



# Temperature Controller TC01/TC02 Manual



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Multi Channel Systems MCS GmbH

Aspenhaustraße 21

72770 Reutlingen

Germany

Phone +49-71 21-909 25 - 0

Fax +49-71 21-909 25 -11

[sales@multichannelsystems.com](mailto:sales@multichannelsystems.com)

[www.multichannelsystems.com](http://www.multichannelsystems.com)

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# 1 Introduction

## 1.1 About this Manual

This manual comprises all important information about the first installation and the proper usage of the temperature controller TC01 and TC02. It is assumed that you have a basic understanding of technical terms, but no special skills are required to read this manual.

Make sure you read the "Important Information and Instructions" prior to install or to operate this temperature controller.

The thermocouple function is added to the standard temperature controller TCX in revision REV G. The devices with a series number higher than SN 2000 are equipped with this function.



## 2 Important Information and Instructions

### 2.1 Operator's Obligations

The operator is obliged to allow only persons to work on the device, who

are familiar with the safety at work and accident prevention regulations and have been instructed how to use the device;

are professionally qualified or have specialist knowledge and training and have received instruction in the use of the device;

have read and understood the chapter on safety and the warning instructions in this manual and confirmed this with their signature.

It must be monitored at regular intervals that the operating personnel are working safely.

Personnel still undergoing training may only work on the device under the supervision of an experienced person.

### 2.2 Important Safety Advice



Warning: Make sure to read the following advice prior to install or to use the device and the software. If you do not fulfill all requirements stated below, this may lead to malfunctions or breakage of connected hardware, or even fatal injuries.



Warning: Obey always the rules of local regulations and laws. Only qualified personnel should be allowed to perform laboratory work. Work according to good laboratory practice to obtain best results and to minimize risks.

The product has been built to the state of the art and in accordance with recognized safety engineering rules. The device may only

be used for its intended purpose;

be used when in a perfect condition.

Improper use could lead to serious, even fatal injuries to the user or third parties and damage to the device itself or other material damage.



Warning: The device and the software are not intended for medical uses and must not be used on humans. MCS assumes no responsibility in any case of contravention.

Malfunctions which could impair safety should be rectified immediately.

## High Voltage

Electrical cords must be properly laid and installed. The length and quality of the cords must be in accordance with local provisions.

Only qualified technicians may work on the electrical system. It is essential that the accident prevention regulations and those of the employers' liability associations are observed.

Each time before starting up, make sure that the mains supply agrees with the specifications of the product.

- Check the power cord for damage each time the site is changed. Damaged power cords should be replaced immediately and may never be reused.
- Check the leads for damage. Damaged leads should be replaced immediately and may never be reused.
- Do not try to insert anything sharp or metallic into the vents or the case.
- Liquids may cause short circuits or other damage. Keep the device and the power cords always dry. Do not handle it with wet hands. Make sure the device and your experiment are set up in a way that makes it impossible that any liquid spills onto the device or drips into the device from the surface of the table.
- Do not short-circuit the outputs of the device.

## Requirements for the Installation and Operation



**Warning:** Improper use (especially a too high setpoint temperature or an inappropriate channel configuration, for example, a too high maximum power can lead to overheating the heating element. Overheating can lead to fire hazards and even fatal injuries. Only advanced users should edit the channel configuration and only with extreme care.

Make sure that the device is not exposed to direct sunlight. Do not place anything on top of the device, and do not place it on top of another heat producing device. Never cover the device, not even partially, so that the air can circulate freely. Otherwise, the device may overheat.

The connected heating elements produce heat and can get hot during operation.

Do not touch the connected heating elements during operation and do not store flammable materials nearby.

Check in regular intervals that the connected heating element does not overheat.

Regard the specifications of the connected heating element.

Use and keep the device only in a dry environment. Fluids or damp air may damage or destroy the device. Spilled liquid can damage or even completely destroy the electronics of the instrument. Avoid it by all means.

Edit the channel configuration only if necessary, and only with extreme care. Test new configurations under personal supervision before operating the instrument unsupervised.

The "Maximum Power" of the channel configurations should not exceed a value that is safe for use with the connected heating element, the temperature protocol, and the experimental setup.

## 2.3 Guarantee and Liability

The general conditions of sale and delivery of Multi Channel System MCS GmbH always apply. The operator will receive these no later than on conclusion of the contract.

Guarantee and liability claims in the event of injury or material damage are excluded when they are the result of one of the following.

- Improper use of the device.
- Improper installation, commissioning, operation or maintenance of the device.
- Operating the device when the safety and protective devices are defective and/or inoperable.
- Non-observance of the instructions in the manual with regard to transport, storage, installation, commissioning, operation or maintenance of the device.
- Unauthorized structural alterations to the device.
- Unauthorized modifications to the system settings.
- Inadequate monitoring of device components subject to wear.
- Improperly executed and unauthorized repairs.
- Unauthorized opening of the device or its components.
- Catastrophic events due to the effect of foreign bodies or Acts of God.

## 3 Installation and Operation

### 3.1 Welcome to the Temperature Controller TC01/02



**Warning:** Improper use, especially a too high setpoint temperature or an inappropriate channel configuration, for example, a too high maximum power, can lead to overheating the heating element. Overheating can lead to fire hazards and even fatal injuries. Only advanced users should edit the channel configuration and only with extreme care.

