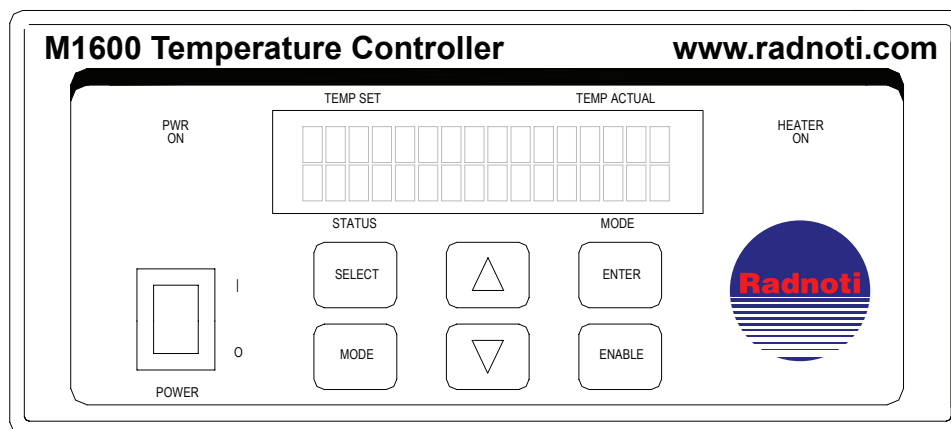

Radnoti Glass Technology, Inc.

M1600

Temperature Controller

Operating Manual



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Description:

The M1600 Temperature Controller is a bench-top controller intended for use with resistive heating elements rated up to 18 Watts. This general purpose instrument can drive various types of heaters including foil and resistive coil types. It accepts feedback from either positive or negative temperature coefficient thermistors, has programmable P, I, and D gains, and will display the temperature in either degrees C, K, or F. In addition it can be programmed for up to five sequential temperature settings along with associated ramp and hold times for each level. A user programmable maximum temperature limit provides protection to the device being heated and a user programmable power limit protects the heating element from being over driven.

Capable of stand-alone operation from a simple keypad interface, these units can also operate over an RS232 connection using our M1600 Application program, LabView® driver, LabWindows® driver, or a simple command line interface from any terminal window.

Specifications:

Parameter	Min	Typ	Max	Unit
Input Voltage (note 1)	100		240	VAC
Input Power			25	VA
Output Power			18	Watts DC
Compliance Voltage			24	VDC
Temperature Control Range (note 2)	20.0		200.0	°C
Set-point Resolution	0.1			°C
Actual Temp. Display Accuracy (note 3)		+/-0.1	+/-0.5	°C
Temperature Stability, 24 hour (note 4)		+/-0.1		°C

1 – Universal input 50-60Hz, no line switching required.

Unit is supplied with a 115V parallel blade line cord for North American use only. For all other applications use an IEC 320 compatible line cord fitted with a plug appropriate for your particular AC wall socket.

2 – Heating mode only. Ambient temperature must always be less than set-point temperature.

3 – Does not account for errors due to sensor tolerances.

4 – Accuracy is strongly dependant on the individual heating system and P, I, and D gain parameters.

Parameter	Unit
Sensor Types (note 3)	Platinum 100 Ω , Platinum 1000 Ω , NTC10K
Output Connector	HIROSE HR10A-7R-6S
Serial Interface	RS232C – DB9
Dimensions	Length: 11.5" (292mm) Width: 5.3" (135mm) Height: 3.0" (76mm) Weight: 5 lbs.



Attention – Please consult this User's Manual whenever this symbol is encountered on your M1600 Temperature Controller.

Conventions used in this manual: Throughout this manual all references to temperature are made with respect to degrees Celsius even though the M1600 can be configured to display degrees C, K, or F.

Front and Rear Panel Features:

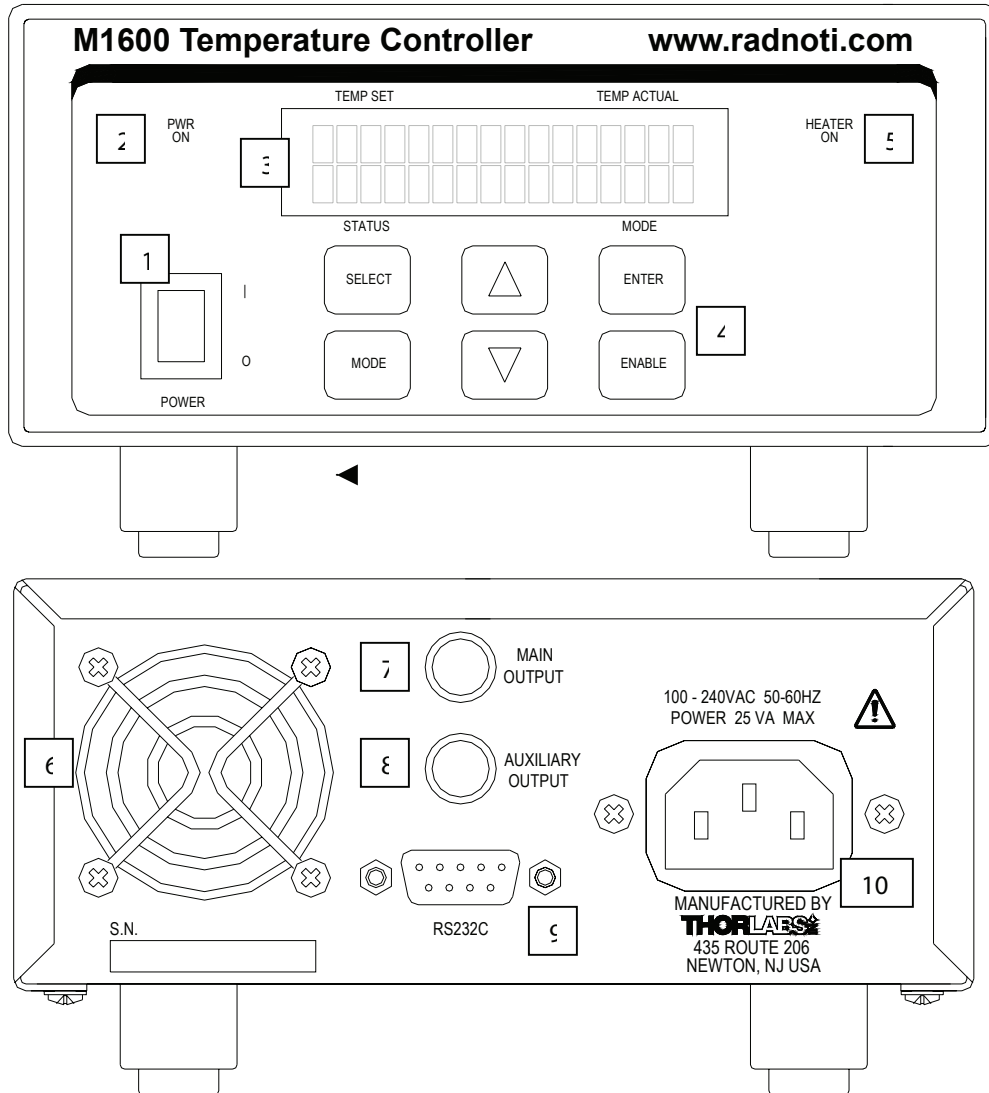


Figure 1 - Front and Rear Panel Features

- 1) Power Switch – Turns the unit On and Off.
- 2) Power On Indicator – When this text is lit, power is applied to the unit.
- 3) LCD Display – Provides status and temperature information when in Main Screen (as shown). Various programmable mode screens are accessible via the Mode Keypad. See Navigating the Front Panel” below.
- 4) Keypads – Used to adjust the temperature set-point (Temp Set), Enable and Disable the output, and navigate through the various Mode screens.
- 5) Heater On Indicator – When this text is lit, the output relay is energized and the heater controller is enabled. Note: there are situations where the indicator (and relay) will NOT be on, yet the heater controller is still enabled – See “Maximum Temperature Shutdown” below.
- 6) Cooling Fan .

- 7) **Main Output** – Use this output to connect to the heating system. See Appendix A for connector information.
- 8) **Auxiliary Output** – This output is intended for use only with Thorlab's GCH Gas Cell Heaters. It provides and unregulated output current proportional to the Main Output current.
- 9) **RS232C DB9 Connector** – Use this connector for all serial interface connections.
- 10) **AC Input Connector**.

