Identifier:	Revision:	Effective Date:
Luma 40-MAN-0	**0**	**5/26/16**

Web Page:
http://www.qnw.com/luma-40-product-family/

Description:

Peltier-based temperature-controlled cuvette holder for use in fluorometers

QUANTUM
N·O·R·T·H·W·E·S·T

QNW Luma 40 User's Guide

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Temperature-Controlled Cuvette Holders
and Custom Instrumentation

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CAUTION

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

WARNING

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

Table of Contents

1. General Information

Thank you for purchasing a Quantum Northwest **Luma 40**. We want you to enjoy many years of faithful service from your instrument. If you have any questions, feel free to contact us directly through our website, www.qnw.com/contact-us/, or by email at service@qnw.com.

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

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

1.1. User Documentation

You have been provided with the following documentation to help you set up and operate your Quantum Northwest **Luma 40** cuvette holder:

- This manual, with safety practices and hazards information, instructions for installing and maintaining the components of the **Luma 40**, and troubleshooting information.
- The **T-App** Help file, located on the **T-App** CD (Quantum Northwest>**T-App** Help).

1.2. Modules, Covers and Panels

The spectrophotometer module that operators and other personnel will routinely access is the instrument's sample compartment, which is designed to contain the QNW **Luma 40**. Customers may insert cuvettes and cuvette accessories into the QNW **Luma 40** while the sample compartment is open.

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

1.3. Other Precautions

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

Use of the QNW **Luma 40** system and accessories may involve materials, solvents and solutions that are flammable, corrosive, toxic or otherwise hazardous. Careless, improper, or unskilled use of such materials, solvents and solutions can create explosion hazards, fire hazards, toxicity and other hazards which can result in death, serious personal injury, and damage to equipment and property.

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

1.4. Warning and Other Symbols

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

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

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

1.5. CE Compliance

Your QNW **Luma 40** cuvette holder has been designed to comply with the requirements of the Electromagnetic Compatibility (EMC) Directive and the Low Voltage (electrical safety) Directive (commonly referred to as the LVD) of the European Union. Quantum Northwest has confirmed that each product complies with the relevant Directives by testing a prototype against the prescribed EN (European Norm) standards.

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

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

EC Declaration of Conformity

We: Quantum Northwest, Inc.

Of: 22910 E Appleway Ave, Suite 4
Liberty Lake, WA 99019-8606
USA

Declare under our sole responsibility that the products:

Models: **Luma 40**,**TC 1**, ***turret*** 6

Types: Temperature Controller, Temperature-Controlled Cuvette Holder

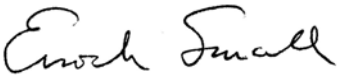
Are in conformity with the following standards and relevant EC directives:

Emissions: EN 61326-1 (2013)

Immunity: EN 61326-1 (2013)

EU Directive: 2004/108/EC, EMC

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

Signed by: 

Name: Enoch W. Small, Ph.D.

Position: President, Quantum Northwest, Inc.

Date: August 22, 2014

Location: Liberty Lake, Washington, USA

2. Specifications

Figure 1. Luma 40 Cuvette Holder

Figure 2. TC 1 Temperature Controller

2.1. Introduction: QNW Luma 40 Cuvette Holder with TC 1 Temperature Controller

Intended Use

The QNW **Luma 40** Cuvette Holder is designed to be inserted into a fluorescence spectrometer, replacing the sample cuvette holder originally supplied with the instrument. The **Luma 40** has four optical ports for absorbance measurements, and comes with the **TC 1** Temperature Controller to control sample temperature during optical measurements. Temperature control is achieved using the **TC 1** Temperature Controller alone or along with a computer interfaced to the **TC 1** Temperature Controller box, using the QNW **T-App** software provided.

Specifications

- Temperature range: -40 to +110 °C
- Temperature precision: ±0.01 °C
- Temperature accuracy: ± 0.2 °C from 0 °C to +80 °C
- Temperature reproducibility: better than ±0.05 °C
- Cuvette size (outside dimensions): 12.5 x 12.5 mm
- Optical port dimensions: 12 mm high x 10 mm wide
- Probes accepted: Series 400 or Series 500
- Cuvette z-height: 15 mm

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

2.2. Measurement Category

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

2.3. Pollution Degree

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

2.4. Overvoltage Category

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

2.5. Environmental Conditions

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

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

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

2.6. Electrical Specifications

Mains Supply

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

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

All power supplies for the **TC 1** Temperature Controller must be single-phase, AC voltage, three-wire system (active, neutral, earth) and should be terminated at an appropriate power outlet receptacle that is within reach

of the power cord. For safety reasons, a separate power outlet receptacle should be provided for each unit in the system. The use of extension cords or outlet adaptors is not recommended.