The temperature controller TC01/02 is used to control the temperature of a connected heating element. It is available with one or two output channels TC01 and TC02, respectively. Handling of both devices is similar and information in the TC01/02 manual applies to both.

The thermocouple function is added to the standard temperature controller in revision REV G. The devices with a series number higher than SN 2000 are equipped with this function.

The TC01/02 is designed for use with Pt100 sensors, which allow a very precise temperature recording and control. Pt100 sensors feature the highest available accuracy and linearity over a wide temperature range. All heating elements that are part of products from Multi Channel Systems MCS GmbH are equipped with Pt100 sensors. Please see the manuals of the heating elements that you are going to use for details.

The TC01/ TC02 uses a Proportional-Integrator (PI) based technology. The setpoint temperature is reached fast and the accuracy is extraordinarily high. The outputs are galvanically isolated against ground, that is, the TC01/ TC02 does not interfere with the experimental setup.

The TC01/02 is a general purpose temperature controller for use of almost any kind of heating element. The PI coefficients are preset in the channel configuration defaults for MCS products. You can set up your own custom configurations to use the temperature controller for your specific heating elements. Preset configurations are available for use with the heating elements that are part of the following products provided by Multi Channel Systems MCS GmbH.

**MEA2100 (-Mini):** compact stand-alone system for recordings from microelectrode arrays with 60, 2 x 60, 120 or 256 channels with integrated amplification, data acquisition, online signal processing, real-time feedback, and integrated stimulus generator.

**USB-MEA256:** compact stand-alone system for recordings from microelectrode arrays with 256 channels with integrated amplification, data acquisition, and analog / digital conversion.

**MEA1060-INV:** 60-channel preamplifier and filter amplifier for microelectrode arrays on inverted microscopes. The same channel configuration applies to MEA1060-INV-BC amplifiers.

**MEA1060-UP:** 60-channel preamplifier and filter amplifier for microelectrode arrays on upright microscopes. The same channel configuration applies to MEA1060-UP-BC amplifiers.

**PH01:** Perfusion cannula with heater and sensor.

**TCW1:** Warming plate with heater and sensor.

**OP Table:** Warming plate with heater and sensor and rectal thermometer with thermocouple sensor.

**Note:** Multi Channel Systems can provide a channel configuration for your application on request.

The TC01/02 heats actively, but the cooling is passive. Therefore, the minimum temperature is defined by the room temperature. A room temperature beyond 5 °C is not recommended.

For advanced applications, the TC01/ TC02 can be remote controlled via the USB port. The actual temperature values can be read on the connected computer and saved as a text file. You can then import this file into your custom evaluation software, for example to plot a temperature curve. You can also set up custom programs for applying automated temperature protocols to the connected heating element. Advanced hardware diagnosis features ensure a superior experimental control.

## 3.2 Setting Up and Connecting the TC01/02

Provide a power supply in the immediate vicinity of the installation site.

1. Place the TC01/02 on a dry and stable surface, where the air can circulate freely and the device is not exposed to direct sunlight.
2. Plug the external power supply cable into the supply power input socket on the rear panel of the TC01/02.
3. Connect the external power supply to the power outlet.
4. Optional, for recording temperature curves or remote control: Connect the USB cable to a free USB port of the data acquisition computer.
5. Connect the TC01/02 to the heating element. Use the cable that is delivered with the heating system or use a custom cable. The cable is plugged into the female D-Sub9 socket. (Channel 1 and Channel 2, if you have a TC02). See also chapter "D-Sub9 Pin Assignment" in the Appendix.
6. **Use of OP Table:** Connect the TC01/02 to the heating element of the heating plate. Use the cable that is delivered with the heating system or use a custom cable. The cable is plugged into the female D-Sub9 socket labeled with "Channel 1". Connect the TC01/02 to the rectal thermometer. Use the provided cable, and connect the rectal thermometer via the thermocouple connector (type T) to the socket labeled with "Thermocouple 1".



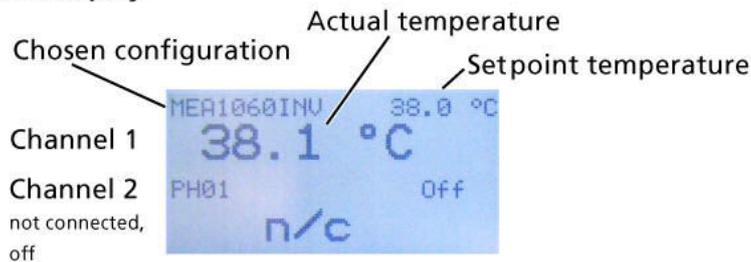
## 3.3 Operating the TC01/02

### 3.3.1 Starting the TC01/02

All functions are set in the menu of the TC01/02, including switching the TC01/02 on and off. If the TC01/02 is switched off, it goes into standby mode. The instrument and display are only switched off completely when the TC01/02 is disconnected from the power supply. Most of the power consumption of 6 W in standby mode is used by the power supply unit.

In the main menu on the display, select On / Off. The TC01/02 starts to control the temperature on the selected channels immediately. If the TC01/02 is connected properly, the actual temperature and the setpoint temperature are displayed in the "Temperature Control" view.

#### TC02 Display



### 3.3.2 General User Interface

The front screen display shows the actual temperature and the setpoint temperature. You can enter the next menu levels by pressing the "Select" button. Go to a menu command with the "Up" and "Down" buttons and press "Select" to select the command highlighted by an arrow and to enter the next menu level. The functionality of the button array on the front panel is described in the following.



