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Description: <b>T-App and Serial Command Control for TC 1 Temperature Controllers</b>			

# QNW

# T-App and Serial Command User's Guide

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# Table of Contents

1.	Specifications .....	5
1.1.	Computer Requirements .....	5
2.	Installing, Starting and Stopping QNW T-App – a Quick Start Guide .....	6
2.1.	Installing QNW T-App .....	6
2.2.	Working at Extended Temperatures .....	6
3.	Glossary of Terms Appearing on the TC 1 Front Panel Display Screen .....	7
4.	Temperature and Stirring Speed Ranges for Cuvette Holders .....	9
5.	Working at High and Low Sample Temperatures at the Laboratory Bench .....	10
5.1.	Thermostating a Liquid Sample in a Cuvette at Temperatures Other Than Room Temperature	10
5.2.	Successfully Working at High and Low Temperatures .....	10
5.3.	Strategies for Working with Quantum Northwest Products at Extreme Temperatures .....	11
5.4.	Summary .....	12
6.	Terms Used in Serial Communications with the TC 1 .....	13
7.	Serial Communications for the TC 1 Temperature Controller .....	14
7.1.	Sample Holder ID Number .....	15
7.2.	Controller Firmware Version .....	15
7.3.	Stirrer .....	15
7.4.	Temperature Control .....	16
7.5.	Target Temperature .....	16
7.6.	Instrument Status .....	17
7.7.	Current Sample Holder Temperature .....	17
7.8.	Error Reporting .....	17
7.9.	Probe Status and Temperature .....	18
7.10.	Temperature Ramping .....	19
7.11.	Heat Exchanger Temperature .....	20
7.12.	Cell Changing .....	21
7.13.	Reference Cuvette .....	21
7.14.	Front Panel Controls .....	22
8.	Elements of the T-App Software Help File .....	23
8.1.	Application Startup Window .....	23
8.2.	Application Control Window .....	24

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8.3.	Application Menus.....	25
8.4.	File Menu .....	25
8.5.	Tools Menu .....	25
8.6.	Temperature Control.....	26
8.7.	Temperature Ramping .....	27
8.8.	Stirrer Control.....	28
8.9.	Show Script Panel.....	29
8.10.	Command Text Box.....	30
8.11.	Plot Menu .....	30
8.12.	Data Shown .....	31
8.13.	Status Panel .....	32
8.14.	Temperature Control Status .....	33
8.15.	Heat Exchanger Temperature .....	34
8.16.	Target Temperature .....	35
8.17.	Magnetic Stirrer Controls.....	35
8.18.	External Probe Status .....	35
8.19.	Plot Axis Label Manipulation .....	36
8.20.	Plot of Data Collected .....	36
8.21.	Scripts: Program Script Commands.....	37
9.	Example Controller Scripts for T-App Software .....	41
9.1.	Controller Scripts for Single Cuvette Holders .....	41
9.2.	Controller Scripts for Dual Cuvette Holders.....	44
9.3.	Controller Scripts for Multiple-Cell Cuvette Holders .....	48

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# 1. Specifications

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## 1.1. Computer Requirements

A computer is required only if **T-App** software has been purchased.

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 link provided by QNW. Contact QNW should you wish to obtain the application by Internet.

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## 2. Installing, Starting and Stopping QNW T-App – a Quick Start Guide

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### 2.1. Installing QNW T-App

Installing the QNW T-App Software (if purchased)

#### CAUTION



**Caution** - Install **T-App** 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.

1. Follow the instructions provided with the software to complete the installation. The instructions are found in a text file titled "Instructions.txt" within the **T-App** folder. Those instructions will be similar to the following:

#### Instruction for installation of T-App

1. Copy the "T-App" folder to a convenient location on the computer to be used.
2. Run "CDM v2.12.12 WHQL Certified.exe" to the install drivers needed for serial communications between the QNW TC 1 temperature controller and the T-App application.
3. Connect the TC 1 to the computer to be used with the USB cable provided with the TC 1 (or any USB cable with the correct plug ends). Turn on the TC 1 power. Installation of the drivers for the USB connection should begin immediately and proceed automatically.
4. Run "T-App.exe". For further information select the Help>(T-App Help) menu item.

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### 2.2. Working at Extended Temperatures

**Section 4**, *Temperature and Stirring Speed Ranges for Cuvette Holders*, summarizes the temperature ranges accessible for cuvette holders that use the QNW TC 1 Temperature Controller. If working at high or low temperatures, consult **Section 5**, *Working at High and Low Sample Temperatures at the Laboratory Bench*, for detailed advice on how to achieve cuvette temperatures far removed from room temperature.

## 3. Glossary of Terms Appearing on the TC 1 Front Panel Display Screen

Term	Meaning
<b>Holder</b>	The temperature measured inside the Peltier-controlled cuvette holder, expressed in degrees Celsius (°C)
<b>ID=n</b>	The type of device being controlled by the TC 1 controller; ID=14 for SINGLE cuvette holder; ID=24 for DUAL; ID=34 for MULTI; ID=00 for specialty device
<b>LKK</b>	The control of the Reference and Sample cuvettes is linked so that control parameters of the Reference cuvette are identical to those of the Sample cuvette, and the TC 1 controller is under the command of an external computer control program (DUAL only)
<b>LNK</b>	The control of the Reference and Sample cuvettes is linked so that control parameters of the Reference cuvette are identical to those of the Sample cuvette, and change is possible only through the Sample cuvette settings (DUAL only)
<b>LOK</b>	The TC 1 controller is under the command of an external computer control program, and that program has locked the front panel to prevent the manual changing of settings
<b>Off</b>	For Ramping or Stirring, the function is not running either by default, or because the SET button was pressed while the function was running
<b>On</b>	For Ramping or Stirring, a valid parameter has been entered, and the SET button has been pressed
<b>POS</b>	The Position number (1, 2, 3, ...) of the cuvette currently in the light beam of the spectrometer (MULTI only)
<b>Probe</b>	The temperature measured by an external probe, positioned by the user, expressed in degrees Celsius (°C)
<b>Ramp</b>	A setting of a rate of linear temperature change of the Peltier-controlled cuvette holder, expressed in degrees Celsius per minute, leading to the desired target temperature (°C /min)
<b>REF</b>	The Reference cuvette of a Reference/Sample cuvette pair (DUAL only)
<b>RElink</b>	The command to link the control of the Reference and Sample cuvettes such that the Reference cuvette receives control identical to that of the Sample cuvette (DUAL only)

<b>SAM</b>	The Sample cuvette of a Reference/Sample cuvette pair (DUAL only)
<b>Stir</b>	A setting of stirring of a magnetic stirrer under a cuvette, expressed in revolutions per minute (rpm)
<b>Target</b>	The value of the temperature being targeted for the Peltier-controlled cuvette holder, expressed in degrees Celsius (°C)
<b>TT</b>	The target temperature set for the Peltier-controlled cuvette holder, expressed in degrees Celsius (°C)
<b>UNlink</b>	The command to unlink the control of the Reference and Sample cuvettes such that the Reference and Sample cuvettes may be controlled independently of each other (DUAL only)
<b>Version</b>	The version number of the firmware used in the TC 1 controller
<b>wTT</b>	The Ramp condition of waiting for a new target temperature to be set, following the setting and activation of a ramp rate

## 4. Temperature and Stirring Speed Ranges for Cuvette Holders

Cuvette Holder Class	Cuvette Holder Type	Stirring Motor Type	Effective Minimum/Maximum Stirring Speed, rpm	Factory Set Minimum/Maximum Temperature, °C	Reasonable Laboratory Minimum/Maximum Temperature, °C
Single	t2 Sport	Direct Current	200 to 1800	-40 to +110	-15 to +110
Single	Versa 20	Direct Current	900 to 1800	-40 to +105	-15 to +105
Single	Versa 20/E Extended Temperature	Direct Current	900 to 1800	-55 to +150	-50 to +150
Single	CD 250	Direct Current	900 to 1800	-40 to +105	-15 to +105
Single	CD 250/E Extended Temperature	Direct Current	900 to 1800	-55 to +150	depends on cuvette
Single	Luma 40	Direct Current	900 to 1800	-40 to +105	-15 to +105
Single	Luma 40/E Extended Temperature	Direct Current	900 to 1800	-55 to +150	-50 to +150
Dual	t2x2 Sport	Direct Current	200 to 1800	-40 to +110	-15 to +110
Multi	Turret 4	Stepper	60 to 1800	-40 to +110	-15 to +110
Multi	Turret 6	Stepper	60 to 1800	-40 to +110	-25 to +110
Multi	T-App	Stepper	60 to 1800	-40 to +110	-15 to +110

### CAUTION



**Caution** - See **Section 5** for a complete discussion of what minimum and maximum temperatures are achievable with Quantum Northwest products under standard laboratory conditions. Attempting to reach the factory set limits may damage the instrument if care is not taken.

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## 5. Working at High and Low Sample Temperatures at the Laboratory Bench

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### 5.1. Thermostating a Liquid Sample in a Cuvette at Temperatures Other Than Room Temperature

A standard spectrophotometer for UV-Vis-NIR absorbance or fluorescence comes with a cuvette holder for the liquid sample and often a second one for the reference sample. The cuvette holders are housed in the sample compartment of the spectrometer on a lab bench. "Room temperature" is often cited when specifying the temperature at which a sample was held when a spectrum was measured. For many situations, this is adequate. For sensitive measurements – either because the sample is chemically different at different temperatures, or its spectra are different at different temperatures – it is necessary to control the temperature of the sample to a precisely set value.

One way of altering the sample temperature of a cuvette holder uses a temperature-controlled circulating water bath (containing water or a mixture of water and another solvent), and a cuvette or cuvette holder that allows the flowing water to directly cool or heat the cuvette. Using such a system, the sample temperature often does not match the temperature of the circulating fluid. Alternatively, a Peltier cuvette holder can be used. A Peltier unit uses thermoelectric cooling/heating to alter the sample temperature. Such control typically occurs much more rapidly and precisely over a wider range of temperatures. With a Peltier cuvette holder, the circulating water bath is used to remove heat from the Peltier's heat exchanger rather than directly influencing the temperature of the sample in the cuvette. Air-cooled Peltier units use air rather than liquid for removing heat from the heat exchanger, and have more limited temperature ranges available to them.

Problems arise at both hot and cold temperatures. As a sample in a cuvette gets warmer, bubbles are likely to form in the cuvette. Left in place, they scatter incident light and create artifacts in spectra. Cold samples are problematic at or below the dew point of the ambient air, as condensation forms on the surface of the cuvette. This condensation also scatters incident light, creating artifacts in spectra. As the temperature is lowered, the condensed water may freeze, causing issues with icing on the cuvette holder and potential damage to the cuvette holder or the spectrometer when the ice melts.

