1 Introduction

The temperature control application pcTC is intended as a basic application interface to the H1000 series temperature controllers from Micromanipulator. The layout of the program interface is closely matched to the functions available from the front panel of the H1000 system. The primary features provided with this application are:

- ❑ Direct access to the H1000 temperature controller using easily understood buttons and displays.
- ❑ Definition of custom temperature control sequences
- ❑ Load/Save any sequence
- ❑ Re-use of sequences within other sequences
- ❑ Access to other applications via DDE interface -- specifically pcProbe^{II} and Metrics ICS
- ❑ Control of pcIndie and pcWfr programs

2 Installation and Use

2.1 Installation

2.1.1 Hardware

See section 3.1 for instructions on the GPIB option setup. The rear panels of the Heat and Cool controllers have 7 pin connectors labeled **Computer Interface.** Connect the **Computer Interface** outputs to the two **RS422 Out** connectors on the **Computer Interface Option** using the supplied cables. Connect either GPIB or RS-232 cable between the computer and interface option.

2.1.2 Software

2.1.2.1 Windows 3.1X

1. Insert diskette in the 3.5" drive.
2. Select ***File/Run*** from program manager.
3. Type in "a:install" in the file name field and then select **OK**.
4. The install program scans for previous installations and then prompts for the destination directory for the installation (usually **c:\hotstage**).
5. Select **OK** to start the installation. After the files have been installed the program prompts for the type of interface to use. Select the interface appropriate for the installation.

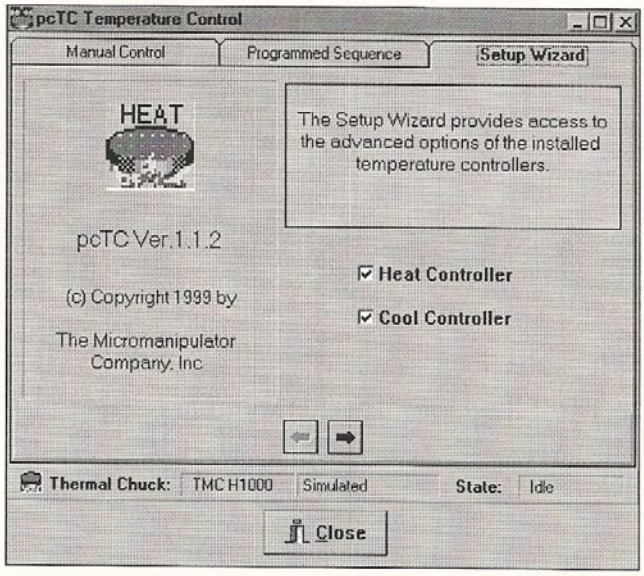
2.1.2.2 Windows 95

1. Insert diskette in the 3.5" drive.
2. Select ***Start/Run*** from the task bar.
3. Type in "a:install" in the ***open*** field and then select **OK**.
4. The install program scans for previous installations and then prompts for the destination directory for the installation (usually **c:\hotstage**).
5. Select **OK** to start the installation. After the files have been installed the program prompts for the type of interface to use. Select the interface appropriate for the installation.

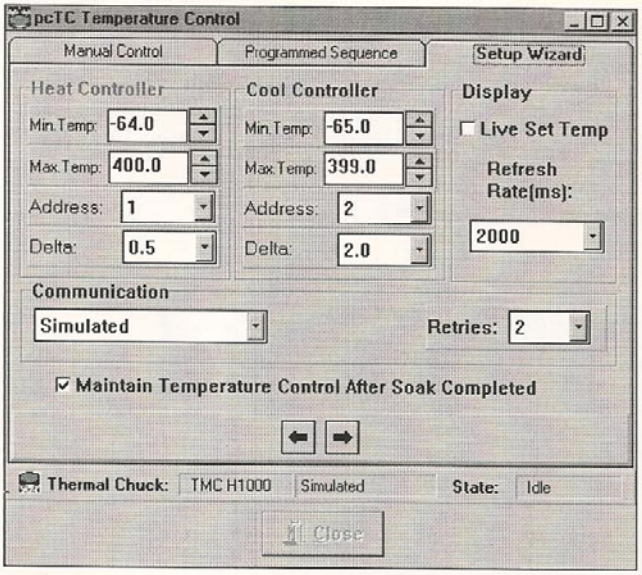
2.2 Setup

1. Start the pcTC program. The **Manual Control** tab window is active.
2. Select the **Setup Wizard** tab. The hot stage system consists of at least a heat controller and usually a cool controller. Make sure that the options installed in your system match those selected in the first setup screen as shown below.

   Select the Forward arrow button ➡ to move to the next setup screen.



3. The operating parameters for the temperature controllers are set in this setup window. Note that all temperatures are in degrees Celsius.



The descriptions for the parameters are as follows:

Min/Max Temp

These parameters provide the minimum and maximum allowable temperatures for temperature control. Normally the heat parameters should be one degree above the cool parameters, however if there are special safety or temperature stress considerations these may be changed as required.

Address

The address refers to the RS-422 interface address on the temperature controller. Normally the Heat controller is at address 1 and the Cool controller is at address 2.

Delta

The delta parameter is used to determine how close the measured chuck temperature must be to the controller set temperature to be considered "at temperature". Normally this value is 0.5 degrees. For example, if the chuck is at 35.6 degrees and the temperature set point is at 36 degrees the software considers the temperature control cycle to be complete.

Live Set Temp

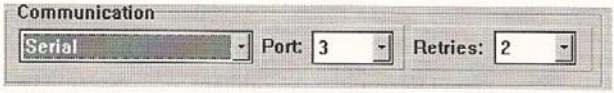
This option causes the pcTC Set Temp display to be updated constantly. Enabling this option slightly affects the update speed of the display, so the default should normally be OFF.

Refresh Rate(ms)

This value is used to determine how often to update the system parameters. The lower the value, the faster the system response. The default is 2000 ms. Note also that this value is the latency time for control operations such as Heat, Cool, and Halt.

Communication

The available communication options are displayed in case the user needs to change the setup of the controller. This is normally set up at the factory and doesn't need to be changed. When selecting ther **SERIAL** option an additional selection appears to the right of the communication selection as follows:



Select the appropriate serial communications port from the list.

NOTE: When changing interfaces always select Simulated first, and then the desired interface. Additionally, it is necessary to boot in Simulated mode before selecting the National Instruments GPIB option.

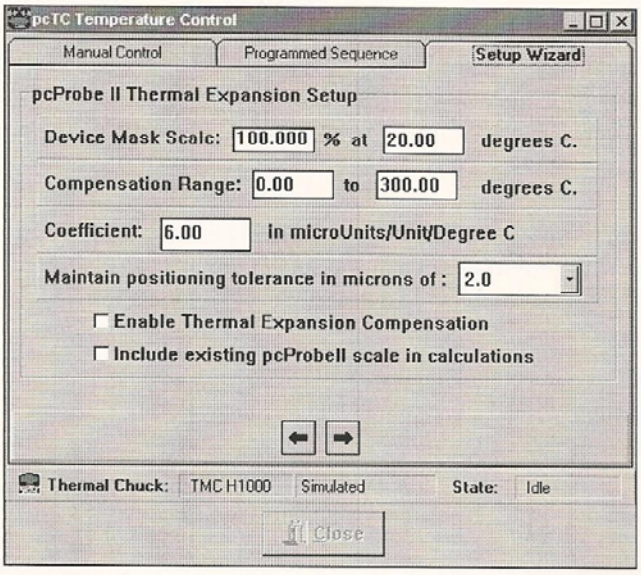
Retries

This option indicates the number of times to retry a command if a communication error occurs. The default value is 2.

Maintain Temperature Control After Soak Completed

This option is used when executing a temperature control sequence. When enabled it causes the set temperature for the soak cycle to be maintained after the soak operation in completed. When disabled the temperature control operation is halted and therefore the chuck will return to ambient temperature after a while. The default is Enabled.

