



## Peltier- and Heating-Controller TC2812-RS232

### User Manual

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## 1. Overview

### 1.1. Application

The **Peltier- and Heating-Controller TC2812-RS232** is a temperature indicator with controlling function and PWM-output for driving thermoelectric (Peltier) elements.

By simply changing the controller-mode the device can be used as a heating controller. This configures the PWM-output for driving resistive heaters or solid state relays (SSR). Controller mode is available from S/N 10500. Older controllers were available in two versions TC2812 for peltier systems and TC2812HT for resistive heaters. Please see manual specific for these versions.

It has a housing for panel mount according to DIN 43700.

It requires an external DC power supply in the range from 12 to 32V and is solely intended for use with a low voltage power supply.

### 1.2. About the documentation

This documentation is valid for **Peltier- and Heating-Controller TC2812-RS232**, FW-Version V110.10 as of 11.11.2016. (S/N 10500 and higher)

The software TCCOM for Windows included in the package is documented in its own manual, supplied with the program. Version V200.34 of the firmware requires TCCOM for Windows V1.81 Build 103 or above.

### 1.3. Items supplied

Supplied items are:

- Peltier- and Heating-Controller TC2812-RS232
- 2 Stk mounting clamps
- 1 connector Sauro CIF, spacing 5.08mm, 4-pole
- 1 connectors Sauro CTF, spacing 3.81mm, 8-pole
- this manual as PDF file on CD
- TCCOM for Windows™ on CD
- User manual TCCOM for Windows™ as PDF-document on CD

As an option:

- Interface cable with 9-pole DSUB receptacle and connector, lengths available: 2m or 3m

## 2. Operation and Installation

### 2.1. Overview

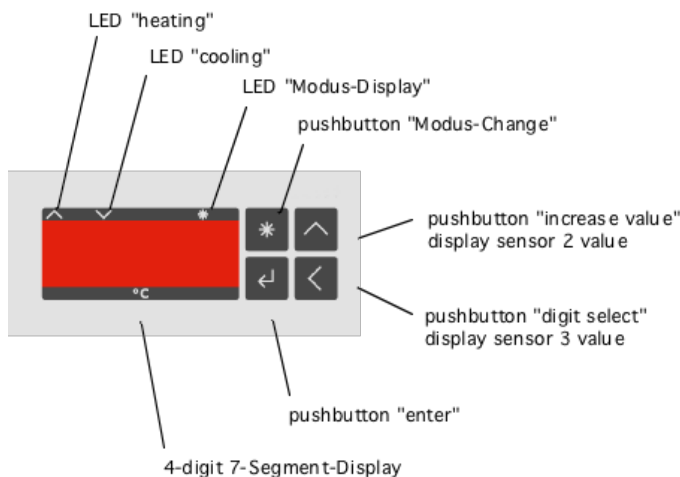
The keys are positioned on the visible front of the TC2812-RS232 Peltier- and Heating-Controller. The connections of the instrument are done via three connectors on the rear of the controller and are not accessible after installation. The instrument will be installed via two snap clamps with fastening screws.

### 2.2. Display and operating elements

The instrument has a 4-digits 7-segment-display. The temperature indication range is -75.0 ... + 175.0. The nominal temperature range is -50.0 ... + 150.0. The unused decimal points are used for displaying the state of the device.

Function of the 3 LEDs:

LED "Heating"	Controller is heating
LED "Cooling"	Controller is cooling
LED "Mode-Display"	Programming mode and other special displays



view of the front panel

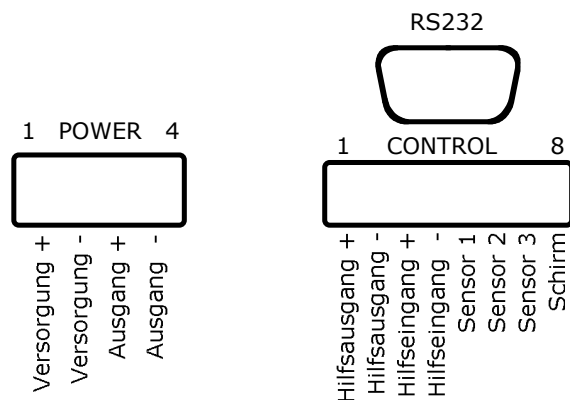
The 4 Keys have the following function:

Key "Mode-Switch"	changes the operating mode
Key "increase value"	in setup mode: increases the value of the selected digit in normal mode: temporarily displays the value of sensor 2 (if present)
Key "Digit selection"	in setup mode: changes the active digit in normal mode: temporarily displays the value of sensor 3 (if present)
Key "Enter"	stores the value or the item changed

## 2.3. Inputs and outputs

### 2.3.1. Overview

The connection is made with three connectors on the rear side of the controller.



view at the connectors

The connection is made via a 4-pole plug for power supply and power output and one 8-pole plugs for signals and sensors.

#### Voltage supply and power output

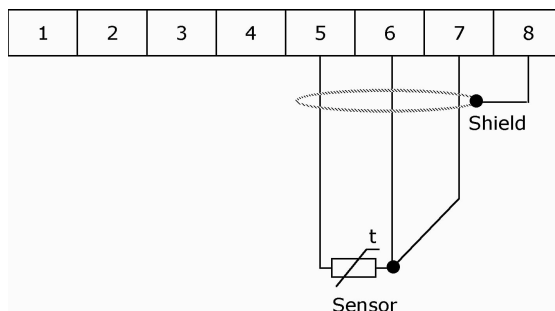
Pin configuration	1	power supply (plus)
	2	power supply (minus)
	3	power output (plus)
	4	power output (minus)

Pin configuration	1	Signal output (plus)
	2	Signal output (minus)
	3	Control input (plus)
	4	Control input (minus)
	5	sensor input (Sensor 1)
	6	3-wire input (Sensor 1)
	7	GND (Sensor 1)
	8	GND (optional shield of sensor cable)
DSUB9 receptable	2	RS232, RX-data from personal computer
	3	RS232, TX-data to personal computer
	5	RS232, signal ground

## 2.3.2. input Sensor 1

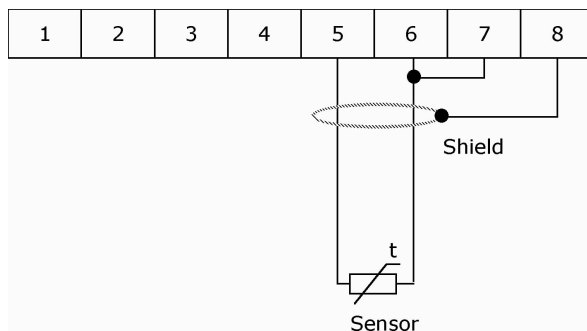
The sensor input can be configured for using Pt100, Pt1000 or a user defined sensor (e.g. PTC or NTC).

Input voltage range	100..1100mV nominal
Sensors	<p>pt100 resistance range apr. 70 .. 167 Ohm (for - 75.0 ... 175.0 °C), sensor current apr. 1.7 mA</p> <p>pt1000 resistance range apr. 700 .. 1670 Ohm (for - 75.0 ... 175.0 °C), sensor current apr. 0.7 mA</p> <p>Spezial resistance range and sensor current depends on the custom sensors properties factory default is pt1000, see above</p>



### Wiring of a 3-wire sensor

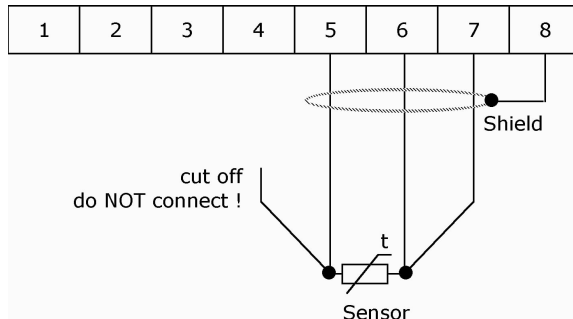
The standard measuring principle is 3-wire technique, where the wire resistance and its changes (within reasonable limits) does not affect the accuracy. Wiring see above.



