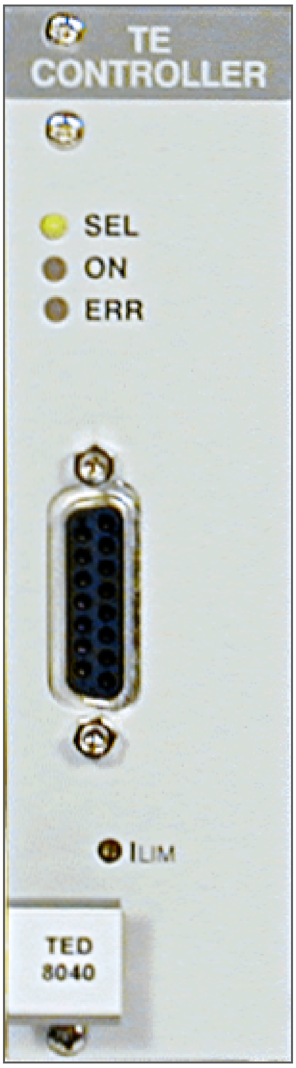
THORLABS

PRO800 / PRO8000 (-4) Series
Modular Temperature Controllers

TED8000
Operation Manual



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Contents

We aim to develop and produce the best solution for your application in the field of optical measurement technique. To help us to live up to your expectations and improve 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.

Thorlabs GmbH

Warning

Sections marked by this symbol explain dangers that might result in personal injury or death. Always read the associated information carefully, before performing the indicated procedure.

Attention

Paragraphs preceeded by this symbol explain hazards that could damage the instrument and the connected equipment or may cause loss of data.

Note

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

Please read these advices carefully!

1 General Information

The TED8000 Modules are Temperature Controllers that are capable to control TEC elements (Peltiers) in order to maintain a constant temperature of e.g. laser diodes

For the PRO8000 mainframe series Thorlabs supplies LabVIEW®- and LabWindows/CVI®-drivers for Windows 32 bit.

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

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 as it was designed for.

Prior to applying power to the TED8000, make sure that the protective conductor of the mains power cord is correctly connected to the protective earth ground contact of the socket outlet! Improper grounding can cause electric shock resulting in damage to your health or even death!

Also make sure that your line voltage agrees with the voltage given on the letterplate of the unit and that the right fuse has been inserted!

Modules of the TED8000 Series are allowed to be operated only a mainframe of the PRO8000 series.

To avoid damage to the modules used or to the mainframe, modules must not be installed or removed when the mainframe is switched on.

All modules must be fixed using the screws provided for this purpose.

The TED8000 must not be operated in explosion endangered environments!

Do not remove covers! Do not obstruct the air ventilation slots in the housing!

Refer servicing to qualified personnel!

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

This precision device is only serviceable if properly packed into the complete original packaging. If necessary, ask for a replacement package prior to return.

All connections to the load must be made using shielded cables, unless otherwise stated.

Semiconductor lasers can deliver up to several 100mW of possibly invisible laser radiation! Improper operation can cause severe eye and health damage!

Pay strict attention to the safety recommendations of the appropriate laser safety class!

Attention

The following statement applies to the products covered in this manual, unless otherwise specified herein. The statement for other products will appear in the accompanying documentation.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Thorlabs is not responsible for any radio television interference caused by modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by Thorlabs. The correction of interference caused by such unauthorized modification, substitution or attachment will be the responsibility of the user.

The use of shielded I/O cables is required when connecting this equipment to any and all optional peripheral or host devices. Failure to do so may violate FCC and ICES rules.

Attention

Mobile telephones, cellular 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 IEC 61326-1.

This product has been tested and found to comply with the limits according to IEC 61326-1 for using connection cables shorter than 3 meters (9.8 feet).

1.2 Ordering Codes and Accessories

Please refer to the actual catalog or the web for an actual list of available plug in modules and accessories and for the complete ordering codes.

Ordering Code	**Short Description**
Temperature Control Modules with standard temperature sensors (NTC 10 kΩ, NTC 100 kΩ; AD590, AD592, LM335):	
TED8020	Temperature Controller Module ± 2 A,
TED8040	Temperature Controller Module ± 4 A
TED8080	Temperature Controller Module ± 8 A
TED80xx-PT	Temperature Control Modules with Pt-100 RTD temperature sensors. Same current ranges as standard controllers
TED80xx-KRYO	Temperature Control Modules with Pt-1000 RTD temperature sensors for cryogenic applications. **Heating only!** Same current ranges as standard controllers.
CAB420-15	Temperature Controller Connection Cable for TED8000 modules, 1.5 m, to connect Thorlabs Laser Diode Mounts

2 Getting Started

2.1 Parts List

Inspect the shipping container for damage.

If the shipping container seems to be damaged, keep it until you have inspected the contents and you have inspected the TED8000 mechanically and electrically.

Verify that you have received the following items within the package:

1. TED8000 Series Module
2. Operating Manual

2.2 Operating Principle

The TED8000 temperature modules are bidirectional current sources to control a TEC element (Peltier). Different types of temperature sensors are supported. Three types of modules are available with respect to the maximum current, resolution and accuracy (see Technical Data 47)

The TED8000 modules contain a closed loop amplifier with adjustable settings for P (proportional), I (integral) and D (differential) share.

Supported temperature sensors

- Standard thermistors (NTC - Negative Temperature Coefficient Thermistor) within two ranges - max. 20 kΩ and max. 200 kΩ
- IC temperature sensors (AD590, AD592, LM335)
- Pt-100 and Pt-1000 (RTD - Resistance Temperature Detectors)

All necessary value settings are made by the mainframe operating elements (keypad and rotational encoder) or via remote control by a computer. The only parameter that must be set manually, is the TEC current limit ("absolute hardware limit").

The values for set temperature or set resistance of the TED8000 modules are set with 16 bit resolution.

Limit values for the TEC current (software limit) are set with a 12 bit resolution.

The actual temperature (resistance) is read back with 16 bit; the TEC current, TEC voltage and the limit for the TEC current (hardware limit) with 15 bit plus sign.

The P, I and D shares of the analog control loop are set by three independent 12 bit DAC (Digital-to-Analog Converters)

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

TEC Element Protection Features

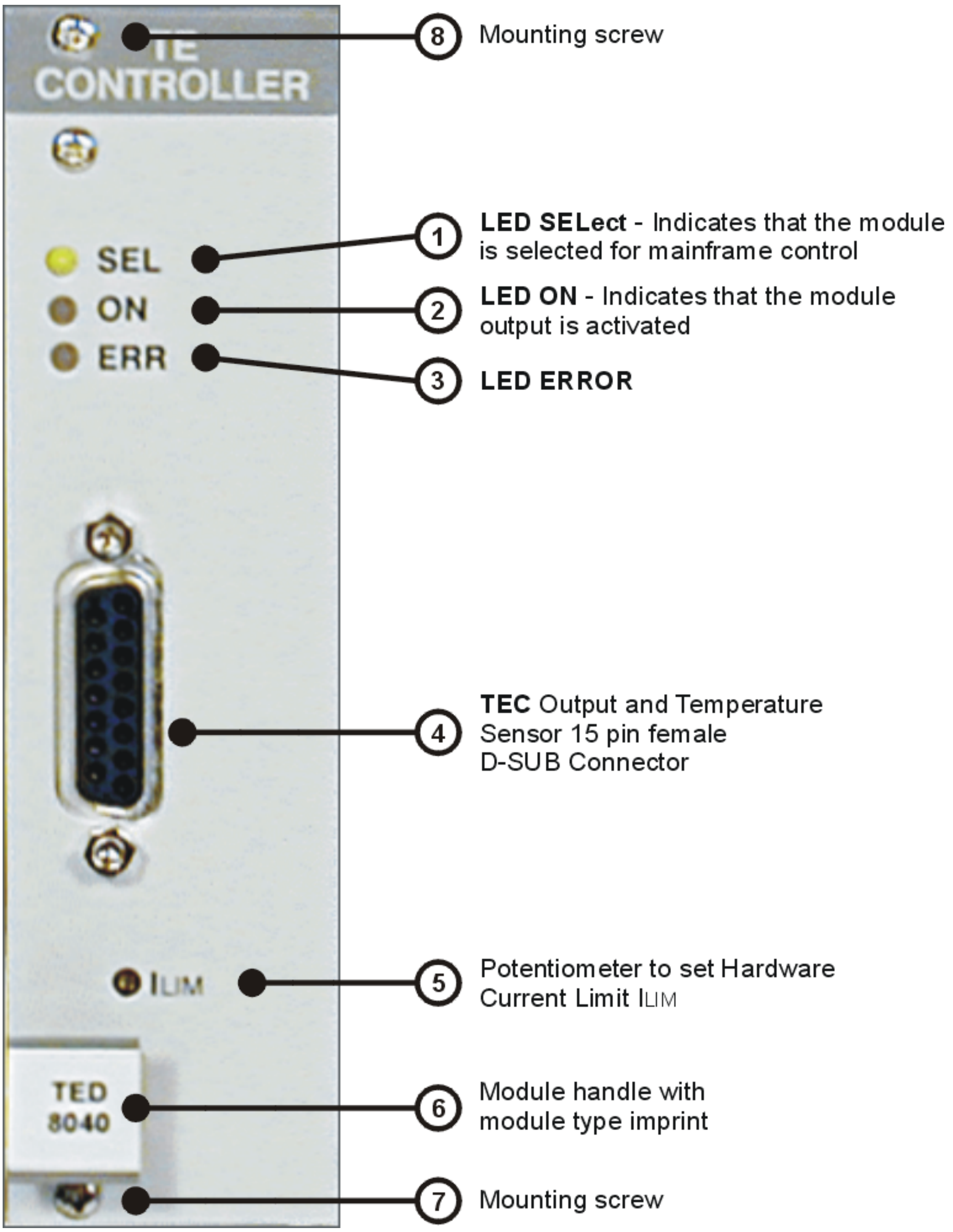
To protect the connected TEC element, the TED8000 modules contain the following protection circuits:

- **Hardware and Software Limits of the TEC current in all operating modes**
  Protection from thermal destruction.
- **Sensor Protection**
  Protection from the use of not supported temperature sensors and from interrupted sensor connection.
- **Open-Circuit Protection of the connection cable to the TEC element**
  Protection from cable damage, bad contact or TEC element with too high resistance. When

tripped, a warning is output, but the output remains switched on - the reason is that even a wrong TEC as still capable to cool the laser diode.