4. Select the ➡ button to move to the next setup screen. This screen appears only when the pcProbe[II] semi-auto prober control software is installed. The values stored here are used to compensate for thermal expansion when operating programmable positioners, microscopes, and stages.



Device Mask Scale

This value is used to define the relationship between actual device dimensions and the original mask. Enter the difference as a percentage along with the temperature used as the reference when compensating for expansion.

Compensation Range

These values are used to define the range for thermal expansion and contraction. The low temperature defines the temperature at which the material stops contracting. The high temperature defines the temperature at which the material stops expanding.

Coefficient

This value is used to calculate the amount of thermal expansion. The expansion is calculated assuming millionths of units growth per whole unit per degree C.

Positioning Tolerance

This value is used to determine how frequently to update the positioning software given a particular thermal expansion coefficient. The lower this number, the higher the update rate for pcProbe^{II}.

Other Options

Select the **Enable Thermal Expansion Compensation** box to enable updating of pcProbe^{II} with new compensation values. If this box is not checked no compensation is included when positioning.

Select the **Include existing pcProbe^{II} scale in calculations** box if the positioning scalar in pcProbe^{II} is required for correct positioning at ambient temperature. Normally this should be OFF.

NOTE: The positioning reference in pcProbe^{II} must be set for a specific temperature using the Set Reference function. If this is not done the location reference used by the positioning system will be incorrect.

If the thermal expansion coefficient for the material is not known, it can be determined with this procedure:

A. Cool the chuck to ambient and wait for the temperature to stabilize. Write down the temperature of the chuck as T1.

B. Locate a corner of a die near the bottom left corner of the wafer. Write down the X,Y coordinates displayed by pcProbe^{II} as X1,Y1.

C. Move diagonally to the same corner of a die on the top left corner of the wafer. Write down the X,Y coordinates displayed by pcProbe^{II} as X2,Y2.

D. Heat the chuck to the highest safe temperature for the material and wait for the temperature to stabilize. Write down the temperature of the chuck as T2.

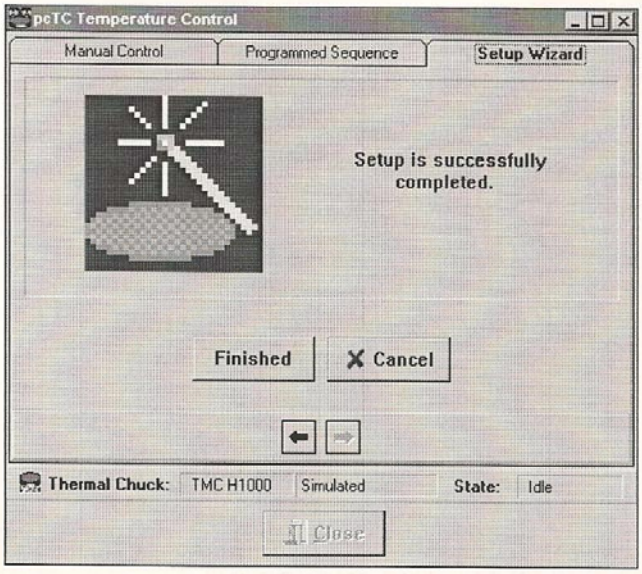
E. Repeat steps B and C using the same two die as before. However, write down the positions from steps B and C as X3,Y3 and X4,Y4, respectively.

F. Calculate the thermal expansion coefficient as follows:

$$coeff = 1.0X10^{6} * [((X4-X3)^{2}+(Y4-Y3)^{2})^{0.5} - ((X2-X1)^{2} + (Y2-Y1)^{2})^{0.5}] / [(T2-T1) * (((X2-X1)^{2} + (Y2-Y1)^{2})^{0.5}]$$

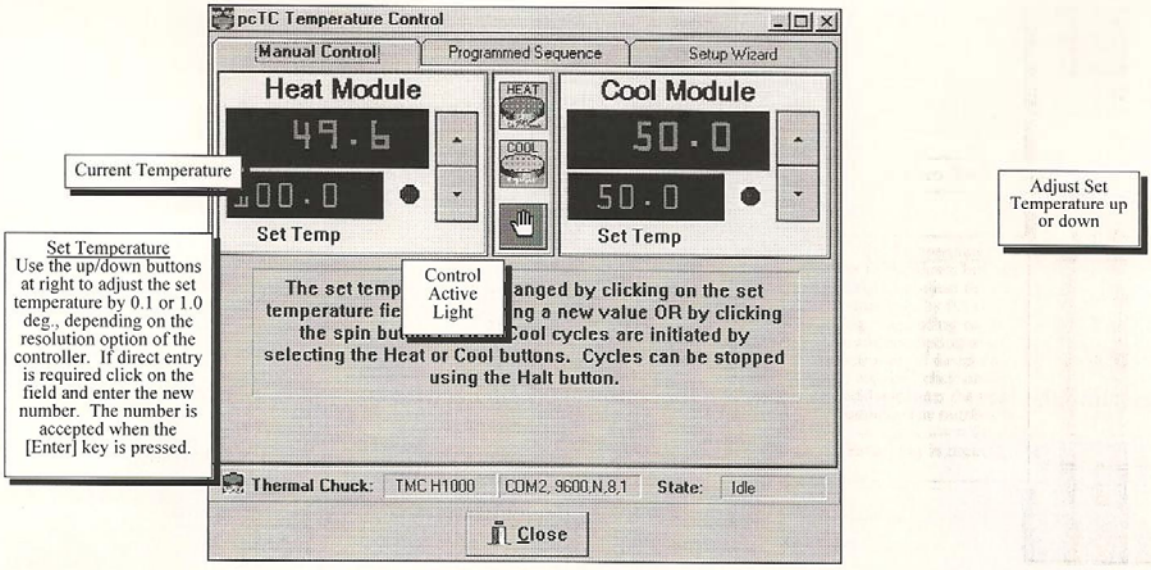
G. Enter the base temperature (T1) as the Device Mask Scale temperature and enter the calculated coefficient value as the Coefficient.

5. Select the ➡ button to move to the next setup screen.



Select the **Finished** button to accept the changes or select **Cancel** to quit without saving any changes. The **Manual Control** tab is selected.

2.3 Manual Operation



Select the ***Manual Control*** tab to access the manual control options for the temperature controller. The main display elements are labeled above. The current temperature as reported by each temperature controller is refreshed every half second or so. The set temperature is read directly from the controller, however the user can change the values by selecting the up/down buttons or by direct entry of the desired temperature. The active lights are on when the associated module is performing temperature control operations. The Heat and Cool active lights should never be on at the same time.

Select the Heat button 

to initiate heat control for the specified heat set temperature. The controller remains in the heat cycle until it is told to Cool or Halt.

Select the Cool button 

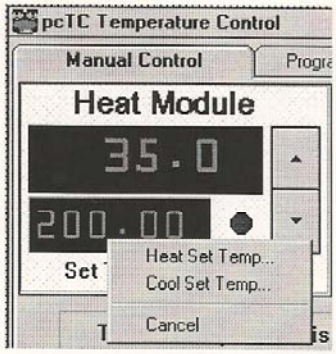
to initiate cool control for the specified cool set temperature. The controller remains in the cool cycle until it is told to Heat or Halt.

Select the Halt button 
to stop temperature control at any time.

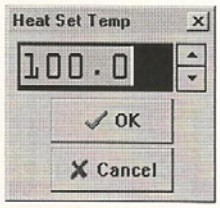
Note: The green heat, cool, & stop LED's on the hot chuck controller are only activated by the buttons on the controller. They do not change in response to pcTC.

Select the Close button to exit pcTC.