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### 5.2. Successfully Working at High and Low Temperatures

Work at any temperature benefits from having the sample in the cuvette stirred using a magnetic stirrer built into the cuvette holder and a stir bar placed in the cuvette. This eliminates temperature gradients in the sample and facilitates more rapid equilibration to the set temperature. For high sample temperatures, up to +150 °C, magnetic stirring also helps dislodge bubbles that may form inside the cuvette as dissolved gases become less soluble with increasing temperature, although degassing samples before measurements is a more reliable means of preventing the artifacts that they cause.

Low temperature work must address the condensation of water on cuvette surfaces that are exposed to the atmosphere. The condensation can be limited by the application of a flow of dry gas (dried air, nitrogen, or argon, for example) to the surface of the cuvette while the sample is chilled. For cuvette holders used inside the sample chamber of a spectrometer, the whole sample compartment can be purged with dry gas.

How low can you go? For low-temperature spectroscopy with a benchtop spectrometer, many factors come into play. With Peltier cuvette holders, achieving low temperatures can be aided by the circulation of precooled liquid through the Peltier heat exchanger. For example, when using ice water at 0.0 °C, Peltier

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cuvette holders will easily approach -25 °C or so. To go lower, circulation of precooled fluids below 0.0 °C is required. The use of 30% methanol-water as the circulating liquid is recommended, since it has ample heat capacity and low viscosity, permitting adequate flow through the heat exchanger. It should be possible to achieve a sample holder temperature about 25 °C lower than that of the circulating fluid.

The final consideration for achieving high and low extended temperatures with a benchtop spectrometer is the amount of insulation that can be positioned around the cuvette holder without obstructing the light beam in and out of the cuvette, and while maintaining normal operation of the spectrometer itself. Typically, spectrometer manufacturers do not provide either the insulation or the guidance on how to craft a well-insulated sample chamber for their products. This is left to the operator, and is often the final factor on whether or not an extended temperature can be reached. Creativity is required in using foam packing material or other foam products, often with tape and rubber bands, to provide the insulation required for the temperature desired.

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### **5.3. Strategies for Working with Quantum Northwest Products at Extreme Temperatures**

Quantum Northwest's Peltier cuvette holders provide not only temperature control, but also stirring and dry gas purging.

Extended temperature spectroscopy ranges are available for UV-Vis-NIR absorbance, fluorescence, fiber optic, flash photolysis, photoacoustic and circular dichroism applications:

- [Versa 20/E](#) family of [products for UV-Vis-NIR spectrophotometry](#)
- [Luma 40/E](#) and [TLC 50 Legacy/E](#) families of [products for fluorescence spectroscopy](#)
- [qpod/E](#) cuvette holder for [fiber optic spectrometers](#)
- [Flash 300/E](#) stand-alone device for [laser flash photolysis and pulsed-laser photoacoustics](#)
- [CD 250/E](#) cuvette holder for [circular dichroism spectrometers](#)

These cuvette holders can be specially built to extend their temperature ranges from their normal range of -40 to +105 °C. Choosing the extended temperature option – denoted by /E – extends this control range to -55 °C to +150 °C. This requires the use of materials that are stable at the high and low temperatures, sensors with extended range, and design details that protect the delicate magnetic stirring motors. The Versa 20, Luma 40 and Flash 300 can be provided with windowed jackets to trap dry gas around the cuvette holder to eliminate condensation and frosting.

The lowest measured temperature reached to date at Quantum Northwest's manufacturing facility in Liberty Lake, WA, USA, was -52.7 °C with an extended temperature Flash 300/E, considerable added insulation, and circulating fluid of -20 °C. This is short of the -55 °C claimed for the extended temperature (/E) products. Why is this?

In short, with an extended temperature product, the user can send a control command to the unit to go to -55 °C; but, whether the unit will actually go to -55 °C depends on whether cold circulating fluid is used, and how well insulated the sample holder is. This situation is analogous to trying to chill a room to 15 °C with a powerful air condition unit, but if the user keeps the windows open on a hot summer day, the room will not likely get to 15 °C. The scientist's ability to customize and maximize the foam insulation around the cuvette holder is usually the key determinant to achieving low temperature spectroscopy without specialty cryogenic devices.

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## 5.4. Summary

Sample temperatures approaching -55 °C and up to +150 °C are possible in a standard benchtop spectrometer. Magnetic stirring is required for extended temperature work. The temperature of the circulating water bath needs to be controlled, and it may be necessary to blend the water with another solvent such as methanol to reach the required temperatures. For cold temperature work, dry gas must flow onto the surface of the cuvette to reduce condensation and ice build-up, and additional insulation must be added to surround the cuvette holder without obstructing the light beam.

For Quantum Northwest Peltier products that operate at extended temperatures, the following temperatures are achievable under the approximate conditions:

- 5 °C – lowest temperature in the open air (with typical humidity), no dry gas flow;
- 10 °C – lowest temperature in an exposed environment but with dry gas flow;
- 25 °C – lowest temperature in an enclosed, dry environment, with 0 °C circulating fluid;
- 40 °C – lowest temperature with a windowed jacket surrounding the cuvette holder, -15 °C circulating fluid, some added insulation;
- 55 °C – lowest possible temperature with a windowed jacket surrounding the cuvette holder, -30 °C circulating fluid, and maximum added insulation.

## 6. Terms Used in Serial Communications with the TC 1

**Section 7** describes in detail the commands used for serial control of the **TC 1** Temperature Controller. The table below summarizes the main commands and their definitions.

Command	Definition
<b>+</b>	On
<b>-</b>	Off
<b>CT</b>	Current temperature of the cuvette holder, degrees Celsius (°C)
<b>ER</b>	Error
<b>FP</b>	Front panel input
<b>HL</b>	High temperature limit of the heat exchanger of the cuvette holder, degrees Celsius (°C)
<b>HT</b>	Current temperature of the heat exchanger of the cuvette holder, degrees Celsius (°C)
<b>ID</b>	Identification of cuvette holder type (Single, Dual, Multi, or specialty device)
<b>IS</b>	Instrument status
<b>LK</b>	Link the reference cuvette settings to those of the sample cuvette
<b>LO</b>	Lock out the front panel from user input through the control buttons
<b>LS</b>	Lowest stirrer speed, revolutions per minute (rpm)
<b>LT</b>	Lowest target temperature allowed, degrees Celsius (°C)
<b>MS</b>	Maximum stirrer speed, revolutions per minute (rpm)
<b>MT</b>	Maximum target temperature allowed, degrees Celsius (°C)
<b>PA</b>	Automatic reporting of probe temperature
<b>PR</b>	External probe connected
<b>PS</b>	External probe status
<b>PT</b>	Probe temperature, degrees Celsius (°C)
<b>PX</b>	Probe temperature precision
<b>R</b>	Automatic reporting (of SS, for example)
<b>RR</b>	Ramp rate, degrees Celsius per minute (°C/min)
<b>SS</b>	Stirrer speed, revolutions per minute (rpm)
<b>TC</b>	Temperature control
<b>TT</b>	Target temperature, degrees Celsius (°C)
<b>VN</b>	Version number of the TC 1 controller firmware
<b>W</b>	Ramp mode is waiting for target temperature input

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## 7. Serial Communications for the TC 1 Temperature Controller

7/19/2016

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**Note:** This document provides the serial communications protocols for version 2.22 of the firmware on the TC 1 family of controllers.

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**TC 1/Single** – for single cuvette holders such as the t2 Sport, Versa 20, Luma 40, CD 250 and Flash 300;

**TC 1/Dual** – for dual independent control for sample and reference cuvettes of the t2x2 Sport and Versa 20x2;

**TC 1/Multi** – for multi-position sample changers such as the qCHANGER 6 and the Turret 6.

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.

### CAUTION



**Caution** - 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 offers the **T-App** 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). 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.

**Note:** The format of the commands is shown below.

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

## 7.1. 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	<b>specialty sample holder</b>
14	<b>single</b>
24	<b>dual</b>
34	<b>turret or linear multi-sample holder</b>

## 7.2. Controller Firmware Version

[F1 VN ?]	What is the <u>V</u> ersion <u>N</u> umber of the controller firmware?
... [F1 VN 2.22]	The controller firmware version number is 2.22.

## 7.3. Stirrer

[F1 MS ?]	What is the <u>M</u> aximum stirrer <u>S</u> peed?
... [F1 MS 2500]	The maximum stirrer speed permitted is 2500 rpm.
[F1 LS ?]	What is the <u>L</u> owest stirrer <u>S</u> peed?
... [F1 MS 300]	The lowest stirrer speed permitted is 300 rpm.
[F1 SS S 1000]	Set <u>S</u> tirrer <u>S</u> peed to 1000 rpm <u>and turn stirring on</u> .
[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.

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[F1 SS R-]	Turn off automatic <b>R</b> 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.

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## 7.4. Temperature Control

[F1 TC +]	Turn <b>T</b> emperature <b>C</b> 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+]	<b>R</b> eport temperature control status when changed by a command.
[F1 TC R-]	Do not report temperature control status when changed.

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## 7.5. Target Temperature

[F1 MT ?]	What is the <b>M</b> aximum <b>T</b> arget temperature setting allowed for this holder?
... [F1 MT 105]	The maximum target temperature allowed is 105 °C.
[F1 LT ?]	What is the <b>L</b> owest <b>T</b> arget temperature setting allowed for this holder?
... [F1 LT -30]	The lowest target temperature allowed is -30 °C
[F1 TT S 23.10]	Set the <b>T</b> arget <b>T</b> emperature to 23.10 °C. 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 °C.
[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.

## 7.6. Instrument Status

[F1 IS ?]	What is the current <u>I</u> nstrument <u>S</u> 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+]	Include 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', ramping off), ' + ' ('plus', ramping on) or 'W'(waiting for TT). See subsection 7.10 for details.
[F1 IS E-]	Stop including the ramp status in the instrument status response (power-on default).

## 7.7. Current Sample Holder Temperature

[F1 CT ?]	What is the <u>C</u> urrent <u>T</u> emperature of the sample holder?
... [F1 CT 22.84]	The current temperature is 22.84 °C.
[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 a 3-second interval).
[F1 CT R+]	<b>R</b> 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).

## 7.8. Error Reporting

[F1 ER ?]	Report the current error ( <b>ER</b> ror).
... [F1 ER -1]	No current error.
... [F1 ER 05]	Cell T out of range (Loose cable? Sensor failure?).
... [F1 ER 06]	Both cell and heat exchanger T out of range (Loose cable?).
... [F1 ER 07]	Heat exchanger T out of range (Loose cable? Sensor failure?).