- **Separate on and off function for each module**
  Protection from operating errors.
- **Control LED for activated TEC current**
  Protection from accidental disabling of the temperature control..
- **Separate over-temperature protection for each module**
  Protection against thermal failure of the module.
- **Laser Protection** can be coupled to a temperature window, if TED8000 modules are present within the same PRO8000 mainframe.

2.3 Operating Elements



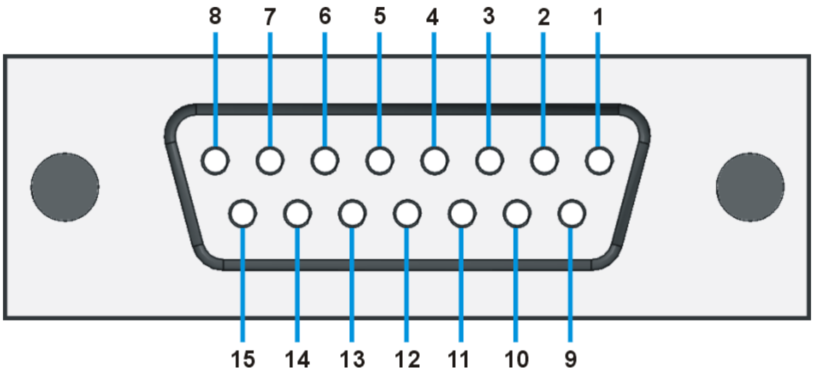
Note

This figure is valid for all TED8000 modules with the exception of the TED8080 which is of double width.

3 External Connections

3.1 TED80x0

Pin Assignment of the Output Connector



Female 15 pin D-SUB Connector

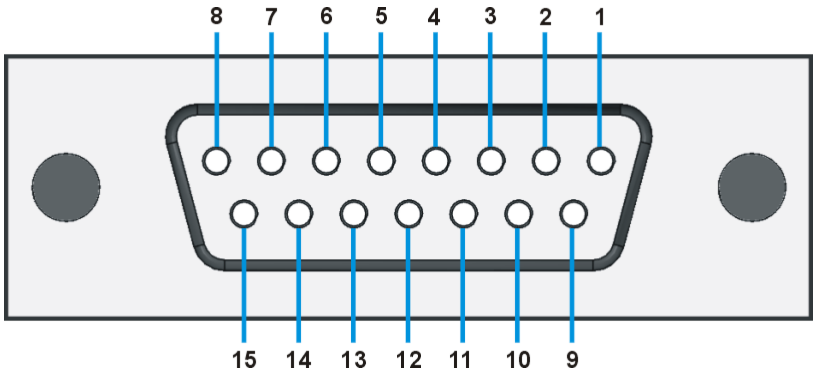
Pin	Connector
	TEC Element
5, 6, 7	TEC Element +
13, 14, 15	TEC Element - (GND)
2	Voltage Detector TEC Element +
9	Voltage Detector TEC Element -
	Status Display
1	Status LED - Anode
8	Status LED - Cathode (GND)
	Temperature Sensor
3	Thermistor - (GND)
4	Thermistor +
10	AD590 -
11	AD590 +
12	(leave open)

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

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.

3.2 TED80x0-PT

Pin Assignment of the Output Connector



Female 15 pin D-SUB Connector

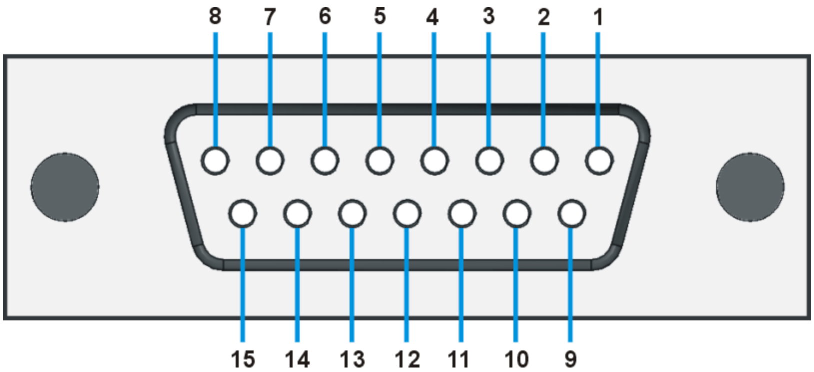
Pin	Connector
	TEC Element
5, 6, 7	TEC Element +
13, 14, 15	TEC Element - (GND)
2	Voltage Detector TEC Element +
9	Voltage Detector TEC Element -
	Status Display
1	Status LED - Anode
8	Status LED - Cathode (GND)
	Temperature Sensor
3	Pt-100 Current Source - (GND)
4	Pt-100 Current Source +
10	Pt-100 Voltage Measurement Input -
11	Pt-100 Voltage Measurement Input +
12	(leave open)

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

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.

3.3 TED80x0-KRYO

Pin Assignment of the Output Connector



Female 15 pin D-SUB Connector

Pin	Connector
	Heater Element
5, 6, 7	Heater Element +
13, 14, 15	Heater Element - (GND)
2	Voltage Detector Heater Element +
9	Voltage Detector Heater Element -
	Status Display
1	Status LED - Anode
8	Status LED - Cathode (GND)
	Temperature Sensor
3	Pt-1000 Current Source - (GND)
4	Pt-1000 Current Source +
10	Pt-1000 Voltage Measurement Input -
11	Pt-1000 Voltage Measurement Input +
12	(leave open)

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

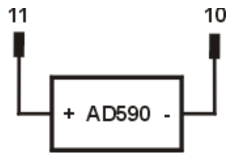
For a 4-point measurement of the TEC voltage connect the TEC element to pin 2 and 9 to measure the voltage directly at the TEC element.

3.4 Connecting a Thermistor

The thermistor is connected between pin 3 and pin 4:

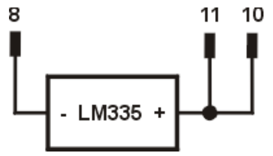
3.5 Connecting an AD590

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

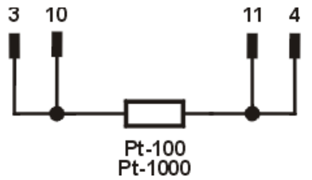


3.6 Connecting a LM335

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



3.7 Connecting a Pt-100 or Pt-1000



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. Connect one end of the sensor pin 4 and 11, the other - to pin 3 and 10.

Pin 3 is connected internally to common ground via a 10 Ω resistor.

What happens if the sensor is faulty or connected wrongly

The measurement inputs (pins 10 and 11) are connected internally to the output pins of the current source (pins 3 and 4) via a 1 kΩ resistor. Therefore the following behavior can be expected in case of a faulty sensor or missing connection:

- **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.

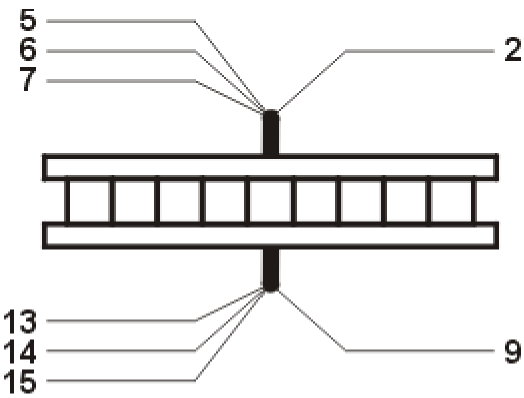
- **Pin 10 and / or Pin 11 are not connected:**
  The resistance measurement is done as 2-wire measurement, the resistances of cable and connectors are included in the measurement. The temperature control works at normal conditions.

- **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.

3.8 Connecting a TEC Element 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 across the cable to the TEC element, caused by the TEC current. The indicated voltage will then be slightly higher.



4-pole Measurement of the TEC Voltage

Attention

An reverse poled TEC element may lead to a thermal runaway and destruction of the connected components. Please refer to section Polarity Check of the TEC Element 14.

3.9 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 TED8000 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 section PID Ajustment 16)
- 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 may still need improvement.

3.10 Connecting the Status Display LED

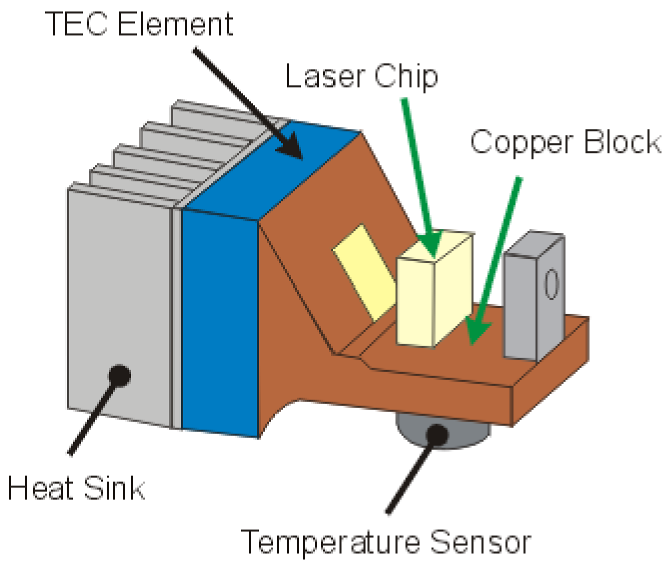
To display the operating status a standard LED may be used between pin 1 and pin 8. The LED will light up when the current output is switched on.