If the on-screen control of temperatures is awkward, an alternate method of setting the temperature is to move the mouse cursor over the Set Temp or chuck temperature display and right click the mouse. The following popup menu appears:

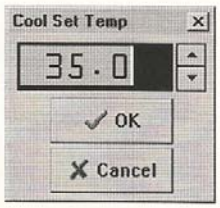


Selecting the Heat Set Temp option opens the following dialog box:



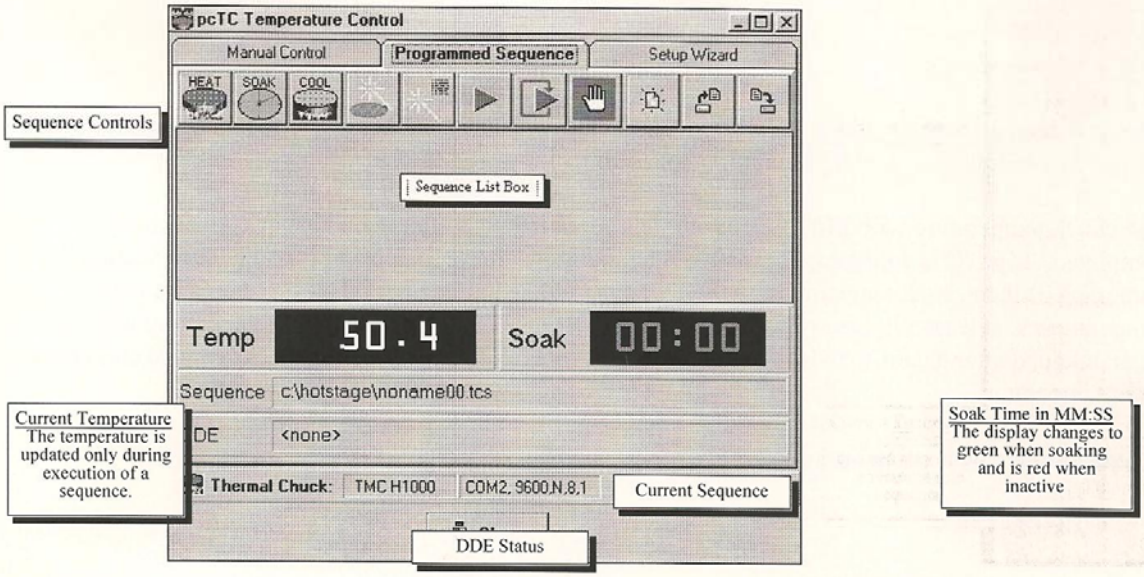
Use the Up/Down buttons to adjust the temperature or enter the desired Heat Set Temperature directly into the edit box. Select **OK** when done, or **Cancel** to quit the operation.

Selecting the Cool Set Temp option opens the following dialog box:



Use the Up/Down buttons to adjust the temperature or enter the desired Cool Set Temperature directly into the edit box. Select **OK** when done, or **Cancel** to quit the operation.

2.4 Sequences



Programmed sequences allow the user to define a custom temperature control sequence and save it for repeated use. Select the **Programmed Sequence** tab to access this window.

There are some operational constraints to consider when developing a sequence. Be aware that the ability of the controller to maintain a set temperature is entirely dependent on the relationship of the set temperature to ambient. The following sections describe the conditions encountered with the various cooling options.

1. Ambient cooling option part numbers:
   C1000-V0-H
   C1000-V1-HE
   C1000-V2-HE

The C1000-V0-H, C1000-V1-HE and C1000-V2-HE cooling options DO NOT control temperature at any set point. These cooling options are used as a quick and convenient way to cool the chuck, without control.

The chuck temperature will drift towards ambient room temperature after a heat or cool cycle is completed. If pcTC is configured to maintain temperature after a soak cycle is completed (Section 2.2

paragraph 3) then the chuck temperature will only be maintained after a heat soak if the heat set point temperature is at least 5C above ambient room temperature.

2. Zero degree cooling option part numbers:
   C1000-V1-C-0
   C1000-V2-C-0

The zero degree cooling options control temperature down to zero degrees C. Cool set points below the set point of the zero degree chiller unit are not controlled.

The chuck temperature will drift towards ambient room temperature after a heat or cool cycle is completed. If pcTC is configured to maintain temperature after a soak cycle is completed (Section 2.2 paragraph 3) then chuck temperature will only be maintained after a heat soak if the heat set point temperature is at least 5 degrees C above ambient room temperature. The chuck temperature will only be maintained after a cool soak if the cool set point temperature is at least 5 degrees C above chiller set point temperature.

3. Sub-zero degree cooling option part numbers:
   HC1000-AC1
   HC1000-DC1

The subzero degree cooling options control temperature down to -65 degrees C. Cool set points below the set point of the ultra low chiller unit are not controlled.

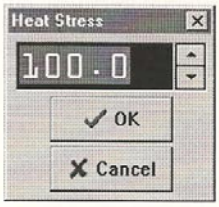
The chuck temperature will drift towards ambient room temperature after a heat or cool cycle is completed. If pcTC is configured to maintain temperature after a soak cycle is completed (Section 2.2 paragraph 3) then chuck temperature will only be maintained after a heat soak if the heat set point temperature is at least 5 degrees C above ambient room temperature. The chuck temperature will only be maintained after a cool soak if the cool set point temperature is at least 5 degrees C above ultra low chiller set point temperature.

2.4.1 Sequence Controls

2.4.1.1 

Heat

The heat button is used to add a heat control step to the sequence. When the button is pressed a dialog appears requesting user entry of the heat set temperature as follows:

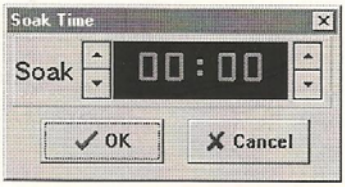


Use the Up/Down buttons to adjust the temperature or enter the desired Heat Stress temperature directly into the edit box. Select **OK** when done, or **Cancel** to quit the operation.

2.4.1.2 

Soak

The soak time is used to maintain the set temperature for a specified time period up to 59 minutes 59 seconds during a sequence. Selecting this button causes the program to request a soak time as follows:

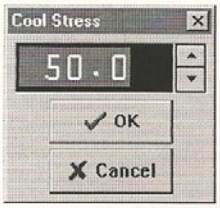


Use the Up/Down buttons to adjust the Minutes and Seconds soak time. Select **OK** when done, or **Cancel** to quit the operation.

2.4.1.3 

Cool

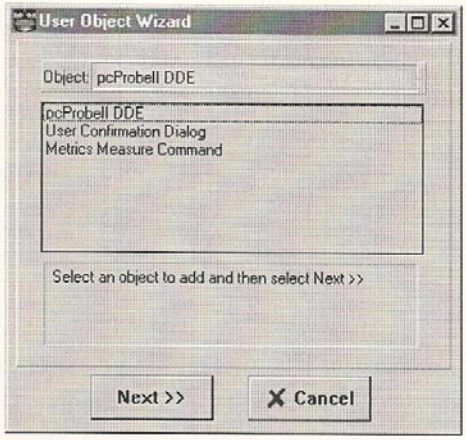
The cool button is used to add a cool control step to the sequence. When the button is pressed a dialog appears requesting user entry of the cool set temperature as follows:



Use the Up/Down buttons to adjust the temperature or enter the desired Cool Stress temperature directly into the edit box. Select **OK** when done, or **Cancel** to quit the operation.