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... [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 has no effect on ER 9 responses).

---

## 7.9. 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 +]                Enable probe status to be **R**eported automatically when a probe is  
  or [F1 PS R+]            installed or removed.  
[F1 PS -]                Disable automatic sending of probe status (power-on default).  
  or [F1 PS R-]

[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 0.5]            The interval is 0.5 °C.  
[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 last two commands have no effect. They are included to maintain compatibility with customer software /

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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 subsection 7.8).

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].

---

## 7.10. 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 ER 9 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 subsection 7.5). When the TT command is received, if temperature control is on (see subsection 7.4) 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/firmware developed for use with the older TC 125/225/425 family of temperature controllers.

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There are no corresponding reference commands (see subsection 7.13) 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 RT S #], [F1 RT ?] 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 (subsection 7.5).

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 the ramp rate set command. Otherwise, setting a new target temperature will cause the controller to drive at maximum to the new target.

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**Note:** The following details aid in running T-App.

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2. The minimum settable ramp rate (using the [F1 RR S #] command) is 0.01 °C/minute. The maximum is 10 °C/min.
3. 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).
4. 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.
5. When the ramp status is '+'/On, sending a [F1 TT S #] command or a [F1 TC -] command will change the ramp status to '-'/Off.

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## 7.11. 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 39.23] The current heat exchanger temperature is 39.23 °C.

[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 °C. 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 8], [F1 TC -] and/or [F1 IS ...] (with parameter 3 = '-'/minus) depending on the current auto-reply settings (see below).

## 7.12. Cell Changing

**Note:** These commands are valid only for a sample holder with multiple cuvette positions.

[F2 DI]	Device initialize: move to home position, then back to the current position setting.
[F2 PI]	Device initialize: move to home position, then back to the current position setting and reply when done.
... [F2 DL 1]	Device is finished moving. (Original reply was OK rather than DL 1)
[F2 DL 3]	Device locate: move to position 3. (Device should be initialized prior to using this command for the first time.)
[F2 DL ?] or [F2 PL ?]	What is the current position?
... [F2 DL 1]	Device is in position 1.
[F2 PL 4]	Device locate: move to position 4 and reply when done. (Device should be initialized prior to using this command for the first time.)
... [F2 DL 4]	Device is now in position 4.
[F2 ?]	What is the current motor status?
... [F2 OK]	Most recent move is complete.
... [F2 BUSY]	Most recent move is still in progress.

## 7.13. Reference Cuvette

**Note:** These commands are valid only for systems with two independently-controlled sample holders. Otherwise, they will cause an ER 9 response.

[R1 ...]

To control and monitor the temperature and status of the reference cuvette using a Dual Temperature Controller, use any commands in subsections 11.1-11.8, 11.10 and 11.11, substituting R1 for F1. There are no corresponding [R1 ...] commands for subsections 11.9 and 11.12.

## 7.14. Front Panel Controls

**Note:** 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 (FP) settings and determine if and how such front panel changes are reported.

[F1 LO (+/-)]                    **L**ockOut (+) 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 (not shown in the MAIN display for a multiposition system). The user will be able to use the left-arrow and right-arrow buttons to move between the settings displays (as if no control program were 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, MAIN REF, and version/ID displays.

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

[F1 LK (+/-)]                    **L**inK (+) 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.

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

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## 8. Elements of the T-App Software Help File



The program T-App comes with a complete Help File. This file may be explored in detail by locating the file T-App Help.chm and clicking on it to open it. Below are elements from the Help file that are useful for getting started with T-App, if purchased.

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### 8.1. Application Startup Window

This Startup Window is displayed while the program searches for a **Temperature Controller** by checking each active COM port on the computer, beginning with the highest.



When a **Controller** is found, this startup window is replaced by the [Application Control Window](#).

If a **Controller** is not found, the startup window changes to that below. Click on the areas where the pointer changes to a hand for further information on the Application Menus and buttons,



This may result if the **Controller** is not connected to power, or if the Bluetooth or USB link between the **Controller** and the computer is not available.

Click the [Try Again button](#) (or use the [File>Restart](#) menu item) once you have corrected the problem. Click the [Exit button](#) (or use the [File>Exit](#) menu item) to terminate the program.

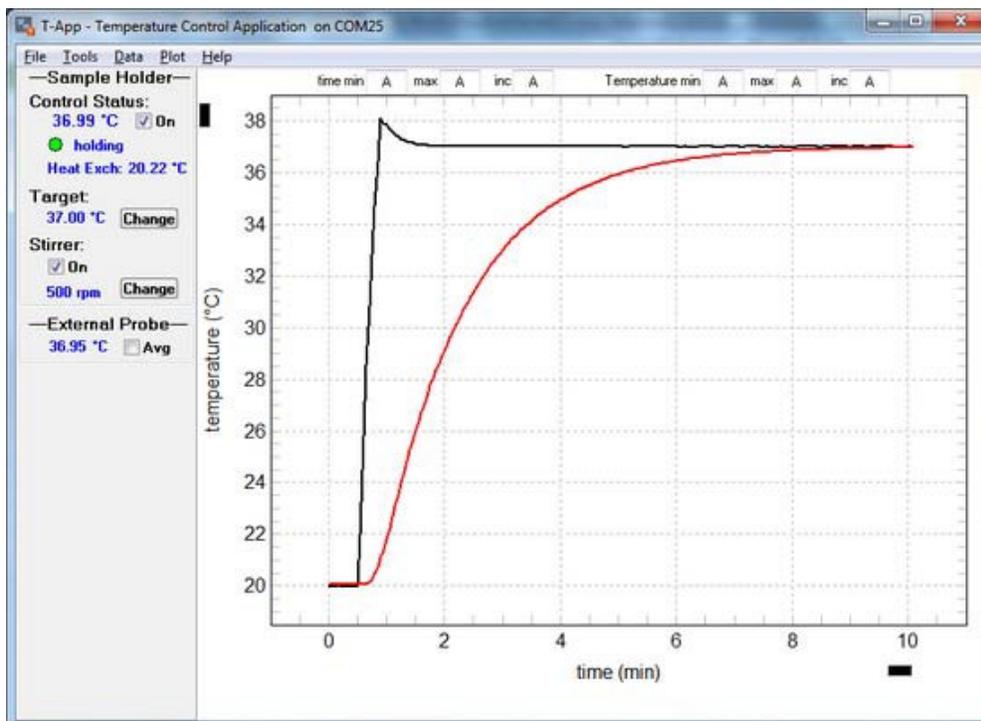
You may also use the [File>\(Work Offline\)](#) menu item to use the program without connecting to a sample holder in order to plot previously saved time/temperature data without being connected to a **Controller**.

## 8.2. Application Control Window

Immediately after **T-App** connects to a **Temperature Controller**, a banner with blinking text appears across the top of the application window as shown below. This banner persists while **T-App** is communicating (coordinating) with the **Controller**. At the end of the coordinating process, **T-App** causes the **Controller** to begin automatically sending temperatures every 3 seconds.

The figure below shows the Application Control Window as it would appear if the user changed the sample holder [Target Temperature](#) from 20 to 37 C while temperature control was on. The black trace is the sample holder temperature and the red trace is the external thermistor probe temperature.

Click on the areas where the pointer changes to a hand for further information on the Application Menu, the Temperature Plot or the Status Panel.

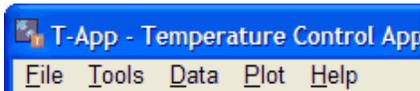


The image above shows the T-App Application window as it would appear using a **TC 1 Temperature Controller** with a Series 400 thermistor probe attached (with the thermistor tip in the stirred sample).

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## 8.3. Application Menus

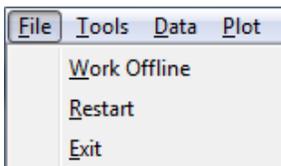
Click on the individual menu bar items (where the pointer changes to a hand) for further information on that menu.



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## 8.4. File Menu

Click on the individual menu item (where the pointer changes to a hand) for further information on that menu item.

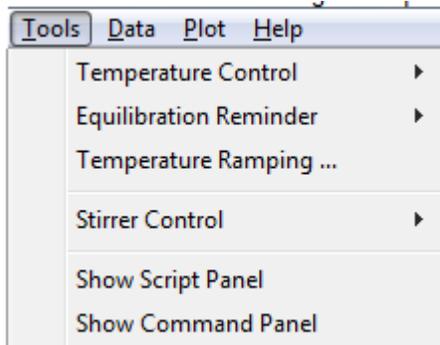


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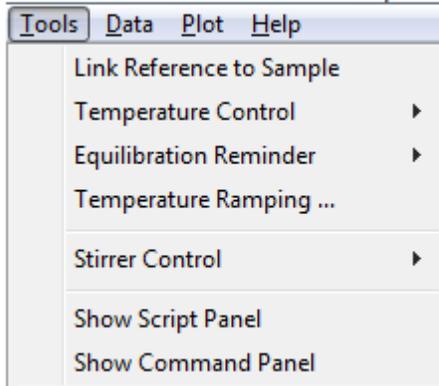
## 8.5. Tools Menu

Click on the individual menu item (where the pointer changes to a hand) for further information on that menu item.

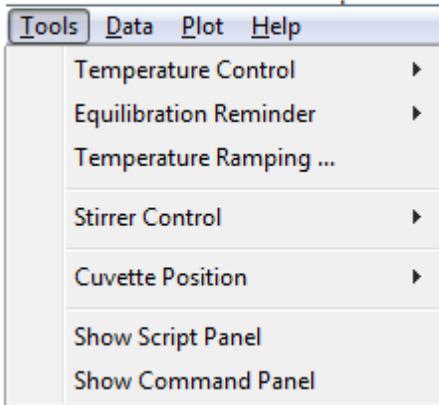
Tools menu items for a single sample holder system.



Tools menu items for a dual sample holder system.

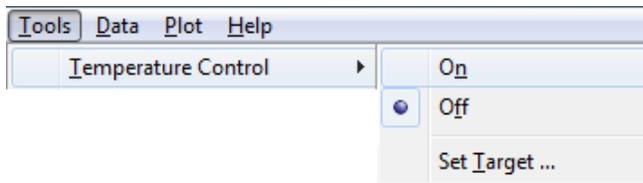


Tools menu items for a multi-position sample holder system.