WARNING

Shock Hazard - Danger of electrocution. Good electrical grounding is essential to avoid potentially serious shock hazards. A 3-wire outlet with ground connection must be provided for the **Luma 40**. Make certain that power outlets are earth-grounded at the grounding pin.

CAUTION

Caution - Never connect or disconnect any cables while the **Luma 40**/**TC 1** Temperature Controller is switched on. Damage to the printed circuit boards may occur.

2.7. Computer Requirements

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

3. Installing, Starting and Stopping the QNW Luma 40

3.1. Installing the QNW Luma 40

Unpacking

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

Note: The **Luma 40** may have been already installed in the spectrophotometer by its manufacturer.

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

You should have received:

- 1x **Luma 40** Cuvette Holder with panel
- 1x opaque lid
- 17x optical slits/blanks
- 1x **TC 1** Temperature Controller
- 1x submersible pump
- 1x bucket for submersible pump
- 1x power cable
- 1x USB cable (if ordered)
- 1x CD containing **T-App** software (if ordered)
- 1x magnetic stir bar
- 1x $\frac{1}{8}$-inch diameter vinyl tubing to connect water and gas
- This manual

Note: Any additional accessories ordered are not listed here.

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

Installing the QNW T-App Software

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

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

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

Figure 3. Submersible pump, bucket, electrical cable, and vinyl tubing for the **Luma 40**

Installing the QNW Luma 40 Hardware

1. Remove the existing sample holder from the spectrometer. Install the **Luma 40** into the sample compartment and secure it in place.
2. Position the bucket to within 75 cm (30 in) above or below the spectrometer.

CAUTION

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

3. OPTIONAL - If a gas such as nitrogen is to be used as dry gas for minimizing condensation at low temperatures, secure the tank to a solid object in the vicinity of the spectrometer.

CAUTION

Caution – When using dry gas do prevent condensation on the cuvette, ensure that the working area is adequately ventilated.

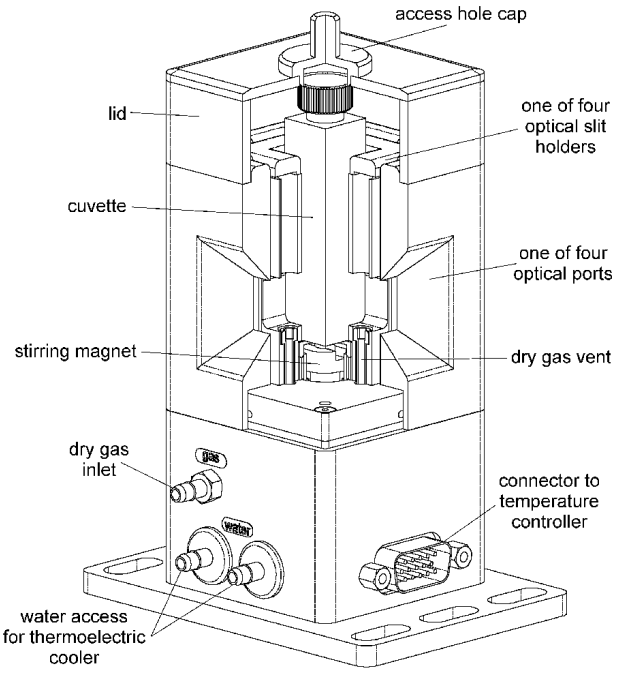


Figure 4. Luma 40 utility connections and features.