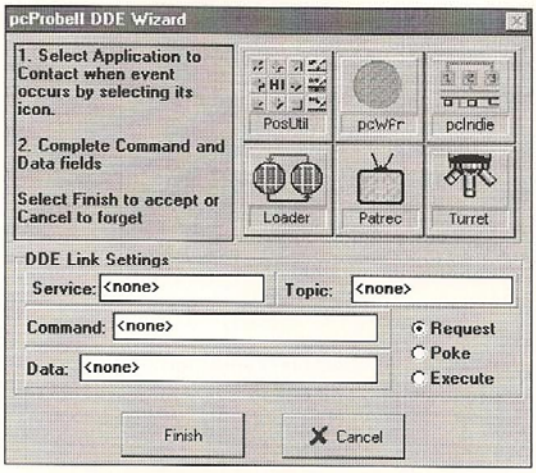
2.4.1.4  Add User Object Action

Sometimes the heating, cooling, and soaking operations alone are not sufficient to handle the requirements for the test sequence. The User Object Action step is intended to provide access to less common operations such as DDE communications and Message Boxes. Selecting this button causes the following dialog box to appear:



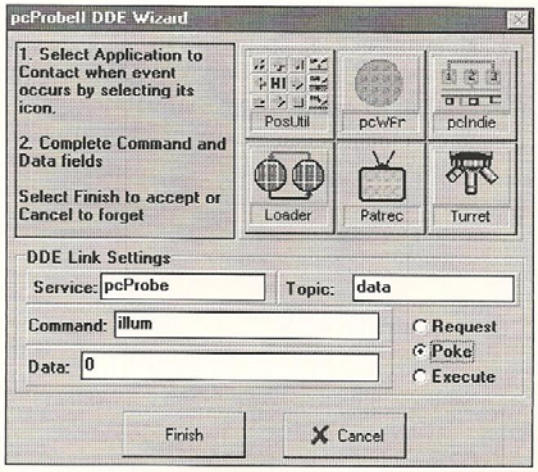
The list box shows the available operations. Select the desired operation and then select **Next>>**

2.4.1.4.1 pcProbe^{II} DDE



The pcProbe^{II} DDE Wizard provides easy access to all the DDE functions available in the pcProbe^{II} system. The Service and Topic boxes are set automatically to the correct values when the desired application icon is selected. These can be manually set to any valid DDE link Service and Topic, however. Three types of DDE transactions are available -- Request, Poke, and Execute. The Request and Execute operations require only the Command string. The Poke operation requires that the Data string be set also. Select **Finish** when done or **Cancel** to quit without saving changes.

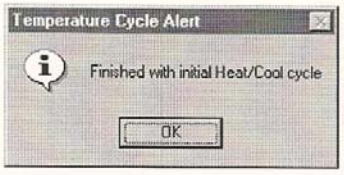
For example, to instruct pcProbe^{II} to turn the illuminator off, perform the following steps. The Wizard will look like this:



1. Select the **PosUtil** icon to fill the Service and Topic fields automatically.
2. Enter '**illum**' in the Command field.
3. Enter '**0**' in the Data field
4. Select the **Poke** DDE option.
5. Select **Finish**.

2.4.1.4.2 User Confirmation/Notification Dialog

The user notification dialog editor provides a way of waiting for user acknowledgment before continuing. For example, assume the Dialog Title is set to ***Temperature Cycle Alert*** and the Dialog Text is set to ***Finished with initial Heat/Cool cycle.*** When the **Test** button is pressed the following dialog box is displayed:

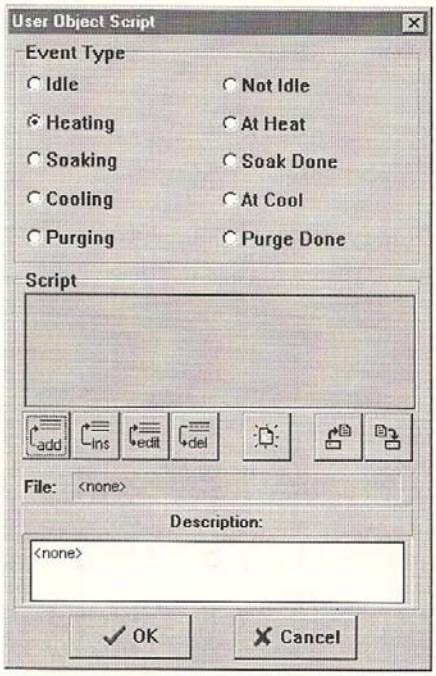


2.4.1.4.3 Metrics Measure Command

This command sends a DDE measure command to Metrics ICS software. This causes the active Metrics test to execute. Reference the Metrics ICS DDE command manual for additional information.

2.4.1.5 Add User Object Script

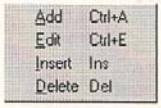
This function provides a method of defining a user object script. The following dialog box is shown when this is accessed:



The Event Type is just a reminder of the type of script being used. The Description field at the bottom is also very useful for documenting the intent of the script.

The Script itself is just a list of the user object actions described in the previous section. Script entries can be added, inserted, edited, and deleted. The New, Open, and Save buttons provide a way of saving scripts for repeated use. Note that a script MUST be saved in order to be used in a programmed sequence.

The edit functions are also available by clicking the right mouse button on the script list. The following popup window appears when the right mouse button is pressed.

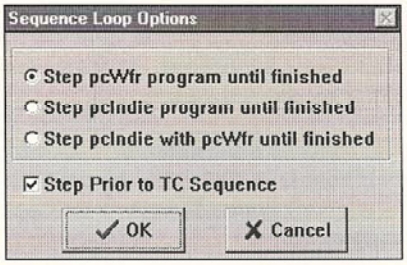


2.4.1.6 Execute Sequence

Once a sequence is defined, select the Execute Sequence button to cause the operations in the sequence to be performed. Select the Halt button to stop execution of a sequence.

2.4.1.7  Execute Sequence with pcWfr and/or pcIndie Programs

This function provides a way of executing the temperature control sequence at each program step of a pcProbe[II] wafer or indie program. The following dialog appears when this operation is selected:



Select the type of program step to be performed from the list provided.

The checked option makes sure that a temperature control sequence is performed on the next untested program step.

If a pcWfr program is not loaded, the sequence just loops continuously.

2.4.1.8  Stop Sequence

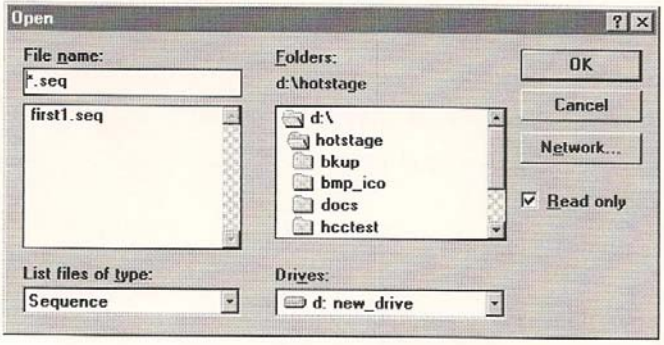
This button stops all temperature control activity and ceases the execution of the sequence.

2.4.1.9  New Sequence

This options clears the sequence list.

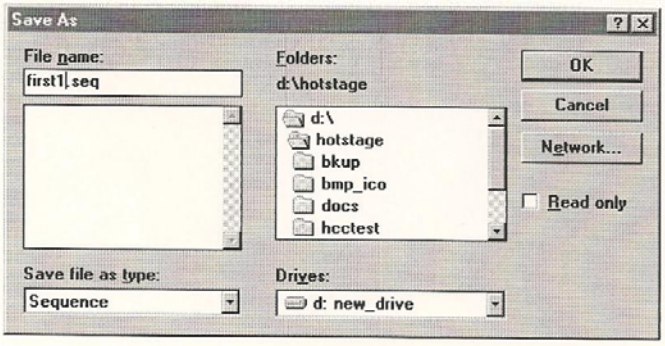
2.4.1.10  Open Sequence

This option allows the user to open a saved sequence. The open dialog box looks like this:



2.4.1.11  Save Sequence

This option allows the user to save a sequence for later use. The save dialog box looks like this:



2.5 A Sequence Example

Assume the following steps were desired for a temperature control sequence:

- ❑ Turn on the illuminator.
- ❑ Wait for 3 seconds.
- ❑ Turn off the illuminator.
- ❑ Heat to 300 degrees and maintain for 5:00 minutes.
- ❑ Cool to 35 degrees and maintain for 5:00 minutes.
- ❑ Perform a Metrics test.
- ❑ Alert the user that the test is complete.