4 Optimization of Temperature Control

4.1 Principle Setup and Function

A typical laser diode module comprises

- the laser diode chip that needs to be temperature controlled;
- the temperature sensor;
- the TEC element;
- the thermal conductor (copper block) that establishes the thermal contact between the laser and the TEC, as well between the laser and the temperature sensor and
- the heat sink.



Possible error sources that impact the temperature control

1. The sensor is not in direct thermal contact with the laser chip. The inhomogeneous temperature within the copper block ("temperature gradient") influences the measurement. Even within the laser chip a temperature gradient is present. Thus, a correct measurement of the real laser chip temperature is not possible. Offset and gain errors of the sensor allow only an estimate of the laser temperature.

   Possible optimization: Sensor calibration

2. A change of the internal power dissipation of the laser, e.g. due to change of the laser current, changes the temperature gradient between laser and sensor as well. This results in a measurement error depending on the mechanical setup of the laser chip and the sensor. Slow changes of the ambient temperature, however, will be compensated well by the control loop since the influence of the ambient temperature on the laser diode can be neglected.

   Possible solution: optimized thermal design

3. The transient response after setting a new temperature is limited since the heat transport in the copper block is relatively slow. Furthermore, the sensor must settle to the laser temperature - it also has a non-negligible thermal capacity.

   Possible optimization: careful adjustment of PID parameters

4.2 PID Adjustment

Temperature control loops are comparatively slow; control oscillations appear with a frequency in the range of several Hz or parts of Hz. The PID adjustment allows to optimize the dynamic behavior. The TED8000 modules allow to set the three parameters P, I and D independently within the range 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%. Please refer to section Setting the P, I and D Share of the Control Loop 26.
- Switch on the output and observe the temperature.

P-share

- Change the set temperature repeatedly between 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, too high values make the system oscillate.

The P-share has been set correctly when the actual temperature remains stable near the set temperature after 2-3 overshoots.

D-share

- Change the set temperature repeatedly between 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.
- Change the set temperature repeatedly between 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.

5 Operating Instruction

Note

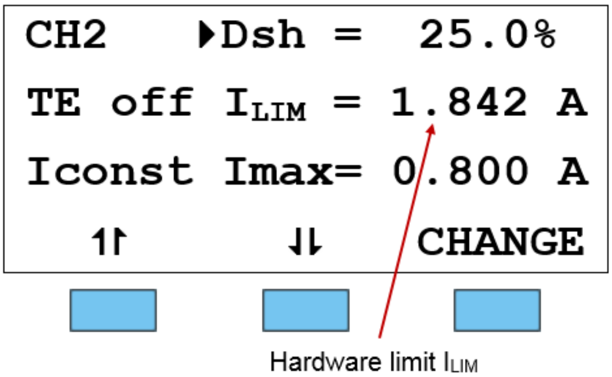
All settings that are made to the TED8000 modules via the Control Panel of the PRO8000 mainframe are applied immediately; no need to confirm settings.

5.1 Pre-Settings

The maximum TEC Current can be limited in order to protect the TEC element. There are two different limits:

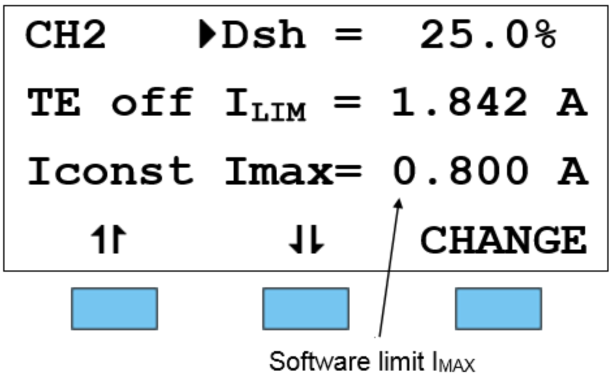
Setting the Hardware Current Limit I_{LIM}

The hardware limit I_{LIM} is set with the potentiometer 5 8 marked **I_{LIM}** at the front panel of the module. The value is displayed continuously in the channel menu of the module so you can observe it during adjustment:



Software Limit I_{MAX}

The software limit I_{MAX} is set in the channel menu or via the IEEE488 interface by the control software, and affects the current control of the TED8000 module via the D/A converter. It yields exactly the same protective function as the hardware limit. See section Changing Parameters 22.



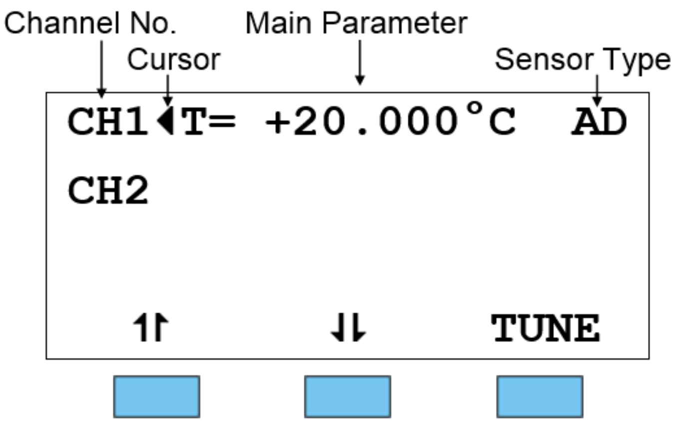
Note

The TEC current limitation is enabled at the lower value of the two limits I_{MAX} or I_{LIM}.

5.2 Functions in the Main Menu

Display

The main menu shows the channel number, the main operating parameter and the type of temperature sensor of the TED8000 module.



Main Parameter

When the module is switched off, the main parameter is the **set temperature T_{SET}**.
After switching on the module, the LED "ON" 8 on the front of the module lights up and the main parameter changes to the **actual temperature T_{ACT}**.

Note

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

Selecting a Module

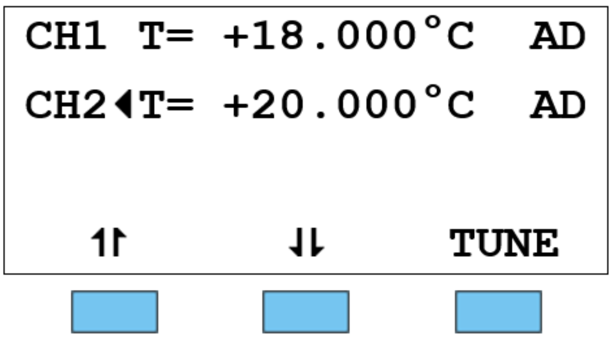
Select a module for further input by setting the cursor to the channel number of the desired module using the soft keys ⇑ and ⇓.

CH4◀

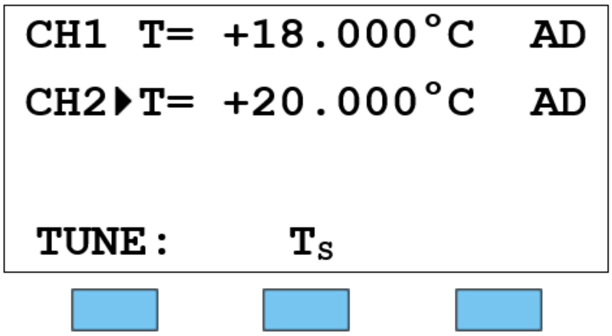
Pressing [CHANNEL] will lead to the channel menu 20.

Setting the temperature

To set the set temperature in the main menu, select the corresponding module (here CH2) with the cursor:



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



Now, the set temperature can be adjusted by means of the tuning knob. Pressing the 

key completes the procedure.

Note

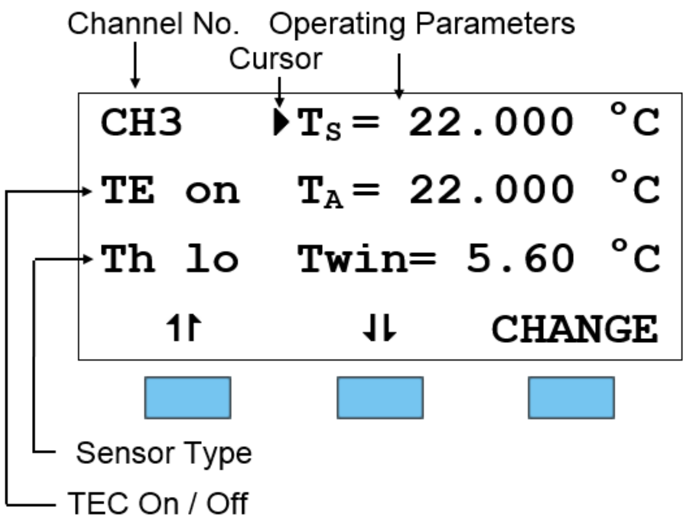
If the TEC current is switched ON, the actual temperature is displayed. In this case the set temperature can still be changed but is not displayed.

5.3 Functions in the Channel Menu

The channel menu is opened from the main menu by pressing the key CHANNEL.
Push CHANNEL or ESC again to return to the main menu.