4. Cut the $\frac{1}{8}$-inch vinyl tubing provided into two lengths (three if you will be using the dry gas purge). Attach one length of tubing from the hose barb of the submersible pump, shown in Fig. 3, to either one of the water hose barbs on the **Luma 40**, labeled "water access for thermoelectric cooler" in Fig. 4. Attach another piece of tubing from the second **Luma 40** water hose barb to the bucket to serve as a drain tube. Add water to the bucket and lower the pump into the bucket, making sure that the pump is below the water line. Using the electrical cable from the pump, connect the pump to the socket on the back of the **TC 1** Temperature Controller. The pump will start automatically when the **TC 1** is operated later.
5. OPTIONAL - If you plan to work at low temperatures, connect a source of dry gas (typically nitrogen) to release upon the cuvette windows. Attach a length of tubing with $\frac{1}{8}$-inch inside diameter to the dry gas hose barb labeled "dry gas inlet" on the base of the **Luma 40** (see Fig. 4). Set the dry gas flow rate to about 50 cc/min.
6. Connect the **Luma 40** electrical cable to the 15-pin, VGA-type connector labeled "Sample" on the back of the **TC 1** Temperature Controller.
7. Plug the power cable into the back of the **TC 1** Temperature Controller and into a wall socket.

CAUTION

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

3.2. Starting the QNW Luma 40

1. Place the magnetic stir bar in a standard 1 x 1-cm square cuvette. Insert a liquid sample into the cuvette.
2. Place the cuvette in the **Luma 40**.
3. OPTIONAL – Use the provided optical slits or blanks around the cuvette in a manner that correctly limits the excitation and emission light. The slits and blanks are discussed in Section 4.1 below.
4. Place the plastic lid on the cuvette holder.
5. OPTIONAL - If you wish to monitor the temperature inside the cuvette, plug a standard Series 400 or Series 500 thermistor probe (not provided) into the ¼ - inch phone jack labeled "probe" in the back panel of the **TC 1**. Place the end of the probe in a region of the sample in the cuvette where it will not occlude the spectrometer light beam.
6. Turn on the **TC 1** controller using the switch on the back panel. On the **TC 1** front panel, press once on the right-arrow button and once on the SET button. These two steps turn on the pump by turning on the temperature control. (The pump runs only when the temperature control is turned on).
7. Check for water leaks.
8. Check that water is flowing from the free tubing end. If it does not, lift the pump off the bottom of the bucket, but not out of the water, and drop it. This usually will get the flow started. If it does not after several tries, lift the pump up close to the water surface and let a small drop of liquid detergent land in the water close to the pump intake.
9. For now, turn the **TC 1** power off.

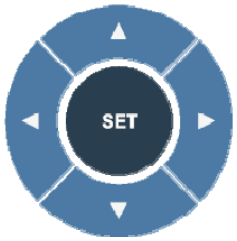


Figure 5. **TC 1** Menu Button

10. Use the left or right arrows on the Menu Button, shown in Fig. 5, to cycle through the four pages of options. These options are described in detail in Section 4.3 below. To turn on stirring and set a temperature, go to the Set Stirring page, use the up and down arrows to set a speed or let it default to 1200 rpm, and press SET to start the stirrer. Then go to the Set Target Temperature page and use the up and down arrows to set a target temperature, for example, 37.0 °C. Press SET to initiate temperature control. The temperature will then change and stabilize.

3.3. Stopping the QNW Luma 40

1. While temperature control is running and the Start page is being displayed, press SET (Fig. 5) to turn off temperature control. To turn off stirring, go to the Set Stirrer page and press SET again.
2. After measurements are completed, turn off power on the back of the **TC 1** controller. This action should power off both the **TC 1** and the **BATH 10** pump, if used. If you are using a circulator pump other than the **BATH 10**, power it off at this time.

4. Step-by-Step Instructions for Using the QNW Luma 40

4.1. Instrument Overview

The **Luma 40**, shown in Fig. 1 and Fig. 4, is a Peltier-effect thermostatting system for standard, square cuvettes (10-mm pathlength) to be used in a fluorescence spectrometer**.** The Peltier effect is based on the reverse thermoelectric effect, a phenomenon in which a temperature difference is caused by a flow of current through a closed circuit consisting of two different metals. The cuvette requires approximately 2 mL of sample for analysis, which can be stirred using a magnetic stirrer while the absorbance measurement is taking place. A microcuvette having internal dimensions less than 10 x 10 mm may also be used, but magnetic stirring would not be possible with this smaller cuvette.

