reading:

":LIMT:SET?"	Read the TEC current software-limit **[:LIMT:SET <NR3><LF>]**
":LIMT:MIN?"	Read the minimum TEC software current -limit allowed **[:LIMT:MIN <NR3><LF>]**
":LIMT:MAX?"	Read the maximum TEC software current – limit allowed **[:LIMT:MAX <NR3><LF>]**
":LIMT:MIN_W?"	Read $I_{TE\ LIM}$ - ADC = 0000 **[:LIMT:MIN_W <NR3><LF>]**
":LIMT:MAX_W?"	Read $I_{TE\ LIM}$ - ADC = FFFF **[:LIMT:MAX_W <NR3><LF>]**

3.2.7 Reading the TEC current hardware-limit (LIMTP)

Reading:

":LIMTP:ACT?"	Read the actual TEC hardware current –limit **[:LIMTP:ACT <NR3><LF>]**
":LIMT:MIN_W?"	Read $I_{TE\ max}$ - DAC = 0000 **[:LIMT:MIN_W <NR3><LF>]**
":LIMT:MAX_W?"	Read $I_{TE\ max}$ - DAC = FFFF **[:LIMT:MAX_W <NR3><LF>]**

➔ (Refer to Chapter 1.6.1, "Setting the limit values" on page 13)

3.2.8 Programming the resistance of the temperature sensor (RESI)

Programming:

":RESI:SET <NR3>"	Program the resistance of the temperature sensor (thermistor, PT100/PT1000)
":RESI:MEAS <NR1>"	RESI as measurement value for “ELCH” on string position <NR1> (1....8)

Reading:

":RESI:SET?"	Read the set resistance of the sensor (thermistor,) **[:RESI:SET <NR3><LF>]**
":RESI:ACT?"	Read the actual resistance of the sensor **[:RESI:ACT <NR3><LF>]**
":RESI:MIN?"	Read the minimum set resistance of the sensor allowed **[:RESI:MIN <NR3><LF>]**
":RESI:MAX?"	Read the maximum set resistance of the sensor allowed **[:RESI:MAX <NR3><LF>]**
":RESI:MIN_W?"	Read R - DAC = 0000 **[:RESI:MIN_W <NR3><LF>]**
":RESI:MAX_W?"	Read R - DAC = FFFF **[:RESI:MAX_W <NR3><LF>]**
":RESI:MIN_R?"	Read R - ADC = 0000 **[:RESI:MIN_R <NR3><LF>]**
":RESI:MAX_R?"	Read R - ADC = FFFF **[:RESI:MAX_R <NR3><LF>]**
":RESI:MEAS?"	Read string position of R (1....8) for “ELCH” as measurement value **[:RESI:MEAS <NR1><LF>]**

3.2.9 Programming the resistance window (RWIN)

Programming:

":RWIN:SET <NR3>"	Program the resistance window

Reading:

":RWIN:SET?"	Read the set resistance window **[:RWIN:SET <NR3><LF>]**
":RWIN:MIN?"	Read the minimum set resistance window allowed **[:RWIN:MIN <NR3><LF>]**
":RWIN:MAX?"	Read the maximum set resistance window allowed **[:RWIN:MAX <NR3><LF>]**
":RWIN:MIN_W?"	Read Rwin - DAC = 0000 **[:RWIN:MIN_W <NR3><LF>]**
":RWIN:MAX_W?"	Read Rwin - DAC = FFFF **[:RWIN:MAX_W <NR3><LF>]**

3.2.10 Selecting the sensor (SENS)

Programming:

":SENS AD"	Sensor is AD590 family
":SENS THL"	Sensor is thermistor (20 kΩ range)
":SENS THH"	Sensor is thermistor (200 kΩ range)
":SENS PT100"	Sensor is PT-100 (only TED8xxx-PT)
":SENS PT1000L"	Sensor is PT-1000 (only TED8xxx-Kryo), low region
":SENS PT1000H"	Sensor is PT-1000 (only TED8xxx-Kryo), high region

Reading:

":SENS?"	Read the actual sensor type **[:SENS AD<LF>]** **[:SENS THL<LF>]** **[:SENS THH<LF>]** **[:SENS PT100<LF>]** **[:SENS PT1000L<LF>]** **[:SENS PT1000H<LF>]**

