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Web Page:
http://www.qnw.com/turret-4-product-family/

Description:

Temperature-Controlled Four-Position Turret Cell Changer for Absorbance or Fluorescence

QUANTUM
N·O·R·T·H·W·E·S·T

QNW Turret 4 User's Guide

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Temperature-Controlled Cuvette Holders and Custom Instrumentation

Notices

The Turret 4 is a precision mechanical device containing 5 stepper motors, gears, super-flexible wire and silicone tubing. It will generally perform more than 200,000 sample changes before requiring repair. If the experiments you plan require an unusually large number of sample changes, please contact Quantum Northwest and purchase a service contract for regular inspection and repair.

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Safety Notices

A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Table of Contents

1. General Information

Thank you for purchasing a Quantum Northwest **Turret 4**. We want you to enjoy many years of faithful service from your instrument. If you have any questions, feel free to contact us directly through our website, www.qnw.com/contact-us/, or by email at service@qnw.com.

Your Quantum Northwest cuvette holder and accessories have been carefully designed so that when used properly, you have an accurate, fast, flexible and safe temperature control system.

Information about safety practices appears throughout the documentation provided with your instrument and accessories to help you safely operate the instrument and accessories. Before using the instrument or accessories, you must thoroughly read these safety practices. ALWAYS operate the instrument and accessories in accordance with these safety practices.

1.1. User Documentation

You have been provided with the following documentation to help you set up and operate your Quantum Northwest **Turret 4** cuvette holder:

- This manual, with safety practices and hazards information, instructions for installing and maintaining the components of the **Turret 4**, and troubleshooting information.
- The **T-App** Help file, located on the **T-App** CD (Quantum Northwest>**T-App** Help).

1.2. Modules, Covers and Panels

The spectrophotometer module that operators and other personnel will routinely access is the instrument's sample compartment, which is designed to contain the QNW **Turret 4**. Customers may insert cuvettes and cuvette accessories into the QNW **Turret 4** while the sample compartment is open.

Any other panels or covers that are retained by screws on the cuvette holder and accessories may be opened ONLY by Quantum Northwest service technicians.

1.3. Other Precautions

Do not block any ventilation grills present on the QNW **TC 1** Temperature Controller.

Use of the QNW **Turret 4** system and accessories may involve materials, solvents and solutions that are flammable, corrosive, toxic or otherwise hazardous. Careless, improper, or unskilled use of such materials, solvents and solutions can create explosion hazards, fire hazards, toxicity and other hazards which can result in death, serious personal injury, and damage to equipment and property.

ALWAYS ensure that laboratory safety practices governing the use, handling and disposal of such materials are strictly observed. These safety practices should include the wearing of appropriate safety clothing and safety glasses.

1.4. Warning and Other Symbols

The following is a list of symbols that appear in conjunction with warnings on the QNW cuvette holder and accessories. The hazard they describe is also shown.

A triangular symbol indicates a warning. The meanings of the symbols that may appear alongside warnings in the documentation or on the instrument itself are as follows.

	When used on a warning label, the user is in danger of an electrical shock.
	When used on warning labels attached to the instrument, refer to the relevant operation or service manual for the correct procedure referred to by that warning label.
	When attached to the rear of the instrument, indicates that the product complies with the requirements of one or more EU directives.

1.5. CE Compliance

Your QNW **Turret 4** cuvette holder has been designed to comply with the requirements of the Electromagnetic Compatibility (EMC) Directive and the RoHS Directive of the European Union. Quantum Northwest has confirmed that each product complies with the relevant Directives by testing a prototype against the prescribed EN (European Norm) standards.

Proof that a product complies with these directives is indicated by:

- the CE Marking appearing on the rear of the product, and
- the following Declaration of Conformity. The Declaration of Conformity is the legal declaration by Quantum Northwest that the product complies with the directives listed above, and shows the EN standards to which the product was tested to demonstrate compliance.

EU Declaration of Conformity

We: Quantum Northwest, Inc.
Of: 22910 E Appleway Ave, Suite 4
Liberty Lake, WA 99019-8606
USA

Hereby declare under our sole responsibility that the following devices:

QNW MODEL (CONTROLLER MODEL)
BATH 10
CD 250™ (TC 1 Controller)
Luma 40™ (TC 1 Controller)
qCHANGER 6™ (TC 1 Controller)
t2 Sport™ (TC 1 Controller)
t2x2 Sport™ (TC 1 Controller)
Turret 4™ (TC 1 Controller)
Turret 6™ (TC 1 Controller)
Versa 20™ (TC 1 Controller)

Comply with the essential requirements of the following applicable European Directives:

Electromagnetic Compatibility (EMC) Directive 2004/108/EC,

RoHS Directive 2011/65/EU.

Conformity is assessed in accordance to the following standards:

EMC Directive:	Emissions	EN 61326-1 (2013) Group 1 Class A
	Immunity	EN 61326-1 (2013) Group 1 Class A

I hereby declare that the equipment models named above have been assessed and found to comply with the relevant sections of the above-referenced specifications. The units comply with the relevant requirements of the applicable Legislation, and I am the person authorized to compile the technical documentation.

Signed by: 

Name: Enoch W. Small, Ph.D.
Position: President, Quantum Northwest, Inc.
Date: February 19, 2016
Location: Liberty Lake, Washington, USA

2. Specifications

Figure 1. Turret 4 Cuvette Holder

Figure 2. TC 1 Temperature Controller

2.1. Introduction: QNW Turret 4 Four-Position Cuvette Holder with TC 1 Temperature Controller

Intended Use

The QNW **Turret 4** Four-Position Cuvette Holder is designed to be inserted into a commercially-available spectrometer, replacing the sample cuvette holder originally supplied with the instrument. The **Turret 4** contains a stepping motor drive for rapid position changes, variable speed magnetic stirring for each cuvette, and dry gas ports under each of the 12 exposed cuvette windows. An opaque cover is provided to permit control of the gaseous environment above the cuvettes and to prevent light leakage into the spectrometer. A variety of optical slits are provided to limit excitation or emitted light. Temperature control is achieved using the **TC 1** Temperature Controller alone or along with a computer interfaced to the **TC 1** Temperature Controller box, using the QNW **T-App** software available for purchase.

Specifications

- Temperature range -25 to +105 °C
- Temperature precision ±0.02 °C
- Cuvette size (outside dimensions) 12.5 x 12.5 mm
- Optical port dimensions 12 mm high x 10 mm wide
- Probes accepted Series 400 or Series 500
- Cuvette z-height 8.5 or 15 mm (specified at time of order)

Note: The "z-height" of a cuvette is the distance between the bottom surface of the cuvette and the designed position for the optical center line, where the incident beam of light strikes the cuvette.

2.2. Measurement Category

The measurement category is IEC 61010:I. Do not to use this equipment for measurements within measurement categories II, III and IV.

2.3. Pollution Degree

The pollution degree is IEC61010:2. Pollution degree "2" applies to a normal indoor atmosphere.