Operating Features:

- 1) **Programmable Proportional (P), Integral (I), and Derivative (D) gain settings.** The P, I, and D gains can each be set to values from 0 to 250 (I and D) and 1 to 250 (P gain only). These values indicate representative shares of each gain stage, not absolute gain values (which are fixed internally). Adjust each of the gains accordingly to effect the best response from the particular heating system being controlled.
- 2) **Automatic Offset Tune** – Often times P, I, D controllers do not (or will not) perform as one would hope, leaving either an offset value or constant oscillations about the set-point. In order to allow tuning the output of the M1600 exactly to the set-point value without having to adjust with the P,I, and D controls we have provided the TUNE function. Ideally the I gain and D gain settings should be set to 0 (zero) and only the P gain should be adjusted to provide a stable temperature. Once the temperature has reached it maximum value (which should be slightly less than the set-point), enabling the TUNE function will digitally calculate the offset and adjust the output to meet the set-point.
- 3) **Selectable Resistive Sensors** – The M1600 allows the use of three different types of resistive temperature sensors. Platinum PT100 and PT1000 resistors with Positive Temperature Coefficients (PTC), and standard Negative Temperature Coefficient 10K resistors (NTC). When selecting NTC10K as the sensor you can also enter the Beta value for the device to provide more accurate operation. The default Beta value shipped with the unit is 3970. See Appendix B for more information on the sensors.
- 4) **Maximum Temperature Limit** – A value for a Maximum Temperature limit can be programmed into the M1600. "TMAX" can range from 20.0 to 205.0 °C. The Set-point value is limited to a maximum of TMAX or 200.0 °C, which ever is lower. If TMAX is set to a value that is below the current set-point temperature then the set-point will automatically be lowered to the TMAX value, as will all Stop Temperatures greater than TMAX that are programmed into the cycle parameters.
- 5) **Maximum Power Limit** – A value for a Maximum output power can be programmed into the M1600. Based on a maximum output voltage of 24 VDC, the PMAX value will provide the proper current limit to the output current source required to limit the maximum power to the heating device.
- 6) **Selectable Temperature Display Units** – All temperature values displayed on the front panel LCD display can be presented in either °C, °K, or °F. Internally the unit operates strictly on °C formats. Due to the conversion factor used, values displayed in °F will not increment at even 0.1° steps, as with °C and °K.
- 7) **Normal vs. Cycle Modes** – Two operating Modes are possible with the M1600. In NORMAL mode the unit operates as a single point controller, maintaining the set-point for as long as the user requires. In CYCLE mode the user can program one to five distinct temperature levels. A "ramp" time, in minutes, can be programmed for each step that determines how long it will take to get from the start temperature to the stop temperature. A "hold" time, in minutes also, can be programmed to determine how long the system will stay at the stop temperature before moving on to the next step. During the course of any step, Cycle Mode can be paused, stopping the ramp or hold timers at their present count. Removing the paused function will resume the cycle at the same point it was paused at.
- 8) **Sensor Alarms** – The M1600 can determine whether a temperature sensing element is short circuited or not installed (open circuit). If this occurs the Temp Actual field in the Main LCD display screen will read !SENSOR! If the sensor alarm occurs during normal operation the output will immediately be disabled. The unit can not become enabled again until the error is resolved. Special Note: The M1600 can only determine shorted or open sensor connections, it can not determine if the installed sensor does not match the programmed sensor selection. Care must be taken to ensure that the settings match the actual sensor used or damage will occur to the heating system!
- 9) **Maximum Temperature Shutdown** – Based on the setting of the TMAX parameter discussed above, if the M1600 reads back a temperature value that equals or exceeds TMAX, the output relay will be opened and !TMAX! will be displayed in the Mode field of the Main display screen. However, the

controller will remain enabled. Once the system temperature reduces down to the set-point value the output relay will re-closed, connecting the controller to the heater again. If the temperature increases past TMAX again the relay will open again. If this cycle occurs three (3) times, on the third time the relay will open and the controller will automatically disable. The TMAX text will continue to be displayed until it is cleared manually by the user by either pressing the SELECT key while in the Main screen, or pressing the Enable Key.

Stand-Alone Operation:

Initial Set-up

- Locate the unit on a dry, level working surface.
- Make sure the **POWER** switch on the front of the unit is in the OFF position (0).
- Plug the female end of the AC line cord provided into the AC Input Receptacle on the rear of the unit. Plug the male end into a properly grounded AC socket.
- Connect the heater to be controlled to the MAIN OUTPUT connector on the rear panel of the unit. Refer to Appendix A for information on proper connections to the output connectors.

Turning ON the Controller

- Press the Power switch to the ON position (|). If the AC line voltage is sufficient and the internal power supply in the unit is fully functional, the PWR ON indicator will light up and the LCD screen will display a brief message stating the model number and the firmware revision. After approximately 2 seconds this message will scroll off of the screen and the “Main” LCD screen will appear.
- The default power-up settings for the Main screen are always Normal Mode, Heater Disabled, the last active Sensor Type used, and the last temperature set-point that was active on the unit. To change these settings see “Navigating the Front Panel” below.
- All parameters from the last working session with the controller will be loaded during unit initialization. These include: PID gain settings, “Tuning” offset, sensor selection – including NTC10K Beta value if applicable, Maximum Temperature TMAX setting, Maximum Power PMAX setting, the last display units used (C, K, or F), and all cycle mode parameters for the five programmable cycle steps.
- If the heater has not been operated yet the Temp Actual field on the LCD display should display a value appropriate for a “cold” system, that is, somewhere around room ambient. If it is noticeably different you should double check that the selected sensor (PTC100, PTC1000, NTC10K) matches the actual sensor used in your heating system.

Enabling the Heater

- Press and release the **ENABLE** keypad on the front panel to turn ON the Heater. At this time the Heater ON indicator will immediately light up. If not see Appendix C – Troubleshooting.
- If successfully enabled the Status field in the LCD screen will read “ENABLED” and the Mode field will read either “NORMAL” or “CYCLE” depending on the particular mode chosen.

Adjusting the Temperature in Normal Mode

- The set-point temperature can be changed at any time while in Normal Mode, whether the controller is enabled or not, simply by pressing the Up or Down arrow keypads. Pressing the Up arrow will increment the temperature by 0.1 degree, while pressing the Down arrow will decrement the temperature by 0.1 degree. As with all of the numeric adjustments that can be done on the M1600, holding the arrow keys down will cause the rate of increase or decrease to accelerate the longer the arrow key is held down.

Turning the Heater OFF

- When necessary, the heater output can be turned OFF by either pressing and releasing the **ENABLE** switch, or pressing the **POWER** switch to the OFF (0) position (which will turn off the entire unit).

- The heater will also turn off immediately if a shorted or open temperature sensor is detected. In that case !Sensor! will be displayed on the LCD screen.
- Whenever the unit is ON and the heater is not enabled the status will be indicated with “DISABLED” on the LCD and the HEATER ON indicator will be turned off.

Navigating the Front Panel:

Overview

- The front panel contains six keypads that can be used for various functions depending on what menu screen is actively displayed.
- The Main screen displays the selected temperature sensor, the basic operating mode Normal or Cycle, the current Temperature Set-point, the current Actual Temperature, and various status messages such as ENABLED, DISABLED, !TMAX!, and !SENSOR! alarms.
- There are five (5) “Mode” screens: PID parameters, Sensor Select, TMAX/PMAX values, Units Display Mode (C, K, or F), and Normal vs. Cycle Mode.
- There is a sixth sub-menu for programming the Cycle Mode parameters Stop Temp, Ramp Time, and Hold Time.
- Use the MODE keypad to access the “mode” screens.
- While a menu is displayed use the SELECT keypad to move the flashing cursor to the various selection options.
- Pressing the ENTER key while in the MAIN screen and Normal Mode has no effect.
- Pressing the ENTER key while in the MAIN screen and CYCLE Mode will PAUSE the cycle. See “More about Cycle Mode” below.
- Pressing the ENTER keypad while in a mode menu screen will accept and save the option that corresponds to the flashing cursor, and advance you to the next menu screen or back to the MAIN screen depending on the situation.
- Use the UP and DOWN keypads to change the set-point temperature while in the MAIN screen.
- Use the UP and DOWN keypads to change numerical options while in any of the “mode” screens.
- Pressing the MODE key at any time while in a mode menu will do one of the following:
 - If you are in the PID Mode screen, pressing the MODE key will advance to the Sensor Select menu without changing any of the current PID values.
 - If you are in the Sensor Select screen, pressing the MODE key will advance to the TMAX/PMAX screen without changing the sensor selection.
 - If you are in the TMAX/PMAX screen, pressing the MODE key will advance to the Display Units Selection screen without changing the units.
 - If you are in the Display Units Selection screen, pressing the MODE key will advance to the Normal vs. Cycle Modes screen without changing the units selection
 - If you are in the Normal vs. Cycle Modes screen, pressing the MODE key will advance to the Main screen without changing the Operating Mode selection.
- Pressing the ENABLE key at any time, in any screen*, will either Enable or Disable the heater, depending on its current status. * While in the cycle parameters screen you can only Disable the heater.

