Instruction
Manual

TURRET 400™
Four-Position Cuvette Holder

QUANTUM
N · O · R · T · H · W · E · S · T

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TURRET 400^{TM} Four-Position Cuvette Holder

Manual Version 07-13-11

The TURRET 400 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 -30 to +105 ºC. The TURRET 400 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. Each turret is provided with the TC 425 Temperature Controller, a microprocessor-based controller using a modified PID algorithm.

SYSTEM SETUP

1. Mount the TURRET 400 in your fluorometer. A typical configuration is shown in Figure 1 on page 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. (We will be pleased to assist you in making the necessary connections for mounting the TURRET 400 in your spectrometer. Please contact us.)

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.

If you purchased the optional BATH 100, simply attach one tube to the brass fitting on the top of the submersible pump let the other tube hang back in the bucket. Put water in the bucket to cover the pump and add ice if low temperatures are to be achieved.

> **Do not exceed an input water pressure of 25 psi (1.7 bar)**, as damage may occur inside the TURRET 400.
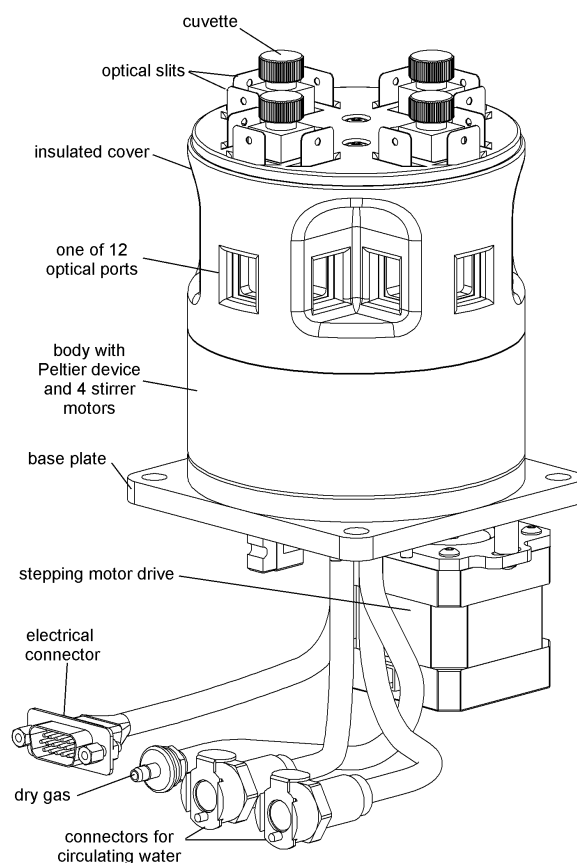

Figure 1.

3. Set and maintain a cooling water flow rate of about 200 - 300 ml per minute. This flow should

require a pressure of approximately 3 - 5 psi (0.2 - 0.3 bar). If a circulating bath is used as the water source, it may not be possible to maintain this flow rate. However, a slower rate will likely be adequate for low temperature work, if pre-cooled circulating water is used.

Cooling water flows through a heat exchanger and removes heat from the thermoelectric device when the temperature of the holder is being lowered. Insufficient flow will allow the heat exchanger temperature to rise. If the temperature of the heat exchanger exceeds a certain cutoff value, temperature control will be automatically shut down to protect the holder.

Cooler circulating water can result in improved performance of the cuvette holder at low temperatures, whereas warmer water can improve performance at very high temperatures. ***Do not use warm or room temperature water when setting temperatures near room temperature, as temperature instabilities are likely to arise.***

4. If needed, connect a source of dry gas to the hose barb labeled "gas." A flow of gas must be used to prevent condensation on the faces of the cuvette when working below the dew point temperature. Set the dry gas flow rate to 200 - 400 cc/min.

5. Connect the Temperature Controller to a power source and to the TURRET 400 using the electrical cords provided.

SYSTEM OPERATION

1. Turn on the power to the TURRET 400 system using the switch located on the left side of the rear panel of the temperature control unit. When the TC 425 is turned on, the display briefly indicates the software version number running in the microcontroller and an ID number that identifies the kind of sample holder that is being controlled (see further information in Appendix 1).

2. Use liquid samples of at least 1.5 ml and place them in standard 1 x 1-cm square fluorescence cuvettes. Standard microcuvettes may also be used. Unless otherwise specified, the TURRET 400 is designed to hold microcuvettes in which the "z" dimension (distance between the bottom of the cuvette and the optical center line) is 8.5 mm.