2.4. Overvoltage Category

The overvoltage category (installation category) is CAT II. See IEC 664 & IEC 61010.

2.5. Environmental Conditions

The area should have a dust-free atmosphere with minimal drafts, vibrations, and corrosive fumes. For optimum performance, the ambient air is recommended to be between 20 and 25 °C, but can be from 5 to 40 °C. Relative humidity should be less than 80%. The instrument is designed for operation at 2,000 m elevation or less.

To avoid damage through spillage of solutions and samples being analyzed, the worktops should be covered with a material that is corrosion resistant and impervious to liquids.

Allow at least two inches of space on both sides, and six inches at the rear of the instruments to permit free air circulation. The power cord and all other connections are located at the rear of the instruments. The power switch is located on the front panel.

2.6. Electrical Specifications

Mains Supply

A standard power cable is provided based on the user's country requirements (18 AWG/115 V AC US/Canada; 1.0 mm/220 V AC international). The required supply voltage is 100-240 V AC (frequency 50 or 60 Hz). The mains voltage fluctuations must not exceed 10% of the nominal voltage.

The installation of electrical power supplies must comply with the rules and/or regulations imposed by local authorities responsible for the supply of electrical energy to the workplace.

All power supplies for the **TC 1** Temperature Controller must be single-phase, AC voltage, three-wire system (active, neutral, earth) and should be terminated at an appropriate power outlet receptacle that is within reach of the power cord. For safety reasons, a separate power outlet receptacle should be provided for each unit in the system. The use of extension cords or outlet adaptors is not recommended.

WARNING

Shock Hazard - Danger of electrocution. Good electrical grounding is essential to avoid potentially serious shock hazards. A 3-wire outlet with ground connection must be provided for the **Turret 4**. Make certain that power outlets are earth-grounded at the grounding pin.

CAUTION

Caution - Never connect or disconnect any cables while the **Turret 4/TC 1** Temperature Controller is switched on. Damage to the printed circuit boards may occur.

2.7. Computer Requirements

The **T-App** temperature application software used for external control of Quantum Northwest temperature controllers requires a personal computer using a Microsoft Windows™ operating system (XP, Vista, 7, 8 or 10). The **T-App** software is normally provided on a CD, requiring a CD player be part of the computer. However, **T-App** may also be downloaded *via* the Internet from a QNW ftp site. Contact QNW should you wish to obtain the application by Internet.

3. Installing, Starting and Stopping the QNW Turret 4

3.1. Installing the QNW Turret 4

Unpacking

After accepting delivery, take the equipment to the installation site. Quantum Northwest instruments are inherently robust, and the packaging is designed to prevent internal damage. However, the contents form part of a precision measuring system and all packages should be handled with care. In transit, sharp jolts must be avoided and the packages should not be inverted or tilted unnecessarily. Markings on the shipping cartons generally indicate which side of the package should be kept on top.

Note: The **Turret 4** may have been already installed in the spectrophotometer by its manufacturer.

Unpacking the equipment is your responsibility. As the packages are opened, ensure that you have received everything you ordered. If there are any discrepancies, notify the supplier. If any items are found to be damaged, immediately notify the carrier and supplier.

You should have received:

- 1x **Turret 4** Four-Position Cuvette Holder

Note: The **Turret 4** may come attached to a front panel designed to replace the front panel of the destination spectrophotometer.

- 1x **TC 1** Temperature Controller
- 1x power cable
- 1x USB or RS-232 (9-pin serial) cable
- 1x DB15 15-pin cable assembly, labeled "**sam**" at both ends (if unit shipped with no front panel)
- 4x magnetic stir bar
- 1x $\frac{1}{8}$-inch diameter vinyl tubing to connect water
- 1x $\frac{1}{16}$-inch diameter vinyl tubing to connect gas
- 1x $\frac{1}{8}$-inch-to-$\frac{1}{16}$-inch barbed reducer fitting
- This manual

Note: Any additional accessories ordered are not listed here.

Any differences from the original order should be referred immediately to your Quantum Northwest sales office. Do not discard any packaging components or filler materials.

Installing the QNW T-App Software (if purchased)

1. Follow the instructions provided with the software to complete the installation.

Note: It is important to install software before connecting the **TC 1** to your computer. Software installation installs a driver. If the **TC 1** Temperature Controller is connected to the computer and turned on before software installation, then the computer may automatically load an incorrect driver that may be difficult to remove.

2. Connect the **TC 1** to your computer using the USB or RS 232 cable provided. The New Hardware installation process will begin automatically and take a few moments to finish.

Installing the QNW Turret 4 Hardware

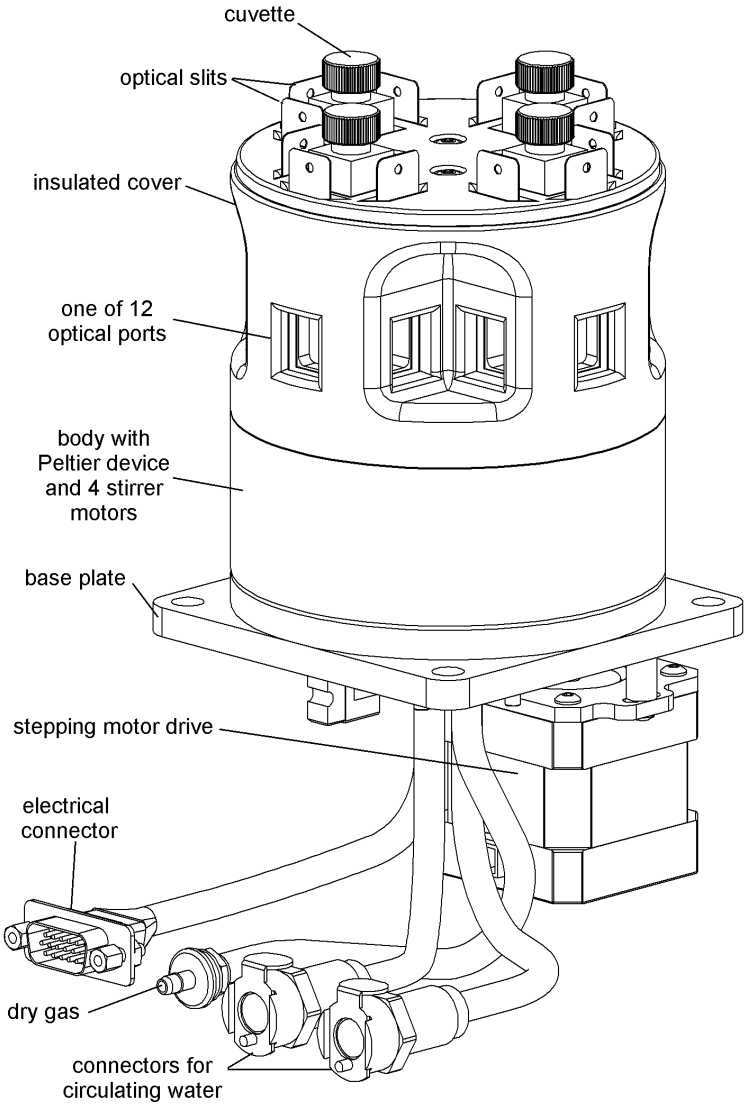

Figure 3. A typical configuration of a **Turret 4**.