#### Up

Goes to the menu command above or increases the displayed parameter value. Tip once to increase the value in a small single step, press longer for larger steps.



#### Down

Goes to the menu command below or decreases the displayed parameter value. Tip once to increase the value in a small single step, press longer for larger steps.



#### Select

Press this button to switch from "Temperature Control" view to the "Main" menu. Selects the command highlighted by an arrow in the menus and enters the next menu level.



#### Back

Leaves the menu level and goes back to the next higher menu level. Settings that were selected or modified are applied and saved automatically when leaving a menu.

### 3.3.3 TC01/02 Menus

Press the "Select" button to enter the "Main" menu. The other menu levels are shown in the following illustration.

### 3.3.4 Setting a Temperature

Important: Please note that there will always be an intrinsic offset between the setpoint and the actual temperature of the connected heating element, depending on the heating element used, the proximity of the sensor to the heating element, and the experimental setup. This offset needs to be determined empirically and taken into account when programming the temperature settings. The accuracy of the TC01/02 ensures that this offset remains stable in a fixed experimental setup, provided that the environmental conditions, for example, the flow rate, are not changed during the experiment.

1. Press the "Select" button to enter the main menu.
2. Move the arrow to the desired channel by pressing the "Up" and "Down" buttons, for example to Channel 1.
3. Press the "Select" button. The "Channel" menu is displayed.
4. Move the arrow to "Set Temperature" and press the "Select" button. The current setpoint temperature is displayed.
5. Modify the displayed value by pressing the "Up" and "Down" buttons.
6. As soon as you leave the menu, the new setpoint temperature is saved. If you do not press a button in the time range of a minute, the new setpoint temperature is also saved, and the screen is reset to the "Temperature Control" view.

### 3.3.5 Channel Configuration



Warning: Improper use (especially a too high setpoint temperature or an inappropriate channel configuration, for example, a too high maximum power) can lead to overheating the heating element. Overheating can lead to fire hazards and even fatal injuries. Only advanced users should edit the channel configuration and only with extreme care.

We recommend to use the factory default settings for use with MCS products. You can modify these settings with the "Edit" command, if required. If you want to restore the factory default settings, select the configuration that you would like to reset, and then select "MCS Defaults".

For safety reasons, the "Edit" menu is locked each time the TC01/02 is switched off. You need to unlock it first by selecting "Unlock Edit" in the "Setup" menu.

The channel parameters are changed in the same way than the temperature. From the "Channel" menu, go to "Configuration", select "Edit", and then select the parameter that you would like to change, and modify it with the "Up / Down" buttons.

The following parameters can be modified:

Proportional gain

Integrator gain

Maximum power

**Example:**

You are using a MEA1060-UP amplifier for upright microscopes on channel 1, and a perfusion cannula PH01 on channel 2 of a TC02. You have to configure each channel for the appropriate instrument. Select, for example MEA2100 for Channel 1 and PH01 for Channel 2 in the "Channel Configuration" menu of the TC02.

Note: The factory default parameters were optimized for an ambient temperature. The configuration for use with the PH01 were optimized for a medium flow rate. Under extreme conditions, you may have to adjust the configuration for your experimental setup.

### 3.3.6 Hardware Diagnosis

This menu should be used for reviewing parameter settings or check the hardware performance in case that you observe any trouble with the instrument. Each channel can be checked separately. If the problem persists, please contact your local retailer. The highly qualified staff will be glad to help you. Keep the displayed information at hand when contacting customer support.

There are four separate screen views with different sets of information in the "Diagnosis" menu. You can toggle between the views by pressing the "Up" and "Down" buttons.

**Diagnosis 1: Measured values**

This diagnose screen view is used for checking the temperature sensor.

<b>Temperature</b>	Actual temperature
<b>Resistance 2</b>	Cable resistance high side of sensor, see also chapter "D-Sub9 Pin Assignment".
<b>Resistance 1</b>	Cable resistance low side of sensor, see also chapter "D-Sub9 Pin Assignment".
<b>Resistance X</b>	Sensor resistance plus cable resistance
<b>Resistance S</b>	Sensor resistance
<b>Board Temp</b>	Board temperature. The TC01/02 will switch off the channel outputs and go into stand-by mode when the board temperature reaches 90 °C.

### Diagnosis 2: Controller settings

This diagnose screen view is used for reviewing and checking the user settings.

<b>Setpoint Temp</b>	Setpoint temperature
<b>P Gain</b>	Proportional gain
<b>I Gain</b>	Integrator gain
<b>Max Power</b>	Maximum output power

### Diagnosis 3: Controller output

This diagnose screen view is used for checking the operation of the internal controller.

<b>Power Set</b>	Output power set by the controller.
<b>Power Out</b>	Actual output power (product of "Current Out" and "Supply Voltage")
<b>Duty Cycle</b>	PWM Duty cycle (internal value)
<b>Current Out</b>	Current through the primary coil of the isolating transformer
<b>Supply Voltage</b>	Supply voltage from power supply

### Diagnosis 4: Heating element

This diagnose screen view is used for checking the connected heating element.