Note: The TURRET 400 is intended to hold cuvettes with a standard wall thickness of 1.25 mm and total width of 12.5 mm. Cuvettes with unusually thick walls will not properly fit and may damage the holder. Also, unusually short cuvettes will be difficult to remove after being pushed all of the way to the bottom of the holder.

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3. Place the cuvettes and samples in the sample holder.

4. Use the provided optical slits around the cuvettes in a manner that correctly limits the excitation and emission light.

5. If needed, place the supplied magnetic stir bars in the cuvettes and turn the magnetic stirrer knob located on the front of the temperature control until the desired speed is reached. Stirrers in all four positions will run at approximately the same speed.

6. To monitor the temperature inside one of the cuvettes, simply plug a standard Series 400 or Series 500 thermistor probe into the ¼ - inch phone plug jack located in the back of the temperature controller. Put the sensor in the cuvette in a position out of the way of the beam and the magnetic stir bar. The controller will sense the presence of the probe and display the measured temperature. This thermometer function is calibrated against a Series 400 probe and the result will have the same specifications typical of these standard probes. If the accurate temperature is needed, then the probe should be calibrated for use in your experiment. These standard probes are manufactured by Yellow Springs Instrument

Company or Digisense, and are readily available through common laboratory suppliers.

7. If needed, place the black plastic cover over the cuvette holder.

8. Set the target temperature using the up/down buttons located to the right of the display window. The normal temperature range is about -10 °C to +105 °C. Lower temperatures generally require additional insulation. Lower temperatures also require pre-cooled circulating fluid with a temperature within 25 °C or so of the target temperature to draw heat from the Peltier device. The temperature controller can control temperatures down as low as -55 °C, although about -30 °C is the limit under practical circumstances. Contact us if you would like suggestions on how to control very low temperatures.

If there is no external probe plugged into the rear of the unit, the TC 425 displays the *holder* temperature, the precise temperature measured in the metal body of the cuvette holder, and the *target* temperature, the temperature that the controller is attempting to achieve. The *holder* temperature sensor is located in the cuvette holder body at cuvette window height in between two of the cuvettes. If a probe is being used, then the controller displays instead the *holder* temperature and the *probe* temperature. To see the *target* temperature, briefly touch either the up or down arrow button.

9. When the sample holder approaches the target temperature, the red light located on the upper left corner of the front panel of the temperature controller, will flash slowly.

10. When the sample holder reaches and holds within ± 0.02 °C of the target temperature, the red light will remain constant.

11. After measurements are completed, depress the run/stop button to stop temperature control, and turn off power and water sources.

ROTATION

Use the numbered position buttons on the front of the controller to bring each of the four cuvettes into position.

1. When the controller is first turned on, no position indicators are illuminated. Depress button 1,2,3 or 4 and the TURRET 400 will first find its home location and then place the designated cuvette into the optical beam.

2. To change from one position to another, simply depress a position button and the unit will rotate there and stop.

3. To home the TURRET 400 before going to a particular position depress the desired position button for approximately 3 seconds. Homing is useful if the power fails, or if the position of the turret has been inadvertently disturbed.

4. The rotation speed has been preset but can be changed to a new desired setting via the Serial Control Program. Please contact us if you desire to make a change in the speed and we can assist you.

ERROR CONDITIONS

Rapid flashing of the red light indicates an error condition. The common errors that will display are:

Error conditions E5, E6 and E7 – Check Cables. One or more of these error conditions is likely to arise if the electrical connection between the Temperature Controller and the TURRET 400 is not secure. In this case, turn off the power to the unit, check the cable, turn on the power, and resume work.

Error condition E8 – Low water flow. This error condition indicates that the heat exchanger on the thermoelectric cooler is getting too warm. This heating will occur if insufficient cooling water is flowing into the device. Error condition E8 will automatically shut down temperature control to

prevent damage to the unit. If this occurs, improve cooling water flow and re-start temperature control.

If correcting these problems does not solve the error messaging, or if other errors are displayed, contact Quantum Northwest by calling (509) 624-9290 or by e-mailing us at quantum@qnw.com.

TEMPERATURE SPECIFICATIONS

Maximum Temperature. The TURRET 400 system is limited to temperatures below 105 °C. A higher target temperature cannot be set since such temperatures may damage internal components. This maximum can be attained with coolant at 15 °C or above.

Minimum Temperature. While the TURRET 400 system is capable of operation as low as -40 °C, the minimum useful temperature depends on the conditions under which it is used.