1. Mount the **Turret 4** in the destination spectrometer. A typical configuration is shown in Figure 3 of this manual, although a wide variety of other configurations is available. Connections typically consist of a 25-pin electrical connector, two tubes carry circulating water for cooling the thermoelectric device, and one tube for dry gas used to prevent condensation on cuvette windows. Please contact Quantum Northwest at service@qnw.com for additional instructions, if needed.
2. Connect a water source to the water connections on the cuvette holder. Flow direction is not important. Typically, this flow is provided from a submersible pump in a small reservoir, a temperature-controlled water bath, or from a tap to a drain. Use a length of tubing with 1/8" (3mm) inside diameter such as the vinyl tubing provided. More details are provided in section 4.3.
3. If the optional BATH 10, BATH 100 or KOOL 440 Koolance circulator was purchased, attach one tube to the brass fitting on the top of the submersible pump let the other tube hang back in the bucket. Position the bucket to within 75 cm (30 in) above or below the spectrometer. Put water in the bucket to cover the pump and add ice if low temperatures are to be achieved.

CAUTION

Caution – Position the bucket in a location that minimizes the risk of spilling the liquid contents.

Note: Secure the two pieces of tubing together with a twist-tie to make it unlikely that the return tubing does not accidently get dragged out of the bucket.

Note: The water in the bucket should be changed frequently (e.g., daily) to avoid bacterial growth.

4. Connect the DB15 15-pin cable assembly between the connectors on the **Turret 4** cuvette holder assembly and on the back of the **TC 1** temperature controller, matching the labels on the cable ends to those on the connectors.

Note: Be careful not to over-tighten the screws to avoid stripping the threads.

CAUTION

Caution - Never connect or disconnect any cables while the **Turret 4/TC 1** Temperature Controller is switched on. Damage to the printed circuit boards may occur.

5. Check that the **TC 1** power switch in the back is in the off position. Plug the power cable into the back of the **TC 1** Temperature Controller and into a wall socket. (The **TC 1** will accept AC voltages from 85 to 264 at 50 or 60 Hz.) Leave the power off.
6. Turn on the water source to the **Turret 4** and check for leaks in the system.

7. OPTIONAL - If you plan to work at low temperatures, connect a source of dry gas, typically nitrogen, to the small hose barb labeled "**gas**" on the front of the cuvette holder assembly. It is very important to use dry gas flow when working at temperatures below the dew point, approximately 5 °C. Not only will the dry gas prevent condensation on the cuvette windows, but it will also prevent condensation in the interior of the **Turret 4** cuvette holders. Use the length of $\frac{1}{16}$-inch tubing provided (a $\frac{1}{8}$- to $\frac{1}{16}$-inch barbed reducer fitting is also provided). Set the dry gas flow rate to about 50 cc/min.

CAUTION

Caution – When using dry gas do prevent condensation on the cuvette, ensure that the working area is adequately ventilated. Secure the gas tank to a solid object in the vicinity of the spectrophotometer. **Never put water through the gas line.**

3.2. Starting the QNW Turret 4

1. Place a magnetic stir bar in a standard 1 x 1-cm square cuvette. Insert a liquid sample into the cuvette.
2. Place the cuvette in the **Turret 4** cuvette holder, position 1.
3. Repeat Steps 1 and 2 for the remaining three positions of the **Turret 4** cuvette holder, if desired.
4. OPTIONAL - If you wish to monitor the temperature inside the cuvette, plug a standard Series 400 or Series 500 thermistor probe (not provided) into the ¼ - inch phone jack labeled "probe" in the back panel of the **TC 1**. Place the end of the probe in a region of the liquid in the cuvette where it will not occlude the spectrometer light beam.
5. Turn on the **TC 1** controller using the power switch on the back panel.

Figure 4. **TC 1** Menu Button

6. Use the left, right, up and down arrows on the Menu Button, shown in Figure 4, to cycle through the controller options. These options are described in detail in Section 4.2 below. To simply set a temperature for the sample cuvettes, and turn on magnetic stirring, press the right arrow once to go to the **Set Target Temp.** page, use the up and down arrows to set a target temperature, say 37.0 °C. Press **SET** to initiate temperature control and seek this temperature. Next, press the right arrow twice to go to the **Set Stirring** page. Use the up and down arrows to set a speed, say 1200 rpm, and press **SET** to start the stirrers. For more detailed use of the menu button, see Section 4.2 below.

3.3. Stopping the QNW Turret 4

1. To turn off temperature control, press the right arrow on the **TC 1** Menu Button (Figure 4) once to go to the Set Target Temp. page and press SET again. To turn off stirring, go to the Set Stirring page and press SET again.
2. After measurements are completed, turn off power on the back of the **TC 1** controller. Power off the circulator pump at this time as well.

4. Step-by-Step Instructions for Using the QNW Turret 4

4.1. Instrument Overview

The **Turret 4**, shown in Figures 1 and 3, is a temperature-controlled, four-position cuvette holder typically used for fluorescence, UV/Vis/NIR spectrophotometry or circular dichroism measurements. Rapid and precise temperature changes may be made in the range of -25 to +105 ºC. The **Turret 4** contains a stepping motor drive for rapid position changes, variable speed magnetic stirring for each cuvette, and dry gas ports under each of the 12 exposed cuvette windows. An opaque cover is provided to permit control of the gaseous environment above the cuvettes and to prevent light leakage into the spectrometer. A variety of optical slits are provided to limit excitation or emitted light, shown in Figure 5.

