CyCLO User Guide

Version 2.00

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1. Hardware

1.1. Introduction

The Adaptive CyCLO is a pulse width modulator intended for thermoelectric cooler or heater applications requiring either uni-directional or bi-directional operation. The Adaptive CyCLO thermoelectric controller features all the hardware and software necessary for standalone heating or cooling applications based on thermoelectric cooler modules (TEC). The controller allows users to easily evaluate a thermoelectric temperature control set up and make decisions once the behaviour of the system is known. It offers an on-board micro USB connection allowing direct interface to a PC for easy programming and evaluation. Users can download the latest version of the Adaptive HMI control software to configure and monitor applications using the CyCLO board.

The board features include

- USB programming interface
- NTC sensor input (default configuration for 10k Ohm NTC)
- Two operating mode feedback LEDs
- Manual set temperature
- Two fan driver output
- One thermoelectric driver output

1.2. Electrical Specification

The electrical parameters for the Adaptive CyCLO board are shown in Table 1 Electrical Specification below.

Input voltage range	11 – 48V DC
Maximum load	7A
Control temperature	0°C to +50°C
Operating temperature	-25°C to + 50°C
Compatible fan	2 wire fan
Fan output voltage range	11 – 48V DC
Sensor type	NTC
Communication interface	USB 2.0 (micro USB)
Temperature control accuracy	+/- 1 C°
Protection	Overcurrent, overvoltage, undervoltage lockout, fuse.

Table 1. Electrical specification

1.3. Board Overview

Figure 1. shows the Adaptive CyCLO connections details and features, which are further detailed in Table 2.

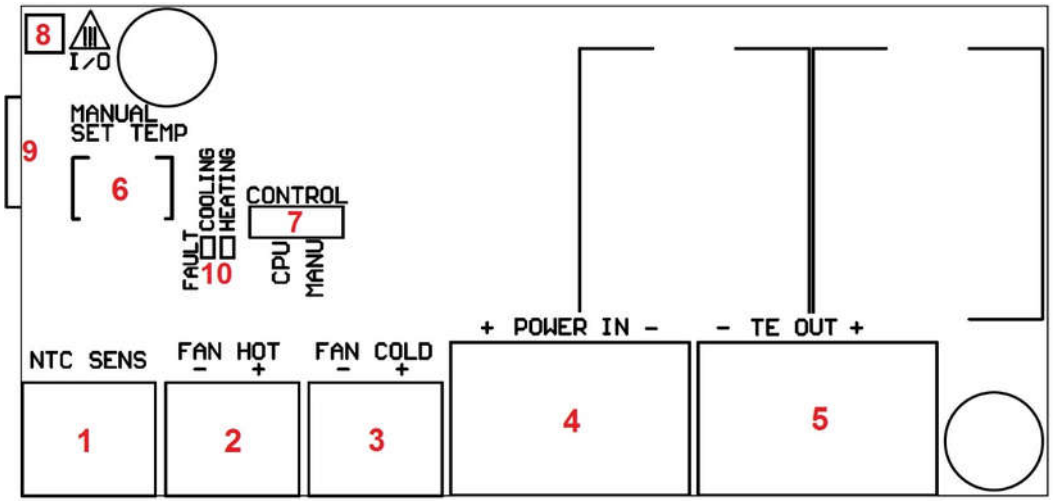


Figure 1. Board connections and functions (top view)

ID	Function	Comment
1	Sensor input	NTC temperature sensor
2	Power output	Fan power
3	Power output	Fan power
4	Power input	Main power
5	Power output	Thermoelectric module or assembly PWM power
6	Temperature control	Manual temperature adjustment
7	Operating mode control	AUTO or MANUAL mode
8	Digital I/O	This is reserved for future use – DO NOT CONNECT
9	Communication	USB 2.0 connection (micro USB)
10	Status LEDs	Visual feedback for heating, cooling and faults Note: alternate flashing indicates fault condition

Table 2. Connector pin functions

1.4. Electrical Installation

Figure 2. shows the required hardware for a thermoelectric control application using Adaptive CyCLO.