The sequence to perform these operations is created as follows:

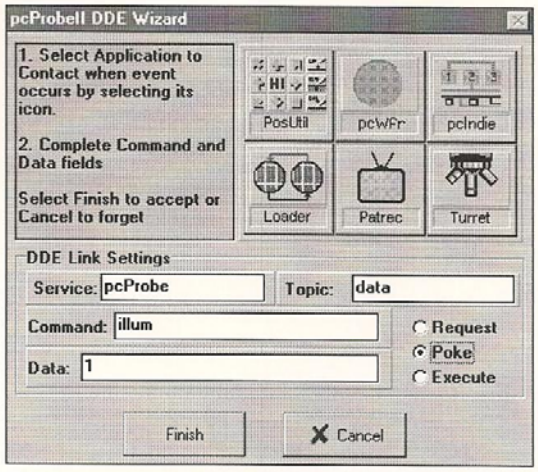
1. Select the Add User Object Action button  . The following box is displayed.

2. Select the pcProbe[II] DDE list option and select **Next>>**. The pcProbe DDE wizard box appears.

3. Select the PosUtil button 

. The Service field is set to 'pcProbe' and the Topic field is set to 'data'.

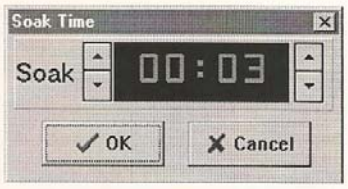
4. Set the Command field to 'illum' and the Data field to '1' to enabled the illuminator. Select the **Poke** operation. The box should look like this:



5. Select **Finish** to accept the information. The sequence list box now has the new step.

6. Select the Soak button 

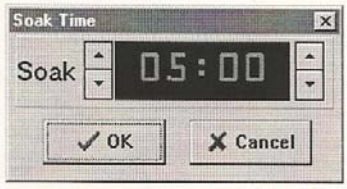
. Click the Up/Down arrows by the seconds display until 3 seconds is displayed as shown below, then select **OK**.



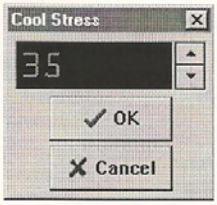
7. Select the User Object Action button and perform steps 2 through 5. The only change is to set the data field in step 4 to '0' to turn the illuminator off.

8. Select the Heat button and set the temperature to 300 as shown below then select **OK**.

9. Select the Soak button and set the soak time to 5 minutes as shown below then select **OK**.

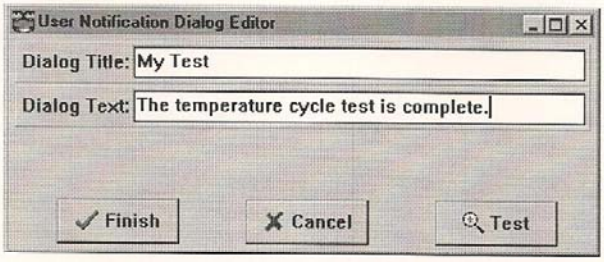


10. Select the Cool button and set the cool temperature to 35 degrees as shown below then select **OK**.

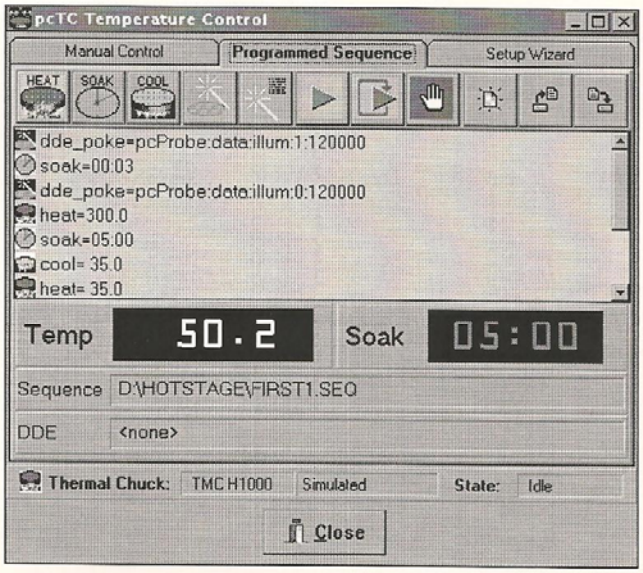


11. Select the Heat button and set the Heat Stress to 35. This step is required because the set temperature is above ambient. Heating is required to maintain a temperature above ambient.
12. Select the Soak button and set the soak time to 5 minutes as in step 9.
13. Select the User Object Action button.
14. Select the Metrics Measure command and select **Next>>**.
15. Select the User Object Action button.

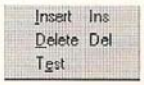
16. Select the User Confirmation Dialog option and select **Next>>**. Fill in the dialog as shown below then select **Finish**.



17. The sequence list should look like this:

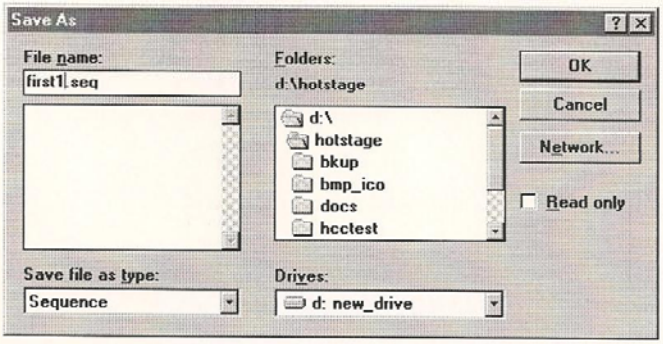


Note that clicking in the list with the right mouse button gives the following popup menu:



Select steps by clicking on them in the list. Steps can be inserted BEFORE the current selected step when the Insert option is checked and appended to the end of the list when the Insert option is NOT checked. The Delete option deletes the current selected step from the sequence. The Test option executes the current selected step.

18. Select the Save button and save the sequence as FIRST1.SEQ as shown below.



19. Execute the program by selecting the Execute button  . The sequence can be stopped at any time by selecting the Halt button  .

3 Reference

3.1 National Instruments GPIB to RS-485 Setup

The GPIB option for the H1000 system uses a National Instruments GPIB-485CT-A Controller. The communications for the H1000 must be set up as shown below. Change the modes for each temperature controller as follows:

1. Press the Up/Down arrows simultaneously until the display changes to 'Input'.
2. Press the Up arrow until the display changes to 'COMM'.
3. There is a hidden button between the Up arrow and the DSPY MODE button. Press this button to move between the COMM options.
4. Set the COMM options as shown below using the Up/Down arrow keys.
5. Press DSPY MODE to accept the changes and return to normal operation.

Heat Module:

BAUD:	9600
DATA:	7o
PROT:	FULL
ADDR:	1
INTF:	422

Cool Module:

BAUD:	9600
DATA:	7o
PROT:	FULL
ADDR:	2
INTF:	422

The default settings for the National Instruments GPIB-485CT-A interface are:

RS-485 Setup/Status Address:	5
H1000 I/O Address:	6
Interface Mode:	G

The wiring of the interface to the H1000 modules is as follows:

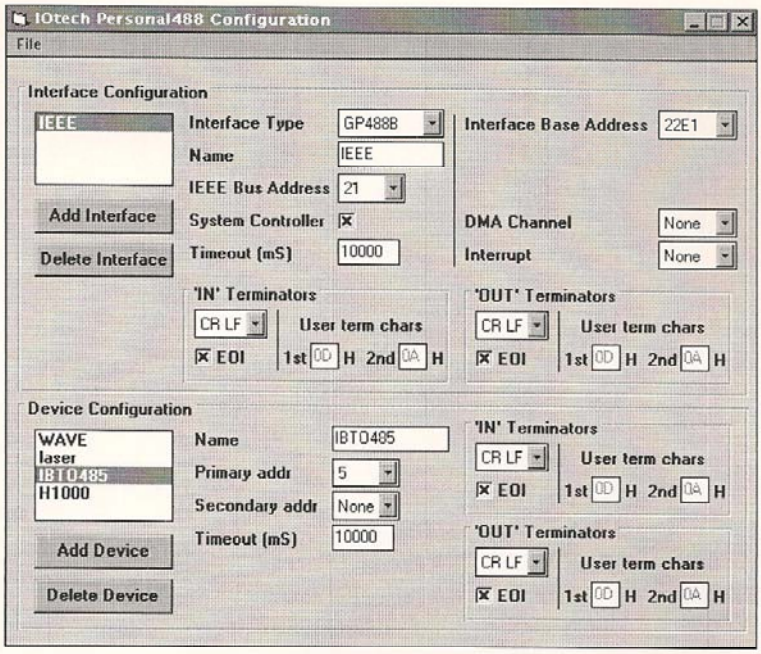
9 Pin	H1000 (Heat and Cool)		
1 GND	5	GND	
4 RXD+	1	TXD+	Requires 1Kohm pull up to +5V and 240 ohm to TXD-
5 RXD-	2	TXD-	Requires 1Kohm pull down to GND
8 TXD+	3	RXD+	
9 TXD-	4	RXD-	

Two GPIB communication boards are supported by pcTC: the IOTech GP488B and the National Instruments AT-GPIB/TNT. The following sections document how to configure these GPIB boards.

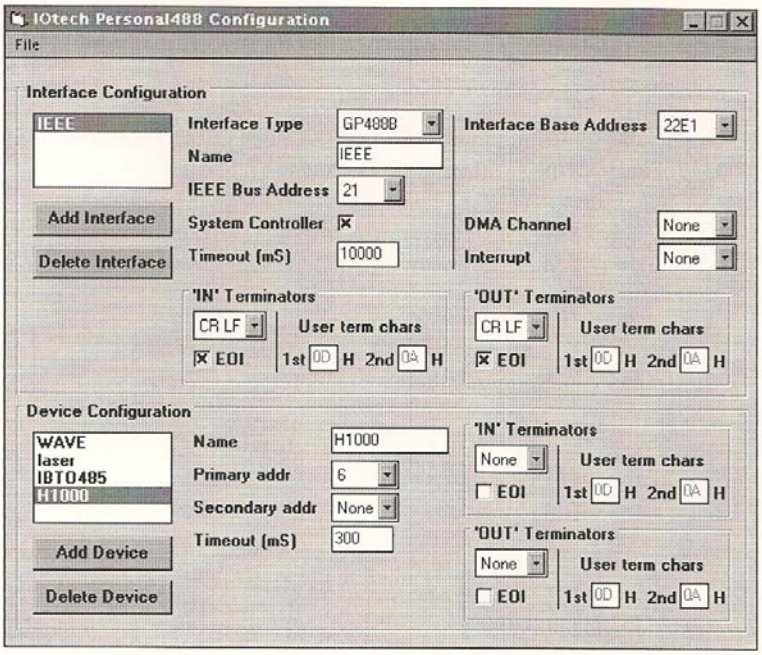
3.1.1 IOTech GP488B

Two devices, 'IBTO485' and 'H1000', must be set up using the IOTech Configuration program \WINDOWS\IEEE488\CONFIG.EXE. The setup screens are shown below.

3.1.1.1 IBTO485 Device Setup



3.1.1.2 H1000 Device Setup



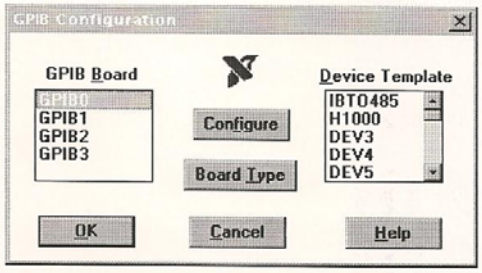
Note that the Device Configuration **'IN'** and **'OUT'** Terminators for the H1000 are set to **None**. The H1000 cannot communicate properly otherwise.

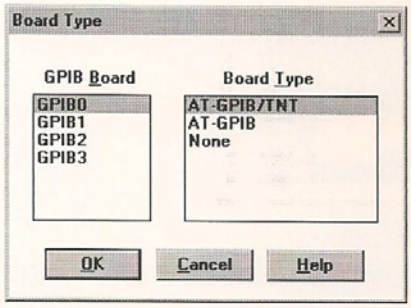
3.1.2 National Instruments AT-GPIB/TNT

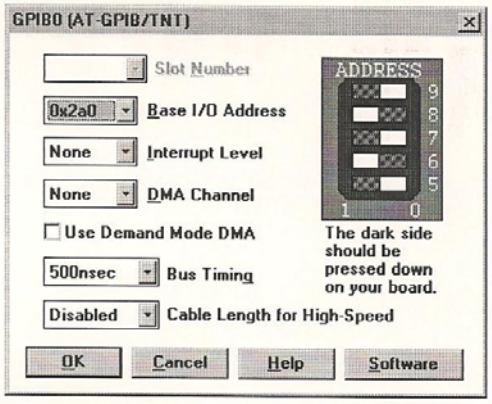
Note: The AT-GPIB/TNT board must NOT be the plug-n-play model and the drivers must be version 2.7.1.

Two devices must be set up using the National Instruments GPIB Configuration program found in the control panel.. The devices are 'IBTO485' and 'H1000'. The setup screens are shown below.

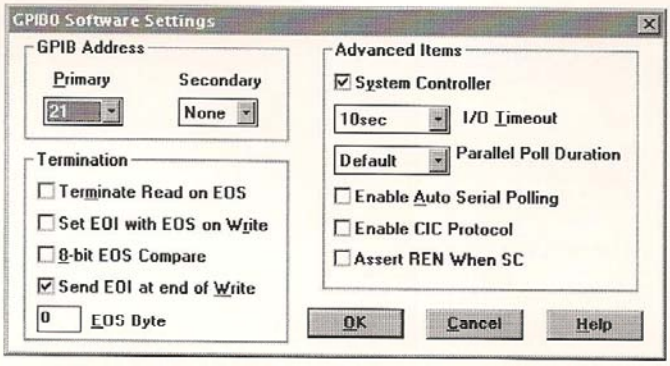
3.1.2.1 GPIB0 Device Setup



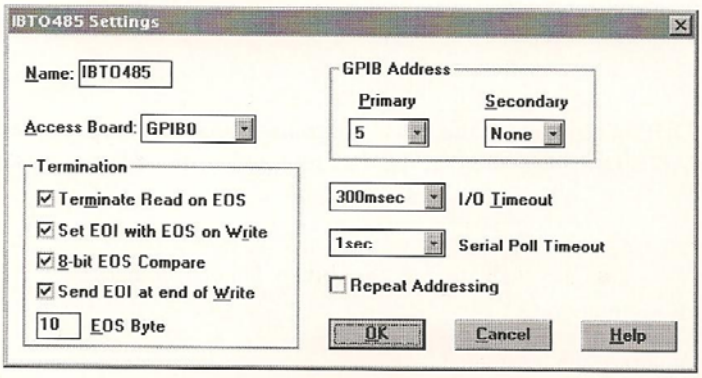




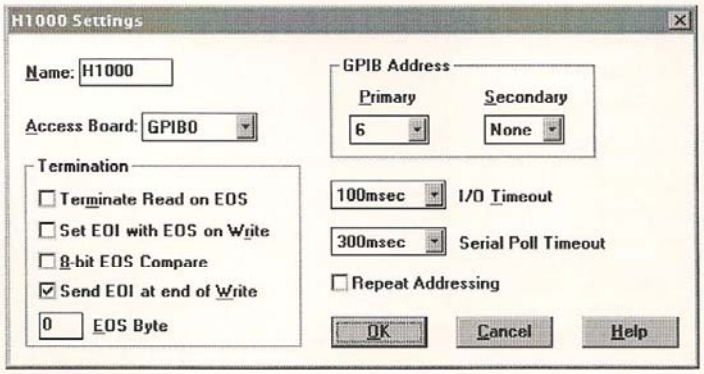
Note: If pcTC is run standalone or with pcProbe[II], any of the device templates may be used for IBTO485 and H1000. However, if pcTC is to be run with Metrics ICS, do NOT use DEV1, DEV2, DEV3, or DEV4, or ICS will not run properly.