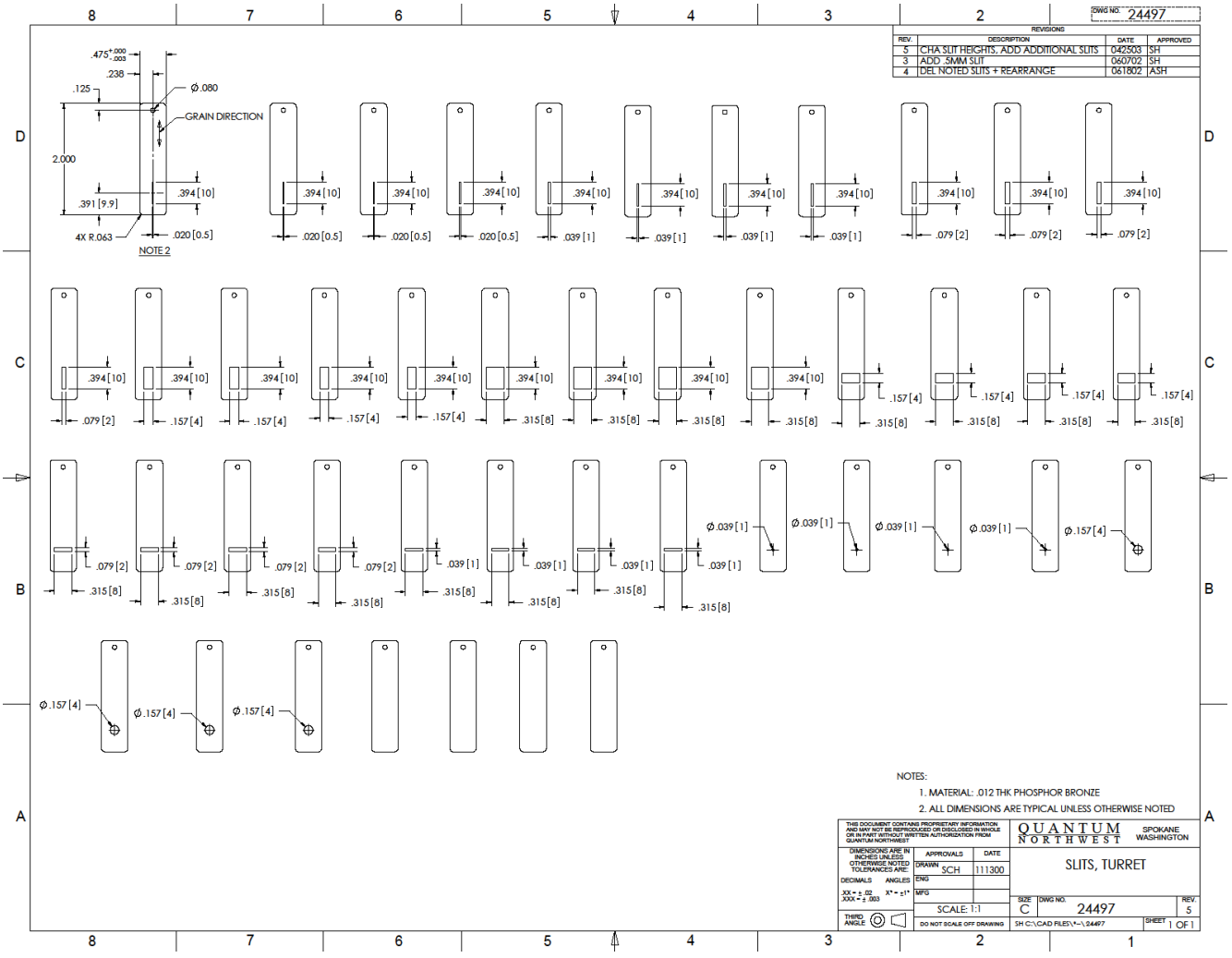

Figure 5. Optical slits provided with the **Turret 4**

Each turret is provided with the **TC 1** Temperature Controller, a microprocessor-based controller using a modified PID algorithm.

Each cuvette holder position holds a standard 10 x 10 mm cuvette with outside dimensions of 12.5 x 12.5 mm. Metal clips are used to push the cuvettes into corners for reproducible positioning and to favor temperature transfer. Walls of the towers are relieved to prevent scratching of the optical surfaces of the cuvettes. The cuvette z-height is 8.5 mm.

Note: Cuvettes must at least 40 mm tall, or they will pass below the metal clip and become stuck.

T-App is a program that permits external computer control of the **TC 1** Temperature Controller. The temperature of the cuvette holders and a temperature sensed by an external probe may be plotted vs time. Simple text scripts may be used to automate multiple operations. **T-App** may be used with a USB cable to connect your computer to the **TC 1**. Full instructions for using **T-App** may be found in the associated Help file.

4.2. Detailed Instructions

Using the Menu Button control arrows

Figure 6. The Menu Button controls (**SET**, **left arrow**, **right arrow**, **up arrow**, and **down arrow**) on the front panel of the **TC 1** controller allow full functionality without an external control program.

The Menu Button allows control of temperature, magnetic stirring and ramping for the **Turret 4** cuvette holder.

Right after the power has been turned on, temperature control will be off with the target temperature (TT) set to 20 °C. Stirring will be off, with the stirring rate set to 500 rpm (the default setting when stirring is turned on). Ramping will be off with the ramp rate set to 0.50 °C/min (the default setting when ramping is turned on).

Use the right and left arrows to cycle through five pages:

– Display – Set Temperature – Set Stirring – Set Ramping – Set Position –

Display

```
Holder =  37.0 ˚C  POS
Target =  37.0 ˚C    1
Probe  =  36.9 ˚C
Ramp On   Stir On
```

Display: This main page shows the actual cuvette *Holder* temperature, the *Target* temperature and a *Probe* temperature (if a probe is present). The page also shows whether the *Ramp* and *Stir* functions are on or off, and the identity of the cuvette *Position Number* (POS n, n=1 to 4) currently in the light pathway. After a few seconds of inactivity, all other pages will revert back to the **Display** page.

When seeking a temperature, the green LED on the front panel will flash slowly. When it has locked onto a new target temperature, the green LED will remain lit. A rapidly flashing red LED usually means a loose electrical cable or inadequate water flow for the Peltier unit.

Note: Pressing the **SET** button while the **Display** page is active results in no action. To start or stop controller functions, access the four other pages, **Set Temperature – Set Stirring – Set Ramping – Set Position.**

Set Target Temperature

```
Set Target Temp.

Target =  37.0 ˚C
Current=  23.6 ˚C Off
```

Set Target Temperature: To set the *Target* temperature, use the up and down arrows. Press **SET** to retain this new *Target* and initiate temperature control. The green LED light will begin flashing slowly as the device seeks the targeted temperature, and the page window will show the *Current* to be *On*.

Discontinue Temperature Control: Press **SET** while the green LED light is lit or slowly flashing to discontinue temperature control. The LED light will turn off completely, and the page window will show the *Current* to be *Off*.

Set Stirring

```
Set Stirring

Stir speed = 1200 rpm
Current = Off
```

Set Stirring: To turn on magnetic *Stirring*, use the up and down arrows to choose an approximate stirring speed between 1 and 2500 rpm. Press **SET** to set the speed and initiate stirring. The page will update to show the *Current* value to be the same as *Stir speed*.

Discontinue Stirring: Press **SET** while the *Stirring* is on (shown by nonzero *Current* rpm) to turn the stirrer off. The page will update to show the *Current* speed to be *Off*.

Set Ramping

```
Set Ramping

Ramp = 0.55°/min
Current = Off
```

Set Ramping: To perform a temperature ramp, set the *Ramp* rate using the up and down arrows, and press **SET**. The page will update to show the *Current* rate in °/min to be the same as the *Ramp* rate. With ramping set, turning on temperature control will generate a linear ramp to the target temperature. When the sample holder reaches the target temperature, no further temperature change occurs, although the *Current* rate will remain as set.