The **Luma 40** is a 4-window cuvette holder designed for fluorescence measurements. Rapid and precise temperature changes may be made throughout the range of -40 to +110 ºC. Variable speed magnetic stirring is provided as well as dry gas purge on the four windows of the cuvette. An opaque lid enhances control of the gaseous environment around the cuvette and reduces light leakage. A variety of optical slits (shown in Fig. 6) are provided to use as apertures for the excitation or for the emitted light.

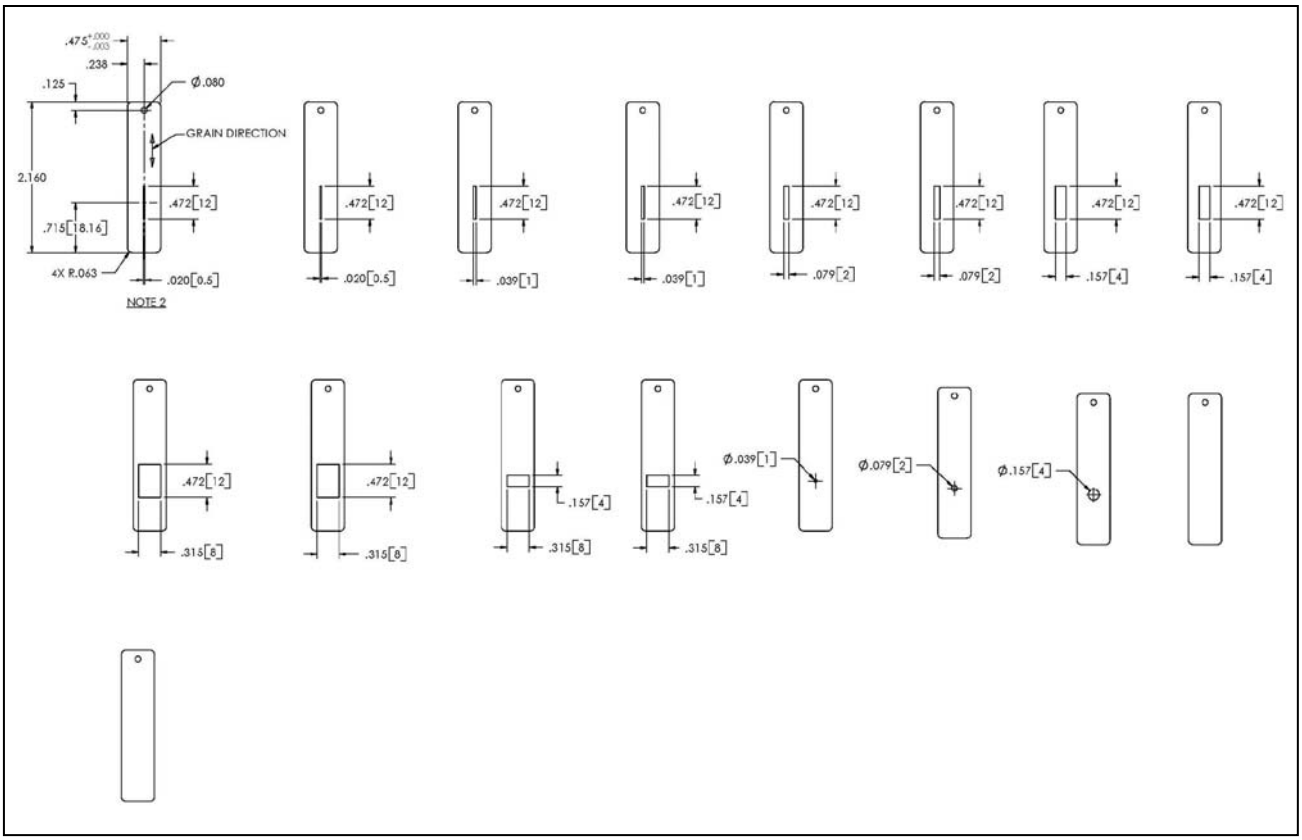


Figure 6. Optical slits and blanks (quantity=17) provided with the **Luma 40**.