<b>On/off</b>	Current channel state
<b>HE Voltage</b>	Output voltage applied to heating element
<b>HE Current</b>	Output current applied to heating element
<b>HE Resistance</b>	Heating element resistance (voltage-current ratio)
<b>HE Power</b>	Output power delivered to heating element (voltage-current product), should be 80 - 90 % of "Power Out", depending on heating element resistance)

### 3.4 Controlling the TC01 / TC02 via TCX-Control Software

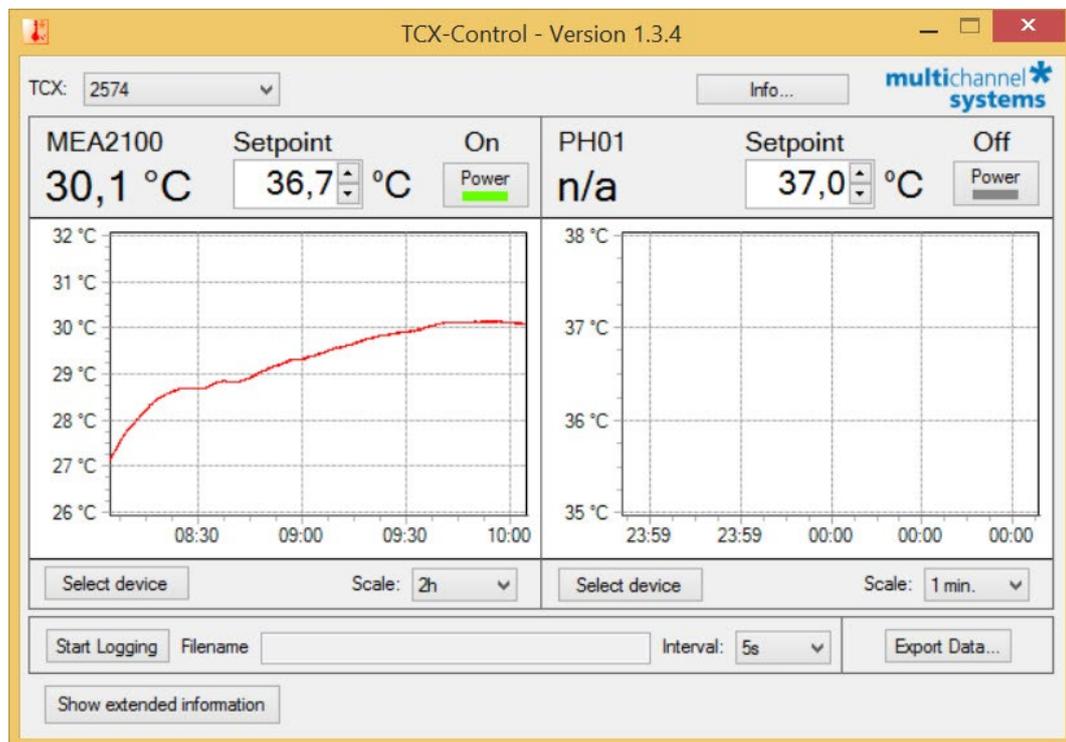
Instead of configuring your TC01/02 via the front panel controls, you can also connect it to a PC with standard USB 2.0 cable and use the software "TCX-Control". With this software, you can control all functions of one or more TC01/02 and it is also possible to read out the actual temperature values on your computer and save the data as a ".txt" file. Then you can import this file into your custom evaluation software, for example, to plot a temperature curve. However, the TC01/02 is also fully functional without the USB 2.0 interface.

#### Setting up the TCX-Control Program

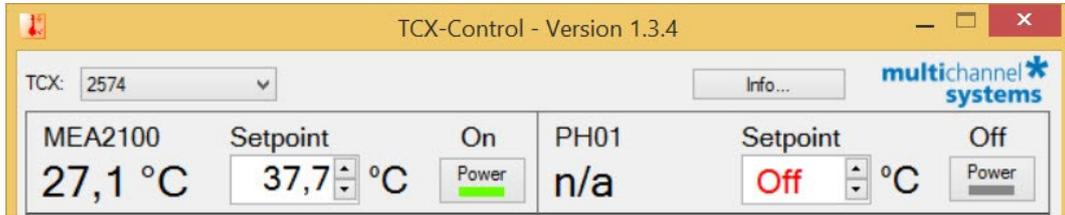
Connect the TC01/TC02 to a USB port of your computer. Start the setup program. This will install TCX-Control on your hard disk drive. Once you connected the TC01/ TC02 to your computer via USB port, a hardware install dialog will appear. Follow the instructions on the screen to install the driver for the TC01/TC02.

#### General User Interface of TCX-Control

Below you can see the main user interface of TCX-Control. The TCX drop down menu shows the serial number of all connected temperature controllers. If you operate more than one temperature controller at a time, you can select here which one you want to monitor.



Two windows show the temperature on the two channels. The scaling of the y-axis is adjusted automatically. The x-axis shows the absolute time taken from the system clock. The scale of the time axis can be altered in the "Scale" drop down menu. Find in each channel window a "Power" button to activate and deactivate the respective channel. The status "Off / On" is displayed.