3.2.11 Programming the PID shares (SHAREP, -I, -D)

Programming:

":SHAREP:SET <NR3>"	Program the P-share
":SHAREI:SET <NR3>"	Program the I-share
":SHARED:SET <NR3>"	Program the D-share

Reading:

":SHAREP:SET?"	Read the P-share **[:SHAREP:SET <NR3><LF>]**
":SHAREI:SET?"	Read the I-share **[:SHAREI:SET <NR3><LF>]**
":SHARED:SET?"	Read the D-share **[:SHARED:SET <NR3><LF>]**
":SHAREP:MIN?"	Read the minimum P-share allowed **[:SHAREP:MIN <NR3><LF>]**
":SHAREI:MIN?"	Read the minimum I-share allowed **[:SHAREI:MIN <NR3><LF>]**
":SHARED:MIN?"	Read the minimum D-share allowed **[:SHARED:MIN <NR3><LF>]**
":SHAREP:MAX?"	Read the maximum P-share allowed **[:SHAREP:MAX <NR3><LF>]**
":SHAREI:MAX?"	Read the maximum I-share allowed **[:SHAREI:MAX <NR3><LF>]**
":SHARED:MAX?"	Read the maximum D-share allowed **[:SHARED:MAX <NR3><LF>]**

➔ (Refer to chapter 1.8.2, "PID adjustment" starting on page 24)

3.2.12 Switching the TEC on and off (OUTP)

Programming:

":TEC ON"	Switching the TEC output on
":TEC OFF"	Switching the TEC output off

Reading:

":TEC?"	Read status of the output **[:TEC ON<LF>]** **[:TEC OFF<LF>]**

3.2.13 Programming the temperature (TEMP)

Programming:

":TEMP:SET <NR3>"	Program the temperature
":TEMP:MEAS <NR1>"	Program temperature to be measurement value for “ELCH” on string position <NR1> (1....8)

Reading:

":TEMP:SET?"	Read the set temperature **[:TEMP:SET <NR3><LF>]**
":TEMP:ACT?"	Read the actual temperature **[:TEMP:ACT <NR3><LF>]**
":TEMP:MIN?"	Read the minimum set temperature allowed **[:TEMP:MIN <NR3><LF>]**
":TEMP:MAX?"	Read the maximum set temperature allowed **[:TEMP:MAX <NR3><LF>]**
":TEMP:MIN_W?"	Read T - DAC = 0000 **[:TEMP:MIN_W <NR3><LF>]**
":TEMP:MAX_W?"	Read T - DAC = FFFF **[:TEMP:MAX_W <NR3><LF>]**
":TEMP:MIN_R?"	Read T - ADC = 0000 **[:TEMP:MIN_R <NR3><LF>]**
":TEMP:MAX_R?"	Read T - ADC = FFFF **[:TEMP:MAX_R <NR3><LF>]**
":TEMP:MEAS?"	Read string position (1....8) of temperature as measurement value for “ELCH”. **[:TEMP:MEAS <NR1><LF>]**

3.2.14 Programming the temperature window (TWIN)

Programming:

":TWIN:SET <NR3>"	Program the temperature window

Reading:

":TWIN:SET?"	Read the set temperature window **[:TWIN:SET <NR3><LF>]**
":TWIN:MIN?"	Read the minimum set temperature window allowed **[:TWIN:MIN <NR3><LF>]**
":TWIN:MAX?"	Read the maximum set temperature window allowed **[:TWIN:MAX <NR3><LF>]**
":TWIN:MIN_W?"	Read Twin - DAC = 0000 **[:TWIN:MIN_W <NR3><LF>]**
":TWIN:MAX_W?"	Read Twin - DAC = FFFF **[:TWIN:MAX_W <NR3><LF>]**

3.2.14.1 Query type of module

Reading:

":TYPE:ID? "	Query type identification of the module (must be 223) **[:TYPE:ID 223<LF>]**
":TYPE:SUB? "	Query sub-type of module : Normal module: 0 PT 100 option: 1 Kryo-option: 2 **[:TYPE:SUB <NR1><LF>]**

