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Quantum Northwest

TC 1

Serial Commands

version 2.22

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1. Serial Communications for the TC 1 Temperature Controller

7/19/2016

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

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).

1.1. Sample Holder ID Number

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

Assigned Identities:

ID = 00	specialty sample holder
14	single
24	dual
34	turret or linear multi-sample holder

1.2. 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.

1.3. 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.

[F1 SS R-]	Turn off automatic R eporting of the stirrer speed and status when changed by a command.
[F1 SS R+]	Turn on automatic reporting of stirrer changes. The power on default setting is to not report the speed or the status when changed. If you then send [F1 SS R+], only the stirring speed will be reported when changed. If you then send [F1 SS R+], both the speed and the status will be reported when changed. If you then send [F1 SS R-], neither the speed nor the status will be reported when changed (back to the power on default setting). Note that the [F1 SS ?] will always result in a stirring speed response. The status response will also be sent if it has been enabled as described above.

1.4. Temperature Control

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

1.5. Target Temperature

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

1.6. 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 1.10 for details.
[F1 IS E-]	Stop including the ramp status in the instrument status response (power-on default).

1.7. 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+]	R eport status of the sample holder temperature when it changes.
... [F1 CT C]	The status of CT is changing.
... [F1 CT S]	The status of CT is stable (CT has stayed within +/-0.05 °C of the target temperature for at least 1 minute.
[F1 CT R-]	Stop reporting changes in the status of CT (power-on default).

1.8. Error Reporting

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

... [F1 ER 08] Inadequate coolant (check flow). Temperature control has shut down.
... [F1 ER 09<<bad command>>] Syntax error on a preceding command where "bad command" is the text of the command that caused the syntax error response.
[F1 ER +] Automatically report errors when they occur.
[F1 ER -] Stop automatic error reports (this setting has no effect on ER 9 responses).

1.9. 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 /

firmware based on the older TC 125, TC 225 and TC 425 temperature controllers (i.e., they will not cause an [F1 ER 9 <<...>>] report – see command class 8).

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

1.10. Temperature Ramping

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

[F1 RR S 0]

or [F1 RR -]

Sets ramp status to '-' /off (but does not change the current ramp rate setting). If either command is sent during a temperature ramp, the controller will then drive at maximum to the last set target temperature.

[F1 RR +]

Set ramp status to 'W' / waiting mode.

In waiting mode the TC 1 is waiting for a new target temperature to be set (see command class 5). When the TT command is received, if temperature control is on (see command class 4) the controller begins ramping the temperature from the current value to the new TT at the previously specified ramp rate. If temperature control was off when the TT command is received, the ramping process does not begin until it is turned on. In either case the ramping state is '+' /on until the ramp is completed or cancelled.

If this command is sent while a ramp is in progress, the ramp status will change to 'W' / waiting and the controller will drive at maximum to the last target temperature set.

[F1 RR ?]

What is the current ramp rate setting? Depending on the R+/R- state as specified below, the ramp status ('W' /waiting, '+' /on or '-' /off) may also be reported.

... [F1 RR 1.00]

Current ramp rate is 1.00 °C/minute.

... [F1 RR W]

Ramp status is waiting.

[F1 RR R-]

Turn off automatic reporting of the rate and ramp status when changed by command or by use of the front panel.

[F1 RR R+]

Turn on automatic reporting of ramp changes. Automatic reports will be sent by the controller when the ramp rate or status is changed by command.

The power on default setting is to not report the ramp rate or the ramp state when changed.

If you then send [F1 RR R+], only the ramp rate will be reported when changed.

If you then send [F1 RR R+], both the rate and the state will be reported when changed.

If you then send [F1 RR R-], neither the rate nor the state will be reported when changed (back to the power on default setting).

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

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

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

[F1 TL +] Ramp the sample and reference identically.

[F1 TL -] or.

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

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

[F1 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 (command class 5).

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

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

Once the ramp is completed, if you want to start another ramp (even using the same ramp rate) you must send the ramp rate set command. Otherwise, setting a new target temperature will cause the controller to drive at maximum to the new target.

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

1. The minimum settable ramp rate (using the [F1 RR S #] command) is 0.01 °C/minute. The maximum is 10 °C/min.
2. For higher ramp settings, the observed rate may be lower than that specified or it may be nonlinear over part of the temperature range because the maximum possible rate of heating or cooling is limited (and dependent on the ramp direction as well as on the temperature).
3. For compatibility with the TC 125/225/425 family of controllers, when the ramping process is completed the controller will send an [F1 TT #] response, where # will be the target temperature used to start the ramp. Depending on automatic reply settings, an [F1 RR -] and/or [F1 IS 0++C-] response may also be sent by the TC 1.
4. When the ramp status is '+'/On, sending a [F1 TT S #] command or a [F1 TC -] command will change the ramp status to '-'/Off.

1.11. 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).

1.12. 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.

1.13. 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 1.1-1.8, 1.10 and 1.11, substituting R1 for F1. There are no corresponding [R1 ...] commands for command classes 1.9 and 1.12.

1.14. 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 ?]
 ...[F1 LO +] or ...[F1 LO -] Query the current lockout state.

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

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.