The fastest possible ramp is determined by how fast the cuvette holder could reach the target temperature without ramping. Attempting to ramp too quickly, especially at high and low temperature extremes, will result in a nonlinear ramp. The slowest ramp that may be set on this page is 0.01 °C/minute. (If needed, much slower ramps may be set through software commands.)

Discontinue Ramping: Press **SET** while the *Ramp* is on (shown by nonzero *Current* °/min) to turn the *Ramp* off. The page will update to show the *Current* rate to be *Off*.

Set Position

```
Set Position

Target  = 4
Current = 1
```

Set Position: To change the cuvette position, use the up and down arrows to choose the desired *Target* position and press **SET**. The controller will move the cuvette holder to the selected cuvette position, reflected by the value of *Current*.

When the cuvette holder is powered on, the device homes to a starting point before seeking the targeted cuvette position. To manually home the device, push and hold the **SET** button for three seconds. This will home the cuvette holder before moving the device to the targeted position.

Note: If the **Turret 4** is accidentally moved manually, see instructions in section 4.10.

4.3. Cooling Water for the Peltier

The Peltier element (or "thermoelectric cooler") is a heat pump. When cooling, it transfers heat from the cuvette tower to the heat exchanger; when heating, electrical polarity is reversed and it transfers heat from the heat exchanger to the tower. When cooling, it is particularly important to transfer this heat away from the Peltier unit. This is accomplished with flowing water through the heat exchanger.

A source of water (or other cooling fluid) must be connected to the $\frac{1}{8}$-inch hose barbs on the side of the **Turret 4**. The optional QNW **BATH 10** may be purchased. It includes a submersible pump, the appropriate fittings for connecting tubing, and a plastic bucket. The **BATH 10** is powered using a connector on the back of the **TC 1** controller. Use tubing to connect the **BATH 10** pump to the **Turret 4**, place the pump in the bucket with water, and run a return tube from the **Turret 4** to the bucket. A more robust pump is available as the **BATH 100**, although the larger pump has a higher wattage and tends to heat the water when used for extended periods of time. An enclosed circulation system, the **KOOL 440** is also available. Details are available on qnw.com.

Cooling water may also be provided from another source, such as a refrigerated cooling bath (or even a tap, for brief use only).

The Peltier unit requires a flow of 100 to 300 mL/min. This flow should require a pressure of about 3 - 5 psi (0.2 - 0.3 bar).

CAUTION

Caution - Do not exceed an input water pressure of 25 psi (1.7 bar), as damage may occur inside the **Turret 4**.

Note: The heat exchanger and hose barbs are brass, and the tubing inside the **Turret 4** is vinyl. Be sure that any circulating fluid used, other than water, will not corrode these materials.

The temperature of the heat exchanger in the **Turret 4** is monitored using a thermistor. If the temperature exceeds 60 °C, then temperature control is shut down to prevent damage to the Peltier element and the warning, "check coolant flow," displayed on the **TC 1** temperature controller. This will happen if the circulating fluid gets too warm and/or is restricted in flow. The heat exchanger temperature may be accessed by computer through the RS 232 or USB connections on the back of the **TC 1** Temperature Controller.

Temperature increases will be faster when room temperature water is used in the circulator. Temperature decreases will be faster when ice water is used. Only water should be circulated using the **BATH 10** or **BATH 100**. When using a refrigerated bath, circulating pre-cooled fluids (such as 30% methanol or diluted ethylene glycol) at below 0 °C will permit measurements below the specified temperature range.

4.4. Dry Gas to Minimize Condensation

Dry gas flows into the **Turret 4** via the small $\frac{1}{16}$-inch hose barb in the base of the unit. It passes up through holes below the optical ports in the cuvette tower to fill the space between the cuvette and the optical mask, preventing condensation on the surface of the cuvette.

Note: A flow of dry gas is necessary any time the **Turret 4** is controlled below the dew point temperature present on the inside of the sample compartment of the spectrometer. For ambient air, this would typically be about 5 °C.

4.5. External Temperature Probe

A $\frac{1}{4}$-inch phone jack labeled "Probe" can be found on the back panel of **TC 1** Temperature Controller. This jack will accept the plug on a standard Series 400 or Series 500 thermistor probe (Item# EW-08484-00 available from Cole Parmer). When a probe is plugged into the jack, the probe temperature is presented on the display of the **TC 1**. Place the probe in the sample to measure the actual temperature of the sample, which will lag in time from the temperature of the cuvette tower.

Excellent Series 500 probes may be obtained with diameters less than 1 mm, providing access to small sample volumes. A disadvantage of these probes is that they are not pre-calibrated.

4.6. External Computer Control

All functions may be accessed either through a Serial (RS 232) or a USB located on the back of **TC 1** Temperature Controller. You may write your own program or purchase the QNW application program **T-App**. **T-App** will plot temperatures of the probe, cuvette tower, and even the Peltier element heat exchanger *vs* time. It will also permit you to set up temperature ramps. If you wish to do your own programming, please see the Appendix for communication instructions and the set of text commands that may be used and responses to the commands.

4.7. Working at Extended Temperatures

Not applicable for this product.

4.8. Troubleshooting

If the submersible pump has operated without being immersed in water, it may not prime properly. If this occurs, place one drop of detergent on the pump intake and try again.

If the **TC 1** display indicates that there is inadequate coolant (see section 4.9), it may be that the circulating water is too warm. Add ice to the water to cool it down.

If a microcuvette is used requiring a z-height of other than 15 mm, spectroscopic measurements may be erratic and erroneous, and the cuvette may be difficult to remove. Use a taller cuvette instead.

4.9. Error Messages

When errors occur, the line 1 of the **TC 1** Temperature Controller display presents an error code. Line 3 of the display identifies the error and line 4 of the display presents possible solutions. The most common events

that cause errors to be displayed are loose cables or inadequate coolant flow. For errors not easily solved, contact QNW at www.qnw.com/contact-us/ or service@qnw.com.

Specific error messages include the following.

5 – cell out of range

warnings: loose cable, sensor failure

The temperature controller is not receiving a reasonable response from the sensor on the cuvette tower. Either the sensor has failed or a cable is not making a good connection.

6 – cell out of range

warnings: loose cable, check cable

The temperature controller is not receiving reasonable responses from either the cell tower or heat exchanger sensors. Since it is very unlikely for both to fail, probably a cable is loose.

7 – heat exchanger error

warnings: loose cable, sensor failure

The temperature controller is not receiving a reasonable response from the sensor on the heat exchanger. Either the sensor has failed or a cable is not making a good connection.

8 – inadequate coolant

warnings: inadequate coolant, water temperature

The sensor on the heat exchanger is reading a temperature above 60 °C. Temperature control has been shut down to prevent damage to the Peltier element. Either the water was too warm or the rate of flow was inadequate to draw sufficient heat from the heat exchanger.

9 – Invalid command

The controller has been sent an invalid text command.