5.3.1 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

The field "Sensor Type" shows:

AD590	If the sensor is an AD590, LM335 or equivalent
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 Pt-100 (Pt-100 option)
Kry hi	If the sensor is a Pt-1000 (200 to 500 Ω; KRYO module only)
Kry lo	If the sensor is a Pt-1000 (480 to 1200 Ω; KRYO module only)

Further lines follow, depending on the sensor type (examples shown):

Thermistor

```
Th.range=low
Exponential
RS = 9.1234 kΩ
RA = 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
```

PT100

```
Rs=100.00 Ω
Ra=100.25 Ω
Rwin=10.50 Ω
```

KRYO

```
low range
Rs=300.00 Ω
Ra=298.45 Ω
Rwin=10.50 Ω
```

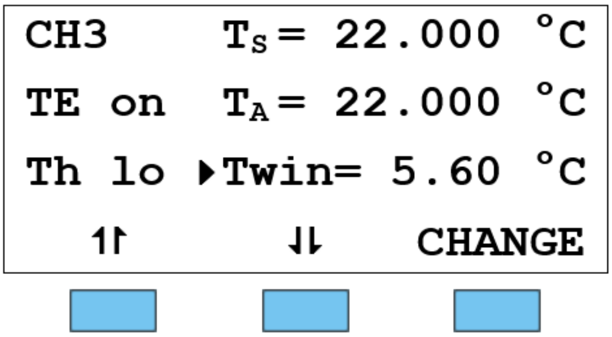
AD590

```
AD590
```

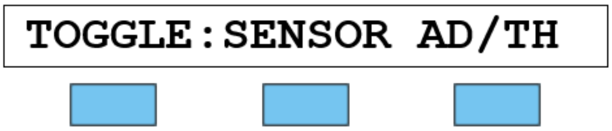
5.3.2 Changing Parameters

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

Example: Change **TWIN**:



Pressing the soft key **CHANGE** activates the tuning knob to change the selected parameter. If the parameter is only to toggle (e.g., the type of the temperature sensor), the function of the soft keys will change:



Pressing the right soft key changes the sensor; pressing the 

key terminates the procedure.

Note

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

5.3.3 Selecting the Type of the Temperature Sensor

The sensor type can be selected in the TED80xx modules by selecting the line "Thermistor" respectively "AD590".

AD590 = AD590 and LM335 families

Thermistor = Thermistor. Please select the corresponding range (HI or LO).

The channel menu displays in the second line the options:

AD590

Th lo

Th hi

The TED8000-PT modules offer instead of AD590/LM335 sensors the Pt-100 sensor:

Thermistor = Thermistor. Please select the corresponding range (HI or LO).

PT100 = Pt-100. No further selection.

The channel menu displays in the second line the options:

PT100

Th lo

Th hi

For the TED8000-KRYO modules, only the Pt-1000 is available as temperature sensor. Two temperature (resistance) ranges are available for selection, see Selecting the Pt-1000 Range (KRYO only) 23.

The channel menu displays in the second line the options:

Kry lo or

Kry hi

Select the desired type and press ESC. Please refer also to Changing Parameters 22.

5.3.4 Selecting the Thermistor Range

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 type and press ESC.

5.3.5 Selecting the Pt-1000 Range (KRYO only)

The temperature range of the Pt-1000 can be selected in the menu line "**Range**".

In "**Low range**", the operating temperature range is 76 K to about 148 K, in the "**High range**" - from 143 K to about 325 K.

The display changes between:

Low range and

High range

5.3.6 Thermistor Calibration

Select the calculation method

If the relation between temperature and resistance for a given thermistor is known, the PRO8 system is able to display temperature directly in °C instead of resistance in Ω. Therefore, a calibration of the sensor in °C is necessary.

Two well known methods to calculate the resistance from temperature are implemented:

- The Exponential Method
- The Steinhart-Hart Method

In the channel menu the approximation method can be selected and the corresponding parameters can be entered. Select the line

`Steinh.-Hart` or **`Exponential`**

The right soft key toggles between the two methods. Select the desired type and press ESC to apply the setting.

Exponential method

The dependency between resistance and temperature of an NTC (thermistor) can be described by the formulas:

$$R(T) = R_0 \text{ x } e^{B_{val} * \left(\frac{1}{T} - \frac{1}{T_0}\right)} \quad \Leftrightarrow \quad T(R) = \frac{B_{val} \text{ x } T_0}{T_0 \text{ x } \ln\left(\frac{R}{R_0}\right) + B_{val}}$$

with:

	$R(T)$	Thermistor resistance at a given temperature T
	R_0	Thermistor nominal resistance at temperature T_0
	T_0	Nominal temperature (typ. 298.15 K = 25° C)
	B_{val}	Energy constant

(Temperature always given in Kelvin)

For R_0, T_0 and B_{val}, please 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. Press ESC to apply the setting. See also Changing Parameters 22.

Steinhart-Hart method

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

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

with the three parameters C1, C2 and C3.

To change the three parameters in accordance with the actual thermistor, select them one by one and set them to the desired value.

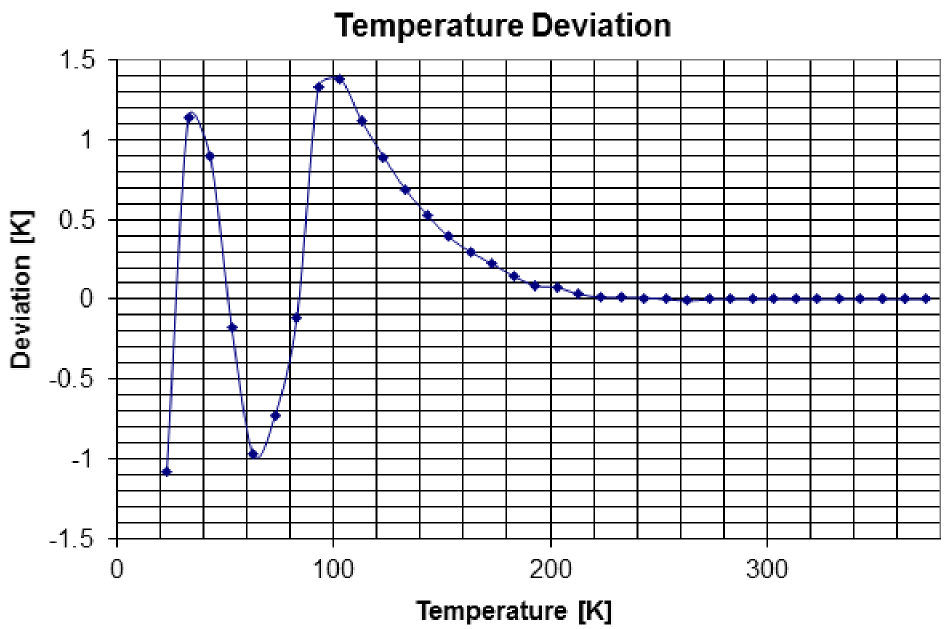
Pressing ESC terminates the input and applies value.

5.3.7 Pt-1000 Calibration (KRYO only)

The Pt-1000 sensor is factory calibrated and does not need any further calibration. The temperature is calculated from the sensor's resistance according to DIN-IEC751.

However, at very low temperatures (below 200 K) certain differences between the DIN-IEC751 calculation model and the real sensor temperature appear.

The following diagram shows the temperature correction values that needs to be applied to the displayed temperature values in order to obtain physically correct temperatures:



Example:

Desired (set) temperature = 100 K. The diagram shows at 100 K a deviation ΔT = +1.4 K.

$$T_{SET} = T_{display} = T_{sensor} - \Delta T = 98.6\ K$$

5.3.8 Setting a Temperature Window

A temperature window can be set to ensure that a laser diode is operated within a defined temperature interval. Particularly, this function can be used with an external control computer. In local mode, the “ERR” led will light up, if the temperature exceeds the window.

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

Press  to apply the setting.

Note

Please keep in mind that if you use the TED8000 module in conjunction with a LDC8xxx laser diode controller, the LDC might switch off the laser current automatically when changing the temperature window, as the actual laser temperature could be outside the new window.

5.3.9 Setting the P, I and D Share of the Control Loop

The temperature control behavior of the TED8000 can be adapted to the individual laser setup by optimizing the P, I and D share parameters of the control loop.

They can be set separately in a range between 0.1 % and 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 apply the setting.

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

Toggle the function using the right soft key.

Press ESC to terminate input.

5.4 Switching ON and OFF

Attention

TED8000 modules can be switched on or off at any time, with no regard if any parameters have been set! So make sure that the appropriate Pre-Settings 17 are made prior to switching on the module!

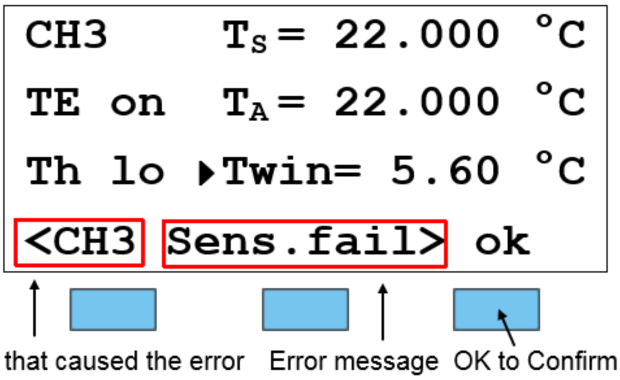
Select the module to be switched on or off in the main menu 18. The LED "SEL" of the selected module lights up.

Press the key ON/OFF to switch on the selected module. The LED "ON" of the selected module will light up, this way indicating that the TEC current is enabled.

5.5 Error Messages

Error messages are shown in the bottom line of the display independent of the actual menu (main menu or channel menu).

If an error occurs while the module is switched on, the display shows for example:



Possible error messages for an TED8000 module are:

Sens. fail Connection to the sensor lost during operation.

NO SENSOR No sensor connected or wrong sensor found when trying to switch on.

OPEN Connection to the TEC element was interrupted during operation.

OTP **O**ver **T**emperature **P**rotection. Module has been switched off due to overheating. The module can be switched on only after cooling down.

TEMP PROT TACT exceeded TWIN. If an LDC80xx was assigned, the laser was switched off.

NOT IF TEC ON Certain parameters are not allowed to be changed while TEC is ON.

OVERTEMP The module is still overheated and cannot be switched on.

If an error occurs during operation, it is displayed in brackets:

<CH3 Sens.fail>

If the error occurs when trying to switch on, it is displayed in cursor arrows:

▶CH1 No Sensor◀

Any error must be confirmed by pushing the "**ok**" soft key. Any further operation is locked until "**ok**" soft key is pushed.