Selecting and Adjusting the Gains – P, I, D and TUNE

- To change the P, I, or D gains:
 - While in the Main Screen press the MODE keypad once.
 - The screen will now display the P, I, and D values as well as the text “TUNE” or DETUNE”.
 - The cursor will be flashing over the “P” for the proportional gain value.
 - Adjust the P gain using the UP or DOWN arrow keys. The P gain is adjustable from 1 to 250.
 - Press the SELECT Key to move the cursor to the “I” for integral gain.
 - Adjust the I gain using the UP or DOWN arrow keys. The I gain is adjustable from 0 to 250.
 - Press the SELECT Key to move the cursor to the “D” for derivative gain.
 - Adjust the D gain using the UP or DOWN arrow keys. The D gain is adjustable from 0 to 250.

- Press the MODE keypad to escape to the next mode screen (sensor select) without making any changes to the current parameters.
- OR press the ENTER key to accept any changes made to the P, I, or D values and return to the MAIN screen. NOTE: The PID screen is the only Mode screen that will return directly to the MAIN screen upon pressing the ENTER key. All other mode screens will save changes and advance to the next mode screen.

■ To Activate or Deactivate the TUNE function:

- The TUNE function is only accessible in NORMAL mode when the heater is Enabled. It cannot be accessed at any time in CYCLE mode or when the heater is disabled.
- While in the Main Screen press the MODE keypad once.
- The screen will now display the PID values and TUNE or DETUNE depending on the status of the TUNE function.
- Press the SELECT key three times to advance to the TUNE/DETUNE text.
- Press the ENTER keypad once.
- The MAIN screen will now be displayed.
- Please refer to “More about the TUNE Function” below for more information on tuning the M1600.

Selecting the Temperature Sensor – PTC100 vs. PTC1000 vs. NTC10K

■ To program the appropriate temperature sensor:

- While in the Main Screen press the MODE keypad TWICE.
- The screen will now display PTC100, PTC1000, NTC10K, and the BETA value.
- The cursor will be flashing over the “P” for PTC100.
- Pressing the ENTER key at this time will select the PTC100 and advance you to the next MODE screen (TMAX/PMAX).
- Otherwise press the SELECT Key to move the cursor to the “P” for PTC1000.
- Pressing the ENTER key at this time will select the PTC1000 and advance you to the next MODE screen (TMAX/PMAX).
- Otherwise press the SELECT Key to move the cursor to the “N” for NTC10K.
- Pressing the ENTER key at this time will select the NTC10K and advance you to the “B” for the Beta value within the same MODE screen.
- Use the UP/DOWN keys to adjust the Beta value in increments of 10 from 2000 to 6000. For entering exact Beta values see “The Command Line Interface” or “The M1600 Application Software” below.
- Pressing the ENTER key at this time will accept the Beta value and advance you to the next MODE screen (TMAX/PMAX).
- Press the MODE keypad to escape to the next mode screen (TMAX/PMAX) without making any changes to the current parameters.
- NOTE: Any attempt to change the sensor while the heater is enabled will immediately disable the heater.

Selecting and Adjusting the Maximum Temperature and Power – TMAX and PMAX

■ To change the TMAX or PMAX values:

- While in the Main Screen press the MODE keypad three times.
- The screen will now display the TMAX and PMAX values.
- The cursor will be flashing over the “T” for the TMAX value.
- Adjust the TMAX value using the UP or DOWN arrow keys. TMAX is adjustable from 20.0 °C to 205.0 °C.
- Press the SELECT Key to move the cursor to the “P” for the PMAX value.
- Adjust the PMAX value using the UP or DOWN arrow keys. PMAX is adjustable from 0.1 Watts to 18.0 Watts.
- Press the MODE keypad to escape to the next mode screen (units select) without making any changes to the current parameters.

- OR press the ENTER key to accept any changes made to the TMAX or PMAX values and then advance to the next mode screen (units select).

Selecting the Unit Display Mode – Celsius vs. Kelvin vs. Fahrenheit

- The MAIN screen and various mode screens display various information regarding the output temperature. These values can be displayed as degrees Celsius, Kelvin or Fahrenheit depending on the user's preference.
- To change the format of the temperature display:
 - While in the MAIN screen press the MODE keypad four times.
 - The screen will now display the Units Display menu with the text "CELSIUS", "KELVIN", and "FAHRENHEIT".
 - The cursor will be flashing over the "C" in CELSIUS.
 - Pressing the ENTER key at this time will select Celsius and advance you to the next MODE screen (Normal vs. Cycle Modes).
 - Otherwise press the SELECT Key to move the cursor to the "K" for KELVIN.
 - Pressing the ENTER key at this time will select Kelvin and advance you to the next MODE screen (Normal vs. Cycle Modes).
 - Otherwise press the SELECT Key to move the cursor to the "F" for Fahrenheit.
 - Pressing the ENTER key at this time will select Fahrenheit and advance you to the next MODE screen (Normal vs. Cycle Modes).
 - Pressing the MODE keypad at any time will advance you to the next mode screen without changing the display format.

Selecting the Operating Mode – Normal vs. Cycle

- To change the operating mode:
 - While in the Main Screen press the MODE keypad five times.
 - The screen will now display NORMAL MODE and CYCLE MODE.
 - The cursor will be flashing over the "N" for NORMAL MODE.
 - Pressing the ENTER key at this time will select Normal Mode and advance you to the MAIN screen.
 - Press the MODE keypad to escape to the MAIN screen without making any changes to the current mode.
 - Otherwise press the SELECT Key to move the cursor to the "C" for CYCLE mode.
 - Press the MODE keypad to escape to the MAIN screen without changing to Cycle mode.
 - Pressing the ENTER key at this time will select Cycle Mode and advance you to the Cycle Parameters screen fro Step 1.

Changing the Cycle Parameters

- The Cycle Parameters menu is a sub-menu of the Normal vs. Cycle Mode menu that can only be accessed if Cycle Mode has been selected.
- The Parameters can only be adjusted if the heater is DISABLED. Although you can navigate and review the parameter settings while a cycle is in progress.
- Once you have accessed the Cycle Parameters menu you can make adjustments as follows:
 - Use the SELECT keypad to move the cursor to the parameter that you wish to change....
 The STOP Temperature is located in the upper left, "T=nnn.n".
 The RAMP time is located in the upper right, "Rt=nnn m"
 The HOLD time is in the lower left, "Ht=nnn m"
 And the STEP # is in the lower right.
 - Use the Up and Down arrow keypads to increment or decrement the parameters.

- Use the SELECT Key to advance to the various parameters.
- The valid range for the STOP temperature is 20.0 °C to TMAX or 200.0 which ever is lower.
- The valid range for the Ramp and Hold times is 1 to 999 minutes.
- Pressing the ENTER keypad at anytime will accept the changes and advance you to the next Step's parameter screen. After Step 5 you will be returned to the MAIN screen
- Pressing the MODE keypad at anytime will return you to the MAIN screen without changes.
- NOTE: The cycles will initiate the next time the heater is enabled.