4.10. Manual Resetting of the Turret 4

Do not rotate the **Turret 4** by hand. When the turret is rotated by hand, it can be left in a position that makes it unable to locate the sensor needed for its homing mechanism. If this occurs, then the **Turret 4** may make a grinding noise and be unable to properly reset its position. Should the **Turret 4** be manually rotated accidentally, power off the **TC 1** Controller. Then, rotate the **Turret 4** so that **cuvette position 1** is squarely in place within the light beam pathway of the spectrometer. Turn the power back on the **TC 1** Controller. The **Turret 4** will home to a starting position, then move to the cuvette position specified by the controller.

5. Maintenance and Spare Parts

5.1. Maintenance

The **Turret 4** and **TC 1** Temperature Controller require very little routine maintenance on the part of the user. For routine cleaning of exposed surfaces, use only a cloth dampened with water or diluted detergent. Do not use organic or abrasive solvents.

CAUTION

Caution – Any action which makes it necessary to open the **Turret 4** or **TC 1** Temperature Controller units must be executed only by QNW technicians or authorized personnel.

The water hoses and their attachments to the **Turret 4**, **TC 1** Temperature Controller, and submersible pump should be inspected prior to each usage to ensure that they are intact. Replace the nylon tubing when it becomes discolored or cracked. Periodically replace the water stored in the bucket to minimize the growth of microorganisms. When not in use, the pump, bucket, and tubing may be stored dry.

5.2. Spare Parts

Vinyl tubing and magnetic stir bars may be obtained from a variety of commercial vendors. For electrical cables to be used with **Turret 4** and **TC 1** Temperature Controller and submersible pumps, please contact QNW at service@qnw.com.

Appendix – Serial Communications for the TC 1 Temperature Controller

2/25/2016

This document provides the serial communications protocols for version 2.2 of the firmware on the **TC 1** family of controllers used for the **Turret 4**:

TC 1 / t2 Sport (and other sample holders) – for the t2 Sport, single temperature controller;

TC 1 / t2x2 Sport – for the t2x2 Sport, dual temperature controller for sample and reference;

TC 1 / multi-sample – for turret or multi position linear, single temperature controller.

The version number and the ID (see below) are shown briefly on the display when the temperature controller is turned on. This initial display can be repeated by pressing the down arrow on the front panel of the controller.

All functions of the temperature controller can be managed from a computer, using the command set described below. If you purchased your unit as a component of a spectrometer from certain manufacturers, this feature may be implemented through traditional RS232 serial connectors on the computer or the spectrometer and on the controller. In this case they will be connected by a standard 15-pin serial extension cable (male connector on one end and female on the other). No driver installation should be needed. Otherwise the serial linkage will be established through a USB connection between the computer and the controller. In this case the controller includes electronics which convert the USB connection to a serial communications port. However, for the port to be available to programs on the computer it will be necessary to load driver software. It is important that the driver software be loaded before connecting a USB cable between the controller and the computer. Contact Quantum Northwest for further information.
Quantum Northwest can provide a control program written specifically for control of all functions of the temperature controller and to track temperature as a function of time. The resulting data can be saved to a text file (two columns, time and temperature, tab delimited) or copied and pasted directly into another program (such as Microsoft Excel). Ask for program T-App. If you expect to create software or firmware that communicates with a TC 1 controller, T-App may prove extremely useful for preliminary testing of controller commands.
In programming for the **TC 1** controller, one must adhere to the conventional notation: 8/N/1.

Baud:	19200
Data Bits:	8
Parity:	None
Stop Bit:	1
Flow Control:	None

For many of the commands listed below the controller returns information in response to the command. All commands and responses are delineated by left and right square brackets ([ ]). Any text sent to the controller not enclosed within brackets will be ignored. In this document an ellipsis (……) is used to distinguish responses from commands.

`[command]`	Purpose of the command (sent to the controller).
`...[response]`	Meaning of the response (received from the controller).

1. Sample Holder ID Number

[F1 ID ?]	What is the ID number of the sample holder being controlled?
...[F1 ID 14]	ID is 14.

Assigned Identities:

ID = 00 – **specialty sample holder** (see command class 14)
14 - **t2**
24 - **t2x2**
34 – turret or linear multi-sample holder

2. Controller Firmware Version

[F1 VN ?]	What is the **V**ersion **N**umber of the controller firmware?
...[F1 VN 2.20]	The controller firmware version number is 2.20.

3. Stirrer

[F1 MS ?]	What is the **M**aximum stirrer **S**peed?
...[F1 MS 2500]	The maximum stirrer speed permitted is 2500 rpm.
[F1 LS ?]	What is the **L**owest stirrer **S**peed?
...[F1 MS 300]	The lowest stirrer speed permitted is 300 rpm.
[F1 SS S 1000]	Set **S**tirrer **S**peed to 1000 rpm and turn stirring on.
[F1 SS S 0]	Turn stirrer off (does not change the speed setting).
[F1 SS +]	Turn stirrer on and set it to the most recent non-zero stirrer speed setting.
[F1 SS -]	Turn stirrer off (this does not change the speed setting)..
[F1 SS ?]	What is the current stirrer speed setting? Depending on the R+/R- state as specified below, the stirrer status ('+'/on or '-'/off) may also be reported.
...[F1 SS 1000]	Stirrer speed setting is 1000 rpm.
...[F1 SS -]	Stirrer status is off.
[F1 SS R-]	Turn off automatic **R**eporting of the stirrer speed and status when changed by a command.
[F1 SS R+]	Turn on automatic reporting of stirrer changes.
	The power on default setting is to not report the speed or the status when changed.
	If you then send [F1 SS R+], only the stirring speed will be reported when changed.
	If you then send [F1 SS R+], both the speed and the status will be reported when changed.
	If you then send [F1 SS R-], neither the speed nor the status will be reported when changed (back to the power on default setting).

Note that the [F1 SS ?] will always result in a stirring speed response. The status response will also be sent if it has been enabled as described above.

4. Temperature Control

[F1 TC +]	Turn **T**emperature **C**ontrol on.
[F1 TC -]	Turn temperature control off.
[F1 TC ?]	What is the current status of temperature control?
...[F1 TC -]	Temperature control status is '-'/off.
[F1 TC R+]	**R**eport temperature control status when changed by a command.
[F1 TC R-]	Do not report temperature control status when changed

5. Target Temperature

[F1 MT ?]	What is the **M**aximum **T**arget temperature setting allowed for this holder?
...[F1 MT 105]	The maximum target temperature allowed is 105 ºC.
[F1 LT ?]	What is the **L**owest **T**arget temperature setting allowed for this holder?
...[F1 LT -30]	The lowest target temperature allowed is -30 ºC
[F1 TT S 23.10]	Set the **T**arget **T**emperature to 23.10 ºC.
	Note: The TC 1 does not turn temperature control on when TT is received (as it does when the front panel controls are used to set the TT).
[F1 TT ?]	What is the current target temperature?
...[F1 TT 71.32]	Target temperature is 71.32 ºC.
[F1 TT +] or [F1 TT R+]	Turn on automatic reporting of the target temperature when changed by a command.
[F1 TT -] or [F1 TT R-]	Turn off automatic reporting of target temperature changes.