6 Communication with a PC

The description of the PRO8000 Series mainframe includes all instructions of how to prepare and execute the programming of the system via a computer interface.

Special operation features of the TED8000 module are described here. See also section Operating Instruction 17.

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 lower or upper cases.

Attention

Prior to programming a TED8000 module the limit value of the TEC current ILIM (hardware limit) for the used TEC element must be set using a screwdriver.
The corresponding potentiometer is marked ILIM and is located on the front panel 8 of the TED8000 module.
The value ILIM is constantly measured by the PRO8000 Series mainframe and can be checked in the channel menu 17 of the TED8000 during setting.

6.1 Nomenclature

Program messages (PC to PRO8000) are written in inverted commas:	**"*IDN?"**
Response messages (PRO8000 to PC) are written in brackets:	**[:SLOT 1]**
Decimal point:	**1.234**
Subsequent parameters are separated with commas:	**"PLOT 2,0"**
Subsequent commands are separated with semicolons:	**"*IDN?;*STB?"**

6.2 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**

(See IEE488.2 50, section 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**

(See IEE488.2 50, section 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**

(See IEE488.2 50, section 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**

(See IEE488.2 50, section 8.7.4)

6.3 Commands and Queries

6.3.1 Select the Module Slot

Command	Explanation Response Example
":SLOT <NR1>"	Selects a slot for further programming **<NR1>** = 1…8 PRO8000, PRO8000-4 **<NR1>** = 1…2 PRO800
":SLOT?"	Queries the selected slot [:SLOT <NR1><LF>]

6.3.2 Thermistor Calibration - Exponential Method

Command	Explanation Response Example
Programming	
":CALTB:SET <NR3>"	Programs the energy constant B_{val}
":CALTR:SET <NR3>"	Programs the nominal resistance R_0
":CALTT:SET <NR3>"	Programs the nominal temperature T_0
Reading	
":CALTB:SET?"	Reads the energy constant B_{val} [:CALTB:SET <NR3><LF>]
":CALTR:SET?"	Reads the nominal resistance R_0 [:CALTR:SET <NR3><LF>]
":CALTT:SET?"	Reads the nominal temperature T_0 [:CALTT:SET <NR3><LF>]
":CALTB:MIN?"	Reads the minimum allowed energy constant B_{val} [:CALTB:MIN <NR3><LF>]
":CALTR:MIN?"	Reads the minimum allowed nominal resistance R_0 [:CALTR:MIN <NR3><LF>]
":CALTT:MIN?"	Reads the minimum allowed nominal temperature T_0 [:CALTT:MIN <NR3><LF>]
":CALTB:MAX?"	Reads the maximum energy constant B_{val} [:CALTB:MAX <NR3><LF>]
":CALTR:MAX?"	Reads the maximum allowed nominal resistance R_0 [:CALTR:MAX <NR3><LF>]
":CALTT:MAX?"	Reads the maximum allowed nominal temperature T_0 [:CALTT:MAX <NR3><LF>]

Refer to section Thermistor Calibration - Exponential Method 29.

Attention

These commands ***do not*** apply to TED8000-KRYO!

Note

The selection by which method (exponential or Steinhart-Hart) the sensor calibration will be executed, depends on the order in which the coefficients are transmitted:

- 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 selected.

6.3.3 Thermistor Calibration - Steinhart-Hart Method

Command	**Explanation** **Response Example**
Programming	
":CALTC1:SET <NR3>"	Programs the Steinhart-Hart coefficient C1
":CALTC2:SET <NR3>"	Programs the Steinhart-Hart coefficient C2
":CALTC3:SET <NR3>"	Programs the Steinhart-Hart coefficient C3
Reading	
":CALTC1:SET?"	Reads the Steinhart-Hart coefficient C1 **[:CALTB:SET <NR3><LF>]**
":CALTC2:SET?"	Reads the Steinhart-Hart coefficient C2 **[:CALTR:SET <NR3><LF>]**
":CALTC3:SET?"	Reads the Steinhart-Hart coefficient C3 **[:CALTT:SET <NR3><LF>]**
":CALTC1:MIN?"	Reads the minimum allowed Steinhart-Hart coefficient C1 **[:CALTB:MIN <NR3><LF>]**
":CALTC2:MIN?"	Reads the minimum allowed Steinhart-Hart coefficient C2 **[:CALTR:MIN <NR3><LF>]**
":CALTC3:MIN?"	Reads the minimum allowed Steinhart-Hart coefficient C3 **[:CALTT:MIN <NR3><LF>]**
":CALTC1:MAX?"	Reads the maximum allowed Steinhart-Hart coefficient C1 **[:CALTB:MAX <NR3><LF>]**
":CALTC2:MAX?"	Reads the maximum allowed Steinhart-Hart coefficient C2 **[:CALTR:MAX <NR3><LF>]**
":CALTC3:MAX?"	Reads the maximum allowed Steinhart-Hart coefficient C3 **[:CALTT:MAX <NR3><LF>]**

Refer to section Thermistor Calibration - Steinhart-Hart Method 30.

Attention

These commands ***do not*** apply to TED8000-KRYO!

Note

The selection by which method (exponential or Steinhart-Hart) the sensor calibration will be executed, depends on the order in which the coefficients are transmitted:

- 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 selected.

6.3.4 Switching the I Share On / Off (INTEG)

Command	Explanation **Response Example**
Programming	
":INTEG ON"	Switches the I share on
":INTEG OFF"	Switches the I share off
Reading	
":INTEG?"	Reads the status of the I share **[:INTEG ON<LF>]** **[:INTEG OFF<LF>]**

6.3.5 Reading the TEC Current (ITE)

Command	Explanation **Response Example**
Programming	
":ITE:MEAS <NR1>"	Programs I_{TEC} to be the measurement value for "ELCH[1])" on position <NR1> (1...8) in the output string.
Reading	
":ITE:ACT?"	Reads the actual TEC (or heater) current **[:ITE:ACT <NR3><LF>]**
":ITE:MIN_R?"	Reads the minimum TEC current for I_{TE} - ADC = 0000 **[:ITE:MIN_R <NR3><LF>]**
":ITE:MAX_R?"	Reads the maximum TEC current for I_{TE} - ADC = FFFF **[:ITE:MAX_R <NR3><LF>]**
":ITE:MEAS?"	Reads the position of the TEC current as measurement value in the "ELCH" output string (**1....8**, **0** if not selected) **[:ITE:MEAS <NR1><LF>]**

[1]) **EL**ectrical **CH**aracterization

6.3.6 Programming the TEC Current Software Limit (LIMT)

Command	**Explanation** **Response Example**
Programming	
":LIMT:SET <NR3>"	Programs the TEC software current limit
Reading	
":LIMT:SET?"	Reads the TEC software current limit **[:LIMT:SET <NR3><LF>]**
":LIMT:MIN?"	Reads the minimum allowed TEC software current limit **[:LIMT:MIN <NR3><LF>]**
":LIMT:MAX?"	Reads the maximum allowed TEC software current limit **[:LIMT:MAX <NR3><LF>]**
":LIMT:MIN_W?"	Reads $I_{TE\,LIM}$ - ADC = 0000 **[:LIMC:MIN_W <NR3><LF>]**
":LIMT:MAX_W?"	Reads $I_{TE\,LIM}$ - ADC = FFFF **[:LIMC:MAX_W <NR3><LF>]**

6.3.7 Reading the TEC Current Hardware Limit (LIMTP)

Command	**Explanation** **Response Example**
Reading	
":LIMTP:ACT?"	Reads the actual TEC hardware current limit **[:LIMTP:ACT <NR3><LF>]**
":LIMT:MIN_W?"	Reads $I_{TE\,MAX}$ - DAC = 0000 **[:LIMT:MIN_W <NR3><LF>]**
":LIMT:MAX_W?"	Reads $I_{TE\,MAX}$ - DAC = FFFF **[:LIMT:MAX_W <NR3><LF>]**

See also section Pre-Settings 17.

6.3.8 Programming the Resistance of the Temperature Sensor (RESI)

Command	**Explanation** **Response Example**
Programming	
":RESI:SET <NR3>"	Programs the set resistance of the temperature sensor (thermistor, Pt-100, Pt-1000)
":RESI:MEAS <NR1>"	Programs **RESI** to be the measurement value for "ELCH[1])" on position <NR1> (1...8) in the output string.
Reading	
":RESI:SET?"	Reads the set resistance of the temperature sensor **[:RESI:SET <NR3><LF>]**
":RESI:ACT?"	Reads the actual resistance of the temperature sensor **[:RESI:ACT <NR3><LF>]**
":RESI:MIN?"	Reads the minimum allowed set resistance of the sensor **[:RESI:MIN <NR3><LF>]**
":RESI:MAX?"	Reads the maximum allowed set resistance of the sensor **[:RESI:MAX <NR3><LF>]**
":RESI:MIN_W?"	Reads R - DAC = 0000 **[:RESI:MIN_W <NR3><LF>]**
":RESI:MAX_W?"	Reads R - DAC = FFFF **[:RESI:MAX_W <NR3><LF>]**
":RESI:MIN_R?"	Reads R - ADC = 0000 **[:RESI:MIN_R <NR3><LF>]**
":RESI:MAX_R?"	Reads R - ADC = FFFF **[:RESI:MAX_R <NR3><LF>]**
":RESI:MEAS?"	Reads the position of R as measurement value in the "ELCH" output string (**1....8**, **0** if not selected) **[:RESI:MEAS <NR1><LF>]**

[1]) **EL**ectrical **CH**aracterization

6.3.9 Programming the Resistance Window (RWIN)

Command	**Explanation** **Response Example**
Programming	
":RWIN:SET <NR3>"	Programs the resistance window.
Reading	
":RWIN:SET?"	Reads the set resistance window. **[:RWIN:SET <NR3><LF>]**
":RWIN:MIN?"	Reads the minimum allowed set resistance window. **[:RWIN:MIN <NR3><LF>]**
":RWIN:MAX?"	Reads the maximum allowed set resistance window. **[:RWIN:MAX <NR3><LF>]**
":RWIN:MIN_W?"	Reads RWIN - DAC = 0000 **[:RWIN:MIN_W <NR3><LF>]**
":RWIN:MAX_W?"	Reads RWIN - DAC = FFFF **[:RWIN:MAX_W <NR3><LF>]**