1. Without special conditions, using room temperature coolant, the minimum is the dew point temperature of the air at the location of use (roughly 5 °C). Below the dew point temperature, condensation on the cuvette windows will interfere with measurements.

2. With a dry gas flow rate of at about 200 cc/min into the gas inlet of the sample holder, the minimum temperature is about -10 °C. Below -10 °C there is a risk of frosting of the cuvette surfaces.

3. When mounted in an enclosure purged with dry gas and using ice water as coolant, the minimum temperature is about -25 °C. An example of such an enclosure is the sample chamber of some spectrophotometers.

Probe Temperature Range. The TC 125, TC 225 and TC 425 temperature controllers accept standard 400 and 500 Series thermistor probes. These probes may be obtained from supply companies such as Cole Parmer (coleparmer.com). Standard 400 Series temperature probes will measure the temperature within ±0.2 °C over the range of 0.0 to 70.0 °C. The probe will operate over the full range of -40 °C to +105 °C, but an individual probe will need to be calibrated by the user outside of the 0.0 to 70.0 °C range. The 500 Series probes are less standardized and may require calibration by the user. 500 Series probes may be convenient, because they are available in very small diameters.

OTHER SPECIFICATIONS

Optical access. The TURRET 400 holds up to four standard 1 cm square cuvettes and precisely maintains their temperature. Access is provided on 3 sides of each cuvette through optical ports 10 mm wide by 10 mm high. A set of 48 Optical slits (see Figure 3) is provided with a variety of rectangular and circular openings. A hole drilled behind each cuvette acts as a light trap.

Variable speed magnetic stirring is provided for experiments in which it is important to rapidly remove photoproducts from the illuminated volume. A stir bar is included.

A dry gas purge is provided. The gas travels through the base of the cuvette holder for temperature equilibration and then blows onto each of the four faces of the cuvette. The gas purge minimizes condensation on the cuvette surfaces. A clear cap with access hole covers the top of the cuvette to provide isolation from the ambient environment

An optional serial interface is available for remote computer control (see page 5 of this manual).

Figure 3. Optical slits provided with the TURRET 400
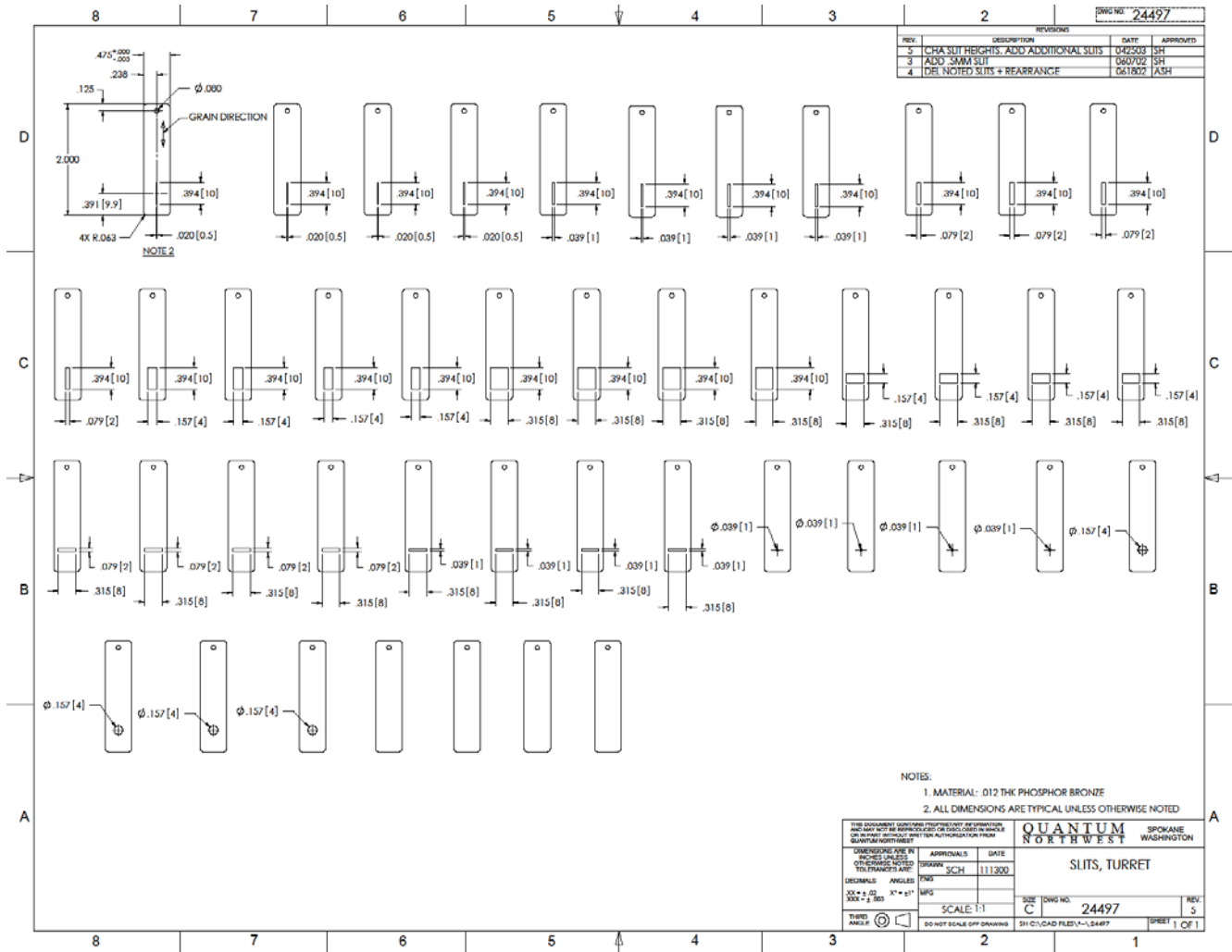
Appendix- Serial Communications for Quantum Northwest Temperature Controllers