6. Instrument Status

[F1 IS ?]	What is the current **I**nstrument **S**tatus?
...[F1 IS 0-+S]	Response is four parameters (or five, see below): number of unreported errors is 0 (0 or 1); stirrer is off (+ is on, - is off); temperature control is on (+ is on, - is off); current sample holder temperature is stable (S is stable, C is changing).
[F1 IS +] or [F1 IS R+]	Automatically report instrument status whenever it changes (e.g., when the sample holder temperature goes from changing to stable).
[F1 IS -]	

or [F1 IS R-]	Stop automatic reports of instrument status when it changes (the power-on default).
[F1 IS E+]	Inlude the ramp status as a fifth parameter in the instrument status response.
...[F1 IS 0-+SW]	The ramp status will be one of three states represented by the characters '-' (minus), '+' (plus) or 'W'. See command class 10 for details.
[F1 IS E-]	Stop including the ramp status in the instrument status response (power-on default).

7. Current Sample Holder Temperature

[F1 CT ?]	What is the **C**urrent **T**emperature of the sample holder?
...[F1 CT 22.84]	The current temperature is 22.84 ºC.
[F1 CT +3]	Periodically report current temperature every 3 seconds.
[F1 CT -]	Stop periodic current temperature reports.
[F1 CT +]	Restart periodic probe temperature reports using the current interval (the power-on default is 3 second interval).
[F1 CT R+]	**R**eport status of the sample holder temperature when it changes.
...[F1 CT C]	The status of CT is changing.
...[F1 CT S]	The status of CT is stable (CT has stayed within +/-0.05 °C of the target temperature for at least 1 minute.
[F1 CT R-]	Stop reporting changes in the status of CT (power-on default).

8. Error Reporting

[F1 ER ?]	Report the current error (**ER**ror).
...[F1 ER -1]	No current error.
...[F1 ER 05]	Cell T out of range (Loose cable? Sensor failure?).
...[F1 ER 06]	Cell & heat exchanger T out of range (Loose cable?).
...[F1 ER 07]	Heat exchanger T out of range (Loose cable? Sensor failure?).
...[F1 ER 08]	Inadequate coolant (check flow). Temperature control has shut down.
...[F1 ER 09<<bad command>>]	Syntax error on a preceding command where "bad command" is the text of the command that caused the syntax error response.
[F1 ER +]	Automatically report errors when they occur.
[F1 ER -]	Stop automatic error reports (this setting have no effect on ER 9 responses).

9. Probe Status and Temperature

[F1 PS ?]	What is the **S**tatus of the TC 1 external **P**robe connector?
...[F1 PR +]	A series 400 thermistor probe is connected.

...[F1 PR -]	No probe is connected.
[F1 PS +] or [F1 PS R+]	Enable probe status to be **R**eported automatically when a probe is installed or removed.
[F1 PS -] or [F1 PS R-]	Disable automatic sending of probe status (power-on default).
[F1 PT ?]	What is the current **P**robe **T**emperature?
[F1 PT +3]	Periodically report the probe temperature every 3 seconds (integers only, the '+' is required).
...[F1 PT 22.37]	The current probe temperature is 22.37 °C.
...[F1 PT NA]	Probe temperature is not available.
[F1 PT -]	Stop periodic probe temperature reports. The interval is retained.
[F1 PT +]	Restart periodic probe temperature reports using the current interval (the power-on default is 3 seconds).
[F1 PA S 0.5]	Set the temperature interval for ***A***utomatic reporting of the **P**robe temperature to 0.5 °C during a ramp. (Increment must be positive, without sign in tenths between 0.1 and 9.9 °C, and will work for ramps going up or down.) Note: this command does not start automatic reporting, it just sets the interval to be used when it is turned on.
[F1 PA ?]	What is the current temperature interval for automatic reporting?
[F1 PA +]	Start automatic reporting of probe temperature at temperature intervals (set by the command above).
[F1 PA -]	Stop automatic reporting of probe temperature every temperature increment.
[F1 PX +]	Change probe temperature returned to a precision of 0.01 °C.
[F1 PX -]	Change probe temperature returned to a precision of 0.1 °C.

Note: Since probe temperatures are always reported to 0.01 °C by the TC 1 controller, these commands have no effect. They are included to maintain compatibility with customer software / firmware based on the older TC 125, TC 225 and TC 425 temperature controllers (i.e., they will not cause an [F1 ER 9 <<….>>] report – see command class 8).

Note: Except for [F1 PS ?] and [F1 PS R(+/-)], any probe related command issued when a probe is not connected to the TC 1 will result in the warning response [F1 NOPROBE].

10. Temperature Ramping

[F1 RR S 0.50]	Sets the ramp rate to 0.50 °C/minute. This command also sets the ramp status to 'W'/ waiting mode (see below). With the exception of 0 the ramp rate must be in the range 0.01 to 10; otherwise an ER9 reply will be returned by the controller, the ramp rate will be set to the nearest allowed value, and the controller will send a second response specifying the ramp rate that was set.

[F1 RR S 0]	
or [F1 RR -]	Sets ramp status to '-'/off (but does not change the current ramp rate setting). If either command is sent during a temperature ramp, the controller will then drive at maximum to the last set target temperature.
[F1 RR +]	Set ramp status to 'W'/ waiting mode. In waiting mode the TC 1 is waiting for a new target temperature to be set (see command class 5). When the TT command is received, if temperature control is on (see command class 4) the controller begins ramping the temperature from the current value to the new TT at the previously specified ramp rate. If temperature control was off when the TT command is received, the ramping process does not begin until it is turned on. In either case the ramping state is '+'/on until the ramp is completed or cancelled.
	If this command is sent while a ramp is in progress, the ramp status will change to 'W'/ waiting and the controller will drive at maximum to the last target temperature set.
[F1 RR ?]	What is the current ramp rate setting? Depending on the R+/R- state as specified below, the ramp status ('W'/waiting, '+'/on or '-'/off) may also be reported.
...[F1 RR 1.00]	Current ramp rate is 1.00 °C/minute.
...[F1 RR W]	Ramp status is waiting.
[F1 RR R-]	Turn off automatic reporting of the rate and ramp status when changed by command or by use of the front panel.
[F1 RR R+]	Turn on automatic reporting of ramp changes. Automatic reports will be sent by the controller when the ramp rate or status is changed by command.

The power on default setting is to not report the ramp rate or the ramp state when changed.
If you then send [F1 RR R+], only the ramp rate will be reported when changed.
If you then send [F1 RR R+], both the rate and the state will be reported when changed.
If you then send [F1 RR R−], neither the rate nor the state will be reported when changed (back to the power on default setting).
Note that the [F1 RR ?] will always result in a ramp rate response. The ramp status response will also be sent if it has been enabled as described above.

The following seven commands, are accepted by and work with the TC 1. They are provided mainly to maintain compatibility with control software/firmw developed for use with the older TC 125/225/425 family of temperature controllers.