More about Cycle Mode:

- The STOP temperature determines the final temperature that the system will try to go to in the amount of time determined by the RAMP time value.
- The Ramp time is how long it will take to go from a starting temperature to a Stop temperature.
- The Hold time is how long the cycle will stay at the Stop temperature before advancing to the next Step, also know as "dwell time".
- The initial starting temperature is determined to be whatever the TEMP SET value is at the start of a cycle. After that, the Start temperature of the subsequent Step is the Stop Temperature from the previous Step. That is, the Stop temperature for Step 1 will be the Start Temperature for Step 2, and so on.
- The number of Steps can be reduced by programming in the same Stop Temperature for any Steps you don't need. That is, if you only want one cycle that ramps from TEMP SET to the Stop temperature over a certain amount of time, simply program in the same Stop temperature for Steps 2 – 5. Once the STEP 1 Hold time expires the cycle will "jump" over Steps 2 – 5 and resume operation in Normal mode.
NOTE: By the same token, if your starting value for TEMP SET is the same as your Stop value for STEP 1, then Step 1 will appear to be jumped over. If ALL off your Stop values are the same as your TEMP SET value then it will appear as though the cycle never happened.
- During the course of a Cycle the following actions can be taken:
 - While in the MAIN screen, pressing the ENTER keypad at anytime will cause the scan to PAUSE. Once paused the cycle will hold at the current ramp or hold time count and remain there with the heater still enabled. Pressing the ENTER keypad again will cause the scan to resume at the current channel.
 - While in any screen, pressing the ENABLE keypad at anytime will cause the Cycle to terminate completely, turning off the heater, disabling the output, and changing the operating mode to Normal.
 - At no time during an active cycle can the set-point be adjusted from the MAIN screen using the UP/DOWN arrow keys.
 - At no time during an active cycle can any of the cycle parameters be adjusted.
- Cycle Mode will be terminated and changed back to Normal Mode as follows:
 - Letting a cycle completely run its course will change the mode back to Normal and the temperature will remain at the last Stop temperature with the heater still enabled.
 - Pressing the ENABLE keypad during an active cycle will terminate the cycle and disable the heater.
 - From the MAIN screen press the MODE keypad five times.
 - The Normal vs. Cycle Mode menu will come on, with NORMAL MODE as the active selection.
 - Pressing the ENTER keypad at this point will terminate the cycle at the current temperature and return you to the MAIN screen. The heater will remain enabled.

More about the TUNE function:

- The TUNE function is a manually enabled feature that digital calculates the offset between the TEMP SET value and the TEMP ACTUAL value. The offset is only calculated at one time and is not actively adjusted after that point.
- Once the TUNE function is activated the TEMP ACTUAL value should slowly adjust to within 0.1°C of the TEMP SET value. The rate of adjustment and accuracy depends on the PID settings.
- The TUNE function should only be set once the output has reached a final value and has settled completely. Activating a TUNE function while the temperature is changing will result in less than ideal performance.
- If the unit is being DETUNED the output will develop an offset between the set-point and actual temperatures.
- NOTE: For best results the I and D values should be set to Zero (0). The output must be completely settled before starting a TUNE function. If for whatever reason the output needs to be returned you must select DETUNE from the Gains mode screen, wait for the offset to settle out, and then select TUNE again.
- The offset value calculated by any tune function will be saved to memory and will be loaded on the next power up of the unit.
- To determine if an offset value exists from a tuning action simply enter the PID Gains mode screen. If the text reads DETUNE, then there is an offset preset.
- In general the offset should be consistent for a large range of temperatures for the same heating system.
- Adjustments to the P, I, or D gains will affect the offset value and therefore, if the P, I, or D values are adjusted after a tuning action has been done, the offset will be DETUNED.
- The TUNE function can only be set while in Normal Mode. It is not accessible while operating in Cycle Mode. Once an offset is tuned in Normal mode, however, the tuning action will still apply to the target temperatures set in the cycle parameters.

More about the TMAX function:

- The TMAX function allows the user to set a maximum temperature that the control will operate to.
- The TEMP SET set-point temperature will be limited to whatever TMAX is (or 200.0 °C whichever is lowest). If the TMAX value is adjusted to a value lower than the current TEMP SET value, the TEMP SET value will be changed to match TMAX.
- The STOP temperature values in the cycle parameters are limited to whatever TMAX is (or 200.0 °C whichever is lowest). If the TMAX value is adjusted to a value lower than any of the current Stop Temp values, the Stop Temp values will be changed to match TMAX.
- If the M1600 reads back a temperature value that equals or exceeds TMAX, the output relay will be opened and !TMAX! will be displayed in the Mode field of the Main display screen. However, the controller will remain enabled. Once the system temperature reduces down to the TEMP SET set-point value the output relay will re-close, connecting the controller to the heater again. If the temperature increases past TMAX again the relay will open again. If this cycle occurs three (3) times, on the third time the relay will open and the controller will automatically disable. The TMAX text will continue to be displayed until it is cleared manually by the user by either pressing the SELECT key while in the Main screen, or pressing the Enable Key.
- If the temperature stabilizes to TEMP SET after having crossed the TMAX threshold less than three times the !TMAX! alarm will remain active in the MAIN screen display to alert a user to the fact that the system exceeded TMAX momentarily. The !TMAX! display can be cleared by pressing the SELECT key while in the MAIN screen.
- Pressing the SELECT key while in the MAIN screen will always clear the TMAX count and reset the alarm.
- Pressing the ENABLE key at any time with a TMAX alarm present will disable the heater and clear and reset the TMAX alarm.

More about the Sensor Alarm:

- The M1600 can determine whether a temperature sensing element is short circuited or not installed (open circuit). If this occurs the Temp Actual field in the Main LCD display screen will read !SENSOR! If the sensor alarm occurs during normal operation the output will immediately be disabled. The unit can not become enabled again until the error is resolved. Special Note: The M1600 can only determine shorted or open sensor connections, it can not determine if the installed sensor does not match the programmed sensor selection. Care must be taken to ensure that the settings match the actual sensor used or damage will occur to the heating system!
- A common sense approach to verifying the proper sensor is selected is to simply connect a heating system to the unit that has been sitting at room ambient temperature for a while. Observe the TEMP ACTUAL value displayed on the M1600. If the sensor has been properly programmed the display will show a value corresponding to the room ambient temperature.

More about Setting the PID gains:

- The PID gains determine the overall stability and accuracy of the entire heating system. Incorrect values, especially for the Integral gain could result in undesired overshoots and instabilities.
- A good approach to setting these values is to start with a mid-range value for the P gain (125) and set both I gain and D gain to zero (0).
- Enable the heater and observe the response and settling times. Typically the system will undershoot the set-point and settle to a value below TEMP SET. Despite the offset, the temperature should remain rather stable.
- If the temperature offset is too great (> 3-4 degrees) then an increase in P gain might be required.
- The offset can now be adjusted out by setting the I gain to a suitable value. ALWAYS start with a low value (typically less than 10). Observe any changes in the system response after each adjustment to I gain. If the value is too large you will observe overshoot and oscillations about the set-point. If it is too low you will not remove the offset.
- After arriving at a value for I gain, apply a Step function to the system by increasing the TEMP SET value by a few degrees. Observe the response and adjust the gains accordingly.
- The D gain is the hardest to observe any influence on, as it general affects the rate at which the system responds to disturbances. For most small heater systems being controlled by the M1600 a value of zero (0) for the D gain is sufficient for good operation.

Operating From a Computer:

Overview

- The M1600 Temperature Controller is fully operational from a remote computer via an RS232 interface.
- Connection from the computer to the M1600 is made with a standard DB9 “straight through” cable, do not attempt operation using a “null modem” cable.
- The M1600 can be accessed directly using a command line interface and any Terminal Communications software such as HyperTerminal.
- It can also be controlled using the M1600 Application Software provided with the unit.

The Command Line Interface

Setting Up and Connecting

- Connect the M1600 to your computer using a standard DB9 cable connected to an available COM port on your computer and the RS232C connector on the rear panel of the unit.
- Open your terminal interface program and, referring to documentation specific to your program, set up the terminal for the COM Port you have connected to:
 - Baud Rate = 115200 Bits Per Second
 - Data Bits = 8
 - Parity = None
 - Stop Bits = 1
 - Flow Control = None
- Apply AC power to the M1600, turn the M1600 On (See “Turning On the Controller” above), and wait for the unit to complete its power on initialization.
- Press the ENTER key on your computer, if the connection is working you will receive the following message on your terminal:

Command error CMD_NOT_DEFINED

- Followed immediately by the prompt:

>

- The basic command structure consists of two types; commands and queries, both of which are sent to the M1600 by a carriage return (CR) or pressing the ENTER key on the computer.
- Most commands follow a format of :

Command = argument (CR)

Where “command” is a keyword and “argument” is a numerical value always followed by a carriage return (CR). See listing below.

- All queries follow a format of :

query? (CR)

Where “query” is a keyword always followed by a question mark (?) and carriage return (CR). See listing below.

