Chroma

TEC Controller

54115-24-8/54130-27-12

User's Manual

TEC Controller
54115-24-8/54130-27-12
User's Manual

Version 1.1
May 2012

Legal Notices

The information in this document is subject to change without notice.

Chroma ATE INC. makes no warranty of any kind with regard to this manual, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Chroma ATE INC. shall not be held liable for errors contained herein or direct, indirect, special, incidental or consequential damages in connection with the furnishing, performance, or use of this material.

CHROMA ATE INC.
66 Hwa-Ya 1st Rd., Hwa-Ya Technology Park, Kuei-Shan 33383, Taoyuan County, Taiwan

Copyright Notices. Copyright 2012 Chroma ATE INC., all rights reserved. Reproduction, adaptation, or translation of this document without prior written permission is prohibited, except as allowed under the copyright laws.

All other brand and product names are trademarks or registered trademarks of their respective holders.

Warranty

All Chroma instruments are warranted against defects in material and workmanship for a period of one year after date of shipment. Chroma agrees to repair or replace any assembly or component found to be defective, under normal use during this period. Chroma's obligation under this warranty is limited solely to repairing any such instrument, which in Chroma's sole opinion proves to be defective within the scope of the warranty when returned to the factory or to an authorized service center. Transportation to the factory or service center is to be prepaid by purchaser. Shipment should not be made without prior authorization by Chroma.

This warranty does not apply to any products repaired or altered by persons not authorized by Chroma, or not in accordance with instructions furnished by Chroma. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, repairs will be billed at cost.

Chroma assumes no responsibility for its product being used in a hazardous or dangerous manner either alone or in conjunction with other equipment. High voltage used in some instruments may be dangerous if misused. Special disclaimers apply to these instruments. Chroma assumes no liability for secondary charges or consequential damages and in any event, Chroma's liability for breach of warranty under any contract or otherwise, shall not exceed the purchase price of the specific instrument shipped and against which a claim is made.

Any recommendations made by Chroma for use of its products are based upon tests believed to be reliable, but Chroma makes no warranty of the results to be obtained. This warranty is in lieu of all other warranties, expressed or implied, and no representative or person is authorized to represent or assume for Chroma any liability in connection with the sale of our products other than set forth herein.

CHROMA ATE INC.
66 Hwa-Ya 1st Rd., Hwa-Ya Technology Park,
Kuei-Shan 33383, Taoyuan County, Taiwan
Tel: 886-3-327-9999
Fax: 886-3-327-2886
e-mail: info@chromaate.com

http://www.chromaate.com

Material Contents Declaration

The recycling label shown on the product indicates the Hazardous Substances contained in the product as the table listed below.

: See **<Table 1>**.

: See **<Table 2>**.

<Table 1>

Part Name	Hazardous Substances					
	Lead	Mercury	Cadmium	Hexavalent Chromium	Polybrominated Biphenyls	Polybromodiphenyl Ethers
	Pb	Hg	Cd	Cr^{6+}	PBB	PBDE
PCBA	O	O	O	O	O	O
CHASSIS	O	O	O	O	O	O
ACCESSORY	O	O	O	O	O	O
PACKAGE	O	O	O	O	O	O

“O” indicates that the level of the specified chemical substance is less than the threshold level specified in the standards of SJ/T-11363-2006 and EU 2005/618/EC.

“×” indicates that the level of the specified chemical substance exceeds the threshold level specified in the standards of SJ/T-11363-2006 and EU 2005/618/EC.

Disposal

Do not dispose of electrical appliances as unsorted municipal waste, use separate collection facilities. Contact your local government for information regarding the collection systems available. If electrical appliances are disposed of in landfills or dumps, hazardous substances can leak into the groundwater and get into the food chain, damaging your health and well-being. When replacing old appliances with new one, the retailer is legally obligated to take back your old appliances for disposal at least for free of charge.

<Table 2>

Part Name	Hazardous Substances					
	Lead	Mercury	Cadmium	Hexavalent Chromium	Polybrominated Biphenyls	Polybromodiphenyl Ethers
	Pb	Hg	Cd	Cr^{6+}	PBB	PBDE
PCBA	×	O	O	O	O	O
CHASSIS	×	O	O	O	O	O
ACCESSORY	×	O	O	O	O	O
PACKAGE	O	O	O	O	O	O

"O" indicates that the level of the specified chemical substance is less than the threshold level specified in the standards of SJ/T-11363-2006 and EU 2005/618/EC.

"×" indicates that the level of the specified chemical substance exceeds the threshold level specified in the standards of SJ/T-11363-2006 and EU 2005/618/EC.

1. Chroma is not fully transitioned to lead-free solder assembly at this moment; however, most of the components used are RoHS compliant.
2. The environment-friendly usage period of the product is assumed under the operating environment specified in each product's specification.

Disposal

Do not dispose of electrical appliances as unsorted municipal waste, use separate collection facilities. Contact your local government for information regarding the collection systems available. If electrical appliances are disposed of in landfills or dumps, hazardous substances can leak into the groundwater and get into the food chain, damaging your health and well-being. When replacing old appliances with new one, the retailer is legally obligated to take back your old appliances for disposal at least for free of charge.

CE

SPORTON LAB.

Certificate No: CB10104052

Report No.: EC232613

CERTIFICATE

- **EQUIPMENT: TEC Controller**
  MODEL NO. : 54130-27-12, 54115-24-8
  APPLICANT : CHROMA ATE INC.
  66 Hwaya 1st Rd., Kueishan Hwaya Technology Park,
  Taoyuan County 33383, Taiwan

SPORTON LAB.

I HEREBY CERTIFY THAT:

THE MEASUREMENTS SHOWN IN THIS TEST REPORT WERE MADE IN ACCORDANCE WITH THE PROCEDURES GIVEN IN **EUROPEAN COUNCIL DIRECTIVE 2004/108/EC.** THE EQUIPMENT WAS **PASSED** THE TEST PERFORMED ACCORDING TO
European Standard EN 61326-1:2006,
(EN 55011:2009/A1:2010 Class A,
EN 61000-3-2:2006/A2:2009, EN 61000-3-3:2008
IEC 61000-4-2:2008, IEC 61000-4-3:2006/A1:2007/A2:2010, IEC 61000-4-4:2004/A1:2010, IEC 61000-4-5:2005, IEC 61000-4-6:2008, IEC 61000-4-8:2009, IEC 61000-4-11:2004).
THE TEST WAS CARRIED OUT ON Mar. 26, 2012 ~ Apr. 06, 2012 AT SPORTON INTERNATIONAL INC. LAB.

Jordan Hsiao

Jordan Hsiao

SPORTON INTERNATIONAL INC. No.8, Lane 724, Bo Ai Street, Zhubei City, Hsinchu County 302, Taiwan, R.O.C.

VERIFICATION

of conformity with Low Voltage Directive

Verification No.: ACT202510LVD

Document holder: **CHROMA ATE INC.**	*Type of product:* **TEC Controller**
Address: **66 Hwaya 1st Rd., Kueishan Hwaya Technology Park, Taoyuan County 33383, Taiwan**	*Type designation:* **54130-27-12, 54115-24-8**
Trade mark: Chroma	*Technical data:* **Input: 100-240Vac, 50/60Hz, Class I** **5A for 54130-27-12,** **3.5A for 54115-24-8** **Output:** **24Vdc / 12A, 280W for 54130-27-12,** **24Vdc / 8A, 160W for 54115-24-8**

A sample of the product has been assessed with respect to CE-marking according to the Low Voltage Directive (2006/95/EC) and found to comply with the essential requirements of the Directive.
The Standard(s) used for showing the compliance and the full details of the results are given in the Test Report as detailed below:

Standard(s)	Report No.	Report Issued Date
EN 61010-1:2010 (Edition 3.0)	ACT202510	April 20, 2012

The holder of the verification is authorized to use this verification in connection with the EC declaration of conformity according to the Directive. The CE marking may only be used if all relevant and effective EC Directives are complied with. Together with the manufacturer's own documented production control, the manufacturer (or his European authorized representative) can in his EC Declaration of Conformity verify compliance with the Low Voltage Directive.

Approved by:

Vincent Tan
Acts Certification and Testing Services
April 20, 2012

CE Acts LVD TESTED

Acts Certification and Testing Services Co., Ltd.
1st Floor, No. 20, Lane 61, Tianshiang Road, Taipei, Taiwan Tel: +886-2-25858775 Fax: +886-2-25983002

Safety Summary

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or specific WARNINGS given elsewhere in this manual will violate safety standards of design, manufacture, and intended use of the instrument. *Chroma* assumes no liability for the customer's failure to comply with these requirements.

BEFORE APPLYING POWER

Verify that the power is set to match the rated input of this power supply.

PROTECTIVE GROUNDING

Make sure to connect the protective grounding to prevent an electric shock before turning on the power.

NECESSITY OF PROTECTIVE GROUNDING

Never cut off the internal or external protective grounding wire, or disconnect the wiring of protective grounding terminal. Doing so will cause a potential shock hazard that may bring injury to a person.

FUSES

Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuse holders. To do so could cause a shock or fire hazard.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. The instrument should be used in an environment of good ventilation.

DO NOT REMOVE THE COVER OF THE INSTRUMENT

Operating personnel must not remove the cover of the instrument. Component replacement and internal adjustment can be done only by qualified service personnel.

Safety Symbols

	DANGER – High voltage.
	Explanation: To avoid injury, death of personnel, or damage to the instrument, the operator must refer to an explanation in the instruction manual.
	High temperature: This symbol indicates the temperature is now higher than the acceptable range of human. Do not touch it to avoid any personal injury.
	Protective grounding terminal: To protect against electrical shock in case of a fault. This symbol indicates that the terminal must be connected to ground before operation of equipment.
	The **WARNING** sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a **WARNING** sign until the indicated conditions are fully understood and met.
	The **CAUTION** sign denotes a hazard. It may result in personal injury or death if not noticed timely. It calls attention to procedures, practices and conditions.
	The **Notice** sign denotes important information in procedures, applications or the areas that require special attention. Be sure to read it carefully.

Unpacking for Check & Inspection

Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials in case the instrument has to be returned. If damage is found, please file claim with carrier immediately. Do not return the instrument to Chroma without prior approval.

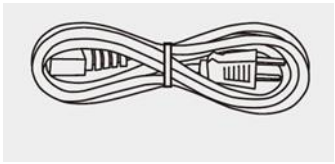
Standard Package

Standard Configuration

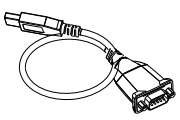
TEC Controller

User's Manual CD

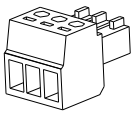
Standard Accessories



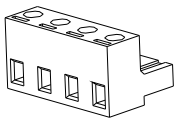
US Power Cord
1.8 Meter
1 pc



USB-232 Cable
1 pc



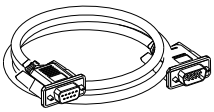
3pin Terminal
1 pc



4pin Terminal
1 pc

5A Fuse
1 pc

3A Fuse
1 pc



RS-232 Cable
1 pc

Note When additional item is required, please inform Chroma the item name.

Storage, Freight & Maintenance

Storage
When not in use, please pack the device properly and store in a suitable environment. (If the storage environment is in good condition, package can be omitted.)

Freight
Please pack the device carefully before moving it. If any of the original packing material is missing, please use suitable alternative material and mark it “fragile” and “keep away from water” to avoid damaging the product.

This product is a piece of precision equipment, so please do not drop or hit it.

Maintenance
In case of any malfunction or abnormality, please refer to the manual, or contact our local distributor for prompt service. Do not touch any parts inside the device to avoid any danger to yourself or damage to the product.

Replacing Fuse

The power range of TEC Controller is AC 100-240V. Be sure to replace the fuse that maps to the power range as the table list below before use.

Voltage Range	Fuse Applied
100V-132V	5A/250V
198V-240V	3A/250V

Confirm the supplied power voltage before changing the fuse. In the meantime, the power cord has to be removed to prevent electric shock. Use a flat screw driver to pry off the fuse box inside the power socket, remove the fuse in it and then install the new fuse inside the fuse box gently. At last, press the fuse box back to the power socket. Only the fuse in the same specification can be replaced and see the figure below for replacement.

Revision History

The following lists the additions, deletions and modifications in this manual at each revision.

Date	Version	Revised Sections
Jan. 2012	1.0	Complete this manual.
May 2012	1.1	Add the following functions: – Over Temperature Protection – TC Open Detection – Panel restores to factory default – Error code shows on panel Modify the “*Message Codes & Definitions*” in the chapter of “*Communication Protocols*”.

Table of Contents

1. Beginning for TEC Controller 1-1
1.1 Basic Setup 1-1
1.2 Front Panel 1-1
1.3 Back Panel 1-2

2. Panel Operation 2-1
2.1 Push Buttons 2-1
2.2 Menu List 2-1
2.3 Main Display 2-3
2.3.1 SET TEMP Sub-menu 2-5
2.3.2 SET OFFSET Sub-menu 2-7
2.3.3 SETUP Sub-menu 2-9
2.3.4 INSTALL Sub-menu 2-11

3. Remote Operation 3-1
3.1 PC Program Installation 3-1
3.2 PC Program Execution 3-1
3.3 Temperature Ramping Sub Program 3-9
3.4 Temperature Cycling Sub Program 3-12
3.5 Engineering Settings 3-14

4. Communication Protocols 4-1
4.1 Serial Communication Configuration 4-1
4.2 Packet Format 4-1
4.3 Message Codes & Definitions 4-2
4.4 Cyclic Redundancy Check 4-5
4.5 Examples 4-5

Appendix A Dimensions & Mechanical Drawings A-1

Appendix B Specifications B-1

1. Beginning for TEC Controller

Thanks for choosing Chroma TEC controllers for your temperature control applications. Our TEC module based temperature control equipments are among the best of the products in this category. Please read the manual carefully and follow the contents for optimal performance of the temperature control system.

1.1 Basic Setup

Here you should have a TEC controller, a temperature control platform which contains a TEC module or a set of TEC modules in parallel or/and serial connections, and one or two T-type thermal couples as temperature sensors. The basic application configuration is shown in Figure 1-1. Besides the required TEC Controller and Temperature Control Platform, you also can have an optional PC linked to the TEC Controller for remote control and monitoring. In some cases, TEC Controller can provide optional alarm and control signals with simple circuit arrangement.

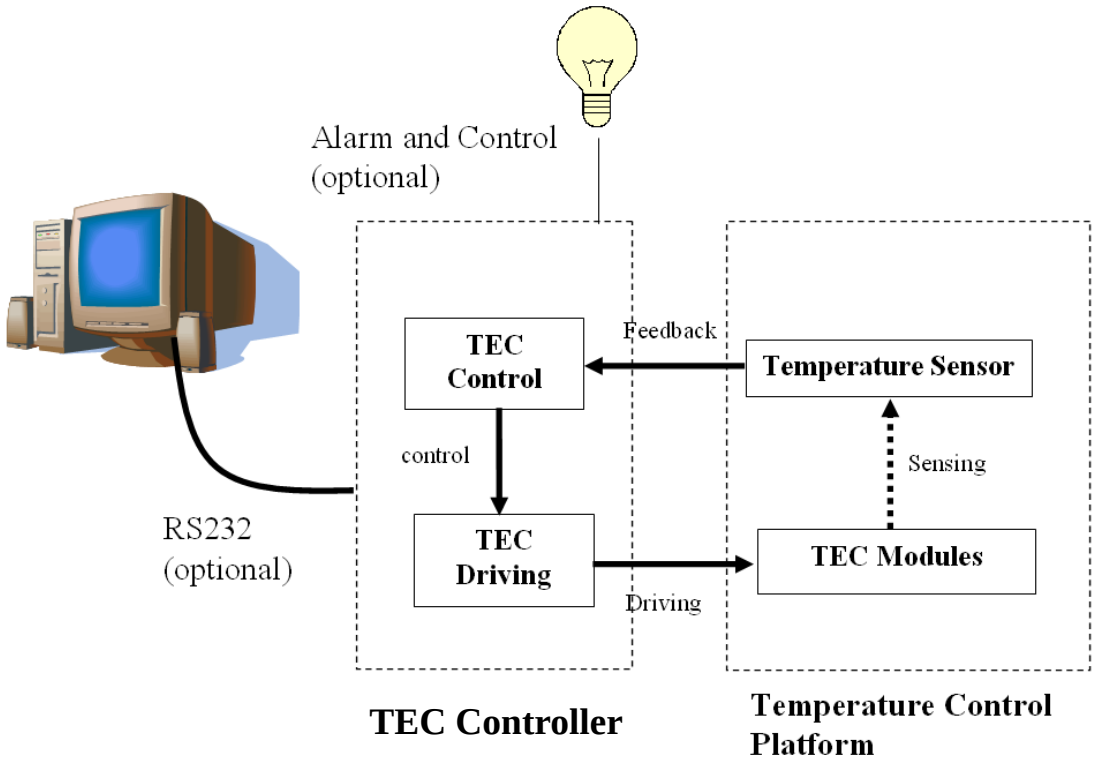


Figure 1-1 Basic Configuration for TEC Temperature Control

1.2 Front Panel

The front panel of a TEC Controller is shown in Figure 1-2. There are 5 push buttons, MENU, Up-arrow, Right-arrow, Enter, and Run/Stop. Also there are LEDs showing some basic operation status. Detail of push button operation will be described in Chapter 2. The definitions of LEDs are listed below.

LED	Color	Indication	Note
POWER	Green	Controller power on	
	off	No power	
AT	Green/ flashing	PID parameters auto tuning in progress	off after tuning complete
	off	Normal operation	
STATUS	Green	Normal	
	Amber	Warning	Temperature not within control range
	Red	Error	Need to check the error code
ENABLE	Green	TEC driving enabled	in "Run" mode
	off	TEC driving disabled	in "Stop" mode

Figure 1-2 TEC Controller Front Panel

1.3 Back Panel

The back panel, as shown in Figure 1-3, contains many connectors. Besides the AC power connector, there are TEC, FAN, ALARM, RS232, INTERFACE I/O, and thermal couple inputs. The details are described in the following.