3.2.15 Reading the TEC voltage (VTE)

Programming:

":VTE:MEAS <NR1>"	Select TEC (or heater) voltage to be measurement value for "ELCH" on string position <NR1> (1....8)

Reading:

":VTE:ACT?"	Read the actual TEC voltage **[:VTE:ACT <NR3><LF>]**
":VTE:MIN_R?"	Read U_{TE} – ADC = 0000 **[:VTE:MIN_R <NR3><LF>]**
":VTE:MAX_R?"	Read U_{TE} – ADC = FFFF **[:VTE:MAX_R <NR3><LF>]**
":VTE:MEAS?"	Read string position (1....8) of peltier voltage as measurement value for "ELCH" . **[:VTE:MEAS <NR1><LF>]**

3.3 1100 ... 1199 TED8xxx error messages

[**1103,"Over temperature"**]

Possible reason: Module temperature too high. Switch off the output and wait until the module has cooled down. Maintain proper air flow.

[**1104,"Wrong or no sensor"**]

Possible reason: Wrong or no sensor connected. Wrong sensor selected.

[**1105,"No calibrating of sensor during TEC on"**]

Possible reason: The sensor can not be calibrated during the TEC output is switched on.

[**1106,"Wrong command for this sensor"**]

Possible reason: A used command is not allowed for the selected sensor. (Example :RWIN with an AD590)

[**1107,"No sensor change during TEC on allowed"**]

Possible reason: The sensor type may not be changed if the TEC output is switched on.

[**1130,"Command not valid for this module"**]

Possible reason: You entered a command which is not valid for this module (e.g. “CALTR” with a Kryo-module)

3.4 Status reporting

The TED8xxxx modules provide three 16 bit registers DEC, DEE and EDE (see Figure 13) together with four 8 bit registers ESR, STB, ESE and SRE (see Figure 14) of the mainframe to program various service request functions and status reporting.

➔ (Please refer to the IEEE488.2-1992 standard chapter 11)