### Wiring of a 2-wire sensor

For 2-wire sensors the GND has to be linked with the 3-wire input terminal. The wire resistance will not be compensated, this leads to the following errors:

- permanent shift as a function of the wire resistance resulting a higher temperature value displayed
- variable error as a function of the temperature change of the cable environment with the cable's temperature coefficient



### Wiring of a 4-wire sensor

For 4-wire sensors one lead may not be connected in order to maintain equal resistance for the forth and back wire, thus building a 3-wire system. The spare wire should be cut off to avoid picking up noise.

The shielding is for all versions optional, its necessity depends on the conditions of the equipment:

Lead length of the sensor > 1m	Shielding recommended in general
pt1000	Shielding recommended in general
Noise occurs, reading disturbed	Shielding is necessary

The maximum length of the sensor leads is limited by the resistance of max. 3 Ohms at 25°C for one leg. Dissimilar leads cause measuring errors (e.g. different wire diameters or materials).

Sensor leads with larger cross section than 0.5 mm<sup>2</sup> or 0.75 mm<sup>2</sup> reduce the wire resistance and thus reduce measurement errors.

### 2.3.3. Auxiliary Output

The instrument has a digital output which serves the signalization of the process status. According to the configuration the output becomes active at:

#### "OK"-function

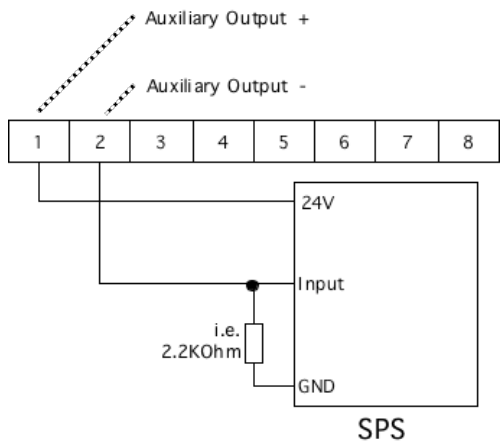
- the auxiliary output will be activated if the actual temperature of sensor 1 is in a range +/- tolerance range around the set-value
- using the dead zone function the output will be activated, when the temperature is inside the dead zone with output stage shut off
- the auxiliary output will be inactive, if any error is set

#### "Alarm"-function

- the auxiliary output will be activated if the actual temperature of sensor 1 is outside +/- alarm range around the set-value
- the auxiliary output will be active, if any error is set

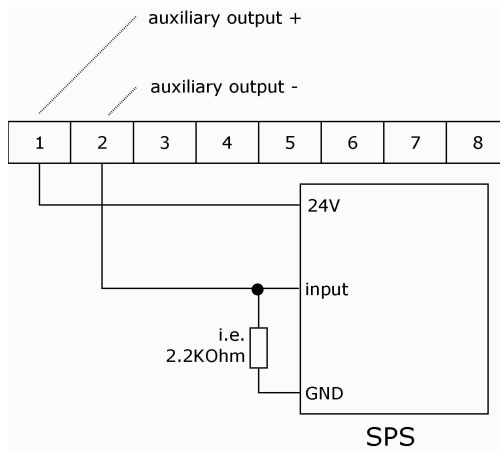
Applicable voltage	max. 30V
Output current	max. 100 mA
Overload protection	limited protection against voltage spikes
Type	NPN-Transistor
Minimum Voltage	< 2V in switched-state

The following diagram shows the connection to a SPS input. A voltage lower than 2 Volts at the SPS-input corresponds to an activated auxiliary output.



Wiring of a SPS to the auxiliary output (LOW-active)

The following diagram shows the wiring to the a SPS input. A voltage higher than > 22 V at the SPS input corresponds to an activated auxiliary output.



Wiring of a SPS to the auxiliary output (HIGH-active)

## 2.3.4. Auxiliary Input

The instrument has a digital input, which can be used to switch the power output on or off or select the set-value. Depending on the configuration:

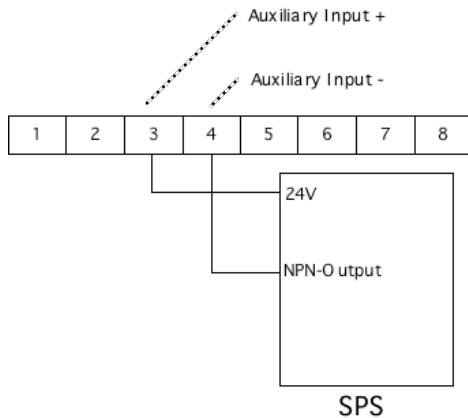
- "OFF"-function, in case of activated input the power output is off (this option is set as default in order to have the device functional without wiring the auxiliary input)
- "ON"-function, the power output is on with input activated
- "DUAL-Mode"-function, the instrument uses set-value 2 with activated input and set-value 1 if inactive or not connected

Maximum input voltage	30V
Input resistance	approx. 1kOhms
Voltage for „ON“	> 5V
Voltage for "OFF"	< 1V

The input works independently of the polarity. Operation with alternating current is not possible, since the power output would be modulated.

The following diagram shows the driving by a NPN-output of a SPS. When the NPN output is on (= LOW) the auxiliary input will be activated.





Wiring of a SPS to the auxiliary Input

## 2.3.5. Power output, Peltier-Controller-Mode

The power output provides a pulse width modulated signal whose polarity is changed automatically to switch from heating to cooling or vice versa.

Output voltage	depending on the supply voltage,
	typically value is supply voltage minus 0.5 .. 1.0V
Output current	12 A max. continuously, 13A for < 60 seconds
PWM frequency	around 4.5 kHz
Overload protection	Over current shut off with automatic retry
Connecting cable	recommended cross section 0.75 ...2.5 mm <sup>2</sup> depending on the Peltier current and lead length

The marking "Ausgang +" and "Ausgang -" refer to the polarity when cooling down. If the system cools when it should heat and vice versa, please exchange the connections

Regarding the EMV compatibility (radiated interference) it is recommended to use twisted wires, especially in case of long cable length.

## 2.3.6. Power output, Heating-Controller-Mode

The power output provides a pulse width modulated signal to be used with resistive heaters or solid state relais.

Output voltage	depending on the supply voltage,
	typically value is supply voltage minus 0.5 .. 1.0V
Output current	12 A max. continuously, 13A for < 60 seconds
PWM frequency	around 4.5 kHz (use with resistive heater connected to the output directly)
	around 3Hz for use with solid state relais
Overload protection	Over current shut off with automatic retry
Connecting cable	recommended cross section 0.75 ...2.5 mm <sup>2</sup> depending on the Peltier current and lead length

The marking "Ausgang +" and "Ausgang -" refer to the polarity when heating !

If the actual temperature is higher than the set value the output is shut off.

**For use with solid state relais the parameter „pwm-limit“ has to be configured to 1.** This activates a slow pwm control sheme with around 3 Hz switching frequency and 16 steps, well suited for solid state relais with zero crossing switch mode.

Regarding the EMV compatibility (radiated interference) it is recommended to use twisted wires, especially in case of long cable length.

## 2.3.7. Voltage supply

The standard version has the controller supply internally connected to the supply + terminal. Both voltages are therefore equal.

Voltage supply	12.. 32V Direct Current
Current consumption	ca. 100 mA plus output current, overall 12.5 A max.
Protection	internal 12.5A fast acting fuse (may only be replaced by the manufacturer – the warranty is cancelled after opening of the case)
Supply cable	recommended cross section 0.75... 2.5 mm <sup>2</sup> depending on the peltier current and lead length

Regarding the EMV compatibility (radiation influence) it is recommended to use twisted leads, especially in case of long lead length.

## 2.3.8. Serial Interface according to RS232C

The optional serial interface supports a simple protocol with software handshake, using signals RXD and TXD only.

The interface is used for factory internal adjustments and diagnostics.

It can be used by the customers for remote control e.g. by a master process control unit. In this case CoolTronic can not be made liable for correct function of the device and the resulting accuracy.

The interface has the following data configuration

Data configuration	8 Data-, 2 Stop-Bits
Parity	none
Baudrate	9600 Baud

The interface signals are connected to the DSUB9 connector.

2	RS232, RX-data from personal computer
3	RS232, TX-data to personal computer
5	RS232, signal ground

Ready to use cables with 2m or 3m length may be ordered as accessories.