Figure 1-3 TEC Controller Back Panel

TEC: There are 4 wires for driving TEC modules, 2 for TEC positive (marked as “+”) and 2 for negative (marked as “-”). For each polarity, one can use only 1 of the 2 wires since they are short internally. However, using 2 wires in parallel reduces the conducting wire resistance, and that is important in large current situation. In applications, several TEC modules can be configured in parallel and/or serial if more than one TEC module is necessary, as shown in Figure 1-4. The maximum driving output is 24 V or 8 A. One needs to know the characteristics of the TEC modules for getting most out of the TEC controller.

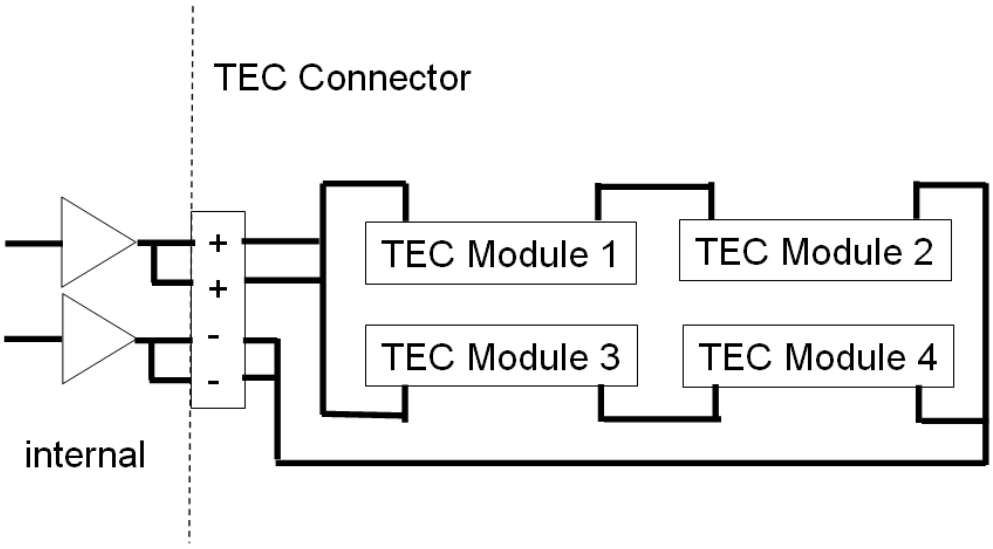


Figure 1-4 Example of TEC Driving Output for Multiple TEC Modules

FAN: In many applications, a fan is used in the temperature control platform to assist dissipating heat drawing from TEC modules. The fan can be powered either from an independent power supply, or simply from the 24VDC power here. To use this power source, please note the fan must be 24VDC and consuming less than 1A. Fans with other specifications must not use this power source and need an extra power supply to meet their power requirement.

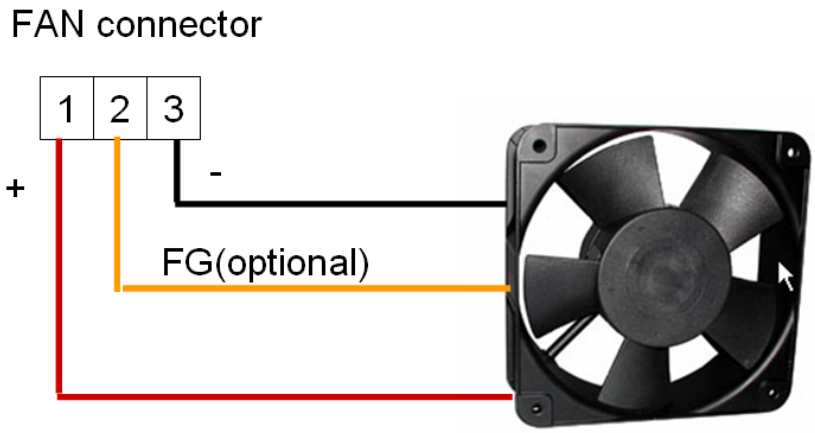


Figure 1-5 Fan Connector Provides a 24VDC, 1A Power Source

The 3 pins for fan connector are 1 for power +, 3 for power -, and 2 for FG (frequency generator), respectively. FG is used for detecting fan rotation and can be omitted if not necessary.

ALARM: It is an internal relay triggered by some alarm signal, such as TEC module failure, temperature sensor failure, or some internal circuit failures. The two connector points are open in normal status, and becomes short when alarm occurs. One can use this to form an alarm loop for lightening a bulb, turn on a siren, or whatever enabled in the loop. Figure 1-6 shows an example using a bulb as the alarm indicator. The rated specification of this connector is 24Vdc, 1A.

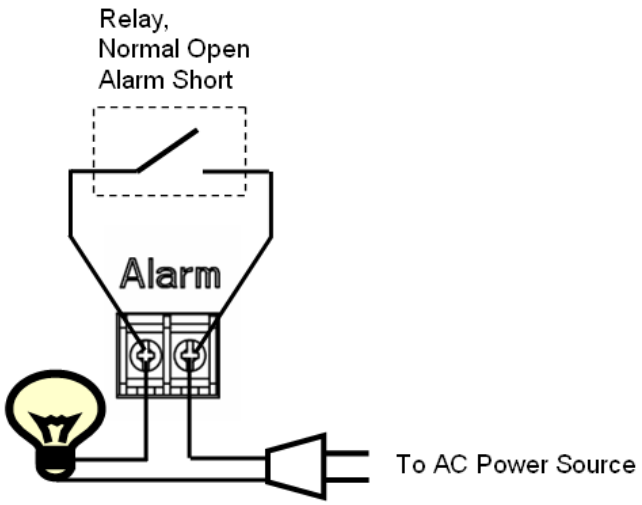


Figure 1-6 Example of Building Alarm Indication Using the Alarm Connector

RS232: This is the serial communication port for PC remote operation. The communication protocols are revealed in Chapter 4. For PC without RS232 ports, a USB-to-RS232 converter is required. It should be easy to get at many computer stores.

INTERFACE I/O: This part is reserved for system integration. It provides digital input/output pins that some test systems can be used for direct signaling. Please contact Chroma if you need the TEC controller to be integrated into your system besides the RS232 communications.

THERMAL COUPLE: There are 2 thermal couple inputs, TC1 and TC2. Please note both thermal couples must be T-type. One can recognize the thermal couple type by blue plugs. In most cases, TC1 is used for feedback of temperature control, and TC2 is just for getting some reference temperature. In certain special cases, both thermal couple inputs can be used for temperature control. Please see section 2.3.1 for detail description. As the TEC Controller is a precision instrument, it is suggested that all front end temperature sensing of Thermocouple sensors (TC1/TC2) are earth grounded to avoid electrostatic interference and causes the device failure.

2. Panel Operation

Figure 2-1 541XX Series Controller Front Panel

2.1 Push Buttons

There are five push buttons on the front panel: MENU, Up-arrow, Right-arrow, Enter, and Run/Stop, as shown in Figure 2-1. The major functions and symbols for these push buttons are list as following:

Push Button	Symbol	Function Description
MENU	MENU	Showing menu items or jumping back to display
Up-arrow	▲	Changing selected item or adjusting numbers
Right-arrow	➡	Changing selected digit in numbers
Enter	↵	Confirming selection or settings
Run/Stop	▶/■	Enable/Disable TEC driving output

2.2 Menu List

All the controller configurations and settings can be done with MENU, Up-arrow, Right-arrow, and Enter buttons. The Run/Stop button is only in charge of driver output. Other operations can be summarized in the menu tree map as shown in Figure 2-2. Each menu tree map item and its corresponding LCD display is described as following.

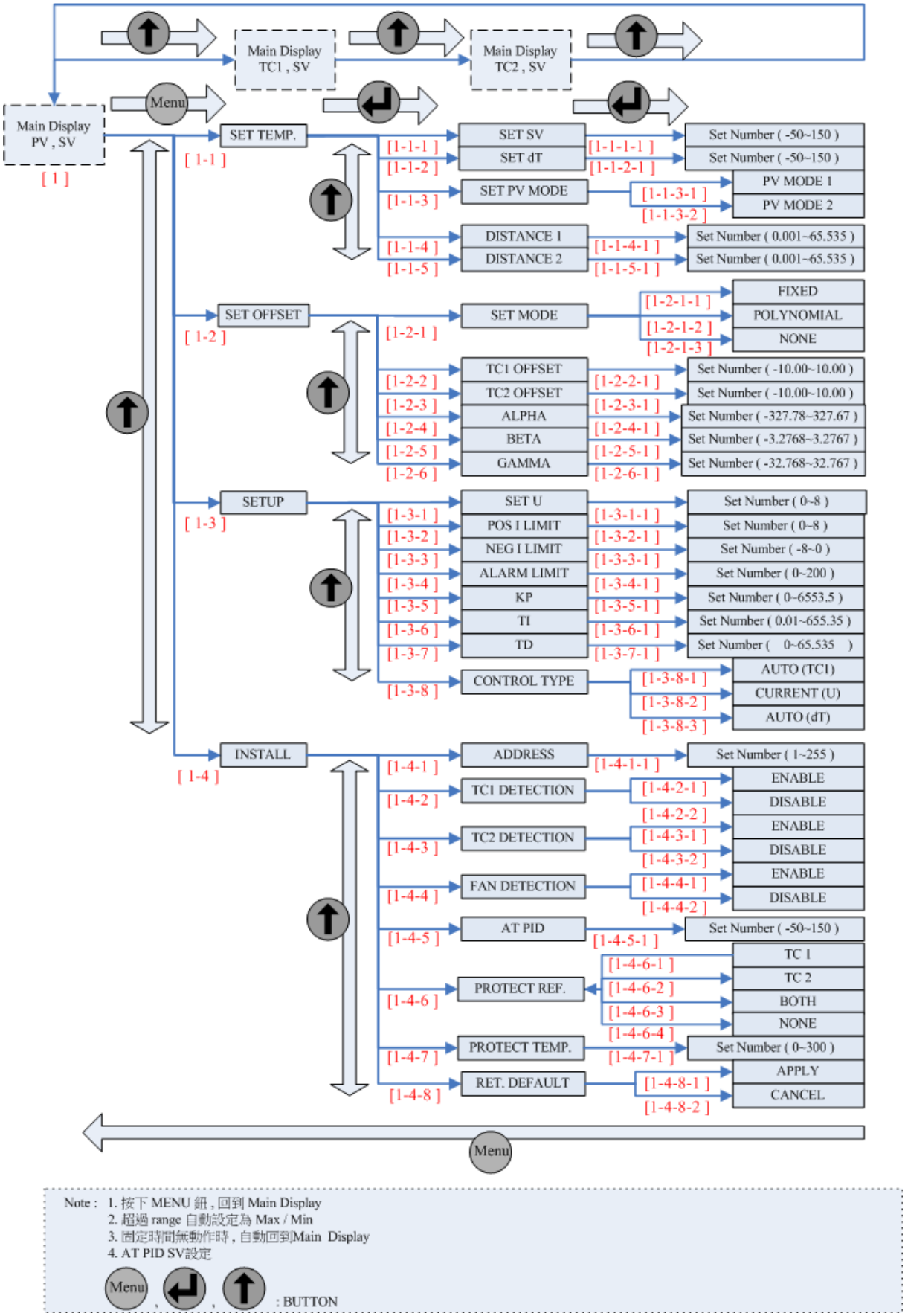
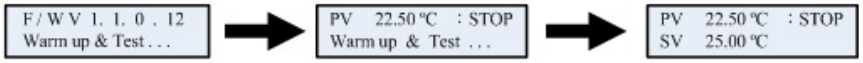


Figure 2-2 Menu Tree Map of Front Panel Operations

2.3 Main Display



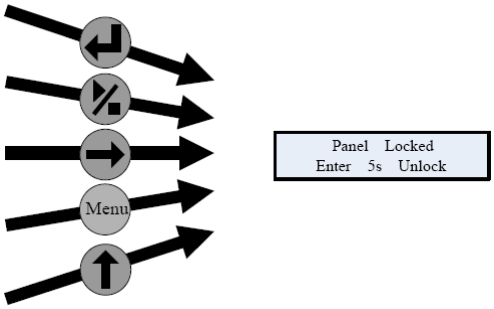
The upper line on the panel shows the firmware version and the lower line shows the internal temperature control status during power on. It will return to normal until the temperature reaches the default. No current output is allowed during warm up.

(Main Display)

This is the initial display when the controller is powered on, and the display when controller runs normally without interruption. If no any button is pushed for 10 seconds during setup, the controller status will go back to normal display automatically and settings without confirm is aborted. PV means Present Value, which shows the temperature read by the temperature sensor. SV means Set Value, which is the target temperature the control should reach. The driver status is shown in the top-right. STOP means the driver output is disabled and no current goes to the TEC module. RUN indicates the driver output is enabled and temperature control is performing.

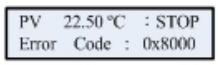
When the controller is just powered on, pushing Run/Stop button may get this warm-up message and output remains at Stop status. Typically 1~3 minutes later, the controller finishes warming up and can start to deliver output.

In some cases of remote control, the panel operation is locked to avoid setting change. Pushing any button will get the Panel Locked message below.



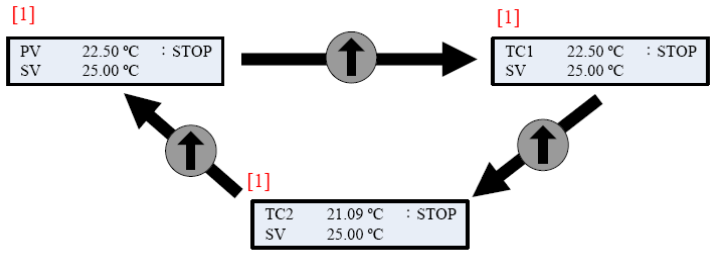
To release panel lock, it can be either done by remote setting (described in Chapter 3), or pushing enter and holding for 5 seconds.

When error occurs, the **STATUS** will light up in red and the lower line on the panel will show the error code. See section 4.3 for detail description of error code.



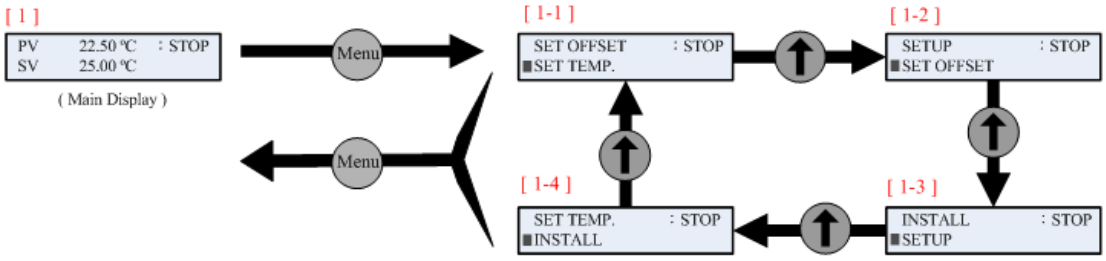
Note This selection menu only valid when the firmware version is 1.1.0.12 or newer.

PV, TC1, and TC2



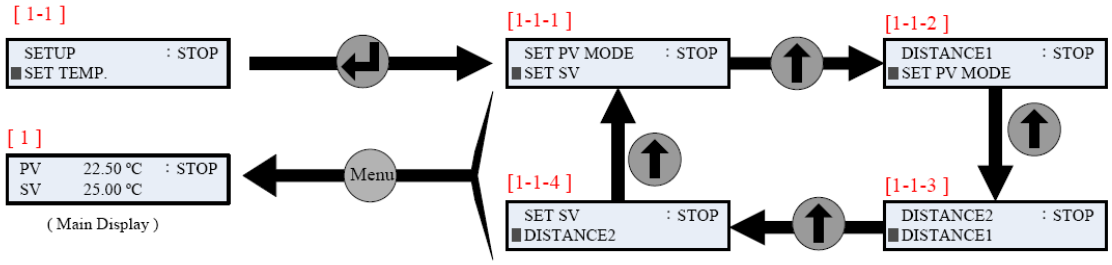
Push *Up-arrow* during Main Display will switching temperature readings of PV, TC1, and TC2. TC1 and TC2 are the temperature readings by the two thermal couples plugged in the back panel. PV, depending on the PV MODE described in the following, can be either the same as TC1, or calculated by linearly extrapolating TC1 and TC2.

SET TEMP, SET OFFSET, SETUP, and INSTALL



Pushing *MENU* at Normal Display will bring up SETUP, SET OFFSET, INSTALL, and SET TEMP selections. All sub-menu items are under these four categories. The black block in front indicates the selection, and *Enter* will go to the sub-menu item selection. To abort the selection, one just pushes *MENU* to go back Normal Display. STOP or RUN at the top-right shows the driving status and has nothing to do with the selection. All setting can be done while the driving output is in either STOP or RUN status.

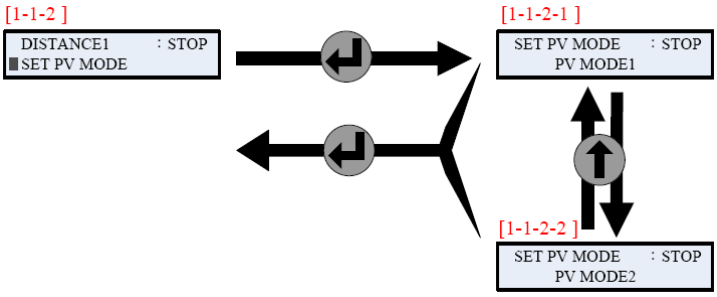
2.3.1 SET TEMP Sub-menu



Once SET TEMP is selected and *Enter* is pressed, SET TEMP sub-menu items will show up. They are SET SV, SET PV MODE, DISTANCE1, and DISTANCE2, as showing above.

SET SV: To set control value of the target temperature.

SET PV MODE: PV is the present target temperature. What the TEC controller does is to equalize PV and SV. There are two control modes to evaluate PV, where



PV MODE 1: PV = TC1 ;
PV MODE 2: PV = TC1 - ((TC2-TC1) * D1) / (D2)

If one can attach thermal couple TC1 directly at the point to be temperature controlled, PV MODE 1 should be chosen. In the case TC1 is used for temperature control and TC2 can be attached anywhere for reference or temperature uniformity check. In some special cases that no thermal couple is allowed to attach the point to be temperature controlled. A prediction method using PV MODE 2 can be used. Figure 2-3 shows such an example. The target temperature is linearly extrapolated by TC1 and TC2 with the PV MODE 2 equation.