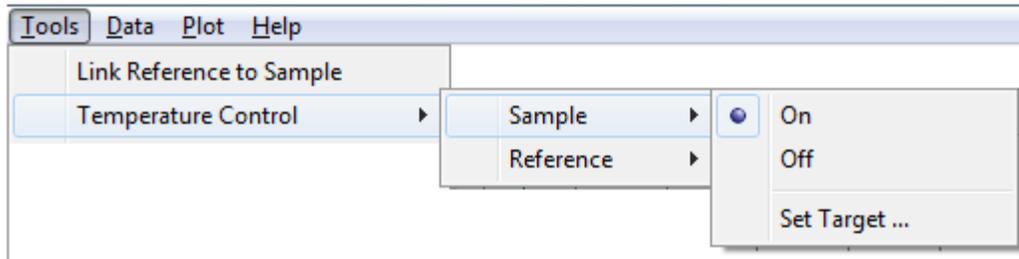


## 8.6. Temperature Control

Tools>(Temperature Control) menu for a single controller, including multi-position controllers.



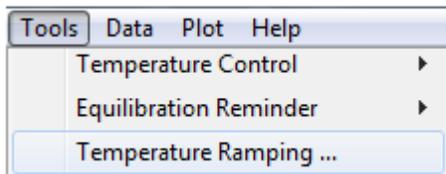
If your system is a dual Temperature Controller with linking turned off, clicking on the "Temperature Control" menu item will present two submenu items, "Sample" and "Reference"; clicking on either of these submenus will present the three choices for changing settings for that holder (shown for Sample below).



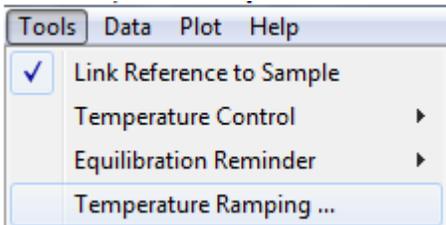
Note: If [Link Reference to Sample](#) is checked, the Sample/Reference choice will not be available (the menu behavior will be identical to a single **Controller**).

## 8.7. Temperature Ramping

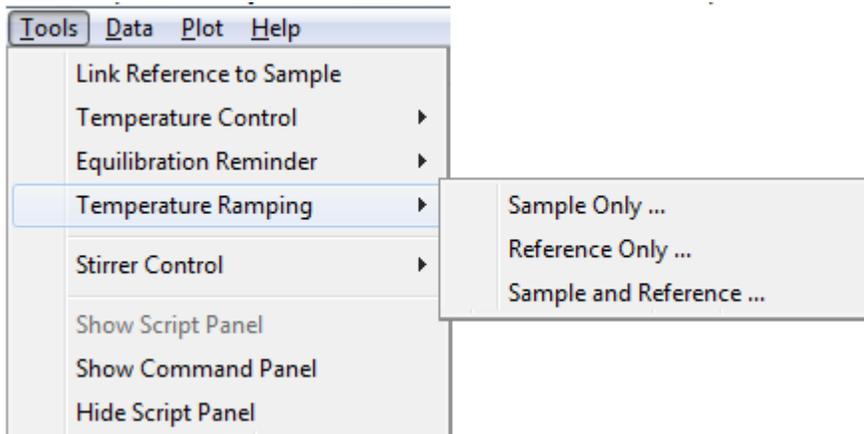
Single sample holder system (including multiple sample position systems).



Dual sample holder system with [Reference Linked to Sample](#).



Dual sample holder system with Reference not linked to Sample.



When you click on one of the Temperature Ramping menu items, a small parameter entry dialog will be presented for entry of two parameters.

The first parameter determines the temperature at which the ramping process will stop (and will reset the Target Temperature to that value).

The second parameter determines the rate for the temperature ramp (degrees C/min). This parameter is always a positive decimal number and must be greater than or equal to 0.01. The maximum value is 10.0.

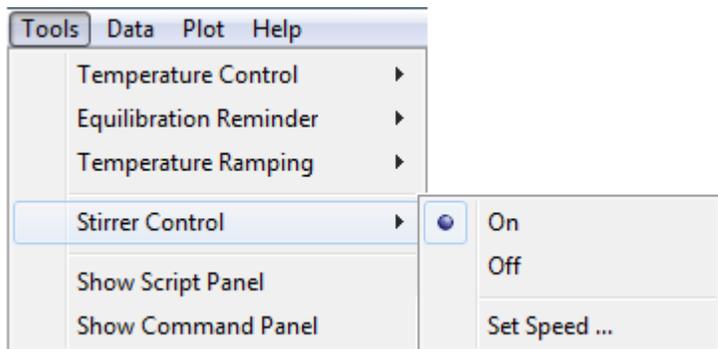
When the entry dialog is closed (if temperature control is turned on), the sample holder temperature will begin to change at the specified rate from the current temperature to the new target temperature. The direction of the ramp (up or down) is determined by these two temperatures.

If you need to stop the ramp before it is completed, set the ramp rate to zero. The system will then heat or cool at maximum capacity to move the sample holder temperature to the Target Temperature.

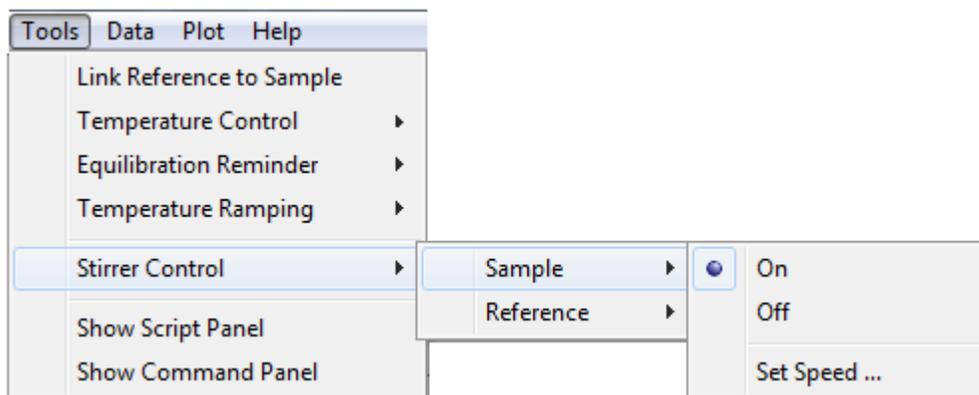
In a dual system, if temperature control is on for both sample and reference then the countdown will not begin until both are stable at the target temperature.

## 8.8. Stirrer Control

Single sample holder system (including multiple sample position systems).

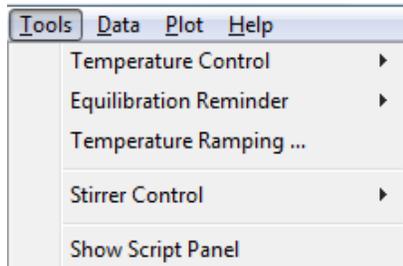


Dual sample holder system.



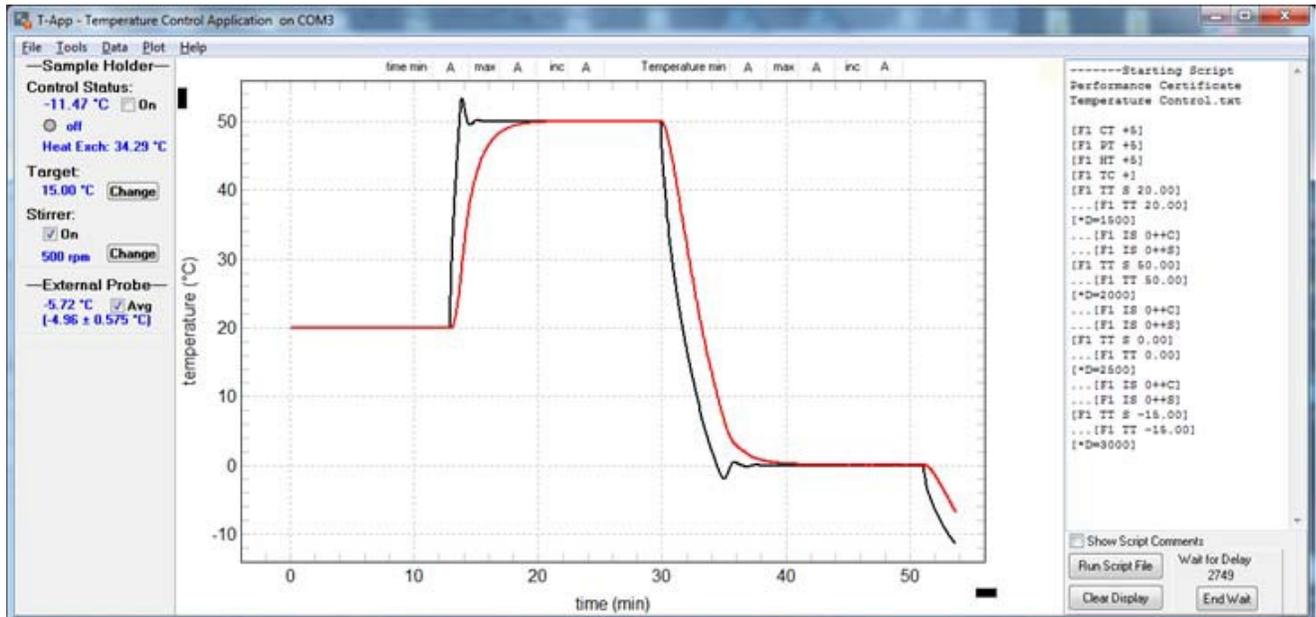
Note: If [Link Reference to Sample](#) is checked, the Sample/Reference choice will not be available.

## 8.9. Show Script Panel



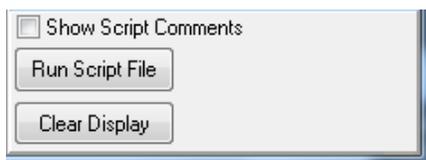
When this menu item is clicked, the right side of the Application Control Window will open to show a vertical panel containing a text display with button controls and other information near the bottom.

The snapshot below was taken when the program was in the middle of running a script. This particular script is used to do a performance run on each sample holder. The performance run for each sample holder is included in the Calibration Certificate found in the hardware manual.

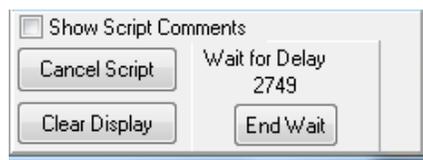


Generally, you should click on the "Clear Display" button before running a script.