**The calibration of the instrument is part of the configuration data. Therefore it is not allowed to exchange the configuration data between individual instruments.**

## 3. Functional description

### 3.1. Overview

The device has two basic modes, the normal mode and the configuration mode. After power on the controller starts in the normal mode.

Pressing the „Mode Switch“ button shortly displays the actual set value. In dual mode this is the active set-value, i.e. the value selected with the auxiliary input.

Pressing the „Mode Switch“ button for long will switch the controller into the configuration mode.

### 3.2. Power on

Immediately after power on the controller shows a test display (all segments and decimal points are illuminated). The device tries to read out a valid configuration from the EEPROM. If this fails, the device shows the error message E100 and is not operational. In case of an E100 error please contact the factory.

The outputs are inactive during the initialization process of the device and if errors are detected.

## 3.3. Normal Mode

In the normal mode the temperature will be measured and displayed continuously. The "mode select" button is continuously checked. The controller processes the actual temperature and the set temperature and calculates the power output setting.

The LED "heating" and LED "cooling" are flashing, if the temperature is outside the alarm range.

The LED "heating" and LED "cooling" are on, if the temperature is between the tolerance- and alarm range.

The LED "heating" and LED "cooling" are off, if the temperature is within the tolerance range.

Using the dead zone function both LED's are on, if the temperature is inside the dead zone.

## 3.4. Set Point Display

To display the set point value press the „mode select“ button, until the "mode display"-LED starts to flash. Now release the button. The controller will show the set value for 3 seconds. After that the instrument automatically returns to display the actual temperature of sensor 1.

## 3.5. Programming the configuration values

To program the configuration values press the „mode select“ button, until the "mode display" starts to flash and continue to hold it down until the controller changes to configuration mode.

Please note, that not all internal values can be programmed using the buttons. Certain values can only be adjusted via the serial interface. In this chapter only the values changeable via the buttons are described.

The following description uses the these conventions:

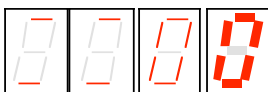
bold:	Segment flashing
normal	Segment consistent on
grey	Segment off

### Step 1 – Switch to the configuration mode

Press button „mode select“

The LED „mode-display“ starts to flash

Keep pressing till the display changes to:



- the 2 most left digits show 2 horizontal lines to indicate that the kind of value can be selected
- the left most digit is blinking and can be changed
- the LED "heating" and LED "cooling" furthermore indicate the state of the controller
- a timeout is running, which returns to the normal mode, if no button is pressed

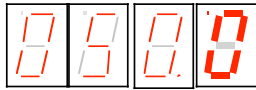
### Step 2 – Selection of the value to be changed

There are the following options:

- press button „enter“ to display the selected parameter
- press button "increase value" or button „digit selection“ to select a different parameter
- press button "mode select" to exit the configuration mode immediately

### Step 3 – adjust value

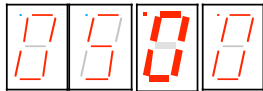
- You have selected the kind of value with the button „increase value“, "digit select" and the button "enter"
- the display jumped to display the value selected, in this example the set temperature:



- the set temperature is displayed (here for instance 50.0°C)
- the last digit flashes

there are the following options:

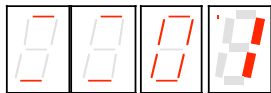
- press button „increase value“ to change the flashing digit (0..9, 0...)
- press button “digit select” to choose another digit



- adjust the desired value using the buttons „increase value“ and „digit select“

#### Step 4 – confirm or reject value

- press button „enter“ to confirm the adjusted value
- all digits flash
- after releasing the „enter“ button the value has been transferred to the non volatile memory
- the display indicates again, which value can be changed, see step 2



- to reject the value - press button „mode select“ to exit immediately the configuration mode without changing the actual value

**Please note, that changed values get effective by leaving the setup mode.**

**During configuration mode all outputs are inhibited to avoid undesirable effects, which may be caused by uncompleted new settings.**

#### Display of the 2 leftmost digits and their meaning

Display	Meaning
00	Set value 1
01	Set value 2
02	tolerance range
03	alarm range
04	filter-time constant
05	Sensor selection
06	controller mode
07	function of auxiliary input
08	function of auxiliary output
09	P
10	I
11	D
12	IL
13	PWM-Limit
14	temperature correction, sensor
15	temperature ramp of the set value

All values are checked for an internally defined value range. If the range is exceeded the value is reset to a start value and must be adjusted again.

If some value was out of range the value will be reset to a default value when selected.

Value range, start value and default value are documented in chapter “Configuration vales”.

## 3.6. Display of specific configuration values

### 3.6.1. Set value 1 and 2

The adjustable range is -75.0 ... 175.0, whereas the nominal range is -50.0 ... 150.0. Hence the highest digit changes only 0 .. 1 .. - (negative sign).

### 3.6.2. Tolerance and alarm range

- the range is 0.0 .. 9.9
- the display is in 1/10°

### 3.6.3. Filter

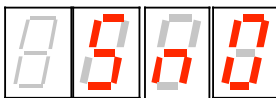
- visualized by „F” for Filter in the left most digit



- Digit 0 und 1 show the time constant in seconds 1 - 2 - 5 - 10 - 20 - 50

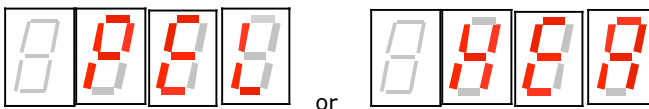
### 3.6.4. Sensor Selection

Display „Sn” for sensor und the identification number 0 – 1 - 2 for Pt100 / Pt1000 and special



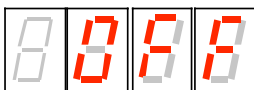
### 3.6.5. Controller Mode

Display "PEL" for Peltier-Controller-Mode and „HEA" for Heating-Controller-Mode

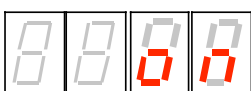


### 3.6.6. Auxiliary input

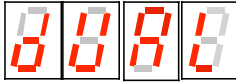
The auxiliary input can optionally be used for switching the power output ON or OFF. Switching OFF is standard, to have the device functional without external wiring. In addition the input may be configured to select the set value.



Display „OFF” corresponds to the switch OFF Function, where the the controller output will be switched off when activated.



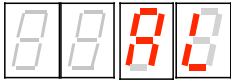
Display „on” corresponds to the switch ON Function, where the the controller output will be switched on when activated.



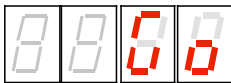
Display "dUAL" enables the "Dual mode". With the auxiliary input activated set value 2 is effective, else set value 1.

### 3.6.7. Auxiliary output

The auxiliary output has two operation modes:



- "AL" corresponds to the Alarm-Function: the output is activated, if the temperature is outside the alarm range



- "Go" corresponds to the Good-Function: the output is activated, if the temperature is inside the tolerance range

### 3.6.8. Control parameter

The Parameter adjustment shows an identification letter in the first digit: (in the example a "P" for the proportional coefficient KP):



Meaning of the identification letter:

- P: Control Parameter KP
- I: Control Parameter KI
- d: Control Parameter KD

The maximum value is 63, in case of exceeding the value the display returns to Zero and it must be set again from start. A value of 0 inhibits the corresponding part of the control algorithm

- L: Control Parameter IL (Integration limit), maximum value 999, a value of 0 inhibits the integral part, the value is multiplied internally by ten

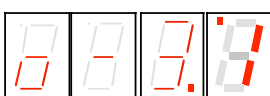
- C: PWM-Limit (C = "C"utoff), value range 0..127, in case of exceeding the value the display returns to Zero and it must be set again from start. PWM-Limit Zero in fact switches off the power output

Heating-Controller-Mode:

PWM-Limit = 1 activates the slow PWM-mode for use with solid state relays (SSR, appr. 3 Hz, 16 steps)

### 3.6.9. Temperature offset setting for sensor 1

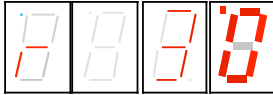
The left most digit shows the identification letter „o“:



To correct errors caused by temperature sensor or wiring, an offset of -9.90 to 9.9 can be input. Use a reference thermometer or an ice bath for calibration.