CAUTION

(1) Two dimension parameters, Distance 1 (D1) and Distance 2 (D2), are required for the calculation.
(2) It is assumed that the temperature difference is linear among target point, TC1, and TC2. This often refers to a one-dimensional structure. For some complicated structures, the linear extrapolation can result in wrong target temperature prediction.
(3) We do not guarantee the accuracy of PV MODE 2 since there can be all kinds of structures that linear extrapolation is not valid. Even for one-dimensional structure, there can be radiation and

convection causing prediction error. So please use PV MODE 2 wisely and carefully.

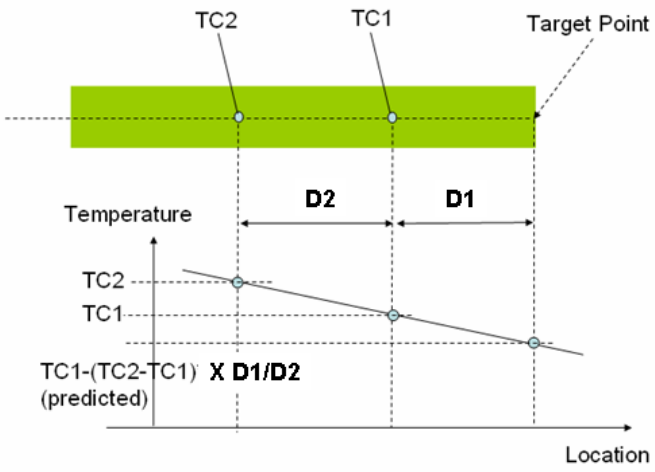


Figure 2-3 Illustration of PV Mode 2 Target Point Temperature Extrapolation

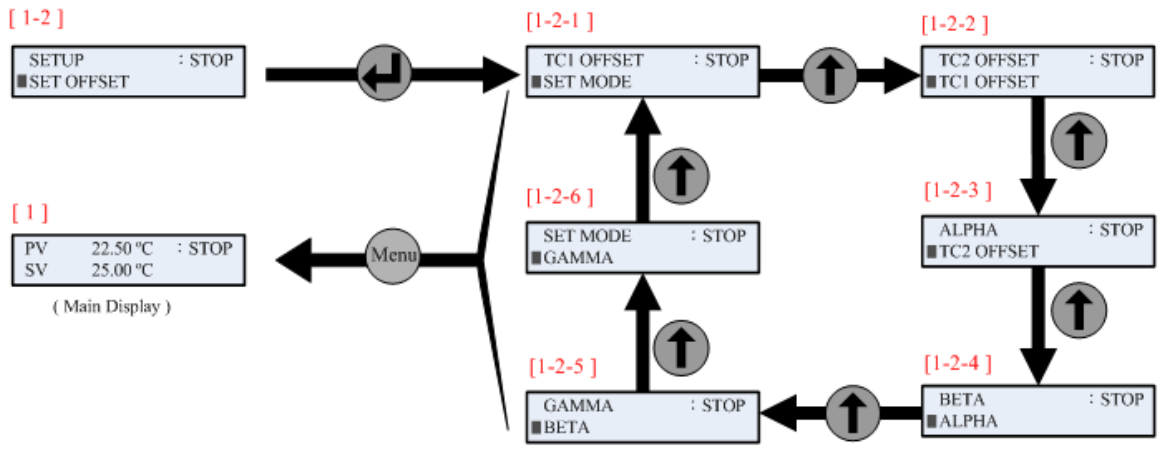
Distance 1: Set the length D1. See the above graph. This is required only for PV MODE2 chosen.

Distance 2: Set the length D2. See the above graph. This is required only for PV MODE2 chosen.

Please note that D1 and D2 are relative. The absolute length and unit is not issues. For example, D1=3mm and D2=5mm. DISTANCE 1 and DISTANCE 2 can be 3 and 5, 30 and 50, 300 and 500, or even 6 and 10 that each pair of input will get the same result.

2.3.2 SET OFFSET Sub-menu

Note This part is implemented for firmware version 1.1 or newer.



Once **SET OFFSET** is selected and ***Enter*** is pressed, **SET OFFSET** sub-menu items will show up. They are **SET MODE**, **TC1 OFFSET**, **TC2 OFFSET**, **ALPHA**, **BETA**, and **GAMMA**, as showing above. They will be explained as follows.

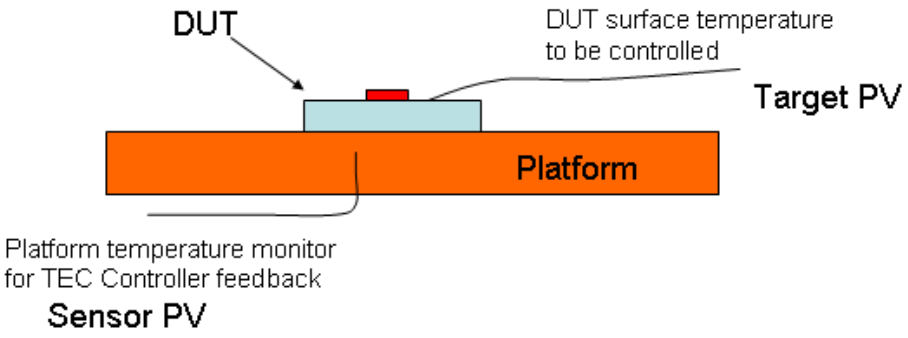


Figure 2-4 Illustration of Temperature Offset between Sensor PV and Target PV

In some cases, TEC controller uses the thermal couple reading from the platform (Sensor PV), while the goal is the control the temperature at somewhere on DUT (Target PV), as shown in Figure 2-4. The best way is to have TC1 directly attached at the point to be temperature controlled (Target PV location); however, TC1 is limited in platform structure for many cases (Sensor PV location). There can be a difference between the two temperatures, Sensor PV and Target PV. In order to precisely control Target PV while using Sensor PV as control feedback, a temperature offset is introduced:

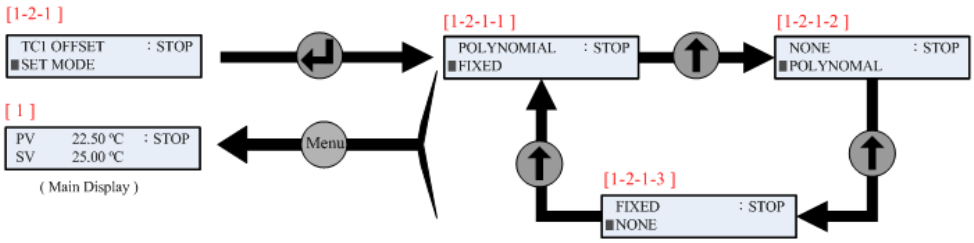
Offset=Target PV-Sensor PV or Target PV=Sensor SV+Offset

In operation, one may attach TC2 to the Target PV point at first and find out what the offset is. Later on, one can correctly predict Target PV without really attaching a temperature sensor to that point in further tests.

Notice The LCD panel and program PV display is actually Target PV, not Sensor PV. Also the control process will equalize SV and Target PV. Once the

offset is activated, the temperature displayed and controlled are directly associated with the point of interest, not the temperature inside the platform.

SET MODE: There are three offset modes to be chosen.



FIXED mode gives constant offset values for TC1 and TC2.

POLYNOMIAL mode calculates the offset for TC1 using the following equation: Offset = $\alpha \times 10^{-6} \times \mathrm{SV}^2 + \beta \times \mathrm{SV} + \gamma$, in POLYNOMIAL mode TC2 offset is ignored and set to 0. NONE will ignore all offset settings and simply let Target PV=Sensor PV (TC1, TC2 offset=0).

Notice

The offset depends on the deviation between SV and ambient temperature. If the platform works only at certain temperature, FIXED mode may be a good solution. For platforms working over a wide temperature range, POLYNOMIAL mode must be used for proper offset compensation. Users must go through the offset measurements at several temperatures, and fits the measurements to find out the polynomial coefficients. Often linear fitting is good enough; however, we provide second-order polynomial for even better fitting.

TC1 OFFSET: Set TC1 offset value. This is effective only in offset FIXED mode.

TC2 OFFSET: Set TC2 offset value. This is effective only in offset FIXED mode.

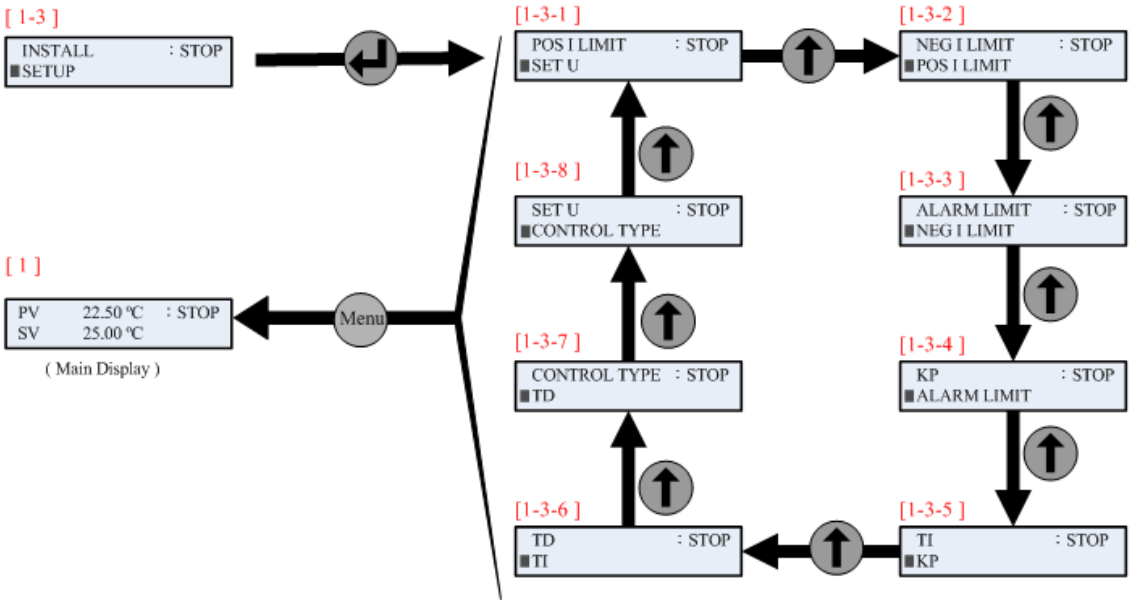
ALPHA: Set the second order coefficient of the offset polynomial. This is effective only in offset POLYNOMIAL mode. Please multiply the second order coefficient by 10^6 before key in the value, since it will be multiply by 10^{-6} again in offset calculation.

BETA: Set the first order coefficient of the offset polynomial. This is effective only in offset POLYNOMIAL mode.

GAMMA: Set the zero order coefficient of the offset polynomial. This is effective only in offset POLYNOMIAL mode.

CAUTION The value is limited at +/-10°C. Any input value or calculation beyond that will be limited at +10°C or -10°C. One reason is to protect the controller and platform from improper offset, for example, wrong polynomial coefficients. The other is that too large offsets indicate a poor thermal conduction between DUT and the platform. It is the thermal conduction should be checked and enhanced, not setting a large offset.

2.3.3 SETUP Sub-menu



Once SETUP is selected and *Enter* is pressed, SETUP sub-menu items will show up. They are SET U, POS I LIMIT, NEG I LIMIT, ALARM LIMIT, KP, TI, TD, CONTROL TYPE, and INTEGRATOR, as showing above.

SET U: This sets the constant TEC driving current when in MANU mode.

POS I LIMIT: This sets the maximum positive TEC driving current for protecting the TEC module.

NEG I LIMIT: This sets the maximum negative TEC driving current for protecting the TEC module.

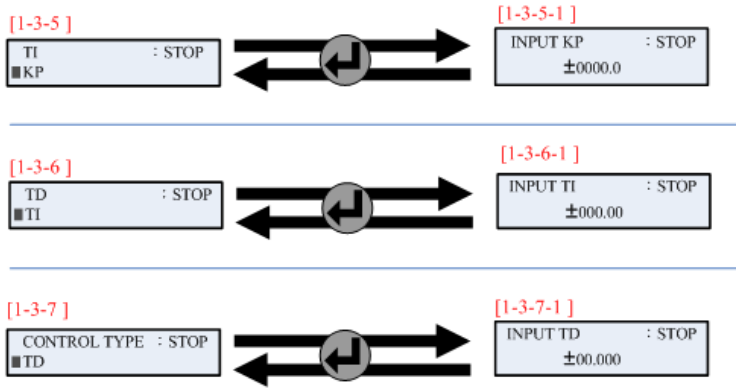
ALARM LIMIT: This sets the PV and SV deviation for warning sign to be on or off. For example, SV is 50°C and ALARM LIMIT is 1°C. When PV is over or under 50±1°C, which is 51°C or 49°C, the Status LED at TEC controller front panel will be amber, indicating that controlled temperature is far away form goal temperature. When PV reaches within 50±1°C, the status LED will turn green indicating nearly arriving goal temperature. The default setting of ALARM LIMIT is 3°C.

KP, TI, and TD: These are the Proportional, Integral, and Differential parameters used in the PID calculation. Depending on the system response, various PID parameters are required for system stability and optimal control. For proper PID parameter settings, please consult Chroma. We can tune these parameters for customers to achieve optimal control in most cases. We do not recommend customers to alter these parameters without knowing a proper way of tuning.

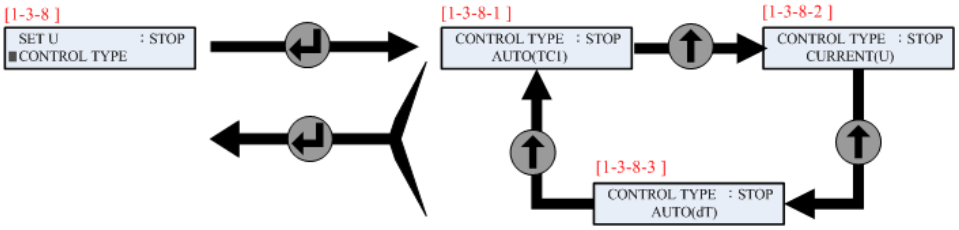
The mathematic for PID control is illustrated as:

$$u = K_P(e + \frac{1}{T_I}\int edt + T_D\frac{de}{dt})$$, where

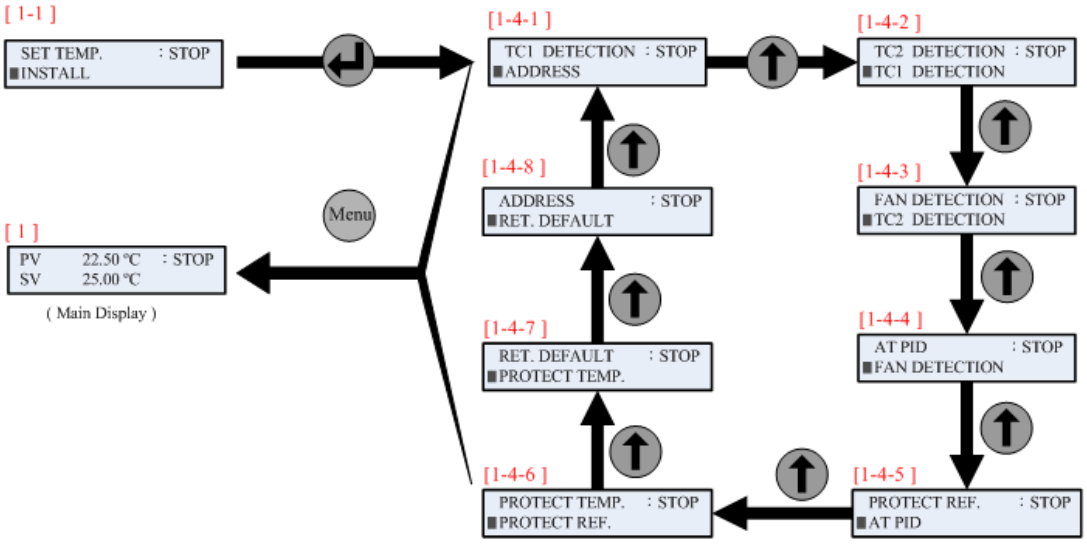
u: controller output
e: error signal, which is the difference between Present Value (PV) and Set Value (SV)
K_P: proportional gain (KP)
T_I: integration time constant (TI)
T_D: differential time constant (TD)



CONTROL TYPE: It can be set to AUTO (TC1 temperature control), CURRENT (U manual constant current) and AUTO (dT different temperature control). In AUTO control type, controller will adjust driving output according to PID control algorithm to reach SV temperature goal. In CURRENT (U) control type, the driving output provides a constant current defined in SET U item. AUTO (dT) mode follow the temperature value read by TC2 to combine the dT value set by user and become the target PV for temperature control.



2.3.4 INSTALL Sub-menu



There are 8 options under INSTALL sub-menu, they are:

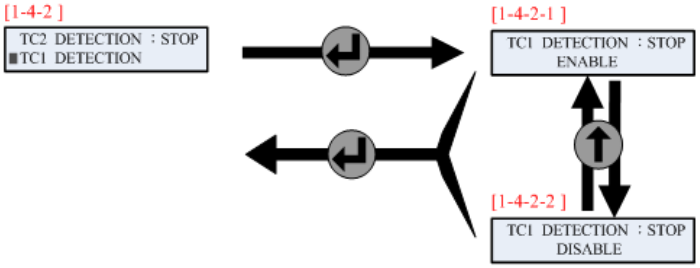
ADDRESS: Each TEC controller has an ID number, also called Address, to be distinguished one from another while in PC communication. In most cases that one PC just links to a TEC controller, the Address can be ignored since Chroma's PC programs can automatically

handle it. However, in some special cases that one has several TEC controllers in a communication links, the PC needs to know which command sends to which TEC controller, and which response message is from which controller. The Address then comes to help the proper communication. The Address can be any integer from 0 to 255, and the default is 255. Please make sure no any two TEC controllers share the same ID number.

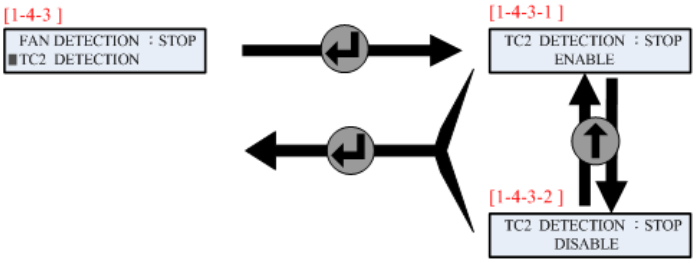
Notice

In order to have multiple controllers in a serial communication links, one needs RS232-to-RS485 converters and maybe a USB-to-RS485 converter for PC.

