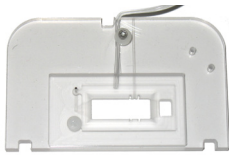


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# Temperature Control Systems

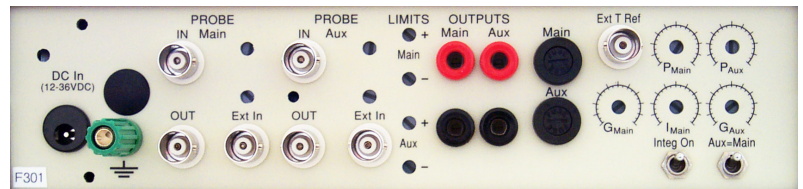


- **3 Temperature Control System versions:**  
**TC2PKG** - (incl. TC2BIP, BT-xx, TH-10Km, HI-xx, MSA-xx) for **no/low flow** situations  
**TC2PKGp** - (incl. TC2BIP, BT-xx, TH-10Km, HI-xx, MSA-xx, HPRE2, FL-1) for **flowing** solutions.  
**TC2PKG3P** - (incl. TC2BIP, BT-xx, TH-10Km, HI-xx, MSA-xx, HPRE2, FL-1, HLS-xx, TC2-CH3) for **flow with 3rd channel** for **objective heater or superfusion (MPRE8)**

- **Bipolar, 2 channel** [3rd heat opt] controller for **heating/cooling** low volume tissue baths
- **Thin transparent (ITO) heaters**
- **DC/Battery** powered to **eliminate** interference
- **Flexible** controller, **many** control options
- **Accurate** temperatures for **wide range** of flow rates
- For **conventional** and **inverted** microscopes
- **Uniform** temperatures ( $<\pm 1^{\circ}\text{C}$ ) obtained over **>35x18mm** area (**HI-24p**)
- **Rapid** temperature changes (eg. with **BT-1-xx** chamber & **HI-24p** Heater  $>0.5^{\circ}\text{C}/\text{sec}$ )
- **External** input for **programmed** temperature changes

## DESCRIPTION

The **Temperature Control Systems**<sup>†</sup> (see below) consist of the sophisticated **TC2BIP** 2 channel controller together with accessories to form a complete setup for patch clamping/microscopy or for experiments with brain slices or other small pieces of tissue (eg. DRG). The system provides excellent optics and reliable and accurate temperature control in small experimental chambers. The **BT-1-xx** tissue chambers are suitable for the study of acutely isolated or cultured cells or small tissue preparations. For temperature control the Main channel of the **TC2BIP** compares the bath temperature (the Aux channel typically compares the **HPRE2** pre-heater temperature) with a reference temperature set either by the **TEMP1** or **TEMP2** controls or by an external programming voltage. The bath temperature is maintained at the reference temperature during changes in flow rate, inflow solution temperature or ambient temperature. The Main channel uses both proportional and integral control, while the Aux channel uses proportional control. The



integrator eliminates the steady state error which exists when small proportional gains are used. The **TC2BIP** was designed to be battery operated to eliminate electrical interference but can also be operated from DC power supplies.

In rapid heating systems the temperature often overshoots before settling to the reference temperature. The **TC2BIP** works to minimize this overshoot, thereby protecting the cells from damage due to transient high temperatures. With proper adjustment of the **TC2BIP** control parameters the temperature across a 15x8mm area in the **BT-1** or larger areas in bigger chambers can be regulated within  $<\pm 1^{\circ}\text{C}$  for flow rates of zero to  $>2\text{ml}/\text{min}$  (higher flow rates can be used with larger chambers). Typically, heating rates of  $>0.5^{\circ}\text{C}/\text{sec}$  can be expected with chamber volumes less than 0.25ml. The cooling rate ( $\tau_{\text{cooling}}$ ) depends on the experimental chamber design as well as the solution flow rate. For the **BT-1** bath,  $\tau_{\text{cooling}}$  ranges from 30 secs (2ml/min) to 112 secs (0.2ml/min) (see Datyner, Gintant and Cohen (1985)<sup>§</sup> for performance of a similar system).

The **HI-24p** heater is a transparent indium tin oxide coated (ITO) heater with a #1 1/2 cover slide thickness. This heater provides a 45x18mm transparent, uniformly heated area 0.18mm thick, suitable for both conventional and inverted microscopes. The **HI-24Tp** heater is thinner (#0 cover slide thickness; 0.12mm) for microscopy studies or use with fluorescence.