07-13-11

This document provides the serial communications protocols for version 9.1 of the firmware on temperature controllers TC 125, TC 225 and TC 425.

The version number and the ID (see below) are shown briefly on the display when the temperature controller is turned on.

With the exception of setting the rate of stirring, 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 and 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 controllers. Ask for program T-App.

To communicate with the 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 ([ ]). In this document an ellipsis (......) is used to distinguish responses from commands. Any text sent to the controller not enclosed within brackets will be ignored.

`[command]`	purpose of the command (sent to the controller)
`......[reply]`	meaning of the reply (received from the controller)

1. Identify

`[F1 ID ?]`	What is the ID number of the sample holder being controlled?
`......[F1 ID 31]`	Sample holder is a four-position turret with probe capability.

> Assigned Identities:
>
> ID = 10 - single cuvette holder
>   11 - single cuvette holder with probe capability
>   12 - high temperature single cuvette holder
>   20 - dual cuvette holder
>   21 - dual cuvette holder with probe capability
>   22 - dual-controlled titrator
>   30 - 4-position turret
>   31 - 4-position turret with probe capability
>   32 - 6-position turret (or linear cell) changer

```
Identity Classes:
            (10 – 13) - single sample holder using a TC 125 controller
            (20 – 22) - two sample holders using a TC 225 controller
            (30 – 31) - multiple cuvette holder using a TC 425 controller
             (32)     - multiple cuvette holder using a TC 125 controller,
```

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2. **Controller Firmware Version**

`[F1 VN ?]`   What is the version number of the controller firmware?

`......[F1 VN 9.1]`   The controller is operating firmware version number 9.1.

---

3. **Stirrer**

`[F1 SS +]`   Turn stirrer on. (Stir rate must be set manually.)

`[F1 SS -]`   Turn stirrer off.

---

4. **Temperature Control**

`[F1 TC +]`   Turn temperature control on.

`[F1 TC -]`   Turn temperature control off.

---

5. **Target Temperature**

`[F1 TT S 23.10]`   Set target temperature to 23.10 ºC.

`[F1 TT ?]`   What is the current target temperature?

`......[F1 TT 71.32]` Target temperature is 71.32 ºC.

`[F1 TT +]`   Turn on automatic reporting of manual changes to the target temperature

`[F1 TT -]`   Turn off automatic reporting of manual changes to the target temperature

`[F1 MT ?]`   What is the maximum target temperature allowed

`......[F1 MT 110]`   The maximum target temperature allowed is 110 ºC

`[F1 LT ?]`   What is the lowest target temperature allowed

`......[F1 LT -30]`   The lowest target temperature allowed is -30 ºC

---

6. **Instrument Status**

`[F1 IS ?]`   What is the current instrument status?

`......[F1 IS 0-+S]`   Response is four parameters:
                       number of unreported errors is 0 (0 to 9)
                       stirrer is off (+ is on, - is off)
                       temperature control is on (+ is on, - is off)
                       temperature is stable (S is stable, C is changing)

`[F1 IS +]`   Automatically report instrument status whenever it changes
                       (e.g., due to manual changes at controller)

`[F1 IS -]`   Stop periodic or automatic reports of instrument status.