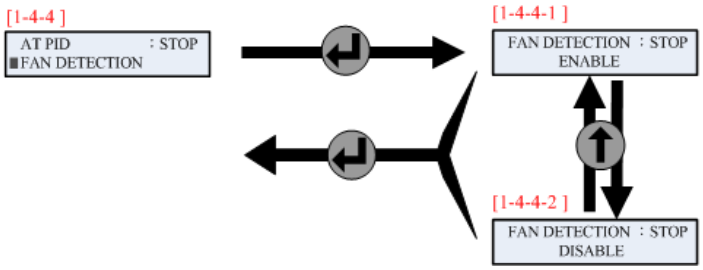
TC1 DETECTION: This selection decides if enabling TC 1 Open Detection function. If enabled, it will follow the TC1 value or the error between PV and SV when output current is on under temperature mode to determine if issuing error alarm. The output will cut off automatically to protect the temperature control device when alarm occurs.



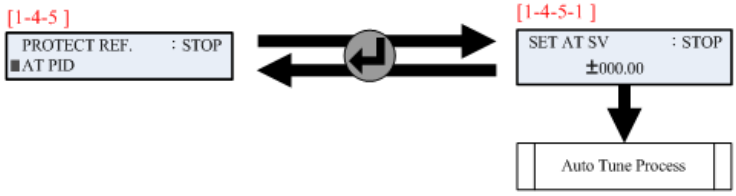
TC2 DETECTION: This selection decides if enabling TC 2 Open Detection function. If enabled, it will follow the TC 2 value to determine if issuing error alarm when the output current is on under temperature mode. The output will cut off automatically to protect the temperature control device when alarm occurs.



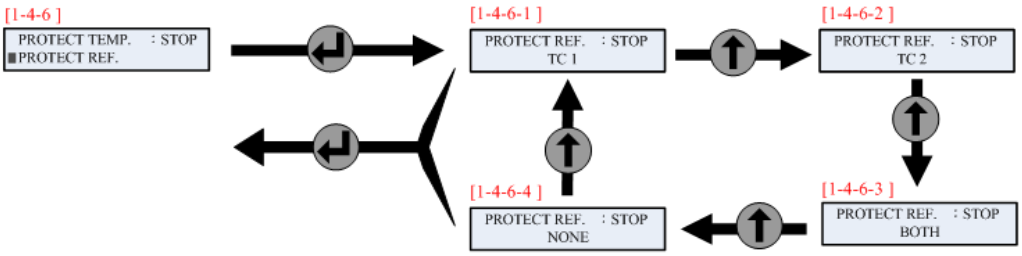
FAN DETECTION: As described in Section 1.3, the FAN power source also has an FG (frequency generator) input to detect fan rotation. If FAN DETECION is set ENABLE, alarm message will be issued when no fan rotation is detected. PC program may also turn off TEC driving output in that case to protect the temperature control platform to be overheated. Fan rotating or not is ignored and no alarm will be issued If FAN DETECION is set to DISABLE.



AT PID: The purpose of AT PID is for PID parameter optimization for temperature platforms without knowing their thermal response characteristics. Simply key in the temperature of control point and then press Enter. The auto tune PID process will proceed. It may take more than 10 minutes to finish tuning, with the AT LED at front panel blinking to indicate process running. The AT LED will be off after tuning is done, and KP, TI, and TD will be replaced with tuning results. Please refer to Section 3.5 for more information.



PROTECT REF.: It needs to cope with next selection to do over temperature protection setting. When the selected source for monitoring over the temperature set by next selection, the system will close the current output automatically to protect the cooling chip. This function is able to select a single temperature monitor point (use TC1 or TC2 to perform over temperature protection) or Both for TC1 and TC2 monitoring simultaneously or None to quit this function.

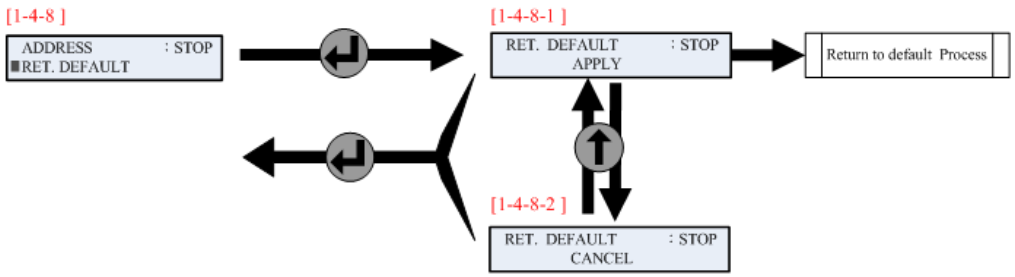


PROTECT TEMP.: When the temperature of selected source for monitoring in previous selection exceeds the set temperature, over temperature protection will activate and close the output current automatically. The parameter value setting is between -50.00°C ~ +150.00°C.

RET. DERAULT: When this function is in use, the following parameters will set to factory default.

TC1, TC2 offset: 0.00 °C
Offset Mode : Fixed mode
Control Type : Auto (TC1)
PV Mode : Mode 0

Current Limit: ±8A(54115-24-8), ±12A(54130-27-12)
U: 1 A
K p: 200
T i: 5
Td: 1
Alarm limit: 100.00°C
TC1, TC2, Fan Detection: Disable
Protect Ref.: None
Protect Temp.: 150.00°C



3. Remote Operation

3.1 PC Program Installation

The controller can be remotely operated through an RS232 linked to a PC. In order to perform remote operation from a PC, one needs to install the Advanced Temperature Control Program (**ATCP**). Please find the program setup CD comes with the controller. Insert the CD into your CD driver and type “X:\setup” in command mode, where X is the driver letter of your CD driver. Follows the installation guide and the program will installed easily.

The program will automatically execute once the installation is finished. Later users can execute program by selecting “Start” → “Program” → “Chroma ATE.” → “ATCP”.

System requirements for Advanced Temperature Control Program are:

Hardware: IBM compatible personal computer with at least Pentium-II CPU, 256 MB RAM, a CD ROM or DVD ROM driver, 20 MB hard disk space, and an RS-232 serial com port. For many PCs without RS-232 com ports nowadays, USB-to-RS232 converters are required. They can be easily obtained from many computer accessory stores.

Software: Operating System of Microsoft Windows 2000, Windows Millennium, Windows XP, or Windows Vista. Other Microsoft Window-based operation systems may be also compatible but not guaranteed. Among these Microsoft window-based operating systems, Windows XP is mostly recommended for its high stability and compatibility. Though we developed ATCP with up-to-date Microsoft Visual Basic, there can be very few compatibility issues with Microsoft Window Vista.

To uninstall ATCP, please activate control panel and select “adding or removing programs”. One will find a list of programs to be updated or removed. Find “ATCP”, select “Remove the application from this computer”, and confirm to remove it.

3.2 PC Program Execution

Before running ATCP, one needs to setup the TEC Controller with a temperature control platform and then links to the TEC Controller with a PC through a RS-232 cable. Once ATCP is running, a language selection dialog, as shown in Figure 3-1, will pop up. At this moment, only English and Traditional Chinese are supported. Once the English version is chosen, the main program window, as shown in Figure 3-2, will appear. The main window can be divided 6 areas. Details for each area are described as follows.

Figure 3-1 ATCP Language Selection

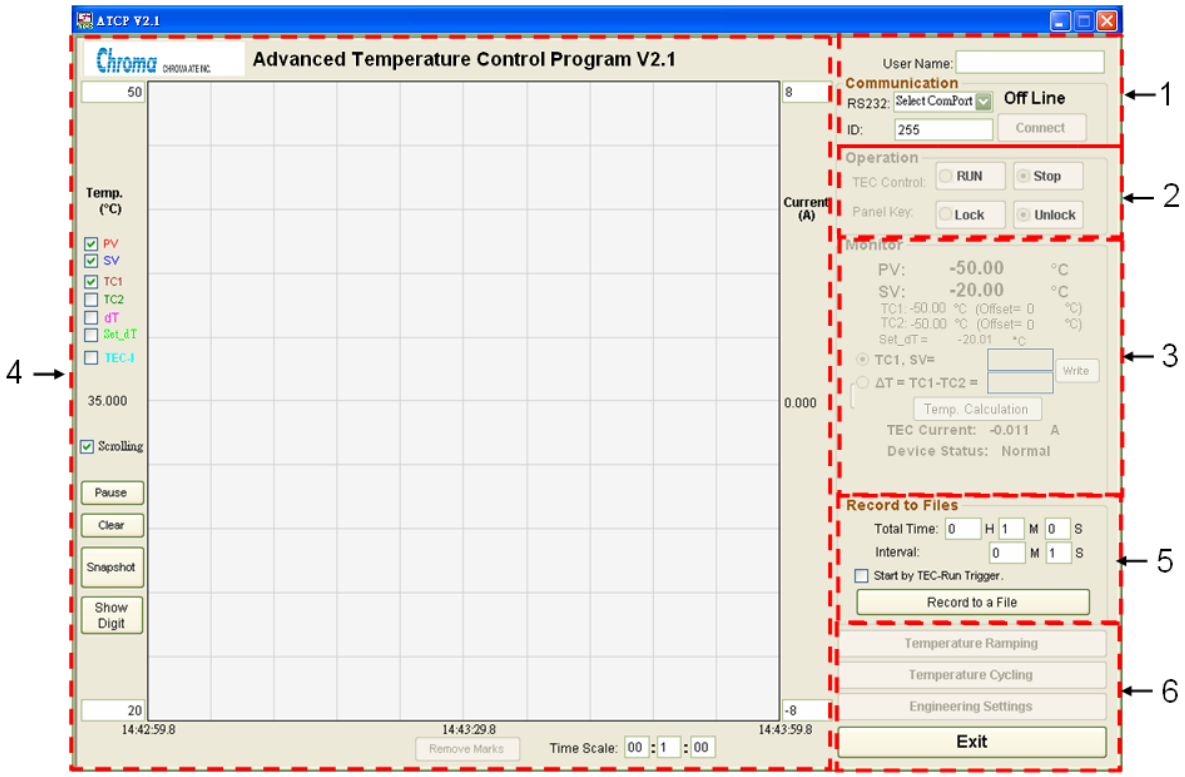
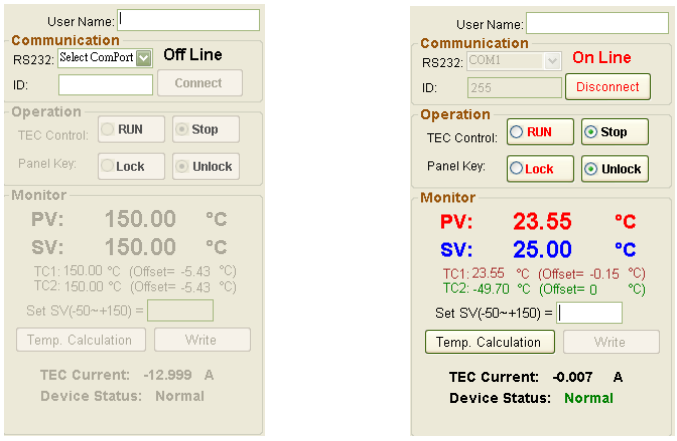


Figure 3-2 ATCP Main Window

1. PC/TEC Controller Communication Link: The user must choose a correct com port first, then press "connect" button. The program will scan for communication address automatically. If a TEC Controller is found, connection status will change from "Off Line" to "On Line". Figure 3-3 shows an example before and after a successful link establishment.



(a) (b)

Figure 3-3 Example of (a) before and (b) after Establishing the Communication Link

CAUTION

(1) User Name is for file record purpose only. The name will be written in the record file. One may leave it blank if not necessary.

(2) In case of more than one TEC Controller in a serial communication link, ID must be specified to tell the program which controller to be chosen. The ID address can be an integer from 0 to 255. Only the controller with matched ID will listen and response to the program. However, most of cases there is only one controller in the link. One can just leave it blank and let the program scan for the ID automatically.

(3) Once the communication is established, many parts in the main window will turn from grey to black or colors, and many input boxes become accepting numbers.

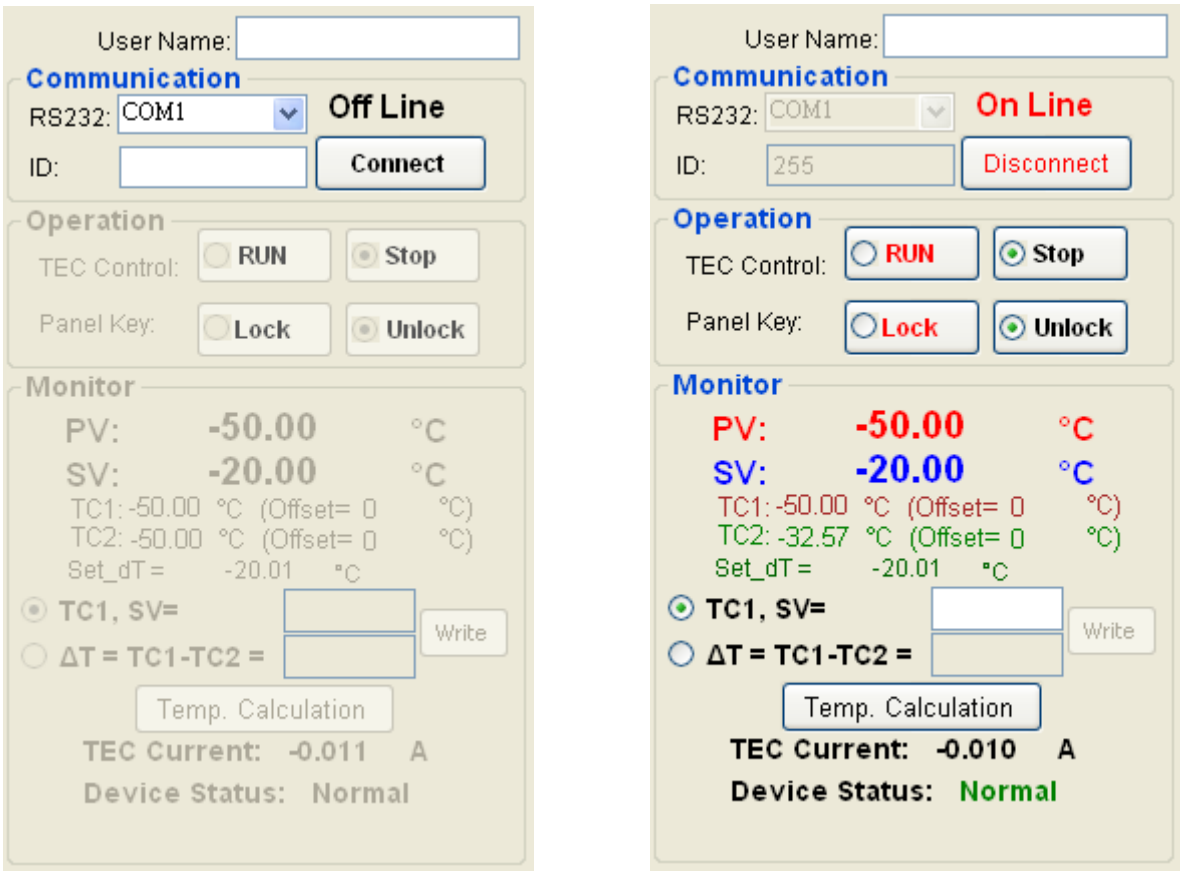
(4) If no TEC Controller is found, a message telling timeout or communication error will pop up. One just needs to select another com port and try again.

2. Operation: There are two settings in this part. TEC Control sets the driving output enabled (RUN) or disabled (STOP). There is no driving output and the temperature control platform will approach ambient temperature is this is set at STOP. Only setting at RUN can activate temperature control. Panel Key sets the operability of controller front panel. The 5 push buttons only work at “Unlock”. Please refer to Chapter 2 for the details of push button operation. No operation can be done through the push buttons if “Lock” is set.

CAUTION

One can remove the “Lock” status by keep pressing “Enter” button for 5 seconds. This is will Unlock the panel operation.

3. Monitor: This shows the Present Value (PV) of target temperature, Setting Value (SV) of target temperature, temperature of thermal couple 1 (TC1), and temperature of thermal couple 2 (TC2). Under the temperature display is an input box for SV. To set the temperature, it just needs to key in a number in the box, and then clicks **Write** as shown in Figure 3-4.



(a) (b)

Figure 3-4 Example of (a) before and (b) after Changing SV from 50°C to 30°C

The lower parts display TEC Current and Device Status. Device Status can be either Normal or Warning, depending on the difference between PV and SV. It shows Normal if the difference is within Alarm Limit setting (will be described in Engineering Setting), and Warning if out of that setting. Regarding to Alarm Limit setting, please refer to Section 2.3.2 for panel operation and Section 3.5 for program operation.

Left to the Write block is the Temp Calculation block. Clicking it will bring up a window for definitions of PV mode (read Section 2.3.1 for detail) and Offset mode (read Section 2.3.2 for detail), as shown in Figure 3-5. In the left part for PV Calculation, as described in Section 2.3.1, Mode 1 takes TC1 as PV, and Mode 2 linearly extrapolates PV from TC1 and TC2. In the right part for Offset Setting, as described in Section 2.3.2, None will ignore and set zero offset, Fixed Mode will take constant values for offsets of TC1 and TC2, while Polynomial Mode calculates TC1 offset using the given second order polynomial as a function of SV, and TC2 offset is ignored. For each mode, check the corresponding round circle to enable inputs.