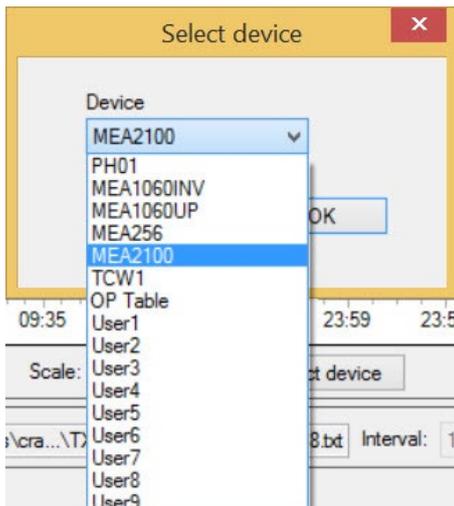


If a channel is deactivated, the status "Off" is displayed above the "Power" button. Additionally the status "Off" is displayed in red letters in the "Setpoint" window in exchange for the setpoint temperature. The actual temperature is displayed as a number and plotted against time.

Click the "Info" button to display the "About" dialog, which shows basic information about the TCX software.



In the select "Device" drop down menu, it is possible to select the type of instrument connected to the respective channel.



Temperature values can be logged to a temperature file. Select a time interval and a file name and press the "Start Logging" button. Time and temperature values will be logged at the selected frequency. The extension of the file is ".txt".

With the "Export Data" option it is possible to start temperature logging retrospectively. When pressing the "Export Data" button, all data from the memory of the TCX-Control software up to the present time is exported to a file. Memory starts when the TCX-Control (NOT the channel) is turned on. The memory holds a maximum of 24 hours of data. If the TCX-Control software has been running more than 24 at the time the export function is used, only the last 24 hours will be saved. The frequency is fixed to 1 second. The extension of the file is "\*.txt".

### Extended Information

It is possible to display the extended information with all parameters from the TC01/02. Click "Show extended information" button in the main menu.

Board Temp.: 26,6 °C		PIC: 1.32		Firmware Updates...
Output U: 24,0 V		PIC2: 1.30		
HW Rev.: G				

Channel 1		Channel 2	
Resist 2: 0,53 Ohm	P gain: 6,00 W/K	Power Set: 2,04 W	
Resist 1: 0,56 Ohm	I gain: 0,90 W/Ks	Power Out: 2,07 W	
Resist S: 114,53 Ohm	Max. P.: 12,0 W	Duty Cycle: 28,3 %	
Resist X: 115,66 Ohm		Output I: 0,088 A	
Heater: 37,73 °C		HE Voltage: 5,43 V	
		HE Current: 0,37 A	
		HE Resist: 14,8 Ohm	
		HE Power: 1,94 W	

These values can be saved to an ASCII file by pressing "Export diagnostics". The default settings for P and I coefficients and maximum power for the different devices can be modified under "Device configuration".

Configuration

Device: MEA2100

Device name: MEA2100

P-coef.: 6.00

I-coef.: 0.90

Max. Power: 12.00

Heater Temp Limit: 255

Enable Heater Temperature Limit

Use Thermocouple as Temperature Sensor

Show always Thermocouple temperatur in extended information

Close

### Use of the OP Table

The OP Table consist of a heating plate for keeping the animal warm, and a rectal thermometer for measuring the body temperature of the animal. Both elements are equipped with a thermo sensor. The heating plate has a Pt100 sensor together with a resistance heating element.

The rectal thermometer has a thermocouple sensor. Connect the heating plate via the D-Sub 9 connector to channel 1 of the TCX. Connect the rectal thermometer via the thermocouple connector to channel 1 socket. Please read chapter "Setting up and Connecting the TCX".

Enable Heater Temperature Limit

Use Thermocouple as Temperature Sensor

Show always Thermocouple temperatur in extended information

Close

Enable the check box "Enable Heater Temperature Limit", and select a temperature limit from the "Heater Temp Limit" drop down menu. This way you make sure that the temperature of the heating plate will not increase too much during the heating phase, and the animal will not suffer.

Enable the check box "Use Thermocouple as Temperature Sensor" if you want to use the thermocouple sensor of the rectal thermometer. If the check box is disabled, the sensor of the heating plate is used for temperature control. To control the settings of both parameters, they are displayed in the "Extended Information" menu.

## Firmware Upgrade

If you like to use a device from Multi Channel Systems MCS GmbH, which is not available in the settings of your temperature controller (for example the TCW1), you probably need to upgrade the software and the firmware and you have to reset the TCX.

**Software:** Install the appropriate software version (for example TCX-Control software Version 1.3.2 and higher).

**Firmware:** Click **"Show extended information"** in the main menu of the TCX-Control program. Additional windows appear, click button **"Firmware Updates"**.

Board Temp.:	27,4 °C	PIC:	1.32	Firmware Updates...
Output U:	23,9 V	PIC2:	1.30	
HW Rev.:	G			

The "Firmware Update" dialog appears.

Firmware Update

Firmware List of the device TC02 (s/n 2574).

Please do not turn off the device during the update!

Firmware			
PIC	1.32	Up to date!	Update
PIC2	1.30	Up to date!	Update

OK

Click the enabled buttons "Update" if necessary, one after the other. The firmware is adapted automatically. The status will be displayed in the status bars.