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

4.2. Detailed Instructions

Using the Menu Button control arrows

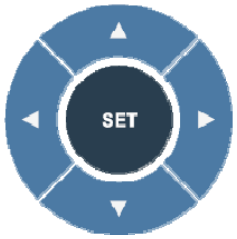


Figure 7. **TC 1** Menu Button control arrows

Refer to Fig. 7 for the appearance of the **TC 1** Menu button. Use the right and left arrows to cycle through four pages:

– Display – Set Target Temperature – Set Stirring – Set Ramping –

Display

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

Figure 8. Example **TC 1** Display page for a single cuvette holder and external probe, with temperature

Display: This main page shows the actual cuvette *Holder* temperature, the *Target* temperature and a *Probe* temperature (if a probe is present). The page also shows whether the *Ramp* and *Stir* functions are on or off. After a few seconds of inactivity, all other pages will revert back to the **Display** page.

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

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

Set Target Temperature

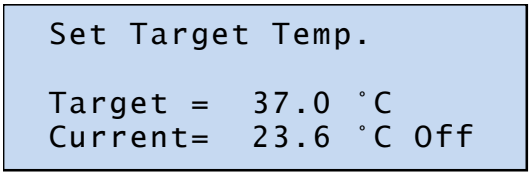


Figure 9. **TC 1** Set Target Temperature page

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

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

Set Stirring

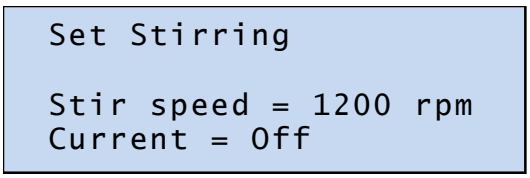


Figure 10. **TC 1** Set Stirring page

Set Stirring: To turn on magnetic *Stirring*, use the up and down arrows to choose an approximate stirring speed between 200 and 2000 rpm. Press **SET** to set the speed and initiate stirring. The page will update to show the *Current* value to be the same as *Stir speed*.

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

Set Ramping

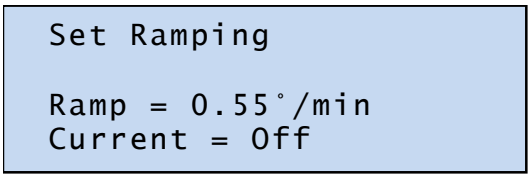


Figure 11. **TC 1** Set Ramping page

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

The fastest possible ramp is determined by how fast the cuvette holder is able to reach the target temperature without ramping. Attempting to ramp too quickly, especially at high and low temperature extremes, will result in a nonlinear ramp. The slowest ramp that may be set on this page is 0.09 °C/minute. (If needed, much slower ramps may be set through software commands.)

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

4.3. Cooling Water for the Peltier

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

A source of water (or other cooling fluid) must be connected to the $\frac{1}{8}$-inch hose barbs on the side of the **Luma 40**. The QNW **BATH 10** includes a submersible pump, the appropriate fittings for connecting tubing, and a plastic bucket. Connect the pump to the **Luma 40**, place it in the bucket with water, and run a return tube to the bucket. A more robust pump is available as the **BATH 100**, although the larger pump has a higher wattage and tends to heat the water when used for extended periods of time.

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

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

CAUTION

Caution - Do not exceed an input water pressure of 25 psi (1.7 bar), as damage may occur inside the **Luma 40**.

Note: The heat exchanger and hose barbs are brass, and the tubing inside the **Luma 40** is vinyl. Be sure that any circulating fluid used, other than water, will not corrode these materials.

The temperature of the heat exchanger in the **Luma 40** is monitored using a thermistor. If the temperature exceeds 60 °C, then temperature control is shut down to prevent damage to the Peltier element and the warning, "check coolant flow," displayed on the **TC 1** temperature controller. This will happen if the circulating fluid gets too warm and/or is restricted in flow. The heat exchanger temperature may be accessed by computer through the RS 232 or USB connections on the back of the **TC 1** Temperature Controller.

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

4.4. Dry Gas to Minimize Condensation

Dry gas flows into the **Luma 40** via the hose barb labeled "gas" in the base of the unit. It passes up through holes below the optical ports in the cuvette tower to fill the space between the cuvette and the optical mask, preventing condensation on the surface of the cuvette.

Note: A flow of dry gas is necessary any time the **Luma 40** is controlled below the dew point temperature present on the inside of the sample compartment of the spectrometer. For ambient air, this would typically be about 5 °C.