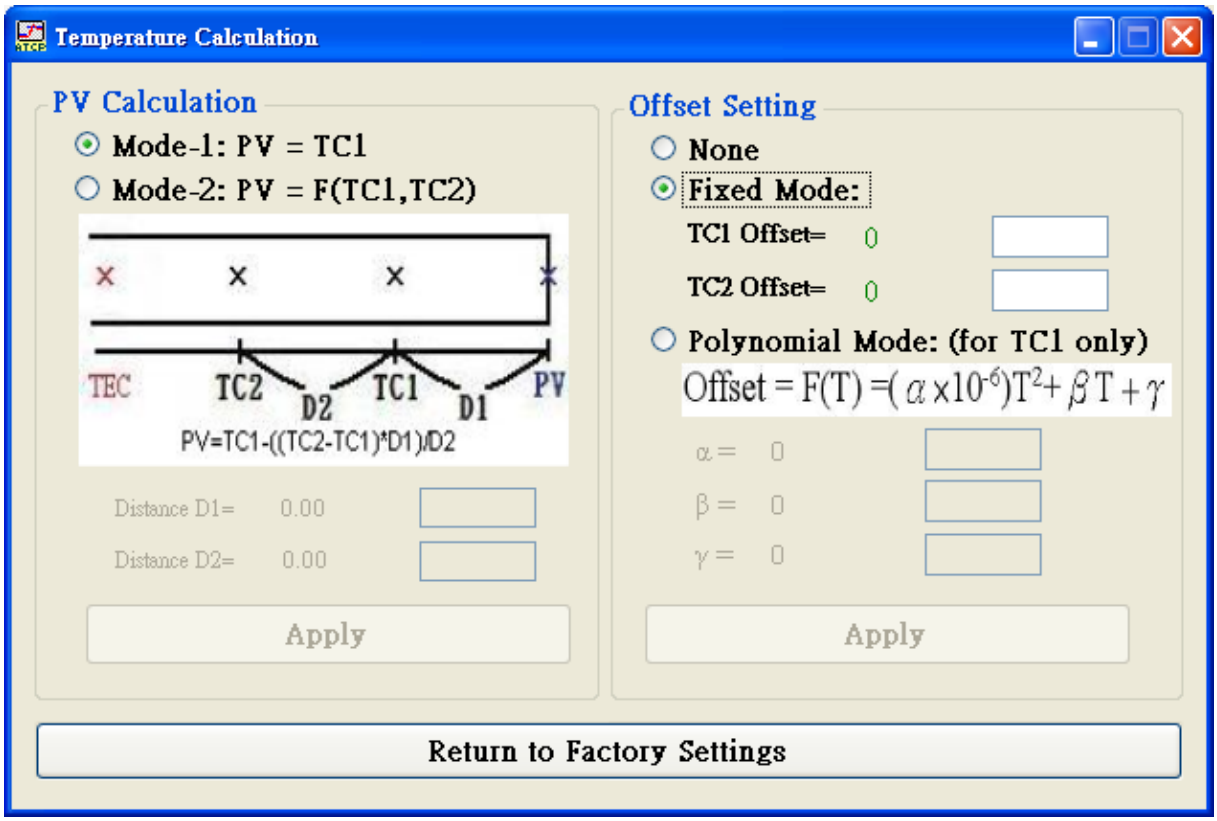


Figure 3-5 Temperature Calculation Definition Window

4. Temperature and TEC Current Time Curves: The graphic window shows PV, SV, TC1, TC2, and TEC current with real time updates. The set the display X-range (time scale) and Y-range (left for temperatures and right for current), one simply keys in the numbers for time and upper/lower limits, as shown in Figure 3-6.

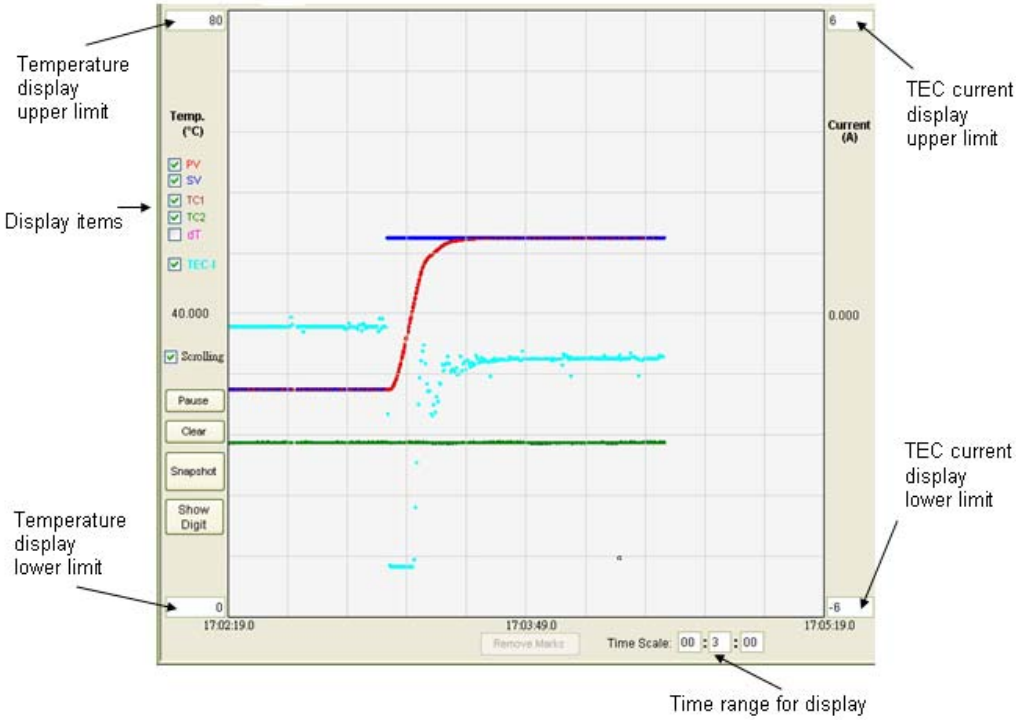


Figure 3-6 X & Y Range Settings for Temperature & TEC Current Time Curves

Beside the range settings, the checking box on the left selects which item to be or not to be displayed. Only the items checked will be displayed, and those are PV, SV, TC1, TC2, and TEC current for the case in Figure 3-6. The Pause button can halt the graphics and the curves stop extension with time. This helps to freeze and analyze the curves. The Clear button will clear the graphics and the curves re-scan from time zero again. The Snapshot button can store the whole main window in graphic form as a jpeg file. Clicking Show Digit will pop up a real-time number display table showing all temperatures and TEC current, as shown in Figure 3-7. dT in this table is defined as TC1-TC2, the temperature difference between the two thermal couples.

CAUTION

(1) After keying in the X or Y scale numbers, one needs to push Clear button to let the scale change taking place.

(2) When the curves reach the time scale, the graphics will be either cleared and curves re-scan from left for Scrolling unchecked (at left center), or be kept but pushed to the left with time for Scrolling checked.

(3) X axis is marked as the time of the day. For example, 17:02:19.0 is 2 minutes and 19 seconds after 5 o'clock PM.

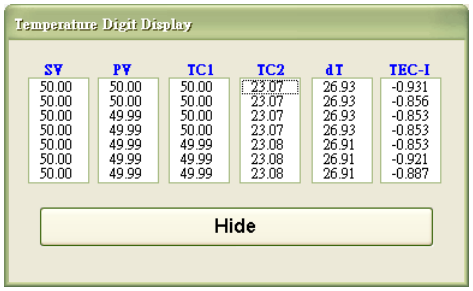


Figure 3-7 Real-time Listing for Temperatures & TEC Current using Show Digit Button

If certain portion of the time curves is to be analyzed, one can hold the left button of mouse to create a selected area and then right click the mouse. A Crop option will pop up, as shown in Figure 3-8. Left click it will pop up a zoom-in graph as shown in Figure 3-9(a). For further analyses, one can double click the mouse left button at desired locations to create markers. A marker is indicated with format (a, b, c), where a, b, and c are the time, temperature, and TEC current at its location. When markers are created, marker subtraction will show up at bottom, as shown in Figure 3-9(b). One can use it to calculate the time, temperature, and TEC current differences between any two markers. This is very helpful to analyze the time curves.

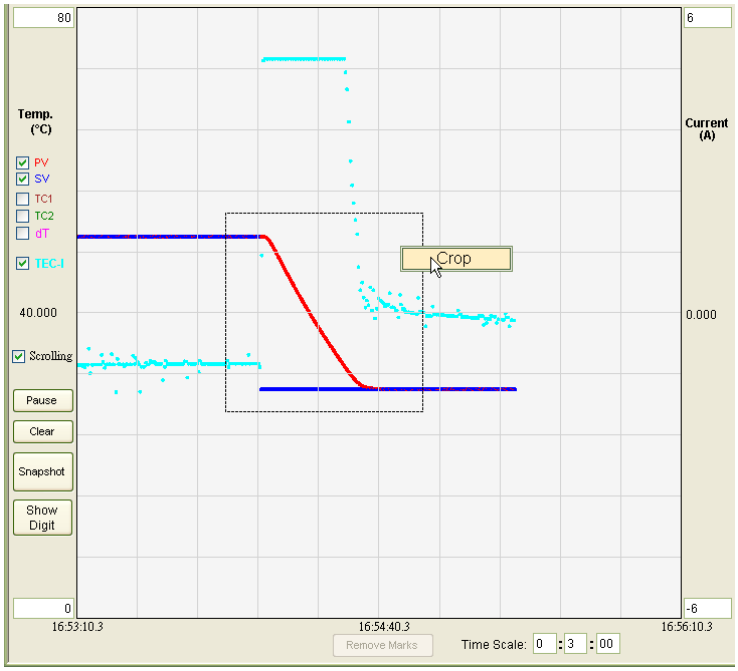


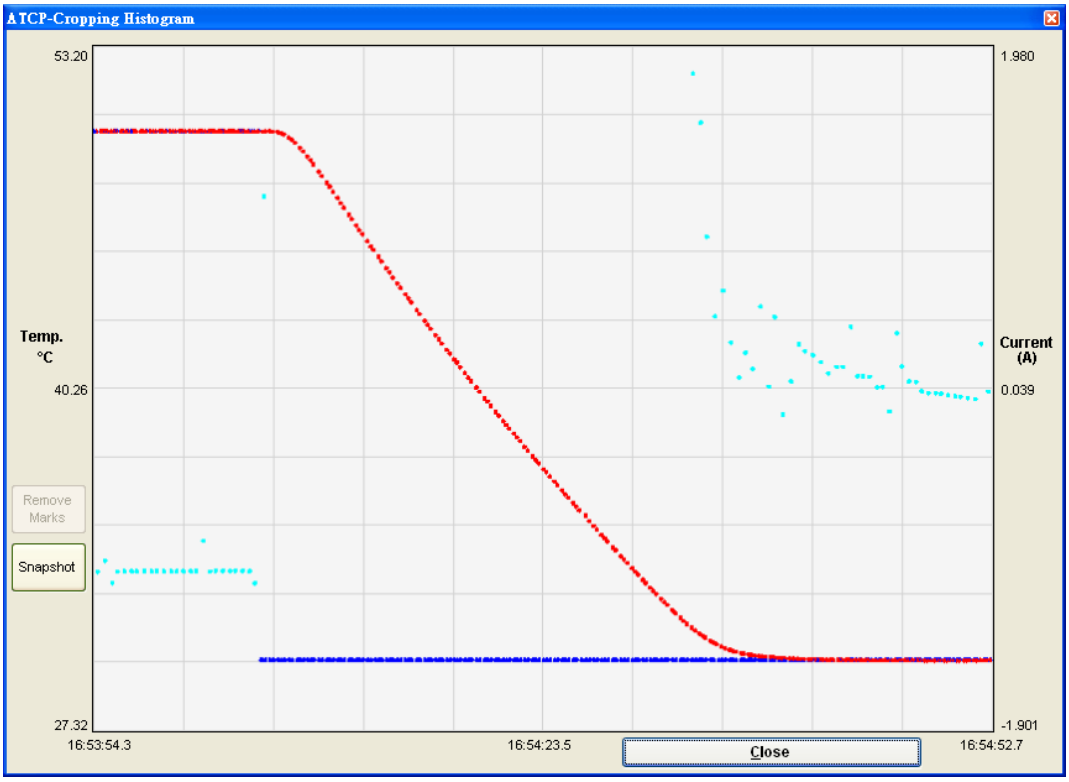
Figure 3-8 Use Mouse to Create a Selected Area & Right Click to Show Crop Option

CAUTION

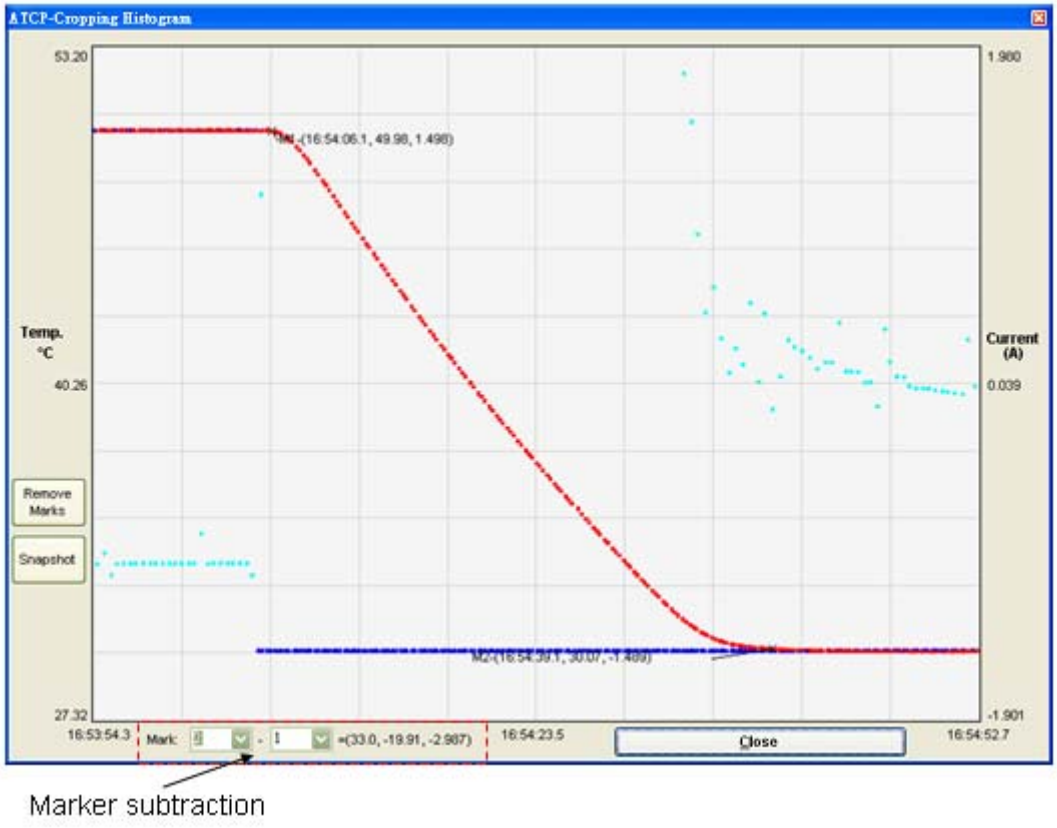
(1) Markers and marker subtraction can also be created at the main graph.

(2) The main graph keeps recording while analyzing the zoom-in graph.

(3) There is no limit on the number of markers. Markers are always effective even they roll out of the curve displaying area, unless the Remove Markers at bottom is clicked.



(a)



(b)

Figure 3-9 Zoom-in Curve Analysis, Double Click to Create Marker for Difference Calculation of Two Markers (time, temperature, TEC current)

5. Record to Files: One can record the time and temperature information into a file by clicking Record to a File button. The first is to set the Total Record Time and Record Interval. Then clicking Record to a File button pops up a file saving window. Select file path and key in the file name. Confirm saving, and the temperatures and TEC current will be saved in to the specified file. There are 2 file formats, .txt and .csv. for selection. The saved file in text format with contents showing in Figure 3-10. The other two formats are the same contents but for read with Microsoft Excel. User Name in the second line is the User Name mentioned in area 1. Other headings are those shown in the program main window and Temperature Calculation. Data contents include Date, Time, SV, PV, TC1, TC2, dT(=TC1-TC2), and TEC-I.

```
User Name =
ID = 255
PV Mode = 1
Distance 1  = 0.00
Distance 2  = 0.00
Offset Mode= None.
-------------------------------------------------------------------------------
Date        Time            SV       PV      TC1      TC2       dT    TEC-I
2009/01/21 17:26:08       0.00    50.00    50.00    23.71    26.29   -1.040
2009/01/21 17:26:09       0.00    50.00    50.00    23.71    26.29   -1.040
2009/01/21 17:26:10       0.00    50.01    50.01    23.71    26.30   -0.922
2009/01/21 17:26:11       0.00    50.01    50.01    23.71    26.30   -0.981
2009/01/21 17:26:12       0.00    50.00    50.00    23.71    26.29   -1.029
2009/01/21 17:26:13       0.00    50.00    50.00    23.71    26.28   -1.028
2009/01/21 17:26:14       0.00    50.00    50.00    23.72    26.28   -1.030
2009/01/21 17:26:15       0.00    50.00    50.00    23.72    26.29    4.898
2009/01/21 17:26:16       0.00    49.88    49.91    23.72    26.19    4.992
2009/01/21 17:26:17       0.00    49.21    49.44    23.72    25.72    4.992
2009/01/21 17:26:18       0.00    48.67    48.80    23.72    25.08    4.992
```

Figure 3-10 Saving File Contents.

CAUTION

(1) .csv and .xls formats can be read with Microsoft Excel. However, Microsoft Excel will be activated during recording if .xls format is chosen. It is possible to cause unknown interruption and errors. For stable running the program during recording, .csv format is recommended. Users can later open the file in Microsoft Excel and save to .xls format.

(2) If the Start by TEC Run Trigger box is checked, the file will be created but no record will start until TEC output is set to RUN (area 2).

6. Sub programs and Engineering Settings: These buttons, except Exit to terminate ATCP, will bring to some powerful sub programs and important control setting. They will be discussed in Sections 3.4 to 3.5.

3.3 Temperature Ramping Sub Program

Clicking Temperature Ramping in area 7 will bring up a setting window as shown in Figure 3-11. The idea for temperature ramping is to create a linear temperature variation with time, for example, changing temperature from 0°C to 100°C in 1000 seconds with 0.1°C /sec increasing rate. Without such a ramping program, the temperature increasing rate is uncontrolled and nonlinear. By setting the Temperature (End) and Time (Temperature (Begin)

is where PV is and no need to set), it calculates the temperature variation Slope. The temperature ramping becomes effective after clicking Start.