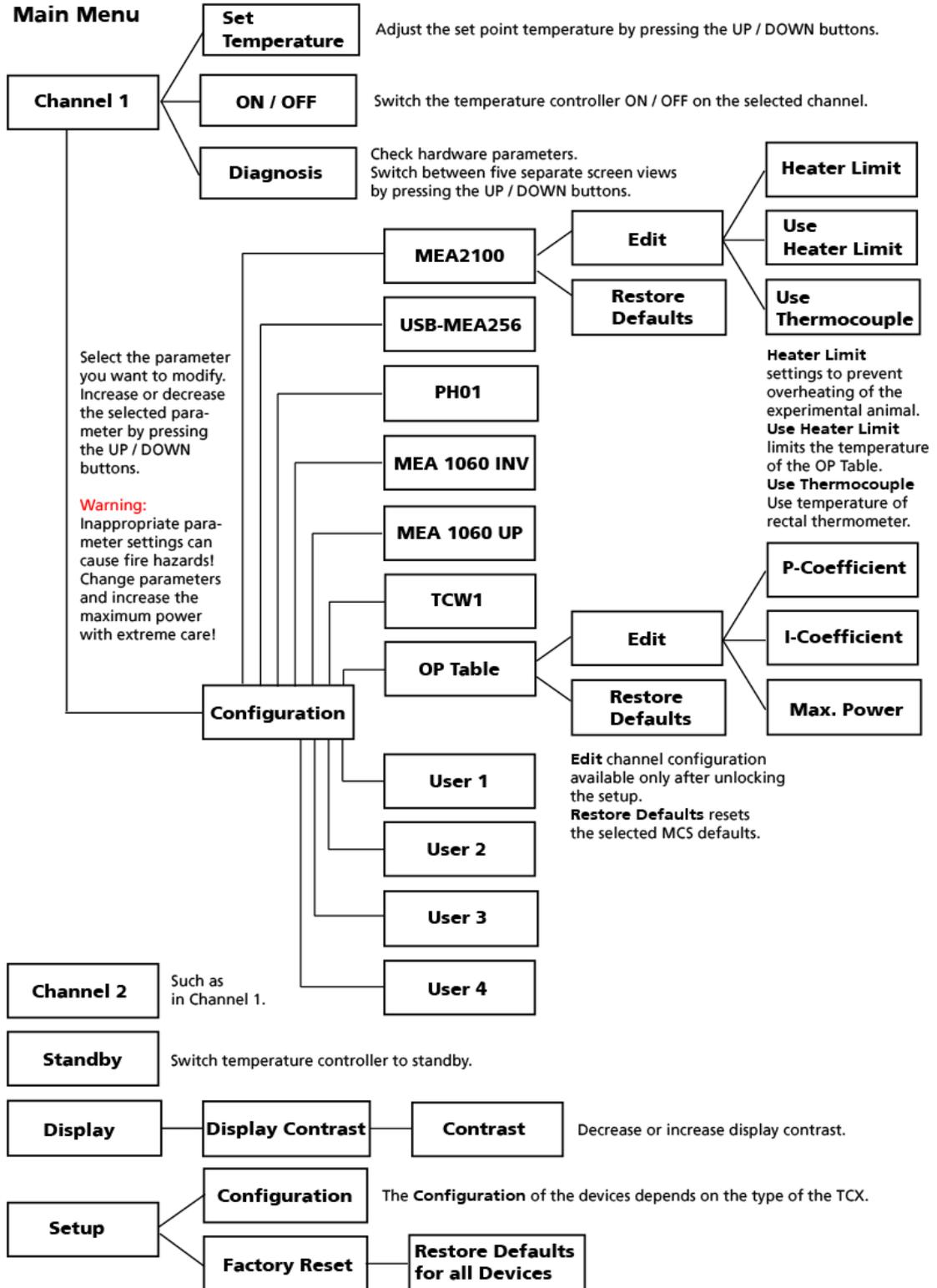
Reset the TCX: In the "Main" menu display of the "Temperature Controller" select "Setup" and "Factory Reset" to apply the new firmware with MCS default settings for all devices, respectively.