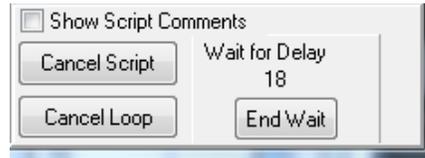
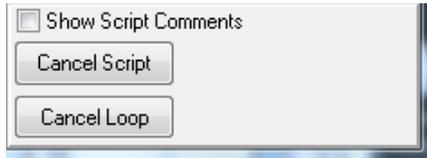
The controls below the text window change depending on whether a delay or wait command is being executed and on whether the current command being executed is inside a loop. Click on the individual control below (where the pointer changes to a hand) for further information on that control.



NO SCRIPT RUNNING.



DELAY/WAIT COMMAND NOT INSIDE A LOOP.



CURRENT COMMAND IS INSIDE A LOOP. DELAY/WAIT COMMAND INSIDE A LOOP.

## 8.10. Command Text Box

This edit box may be used to send commands to the Temperature Controller.

The edit box content always starts out as "ENTER / SELECT". When you click on it the first time this content is automatically selected, ready to be replaced when a command entered using the keyboard.

Clicking the arrow at the right end of the edit box will present a drop-down list as shown (below left). Initially the list will include only prototype commands. Click on the command wanted and it will appear in the edit box (below, center). Change the prototype symbol '+' to a plus or minus; '#' to an appropriate number (below right).



To send the command to the QNW Temperature Controller either hit the Enter key on the keyboard (while still in the command edit box) or click on the Send Command-> button.

See the Controller Serial Command List for more information on the serial commands that are available.

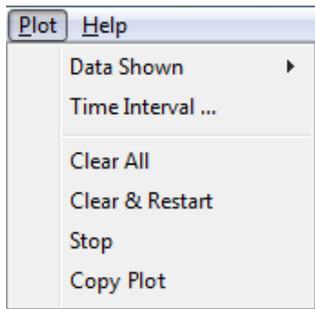
The Listing Control subset of the Program Commands may also be used. For example, the command [\*LCT -] tells the program not to display sample holder temperature (CT) replies from the Temperature Controller in the multi-line text box.

New commands can be added to the list. For example, to insert the command [F1 TT S 37] (above right) hold the Shift key down while hitting the Return key (the blinking cursor must be in the edit box). The command will be inserted into the list but will not be sent to the Controller.

Commands can be removed from the list by selecting the command (so it appears in the edit box) then hold the Shift key down while hitting the Delete key.

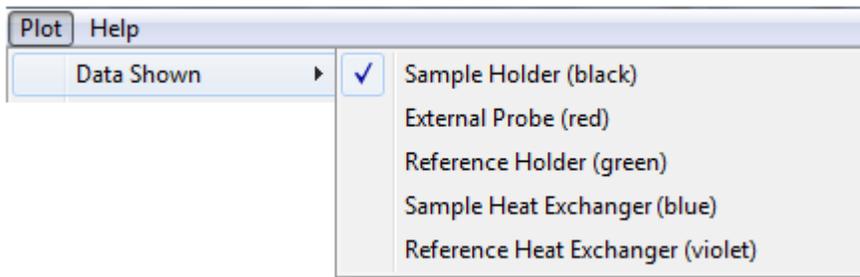
## 8.11. Plot Menu

Click on the individual menu item (where the pointer changes to a hand) for further information on that menu item.

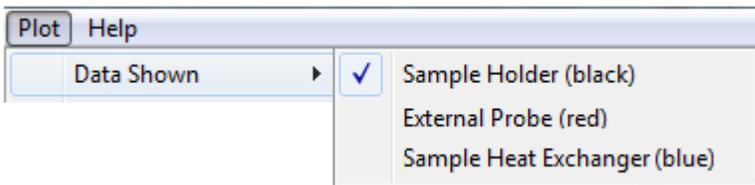


## 8.12. Data Shown

Dual with external probe



Single (or multi-sample) with external probe



## 8.13. Status Panel

Click on the individual controls where the pointer changes to a hand for further information on that control.

### Single cuvette holder

WITHOUT PROBE ATTACHED

**Sample Holder**

Control Status:  
 20.00 °C  On  
 ● holding  
 Heat Exch: 27 °C

Target:  
 20.00

Stirrer:  
 On  
 1500 rpm

WITH PROBE ATTACHED

**Sample Holder**

Control Status:  
 20.00 °C  On  
 ● holding  
 Heat Exch: 27 °C

Target:  
 20.00

Stirrer:  
 On  
 1500 rpm

**External Probe**  
 19.9 °C  Avg

### Dual cuvette holder

WITHOUT PROBE ATTACHED

**Sample Holder**

Control Status:  
 20.00 °C  On  
 ● off  
 Heat Exch: 23.70 °C

Target:  
 20.00

Stirrer:  
 On  
 0 rpm

**Reference Holder**

Control Status:  
 25.00 °C  On  
 ● off  
 Heat Exch: 24.21 °C

Target:  
 25.00

Stirrer:  
 On  
 0 rpm

WITH PROBE ATTACHED

**Sample Holder**

Control Status:  
 20.00 °C  On  
 ● off  
 Heat Exch: 23.70 °C

Target:  
 20.00

Stirrer:  
 On  
 0 rpm

**External Probe**  
 19.74 °C  Avg

**Reference Holder**

Control Status:  
 25.00 °C  On  
 ● off  
 Heat Exch: 24.21 °C

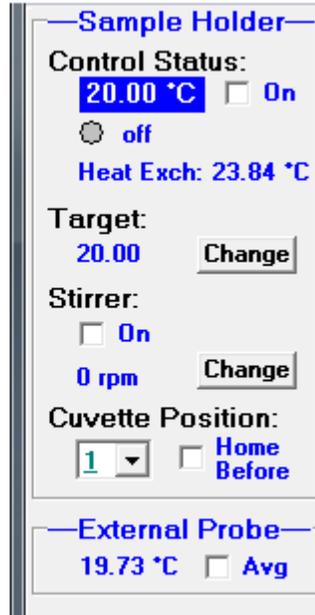
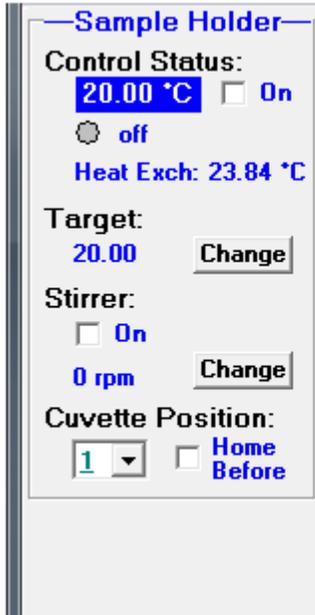
Target:  
 25.00

Stirrer:  
 On  
 0 rpm

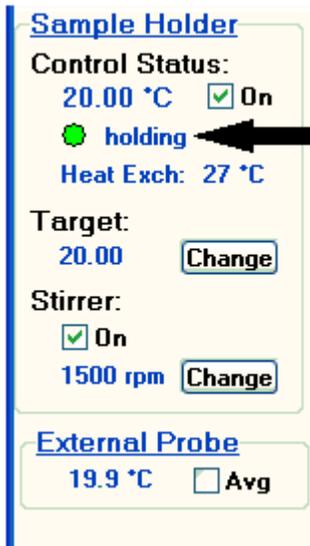
**Multi cuvette holder**

WITHOUT PROBE ATTACHED

WITH PROBE ATTACHED



## 8.14. Temperature Control Status



When temperature control is off, the circle will be a steady gray and the label will read "off".

When temperature control is on but the sample holder temperature is not stable, the small circle will alternate slowly between green and gray and the label to its right will read "seeking".

When temperature control is on and the sample holder temperature is stable, the circle will be a steady green and the label will read "holding".

If an error condition occurs that causes temperature control to be turned off the circle and the caption to its right will alternate rapidly between red and gray.



## 8.15. Heat Exchanger Temperature



The temperature of the heat exchanger in the sample holder is displayed here.

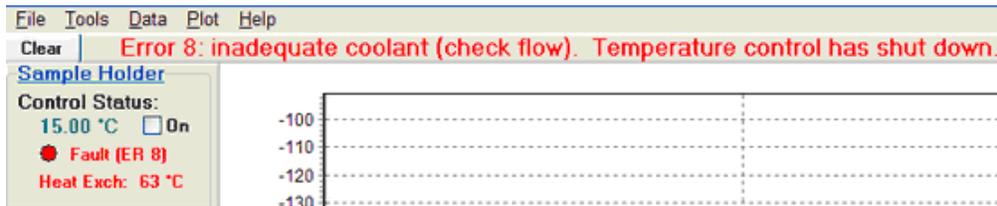
The heat exchanger temperature is dependent on the temperature and the rate of flow of the water being circulated through the sample holder and on the temperature control settings.

As a warning, when the heat exchanger temperature is within 10 °C of the preset limit (typically 60 °C, the color of the label will change to orange. To correct the problem, you must reduce the temperature of the water (for example, by adding ice or cold water to the coolant container).

If the heat exchanger temperature exceeds that preset limit, temperature control will automatically be turned off to prevent damage to the system.

If temperature control does turn off, the label will turn red and an error message will display below the menu bar as illustrated below; also, the [Temperature Control Status](#) will show the error number and begin flashing red. The error message (and the flashing of the status control) can be removed at any time by clicking on the Clear button to the left of the message.

Once the problem with the heat exchanger temperature is corrected, you can restart temperature control by clicking on the [Temperature Control On/Off checkbox](#) or using the menu item [Tools>\(Temperature Control\)>On](#). The error screen on the TC 1 will be cleared by restarting temperature control using **T-App**; this screen can also be cleared by pressing the SET button on the front of the TC 1.



## 8.16. Target Temperature

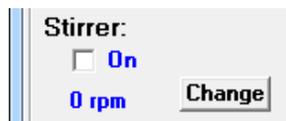


The Target Temperature is the Sample Holder Temperature that you want to use. If Temperature Control is On, the **Controller** will either be driving the holder temperature to the target or maintaining the holder temperature at the target.

The number displayed is the current Target Temperature. When the Change button to the right of the number is clicked a small parameter entry dialog will appear where you can change the Target Temperature setting.

The [Tools>\(Temperature Control\)>\(Set Target\)](#) menu item may also be used to change the Target Temperature.

## 8.17. Magnetic Stirrer Controls

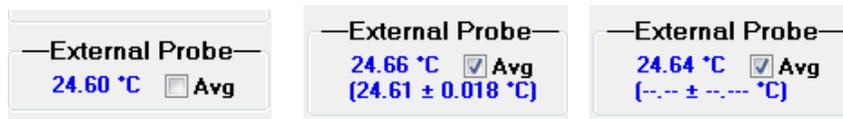


The checkbox may be used to turn the magnetic stirrer on (checked) or off (unchecked).