6.3.10 Selecting the Sensor (SENS)

Command	**Explanation** **Response Example**
Programming	
":SENS AD"	Sensor: AD590 / LM335 Series
":SENS THL"	Sensor: Thermistor, 20 kΩ range
":SENS THH"	Sensor: Thermistor, 200 kΩ range
":SENS PT100"	Sensor: Pt-100 [1])
":SENS PT1000L"	Sensor: Pt-1000, low temperature range [2])
":SENS PT1000H"	Sensor: Pt-1000, high temperature range [2])
Reading	
":SENS?"	Reads the actual sensor type **[:SENS AD<LF>]** **[:SENS THL<LF>]** **[:SENS THH<LF>]** **[:SENS PT100<LF>]** **[:SENS PT1000L<LF>]** **[:SENS PT1000H<LF>]**

[1]) Only for TED8000-PT

[2]) Only for TED8000-KRYO

6.3.11 Programming the PID Shares (SHAREP, SHAREI, SHARED)

Command	**Explanation** **Response Example**
Programming	
":SHAREP:SET <NR3>"	Programs the P share
":SHAREI:SET <NR3>"	Programs the I share
":SHARED:SET <NR3>"	Programs the D share
Reading	
":SHAREP:SET?"	Reads the P share **[:SHAREP:SET <NR3><LF>]**
":SHAREI:SET?"	Reads the I share **[:SHAREI:SET <NR3><LF>]**
":SHARED:SET?"	Reads the D share **[:SHARED:SET <NR3><LF>]**
":SHAREP:MIN?"	Reads the minimum allowed P share **[:SHAREP:MIN <NR3><LF>]**
":SHAREI:MIN?"	Reads the minimum allowed I share **[:SHAREI:MIN <NR3><LF>]**
":SHARED:MIN?"	Reads the minimum allowed D share **[:SHARED:MIN <NR3><LF>]**
":SHAREP:MAX?"	Reads the maximum allowed P share **[:SHAREP:MAX <NR3><LF>]**
":SHAREI:MAX?"	Reads the maximum allowed I share **[:SHAREI:MAX <NR3><LF>]**
":SHARED:MAX?"	Reads the maximum allowed D share **[:SHARED:MAX <NR3><LF>]**

Please see also PID Adjustment 16.

6.3.12 Switching the TEC On / Off (TEC)

Command	**Explanation** **Response Example**
Programming	
":TEC ON"	Switches the TEC output ON
":TEC OFF"	Switches the TEC output OFF
Reading	
":TEC?"	Reads the TEC output status: **[:TEC ON<LF>]** **[:TEC OFF<LF>]**

6.3.13 Programming the Temperature (TEMP)

Command	**Explanation** **Response Example**
Programming	
":TEMP:SET <NR3>"	Programs the set temperature
":TEMP:MEAS <NR1>"	Programs **TEMP** to be the measurement value for "ELCH[1])" on position <NR1> (1...8) in the output string.
Reading	
":TEMP:SET?"	Reads the set temperature **[:TEMP:SET <NR3><LF>]**
":TEMP:ACT?"	Reads the actual temperature **[:TEMP:ACT <NR3><LF>]**
":TEMP:MIN?"	Reads the minimum allowed set temperature **[:TEMP:MIN <NR3><LF>]**
":TEMP:MAX?"	Reads the maximum allowed set temperature **[:TEMP:MAX <NR3><LF>]**
":TEMP:MIN_W?"	Reads T - DAC = 0000 **[:TEMP:MIN_W <NR3><LF>]**
":TEMP:MAX_W?"	Reads T - DAC = FFFF **[:TEMP:MAX_W <NR3><LF>]**
":TEMP:MIN_R?"	Reads T - ADC = 0000 **[:TEMP:MIN_R <NR3><LF>]**
":TEMP:MAX_R?"	Reads T - ADC = FFFF **[:TEMP:MAX_R <NR3><LF>]**
":TEMP:MEAS?"	Reads the position of **TEMP** as measurement value in the "ELCH" output string (**1....8**, **0** if not selected) **[:TEMP:MEAS <NR1><LF>]**

[1]) **EL**ectrical **CH**aracterization

6.3.14 Programming the Temperature Window (TWIN)

Command	**Explanation** **Response Example**
Programming	
":TWIN:SET <NR3>"	Programs the temperature window.
Reading	
":TWIN:SET?"	Reads the temperature window. **[:TWIN:SET <NR3><LF>]**
":TWIN:MIN?"	Reads the minimum allowed temperature window. **[:TWIN:MIN <NR3><LF>]**
":TWIN:MAX?"	Reads the maximum allowed temperature window. **[:TWIN:MAX <NR3><LF>]**
":TWIN:MIN_W?"	Reads TWIN - DAC = 0000 **[:TWIN:MIN_W <NR3><LF>]**
":TWIN:MAX_W?"	Reads RWIN - DAC = FFFF **[:RWIN:MAX_W <NR3><LF>]**

6.3.15 Query Type of Module

Command	**Explanation** **Response Example**
Reading	
":TYPE:ID?"	Reads the module ID (here 223 for TED8000) **[:TYPE: 223<LF>]**
":TYPE:SUB?"	Queries the module's sub-type: **[:TYPE:SUB <NR1><LF>]** where the <NR1> value stands for: 0 = Standard TED8000 1 = TED8000-PT 2 = TED8000-KRYO

6.3.16 Reading the TEC Voltage (VTE)

Command	**Explanation** **Response Example**
Programming	
":VTE:MEAS <NR1>"	Programs TEC (or heater) voltage to be the measurement value for "ELCH[1])" on position <NR1> (1...8) in the output string.
Reading	
":VTE:ACT?"	Reads the actual TEC (or heater) voltage **[:VTE:ACT <NR3><LF>]**
":VTE:MIN_R?"	Reads the minimum U_{TE} - ADC = 0000 **[:VTE:MIN_R <NR3><LF>]**
":VTE:MAX_R?"	Reads the maximum U_{TE} - ADC = FFFF **[:VTE:MAX_R <NR3><LF>]**
":VTE:MEAS?"	Reads the position of the TEC voltage as measurement value in the "ELCH" output string (**1....8**, **0** if not selected) **[:VTE:MEAS <NR1><LF>]**

[1]) **EL**ectrical **CH**aracterization

6.4 IEEE Error Messages

[1103, "Over temperature"]

Reason: **O**ver **T**emperature **P**rotection was tripped. The module is overheated and cannot be switched on. Wait until the module has cooled down.

[1104,"Wrong or no sensor"]

Reason: Attempt to switch on the TEC controller, while no sensor is connected or wrong sensor is selected.

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

Reason: The sensor cannot be calibrated while the TEC output is switched on.

[1106,"Wrong command for this sensor"]

Reason: The used command is not allowed for the selected sensor, e.g., attempt to set a thermistor resistance value, while the selected and recognized sensor is an AD590)

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

Reason: The sensor type cannot be changed while the TEC output is switched on.

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

Reason: A command was entered that is not valid for the present module type (e.g. “CALTR” with a KRYO module).

6.5 Status Reporting

The TED8000 module provides three 16 bit registers 40

DEC Device Error Condition Register

DEE Device Error Event Register

EDE Device Error Event Enable Register

together with four 8 bit registers 41 of the PRO8000 mainframe

ESR Standard event status register

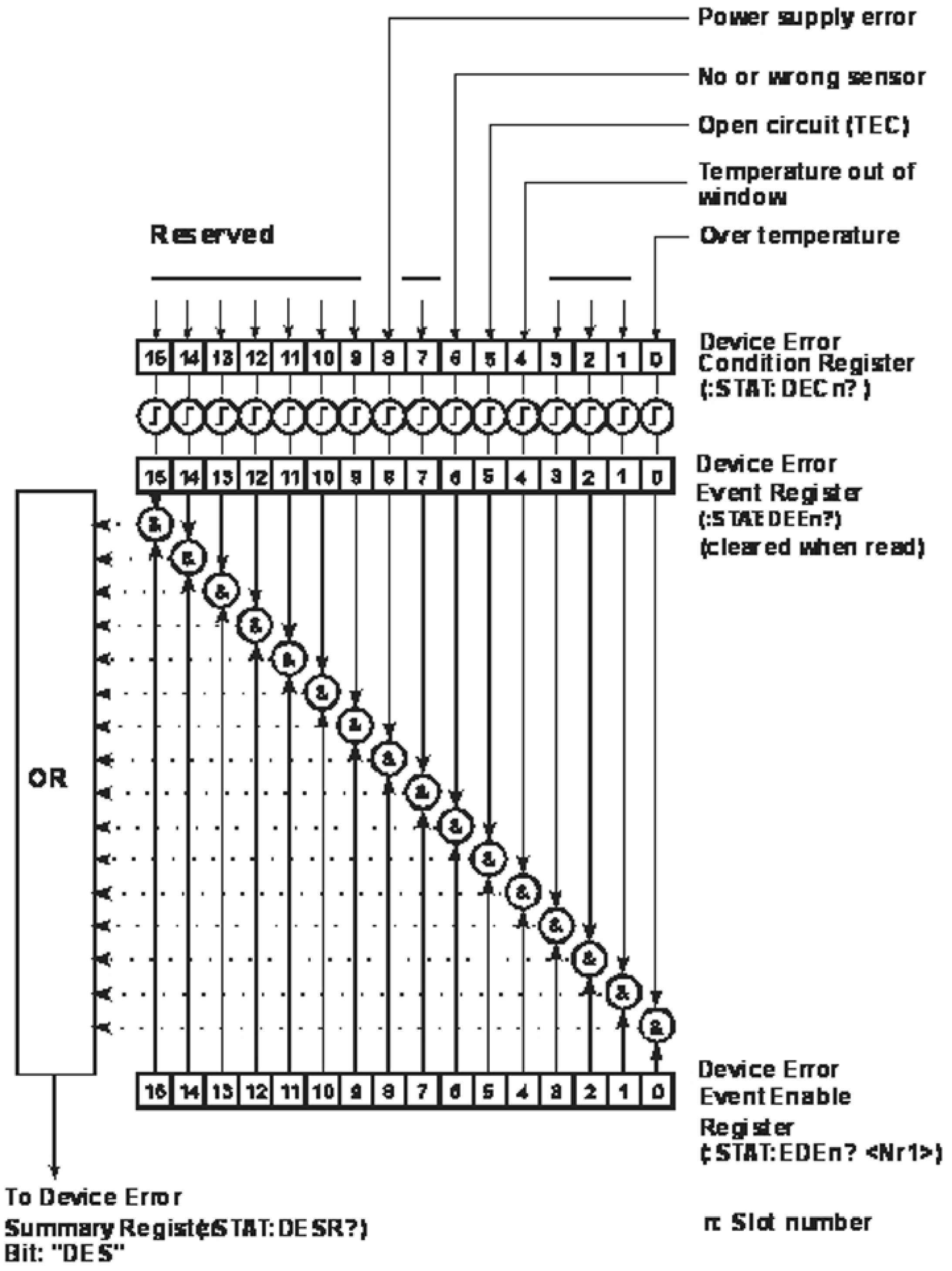
ESE Standard event Status Enable Register