3.1.2.2 IBTO485 Device Setup



3.1.2.3 H1000 Device Setup



3.2 DDE Operation

This section describes all the available DDE commands to the pcTC program. The DDE topic required for communication to pcTC is **HOTSTAGE|DATA**. Note that the data returned with DDE requests has CR/LF at the end of the string.

3.2.1 Command Summary

temp -- Get the chuck temperature in degrees C.

heat -- Set/Get the heat set temperature in degrees C.

cool -- Set/Get the cool set temperature in degrees C.

soak -- Get the soak time in seconds.

manual -- Get manual control status and perform heat or cool temperature control.

exec -- Execute temperature cycle sequence and get status.

sequence -- Load/Get temperature control sequence file.

3.2.2 Get chuck temperature

DDE Item: temp

DDE Request Data: current chuck temperature in degrees C.

3.2.3 Get/Set heat temperature

DDE Item: heat

DDE Request Data: current chuck heat set temperature

DDE Poke Data: chuck set temperature

3.2.4 Get/Set cool temperature

DDE Item: cool

DDE Request Data: current chuck cool set temperature

DDE Poke Data: chuck set temperature

3.2.5 Get soak time

DDE Item: soak

DDE Request Data: remaining time for soak in seconds. If the time is positive a soak operation is in progress, whereas a negative value indicates that soak is inactive

3.2.6 manual

DDE Item: manual

DDE Request Data: current status of manual operation with

heat = heat cycle in progress

cool = cool cycle in progress

stop = cycle has been stopped

idle = manual operation is inactive

DDE Poke Data: Perform operations as follows:

heat = start heat cycle

cool = start cool cycle

stop = stop cycle

3.2.7 Executetemperature control sequence/Getstatus

DDE Item: exec

DDE Request Data: returns **idle** when no sequence is active.

returns status of sequence operation with the form

<step#>:<operation>=<parameters>

e.g. **1:heat=150.0**

Note that the first step in the sequence is step 0.

DDE Poke Data: data commands are:

<step#>	execute the specific step #
all	execute sequence from start to finish
stop	stop execution of the sequence

3.2.8 Load/Gettemperature control sequence

DDE Item: sequence

DDE Request Data: returns current sequence file name and the number of steps in the sequence as <steps>:<file>. E.G - **5:c:\hotstage\first1.seq**

DDE Poke Data: sequence file name to load. e.g.-- **c:\hotstage\first1.seq**

3.3 Hotstage.ini

This file contains all the setup information for the pcTC program. The following listing is configured for a simulated hot chuck. Comments are to the right.

```
[Installed]                 This section defines the type and number of temperature controllers
max=1                       installed.  At this time the only type is HC1000_0
0=HC1000_0
retry_status=2              Number of retries to attempt when a comm error occurs
soaktckill=no               Flag to stop temperature control after a soak cycle
updatetimer=2000            Update temperature timer interval in milliseconds ( lower=faster)
tracksettemp=no             Always track controller set temperature flag (slows response)


[HC1000_0]                  Configuration section for the H1000 system.
max=2                       Number of temperature control modules installed -- 1 or 2
0=TC_1000_0                 Type of module for first controller
1=TC_1000_1                 Type of module for second controller (if present )
soak=3000                   Default soak time in milliseconds
remote=off                  Reserved for later use
lockout=off                 Reserved for later use
latcherr=yes                Reserved for later use

[TC_1000_0]                 TC Module 0 configuration
type=heat                   Type of controller -- must be 'heat' or 'cool'
address=1                   RS-422 Address of controller -- 1=heat  2=cool
delta=0.5                   Difference of actual vs set temp for 'At Temperature' state
ramprate=2.0                Reserved for later use
stress=152.0                Default set temperature
units=c                     Temperature units -- c=celsius  f=fahrenheit  k=kelvin
mintemp=-64.0               Minimum temperature allowed for TC
maxtemp=400.0               Maximum temperature allowed for TC
comm=SIMCOMM                Communications type -- must 'SIMCOMM', "ATGPIBW_0", "GP488B_0",
                            or 'RS_232_0'
random=yes                  SIMCOMM mode only.  yes=return set temp +/- random(delta)
                                    no=display simulated communications box (not recommended)
resolution=0.1              Display and TC resolution for temperature
MinDelta=0.1                Minimum value for 'At Temperature' delta described above
MaxDelta=10.0               Maximum value for 'At Temperature' delta described above
MinResolution=1.0           Minimum display and TC resolution
MaxResolution=0.1           Maximum display and TC resolution
usecal=yes                  Enable use of calibration data
caldeviation=100.0          Maximum allowable deviation between measured and indicated
0=-65.0,-65.0               Calibration points in the form <point#>=<measured>,<indicated>
1=-50.00,-50.00                 where <measured> = External Temperature Standard
2=0.00,0.00                           <indicated> = Heat or Cool module Temperature
3=50.00,50.00
4=100.00,100.00
5=150.00,150.00
6=200.00,200.00
7=250.00,250.00
8=300.00,300.00
9=350.00,350.00
```

```
10=400.00,400.00
11=450.00,450.00


[TC_1000_1]                 TC Module 1 configuration -- see above for item descriptions
type=cool
address=2
delta=0.5
ramprate=2.0
stress= 50.0
units=c
mintemp=-65.0
maxtemp=399.0
comm=SIMCOMM
random=yes
resolution=0.1
MinDelta=0.1
MaxDelta=10.0
MinResolution=1.0
MaxResolution=0.1
usecal=yes
caldeviation=100.0
0=-65.0,-65.0
1=-50.00,-50.00
2=0.00,0.00
3=50.00,50.00
4=100.00,100.00
5=150.00,150.00
6=200.00,200.00
7=250.00,250.00
8=300.00,300.00
9=350.00,350.00
10=400.00,400.00
11=450.00,450.00


[SIMCOMM]                   Simulated commumications section
type=simulated              Communications Type
prompt=yes                  Reserved for later use

[RS_232_0]                  RS-232 communications section
type=rs232                  Communications type
baud=9600                   Baud rate -- must be valid baud rate
stop=1                      stop bits -- must be '1' or '2'
bits=7                      data bits -- must be '7' or '8'
parity=odd                  parity -- must 'odd' 'even' or 'none'
port=0                      Comm port with 0=com1, 1=com2

[ATGPIBW_0]                 National Instruments AT-GPIB card setup
type=natinst                Comm Type
board=gpib0                 Board ID
dev1=IBTO485                NI GPIB-485CT-A Status/Setup Device ID
dev2=H1000                  RS-485 I/O Device ID

[GP488B_0]                  IOTech GP488B card setup
type=iotech                 Comm Type
```

```
board=ieee                  Board ID
dev1=IBTO485                NI GPIB-485CT-A Status/Setup Device ID
dev2=H1000                  RS-485 I/O Device ID

[THX]                       Thermal expansion settings
scale=1.00000000            wafer mask scalar
ambient=20.00               ambient reference for temperature compensation
lowtemp=0.00                low temperature for expansion compensation range
hightemp=300.00             high temperature for expansion compensation range
coeff=6.00                  coefficient of thermal expansion as microUnits/Unit/Degree
enabled=yes                 Enable flag for thermal expansion
tolerance=3                 tolerance list index
existing=yes                use existing pcProbe scalar valuc
```

```
board=ieee                  Board ID
dev1=IBTO485                NI GPIB-485CT-A Status/Setup Device ID
dev2=H1000                  RS-485 I/O Device ID

[THX]                       Thermal expansion settings
scale=1.00000000            wafer mask scalar
ambient=20.00               ambient reference for temperature compensation
lowtemp=0.00                low temperature for expansion compensation range
hightemp=300.00             high temperature for expansion compensation range
coeff=6.00                  coefficient of thermal expansion as microUnits/Unit/Degree
enabled=yes                 Enable flag for thermal expansion
tolerance=3                 tolerance list index
existing=yes                use existing pcProbe scalar valuc
```