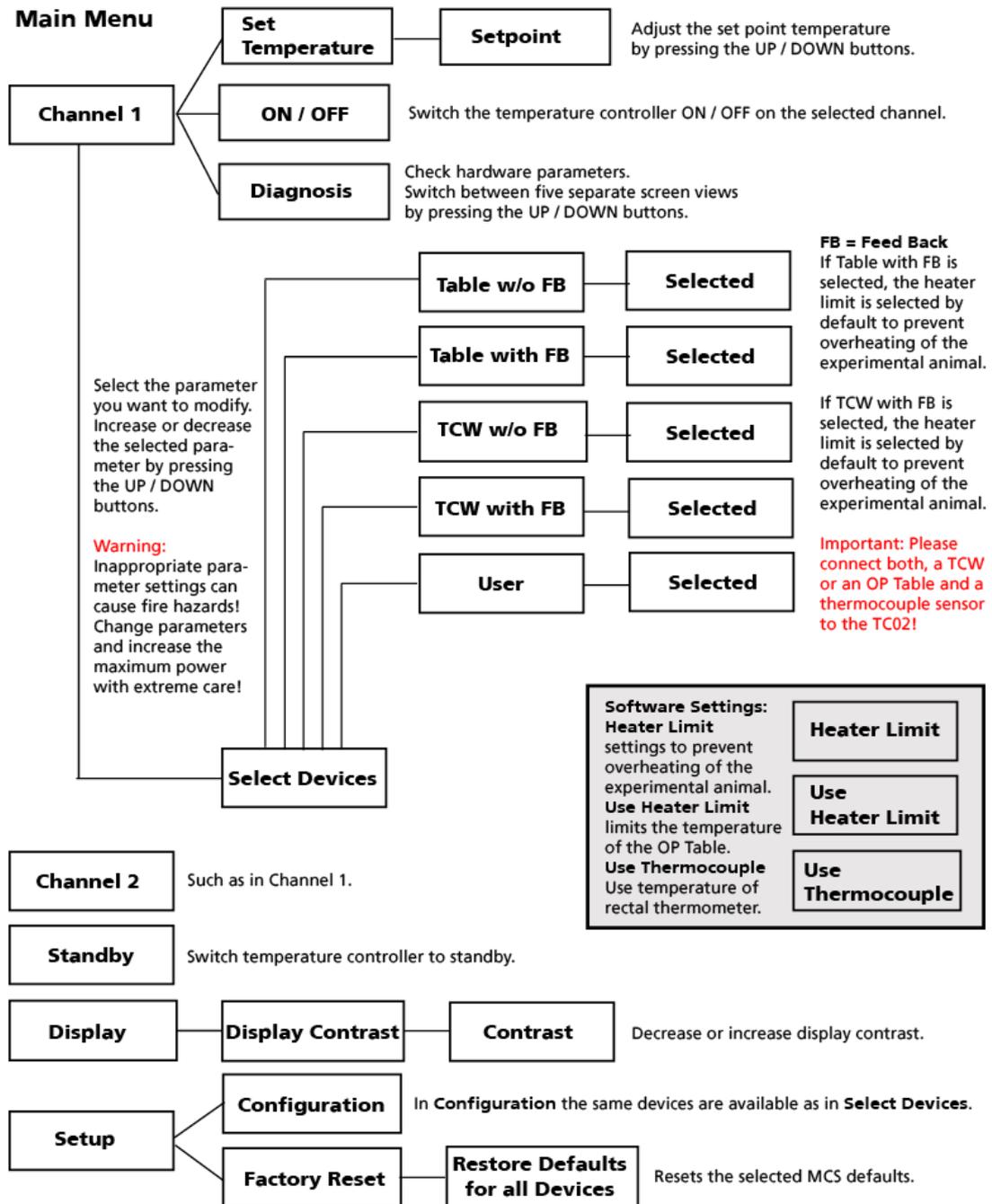
# 4 Appendix

## 4.1 Control via Front Panel

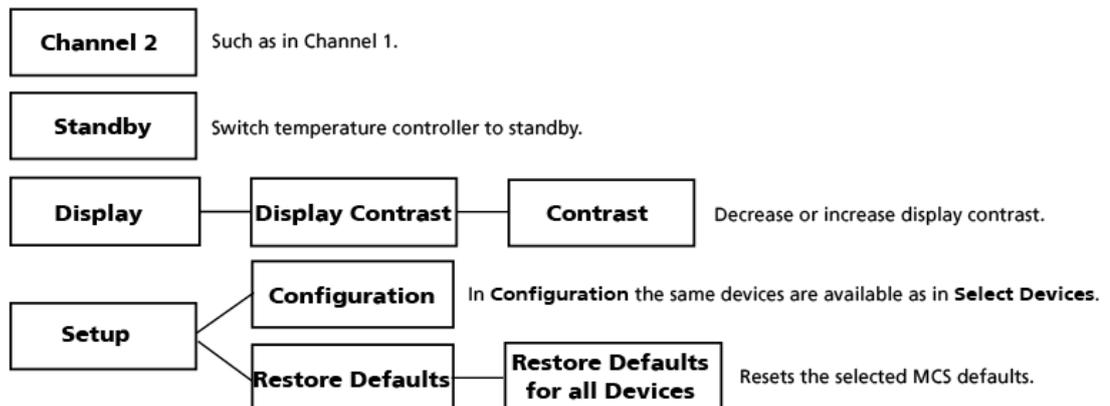
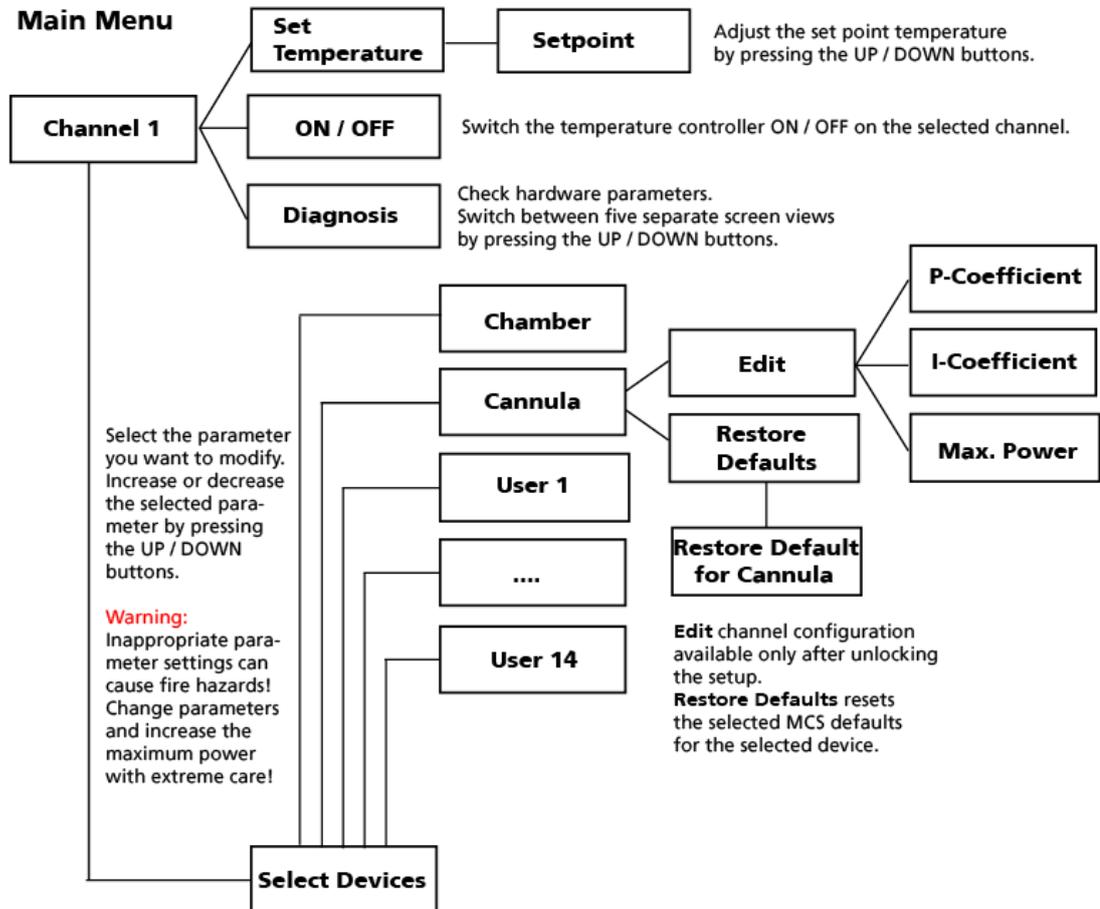
### 4.1.1 Version: Standard