## 3.6.10. Temperature set-value ramp

The left most digit shows the identification letter „r“:



The ramp value in 0.1°C is displayed, in our example 3.0°C. The value range is 0.0 to 9.9.

A value of 3.0 means, that the internal set point value will be increased linearly with a rate of 3.0°C per minute

A selected value of 0.0 inhibits the ramp function, any change of the setpoint will become effective immediately.

The „nominal set point value“ is the value, which appears after short pressing the mode button.

The “actual set point value” is an internal value, which will be evaluated based on the ramp adjustment and nominal set point value, as well as on the prehistory.

When you turn on the controller the ramp starts at the actual temperature, the actual set point temperature is set to that value. In all other cases the starting point is the actual (internal) set point temperature.

## 3.7. Host mode

When the controller receives characters via the serial interface, they are decoded and if a valid command is recognized, it is executed immediately. The device in parallel processes and displays the sensor values and performs the control algorithm.

**There is no visualization on the display during the interface access. Values changed in the internal data-structure will be used immediately. Values changed in the EEPROM will only become effective, when the command u\_0\_0 is sent. This happens automatically by using the program TCCOM for Windows. In case of using your own control program the procedure described above has to be implemented.**

**In case of uncertainty whether all values have been updated, it is recommended to turn off and on the controller, after altering the configuration !**

**The calibration is part of the configuration data and unique for each controller. Therefore it is not allowed to exchange data sets between different controllers.**

## 3.8. Range error

If the actual value falls below -75.0°C or exceeds +175°C, the controller will enter a temporary error status. The display shows a flashing “9999”. The power output is switched off. The instrument checks continuously the measuring value. If the value returns within the allowed limits, the controller returns automatically to normal operation.

Please note, that only in the range of -50.0 ... + 150.0°C the accuracy of the measurement is guaranteed.

## 3.9. Error messages

A non fatal error will be displayed as „Ennn“ for 5 Seconds after its detection, then the controller returns to normal operation. If the error is still present, it is displayed again immediately.

Fatal errors will be displayed permanently. They can only be reset by switching the device off and on.

Error Number	Meaning	Error cause – and removal
<u>Non fatal error</u>		
E001	General error	several causes > contact factory
E002	Error of writing the EEPROM	The writing of the configuration value has failed > repeat configuration-step > contact factory
E003	over-current error	Short circuit at the output, Peltier module defect > check wiring / correction > check Peltier module / replace > if permanent contact factory
E004	controller overheated	temperature inside of the controller is too high, ambient temperature too high, Instrument exposed directly to the sun, output overloaded > avoid excessive external warming > eliminate overload > eventually try to reduce PWM-Limit  usually this error disappears because the controller cools down with output stage shut off. If the the reason persists, the device performs some sort of cycling between normal operation and E004 error. To avoid damages, fatal error E400 will be set after a certain number of cycles
E009	Watchdog error	interference or software error > one time appearance may be ignored > else contact factory
E010	supply voltage too low	the supply voltage is below 11.5V > check power supply
E011	supply voltage too low	the supply voltage is above 32V > check power supply
<u>Fatal error</u>		
E100	EEPROM contains no valid configuration	power supply failure during prior configuration change, unsuitable TCCOM version, invalid commands or parameter values used > Switch off / switch on to reset fatal error > re-configure > contact factory
E200	Stack error	excessive electronic noise or program failure > Switch off / switch on to reset fatal error > one time appearance to be ignored > else contact factory
E400	permanent overheating	controller overheated several times since power up > Switch off / switch on to reset fatal error > eliminate cause for overheating (see E004) > contact factory



## 3.10. Communication

### 3.10.1. Overview

The information below will be required for the implementation of own Control-Software. Otherwise you can ignore them.

**Warning: wrong usage of the commands shown here can render the controller useless, can destroy the controller and the system attached. High temperature and high currents can occur. Danger of injuries and fire hazard !**

### 3.10.2. Block format

Communication uses a simple ASCII-Protocol. To simplify the use of the serial communication the program "TCCOM.EXE" has been developed. It is included with the RS232 option.

It is also possible to use a simple Terminal-Program even it's less comfortable.

Synchronisation	*
Command (Master only)	<address> _ <command> _ <parameter> _ <value>§
Acknowledge (Slave only)	. / ? / #
Response (Slave only)	<value> §

The several components are defined as follows:

address	A..Z (at present only A)
command	a..z (used: d, r, u, w)
parameter	0..65535 (no leading zeros, negative figures will be transferred as positive figures, and then interpreted accordingly - "typecasted")
value	0..65535 (no leading zeros, negative figures will be transferred as positive figures, and then interpreted accordingly "typecasted")

### 3.10.3. Character set

*	Reset communication (from Master to re-synchronize)
A..Z	Address
a..z	commands
_	(underline) is separation character between values
§	End of the message (hex 0x15 or decimal 21 !)
.	acknowledge "OK"
?	acknowledge "unknown / incomplete command sequence"
#	Internal fault

### 3.10.4. Data flow

Each communication is initiated by the Master (PC), by sending a "\*" as synchronization. Hence the Slave (TC2812-RS232) changes to the basic communication state.

Now the Master sends address and command (in our example „A\_r\_0\_0“). After each character, the received character is returned by the Slave (echo). It is very important to check for the echo before sending the next character by the master. Sending the whole command as a string at once will fail !

Finally [15] (hex value) represents the end of the message "§".

Now the Slave executes the command. In case of success it sends a ".". In case of a command the communication is finished. If it was a request, the answer (in our example "65394§") is appended. [15] represents the end of the answer string "§".

Excerpt from a Log file (bold font corresponds to data traffic, normal "High level"-Information, special character are given as hex value in [ ]):

```
15:46 29.07.02001 15:46 TCCOM for Windows
15:46 -----> r_50_0
15:46 > A_r_50_0
15:46 > *A
15:46 < A
15:46 > _
15:46 < _
15:46 > r
15:46 < r
15:46 > _
15:46 < _
15:46 > 5
15:46 < 5
15:46 > 0
15:46 < 0
15:46 > _
15:46 < _
15:46 > 0
15:46 < 0
15:46 > [15]
15:46 < [15]
15:46 < .
15:46 < . (OK)
15:46 < 65394[15]
15:46 < 65394
15:46 -----< -142
```

### 3.10.5. Debug mode

Initiated with the command d\_1\_0 the TC2812-RS232 starts to send internal values continuously until the reception of the command d\_0\_0.

The values sent are recorded by the program TCCOM and can be displayed in graphical form using the function "Recorder".

## 4. Usage with TCCOM for Windows

### 4.1. Warning

**The program allows extensive changes of internal parameters. Misuse of the program may render the attached controller unusable.**

**Components attached to the controller or the controller itself may be destroyed. Risk of excessive currents and temperature. Risk of Fire hazard and Injuries !**

Therefore it is mandatory to read and understand the manual prior to using the program. Please also consult the manual accompanying the controller and other components of the system. Be sure to understand what you are doing, before using the program

In case of unexpected effects or any uncertainty disconnect the system from power supply and consult the manufacturer or his sales representative.

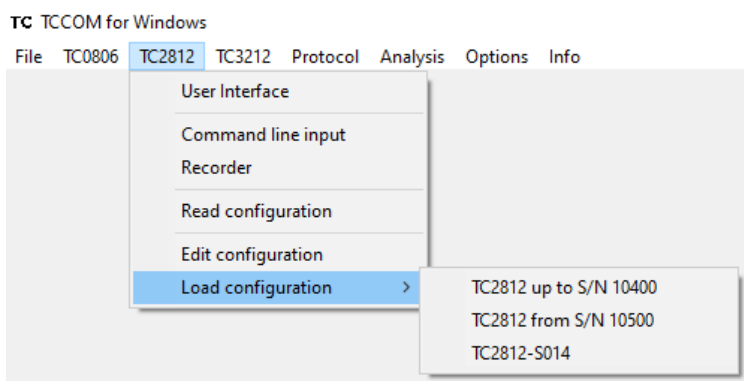
**CoolTronic GmbH cannot be made liable for any damages caused by the use of the program.**

### 4.2. Overview

This documentation applies for TCCOM for Windows version V1.8.1 Build 103 or higher. Only the function specific for TC2812-OEM-TFS01 are described here.