<sup>§</sup>Ref: Datyner, Gintant & Cohen (1985). "Versatile temperature controlled tissue bath for studies of isolated cells using an inverted microscope." *Pflügers Archiv*, **403**, 318-323.

<sup>†</sup>You need to purchase a power supply for the TCS. We recommend different power supplies depending on the application. Typically a 12V (or 13.8V, max. 4.5Amp) regulated supply for whole cell, intracellular or microscopy studies. For single channel or smaller whole cell currents we suggest a 12V (>15AH) gel battery and charger. For use with Peltier elements an additional 12V (>15AH) battery is recommended to boost the supply to 24V. For high resistance heaters (eg. 50Ω) a 36V supply is recommended. Please call or see website for more details. ...over

## Controls

### Front controls

**TEMP1,2:** 2 setpoints allow switching between two preset temperatures or independent setpoints.

**POWER:** Controls overall output power to limit rate of temp increase and put controller in standby mode.

**Aux/Main:** Display temperature of main probe or auxiliary probe. Output at rear can be used to monitor Aux temperature continuously with a DVM.

**Cool/Heat or Heat:** Cool/Heat is used for Peltier devices. Heat is used for resistance type heaters.

**OUTPUTS:** LEDs display output current and direction of current.

**Aux On/Off:** Shuts down Aux output.

**Low Pwr:** Indicates when power input is too low for proper function.

### Rear controls

**PROBE Main:** Accepts **TH-10Km**, YSI-400 and YSI-500 series or compatible probes. Two adjustments allow customization for miniature non-interchangeable probes (eg. **TH-1**).

**OUT:** Temperature output for DVM, computer or chart recorder.

**Ext In:** Allows input from other probes (eg. Sensortek).

Automatically switches to external input.

**PROBE Aux:** As for Main.

**T Aux Offset:** Offsets Aux reference  $\pm 6^{\circ}\text{C}$ .

**LIMITS:** Sets max output voltage for particular heater type. Min is max output voltage for Peltier for cooling.

**OUTPUTS:** Output to Main heater (or Peltier) and Aux heater (pre-heater or Peltier). (3rd channel uses MiniDIN connector for heater/thermistor.)

**Fuses:** Protects controller power amplifier from overload. Internal fuse and microcontroller based overload/short protection. Internal heatsink overheating sensing and shutdown.

**Ext T Ref:** External temperature programming (eg. for computer setting of temperature).

**P<sub>Main</sub>:** Proportional gain for main output.

**I<sub>Main</sub>:** Integral gain for main output.

**Integ On:** Integrator on/off control.

**P<sub>Aux</sub>:** Proportional gain for auxiliary output.

**G<sub>Main</sub>:** Overall gain of output amplifier for main output.

**G<sub>Aux</sub>:** Overall gain of output amplifier for auxiliary output.

**Aux=Main:** Aux output= $G_{Aux}/G_{Main}$  x Main output (pre-heater as slave).

## Specifications

**Temp Ref Range:**  $0^{\circ}\text{C}$  to  $50^{\circ}\text{C}$  (can be extended to  $>60^{\circ}\text{C}$ )

**Output (Main & Aux)**

DC In:12V max: -8V to +8V; 5-15 $\Omega$  load; 2Amp max

DC In:24V max: -12V to +8V; 5 $\Omega$  load; 2Amp max

max: -18V to +18V; 15 $\Omega$  load; 2Amp max

DC In:36V max: -28V to +28V; 50 $\Omega$  load; 0.7Amp max

3rd channel : max: 8V 1.5Amp.

**Suitable heaters:** 3.5 - 50 $\Omega$  resistance. eg. **HI-24xp**., **HI-5xDp**, **HC-1p**

For 50 $\Omega$  heaters need >24V supply.

**Suitable Peltier:** 12V, 2A device.

**Supply Voltage: Resistive heater**

12V at 4.0Amp max. Typ. 1.5 Amp. for **HI-24** & **HPRE2**

36V at 1.4Amp max.

**12V Peltier element**

18V at 4.0Amp max.