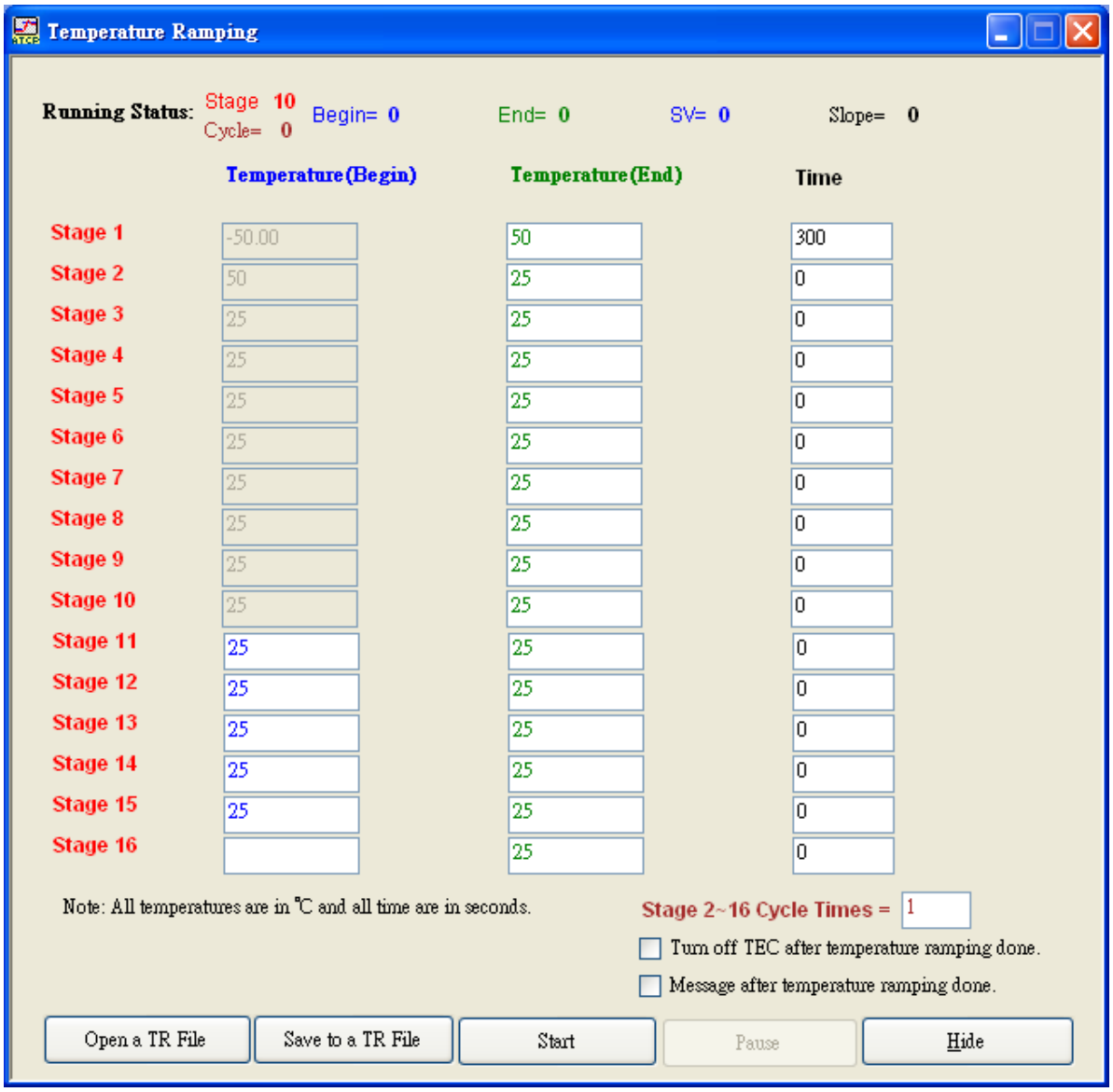


Figure 3-11 Temperature Ramping Setting Window

Figure 3-12 shows PV and SV temperature curves according to the temperature ramping setting in Figure 3-11. This case shows just 1 ramping stage because Time setting of other stages are all zeros. One may create multiple ramping up to 10 stages. The ramping settings can be loaded from or saved to a file by clicking Open a TR File or Save to a TR File, respectively. During the ramping, one can halt the ramping and resume the ramping. Once Pause is clicked, SV will stay at the same value until it is clicked again. The temperature increasing slope is the same after resuming ramping, and the total ramping time will be the Time setting plus the halt time. Figure 3-10 shows an example with Pause during the ramping. Hide will shrink and iconize the temperature ramping setting window to the task bat at bottom of the PC monitor.

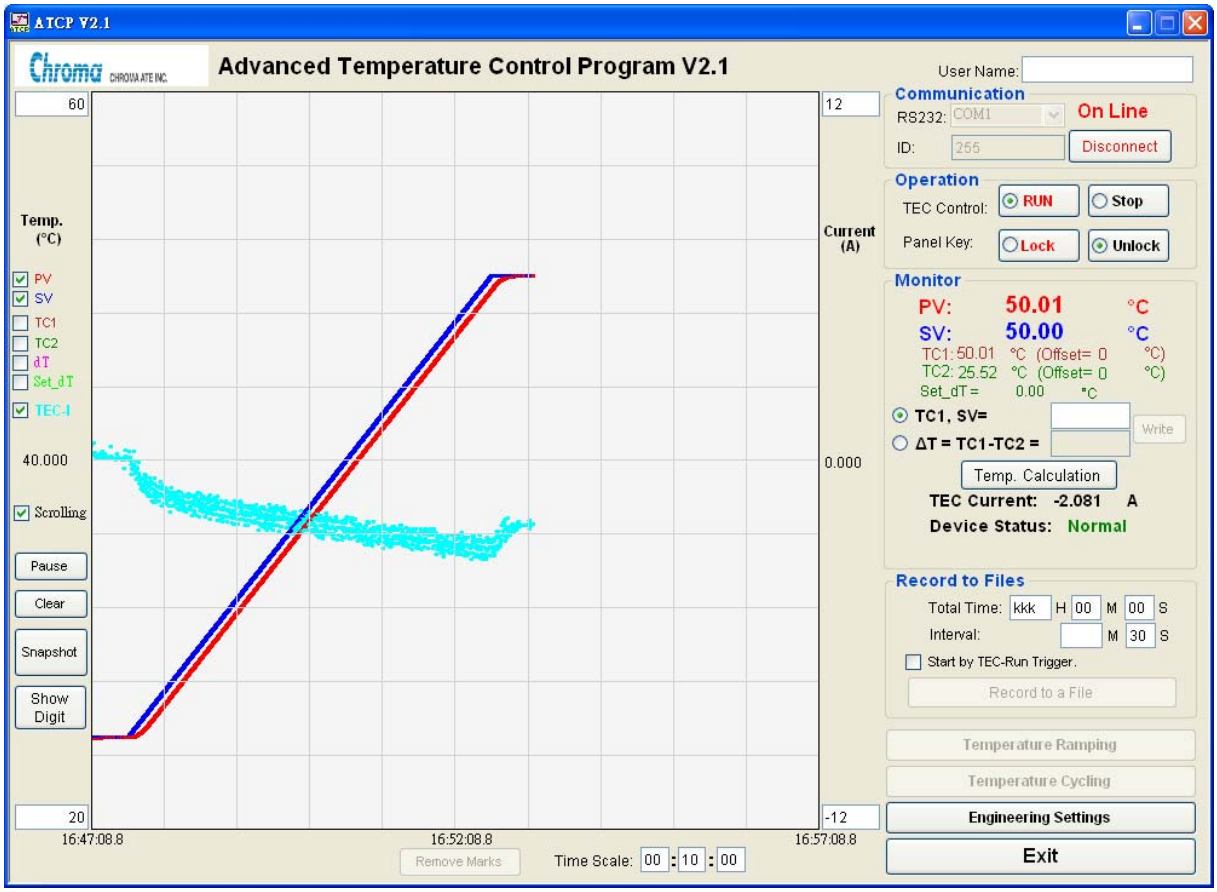


Figure 3-12 A Temperature Ramping Execution Example.

CAUTION

(1) Do not set Time shorter than the temperature rising/falling capability of your platform, or PV cannot follow the ramping SV. The purpose for this temperature ramping sub program is for some slowly temperature varying applications.

(2) There is always some tracking error between PV and SV during ramping. It can be <0.1°C to 1°C depending on the ramping slope, the higher slope, the larger tracking error. However, PV is as linear as SV and one can take PV as a time delay of SV.

(3) In temperature ramping setting, Temperature (Begin) of stage 1 is PV at that moment, which may not be the starting temperature one wants. One can set his/her starting temperature as Temperature (End) of stages 1 and 2 and some time for PV to be stable at that temperature. The real ramping behavior can start from stage 3.

(4) The temperature will remain at the final setting after the Temperature Ramping sub program is finished, or one can automatically turn the TEC output off by checking the Turn off TEC after temperature ramping done at the right bottom of the setting window.

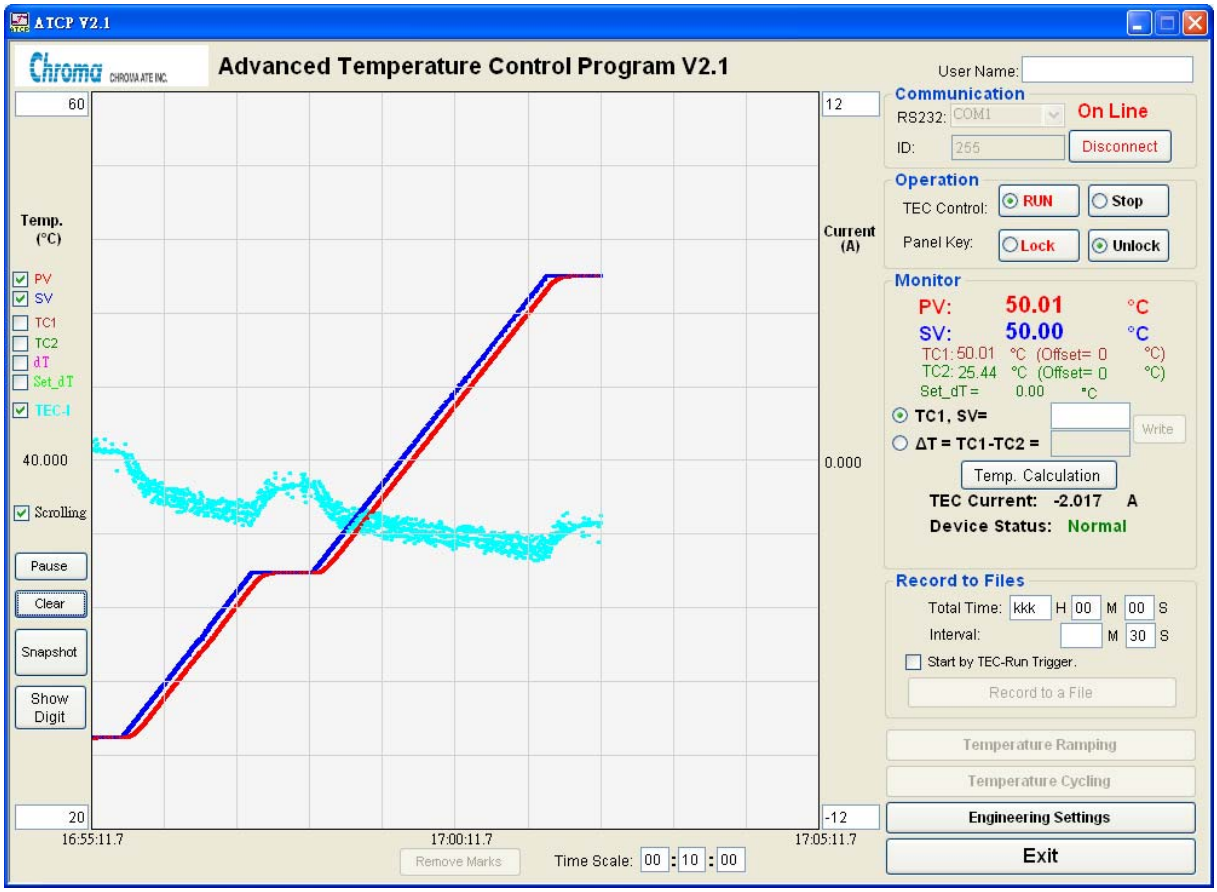


Figure 3-13 Temperature Curves with Pause during Ramping

3.4 Temperature Cycling Sub Program

Clicking Temperature Cycling in area 7 will bring up a setting window as shown in Figure 3-14. Temperature cycling is a common temperature control activity to qualify or screen devices and components. A stage of temperature cycling is formed by several temperature steps and a cycling number. The temperature will go by Step 1 → Step 2 →……. →Step N →Step 1(next cycle) → Step 2 →……. →Step N for the specified number of cycles. The sub program provides as many as 10 stages of temperature cycling settings, and 5 steps for each stage. With that some complicated temperature cycling process can be achieved. For those stages and steps no need to use, just fill in "0" in time setting. The temperature cycling settings can be loaded from or saved to a file by clicking Open a TC File or Save to a TC File, respectively. During temperature cycling, one can halt the cycling and resume the cycling. Once Pause is clicked, SV will stay at the same value until it is clicked again. Figure 3-12 shows the temperature curves for an example of temperature cycling. This is for the setting in Figure 3-11, where 3 cycles and 3 steps in each cycle are specified. Hide will shrink and iconize the temperature cycling setting window to the task bat at bottom of the PC monitor.

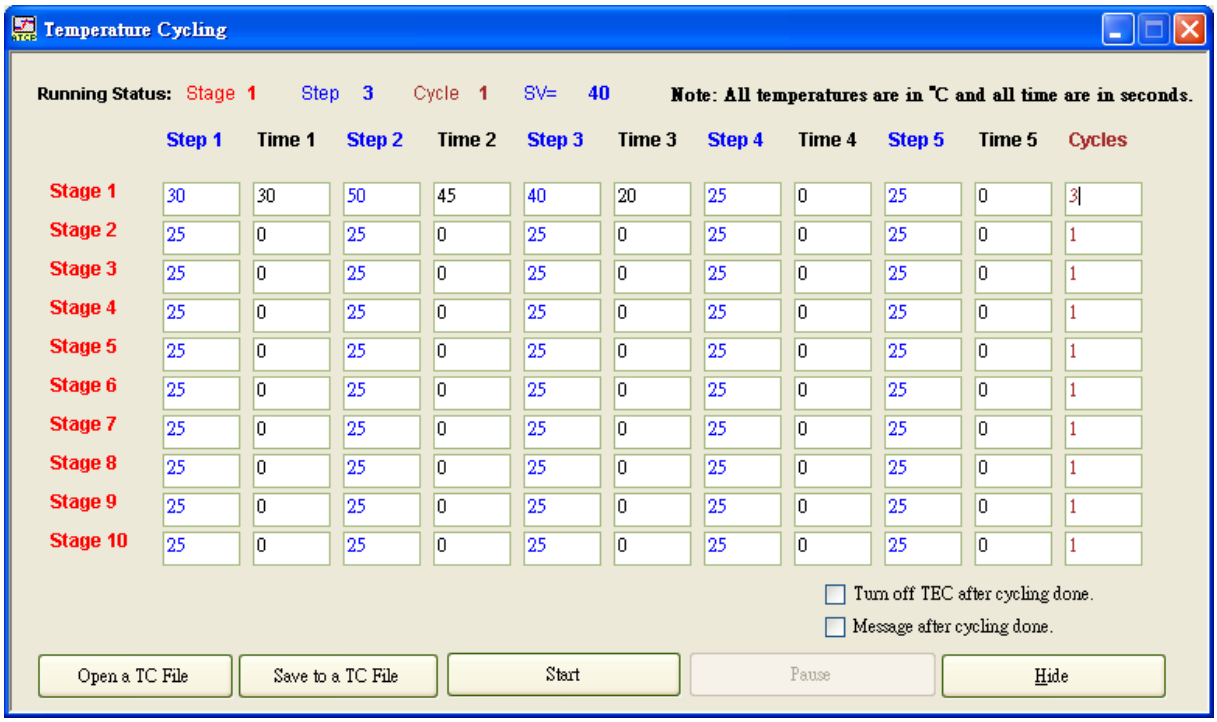


Figure 3-14 Setting Window for Temperature Cycling Sub Program

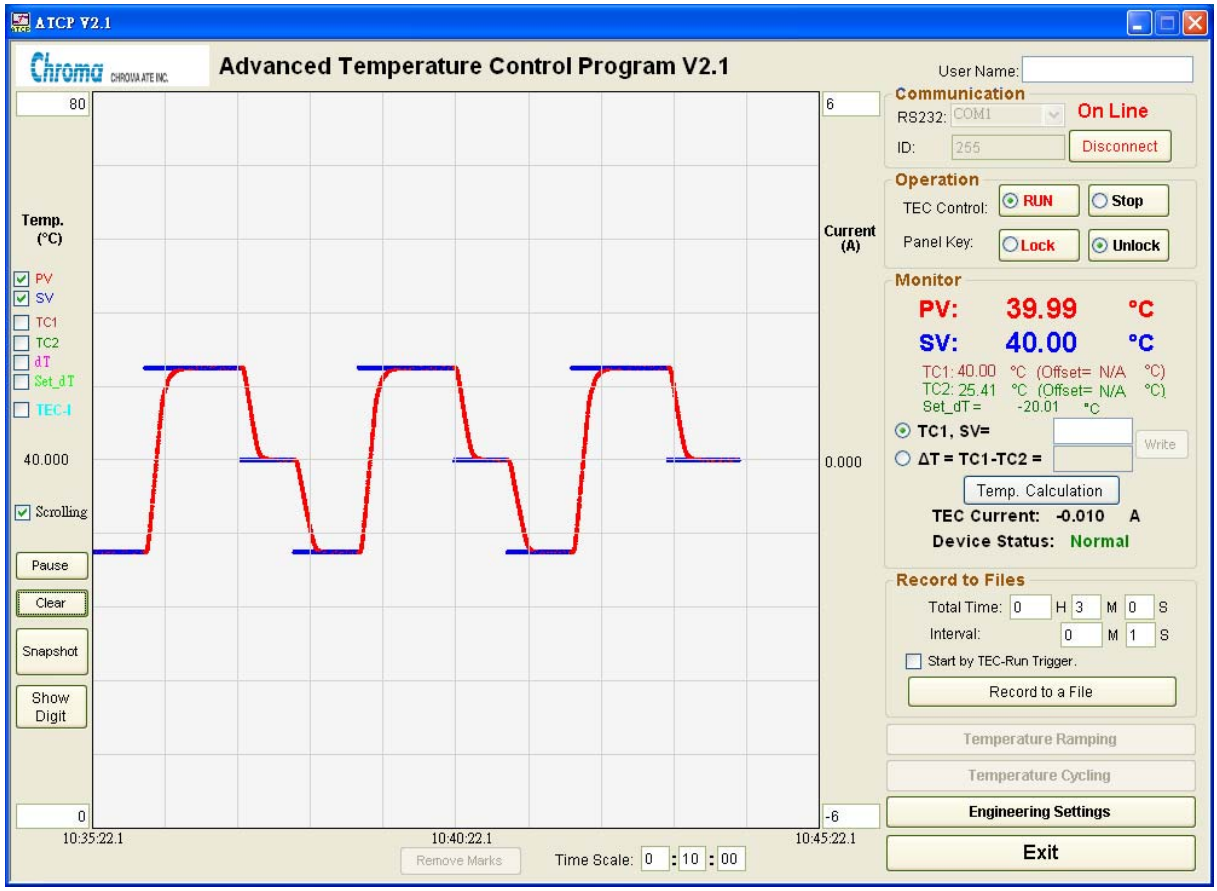


Figure 3-15 Temperature Curves for the Temperature Cycling Setting in Figure 3-14

CAUTION

(1) The time setting after each step specifies how long PV stays at that temperature. The rising or falling time from one step to the next step is not taken into consideration. PV staying time starts to count when it reach +/-0.3°C of the step setting temperature. For example, it is 50°C and 45 sec for Step 2. As long as PV reaches 49.7°C from Step 1, the staying time starts to count. 45 sec later, SV change to Step 3 temperature and PV varies again.