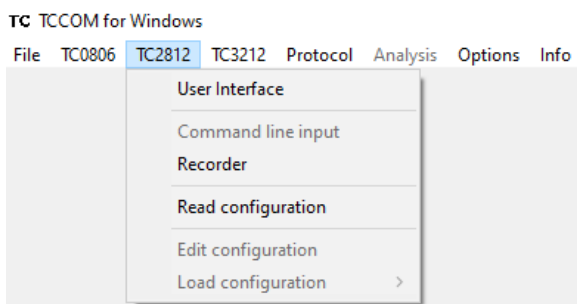
Concerning all other functions of the program refer to the software manual. General knowledge and experience with Windows™ programs is required.

The Menu "TC2812" provides the standard operation options for the controller TC2812-OEM-TFS01 and allows the configuration of most internal values. The factory defined linearization table and other factory setup values are not accessible, therefore are not allowed to be changed.



Menu TC2812 with expert mode activated

The above picture shows the available commands with expert mode activated. In normal mode some commands are not available.



Menu TC2812 in normal mode

## 4.3. User Interface

The user Interface allows the setting of all parameters of the TC2812-OEM-TFS01 needed for normal operation.

### Observe warnings given in chapter 4.1

User Interface TC2812 from S/N 10500

**Basic settings**

- Temperature set value 1: 0.0
- Temperature set value 2: 10.0
- Temperature ramp: 0.0
- Tolerance range: 0.5
- Alarm range: 2.0
- Temperature offset: 0.0

**Filter**

- 1.0 sec
- 2.0 sec
- 5.0 sec
- 10.0 sec
- 20.0 sec
- 50.0 sec

**Controller**

- KP: 30
- KI: 1
- KD: 30
- IL (x 10): 26
- PWM limit: 127

**Error**

- Configuration invalid
- Stack error
- EEPROM
- Write error
- Overcurrent
- Overtemperature Device
- Range error
- General
- Watchdog
- Overvoltage
- Undervoltage

**Sensor type**

- pt100
- pt1000
- Special

**Operation mode**

- Peltier controller
- Heating controller

**Information**

- Actual temperature 1: -0.1
- Do temperature update: Yes
- Firmware version: 110.10
- Device temperature: 30.6

**Output**

- OK
- Alarm
- Active

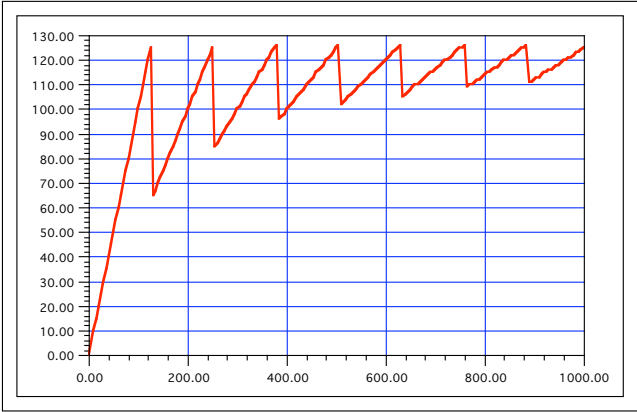
**Input**

- Turn off
- Turn on
- Dual mode
- Active

Buttons: Close, Save, Load, Read, Update

User interface

Item	Description
<b>Basic settings</b>	
Temperature set value 1 + 2	temperature set points for the controller, range -50.0 ... + 150.0°C, sensor 1 is used for the control loop !
Temperature ramp	speed of change of the temperature set value, range 0.0 .. 9.9°C / Minute. a setting of 0.0 disables the linear ramp function
Tolerance range	defines a range around the set value in between the set value is regarded as reached. If in range: <ul style="list-style-type: none"> <li>- both LED's „heating“ and „cooling“ will be shut off</li> <li>- the auxiliary output will be active if option „OK“ is configured</li> </ul>
Alarm range	defines a range around the set value outside which the temperature is regarded as critical. If out of range: <ul style="list-style-type: none"> <li>- LED „heating“ or „cooling“ will blink</li> <li>- the auxiliary output will be active if option „ALARM“ is configured</li> </ul>
Temperature offset	value to compensate errors caused by sensor 1 itself or the system setup
<b>Filter</b>	time constant of the digital filter, also defines the sampling rate of the controller. Can be used to adapt to the timing of the open loop control system
	Note: control systems with dead time require a larger filter time constant

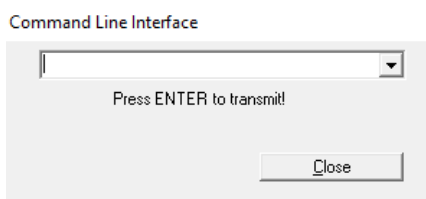
Item	Description
<u>Controller</u>	
KP	Proportional coefficient of the controller, value range 0..63, typical values: 5..30
KI	Integral coefficient of the controller, value range 0..63, typical values: 1..5
KD	Derivative coefficient of the controller, value range 0..63, typical values: 5..30
IL	<p>limit for the integration sum, value range 0..999, internally multiplied with 10 (range applied = 0..9999)</p> <p>the value added to the PWM value is calculated as follows:</p> $I - \text{Anteil} = \frac{I - \text{Summe}}{\left(\frac{IL}{\text{PWM-Limit}} + 1\right)}$ <p>the maximum I-Part added to the pwm value as function of IL is shown in the graph below:</p> <p>PWM-value as function of Integration sum and applied IL-value</p> <ul style="list-style-type: none"> <li>- using a value of 126, 253 .. has the effect, that the integral part alone can drive the output stage to 100% power</li> <li>- smaller value may reduce the tendency to overshoot</li> <li>- smaller value may also cause permanent control errors, which means that the control loop is not capable to reach the desired set point</li> </ul>
	
	Diagram: PWM-Value as function of IL-setting
PWM	limit for the output stage, range 0..127, default value is 127 (= 100% power), a value of 0 shuts down the output stage
Sensor type	selection of sensor type: pt100, pt1000 or special sensor
<u>(auxiliary) Input</u>	
Turn off	the output stage will be shut off, when the auxiliary input is activated (Standard value, to make the controller functional without wiring the input)
Turn on	the output stage will be turned on, when the auxiliary input is activated

Item	Description
DUAL mode	with auxiliary input activated the controller works with set value 2, else with set value 1
<u>(auxiliary) Output</u>	
OK	the auxiliary output will be activated if the actual temperature of sensor 1 is in a range +/- "Tolerance range" around the active set value
Alarm	the auxiliary output will be activated if the actual range" around the active set value
Operation mode	selects Peltier controller mode or Heating controller mode <u>Peltier controller mode</u> <ul style="list-style-type: none"><li>- polarity of output is changed for cooling / heating</li></ul> <u>Heating controller mode</u> <ul style="list-style-type: none"><li>- output is pulse width modulated if temperature below set value</li><li>- output is off if temperature above set value</li><li>- Slow-PWM-Mode for solid state relays (SSR) available</li></ul>
<u>Information</u>	
Actual temperature 1	actual value of temperature in 1/10 °C of sensor 1 will be updated only, if the option "Do temperature update - Yes" is activated, if not, the value is displayed which was valid at the last time the user clicked on the „Read" or „Update" button
Do temperature update	see above  Note: if using the „Recorder" function, this option must be OFF !
Firmware version	displays the firmware-version of TC2812-OEM-TFS01 in format: nnn.mm  nnn    main version mm    sub version
Device temperature	temperature measured in the controller-chip in °C.  <u>Note:</u> This value may differ a few degrees celsius from the real temperature inside the housing of the TC2812-OEM-TFS01
<u>Error</u> (fatal errors in red)	
Configuration invalid	configuration memory does not contain valid data
Stack error	(stack error) internal firmware error or interference problem
EEPROM	failure while writing the configuration to the EEPROM
Over-current	overload or short circuit at the output of the TC2812-OEM-TFS01
Over-temperature Device	the TC2812-OEM-TFS01 is overheated, temperature of the environment too high or overload

Item	Description
Range error	(range error) the actual value of sensor 1 is outside the allowed range (< -75.0 oder > 175.0°C)
General	different internal failures of the TC2812-OEM-TFS01
Watchdog	the program flow has been interfered, the monitoring function was activated
Overvoltage	(under voltage) the supply voltage is below the lower limit
Undervoltage	(over voltage) the supply voltage is beyond the upper limit

Button	Description
Close	close the dialog
Save	save values of the user interface to disk
Load	load values from disk
Read	read data from TC2812-OEM-TFS01
Update	update data of the TC2812-OEM-TFS01

## 4.4. Command line interface



Command line interface

With this dialog „Low-Level“ commands in the form r\_0\_0 may be sent to the controller. The answer will be displayed in the log window if the necessary options are set. Requires in depth knowledge of the command set.