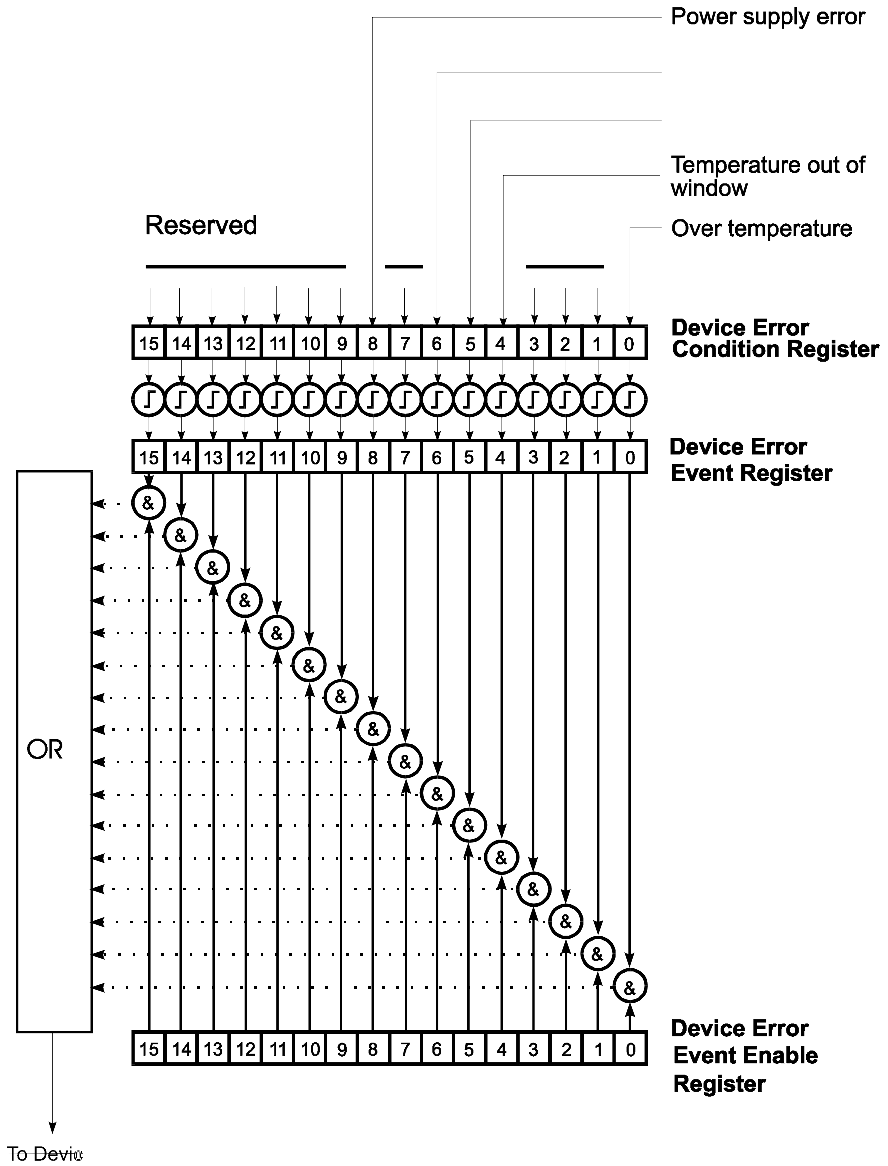

Figure 13 The TED8xxx device error registers DEC, DEE and EDE

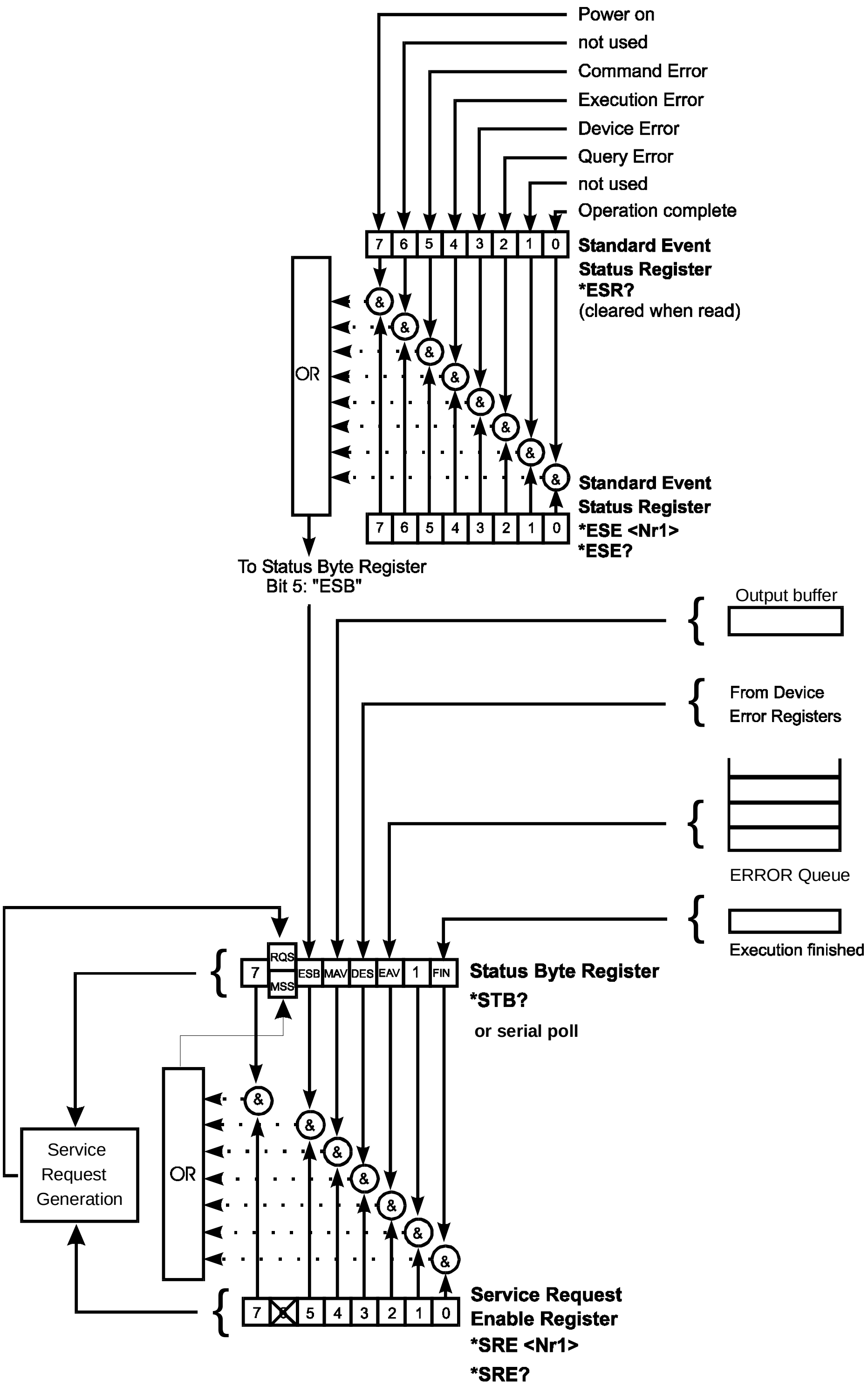

Figure 14 The PRO8000 (-4) / PRO800 register ESR, ESE, STB and SRE

3.4.1 Standard event status register (ESR)

The bits of this register represent the following standard events:

Power on This event bit indicates, that an off to on transition has occurred in the power supply. So it is high after turning on the device for the first time.

User request (Not used)

Command error A command error occurred.

Execution error An execution error occurred.

Device dependent error A device dependent error occurred.

Query error A query error occurred.

Request control (Not used)

Operation complete Can be set with **"*OPC".**

The ESR can be read directly with the command **"*ESR?".** This read command clears the ESR. The content of the ESR can not be set.

The bits are active high.

3.4.2 Standard event status enable register (ESE)

The bits of the ESE are used to select, which bits of the ESR shall influence bit 5 (ESB) of the STB. The 8 bits of the ESE are combined with the according 8 bits of the ESR via a wired “AND”-function. These 8 results are combined with a logical “OR”-function, so that any "hit" leads to a logical 1 in bit 5 (ESB) of the STB. As any bit of the STB can assert an SRQ, every event (bit of the ESR) can be used to assert an SRQ.

3.4.3 Status byte register (STB)

The bits of this register are showing the status of the PRO8000 (-4) / PRO800.

RQS	RQS: Request service message: Shows, that this device has asserted SRQ (read via serial poll).
MSS	Master summary status: Shows that this device requests a service (read via **"*STB?"**).
MAV	(Message AVailable) This bit is high after a query request, as a result "waits" in the output queue to be fetched. It is low, if the output queue is empty.