(2) The temperature will remain at the final step after the Temperature Cycling sub program is finished, or one can automatically turn the TEC output off by checking the Turn off TEC after cycling done at the right bottom of the setting window.

3.5 Engineering Settings

A control system can be complicated and a lot of mathematics can be involved. As mentioned in Section 2.3.2, PID control algorithm is applied in TEC Controllers. In order to achieve optimal control, proper PID parameters must be given.

By clicking Engineering Settings in area 7, a setting window as shown in Figure 3-16 will pop up. The above auto detects the control model and firmware version. Many parts in grey do not allow change and are for factory internal setting only. The top 3 items, KP, TI, and TD are the key parameters for control.

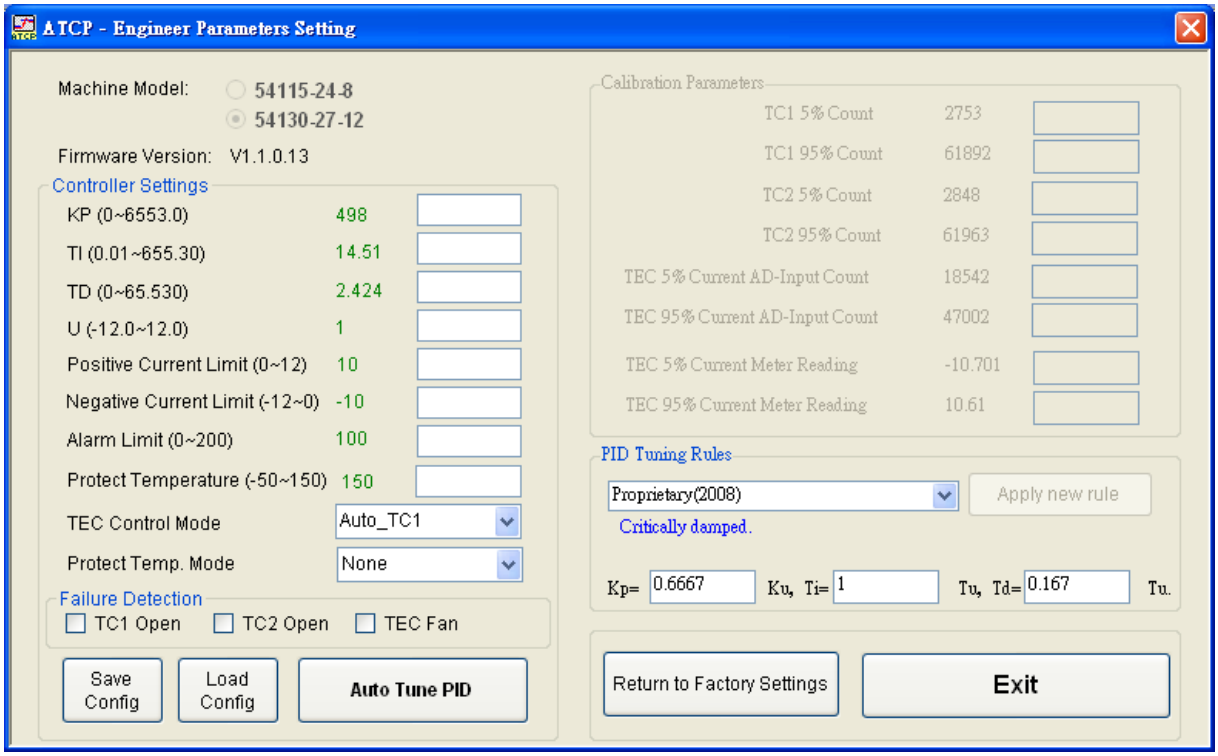


Figure 3-16 Engineering Setting Window

Different control platforms will need various set of these parameters. For example, a platform with KP=831, TI=7.07, and TD=1.104 can achieve very good control. Then the temperature time curves in Figure 3-17 shows such a nice control behavior, fast response time, very small overshoot/undershoot, and high temperature stability at 0.01°C. On the contrary, a set of wrong PID parameters, KP=1800, TI=2, and TD=3 will result in unstable control as shown in Figure 3-18. One may notice not only the response time and overshot/undershoot are longer and larger, but also stable control cannot be reached. Small PV ringing exists around SV. Furthermore, TEC current shows some drastically oscillation. So it is critically important to set the PID parameters right for stable or even optimal control.

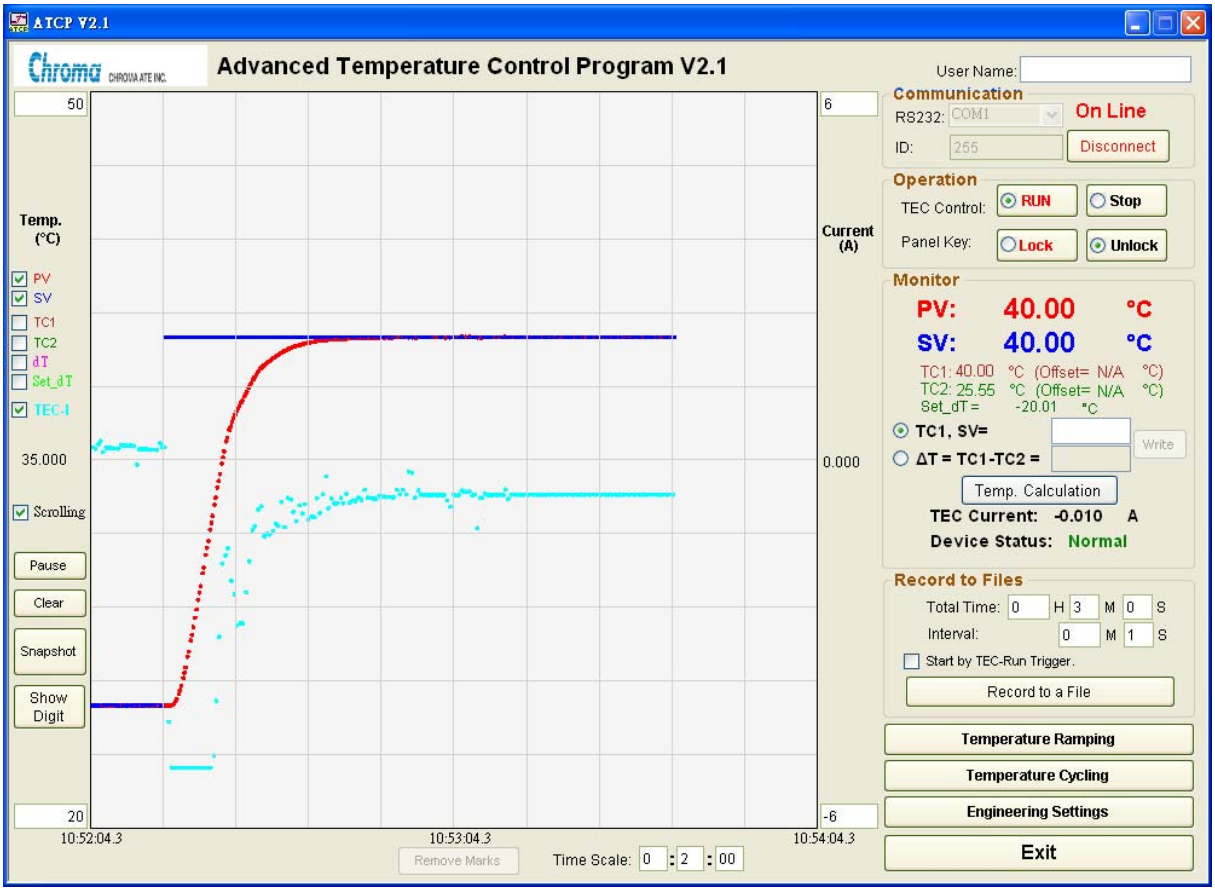


Figure 3-17 Temperature Curves Showing an Optimal Control

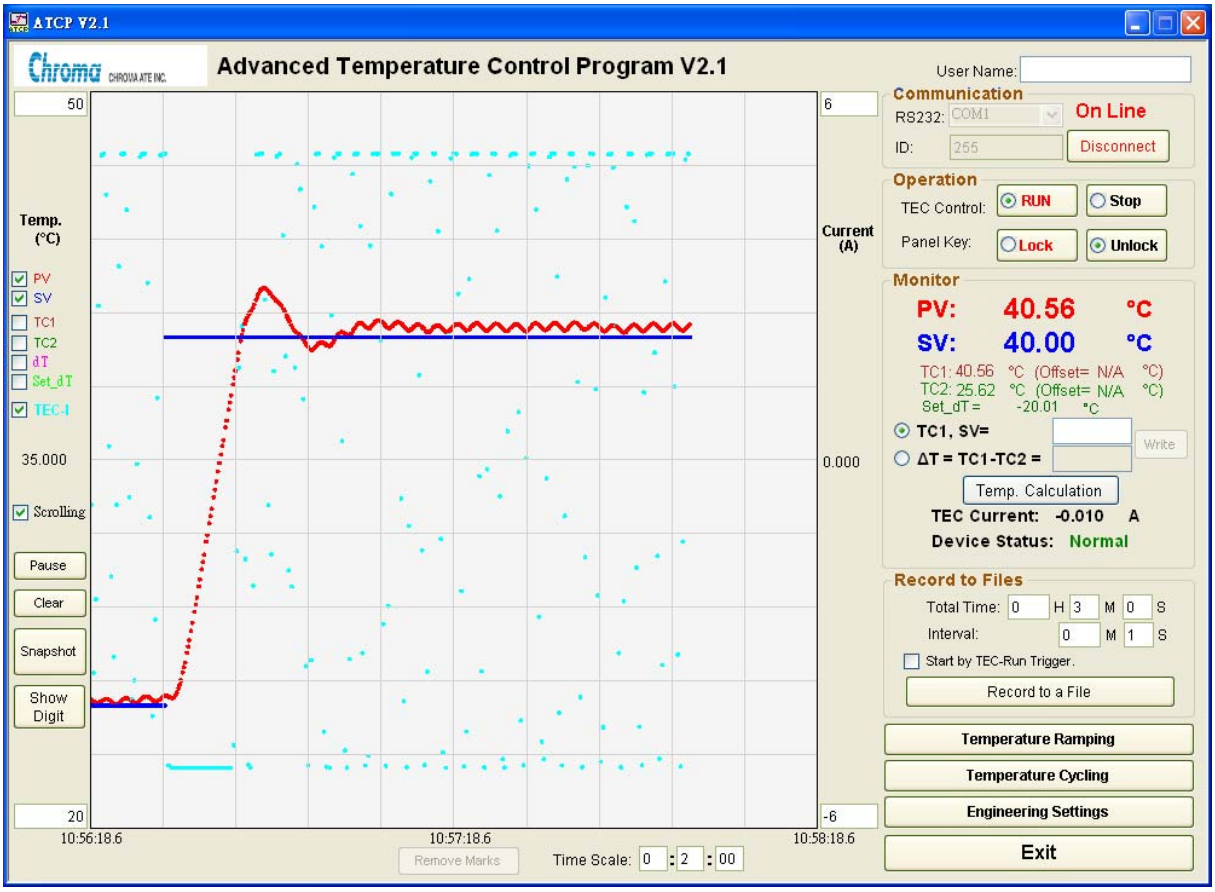
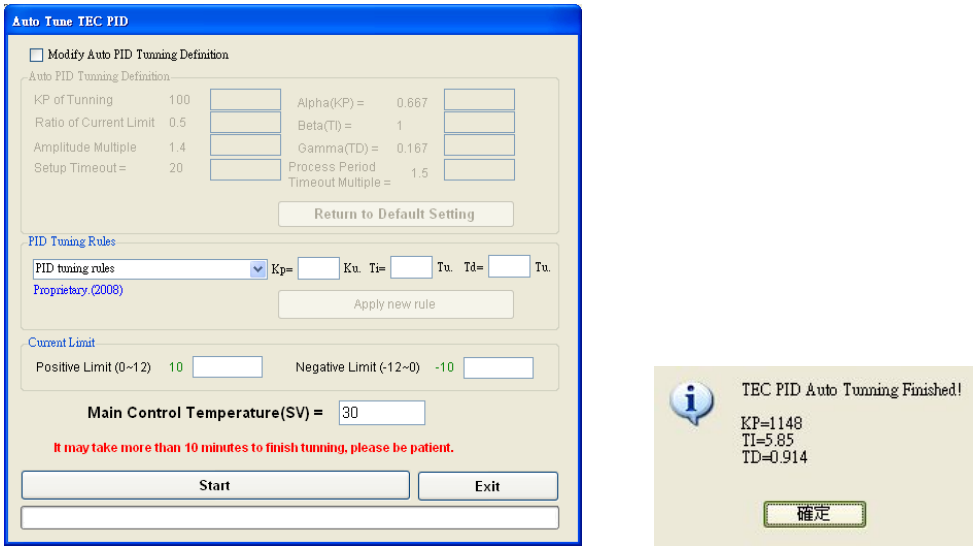


Figure 3-18 Temperature Curves Showing a Mismatched Control

Given a temperature control platform, it is hard to know what numbers of PID parameters match it well. Here we provide an auto tune function which can find out the best PID parameters for customers. Clicking Auto Tune PID will pop up a window as shown in Figure 3-19(a). Simply key in Main Control Temperature (SV) number and hit Start, the PID auto tune process will go. PID parameters will be updated automatically after finishing the auto tune process.



(a) (b)

Figure 3-19 Auto Tune PID (a) in Progress & (b) Completed.

CAUTION

(1) Optimal PID parameters depend on target SV. That is why one needs to key in Main Control Temperature (SV) before PID auto tune. However, in most systems it is not critical for a wide range of temperature operation. For example, if the system is planned to be temperature controlled from 0 to 100°C, auto tune PID at 50°C, middle of working range, may work just fine at 0°C and 100°C.

(2) Auto tune PID can take more than 5 minutes to complete. Clicking Stop during the process will abort it and PID parameters remain unchanged.

(3) One may try auto tune PID several times on the same platform and get different sets of KP, TI, and TD each time. This is normal since the optimal PID parameters are not unique. However, for a well behaved platform, all the difference should be within a small range, say, 20% or even 10%. Only ill behaved platforms will exhibit large PID parameter difference each time of auto tune PID, and the platform itself can have stability problems.

(4) Do not to check Modify Auto PID Tuning Definition box, unless your platform is very special and even Auto Tune PID cannot achieve stable control. Consult Chroma and we will provide necessary assistance.

The PID parameters can be saved to or loaded from a configuration file by clicking Save Config or Load Config, respectively. It is important to save the PID and configuration parameters for a platform in case the controller may access different platforms at different time.

There are several more configuration settings. Please refer to Section 2.3.2 for definitions of U, Positive Current Limit, Negative Current Limit, Alarm Limit, TEC Control Mode and TEC Fan Failure Detection. All these settings will be saved to or loaded from the configuration file as well.

4. Communication Protocols

Customers may want to develop their own remote controls to fulfill their application needs. For example, a complicated system can contain not only the temperature control part but also mechanical and electrical testing parts. A fully integration of all parts is required. In such cases, customers can write their integration programs based on the following Chroma Advanced Controller Communication Protocols, or ask Chroma ATE for service.

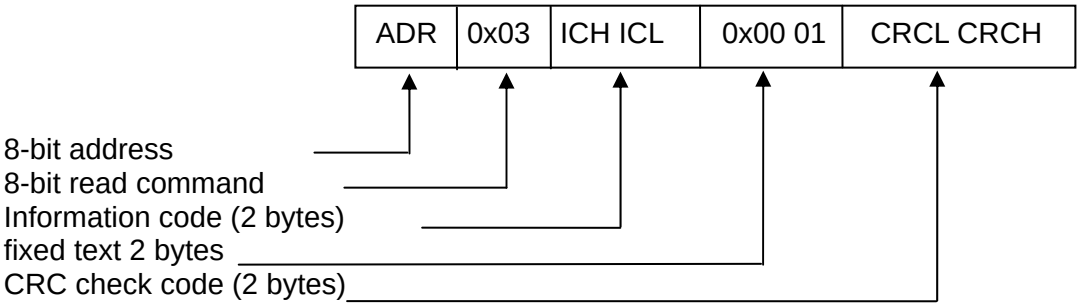
Chroma Controller Advanced Communication Protocols are based on the following formats:

4.1 Serial Communication Configuration

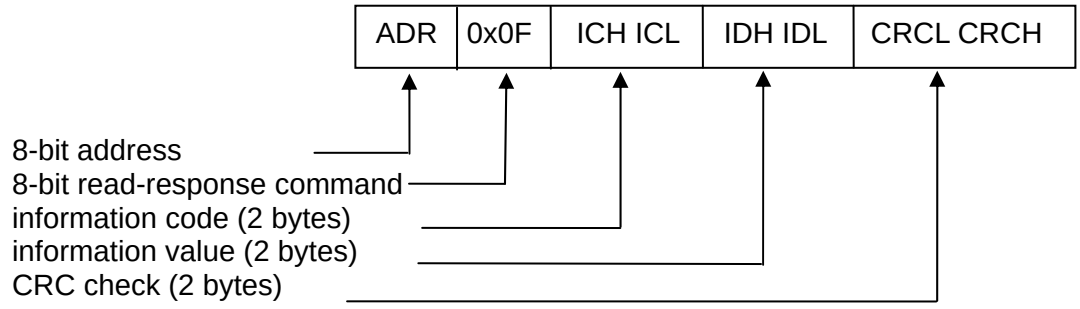
The following serial communication configuration is used: baud rate 9,600 bps, byte format 8, n, 1.