**Observe Warnings given in chapter 4.1 !**

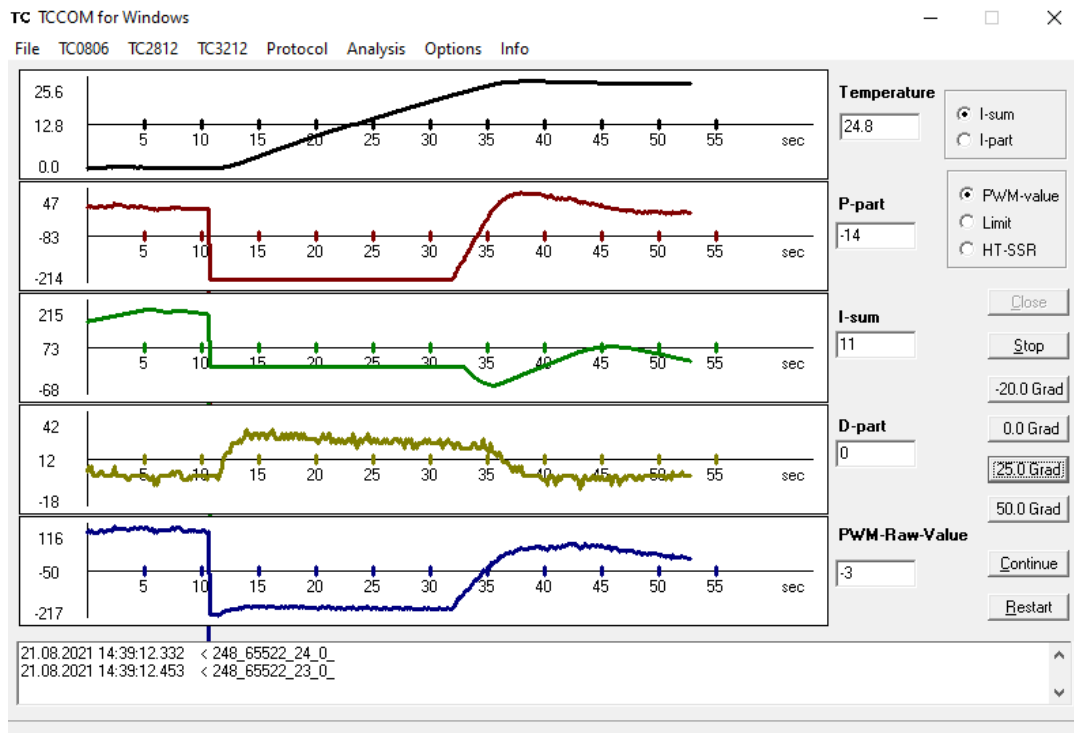
## 4.5. Recorder

The „Recorder“ function uses a special debug mode of the TC2812-OEM-TFS01. After activated, the controller sends internal values continuously until stopped. This function is a „mighty“ tool for optimizing the control loop settings.

The scale of the display will be adapted automatically. Minimum, maximum and mean value are displayed as numerical value (see vertical axes)

Item	Description
Temperature	actual value of the temperature in 1/10°C
P-part	Proportional part of the controller
	Note: this is a raw value which is normalized to form the control output value

Item	Description
I-sum	Integration sum or integral part of the controller (selectable via I-Sum or I-part)  Note: this is a raw value which is normalized to form the control output value
D-part	Derivative part of the controller  Note: this is a raw value which is normalized to form the control output value
PWM-Raw-Value	PWM-Value, the value used to drive the output stage, range -127 ..0..+127 or +/- PWM-Limit  Note: you can select which value is displayed: <ul style="list-style-type: none"> <li>- "Normal" the raw value</li> <li>- "Limit" the limited value, which shows the effective output power</li> <li>- „HT-SSR" value normalized for the slow PWM mode used for driving solid state relays (SSR) , range 0..15</li> </ul>



## Recorder-Display

Button	Description
Close	ends the recorder display
-20.0 Grad	set the temperature set value of the TC2812-OEM-TFS01 to -20.0°C  (-20.0°C is an example - the value may be changed using the program settings)



Button	Description
0.0 / 25.0 / 50.0 Grad	additional buttons to change the active set value
Stop	stops the Recorder
Continue	restarts the recorder preserving the recorded values  Note: when stopped the values are not recorded, therefore there may be a „jump“ of the values
Restart	(reset) clears all values and restarts the recorder  Note: the scale will be reset and recalculated

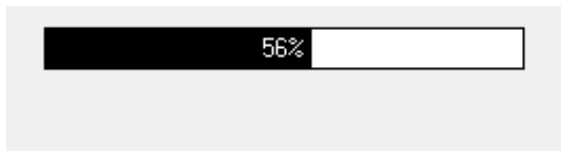
## 4.6. Manage configuration

In the normal mode solely „read out configuration is available. In this mode only 3 button are enabled, values cannot be edited.

Button (German expression)	Description
Close	closes the dialog
Save	saves the configuration data to disk
Read	read configuration from TC2812-OEM-TFS01

Invoking „Read“ will read the actual configuration data from the TC2812-OEM-TFS01 and display the values in the dialog. The data may then be stored to disk.

### Read configuration data ...



Time bar during read out

Only functional with a TC2812-OEM-TFS01 attached to the serial communication line.

With the „Expert mode“ (see Options / General options) active, additional buttons are enabled:

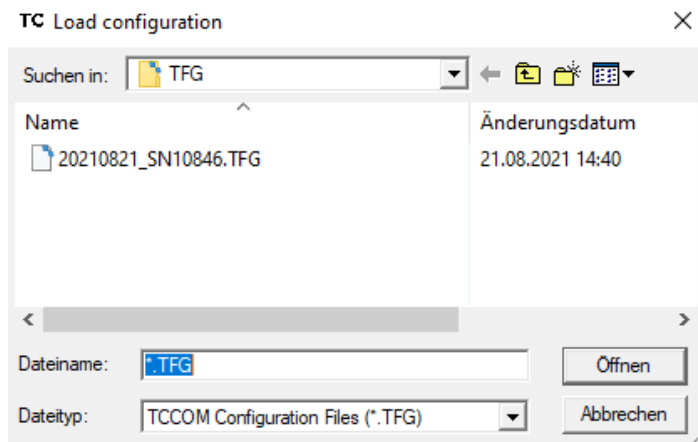
Button	Description
Close	closes the dialog
Save	saves the configuration data to disk
Load	load configuration data from disk
Read	read configuration data from TC2812-OEM-TFS01
Update	update configuration data of the TC2812-OEM-TFS01

Invoking „Edit Configuration“ will read the actual configuration data from the TC2812-OEM-TFS01 and display the values in the dialog.

Invoking „Load configuration“ will open a dialog to select the file to open, then load the data from disk and display the values in the dialog.

All values except the factory settings are editable. The data may be loaded from and stored to disk. The configuration data may be read from and sent to the TC2812-OEM-TFS01.