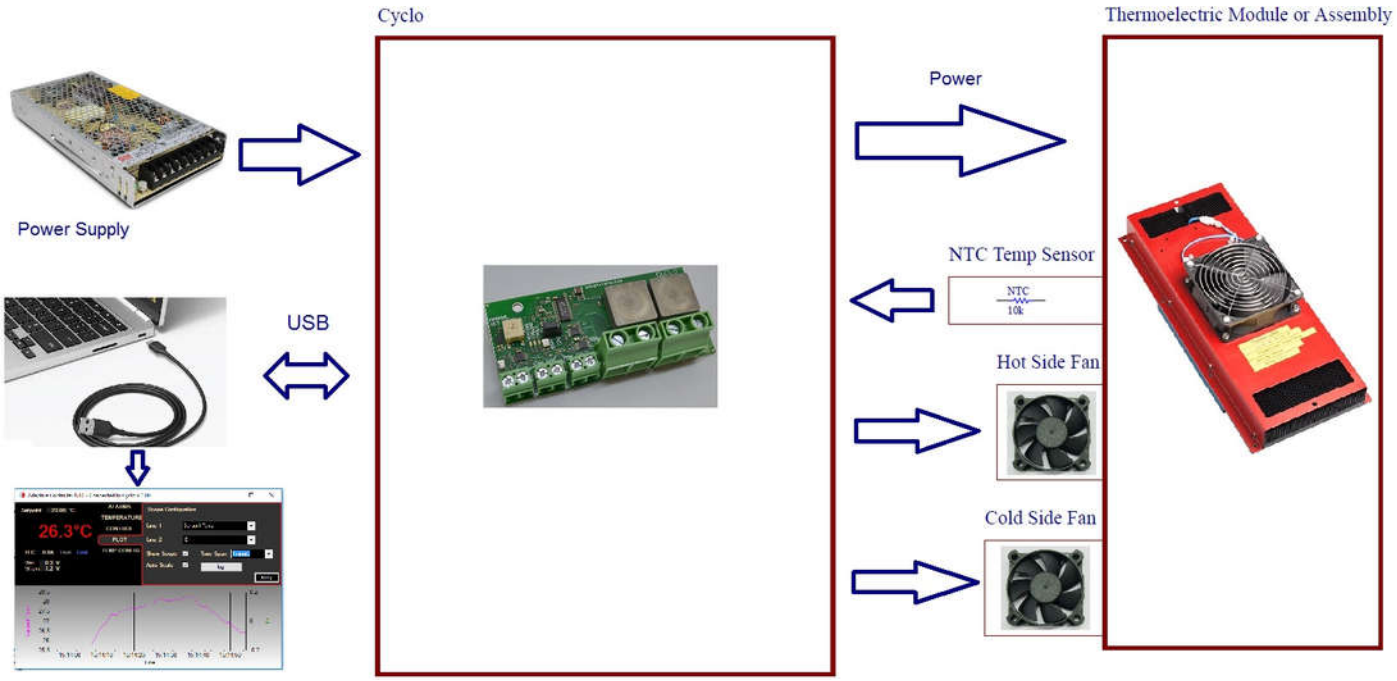


Figure 2. Thermoelectric cooling / heating application setup

The connectors used for integrating CyCLO into a typical system are shown in the connector layout diagram below.

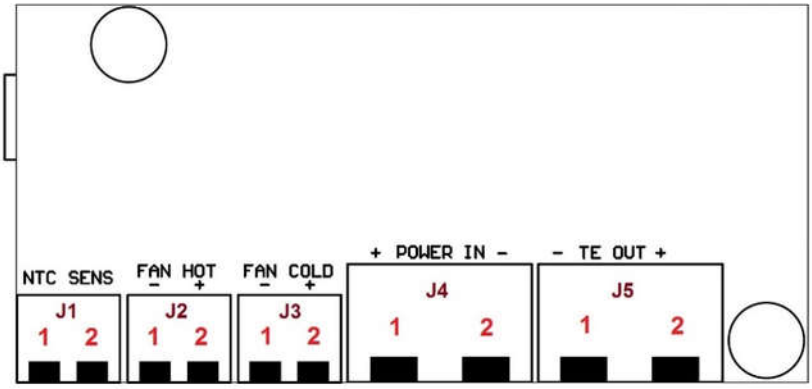


Figure 3. Connector map (top view)

The signal definition and maximum limit is listed for each user accessible CyCLO connector in table 3 below.