Terminal Commands and Queries

- The following list shows all of the available commands and queries, and summarizes their functions:

ens	- Toggle Enable State	If the unit is disabled, ens will enable it, otherwise it will disable.
tset	- Set Temperature	tset=nnn.n (20.0 to 200.0 to TMAX)
tset?	- Get TEMP SET Value	Returns the current value for TEMP SET.
tact?	- Current Temperature	Returns the current value of TEMP ACTUAL.
temps?	- Get TEMP SET Value and TEMP ACTUAL	Returns TEMPS SET and TEMP ACTUAL.
stat?	- Status Query	Returns the Status Byte (see below).
mode	- Assign Operating Mode	mode=normal or mode=cycle.
pgain	- Set P Gain	pgain=nnn (1 to 250)
igain	- Set I Gain	igain=nnn (0 to 250)
dgain	- Set D Gain	dgain=nnn (0 to 250)
pid?	- Get PID Gains	Returns P, I, D values respectively.
unit	- Set Degree Units - C, K, or F	unit=c or unit=k or unit=f.
sns	- Select Sensor	sns=ptc100 or sns=ptc1000 or sns=ntc10k
sns?	- Get Sensor	Returns current sensor selection.
beta	- Set NTC10K Beta Value	beta=nnnn (2000 to 6000).
pmax	- Set Max Power	pmax=nn.n (0.1 to 18.0)
tmax	- Set Max Temperature	tmax=nnn.n (20.0 to 205.0)
pmax?	- Get Max Power	Return current PMAX value.
tmax?	- Get Max Temperature	Return current TMAX value.
beta?	- Get NTC10K Beta Value	Return current Beta value.
stop	- Set StopTmp	stop=nnn.n (20.0 to 200.0 or TMAX) See Below
ramp	- Set Ramptime	ramp=nnn (1 to 999) See Below
hold	- Set Holdtime	hold=nnn (1 to 999) See Below
cycle	- Set Cycle Number	cycle=n (1 to 5) See Below
cycles?	- Cycle mode Parameters	Returns cycle parameters for all five steps. See Below.
pause	- Pause cycle	pause(cr). Initiates or terminates a pause to cycle mode.
config?	- Get Current Configuration	Returns ALL pertinent set-up parameters. See Below.
tune	- Tune Temperature	tune(cr). Initiates or terminates (detunes) a tuning function.
tune?	- Is Tune Function Set?	Returns offset value. "0" represent no tune performed.
commands?	- Commands Query	Returns a list of available commands.
id?	- Identification Query	Returns the unit identification string.
*idn?	- Identification Query	Returns the unit identification string.

- All commands and queries are in **lower case** letters.
- All temperature inputs and read backs are in degrees C only, regardless of what the display units are for the front panel LCD of the M1600.

■ The Status Byte

The "Status Byte" is an 8 bit hexadecimal value that is returned as part of the **stat?** query. Each bit corresponds to the following definitions to provide a snapshot of the status of the unit at any given time.

Bit 0:	0 = Disabled	1 = Enabled
Bit 1:	0 = Normal Mode	1 = Cycle Mode
Bit 2:	0 = NTC10K	1 = PTC100 (sensor select bit one)
Bit 3:	0 = See Bit2	1 = PTC1000 (sensor select bit two)
Bit 4:	0 = See Bit5	1 = Degrees C (unit select bit one)
Bit 5:	0 = Degrees K	1 = Degrees F (unit select bit two)
Bit 6:	0 = No Sensor Alarm	1 = Sensor Alarm
Bit 7:	0 = cycle not paused	1 = cycle paused

If a TMAX alarm is also present when the stat? query is sent, the text "*Tmax ERROR*" will also be returned.

■ Setting the Cycle Parameters from the Command Line

- The cycle parameters (Stop temp, Ramp time, and Hold time) can be programmed from the command line interface as follows:

- 1) Set the STEP number that the three parameters will apply to by typing - *cycle=n* where n represents the Step number (1 to 5).
- 2) Enter valid values for the Stop temp by typing - *stop=nnn.n* (20.0 to 200.0 or TMAX)
- 3) Enter valid values for the Ramp time by typing - *ramp=nnn* (1 to 999)
- 4) Enter valid values for the Hold time by typing - *hold=nnn* (1 to 999)

Until the cycle number is changed to another value, any values entered for stop, ramp, or hold will apply to the current value of cycle.

Typing the *cycles?* query will return a string of fifteen comma delineated numbers, five groups of three values. Each group of three values represents the stop temp, ramp time, and hold time for each successive cycle step. The value of the stop temp is an integer value 10 times greater than the actual temperature value. i.e. a value of 600 represents 60.0 degrees.

■ The Configuration Command

Typing *config?* into the command line interface will return a list of all of the pertinent set-up parameters to allow a user to view all items at a glance. The following is a typical return ...

> config?

Tset = 54.3 C

Pgain = 126, Igain = 0, Dgain = 0

Sensor = PTC100

Tmax = 200.0 C

Pmax = 15.9 Watts

Temperature Display Units are CELSIUS

Unit is in Normal Mode

Step1:

StopTemp = 60.0 C, RampTime = 1 m, HoldTime = 5 m

Step2:

StopTemp = 70.0 C, RampTime = 5 m, HoldTime = 5 m

Step3:

StopTemp = 80.0 C, RampTime = 5 m, HoldTime = 5 m

Step4:

StopTemp = 90.0 C, RampTime = 5 m, HoldTime = 5 m

Step5:

StopTemp = 100.0 C, RampTime = 5 m, HoldTime = 5 m

The M1600 Application Software

The M1600 Application Software provides an easy graphical interface between a computer and the M1600 Tunable Laser Source.

Installing the M1600 Application Software

- The M1600 Application Software is compatible with Windows operating systems from Win2000 and greater.
- Insert the M1600 Application Software CD-ROM that is included with your unit into the CD-ROM drive of your computer.
- Right-Click the START button and click on RUN.
- BROWSE the CD-ROM drive until you find "setup.exe".
- Click on "setup.exe" to highlight it then click on OK.
- Click on OK from the RUN window and follow the installation directions.
- This program requires National Instrument's VISA and IVI Runtime Software. If you have any National Instrument products installed on your computer there is a good chance that these programs already reside on your machine. If they do not you will be prompted for them when you initially run the M1600 Application Software. These programs are included on the M1600 Application Software CD-ROM. To install them browse the CD-ROM and find the corresponding folders (one for each program). Open the folder and run the appropriate set-up files.

Setting Up and Connecting

- Connect the M1600 to your computer using a standard DB9 cable connected to an available COM port on your computer and the RS232C connector on the rear panel of the unit.
- Apply AC power to the M1600, turn the M1600 On (See "Turning On the Controller" above), and wait for the unit to complete its power on initialization.
- Open the M1600 Application program. See "Installing the M1600 Application Software" above.
- The initial window should look like this....