DES	(Device Error Status) This bit is high after a device error occurred. Which device errors will set this bit is defined with the EDE.
EAV	(Error AVailable) This bit is high as long as there are errors in the error queue.
FIN	(command FINished) This bit is high, after a command has finished and all bits of the STB have been set.

The STB can be read directly with the command **"*STB?".** The content of the STB can not be set. The bits are active high.

All bits except bit 6 of the STB can be used to assert a service request (SRQ)
➔ (Please refer to 3.4.5). Alternatively the SRQ can be recognized using the command **"*STB?"** (Please refer to 3.4.6) or by serial poll (Please refer to 3.4.7).

3.4.4 Service request enable register (SRE)

The bits of the SRE are used to select, which bits of the STB shall assert an SRQ.
Bit 0, 1, 2, 3, 4, 5 and 7 of the STB are related to the according 7 bits of the SRE by logical “AND”. These 7 results are combined by a logical "OR", so that any "hit" leads to a logical 1 in bit 6 of the STB and asserts an SRQ.

3.4.5 Reading the STB by detecting SRQ

If an SRQ is asserted (see 3.4.4) bit 6 of the STB is set to logical 1, so that the controller can detect which device asserted the SRQ by auto serial polling.

3.4.6 Reading the STB by `"*STB?"` command

If the controller does not "listen" to SRQ's at all, the service request can be detected by reading the status byte with the command **`"*STB?"`**.

If bit 6 is logical 1, a service request was asserted.

3.4.7 Reading the STB by serial poll

If the controller does not support auto serial poll, the service request can also be detected via manual serial poll.

If bit 6 is logical 1, a service request was asserted.