STB Status Byte Register

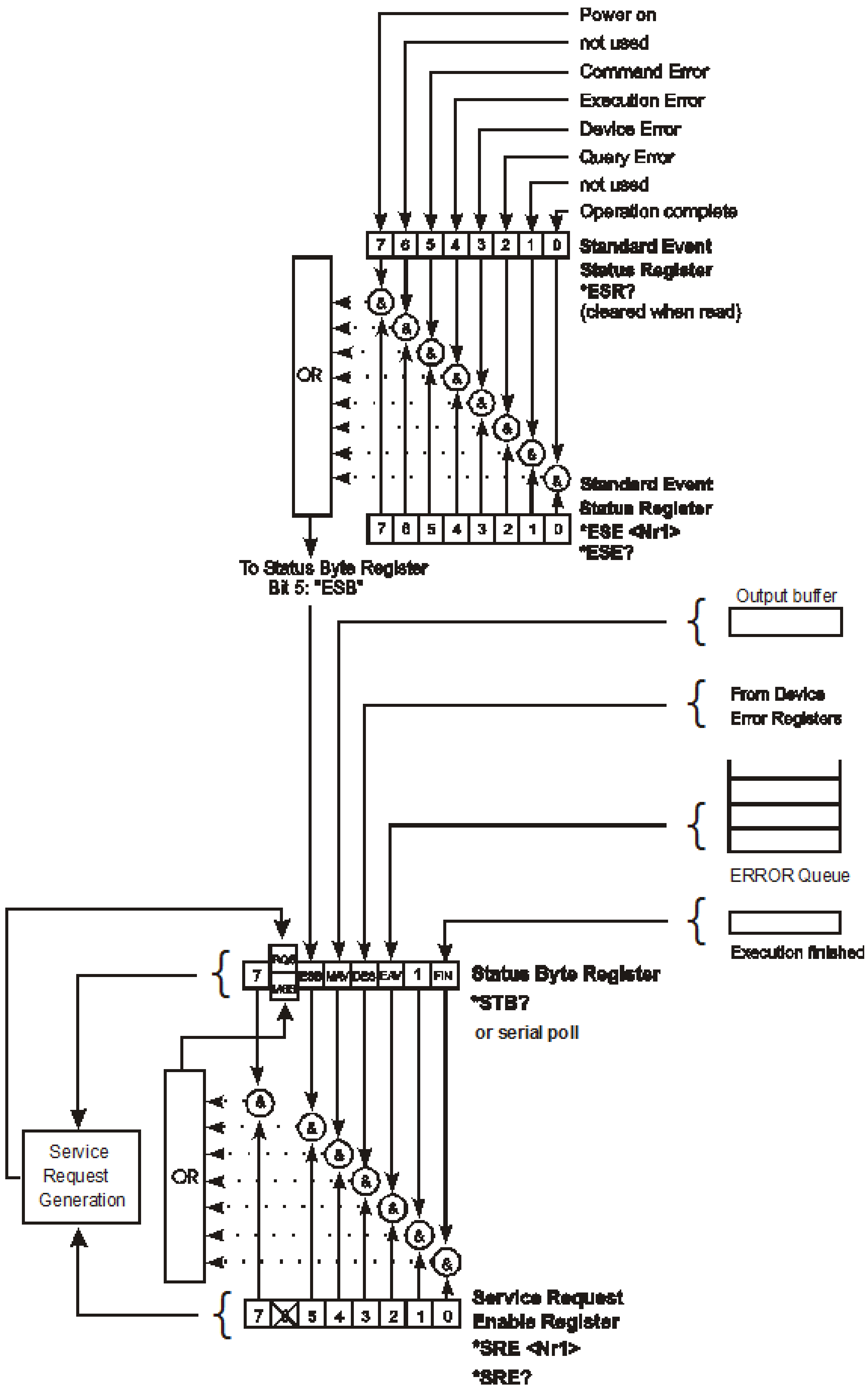
SRE Service Request Enable Register

to program various service request functions and status reporting.

See also IEE488.2 Standard 50, section 11.



Structure of the registers DEC, DEE and EDE



Structure of the registers ESR, ESE, STB and SRE

6.5.1 Standard Event Status Register (ESR)

Using the command **"*ESR?"**, the ESR can be read directly. Reading the ESR clears it at the same time. The content of the ESR can not be set.

The bits are active-high and represent the following standard events:

Power on :	This bit indicates the OFF to ON state of the power supply. State = HIGH after switching 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 (module error) occurred.
Query error:	An error occurred when trying to query a value.
Request control:	not used
Operation complete:	Can be set with **"*OPC"**. All started operations have been completed. System is in idle mode.

6.5.2 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 Status Byte Register (STB).
The 8 bits of the ESE are connected by logical "AND" with the according 8 bits of the ESR. The 8 results are connected by logical "OR", so that any "hit" leads to a logical 1 of 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.

6.5.3 Status Byte Register (STB)

The bits of this register show the status of the PRO8000 mainframe. The register can be read out using ***STB?**. The content of the STB can not be set. The bits are active-high.

RQS	**R**e**Q**uest **S**ervice message: Shows that this device has asserted SRQ (read via serial poll).
MSS	**M**aster **S**ummary **S**tatus: Shows that this device requests a service (read via **"*STB?"**).
MAV (Message AVailable)	This bit is HIGH after a query, as a result "waits" in the output queue to be fetched. If the output queue is empty, it is LOW.
DES (Device Error Status)	This bit is HIGH after a device error occurred. EDE defines which device errors this bit sets.
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.

All bits except bit 6 of the STB can be used to assert a service request (SRQ 43). Alternatively the SRQ can be recognized using the command "*STB?" 43 or by serial poll 43.

6.5.4 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 combined by logical "AND" with the according 7 bits of the SRE. These 7 results are combined by logical "OR", so that any "hit" leads to a logical 1 in bit 6 of the STB and asserts an SRQ.

6.5.5 Reading the STB by Detecting SRQ

If an SRQ 43 is asserted, bit 6 of the STB is set to logical 1, so that the controller can detect by auto serial polling, which device asserted the SRQ.

6.5.6 Reading the STB by *STB? Command

If the controller does not "listen" to SRQs 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.

6.5.7 Reading 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.

6.5.8 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 TED8000 modules the bits 0, 4, 5, 6 and 8 are used

Bit 0 - Over temperature
TED8000 is overheated. Wait until the module has cooled down. Maintain proper air flow.

Bit 4 - Temperature out of window
The temperature of the device under control is out of specified window.

Bit 5 - Open circuit
The TEC circuit is open (interrupted connection).

Bit 6 - No or wrong Sensor
A temperature sensor could not be recognized, or the type of the recognized sensor does not match the setting of the TED8000.

Bit 8 - Power supply error
Internal power supply error.

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

6.5.9 Device Error Event Register (DEE)

The bits of this register hold the errors that occurred during operation (operation errors). So each bits of the DEC sets the according bit of the DEE.
The DEE can be read but not set.
Reading out clears the DEE.

6.5.10 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 combined by logical "AND" to the according 8 bits of the DEE. These 8 results are combined 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.

7 Maintenance and Service

Protect the TED8000 from adverse weather conditions. The TED8000 is not water resistant.

Attention

To avoid damage to the instrument, do not expose it to spray, liquids or solvents!

The unit does not need a regular maintenance by the user. It does not contain any modules and/or components that could be repaired by the user himself. If a malfunction occurs, please contact Thorlabs 56 for return instructions.

Do not remove covers!

In order to ensure best performance, accuracy and reliable operation, Thorlabs recommends a **recalibration after 24 months.**

7.1 Troubleshooting

In the case that your TED8000 shows malfunction please check the following topics:

- **The module does not work at all (no display on the mainframe):**
  - Is the mainframe connected properly to the mains power supply?
    - Connect the mainframe to the power line, take care of the correct voltage setting and grounding of the mainframe.
  - Is the mainframe turned on?
    - Turn on the power key switch.
  - Check the fuse at the rear panel of the mainframe.
    - If blown, replace the fuse with the correct type (one spare fuse is inserted in the fuse holder). Please refer to section Exchanging the Mains Fuse in the PRO8000 Series Manual.