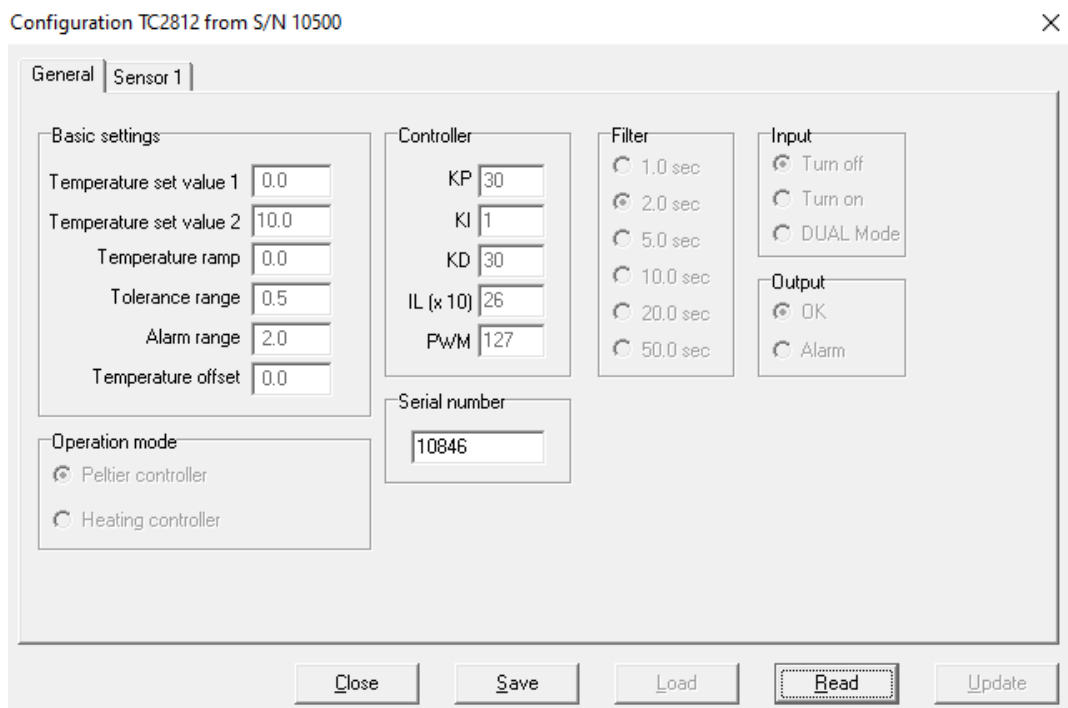
Note: read and update are only functional with a controller attached to the serial communication line.



file open dialog for "Load configuration"

Because of the numerous values available they are distributed over two „tabs“ with the names „General“ and „Sensor 1“.

The purpose of the different values are explained below.



Configuration dialog - general settings  
(depending on the firmware-version some values may not be available)

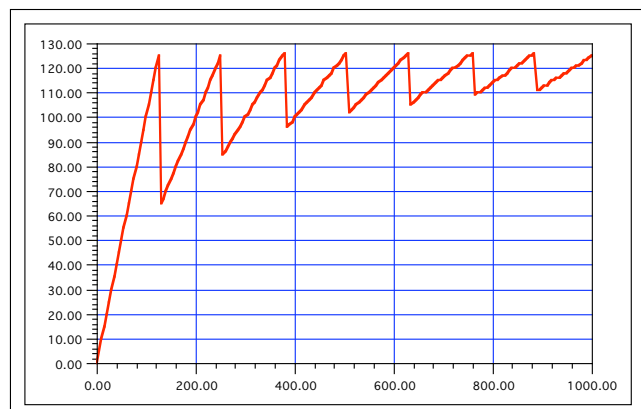
Item	Description
<b>Basic settings</b>	
Temperature set value 1 + 2	temperature set points for the controller, range -50.0 ... + 150.0°C, sensor 1 is used for the control loop !

Item	Description
Temperature ramp	speed of change of the temperature set value, range 0.0 .. 9.9°C / Minute. a setting of 0.0 disables the ramp function
Tolerance range	defines a range around the set value in between the set value is regarded as reached. If in range: <ul style="list-style-type: none"> <li>- both LED's „heating“ and „cooling“ will be shut off</li> <li>- the auxiliary output will be active if option „OK“ is configured</li> </ul>
Alarm range	defines a range around the set value outside which the temperature is regarded as critical. If out of range: <ul style="list-style-type: none"> <li>- LED „heating“ or „cooling“ will blink</li> <li>- the auxiliary output will be active if option „ALARM“ is configured</li> </ul>
Temperature offset	value to compensate errors caused by sensor 1 itself or the system setup
<u>Filter</u>	time constant of the digital filter, also defines the sampling rate of the controller. Can be used to adapt to the timing of the open loop control system  Note: control loops with dead time require a larger filter value
<u>Controller</u>	
KP	Proportional coefficient of the controller, value range 0..63, typical values: 5..30
KI	Integral coefficient of the controller, value range 0..63, typical values: 1..5
KD	Derivative coefficient of the controller, value range 0..63, typical values: 5..30
IL	limit for the integration sum, value range 0..999, internally multiplied with 10 (range applied = 0 .. 9990)

the value added to the PWM value is calculated as follows:

$$I - \text{Anteil} = \frac{I - \text{Summe}}{\left(\frac{IL}{\text{PWM-Limit}} + 1\right)}$$

the maximum I-Part added to the pwm value as function of IL is shown in the graph below:



Item	Description
IL (continued)	<p>PWM-value as function of Integration sum and applied IL-value</p> <ul style="list-style-type: none"><li>- using a value of 126, 253 .. has the effect, that the integral part alone can drive the output stage to 100% power</li><li>- smaller value may reduce the tendency to overshoot</li><li>- smaller value may also cause permanent control errors, which means that the control loop is not capable to reach the desired set point</li></ul>
PWM	limit for the output stage, range 0..127, default value is 127 (= 100% power), a value of 0 shuts down the output stage
<u>(auxiliary) Input</u>	
Turn off	the output stage will be shut off, when the auxiliary input is activated (Standard value, to make the controller functional without wiring the input)
Turn on	the output stage will be turned on, when the auxiliary input is activated
DUAL mode	with auxiliary input activated the controller works with set value 2, else with set value 1
<u>(auxiliary) Output</u>	
OK	the auxiliary output will be activated if the actual temperature of sensor 1 is in a range +/- "Tolerance range" around the active set value
Alarm	the auxiliary output will be activated if the actual range" around the active set value
Operation mode	selects Peltier controller mode or Heating controller mode <u>Peltier controller mode</u> <ul style="list-style-type: none"><li>- polarity of output is changed for cooling / heating</li></ul> <u>Heating controller mode</u> <ul style="list-style-type: none"><li>- output is pulse width modulated if temperature below set value</li><li>- output is off if temperature above set value</li><li>- Slow-PWM-Mode for solid state relays (SSR) available</li><li>- polarity of output is changed for cooling / heating</li></ul>
Serial number	serial number, for information only, not editable

Configuration TC2812 from S/N 10500 X

General **Sensor 1**

Adjustment				Factory settings			Sensor type	
ADC value	pt100	pt1000	Special		pt100	pt1000	Special	
-75.0	7974	8798	8798	PosComp	13	9	9	<input checked="" type="radio"/> pt100
-50.0	11516	12079	12079		-8	-8	-8	<input type="radio"/> pt1000
-25.0	14983	15214	15214	NegComp	-8	-11	-11	<input type="radio"/> Special
0.0	18400	18175	18175		2	6	6	
25.0	21747	21007	21007	RefTemp	22872	22872	22872	
50.0	25045	23695	23695		3312	2362	2362	
75.0	28301	26254	26254		3731	720	720	
100.0	31484	28690	28690		16	16	16	
125.0	34624	31054	31054		0	0	0	
150.0	37694	33295	33295		0	0	0	
175.0	40713	35424	35424					

Close Save Load Read Update

Configuration-dialog - Sensor 1

Item	Description
<b><u>Adjustment</u></b>	
pt100	linearization table with values of the AD-converter for temperature steps -75.0°C bis +175.0°C for sensor type pt100  Note: Factory setting, not editable
pt1000	linearization table with values of the AD-converter for temperature steps -75.0°C bis +175.0°C for sensor type pt1000  Note: Factory setting, not editable
Special	linearization table with values of the AD-converter for temperature steps -75.0°C bis +175.0°C for sensor „Special“  Note: Factory setting valid for pt1000
<b><u>Factory settings</u></b>	
internal values	compensation of drift  Note: factory setting, not editable  When changing the linearization table "Special" all values must be set to zero to disable compensation of temperature drift and 3-wire-correction. These values can be determined in factory only.
<b><u>Sensor type</u></b>	
	select sensor type: pt100 / pt1000 / Special („Special" selects a linearization table which can be adapted by the customer, factory default is pt1000)