3.4.8 Device error condition register (DEC)

The bits of this register show the errors, that occur during operation (operation errors). The bits are active high.

If the error disappears, the bits are reset to low.

For the TED8xxx temperature controller modules bits 0, 4, 5, 6 and.8 are used:

(0) Over temperature	Temperature too high. Wait until the module has cooled down. Maintain proper air flow.
(4) Temperature out of window	TEC temperature is out of specified window.
(5) Open circuit	TEC circuit is open.
(6) No or wrong sensor	Temperature sensor not connected or wrong type.
(8) Power supply error	Internal powersupply error.

The DEC can be read but not set. Reading does not clear the DEC.

3.4.9 Device error event register (DEE)

The bits of this register hold the errors, that occurred during operation (operation errors). So each bit of the DEC sets the according bit of the DEE.

The DEE can be read but not set. Reading clears the DEE.

3.4.10 Device error event enable register (EDE)

The bits of the EDE are used to select, which bits of the DEE shall influence bit 3 (DES) of the STB. The 8 bits of the EDE are related by logical "AND" to the according 8 bits of the DEE. This 8 results are connected by logical "OR", so that any "hit" leads to a logical 1 in bit 3 (DES) of the STB. As any bit of the STB can assert an SRQ, every error (bit of the DEE) can be used to assert an SRQ.

4 Service and Maintenance

4.1 General remarks

The TED8xxx modules do not need any maintenance by the user.

If highest precision of measurements is vital to you, you should have recalibrated the TED8xxx module about every two years.

4.2 Troubleshooting

In case that one module of your PRO8000 / PRO800 system shows malfunction please check the following items:

◆ Module does not work at all (no display on the mainframe):

- Mainframe PRO8000 (-4) / PRO800 connected properly to the mains?
  - Connect the PRO8000 (-4) / PRO800 to the power line, take care of the right voltage setting of your mainframe.

- Mainframe PRO8000 (-4) / PRO800 turned on?
  - Turn on your PRO8000 (-4) / PRO800 with the key mains-switch.

- Control the fuse at the rear panel of the PRO8000 (-4) / PRO800 mainframe.
  - If blown up, replace the fuse by the correct type

➔ (refer to your PRO8000 (-4) / PRO800 mainframe operating manual to select the appropriate fuse)

◆ The PRO8000 (-4) / PRO800 display works, but not the module:

- Is the module inserted correctly and are all mounting screws tightened?
  - Insert the module in the desired slot and tighten all mounting screws properly.

- Do you have selected the desired module?
  - (The LED "SEL" on the front panel of the module must be on)
    Select the desired module on the display by means of the up- and down arrow keys.

- Do you have turned on the temperature controller in the main menu or one of the sub-menus?
  - Change the status setting from "off" to "on".

➔ The LED "ON" on the front panel of the module must be on

- ➢ Are the hard- and/or software limits I_{LIM} and I_{MAX} set to 0?
  - Adjust the hardware limit I_{LIM} by means of the potentiometer on the TED8xxx front panel and the software limit I_{MAX} in the channel menu to appropriate values.

◆ <u>You don't get the desired operation temperature</u>

- ➢ Is the TEC (or heater with the TED8xxx-Kryo) connected properly to the front connector?
  - Check all cables.
  - Check the correct polarity (see section 1.7.3)

➢ Is the temperature sensor connected properly and are his parameters entered correctly?
  - Check the corresponding connections and polarities of the temperature sensor (refer to chapters 1.7.4, to 1.7.7)
  - Check the software-settings in the channel menu
  - Select the corresponding temperature sensor.
  - Enter the right set-values for resistance (R_S,R_0) and Temperature (T_0)

◆ <u>Set temperature differs from actual temperature (of the laser)</u>

- ➢ Is the sensor calibrated properly?
  - Enter the right calibration factors (thermistor). Refer to section 2.2.6.

If you don't find the error source by means of the trouble shooting list or if more modules work erratic please <u>first connect the *Thorlabs-Hotline* *(blueline@thorlabs.com)*</u> before sending the whole PRO8000 (-4)/800 system for checkup and repair to *Thorlabs*-Germany.