4.2 Packet Format

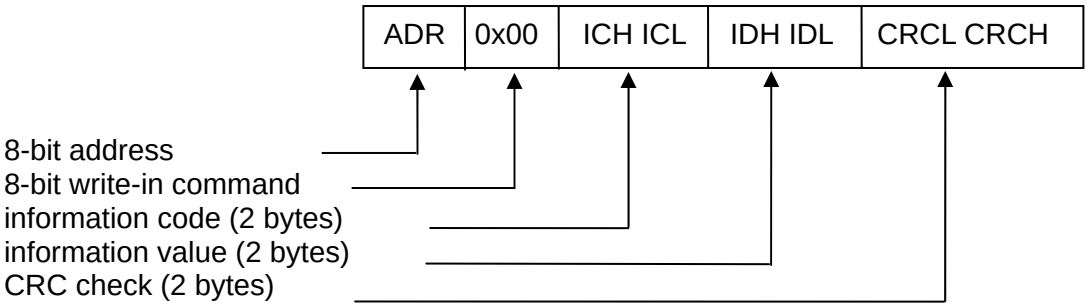
To read information from the controller, sending by a PC:



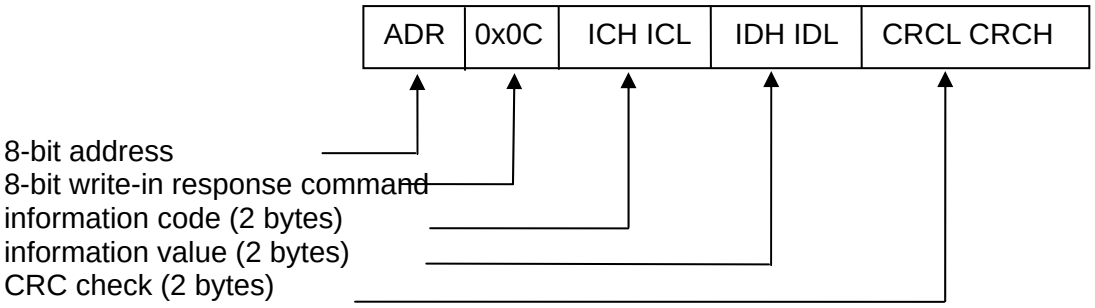
Respond to read information, sending by the controller:



To write information to the controller, sending by a PC:



Respond to write information, sending by the controller:



The communication between a PC and the controller is simple. First the PC sends an either read or write packet, then the controller will respond a packet. For a read packet, the controller will report the read contents in the responding packet. For a write packet, exactly the same content except the write-response code and CRC, will be responded. All 2-byte codes or data are the high byte first followed by the low byte, except CRC which the low byte comes in front of the high byte.

Notice

A PC packet with undefined information code, incorrect read/write operation, wrong CRC, or wrong packet format will be ignored and will get no response from the controller.

4.3 Information Codes & Definitions

Info. Code	Description	Readable	Writeable	Data	Size In Byte	Definition
0x0000	Temp. of PV	Yes	No	0x0000~FFFF	2	÷100 (1)
0x0001	Temp. of TC_1	Yes	No	0x0000~FFFF	2	÷100 (1)
0x0002	Temp. of TC_2	Yes	No	0x0000~FFFF	2	÷100 (1)
0x0003	TC_1 Temp. offset (5)	Yes	Yes	0x0000~FFFF	2	÷100 (1)(3)(4)
0x0004	TC_2 Temp. offset (5)	Yes	Yes	0x0000~FFFF	2	÷100 (1)(3)(4)
0x0005	TEC Current	Yes	No	0x0000~FFFF	2	÷1000 (1)
0x0006	Controller Address (5)	Yes	Yes	0x0000~00FF	2	÷1 (1)
0x0007	SV (5)	Yes	Yes	0x0000~FFFF	2	÷100 (1)
0x0008	PV Mode Setting (2) (5)	Yes	Yes	0x0000	2	PV=T0
				0x0001		PV=f(T0,T1)
0x0009	Distance setting - L1 (2) (5)	Yes	Yes	1~65535	2	÷1000 (1)

0x000A	Distance setting – L2[(2)] [(5)]	Yes	Yes	1~65535	2	÷1000 [(1)]
0x000B	dT Temperature	Yes	Yes	0x0000~FFFF	2	÷100 [(1)]
0x000C	TC1 Open Detection	Yes	Yes	0x0000	2	Disable
				0x0001		Enable
0x000F	Ext. Fan Failure Detection	Yes	Yes	0x0000	2	Disable
				0x0001		Enable
0x0010	Initialization Status	Yes	No	0x0000	2	Still Warming Up
				0x0001		Ready
				0x0002		System Reset
				0x0003		TECi Out-of-Lock Trigger
0x0011	Alarm Status	Yes	No	0x0000	2	Normal
				0x0001		Warning
				0x0002		Alarm
				0x0003		Fatal Error
0x0012	Warning Code	Yes	No	0x0000	2	Normal
				Bit0=1		Reserved
				Bit1=1		Reserved
				Bit2=1		Reserved
				Bit3=1		| PV-SV| > Alarm-limit
				Bit4~15		Reserved
0x0013	Alarm Code	Yes	No	0x0000	2	Normal
				Bit0=1		TEC Open Circuit
				Bit1~15		Reserved
0x0014	Fatal Error Code	Yes	No	0x0000	2	Normal
				Bit0=1		TECi fail
				Bit1=1		+8VM fail
				Bit2=1		Reserved
				Bit3=1		+15VAM fail
				Bit4=1		-15VAM fail
				Bit5=1		+5VAM fail
				Bit6=1		-5VAM fail
				Bit7=1		+5VDM fail
				Bit8=1		Int. fan fail
				Bit9=1		Internal TEC Out-of-Lock
				Bit10=1		Ex-FAN fail
				Bit11=1		In-Device Temp. > upper limit
				Bit12=1		OTP protection
				Bit13=1		Cooling chip error
				Bit14=1		TC1 monitor error
				Bit15=1		TC2 line broken
0x0015	Machine Model Number	Yes	No	0x0000~FFFF	2	0x0000: 54115-24-8 0x0001: 54130-27-12 others: TBD
0x0016	MCU firmware version number	Yes	No	0x0000~FFFF	2	0.0.0.0~ 15.15.15.15

0x001E	Positive Current Limit(5)	Yes	Yes	0~8000/12000 (0~8A for 150W) (0~12A for 300W)	2	÷1000 (1)
0x001F	Negative Current Limit(5)	Yes	Yes	0~8000/12000 (0~8A for 150W) (0~12A for 300W)	2	÷1000 (1)
0x0020	TEC Driver Run/Stop	Yes	Yes	0x0000	2	Run
				0x0001		Stop
0x0021	TEC KP(5)	Yes	Yes	0000~65535	2	÷10 (1)
0x0022	TEC Ti(5)	Yes	Yes	1~65535	2	÷100 (1)
0x0023	TEC Td(5)	Yes	Yes	0000~65535	2	÷1000 (1)
0x0024	TEC U(5)	Yes	Yes	0x0000~FFFF (-8A~+8A: 150W) (-12A~+12A: 300W)	2	÷1000 (1)
0x0026	TC2 Open Detection	Yes	Yes	0x0000	2	Disable
				0x0001		Enable
0x0025	Alarm Limit(5)	Yes	Yes	0~20000 (0~200°C)	2	÷100(1)
0x0027	Control Type(5)	Yes	Yes	0x0000	2	Auto fixed temp. (TC1)
				0x0001		CC output
				0x0002		Auto fixed temp. (dT)
0x002D	Panel Key Lock	Yes	Yes	0x0000	2	lock
				0x0001		Unlock
0x0032	OTP Mode	Yes	Yes	0x0000	2	TC1
				0x0001		TC2
				0x0002		TC1,TC2
				(#)0x0003		Disable
0x0033	OTP Temp.	Yes	Yes	0x0000~FFFF	2	÷100 (1)
0x0034	Offset Mode Setting(4) (5)	Yes	Yes	(#)0x0000	2	Fixed Mode
				0x0001		Polynomial Mode
				0x0002		None
0x0035	Polynomial Offset Mode Alpha(5)	Yes	Yes	0x0000~FFFF	2	÷100(1)(4)
0x0036	Polynomial Offset Mode Beta(5)	Yes	Yes	0x0000~FFFF	2	÷10000 (1) (4)
0x0037	Polynomial Offset Mode Gamma(5)	Yes	Yes	0x0000~FFFF	2	÷1000 (1) (4)

(1) Value is calculated by (a) converting the signed hexadecimal integer into a signed decimal integer (result between -32768 and +32768), (b) dividing the decimal integer by the ÷ number, and then (c) compared with the setting limits. For example, reading temperature of TC1 gets value FEC8H. This corresponds to -312 decimal for signed integer. Dividing -312 by 100 results in -3.12. So the temperature is -3.12°C. Another example to set the current limit by giving value 3020H. This corresponds to +12320 in decimal, and +12.32 after divided by 1000. Since this exceeds the current limit range +8A, the result will be kept at +8A instead.
(2) Please refer to Section 2.3.1 for detail.
(3) Value limited from -10 to +10.
(4) Please refer to Section 2.3.2 for detail.
(5) These values will be stored in the non-volatile memory of the controller.

The definitions of these information items can be referred to Chapter 2 for details.

4.4 Cyclic Redundancy Check

CRC-16 algorithm is used to generate the CRC code. It divides the string polynomial by 0xA001, as described in the following subroutine in C language:

```
#define POLYNOMIAL                  0xA001
unsigned int Calc_CRC(unsigned char *start_of_packet, unsigned char *end_of_packet)
{
        unsigned int crc;
        unsigned char bit_count;
        unsigned char *char_ptr;
        char_ptr = start_of_packet;
        crc=0xffff;
        do {
                crc ^= (unsigned int)*char_ptr;
                bit_count = 0;
                do {
                        if (crc & 0x0001) { crc>>= 1;    crc^= POLYNOMIAL; }
                        else                             crc>>= 1;
                }while (bit_count++ <7);
        }while (char_ptr++ <end_of_packet);
        return(crc);
}
```

4.5 Examples

Here we list several examples for reference. Assuming the controller address is set at 255 (0xFF).

Example 1: Set the temperature goal (SV) at 30°C.
PC sends: FF 00 00 07 0B B8 A2 97
Controller responds: FF 0C 00 07 0B B8 B2 96

Example 2: Set the positive current limit to 8 A
PC sends: FF 00 00 1E 1F 40 7D D2
Controller responds: FF 0C 00 1E 1F 40 6D D3

Example 3: Set the negative current limit to 6 A
PC sends: FF 00 00 1F 17 70 2B C6
Controller responds: FF 0C 00 1F 17 70 3B C7

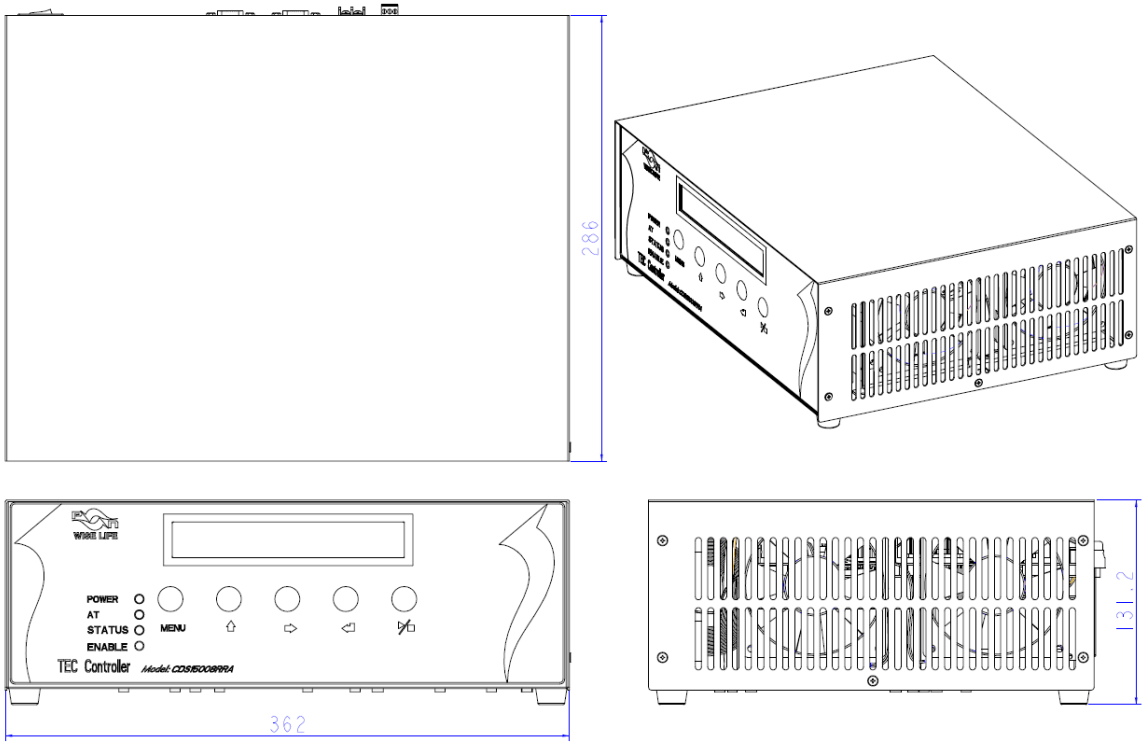
Example 4: Read TC1 temperature
PC sends: FF 03 00 01 00 01 C0 14
Controller responds: FF 0F 00 01 0A 14 17 7A
The result tells the TC1 temperature to be 25.80°C.

Example 5: Set the TEC driving output to "RUN" status
PC sends: FF 00 00 20 00 00 15 DE
Controller responds: FF 0C 00 20 00 00 05 DF

Example 6: Set the TEC driving output to "STOP" status
PC sends: FF 00 00 20 00 01 D4 1E
Controller responds: FF 0C 00 20 00 01 C4 1F

For further assistance of communication program, please contact Chroma ATE Inc.

Appendix A Dimensions & Mechanical Drawings



unit: mm

Appendix B Specifications

Absolute Maximum[1]

Specification Item	Symbol	Value	Unit
Power Supply Voltage	Vs	90 to 260 50/60 Hz	VAC
Power Supply Current at 110VAC		3.5/5[2]	A
Power Supply Current at 220VAC		2/3[2]	A
TEC Output Voltage	Vout	24	VDC
TEC Output Current	Iout	±8/12[2]	A
TEC Driving Output Power	Pout	160/280[2]	W
Storage Temperature		-20~60	°C
Storage Humidity		80	%RH

Note
(1) Workable but specification not guaranteed.
(2) For model 54115-24-8/54130-27-12.

Specifications

Specification Item		Symbol	Value	Unit
Temperature Control Specifications				
Setting Temperature Range[1]		Tc	-50 to 150	°C
Setting Temperature Resolution			0.01	°C
Temperature Control Stability[2]		Tc	< +/-0.03	°C
Temperature Monitoring Specifications				
Monitoring Temperature Range		Tm	-50 to 150	°C
Temperature Sensor Type			T-type Thermal Couple	
Monitoring Temperature Resolution			0.01	°C
Monitoring Temperature Relative Accuracy[3]			<+/-0.3	°C
Monitoring Temperature Absolute Accuracy			<+/-(0.3+0.002×|T-25|) [4]	°C
Environmental[5]				
Altitude			2000	M
Working Temperature			5~40	°C
Humidity			Maximum 80% RH at 31°C decreasing to 50% RH at 40°C	%RH
Other Specifications				
Power Requirement			100 to 240 VAC, 50/60 Hz, 3.5A(54115-24-8) 100 to 240 VAC, 50/60 Hz, 5A(54130-27-12)	
Maximum Power Consumption		P_max	200/320	W
Transient overvoltage at main supply			2500	V
Pollution degree			2	
Degree of protection			IP20	
Fuse	Model 54115-24-8		3/2 A for 110/220 VAC	
	Model 54130-27-12		5/3 A for 110/220 VAC	
PC Communication Port			RS-232, Half Duplex	
Dimensions (Width x Depth x Height)			362x286x131.2/14.3x11.3x5.17	mm^3/in.
Weight			Approx. 6.2/13.7	kg/lb

Note

(1) In applications, the temperature range can be reached strongly depends on the platform structure and environment. It is a portion of the controller setting range and less than the controller setting range.
(2) The temperature control stability depends on not only the controller but also platform and environment. The PID parameters must be optimized for the platform. Avoid any liquid or air turbulence around the platform. Attach the temperature feedback thermal couple firmly with good thermal conductivity. Shield for electromagnetic interference if necessary. Extremely high control temperature stability can be achieved with all these issue taken care.
(3) Monitoring Temperature Relative Accuracy is defined as the temperature difference between the two thermal couples reading the same thermal point.
(4) It is the working ambient temperature, which must be thermal balance within 20~30°C, and exclude thermal couples error for controller specifications to be guaranteed.
(5) The TEC Controller is for indoor use only.

CHROMA ATE INC.

致茂電子股份有限公司

66 Hwaya 1st Rd.

Kuei-shan Hwaya Technology Park

Taoyuan County 33383, Taiwan

33383 台灣桃園縣龜山鄉

華亞科技園區華亞一路 66 號

T +886-3-327-9999

F +886-3-327-8898

Mail: info@chromaate.com

http://www.chromaate.com

Copyright by CHROMA ATE INC. All Rights Reserved.
All other trade names referenced are the properties of their respective companies.