`......[F1 IS R]`   The controller has been powered off and back on again.

---

7. **Heat Exchanger Temperature**

`[F1 HL ?]`   What is the high temperature limit for the heat exchanger

```
......[F1 CT 60]        The heat exchanger high temperature limit is 60 ºC
[F1 HT ?]                What is the current temperature of the heat exchanger?
......[F1 CT 39]        The current heat exchanger temperature is 39 ºC.
[F1 HT +3]              Automatically report heat exchanger temperature every 3 seconds
[H1 CT -]              Stop periodic heat exchanger temperature reports.
```

8. <u>Current Temperature</u>

```
[F1 CT ?]              What is the current temperature of the holder?
......[F1 CT 22.84]    The current temperature is 22.84 ºC.
[F1 CT +3]             Automatically report current temperature every 3 seconds.
[F1 CT -]              Stop periodic current temperature reports.
```

9. <u>Probe Status</u>

```
[F1 PS ?]              Is there an external temperature probe connected?
......[F1 PR +]        A probe is connected.
......[F1 PR -]        No probe is connected.
[F1 PS +]             Enable probe status to be sent automatically when a probe is
                        installed or removed.  This is the default.
[F1 PS -]             Disable automatic sending of probe status.
[F1 PT ?]             What is the current probe temperature?
[F1 PT +3]            Automatically report the probe temperature every 3 seconds.
......[F1 PT 22.3]    The current probe temperature is 22.3 degrees.
......[F1 PT NA]      Probe temperature is not available.
[F1 PT -]            Stop automatic probe temperature report.
[F1 PA S 0.5]        Set the increment for automatic reporting of the probe temperature
                       to 0.5  degrees during a ramp. (Increment must be positive)
                       without sign in tenths between 0.1 and 9.9 degrees and will
                       work for ramps going up or down.)
[F1 PA +]            Start automatic reporting of probe temperature every temperature
                       increment.
......[F1 PT 30.5]   The current probe temperature is 30.5 degrees.
[F1 PA -]           Stop automatic reporting of probe temperature every temperature
                       increment.
[F1 PX +]           Change probe temperature returned to a precision of 0.01 degree.
```

10. <u>Error Reporting</u>

```
[F1 ER ?]            Report the current error.  For a more complete description, see
                       "Error Codes" in the help system of the Serial Control
                       Program.
......[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]     Syntax error on a preceding command.
[F1 ER +]           Automatically report errors when they occur
```

```
[F1 ER -]                 Stop automatic error reports
```

---

11. <u>Temperature Ramping</u>

```
[F1 RS S 3]               Set the time increment to 3 seconds (must be a positive integer).
[F1 RT S 10]              Set the temperature increment to 0.1 ºC (a positive integer, units are
                              hundredths  of a degree).
[F1 TL +]                 Ramp the sample and reference identically.
[F1 TL -]                 Ramp the sample while the reference remains stable.
```
   The default is to ramp the sample while the reference remains stable. There is no query for this setting. Ramping both the sample and reference at different rates or to different target temperatures (see below) is not possible.

The ramp rate (ºC/min) is calculated as (RT / 100) / (RS / 60). Ramp rates corresponding to selected RS and RT pairs are given in the table below.

°C/min	0.05	0.1	0.2	0.5	1	2	5	10
RS	12	12	6	6	3	3	3	3
RT	1	2	2	5	5	10	25	50

Note: For the higher ramp settings, the observed rate may be lower than that calculated from RT and RS 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 temperature).

To Ramp the temperature:
1. equilibrate at the starting temperature,
2. set the time (RS) and temperature (RT) increments,
3. set a new target temperature.

The new target may be above or below the current temperature and, 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 RS and RT may be reset and a new ramp initiated by setting another target temperature.

Once you are done, terminate ramping by resetting both RS and RT to 0. Otherwise, setting a new target temperature later will initiate a ramp to that target temperature.

---

12. <u>Cell Changing</u>

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.
```

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13. <u>Reference Cuvette (TC 225 only)</u>

```
[R1 … ]
```

To control the temperature of the reference cuvette of a Dual Temperature Controller, use any commands in classes 3-8, substituting R1 for F1.   There are no corresponding [R1 ...] commands for classes 9 – 11.

If you wish to ramp the temperature of the reference and sample cuvettes together, please note the linking command [F1 TL +] in command class 11.