(refer to section 5.4, "Addresses " on page 75

5 Listings

5.1 List of abbreviations

The following abbreviations are used in this manual:

ADC	Analog to Digital Converter
ASCII	American Standard Code for Information Interchange
CLR	CLeaR
CR	Carriage Return
CRD	Character Response Data
DAC	Digital to Analog Converter
D-Share	Differential share
DCL	Device Clear
DEC	Device Error Condition Register
DEE	Device Error Event Register
DES	Device Error Status
EAV	Error AVailable
EDE	Enable Device Error Event Register
ELCH	ELectrical Characterization
EOI	End Of Information
ESE	Standard Event Status Enable register
ESR	Event Status Register
FIN	Command FINished
GET	Group Execute Trigger
GTL	Go To Local
GPIB	General Purpose Interface Bus
IEEE	Institute for Electrical and Electronic Engineering
I-Share	Integral share
LDC	Laser Diode Controller
LED	Light Emitting Diode
LF	Line Feed
LLO	Local Lockout
NR1	Numeric Response data of type 1
NR2	Numeric Response data of type 2
NR3	Numeric Response data of type 3
MAV	Message AVailable)

MSS	Master Summary Status
OTP	Over TemPerature
PC	Personal Computer
P-Share	Proportional share
PT100	PlaTinum sensor, 100 Ω nominal resistance
PT1000	PlaTinum sensor, 1000 Ω nominal resistance
RQS	ReQuest Service Message
SDC	Selected Device Clear
SEL	SELect
SRE	Service Request Enable Register
SRQ	Service ReQuest
STB	STatus Byte Register
SW	Soft Ware
TEC	ThermoElectric Cooler (Peltier Element)
TRG	TRiGger

5.2 List of figures

5.3 Certifications and compliances

Certifications and compliances

<table>
<tr><th>Category</th><th colspan="3">Standards or description</th></tr>
<tr><td rowspan="10">EC Declaration of Conformity - EMC</td><td colspan="3">Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:</td></tr>
<tr><td colspan="2">EN 61326</td><td>EMC requirements for Class A electrical equipment for measurement, control and laboratory use, including Class A Radiated and Conducted Emissions[1,2,3] and Immunity.[1,2,4]</td></tr>
<tr><td></td><td>IEC 61000-4-2</td><td>Electrostatic Discharge Immunity (Performance criterion C)</td></tr>
<tr><td></td><td>IEC 61000-4-3</td><td>Radiated RF Electromagnetic Field Immunity (Performance criterion B)</td></tr>
<tr><td></td><td>IEC 61000-4-4</td><td>Electrical Fast Transient / Burst Immunity (Performance criterion C)</td></tr>
<tr><td></td><td>IEC 61000-4-5</td><td>Power Line Surge Immunity (Performance criterion C)</td></tr>
<tr><td></td><td>IEC 61000-4-6</td><td>Conducted RF Immunity (Performance criterion B)</td></tr>
<tr><td></td><td>IEC 61000-4-11</td><td>Voltage Dips and Interruptions Immunity (Performance criterion C)</td></tr>
<tr><td colspan="2">EN 61000-3-2</td><td>AC Power Line Harmonic Emissions</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td rowspan="3">Australia / New Zealand Declaration of Conformity - EMC</td><td colspan="3">Complies with the Radiocommunications Act and demonstrated per EMC Emission standard[1,2,3]:</td></tr>
<tr><td colspan="2">AS/NZS 2064</td><td>Industrial, Scientific, and Medical Equipment: 1992</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td>FCC EMC Compliance</td><td colspan="3">Emissions comply with the Class A Limits of FCC Code of Federal Regulations 47, Part 15, Subpart B[1,2,3].</td></tr>
</table>

[1] Compliance demonstrated using high-quality shielded interface cables, including with CAB4x series cables installed at the TEC OUT ports.

[2] Compliance demonstrated with the TED8x series modules installed in Thorlabs GmbH PRO8x series mainframes.

[3] Emissions, which exceed the levels required by these standards, may occur when this equipment is connected to a test object.

[4] Minimum Immunity Test requirement.

5.4 Addresses

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Please call our hotline, send an E-mail to ask for your nearest distributor or just visit our homepage **http://www.thorlabs.com**