# Table of Contents

**Introduction**

About this Manual  

1

**Important Information and Instructions**

Operator’s Obligations  

3  

Important Safety Advice  

4  

Guarantee and Liability  

3

**Installation and Operation**

Welcome to the Temperature Controller TC01/02  

7  

Setting Up and Connecting the TC01/02  

8  

Operating the TC01/02  

8  

Starting the TC01/02  

8  

General User Interface  

9  

TC01/02 Menus  

10  

Setting a Temperature  

11  

Channel Configuration  

11  

Hardware Diagnosis  

12  

Controlling the TCX via USB Port  

14

**Appendix**

D-Sub9 Pin Assignment  

19  

Parameter Ranges  

19  

MCS Default PI Coefficients  

20  

Technical Specifications  

20  

Contact Information  

21  

Scope of Delivery  

21

**Index**

23
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.
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 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.
2.3 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.

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.
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 TC01/02 was 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 provided 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.

- 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.

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. (CH1 for channel 1, CH2 for channel 2, if you have a TC02) See also chapter "D-Sub9 Pin Assignment" in the Appendix.

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.
3.3.2 General User Interface

The 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.

- **Channel 1**
  - Set Temperature
  - ON / OFF
  - Diagnosis

- **Configuration**
  - TCW1
  - PH01
  - MEA1060-IN
  - MEA1060-UP

- **User 1**
- **User 2**
- **User 3**
- **User 4**

- **Channel 2**
  - Such as Channel 1.

- **Standby**
  - Switch temperature controller to standby.

- **Display**
  - Display Contrast
  - Contrast

- **Setup**
  - Factory Reset

---

**Adjust the setpoint temperature by pressing the UP / DOWN buttons.**

**Switch the temperature controller ON / OFF on the selected channels.**

**Check hardware parameters. Switch between four separate screen views by pressing the UP / DOWN buttons.**

**Select**

**Edit**

**MCS Defaults**

**P-Coefficient**

**I-Coefficient**

**Max. Power**

**Select the appropriate channel configuration for the connected heating element.**

**Edit channel configuration available only after unlocking the setup.**

**Reset the selected channel configuration to MCS defaults.**

**Select the parameters that you want to modify. Increase or decrease the selected parameter by pressing the UP / DOWN buttons.**

**Warning:**

Inappropriate parameter settings can cause fire hazards! Change parameters and increase the maximum power only with extreme care!
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 MEA1060-UP 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 view by pressing the **Up** and **Down** buttons.

**Diagnosis 1: Measured values**

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

- **Temperature**
  - Actual temperature
- **Resistance 2**
  - Cable resistance high side of sensor, see also chapter "D-Sub9 Pin Assignment".
- **Resistance 1**
  - Cable resistance low side of sensor, see also chapter "D-Sub9 Pin Assignment".
- **Resistance X**
  - Sensor resistance plus cable resistance
- **Resistance S**
  - Sensor resistance
- **Board Temp**
  - 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.

- **Setpoint Temp**
  - Setpoint temperature
- **P Gain**
  - Proportional gain
- **I Gain**
  - Integrator gain
- **Max Power**
  - Maximum output power

**Diagnosis 3: Controller output**

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

- **Power Set**
  - Output power set by the controller.
- **Power Out**
  - Actual output power (product of **Current Out** and **Supply Voltage**)
- **Duty Cycle**
  - PWM Duty cycle (internal value)
- **Current Out**
  - Current through the primary coil of the isolating transformer
- **Supply Voltage**
  - Supply voltage (from power supply)
Diagnosis 4: Heating element

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

- **On/off**: Current channel state
- **HE Voltage**: Output voltage applied to heating element
- **HE Current**: Output current applied to heating element
- **HE Resistance**: Heating element resistance (voltage-current ratio)
- **HE Power**: 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 TCX via USB Port

Instead of configuring your TC01/02 via the front panel controls, you can also connect it to a PC with standard USB 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 interface.

3.4.1 Setting up the TCX-Control Program

Connect the TC01/02 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 TC01/02 to your computer via USB port, a hardware install dialog will appear. Follow the instructions on the screen to install the driver for the TC01/02.

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 TC01/02 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 drop down menu in exchange for the setpoint temperature.

The actual temperature is displayed as a number and plotted against time. There is also a selection field to adjust the **Setpoint temperature**. Under 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".
3.4.2 Extended Information

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

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**.
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 in the TCX.

1. **Software**: Install the appropriate software version (for example for TCW1, TCX-Control software Version 1.1.9 and higher).
2. **Firmware**: Click Show extended information in the main menu of the TCX-Control program. Three additional windows appear, labeled with "New" if firmware upgrade is necessary. Click the enabled buttons "Update" one after the other. The firmware is adapted automatically.

   ![Firmware Upgrade Table]

3. **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, including TCW1 respectively.

   ![Reset TCX Diagram]
4 Appendix

4.1 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**

![Diagram of D-Sub9 Pin Assignment](image)

*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.*

4.2 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>0.0 to 105.0</td>
</tr>
<tr>
<td>P</td>
<td>0.1 to 99.99</td>
</tr>
<tr>
<td>I</td>
<td>0.01 to 100.0</td>
</tr>
<tr>
<td>Power</td>
<td>0 to 30 W</td>
</tr>
</tbody>
</table>
4.3 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.

<table>
<thead>
<tr>
<th>TCW1</th>
<th>PH01</th>
<th>MEA 1060-UP</th>
<th>MEA 1060-INV</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>60.00</td>
<td>2.00</td>
<td>4.00</td>
</tr>
<tr>
<td>I</td>
<td>75.00</td>
<td>2.00</td>
<td>1.50</td>
</tr>
</tbody>
</table>

4.4 Technical Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>10 °C to 40 °C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>0 °C to 50 °C</td>
</tr>
<tr>
<td>Dimensions (W x D x H)</td>
<td>170 mm x 224 mm x 66 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>1.5 kg</td>
</tr>
<tr>
<td>Supply voltage and current</td>
<td>24 V and 4 A</td>
</tr>
<tr>
<td>Desktop AC Power Adapter</td>
<td>85 VAC to 264 VAC @ 47 Hz to 63 Hz</td>
</tr>
<tr>
<td>Sensor type</td>
<td>PT 100</td>
</tr>
<tr>
<td>Measuring method</td>
<td>four wire measuring bridge</td>
</tr>
<tr>
<td>Measuring temperature range</td>
<td>0 °C to 105 °C</td>
</tr>
<tr>
<td>Number of output channels</td>
<td>1 (TC01), 2 (TC02)</td>
</tr>
<tr>
<td>Output voltage</td>
<td>max. 24 V</td>
</tr>
<tr>
<td>Output current</td>
<td>max. 2.5 A per channel</td>
</tr>
<tr>
<td>Output power</td>
<td>max. 30 W per channel</td>
</tr>
<tr>
<td>Resistance of heating element</td>
<td>5 - 100 Ω</td>
</tr>
<tr>
<td>Control range</td>
<td>Ambient temperature (min. 5 °C) to 105 °C</td>
</tr>
<tr>
<td>Control interface</td>
<td>USB 2.0</td>
</tr>
</tbody>
</table>

Note: Outputs are isolated against ground.
4.5 Contact Information

Local retailer

Please see the list of official MCS distributors (sales info) on the web site.

User forum

The Multi Channel Systems User Forum provides the opportunity for you to exchange your experience or thoughts with other users worldwide.

News Letter

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)

4.6 Scope of Delivery

Controlling the TC01/02 via USB Port

1 TC01/02 main device
1 Main cable
1 USB 2.0 cable
1 TCX Manual