4.5. External Temperature Probe

A ¼-inch phone jack labeled "Probe" can be found on the back panel of **TC 1** Temperature Controller. This jack will accept the plug on a standard Series 400 or Series 500 thermistor probe (Item# EW-08484-00 available from Cole Parmer). When a probe is plugged into the jack, the probe temperature is presented on the display of the **TC 1**. Place the probe in the sample to measure the actual temperature of the sample, which will lag in time from the temperature of the cuvette tower.

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

4.6. External Computer Control

All functions may be accessed either through a Serial (RS 232) or a USB located on the back of **TC 1** Temperature Controller. You may write your own program or purchase the QNW application program **T-App**. **T-App** will plot temperatures of the probe, cuvette tower, and even the Peltier element heat exchanger *vs*

time. It will also permit you to set up temperature ramps. If you wish to do your own programming, please see the Appendix for communication instructions and the set of text commands that may be used and responses to the commands.

4.7. Working at Extended Temperatures

Not applicable for this product.

4.8. Troubleshooting

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

If the **TC 1** display indicates that there is inadequate coolant (see section 4.13), it may be that the circulating water is too warm. Add ice to the water to cool it down.

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

4.9. Error Messages

When errors occur, the line 1 of the **TC 1** Temperature Controller display presents an error code. Line 3 of the display identifies the error and line 4 of the display presents possible solutions. The most common events that cause errors to be displayed are loose cables or inadequate coolant flow. For errors not easily solved, contact QNW at www.qnw.com/contact-us/ or service@qnw.com.

Specific error messages include the following.

---

5 – cell out of range

warnings: loose cable, sensor failure

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

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6 – cell out of range

warnings: loose cable, check cable

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

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7 – heat exchanger error

warnings: loose cable, sensor failure

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

8 – inadequate coolant

warnings: inadequate coolant, water temperature

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

9 – Invalid command

The controller has been sent an invalid text command.

5. Maintenance and Spare Parts

5.1. Maintenance

The **Luma 40** and **TC 1** Temperature Controller require very little routine maintenance on the part of the user. For routine cleaning of exposed surfaces, use only a cloth dampened with water or diluted detergent. Do not use organic or abrasive solvents.

CAUTION

Caution – Any action which makes it necessary to open the **Luma 40** or **TC 1** Temperature Controller units must be executed only by QNW technicians or authorized personnel.

The water hoses and their attachments to the **Luma 40**, **TC 1** Temperature Controller, and submersible pump should be inspected prior to each usage to ensure that they are intact. Replace the nylon tubing when it becomes discolored or cracked. Periodically replace the water stored in the bucket to minimize the growth of microorganisms. When not in use, the pump, bucket, and tubing may be stored dry.

5.2. Spare Parts

Vinyl tubing and magnetic stir bars may be obtained from a variety of commercial vendors. For electrical cables to be used with **Luma 40** and **TC 1** Temperature Controller and submersible pumps, please contact QNW at service@qnw.com.

Appendix – Serial Communications for the TC 1 Temperature Controller

This document provides the serial communications protocols for version 1.0 of the firmware on the **TC 1** family of controllers used for the **Luma 40**.

All functions of the temperature controller can be managed from a computer, using the command set described below. If you purchased your unit as a component of a spectrometer from certain manufacturers, this feature may be implemented through traditional RS232 serial connectors on the computer or the spectrometer and on the controller. In this case they will be connected by a standard 15-pin serial extension cable (male connector on one end and female on the other). No driver installation should be needed.

Otherwise the serial linkage will be established through a USB connection between the computer and the controller. In this case the controller includes electronics which convert the USB connection to a serial communications port. However, for the port to be available to programs on the computer it will be necessary to load driver software. It is important that the driver software be loaded before connecting a USB cable between the controller and the computer. Contact Quantum Northwest at support@qnw.com for further information. Quantum Northwest can provide a control program written specifically for control of all functions of the temperature controller. Ask for program **T-App**.

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

1. Identify

`[F1 ID ?]`	What is the ID number of the sample holder being controlled?
`.....[F1 ID 14]`	Sample holder is a **t2, Luma 40,** or other single cuvette sample holder.