Click on the Change button to reset the speed of the stirrer. The current speed setting is shown to the left of the button. The submenus of the [Tools>\(Stirrer Control\)](#) menu item may also be used to change the stirrer properties.

## 8.18. External Probe Status

The External Probe Status will be displayed only if a Series-400 or Series-500 thermistor probe is connected to the 1/4-inch phone jack in the back of the sample holder. This probe input is intended to provide a means to directly measure the temperature of the sample in the cuvette.



The number to the left of the Avg checkbox is always the most recent temperature from the probe. If a probe temperature is not yet available, the digits will be replaced by dashes.

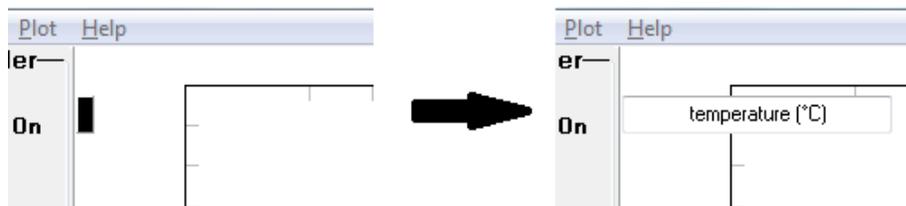
The left image shows the display for when the Avg box is not checked.

When the Avg checkbox is checked (by clicking on it), all controller models send probe readings with two decimal digits. The numbers in parentheses beneath the checkbox (middle image) list the mean value of the most recent 20 temperatures for the probe followed by the average deviation from that mean. The mean value should provide a more reproducible sample temperature if it has been stable long enough for 20 temperatures from the stable period to have been acquired.

If 20 temperatures are not yet available, the mean and average deviation are replaced by dashes (image on the right).

## 8.19. Plot Axis Label Manipulation

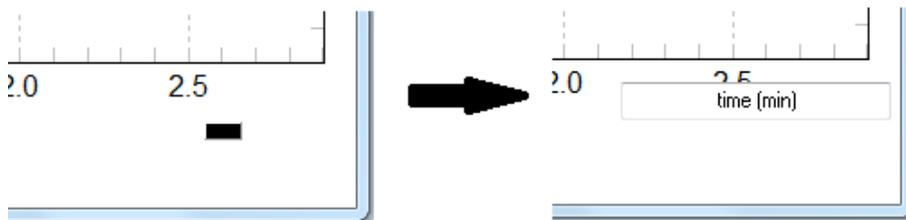
The label on the vertical axis can be changed by clicking on the small black rectangle near the upper-left corner of the plot; this will make a text box appear for changing the label. After new text has been entered, hitting the Tab or Return key will cause the text box to close and the modified axis label to appear on the plot.



BEFORE CLICKING ON THE BLACK RECTANGLE.

AFTER CLICKING ON THE BLACK RECTANGLE.

The label on the horizontal axis can be changed by clicking on the small black rectangle near the lower-right corner of the plot; this will make a text box appear for changing the label. After new text has been entered, hitting the Tab or Return key will cause the text box to close and the modified axis label to appear on the plot.

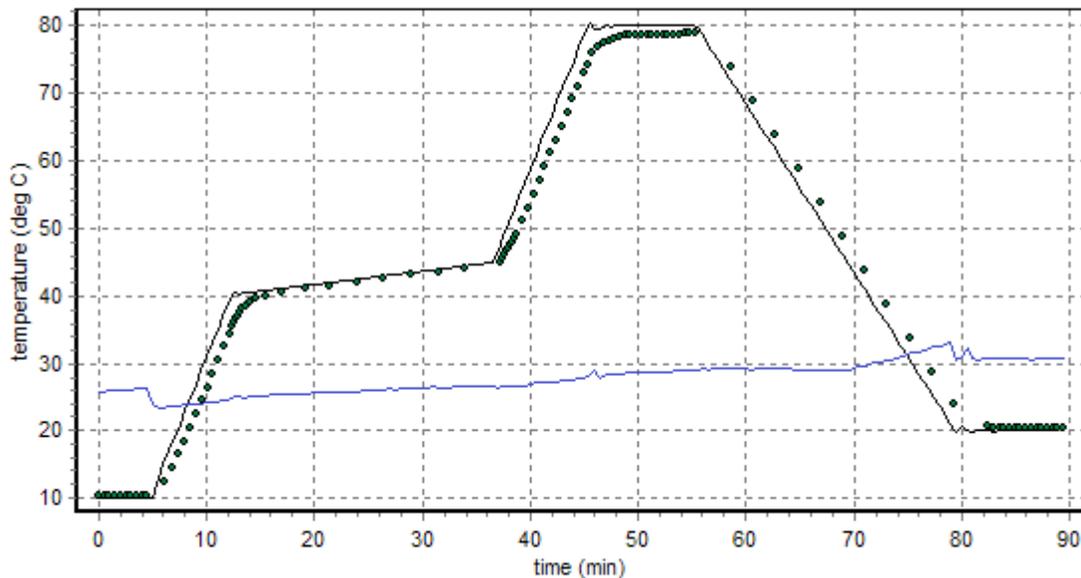


BEFORE CLICKING ON THE BLACK RECTANGLE.

AFTER CLICKING ON THE BLACK RECTANGLE

## 8.20. Plot of Data Collected

This plot shows an example of temperature as a function of time data that would result from using the [Example Script](#).



black - temperature of the sample holder. blue - temperature of the heat exchanger.

dotted black - temperature of the [external probe](#) (with the thermistor tip in the liquid sample).

Individual time/temperature points are shown for the external probe data to illustrate special methods of reporting probe temperatures used in the Example Script. Normally the probe data are shown as a red line.

## 8.21. Scripts: Program Script Commands

The Program Script Commands are used to control the behavior of a script and are not sent to the **QNW Temperature Controller**.

### Delay and Wait commands

Progress of the Delay and Wait commands is tracked in the [Delay/Wait Countdown Display](#) at the bottom of the [Script Panel](#).

**[\*D #]** - Delay # INTERVALS before running the next command. Example: **[\*D 120]** will cause a delay of 120 of the INTERVAL units as defined in the first line of the script (see the [Example Script](#) which sets the INTERVAL to 0.01 minutes).

While the delay is active, a countdown of the number of script INTERVALs remaining is included in the **Countdown Display** (see **Window View 2** in the **Script Panel**).

**[\*WRP>=#]** **[\*WRP<=#]** These commands are included to be compatible with older scripts. **T-App** now interprets them as **[\*WCT>=#]** and **[\*WCT<=#]**

**[\*WCT>=#]** - Wait until the current (holder) temperature exceeds or equals a particular value (# as an integer).

**[\*WCT<=#]** - Wait until the current temperature decreases to or below a particular value (# as an integer).

The current temperature is the temperature of the metal body of the sample cuvette holder.

---

**[\*WPT>=#]** - Wait until the probe temperature exceeds or equals a particular value (# as an integer).

**[\*WPT<=#]** - Wait until the probe temperature decreases to or below a particular value (# as an integer).

The probe temperature is the reading of the standard 400 series or 500 series probe (usually the probe is inserted in the sample cuvette).

**[\*WRT>=#]** - Wait until the reference temperature exceeds or equals a particular value (# as an integer).

**[\*WRT<=#]** - Wait until the reference temperature decreases to or below a particular value (# as an integer).

The reference temperature is the temperature of the metal body of the reference cuvette holder (dual **Controller** only).

**[\*WT #]** - This command will be interpreted as a **[\*WT 1000 1]** command to maintain compatibility with older script files.

**[\*WT (#1) (#2)]** - This program command will cause the script to Wait until the sample holder

Temperature is stable before continuing to the next script command in the list. Temperature stability is determined by an algorithm built into the **QNW Temperature Controller**. The parameter (#1) determines how often the program sends a status query to the **Controller** (**[F1 IS ?]**, see the [Controller Serial Command List](#)). Each time this query is received, the **Controller** returns a status reply which includes information as to whether the temperature is still changing or has met the criteria for being stable (controlled). The parameter (#2) specifies the maximum number of status queries that will be sent before the wait is canceled.

The time between status queries is the product of the parameter (#1) and the script INTERVAL as defined in the second line of the script (see the [Example Script](#)).

While the wait is active, the number of times the **Controller** has been queried is displayed followed by a countdown to the next query.

Note: if the command **[F1 IS +]** has been sent to the **Controller**, the instrument status reply will be sent by the **QNW Temperature Controller** automatically when the sample holder temperature becomes stable. In this case the command form **[\*WT (#1) 1]** is recommended where (#1) is chosen to give a 10-minute period (for example, if INTERVAL IS 0.6 seconds or 0.01 minutes, then (#1) should be set to 1000). Typically, stable sample holder temperature is attained within 10 min of setting a new target temperature.

**[\*WD #]** - This command is no longer accepted because it does not work in Windows XP or later.

### **Beep Control commands**

**[\*BCT +]** or **[\*BCT-]** - Turn on (+) or off (-) beeping by the computer whenever a sample holder (current) temperature report is received from the **Controller**.

**[\*BPT +]** or **[\*BPT-]** - Turn on (+) or off (-) beeping by the computer whenever a probe temperature report is received from the **Controller**.

**[\*BRT +]** or **[\*BRT-]** - Turn on (+) or off (-) beeping by the computer whenever a reference holder temperature report is received from the **Controller**.

### **Warning Control commands**

**[\*E+]** or **[\*E-]** - These commands are no longer supported because they are not needed for **T-App** version 2.00. Older scripts that include these commands will still run without generating an error response.

---

**Listing Control command**

- [\*LIS +]** or **[\*LIS -]** - Enable (+) or Disable (-) listing of Instrument Status replies during running of a script.
- [\*LER +]** or **[\*LER -]** - Enable (+) or Disable (-) listing of Error Message replies during running of a script.
- [\*LCT +]** or **[\*LCT -]** - Enable (+) or Disable (-) listing of Current Temperature replies during running of a script.
- [\*LPT +]** or **[\*LPT -]** - Enable (+) or Disable (-) listing of Probe Temperature replies during running of a script.
- [\*LRT +]** or **[\*LRT -]** - Enable (+) or Disable (-) listing of Reference Temperature replies during running of a script.

These ten program commands can be used to control whether the indicated information, sent from the **Controller** to the program, are to be listed (displayed) in the Script Panel or the Command Panel while a script is running. Disabling the listings may be useful to make progress of the script clearer since, under some conditions, large numbers of Instrument Status replies and Temperatures replies may be generated while the script is running. Disabling affects only the listing of these various replies -- the replies will still have their normal effects in the Main Window.