## 4.1.2 Version: Customer II



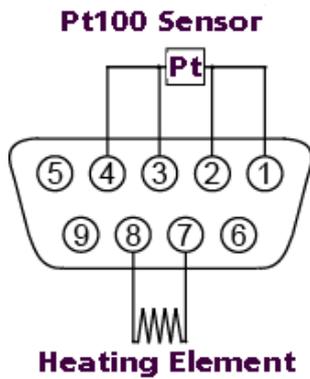
### 4.1.3 Version: Customer III



## 4.2 D-Sub9 Pin Assignment

Pins 1 to 4 of the female D-Sub9 input connector should be connected to the temperature sensor, and pins 7 and 8 to the heating element. The other three pins are not needed for operation.

### TC01 / TC02: D-Sub Pin Assignment



Note: A four-wire circuit is required for use with Pt100 sensors. Each of the two pairs assigned to pins 1/2 and 3/4 have to be connected together in close proximity to the PT100 sensor for proper operation. The current flows through the sensor from pin 1 to 4, and the voltage is measured between pins 2 and 3. The resistance between pin 1 and the sensor is measured as "Resistance 1", and the resistance between pin 4 and the sensor is measured as "Resistance 2", see also chapter "Hardware Diagnosis".

### 4.3 Parameter Ranges

The setpoint temperature and the PI coefficients can be modified in the following ranges. The maximum power of the TCX is 30 W. If you connect a device with a maximum power less than 30 W, please decrease the maximum power to protect the device against destruction.

Parameter	Range
T	0.0 to 105.0
P	0.1 to 99.99
I	0.01 to 100.0
Power	0 to 30 W

### 4.4 MCS Default PI Coefficients

Note: The following PI parameters have been optimized at an ambient temperature of 25 °C, the PI coefficients for use with the PH01 at a flow rate of 3 ml/min. You may have to adjust these PI coefficients for your experimental setup, especially if the ambient temperature or the flow rate differ at large from those used by MCS. Using suboptimal PI coefficients can lead to an oscillation of the actual temperature, which is harmless, but may result in an unwanted behavior of the temperature controller.

	OP Table	TCW	PH01	MEA1060-UP	MEA1060-INV	USB-MEA256	MEA2100
P	10.00	60.00	2.00	4.00	6.00	6.00	6.00
I	1.00	75.00	2.00	1.50	0.90	0.90	0.90

## 4.5 Technical Specifications

Operating temperature	10 °C to 40 °C
Storage temperature	0 °C to 50 °C
Dimensions (W x D x H)	170 mm x 224 mm x 66 mm
Weight	1.5 kg
Supply voltage and current	24 V and 4 A
Desktop AC Power Adapter	85 VAC to 264 VAC @ 47 Hz to 63 Hz
Sensor type	Pt 100
Measuring method	four wire measuring bridge
Measuring temperature range	0 °C to 105 °C
Number of output channels	1 (TC01), 2 (TC02)
Output voltage	max. 24 V
Output current	max. 2.5 A per channel
Output power	max. 30 W per channel
Resistance of heating element	5 - 100 $\Omega$
Control range	Ambient temperature (min. 5 °C) to 105 °C
Control interface	USB 2.0
Thermocouple probe connectors	Type T
TCX-Control	Version 1.3.4
Operating system	Microsoft Windows ® Windows 10, 8.1, and Windows 7 (32 or 64 Bit) English and German Version supported Firmware Version > 1.3.0

**Note:** Outputs are isolated against ground.

## 4.6 Contact Information

### **Local retailer**

Please see the list of official MCS distributors on the web site in [Sales](#).

### **Newsletter**

If you have subscribed to the [Newsletter](#), you will be automatically informed about new software releases, upcoming events, and other news on the product line. You can subscribe to the list on the MCS web site.

[www.multichannelsystems.com](http://www.multichannelsystems.com)

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