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

Assigned Identities:

ID = 00 – specialty sample holder
14 – t2
24 – t2x2
34 – turret6 or other multi-sample holder

2. Controller Firmware Version

[F1 VN ?]	What is the version number of the controller firmware?
......[F1 VN 1.00]	The controller is operating firmware version number 1.00.

3. **Stirrer**

[F1 MS ?]	What is the maximum stirrer speed?
......[F1 MS 2500]	The maximum stirrer speed is 2500 rpm.
[F1 LS ?]	What is the lowest stirrer speed?
......[F1 MS 300]	The lowest stirrer speed is 300 rpm.
[F1 SS S 1000]	Set stirrer speed to 1000 rpm.
[F1 SS S 0]	Turn stirrer off and set the speed to zero.
[F1 SS +]	Turn stirrer on and set it to the most recent non-zero stirrer speed setting.
[F1 SS -]	Turn stirrer off.
[F1 SS ?]	What is the current stirrer speed setting?
......[F1 SS 1000]	Stirrer speed setting is 1000 rpm.

4. Temperature Control

[F1 TC +]	Turn temperature control on.
[F1 TC -]	Turn temperature control off.

5. Target Temperature

[F1 TT S 23.10]	Set target temperature to 23.10 ºC.
[F1 TT ?]	What is the current target temperature?
......[F1 TT 71.32]	Target temperature is 71.32 ºC.
[F1 TT +]	Turn on automatic reporting of manual changes to the target temperature.
[F1 TT -]	Turn off automatic reporting of manual changes to the target temperature.
[F1 MT ?]	What is the maximum target temperature allowed?
......[F1 MT 110]	The maximum target temperature allowed is 110 ºC.
[F1 LT ?]	What is the lowest target temperature allowed?
......[F1 LT -40]	The lowest target temperature allowed is -40 °C.

6. Instrument Status

[F1 IS ?]	What is the current instrument status?
......[F1 IS 0-+S]	Response is four parameters: -number of unreported errors is 0 (0 to 9)

−stirrer is off (+ is on, - is off)
−temperature control is on (+ is on, - is off)
−temperature is stable (S is stable, C is changing)

[F1 IS +]	Automatically report instrument status whenever it changes (e.g., due to manual changes at the controller)
[F1 IS −]	Stop automatic reports of instrument status.
......[F1 IS R]	The controller has been powered off and back on again.

7. Current Sample Temperature

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

8. Error Reporting

[F1 ER ?]	Report the current error.
......[F1 ER 0]	No current error.
......[F1 ER 5]	Cell T out of range (Loose cable? Sensor failure?).
......[F1 ER 6]	Cell & heat exchanger T out of range (Loose cable?).
......[F1 ER 7]	Heat exchanger T out of range (Loose cable? Sensor failure?).
......[F1 ER 8]	Inadequate coolant (check flow). Temperature control has shut down.
......[F1 ER 9 <<bad command>>]	Syntax error on a preceding command where <<bad command>> is the command that caused the syntax error.
[F1 ER +]	Automatically report errors when they occur.
[F1 ER −]	Stop automatic error reports.

9. Probe Status and Temperature

[F1 PS ?]	Is there an external temperature probe connected?
......[F1 PR +]	A probe is connected.
......[F1 PR −]	No probe is connected.
[F1 PS +]	Enable probe status to be sent automatically when a probe is installed or removed. This is the default.
[F1 PS −]	Disable automatic sending of probe status.
[F1 PT ?]	What is the current probe temperature?
[F1 PT +3]	Periodically report the probe temperature every 3 seconds.

`......[F1 PT 22.3]`	The current probe temperature is 22.3 degrees.
`......[F1 PT NA]`	Probe temperature is not available.
`[F1 PT -]`	Stop periodic probe temperature reports.
`[F1 PA S 0.5]`	Set the increment for automatic reporting of the probe temperature to 0.5 degrees during a ramp. (Increment must be positive, without sign in tenths between 0.1 and 9.9 degrees, and will work for ramps going up or down.)
`[F1 PA +]`	Start automatic reporting of probe temperature every temperature increment (set by the command above).
`......[F1 PT 30.5]`	The current probe temperature is 30.5 degrees.
`[F1 PA -]`	Stop automatic reporting of probe temperature every temperature increment.
`[F1 PX +]`	Change probe temperature returned to a precision of 0.01 degree.