## 5. Command set

**Warning: wrong usage of the commands shown here can render the controller useless, can destroy the controller and the system attached. High temperature and high currents can occur. Danger of injuries and fire hazard.**

### RAM-General configuration

read/write command r .. _ / w_ .. _	Meaning	Default	value range	remarks
0	setValue_1	0	-750...1750	set value 1 (nominal range -50.0 .. 150.0 °C)
1	setValue_2	100	-750...1750	set value 2 (nominal range -50.0 .. 150.0 °C)
2	tolRange	5	+/- 99	tolerance range (0 .. +/- 9.9 °C)
3	alarmRange	20	+/- 99	alarm range (0 .. +/- 9.9 °C)
4	filter	0	0..5	index into filter table (1/2/5/10/20/50 s)
5	cfg	0	b ii oo mm ss	ii =aus in, oo = aux out, mm = controller mode, ss = sensor-select
6	KP	30	0..63	proportional coefficient
7	KI	1	0..63	Integral coefficient
8	KD	30	0..63	derivative coefficient
9	IL	26	0..999	integration-limit, internally multiplied with 10
10	pwmLimit	127	0, 1 ..127	PWM-limit
11	offset	0	-127 .. 127	Offset compensation (0 .. +/- 12.7 °C)
12	setValRamp	0	0..99	Temperature-Ramp [0.0 ..9,9°C]

### EEPROM-General configuration

read/write command r .. _ / w_ .. _	Meaning	Default	value range	remarks
300	setValue_1	0	-750...1750	set value 1 (nominal range -50.0 .. 150.0 °C)
301	setValue_2	100	-750...1750	set value 2 (nominal range -50.0 .. 150.0 °C)
302	tolRange	5	+/- 99	tolerance range (0 .. +/- 9.9 °C)
303	alarmRange	20	+/- 99	alarm range (0 .. +/- 9.9 °C)
304	filter	0	0..5	index into filter table (1/2/5/10/20/50 s)
305	cfg	0	b ii oo mm ss	ii =aus in, oo = aux out, mm = controller mode, ss = sensor-select
306	KP	30	0..63	proportional coefficient
307	KI	1	0..63	Integral coefficient
read/write command r .. _ / w_ .. _	Meaning	Default	value range	remarks
308	KD	30	0..63	derivative coefficient
309	IL	26	0..999	integration-limit, internally multiplied with 10

310	pwmLimit	127	0, 1 ..127	PWM-limit
311	offset	0	-127 .. 127	Offset compensation (0 .. +/- 12.7 °C)
312	setValRamp	0	0..99	Temperature-Ramp [0.0 ..9,9°C]

## Requests and maintenance commands

Read / Write Command	Meaning	Default	Values	Remarks
100	raw value Sensor 1		read only	0..32767
101	linearized value Sensor 1		read only	-1500..3500 0.05°C
102	actual value Sensor 1		read only	-750..1750 0.1°C
103	P-part	read only		control result
104	I-part	read only		control result
105	D-part	read only		control result
106	FW-Version	read only	100.00 .. 320.99	100 .. 320 main version, 00..99 Subversion
107	chip temperatureread only		0..32767	internal value
120	actual value Sensor 1		read only	-750..1750 0.1°C
150	testPWM		0..127	set constant pwm value for output stage > no control calculation
151	testMinTemp		-750..1750	lower temperature limit for test with constant PWM
151	testMaxTemp		-750..1750	upper temperature limit for test with constant PWM

**Warning: wrong use of commands 150..152 will destroy controller and system and may cause overheating and fire hazard. Use solely at users own risk !**

200	CmdGetDeviceType	read only		get device type
201	CmdGetDeviceState	read only		get device state
202	CmdGetErrorState	read only		get error state

Read commands have a parameter value of 0, for write commands the desired value has to be appended.

**Another warning: Only the commands released for end users are documented. Using other command codes may damage the controller and is strictly forbidden!**

### Meaning of the structure information

RAM	interne configuration data structure, only valid until next power off
EEData	same values a cfgTeble, but stored permanently in nonvolatile memory. These values will be reloaded at next power on.

### Attention:

Excessive writing to the EEData can cause a wear out of the component and result in data loss.

Values from EEData must be transferred to RAM with the command u\_0\_0 to be effective !

## 6. Configuration values

minimum value	maximum value	reset value	default value	description
-75.0	175.0	0.0	0.0	set value 1

-75.0	175.0	0.0	0.0	set value 2
0.0	9.9	0.0	0.5	tolerance range
0.0	9.9	0.0	2.0	alarm range
1	50	1	2	filter time constant
0	63	0	30	KP
0	63	0	1	KI
minimum value	maximum value	reset value	default value	description
0	63	0	30	KD
0	999	0	25	IL (internal value *10, default 25 yields 250)
0	127	0	127	PWM-Limit
-9.9	9.9	0.0	0.0	Offset, Sensor1
0.0	9.9	0.0	0.0	temperature ramp

## Values allowed

## Description

Sn0 .. Sn2 (= Pt100 / pt1000 / Spezial)  
On / Off / DUAL  
Alarm / Good  
PEL / HEA

sensor type  
auxiliary input  
auxiliary output  
controller-mode: Peltier / Heating-Controller

## 7. State codes

answer to request CmdGetDeviceState (r\_202\_0), shown as binary values

State value	Meaning
0000 0000 0000 000X	0: auxiliary output active 1: auxiliary output not active
0000 0000 0000 00X0	0: auxiliary input active 1: auxiliary input inactive

## 8. Error codes

answer to request CmdGetErrorState (r\_203\_0), shown as binary values

Error value	Meaning
0000 0000 0000 0001	range error, Sensor 1
0000 0000 0000 0010	general error
0000 0000 0000 0100	EEPROM write error
0000 0000 0000 1000	over current
0000 0000 0001 0000	over temperature, controller
0000 0010 0000 0000	Watchdog
0000 0100 0000 0000	overvoltage
0000 1000 0000 0000	undervoltage
0001 0000 0000 0000	not implemented
0010 0000 0000 0000	permanently overheated
0100 0000 0000 0000	configuration invalid
1000 0000 0000 0000	Stack error



## 9. Sensor-Table

The sensor tables show the nominal value of the sensor and the resulting voltage, current and power values calculated for ideal conditions (without tolerances). The real values may differ.

Sensor pt100 is fed via a resistor of 1825 Ohm with a supply of 3.3V

Temperature [°C]	Sensor value [Ohm]	sensor voltage [V]	sensor current [mA]	sensor power [mW]
-75.0	70.332	0.1225	1.7411	0.2132
-50.0	80.306	0.1391	1.7320	0.2409
-25.0	90.192	0.1554	1.7231	0.2678
0.0	100.000	0.1714	1.7143	0.2939
25.0	109.735	0.1872	1.7057	0.3192
50.0	119.397	0.2026	1.6972	0.3439
75.0	128.987	0.2178	1.6889	0.3679
100.0	128.505	0.2171	1.6893	0.3667
125.0	144.182	0.2416	1.6758	0.4049
150.0	157.325	0.2619	1.6647	0.4360
175.0	166.627	0.2761	1.6569	0.4575

Sensor pt1000 is fed via a resistor of 3650 Ohm with a supply of 3.3V.  
(this also applies when using the "Spezial" sensor selection)

Temperature [°C]	Sensor value [Ohm]	sensor voltage [V]	sensor current [mA]	sensor power [mW]
-75.0	703.320	0.5331	0.7580	0.4041
-50.0	803.063	0.5951	0.7411	0.4410
-25.0	901.923	0.6539	0.7250	0.4740
0.0	1'000.000	0.7097	0.7097	0.5036
25.0	1'097.350	0.7628	0.6951	0.5302
50.0	1'193.970	0.8134	0.6813	0.5541
75.0	1'289.870	0.8617	0.6680	0.5756
100.0	1'285.050	0.8593	0.6687	0.5746
125.0	1'441.820	0.9344	0.6481	0.6056
150.0	1'573.250	0.9940	0.6318	0.6280
175.0	1'666.270	1.0343	0.6207	0.6420