There are no corresponding reference commands (see command class 13) for the TL commands.

[F1 TL +]	Ramp the sample and reference identically.
[F1 TL -] or.	
[F1 TL 0]	Ramp the sample and reference independently (the power on default).

[F1 RS S #], [F1 RS ?]	Set or query the RS parameter (# is a positive integer).
[F1 RS S #], [F1 RS ?]	Set or query the RT parameter (# is a positive integer).

RS and RT provide an alternate method of setting the ramp rate.

If the last set command for RS or RT results in both set to positive values (even if the actual setting is not changed by the command), they are used to calculate RR for actual use by the firmware and the ramp status is set to 'W'/waiting.

If ramp status is 'W'/waiting or '+'/ramping, setting both RS and RT to 0 will change the status to '-'/off (but will not change the ramp rate setting).

To Ramp the temperature:

1. equilibrate at the starting temperature;
2. set the ramp rate;
3. set a new target temperature (command class 5).

The target temperature may be above or below the current temperature; as soon as it is set, the ramp will begin, up or down, to that new target.

After reaching the target, the controller will hold at that temperature. At any time a new ramp rate and target temperature can be set to start a new ramp.

Once the ramp is completed, if you want to start another ramp (even using the same ramp rate) you must send ramp rate set command. Otherwise, setting a new target temperature later will initiate a ramp to that target temperature.

Notes:

1 The minimum settable ramp rate (using the [F1 RR S #] command) is 0.01 °C/minute. The maximum is 10 °C/min.

2 For higher ramp settings, the observed rate may be lower than that specified or it may be nonlinear over part of the temperature range because the maximum possible rate of heating or cooling is limited (and dependent on the ramp direction as well as on the temperature).

3 For compatibility with the TC 125/225/425 family of controllers, when the ramping process is completed the controller will send an [F1 TT #] response, where # will be the target temperature used to start the ramp. Depending on automatic reply settings, an [F1 RR -] and/or [F1 IS 0++C-] response may also be sent by the TC 1.

4 When the ramp status is '+'/On, sending a [F1 TT S #] command or a [F1 TC -] command will change the ramp status to '-'/Off.

11. Heat Exchanger Temperature

[F1 HT ?]	What is the current temperature of the heat exchanger?
[F1 HT +3]	Start periodic heat exchanger temperature reports every 3 seconds.
...[F1 HT 39]	The current heat exchanger temperature is 39 ºC.
[F1 HT -]	Stop periodic heat exchanger temperature reports.
[F1 HL ?]	What is the high temperature limit for the heat exchanger?
...[F1 HL 60]	The heat exchanger high temperature limit is 60 ºC.
	In operation with temperature control on, if the HT parameter exceeds HL, the TC 1 will turn temperature control off. It will also send [F1 ER 9], [F1 TC -] and/or [F1 IS …] (with parameter 3 = '-'/minus) depending on the current auto-reply settings (see below).

12. Reference Cuvette

These commands will have an effect only for systems with two independently-controlled sample holders.

[R1 ...]

To control and monitor the temperature and status of the reference cuvette using a Dual Temperature Controller, use any commands in classes 3-8, 10 and 11, substituting R1 for F1. There are no corresponding [R1 …] commands for command classes 1, 2, 9 and 12.

13. Program Control of User Access to the Front Panel and of Automatic Reports of Front Panel (FP) changes

The TC 1 can be controlled manually using the buttons and the display on the front. Once a control program has connected to the TC 1, the controller will automatically send reports to the program whenever a manual change has been made. The commands in this section allow the program to control access to front panel settings and determine if and how such front panel changes are reported.

[F1 LO (+/-)] **L**ock**O**ut (+) or do not lockout (-) the front panel. When lockout is on (+) the front panel will display "LOK" or "LLK" in the upper right corner of the display. The user will be able to use the left-arrow and right-arrow button to move between the settings displays (as if no control program was connected) but the up-arrow, down-arrow and SET buttons will not allow changes in the settings. The up-arrow and down-arrow buttons will work to move between the main "SAM", "REF" and version/ID displays.

[F1 LO ?] Query the current lockout state.
...[F1 LO +] or ...[F1 LO -]

[F1 LK (+/-)] **L**in**K** (+) or unlink (-) the reference to/from the sample. This command is only available for a dual sample holder system. When link is on (+) the front panel will display "LNK" or "LKK" in the upper right corner of the display. The user will be unable to change any of the REF settings (they will be locked as described above). When the user changes a "SAM" setting using the front panel controls (such as temperature control On/Off, stirrer speed, ramp rate) the identical change will automatically be made for "REF'.

[F1 LK ?] Query the current link state.
...[F1 LK +] or ...[F1 LK -]

T-App uses this command to turn linking off in the temperature controller and handles linking of the reference settings to the sample settings in the program (see link reference to sample).

"LKK" in the upper right corner of the display indicates that both lockout and link have been turned on by the control program. Note: Do not attempt to run a control program with the temperature controller in linked mode; that capability is not available at the current time. Only use the [F1 LK -] command to make sure the controller is not in linked mode.

[F1 FP (+/-)] Report (+) or do not report (-) changes made by use of the **F**ront **P**anel controls on the TC 1. The poweron default is to report FP changes.
Setting changes are reported by [F1 TT #], [F1 SS #] and [F1 RR #] replies.
The poweron default for status changes is to report by [F1 TC (+/)], [F1 SS (+/)] or [F1 RR (+/)] replies, even if the control program has not turned these status

change replies. The control program cannot turn these responses off (except as described below).

If the control program has sent [F1 IS +] or [F1 IS R+] commands to turn automatic instrument status reports on, status changes resulting from use of the front panel controls will be reported only by the instrument status reply, [F1 IS ….].

There is no query command for the FP state.

14. Cell Changing

The commands in this class will have no effect unless the sample holder has multiple positions. This includes all TC 425 controllers (4 positions with buttons on the controller that can be used to change the position manually) and some TC 125 controllers (more than 4 positions and no buttons, so software must be used to control the position setting).

[F2 DI]	Device initialize: move to home position.
[F2 PI]	Device initialize: move to home position and reply when done.
.....[F2 OK]	Device is finished moving.
[F2 DL 3]	Device locate: move to position 3. (Device must be initialized prior to using this command.)
[F2 PL 6]	Device locate: move to position 6 and reply when done.
.....[F2 DL 6]	Device is now in position 6.
[F2 ?]	Report status of device.
.....[F2 OK]	Device is ready to accept commands.
.....[F2 BUSY]	Device is busy running commands.
[F2 PL ?]	What is the device location (position)?
.....[F2 DL 2]	Device is in position 2. (If reply is 0, device is not initialized.)
[F2 DD 2]	Set speed to 2 (acceptable range 2-250 with 2 being fast, 250 being slow).
[F2 DD ?]	What is the current device speed?
.....[F2 DD 2]	Device is set to speed setting 2. If reply is 0, then the firmware default value (which depends on the sample holder) is being used.