Note: some earlier versions of **T-App** defaulted to listing temperature replies in the Command/Script panel. **T-App** version 2.00 defaults to not listing them.

**Miscellaneous commands**

**[\*R]** - This program command is used only at the end of a script. It will cause the script to be repeated, starting at the beginning. The script will then repeat forever or until the [Cancel Script](#) button is clicked.

**[\*P]** - If the plot window is displayed while a script is running, the data in the plot may not be automatically updated unless a delay (\*D) or wait (\*W) command is being processed. This program command will cause the plot window to update (replot to show all data collected to that point).

**[\*CTD]** - This command will clear the time and temperature data from the [Time/Temperature Plot](#) of the [Application Control Window](#). In addition, the time parameter in the displays will be restarted at zero and listing of time/temperature data in the display windows will be started. Whatever display interval was in effect at the time this command is executed is retained (set by a script command or by clicking on the (Plot>Set Interval) menu item).

**[\*MSG + message]** or **[\*MSG - message]** - This command will stop execution of the script and present a dialog box containing the second command parameter ("message"); change this parameter to the wording you want the dialog box to display. The first parameter (+ or -) determines whether the computer beeps (+) or not (-) while the dialog box is visible. Clicking on the "OK" button in the dialog box closes it and execution of the script continues.

**[\*LS #]** and **[\*LE]** - The **[\*LS #]** command defines the start of a loop (a repeat of a series of commands) within the script; the parameter '#' is an integer specifying how many times the loop is to be run. The **[\*LE]** command defines the end of the series of commands included in the loop. A script may contain more than one loop. Also, smaller loops can occur within larger loops.

**[\*WPL]** -- When the positioning commands

[F2 PL #] = go to position #

or [F2 PI] = go to home and back to the last position

---

are sent to the **Temperature Controller**, it automatically sends the reply [F2 DL #] when the positioning process is completed. The [\*WPL] command waits for this reply before continuing to the next command in the script.

**[\*PL+]** -- This command will cause the sample position to change to the next higher number. If the current position is the highest number position, it will move to position 1.

**[\*PL-]** -- This command will cause the sample position to change to the next lower number. If the current position is 1, it will move to the highest number position.

**[\*TT+#]** or **[\*TT-#]** -- Increments or decrements the sample holder target temperature.

**[\*RT+#]** or **[\*RT-#]** -- Increments or decrements the reference holder target temperature.

## 9. Example Controller Scripts for T-App Software

These scripts and others are provided when the **T-App** program is purchased from Quantum Northwest. They are designed to be used with a **TC 1** Temperature Controller connected to a Peltier-based cuvette holder. Each script is a simple text file (.txt) that is read into the **T-App** program and activated. Each script is easily edited to suit the user's needs.

### 9.1. Controller Scripts for Single Cuvette Holders

The following are scripts designed for use with single cuvette holders, for example the t2 Sport, Versa 20 and Luma 40, with the TC 1 Temperature Controller.

*Script, Step 20 to 50 °C at 1 °C Intervals (TC 1 Controller, t2 Sport Cuvette Holder)*

#### Controller Script

Interval = .6     Set the time interval between commands to .6 seconds.

#### Initial Setup

```
[F1 CT +6]     Report current cuvette holder temperature every 6 seconds.
[F1 PT +6]     Report current probe temperature every 6 seconds.
[F1 HT +6]     Report heat exchanger temperature periodically.
[F1 TT S 20]    Set target temperature to 20 deg C
[F1 TC +]      Temperature control on
[F1 SS S 500]   Set stirring to 500 rpm (also turns stirring on)
[*CTD]        Clear time/temperature data and reset time to zero
```

Step up to 50 C, 1 C intervals:

```
[*LS 32]Start loop
  [*WT 1000 2] Wait for stable temperature (or 20 min maximum)
  [*D 600]     Wait 6 min for sample equilibration
               Notify user, with beeping.
  [*MSG + Ready (note T and make measurement)]
  [*TT+1]      Increase target T by 1C
[*LE]
```

#### Clean-up

```
[F1 CT -]     Stop periodic sample holder temperature reporting.
[F1 PT -]     Stop periodic probe temperature reporting.
[F1 HT -]     Stop periodic heat exchanger temperature reporting.
[F1 TC -]     Temperature control off
[F1 SS -]     Stirring off
```

---

*Script, Ramp 20 to 50 °C at 1 °C per minute (TC 1 Controller, t2 Sport Cuvette Holder)*

---

**Controller Script**

Interval = .6    Set the time interval between commands to .6 seconds.

-----  
**Initial Setup**

[F1 CT +6]    Report current cuvette holder temperature every 6 seconds.  
[F1 PT +6]    Report current probe temperature every 6 seconds.  
[F1 HT +6]    Report heat exchanger temperature periodically.  
[F1 TT S 20]    Set target temperature to 20 deg C  
[F1 TC +]    Temperature control on  
[F1 SS S 500]    Set stirring to 500 rpm (also turns stirring on)  
[\*WT 1000 2]    Wait for stable temperature (or 20 min maximum)  
[\*D 600]    Wait 6 min for sample equilibration

-----  
**Ramp up to 50:**

[F1 RR S 1]    Set Ramp rate to 1 deg C.  
[F1 TT S 50.00]    Set Target Temperature to 50.00 deg C, to start ramping process.  
[\*CTD]    Clear time/temperature data and reset time to zero  
[\*WCT>=50]    Wait until the sample holder temperature reaches 50.00 deg C.

-----  
**Clean-up**

[F1 PT -]    Stop periodic probe temperature reporting.  
[F1 CT -]    Stop periodic sample holder temperature reporting.  
[F1 HT -]    Stop periodic heat exchanger temperature reporting.  
[F1 TC -]    Temperature control off  
[F1 SS -]    Stirring off  
[\*MSG + Script run is complete]    Notify user, with beeping.

---

*Script, Performance Run (TC 1 Controller, t2 Sport Cuvette Holder, with External Probe)*

---

**Controller Script**

Interval = .6 sec (0.01 min)    time interval between commands  
[F1 CT +5]    Report sample holder temperature periodically.  
[F1 PT +5]    Report probe temperature periodically.  
[F1 TC +]    Turn on Temperature Control  
[F1 TT S 20.00]    Set Target Temperature to 20 C  
[\*D=1500]    Wait 15 minutes  
[F1 TT S 50.00]    Set 50 C Target  
[\*D=2000]    Wait 20 minutes  
[F1 TT S 0.00]    Set 0 C Target

[*D=2500]	Wait 25 minutes
[F1 TT S -15.00]	Set -15 C Target
[*D=3000]	Wait 30 minutes
[F1 TT S 80.00]	Set 80 C Target
[*D=3000]	Wait 30 minutes
[F1 TT S 20.00]	Set 20 C Target
[*D=2500]	Wait 25 minutes
[F1 PT -]	Stop periodic probe temperature reporting.
[F1 CT -]	Stop periodic sample holder temperature reporting.
[F1 TC -]	Turn off sample Temperature Control

*Script, Multiple Ramp (TC 1 Controller, t2 Sport Cuvette Holder, no External Probe)*

Controller Script

Interval = 1.2 Set the time interval between commands to 1.2 seconds (0.02 min).

-----  
 Initial Setup

-----  
 [F1 TC +] Turn on Temperature Controls.  
 [F1 TT S 10] Set Target Temperature to 10 deg C.  
 [F1 SS S 500] Set Stirrer Speeds to 500 rpm (turns stirrers on).  
 [F1 CT +10] Report sample cuvette holder temperature periodically.  
 [F1 HT +10] Report heat exchanger temperature periodically.  
 [\*CTD] Clear time/temperature displays and reset time to zero  
 [\*MSG - This script requires pre-equilibration to 10 C. Close this message (click OK). Then, when equilibrated, click on the "End Wait" button (lower right corner of window).]  
 [\*D=1500] Wait 30 minutes or until user clicks the "End Wait" button.  
 [\*CTD] Clear time/temperature displays and reset time to zero  
 [\*D=250] Collect temperatures for 5 minutes.  
 -----

First Ramp to 40 at 4 degC/min:

-----  
 [F1 RR S 4.0] Set Ramping Rate to 4 deg/min.  
 [\*BPT +] Turn on the option for computer to beep each time a probe temperature report is received.  
 [F1 TT S 40] Set Target Temperature to 40 deg C, to start ramping process.  
 [\*WCT>=40] Wait until the sample temperature reaches 40 deg C.  
 -----

Second Ramp to 45 at 0.2 degC/min:

-----  
 [F1 RR S 0.2] Set Ramping Rate to 0.2 deg/min.  
 [F1 TT S 45] Set Target Temperature to 45 deg C to start ramping process.  
 [\*WCT>=45] Wait until the sample temperature reaches 45 deg C.  
 -----

Third Ramp to 80:

-----  
 [F1 RR S 4.0] Set Ramping rate to 4 deg/min.  
 [F1 TT S 80.00] Set Target Temperature to 80.00 deg C to start ramping process.  
 [\*D 100] Wait 2 min before changing probe temperatures spacing.  
 [\*WCT>=80] Wait until the sample temperature reaches 80 deg C.  
 -----

[\*BPT -] Turn off the computer beep each time a probe temperature report is received.  
 [\*D 500] Wait 10 min to allow temperatures to stabilize.

-----  
 Ramp back to 20:  
 -----

[F1 RR S 2.5] Ramping rate to 2.5 deg C per minute.  
 [F1 TT S 20] Set Target Temperature to 20 deg C to start ramping process.  
 [\*WCT<=20] Wait until the sample temperature reaches 20 deg C.  
 [\*D 150] Hold 3 minutes to allow the probe temperature to catch up.

-----  
 Clean up  
 -----

[\*D 350] Wait another 7 minutes for final equilibration.  
 [F1 CT -] Stop periodic sample holder temperature reporting.  
 [F1 HT -] Stop periodic heat exchanger temperature reporting.  
 [F1 TC -] Temperature control off  
 [F1 SS -] Stirring off  
 [\*MSG + The multiramp script run is complete] Notify user, with beeping.

## 9.2. Controller Scripts for Dual Cuvette Holders

The following are scripts designed for use with dual cuvette holders, for example the t2x2 Sport, with the TC 1 Temperature Controller.

-----  
*Script, Step 20 to 50 °C at 1 °C Intervals (TC 1 Controller, t2x2 Sport Dual Cuvette Holder)*  
 -----

Controller Script

Interval = .6 Set the time interval between commands to .6 seconds.