- ❑ pcTC requires that for a given measured temperature, the maximum deviation between the measured and indicated temperature be less than 100 degrees C.
- ❑ The indicated values for table entry n must be less than those for table entry n+1. e.g.- P[1]=(23.0,25.0) P[2]=(33.0,22.0) is invalid.
- ❑ When measuring temperatures above or below those available in the table, the difference between measured and indicated on the nearest point is subtracted from the value.
- ❑ The calibration algorithm assumes that the temperature variation is linear between table entries. Typically, the more calibration points available, the more accurate the temperature control.
- ❑ The temperature and Set Temp readings on pcTC are calibrated readings generated using the calibration table. The temperature displayed on the H1000 Heat Control Module is uncalibrated. The SET TEMP value on the H1000 is the adjusted value required to attain the desired pcTC set temperature.
- ❑ BE PATIENT! The temperature control system and external temperature reference take a while to stabilize at the set temperature.

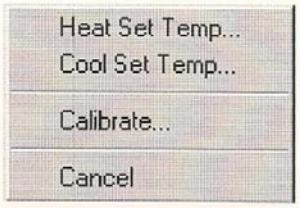
Entering Software Calibration Data

Note: Temperature calibration is normally done directly with the H1000 controllers, but software calibration is available as a backup. If software calibration is used, calibration programmed directly into the H1000 controllers musts be cleared first. See the H1000 documentation for instructions.

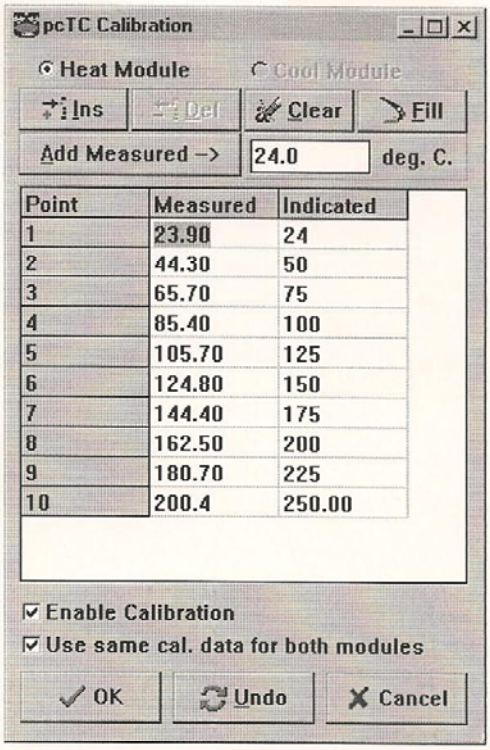
The following procedure can be used to generate calibration data for an H1000 module:

1. If pcTC is running, shut it down.
2. Make a backup copy of the hotstage.ini file, usually located in C:\HOTSTAGE\HOTSTAGE.INI.
3. Use the Windows' Accessory *Wordpad* to access the hotstage.ini file, usually located at C:\HOTSTAGE\HOTSTAGE.INI.
4. Turn calibration on by modifying or adding the following entry in the [Installed] section of the hotstage.ini file:

   swcal = yes
5. Save and exit hotstage.ini.
6. Make sure the chuck is at ambient temperature and start pcTC.
7. Move the mouse cursor over either the Heat module display for temperature and click the right mouse button. The menu shown below appears over the temperature:

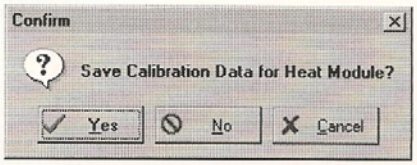


8. Select the ***Calibrate*** option. The following dialog box is displayed:



9. Disable calibration by clicking on the ***Enable Calibration*** check box and removing the check mark.

10. Select ***OK***. The following confirmation box appears:



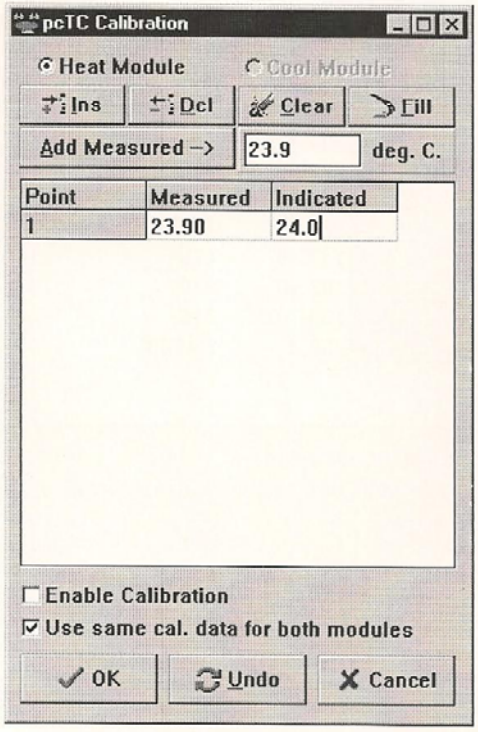
11. Select ***Yes***. This turns off calibration compensation in pcTC.

12. Re-open the calibration dialog box as in step 2.

13. Click the ***Clear*** button. The calibration table is emptied.

14. Enter the current temperature measured by the external reference in the edit box to the right of the *Add Measured* button. For Example, 23.9. Click the *Add Measured* button and the entry is added to the table.

15. Select the ***Indicated*** column entry and type in the value displayed by the Heat module, for example, 24.0. At this point, the table looks like this:



16. Select the ***Set Temp*** field for the Heat Module. Enter the desired set temperature for the first calibration point -- e.g. 50.0.

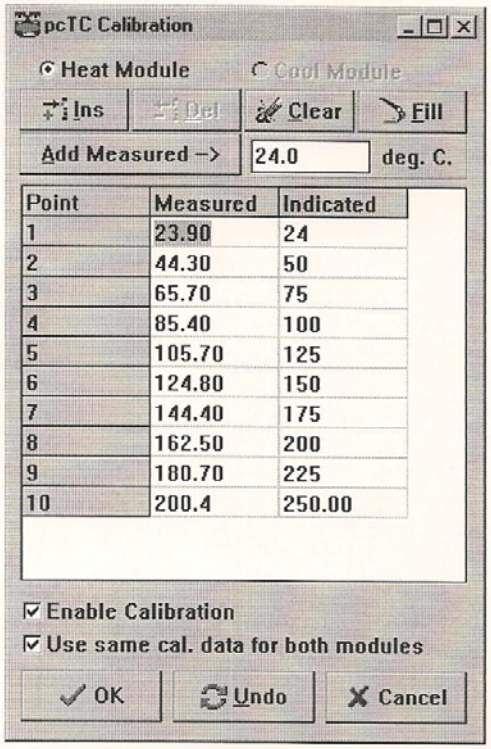
17. Select the Heat button.

18. Wait for the H1000 and external temperature reference to reach the set temperature and stabilize on a reading.

19. Select the ***Ins*** button to insert the new reading for the set temperature in the list.

20. Select the Measured value for the point and enter the value displayed on the external temperature reference. e.g. 44.3.

21. Repeat steps 16 through 20 at the desired intervals until the measured temperature is at or above the highest level required during testing. The final table will look something like this:



22. Enable Calibration by clicking on the ***Enable Calibration*** check box.

23. Select OK and when prompted to Save, select Yes.

24. The calibration data is saved to disk and used by pcTC. Test the settings by comparing the readings of the external reference to the display on pcTC.