**Dimensions:** 8.0 x 10.0 x 3.0 inches (LxWxH)

## Application notes

### Power supply options

The **TC2BIP** has very flexible power options and heater resistance options. For resistive heaters 15-5 $\Omega$  a 12V supply will provide from 4-13Watts of power respectively. For 12V Peltier devices a 18-24V supply (eg. two 12V gel batteries in series) is ideal although a 13.8V DC supply is often adequate. If you are using resistive heaters with high resistances (eg. 50 $\Omega$ ) you can use a higher power supply (up to 36V). The  $G_{Main}$  and  $G_{Aux}$  controls allow expansion of the output voltage range at these higher supply voltages.

### Chambers

The **BT-1** Bath performance is described in Datyner, Gintant & Cohen (1985). It provides for rapid solution changes (eg. 6 times/min at 1.5ml/min flow rate), reliable temperature control and uniform temperatures (with the **HI-24p/25p** heaters). Baths with a central chamber (preferably rectangular) with similar dimensions to the **BT-1-xx** will provide predictable rates of heating/cooling and good temperature uniformity. The **HI-24p/25p** heaters

will also suit baths with larger working areas (up to 45mm x 18mm). If you want advice on adapting baths that you currently use please call us.

Figures of better than  $\pm 0.2^{\circ}\text{C}$  are often quoted in describing temperature controller regulation. Since the exact conditions (flow rate, probe location, ambient temp. etc.) affect this figure and cells are often not located adjacent to the probe, actual temperatures in different locations in the experimental chamber must be measured under actual conditions of use (see Datyner, Gintant and Cohen (1985)). Use of the **HI-24p/25p** heaters and **HPRE2** Pre-heater optimizes the temperature uniformity.

Our **BT-I55D** or **HWPT-96OL/NK** transparent microscope heater stages are intended for heating 30mm culture dishes or any other transparent dishes.

### Temperature probes

The **TC2BIP** accepts **TH-10Km** (standard), **TH-2Km**, YSI-400 and YSI-500 probes. The Ext In for each PROBE accepts sensor outputs with 10mV/ $^{\circ}\text{C}$  (eg. Sensortek thermocouple transducers).

### Special optics (eg. fluorescence)

The **HI-24Tp** can be used for fluorescence microscopy or where there is limited working distance (transmission data is available on a separate **ITO heater flyer**).

### Pre-heating

The **HPRE2** is a miniature pre-heater with a thermistor for sensing the pre-heater temperature. The pre-heater supports a wide range of flow rates. The cable plugs into the Probe Aux and Aux Output.



### Superfusing

The **MPRE8** is a miniature 8 channel pre-heater with a tiny dead volume (1-2 $\mu\text{l}$ ) and internal thermistor that can be used for superfusing cells, small pieces of tissue for perfusing small chambers at low flow rates (<1ml/min). It plugs into the Main, Aux or TC2-Ch3 channel of the **TC2BIP**.



### Subambient temperatures

The **TC2BIP** can drive 12V Peltier devices. When switched to Cool/Heat the outputs can swing both positive (for heating) and negative (for cooling). Our **CH** Cooling/Heating module can be directly driven by the **TC2BIP**. Another option is to use the **CH** to pre-cool and then reheat and control the inflow temperature with the **HPRE2**. This allows rapid increases and decreases in temperature.

### Other applications

The **TC2BIP** is versatile enough to be adapted to many different temperature control tasks. For example with a special heater it has been used to control the temperature of fluid entering kidney tubules. Other labs have used it with larger tissue chambers for a variety of tissues including whole lenses. Please call if you want advice on any special application.

### Opt. 3rd channel superfusion/objective heating

An optional 3rd heat only channel (**TC2-Ch3**) is available for the **TC2BIP**. It can be used for microscope objective heating (with **HLS-1p**) for immersion lenses or for superfusing solutions via our **MPRE8**. The upgrade can be installed later (or pre-installed eg. **TC2PKG3P**).

## Accessories (partial list)

**Probes:** **TH-10Km**, **TH-2Km**

**ITO Heaters:** **HI-24p**, **HI-24Tp**, **HI-22Dp**, **HI-25Dp**, **HI-55Dp**, **HI-57Dp**, **HI-711Dp**

**Foil heaters:** **HLS-1p**, **HLS-8x.8p**

**Extra channel:** **TC2-Ch3**

**Pre-heaters:** **HPRE2**, **HPRE2HF**, **MPRE8**

**Positioning:** **FL-1**