- **The 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.
  - Is the desired module selected?
    - Select the desired module on the display by means of the up- and down arrow keys. (LED “SEL” on the front panel lights up).
  - Is the TEC output turned ON 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 light up.
  - Is the hardware limit I_{LIM} and / or the software limit I_{MAX} set to 0?
    - Adjust the hardware limit I_{LIM} by means of the potentiometer on the TED8000 front panel and the software limit I_{LIM} in the channel menu to appropriate values.

- **You don't get the desired operation temperature**
  - Is the TEC element (or the heater, if TED8000-KRYO) connected properly and are the temperature sensor parameters entered correctly?
    - Check all cable connections.
    - Check the software settings in the Channel menu 20.
    - Verify the temperature sensor selection.
    - Verify the temperature sensor parameter settings. See section Selecting the Type of the Temperature Sensor 22 and subsequent.

- **The actual temperature of the device under control differs from the set temperature**
  - Is the temperature sensor calibrated correctly?
    - Verify the entered temperature sensor parameters. See section Thermistor Calibration 24.
  - Is the PID loop set up correctly?
    - Verify the PID share adjustment, see section PID Adjustment 16.

If above hints could not resolve the malfunction, please contact Thorlabs 56 for technical support and/or return instructions.

8 Appendix

8.1 Technical Data

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

Parameter	TED8020	TED8040	TED8080
TEC Current Control Range	-2 to +2 A	-4 to +4 A	-8 to +8 A
Compliance Voltage	> 8 V		
Maximum Output Power	16 W	32 W	64 W
Measurement Resolution TEC Current	0.07 mA	0.15 mA	0.3 mA
Measurement Accuracy TEC Current	± 10 mA	± 20 mA	± 50 mA
Measurement Resolution TEC Voltage	0.3 mV		
Measurement Accuracy TEC Voltage	± 20 mV		
Noise and Ripple (typ.)	< 1 mA	< 2 mA	< 4 mA
TEC Current Limit			
Setting Range Potentiometer ILIM	0 to ≥ 2 A	0 to ≥ 4 A	0 to ≥ 8 A
Resolution D/A Converter	0.5 mA	1 mA	2 mA
Accuracy	± 20 mA	± 40 mA	± 80 mA
Other Data			
Module Width	1 Slot	1 Slot	2 Slots
Weight	< 500 g	< 600 g	< 700 g

Temperature Control (Common)	
AD590 / AD592 / LM335 IC Sensors	
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 (24h, typ.)	< 0.001 °C
Thermistor (Calibrated / Not Calibrated, Temperature Display in Ω)	
Measurement Current	100 µA / 10 µA [1])
Control Range	5 Ω to 20 kΩ / 50 Ω to 200 kΩ [1])
Resolution	0.3 Ω / 3 Ω [1])
Setting Accuracy	±2.5 Ω / ±25 Ω [1])
Resistance Stability (24h, typ.)	< 0.5 Ω / 5 Ω [1])
Thermistor (Calibrated, Temperature Display in °C)	
Measurement Current	100 µA / 10 µA [1])
Control Range	Temperature at 20 kΩ / 200 kΩ to 150 °C [2])
Resolution	[2])
Setting Accuracy	[2])

Temperature Control (Common)	
Temperature Stability (24h, typ.)	[2])
Pt-100 (Optional; for TED80xx-PT only)	
Control Range	-12.375 °C … +90.000 °C
Measurement Accuracy	±0.3 °C
Measurement Resolution	0.0015 °C
Accuracy	±0.3 °C
Temperature Stability (24h, typ.)	< 0.005 °C
Pt-1000 (Optional; for TED80xx-KRYO only)	
Measurement Current	1 mA / 400 µA [3])
Control Range	20 K to 310 K [3])
Resolution	2 mK (within 20 K to 155 K)
Accuracy	2 K / 0.5 K [4]) (within 20 K to 155 K)
Temperature Stability (24h, typ.)	0.005 K (within 20 K to 155 K)
Temperature Control Loop	
Type	PID, Analog
P, I and D Shares	To Be Set Separately
Setting Range	0.1 to 100 %
Setting Resolution	12 bit
General	
Warm-up Time for Rated Accuracy	≤15 min
Operating Temperature Range [2])	0 - 40 °C
Storage Temperature Range	-40 to 70 °C
Output Connector	D-Sub 15 Pin, Female

[1]) Depending on the Selected Range (20 kΩ / 200 kΩ)
[2]) Depending on Thermistor Specification
[3]) Depending on Selected Range (High / Low)
[4]) After Applying Correction Factors as Stated in Section Pt-1000 Calibration (KRYO only) 25

8.2 Certifications and Compliances

Category	Standards or description	
EC Declaration of Conformity - EMC	Meets intent of Directive 2004/108/EC [1] for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:	
	EN 61326	EMC requirements for Class A electrical equipment for measurement, control and laboratory use, including Class A Radiated and Conducted Emissions [2,3,4] and Immunity [2,3,5]
	IEC 61000-4-2	Electrostatic Discharge Immunity (Performance Criterion C)
	IEC 61000-4-3	Radiated RF Electromagnetic Field Immunity (Performance Criterion B)
	IEC 61000-4-4	Electrical Fast Transient / Burst Immunity (Performance Criterion C)
	IEC 61000-4-5	Power line Surge Immunity (Performance criterion C)
	IEC 61000-4-6	Conducted RF Immunity (Performance Criterion B)
	IEC 61000-4-11	Voltage Dips and Interruptions Immunity (Performance Criterion C)
	EN 61000-3-2	AC Power Line Harmonic Emissions
Australia / New Zeeland Declaration of Conformity - EMC	Complies with the Radiocommunications Act and demonstrated per EMC Emission standard [2,3,4]	
	AS/NZ 2064	Industrial, Scientific, and Medical Equipment: 1992
FCC EMC Compliance	Emissions comply with the Class A Limits of FCC Code of Federal Regulations 47, Part 15, Subpart B [2,3,4].	

[1] Replaces 89/336/EEC.

[2] Compliance demonstrated using high-quality shielded interface cables shorter than or equal to 3 meters, including with CAB4xx Series cables installed at the TEC OUT port.

[3] Compliance demonstrated with the TED8000 Series modules installed in the Thorlabs PRO8xxx Series Mainframes.

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

[5] Minimum Immunity Test requirement.

8.3 Literature

[1] IEEE488.2-1992 - IEEE Standard Codes, Formats, Protocols, and Common Commands for Use With IEEE Std 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation

Available at http://www.ieee.org/publications_standards/index.html .

8.4 Warranty

Thorlabs warrants material and production of the TED8000 for a period of 24 months starting with the date of shipment. During this warranty period Thorlabs 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. The customer will carry the shipping costs to Thorlabs, in case of warranty repairs Thorlabs 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 warrants the hard- and/or software determined by Thorlabs for this unit to operate fault-free provided that they are handled according to our requirements. However, Thorlabs does not warrant a fault free and uninterrupted operation of the unit, of the software or firmware for special applications nor this instruction manual to be error free. Thorlabs 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 stated by us or unauthorized maintenance.

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

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

8.5 Copyright and Exclusion of Reliability

Thorlabs has taken every possible care in preparing this document. We however assume no liability for the content, completeness or quality of the information contained therein. The content of this document is regularly updated and adapted to reflect the current status of the hardware and/or software. We furthermore do not guarantee that this product will function without errors, even if the stated specifications are adhered to.

Under no circumstances can we guarantee that a particular objective can be achieved with the purchase of this product.

Insofar as permitted under statutory regulations, we assume no liability for direct damage, indirect damage or damages suffered by third parties resulting from the purchase of this product. In no event shall any liability exceed the purchase price of the product.

Please note that the content of this document is neither part of any previous or existing agreement, promise, representation or legal relationship, nor an alteration or amendment thereof. All obligations of *Thorlabs* result from the respective contract of sale, which also includes the complete and exclusively applicable warranty regulations. These contractual warranty regulations are neither extended nor limited by the information contained in this document. Should you require further information on this product, or encounter specific problems that are not discussed in sufficient detail in the document, please contact your local *Thorlabs* dealer or system installer.

8.6 Thorlabs 'End of Life' Policy

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

This offer is valid for Thorlabs electrical and electronic equipment

- sold after August 13th 2005
- marked correspondingly with the crossed out “wheelie bin” logo (see figure below)
- sold to a company or institute within the EC
- currently owned by a company or institute within the EC
- still complete, not disassembled and not contaminated

As the WEEE directive applies to self contained operational electrical and electronic products, this “end of life” take back service does not refer to other Thorlabs products, such as

- pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- components
- mechanics and optics
- left over parts of units disassembled by the user (PCB’s, housings etc.).

Waste treatment on your own responsibility

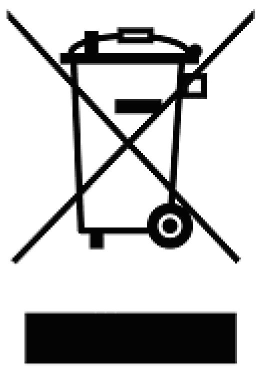
If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

WEEE Number (Germany) : DE97581288

Ecological background

It is well known that waste treatment pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS Directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE Directive is to enforce the recycling of WEEE. A controlled recycling of end-of-life products will thereby avoid negative impacts on the environment.



Crossed out
"Wheelie Bin" symbol

8.7 List of Acronyms

The following abbreviations are used in this manual:

AC	Alternating Current
ADC	Analog to Digital Converter
AG	Anode Ground
CG	Cathode Ground
CLR	CLeaR
CR	Carriage Return
CRD	Character Response Data
DAC	Digital to Analog Converter
DC	Direct Current
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
EDFA	Erbium Doped Fiber Amplifier
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
IEEE	Institute for Electrical and Electronic Engineering
LD	Laser Diode
LDC	Laser Diode Controller
LED	Light Emitting Diode
LF	Line Feed
LLO	Local Lockout
LS	Laser Source Module
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 Protection
PC	Personal Computer
PD	Photo Diode
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

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