10. Temperature Ramping

`[F1 RR S 2.10]`	Set the ramp rate to 2.10 °C/minute.
`[F1 RR ?]`	What is the current ramp rate?
`......[F1 RR 2.10]`	Current ramp rate is 2.10 °C/minute.

For the following three commands, there are no corresponding reference commands ([R1 . . .]; see command class 13).

`[F1 TL +]`	Ramp the sample and reference identically.
`[F1 TL -]`	Ramp the sample while the reference remains stable.
`[F1 TL 0]`	Ramp the sample and reference independently.

The default is to ramp the sample while the reference remains stable. Ramping both the sample and reference at different rates or to different target temperatures (see below) is not possible.

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 you are done, set the ramp rate to 0. Otherwise, setting a new target temperature later will initiate a ramp to that target temperature.

Notes:

The minimum settable ramp rate is 0.01 °C/minute.

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

When the ramping process is completed the controller will send a response of the form [F1 TT #] as a notification of the end of the ramp. This response can be blocked at any time by previously sending the command [F1 TT -] (see command class 5).

11. Heat Exchanger Temperature

[F1 HL ?]	What is the high temperature limit for the heat exchanger?
......[F1 HT 60]	The heat exchanger high temperature limit is 60 ºC.
[F1 HT ?]	What is the current temperature of the heat exchanger?
......[F1 HT 39]	The current heat exchanger temperature is 39 ºC.
[F1 HT +3]	Start periodic heat exchanger temperature reports every 3 seconds.
[F1 HT -]	Stop periodic heat exchanger temperature reports.

12. Cell Changing

These commands will have an effect only for a sample holder with multiple cuvette positions.

[F2 DI]	Device initialize: move to home position.
[F2 PI]	Device initialize: move to home position and reply when done.
......[F2 DL 1]	Device is finished moving.
[F2 DL 3]	Device locate: move to position 3. (Device should be initialized prior to using this command for the first time.)
[F2 PI]	Device initialize: move to home, then to position 1 and reply when done.
......[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 DD 400]	Set speed to 400 (acceptable range 100 – 900, with a default of 500).

13. Reference Cuvette

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

[R1 ...]

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

If you wish to ramp the temperature of the reference and sample cuvettes together, please note the linking command, [F1 TL +], in command class 10.

14. Specialty Sample Holder

For a Specialty Sample Holder (ID = 00) controlled by a TC 1, there will be a second response to the [F1 ID ?] command.

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

`.....[F1 ID 00]` Sample holder is a **Specialty Sample Holder**

`.....[F1 FS (+/–)(+/–)(+/–)(+/–)(+/–)]`

This response will automatically follow the `[F1 ID 00]` response. It defines the Functional Status (functionality) of the holder through its five (+/-) parameters. Each parameter defines whether the holder has (+) or does not have (–) the functionality as defined in the table below.

parameter #	functionality
1	Temperature Control
2	Stirring Control
3	External Probe
4	Multiple Sample Positions
5	Reference Holder

As appropriate to the functionality, the commands and responses in command classes 2 – 13 will also be available.

15. Control of Automatic Reports

The TC 1 can be controlled manually using the buttons and the display on the front. When a computer program is in use, the TC 1 will automatically send reports to the program whenever a manual change has been made. The commands in this section are intended to allow the program to prevent the TC 1 from sending those automatic reports.

`[F1 XX R(+/-)]` Stop (R-) or start (R+) reporting all manual changes, including those starting with [R1 and [F2.

By replacing the XX with individual command codes, a program can selectively stop or start reporting of manual changes.

`[F1 SS R-]` Stop reporting manual changes for the sample stirrer.

`[F1 TC R-]` Stop reporting manual changes for the sample temperature control.

`[F1 TT R-]` Stop reporting manual changes for the sample target temperature.

`[F1 PR R-]` Stop reporting manual changes for the external probe connection.

`[F1 RR R-]` Stop reporting manual changes for the sample ramp rate.

`[F2 PL R-]` Stop reporting manual changes for the sample position.

`[R1 SS R-]` Stop reporting manual changes for the reference stirrer.

[R1 TC R-]	Stop reporting manual changes for the reference temperature control.
[R1 TT R-]	Stop reporting manual changes for the reference target temperature.
[R1 RR R-]	Stop reporting manual changes for the reference ramp rate.