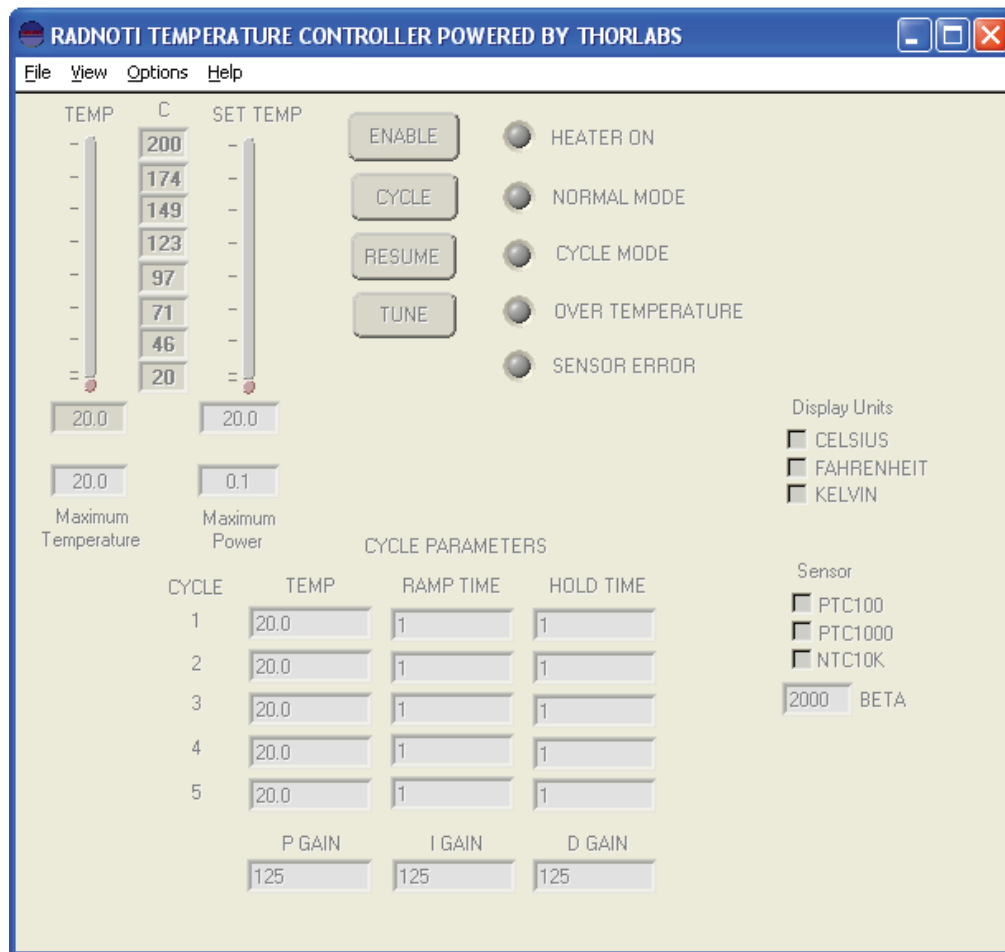


Figure 2 - M1600 Application Opening Screen

- Click on the "Options" menu and then select "Serial Connection" and then "Com Port". Select the com port that you have the M1600 connected to. Note: the baud rate is fixed at 115200.
- Click on the "File" menu and choose "Open Connection".
- Once you are connected the window will become active and the current status of the unit will be reflected on the screen.

Operating in Normal Mode

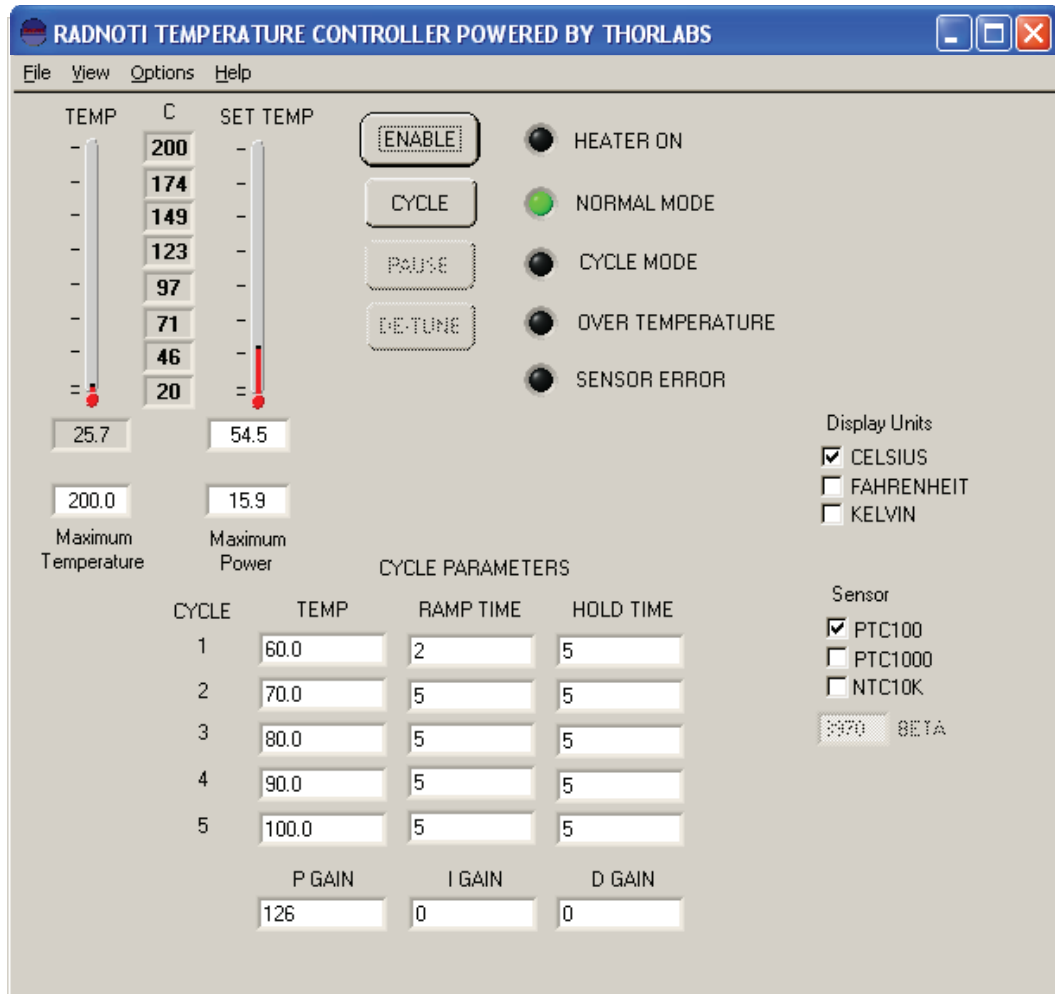


Figure 3 - Active Connection between Computer and Unit

- Figure 5 shows an active connection to a unit set to 54.5 °C and configured for Normal Mode.
- To Enable the heater click on the button labeled ENABLE.
- Any changes made from the Application Software will be reflected on the LCD of the M1600.
- Any changes made from the M1600 will also be reflected on the Application Software.
- The time for these updates to take effect varies with the computer.

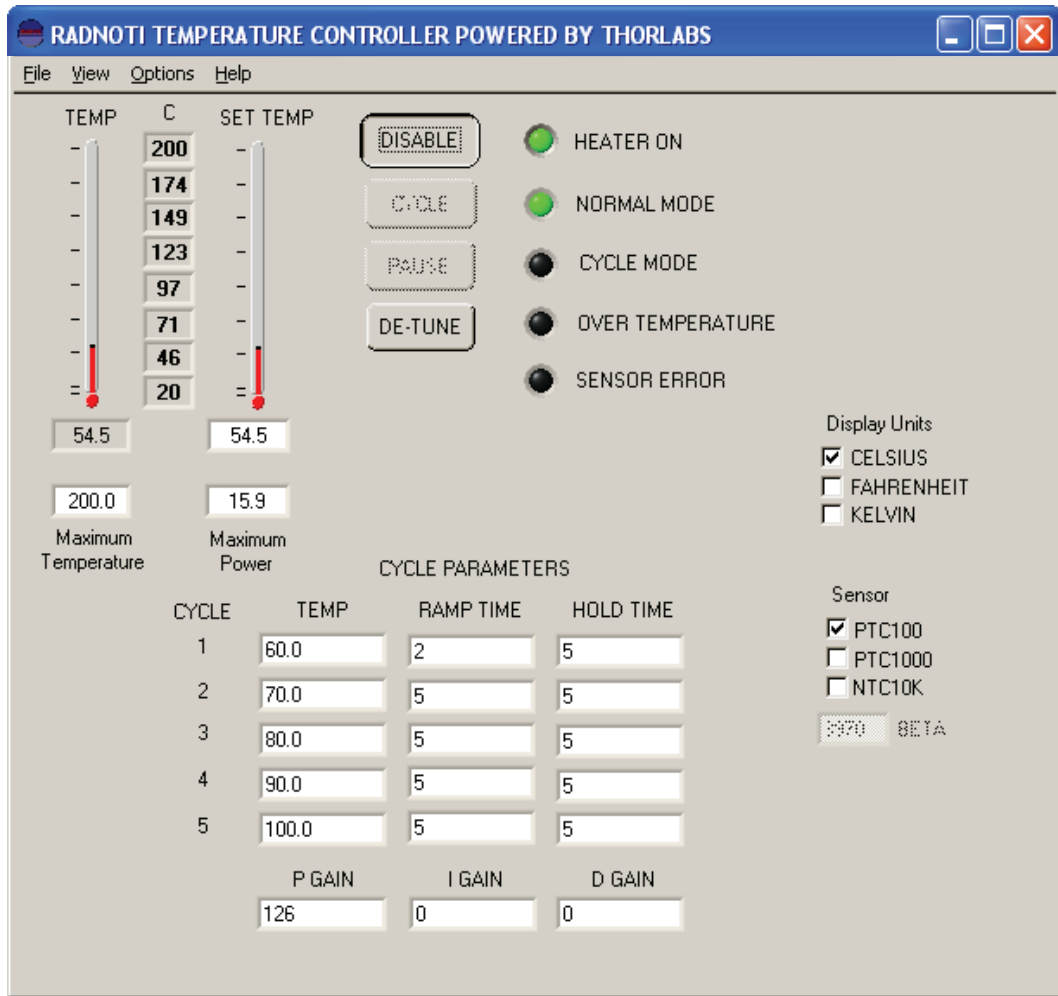


Figure 4 - Heater Enabled in Normal Mode

- Once connected the SET TEMP can be changed by one of two methods:
 - Click and hold the TEMP SET slide control and drag the slider to the next desired temperature.
 - Double click in the TEMP SET window to highlight the temperature text and then enter the value for the temperature, from 20.0 °C to TMAX or 200.0 °C.