-----  
 Initial Setup  
 -----

[F1 CT +6] Report current cuvette holder temperature every 6 seconds.  
 [F1 PT +6] Report current probe temperature every 6 seconds.  
 [R1 CT +6] Report reference cuvette holder temperature periodically.  
 [F1 HT +6] Report heat exchanger temperature periodically.  
 [R1 HT +6] Report reference heat exchanger temperature periodically.  
 [F1 TT S 20] Set target temperatures to 20 deg C  
 [R1 TT S 20] Set target temperature to 20 deg C  
 [F1 TC +] Temperature controls on  
 [R1 TC +]  
 [F1 SS S 500] Set stirring to 500 rpm (also turns stirring on)  
 [R1 SS S 500]  
 [\*CTD] Clear time/temperature data and reset time to zero

-----  
 Step up to 50 C, 1 C intervals:  
 -----

[\*LS 32] Start loop  
 [\*WT 1000 2] Wait for stable temperature (or 20 min maximum)

[\*D 600] Wait 6 min for sample equilibration  
 Notify user, with beeping.  
 [\*MSG + Ready (note T and make measurement)]  
 [\*TT+1] Increase target T by 1C  
 [\*RT+1]  
 [\*LE]

-----  
 Clean-up  
 -----

[F1 CT -] Stop periodic sample holder temperature reporting.  
 [F1 PT -] Stop periodic probe temperature reporting.  
 [F1 HT -] Stop periodic heat exchanger temperature reporting.  
 [R1 CT -] Stop periodic reference holder temperature reporting.  
 [R1 HT -] Stop periodic reference exchanger temperature reporting.  
 [F1 TC -] Temperature controls off  
 [R1 TC -]  
 [F1 SS -] Stirring off  
 [R1 SS -]

*Script, Ramp 20 to 50 °C at 1 °C per minute (TC 1 Controller, t2x2 Sport Dual Cuvette Holder)*

Controller Script

Interval = .6 Set the time interval between commands to .6 seconds.

-----  
 Initial Setup  
 -----

[F1 CT +6] Report current cuvette holder temperature every 6 seconds.  
 [R1 CT +6] Report reference cuvette holder temperature periodically.  
 [F1 HT +6] Report heat exchanger temperature periodically.  
 [R1 HT +6] Report reference heat exchanger temperature periodically.  
 [F1 TT S 20] Set target temperatures to 20 deg C  
 [R1 TT S 20]  
 [F1 TC +] Temperature controls on  
 [R1 TC +]  
 [F1 SS S 500] Set stirring to 500 rpm (also turns stirring on)  
 [R1 SS S 500]  
 [\*WT 1000 2] Wait for stable temperature (or 20 min maximum)  
 [\*D 600] Wait 6 min for sample equilibration

-----  
 Ramp up to 50:  
 -----

[F1 RR S 1] Set Ramp rates to 1 deg C.  
 [R1 RR S 1]  
 [F1 TT S 50.00] Set Target Temperatures to 50.00 deg C to start ramping process.  
 [R1 TT S 50.00]  
 [\*CTD] Clear time/temperature data and reset time to zero  
 [\*WCT>=50] Wait until the sample holder temperature reaches 50.00 deg C.  
 -----

**Clean-up**

```

-----
[F1 CT -]      Stop periodic sample holder temperature reporting.
[F1 HT -]      Stop periodic heat exchanger temperature reporting.
[R1 CT -]      Stop periodic reference holder temperature reporting.
[R1 HT -]      Stop periodic reference exchanger temperature reporting.
[F1 TC -]      Temperature controls off
[R1 TC -]
[F1 SS -]      Stirring off
[R1 SS -]
[*MSG + Script run is complete] Notify user, with beeping.
  
```

*Script, Performance Run (TC 1 Controller, t2x2 Sport Dual Cuvette Holder, with External Probe)*

**Controller Script**

Interval = .6 sec (0.01 min) time interval between commands

```

[F1 CT +5]      Report sample holder temperature periodically.
[R1 CT +5]      Report reference holder temperature periodically.
[F1 PT +5]      Report probe temperature periodically.
[F1 TC +]       Turn on sample Temperature Control
[R1 TC +]       Turn on reference Temperature Control
[F1 TT S 20.00] Set sample Target Temperature to 20 C
[R1 TT S 20.00] Set reference Target Temperature to 20 C
[*D=1500]       Wait 15 minutes
[F1 TT S 50.00] Set sample 50 C Target
[R1 TT S 50.00] Set reference 50 C Target
[*D=2000]       Wait 20 minutes
[F1 TT S 0.00]  Set sample 0 C Target
[R1 TT S 0.00]  Set reference 0 C Target
[*D=2500]       Wait 25 minutes
[F1 TT S -15.00] Set sample -15 C Target
[R1 TT S -15.00] Set reference -15 C Target
[*D=3000]       Wait 30 minutes
[F1 TT S 80.00] Set sample 80 C Target
[R1 TT S 80.00] Set reference 80 C Target
[*D=3000]       Wait 30 minutes
[F1 TT S 20.00] Set sample 20 C Target
[R1 TT S 20.00] Set reference 20 C Target
[*D=2500]       Wait 25 minutes
[F1 PT -]       Stop periodic probe temperature reporting.
[F1 CT -]       Stop periodic sample holder temperature reporting.
[R1 CT -]       Stop periodic reference holder temperature reporting
[F1 TC -]       Turn off sample Temperature Control
[R1 TC -]       Turn off reference Temperature Control
  
```

---

*Script, Multiple Ramp (TC 1 Controller, t2x2 Sport Dual Cuvette Holder, no External Probe)*

---

**Controller Script**

Interval = 0.6 Set the time interval between commands to 0.6 seconds (0.01 min).

-----  
**Initial Setup**

-----  
[F1 TC +] Turn on Temperature Controls.  
[R1 TC +]  
[F1 TT S 10] Set Target Temperatures to 10 deg C.  
[R1 TT S 10]  
[F1 SS S 500] Set Stirrer Speeds to 500 rpm (turns stirrers on).  
[R1 SS S 500]  
[F1 CT +10] Report sample cuvette holder temperature periodically.  
[F1 HT +10] Report heat exchanger temperature periodically.  
[R1 CT +10] Report reference cuvette holder temperature periodically.  
[R1 HT +10] Report reference heat exchanger temperature periodically.  
[\*CTD] Clear time/temperature displays and reset time to zero  
[\*MSG - This script requires pre-equilibration to 10 C. Close this message (click OK). Then, when equilibrated, click on the "End Wait" button (lower right corner of window).]  
[\*D=3000] Wait 30 minutes or until user clicks the "End Wait" button.  
[\*CTD] Clear time/temperature displays and reset time to zero  
[\*D=500] Collect temperatures for 5 minutes.

-----  
**First Ramp to 40 at 4 degC/min:**

-----  
[F1 RR S 4.0] Set Ramp Rates to 4 deg/min.  
[R1 RR S 4.0]  
[F1 TT S 40] Set Target Temperatures to 40 deg C, to start ramping process.  
[R1 TT S 40]  
[\*WCT>=40] Wait until the sample temperature reaches 40 deg C.

-----  
**Second Ramp to 45 at 0.2 degC/min:**

-----  
[F1 RR S 0.2] Set Ramp Rates to 0.2 deg/min.  
[R1 RR S 0.2]  
[F1 TT S 45] Set Target Temperatures to 45 deg C to start ramping process.  
[R1 TT S 45]  
[\*WCT>=45] Wait until the sample temperature reaches 45 deg C.

-----  
**Third Ramp to 80:**

-----  
[F1 RR S 4.0] Set Ramp rates to 4 deg/min.  
[R1 RR S 4.0]  
[F1 TT S 80.00] Set Target Temperatures to 80.00 deg C to start ramping process.

```
[R1 TT S 80.00]
[*WCT>=80]    Wait until the sample temperature reaches 80 deg C.
[*D 1000]     Wait 10 min to allow temperatures to stabilize.
```

-----  
 Ramp back to 20:

```
[F1 RR S 2.5] Ramp rates to 2.5 deg C per minute.
[R1 RR S 2.5]
[F1 TT S 20]   Set Target Temperatures to 20 deg C to start ramping process.
[R1 TT S 20]
[*WCT<=20]    Wait until the sample temperature reaches 20 deg C.
[*D 1000]     Wait 10 minutes.
```

-----  
 Clean up

```
[F1 CT -]     Stop periodic sample holder temperature reporting.
[F1 HT -]     Stop periodic heat exchanger temperature reporting.
[R1 CT -]     Stop periodic reference holder temperature reporting.
[R1 HT -]     Stop periodic reference exchanger temperature reporting.
[F1 TC -]     Temperature control off
[R1 TC -]
[F1 SS -]     Stirring off
[R1 SS -]
[*MSG + The multiramp script run is complete]  Notify user, with beeping.
```

### 9.3. Controller Scripts for Multiple-Cell Cuvette Holders

The following are scripts designed for use with multiple cuvette holders, for example the qCHANGER 6, Turret 4 and Turret 6, with the TC 1 Temperature Controller.

*Script, Move Any Multi-Cell Cuvette Holder (TC 1 Controller)*

Controller Script

```
Interval = .6    (0.01 min)
This script will only work with T-App 1.50 or later
[F2 PL 1]       go to position 1
[*WPL]          wait for position change
[*D 50]         wait 30 seconds
[*LS 50]        loop 50 times
  [*LS 6]       loop 6 times
    [*PL+]      move to next position
    [*WPL]      wait for position change
    [*D 50]     wait 30 seconds
  [*LE]         end of loop 6 times
[*LE]          end of loop 50 times
```

---

*Script, Move the Turret 4 Four-Position Cuvette Holder (TC 1 Controller)*

---

Controller Script

Interval = .6 (0.01 min)

This script will work with any T-App

```
[F2 PL 1]    go to position 1
[*D 50]     wait 30 seconds
[F2 PL 2]    go to position 2
[*D 50]     wait 30 seconds
[F2 PL 3]    go to position 3
[*D 50]     wait 30 seconds
[F2 PL 4]    go to position 4
[*D 50]     wait 30 seconds
[*R]        repeat from the beginning
```

---

*Script, Move the Turret 6 or T-App Six-Position Cuvette Holder (TC 1 Controller)*

---

Controller Script

Interval = .6 (0.01 min)

This script will work with any T-App

```
[F2 PL 1]    go to position 1
[*D 50]     wait 30 seconds
[F2 PL 2]    go to position 2
[*D 50]     wait 30 seconds
[F2 PL 3]    go to position 3
[*D 50]     wait 30 seconds
[F2 PL 4]    go to position 4
[*D 50]     wait 30 seconds
[F2 PL 5]    go to position 5
[*D 50]     wait 30 seconds
[F2 PL 6]    go to position 6
[*D 50]     wait 30 seconds
[*R]        repeat from the beginning
```