As with the other operating methods the SET TEMP can be changed at any time, whether the heater is Enabled or not, except during Cycle Mode.

- To Disable the heater click on the DISABLE button.

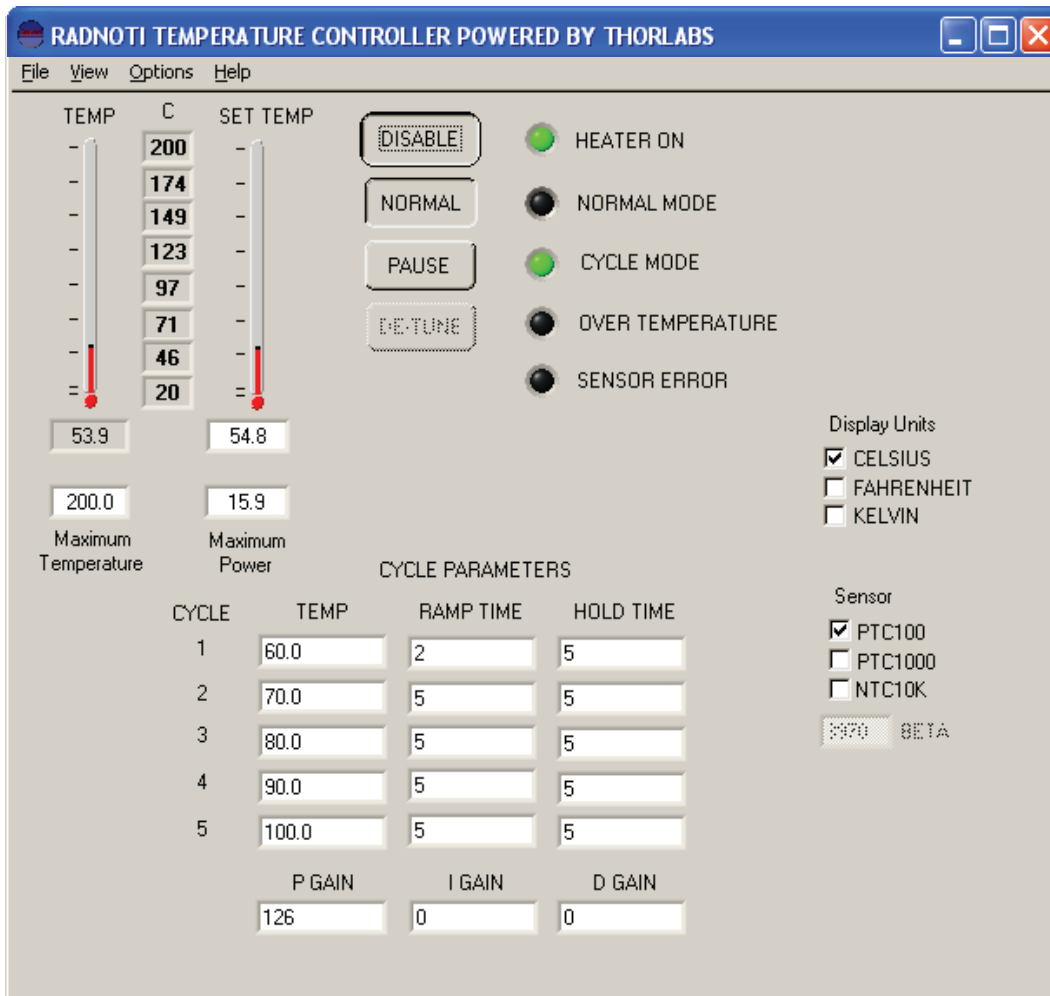


Figure 5 - Heater Enabled in Cycle Mode

Operating in Cycle Mode

■ To change the M1600 from Normal Mode to Cycle Mode:

- With the heater disabled click on the CYCLE button.
- The Cycle Mode indicator will now turn on.
- Clicking on the ENABLE button will initiate the cycle.
- To return to Normal mode click on the NORMAL button or...
- Click on the ENABLE button.
- To PAUSE a cycle, click on the PAUSE button.

■ To change the Cycle Mode parameters:

- All of the cycle mode parameters are visible on the GUI screen.
- To change any or all of the parameters simply double click on the value you wish to change and enter in a valid new value.
- Hitting a carriage return (Enter Key), Tab key, or clicking on any other box on the GUI will cause the program to accept the new value entered and send it to the M1600.
- Parameters can NOT be changed while a cycle is in progress.

■ Changing other parameters:

- Changing any of the other values is done in much the same manner as described above. Text box values can be entered by double clicking the text box and entering a new value, followed by the Enter key, tab key, or clicking elsewhere on the screen.
- Items such as the sensor and display units are changed by checking the appropriate boxes.
- Any out of range values that might be entered will be rejected and you will be prompted to re-enter a valid value.

■ Hiding graphics in the GUI:

- Various components of the GUI can be hidden from view to provide a cleaner, less cluttered display.
- Click on the View menu and select or deselect the various choices to be displayed on the screen.

Disconnecting from the M1600

- To disconnect from the unit choose “Close Connection” from the “File” menu.
- Exiting the program is done by either clicking on the X in the upper right hand corner of the screen or choosing EXIT from the FILE menu.

Appendix A – Output Connector Pin-outs

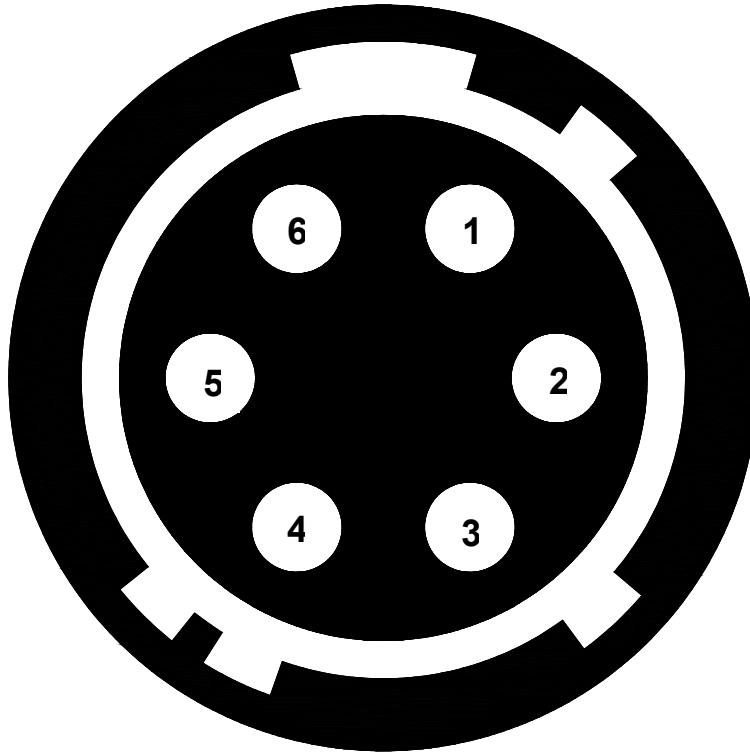


Figure 6 - Detail of Main and Auxiliary Connector as viewed from the Rear panel

PIN ASSIGNMENTS:

PIN 1 – HEATER OUTPUT POSITIVE

PIN 2 – HEATER OUTPUT RETURN (GROUND)

PIN 3 – RESERVED (DO NOT CONNECT TO THIS PIN)

PIN 4 – SENSOR INPUT (+)

PIN 5 – SENSOR INPUT (GROUND)

PIN 6 – RESERVED (DO NOT CONNECT TO THIS PIN)

Appendix B – Temperature Sensor Specifications

The M1600 is compatible with two types of Platinum Thermistors – PT100 Ω and PT1000 Ω , and also compatible with NTC 10K Ω Thermistors. The following specifications are used for determining the set point and read back values from these three types of Thermistors....

PT100 Ω and PT1000 Ω :

For the temperature range of 0 to 850 $^{\circ}$ C:

$$R_T = R_0 (1 + AT + BT^2) \quad \text{Eq. 1 in accordance with IEC 751,2:1995-07 [DIN EN 60751; 1996-07]}$$

Where:

$$A = 3.9083 \times 10^{-3} \text{ }^{\circ}\text{C}^{-1}$$

$$B = - 5.775 \times 10^{-7} \text{ }^{\circ}\text{C}^{-2}$$

R_T is the resistance in Ω at temperature T .

T is the temperature in $^{\circ}\text{C}$.

$R_0 = 100$ for the PT100 Ω

$R_0 = 1000$ for the PT1000 Ω

NTC10K:

$$R_T = 10000 \times \exp^{(\text{beta} \times ((1 / T) - (1/298)))} \quad \text{Eq. 2}$$

Where:

R_T is the resistance in Ω at temperature T .

T is the temperature in $^{\circ}\text{K}$.

Beta is the constant associated with the particular Thermistor.

Appendix C – Troubleshooting

The following represents some typical problems that may be encountered while using the M1600, and possible solutions.

Problem – Unit does not turn On when switching the power switch to the ON position.

- 1 – Make sure AC line cord is fully inserted into the AC Input receptacle and plugged into an outlet providing 100 to 240 VAC.
- 2 – Fuse(s) may be open. Refer to Appendix D for information on replacing open fuses. If the problem persists please return the unit to Thorlabs for evaluation.

Problem – Unit does not Enable the Heater when pressing the ENABLE key.

Make sure a compatible temperature sensor is installed. If one is not, you should be seeing a message that says “!SENSOR!” on the front panel LCD.

Problem – I can’t adjust the TEMP SET value using the UP/DOWN arrow keys.

If you are operating in CYCLE mode you will not be able to make adjustments to the set-point using the UP/DOWN keys in the MAIN screen. If you need to make adjustments, first terminate cycle mode, and either reprogram the cycle parameters (see Navigating the Keypad), or operate the unit in Normal mode.

Problem – I can’t adjust my TEMP SET value above a certain value – which is below the 200.0 degree maximum capability.

The TEMP SET value is limited by the TMAX maximum temperature setting. If you need to operate at a higher temperature you must first increase TMAX.

Problem – When I reach my TEMP SET value the unit displays !TMAX!.

The TMAX value is the same as the TEMP SET value. Either increase the TMAX value or lower the TEMP SET value.

Problem – The unit appears to be holding the TEMP SET value, but there is a !TMAX! message on the display.

The unit exceeded the TMAX setting at some time, but during the reset phase it settled to the correct level. This is normal, simply press the SELECT Key from the MAIN screen to clear the alarm.

Problem – The unit is Enabled but doesn’t seem to be driving the heater.

- 1 – The PMAX value is too low. Increase the PMAX value to the maximum rating of the heater you are driving.
- 2 – The output connector is not fully inserted into the MAIN OUTPUT connector.

Problem - The unit overshoots the set point by a large amount.

- 1 – Check your I Gain setting. It may be too high and should be lowered.
- 2 – You have a sensor installed but it is the wrong type.

Problem – I can’t connect to the M1600 over the RS232 com port.

- 1 – Make sure that the com port is configured correctly for the unit. Refer to The Command Line Interface – Setting Up and Connecting for the correct com port settings.
- 2 – The incorrect com port is selected on your terminal program or M1600 Application.

Appendix D – Changing the Input Fuses and General Maintenance



The AC Line Voltage and Installing Fuses:

Your M1600 Series Temperature Controller will operate from AC line voltages ranging from 100 VAC to 240 VAC at 50 – 60 Hz. There is no need to configure the unit for specific line voltages.

If for some reason you need to replace an open fuse, you must perform the following procedure:

- **Remove any AC Input cords that may be connected to the unit.**
- Remove the cover of the unit by removing the two 4-40 Phillips head screws located on the bottom rear of the unit and sliding the cover off. Refer to Figure 1.
- Refer to Figure 3. Locate the two Fuse Holders near the AC Input Module towards the back of the unit. Remove the cover to each fuse holder. The fuse is installed in the cover. Remove the existing fuse and install the appropriate replacement fuse.

Use 250mA 250 VAC Type T 5x20mm style fuse

In all cases use only 5mm x 20mm 250VAC Type T Fuses

- Reinstall the cover and replace the two 4-40 Phillips head screws.

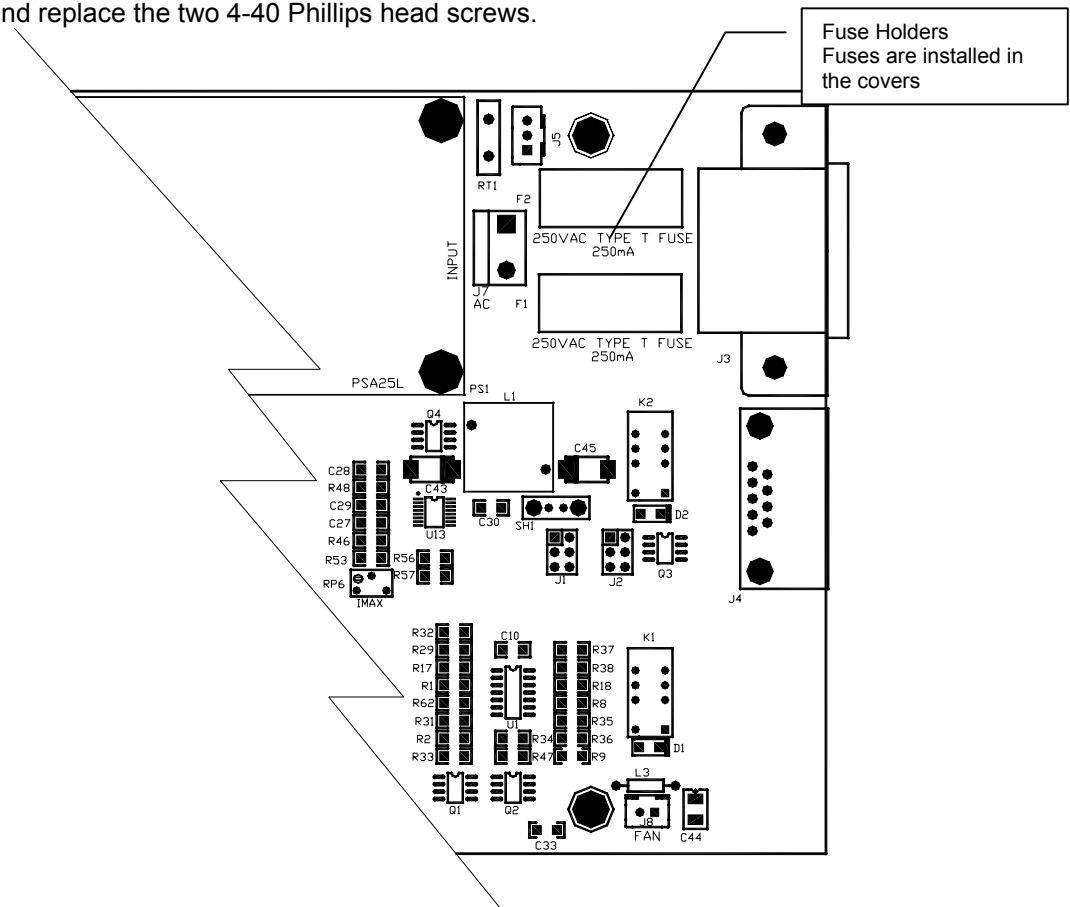


Figure 7 - Location of Fuse Holders

General Maintenance:

Aside from the AC Input fuses there are no user serviceable parts in the M1600. If you suspect something has failed on the unit, and you have first referred to Appendix B – Troubleshooting, please contact Thorlabs for advice on returning the unit for evaluation.

Cleaning:

The unit can be cleaned using a soft, slightly damp cloth. Avoid using any solvents on or near the unit.