Connector ID	Pin ID	Name	I/O	Type	Voltage max [V]	Current max. [A]
J1	1	NTC SENS -	Output	NTC sensor negative	0	0.001
J1	2	NTC SENS +	Output	NTC sensor positive	1.25	0.001
J2	1	FAN HOT -	Output	Fan 1 output positive	0	2
J2	2	FAN HOT +	Output	Fan 1 output negative	48	2
J3	1	FAN COLD -	Output	Fan 2 output positive	0	2
J3	2	FAN COLD +	Output	Fan 2 output negative	48	2
J4	1	POWER IN +	Input	ECU power positive	48	14
J4	2	POWER IN -	Input	ECU power negative	0	14
J5	1	TE OUT -	Output	TEC / Assembly -	0	10
J5	2	TE OUT +	Output	TEC / Assembly +	48	10

Table 3. Connector pin description and electrical parameters

Figure 4 below, shows the recommended wiring diagram for connecting the components making up a typical thermoelectric system. To reduce potential interference problems to a minimum ensure that the wires used for connecting the power supply to the controller, and especially from the controller to the thermoelectric assembly ('TE OUT-' and 'TE OUT+') are sized correctly for the modules power and kept as short as possible. Wire lengths can be optimised by mounting the CyCLO controller right at the thermoelectric assembly's connection output.

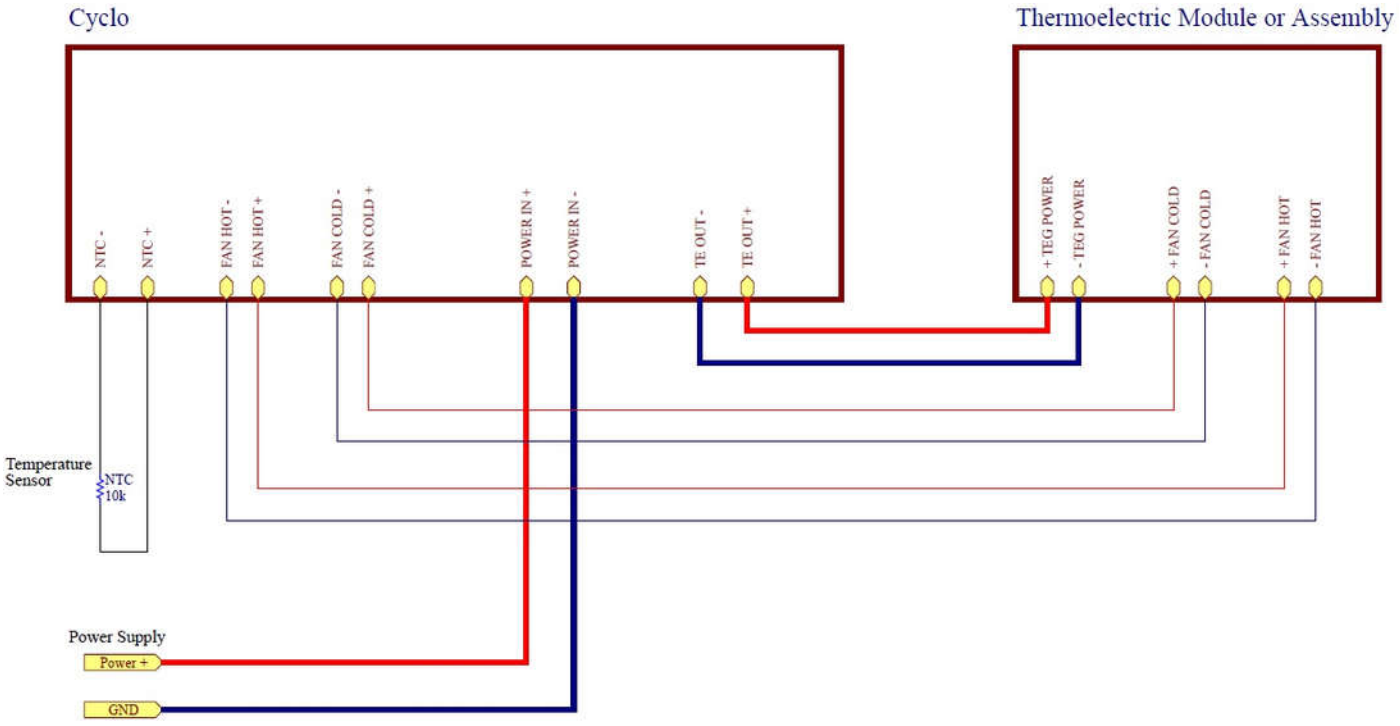


Figure 4. Wiring diagram

1.5. Temperature Sensor

It is recommended that adequate thermal flow is maintained between the thermoelectric cooler module (TEC) and the temperature sensor. Tight thermal coupling results in better temperature control accuracy. The CyCLO controller is factory configured for use with a 10K NTC thermistor (part number: NTCALUG02A103FL). The board then undergoes calibration using this part. If a different part is to be used, the thermistor configuration must be updated to suit and recalibration performed to maintain accuracy.

1.6. Mechanical Dimensions

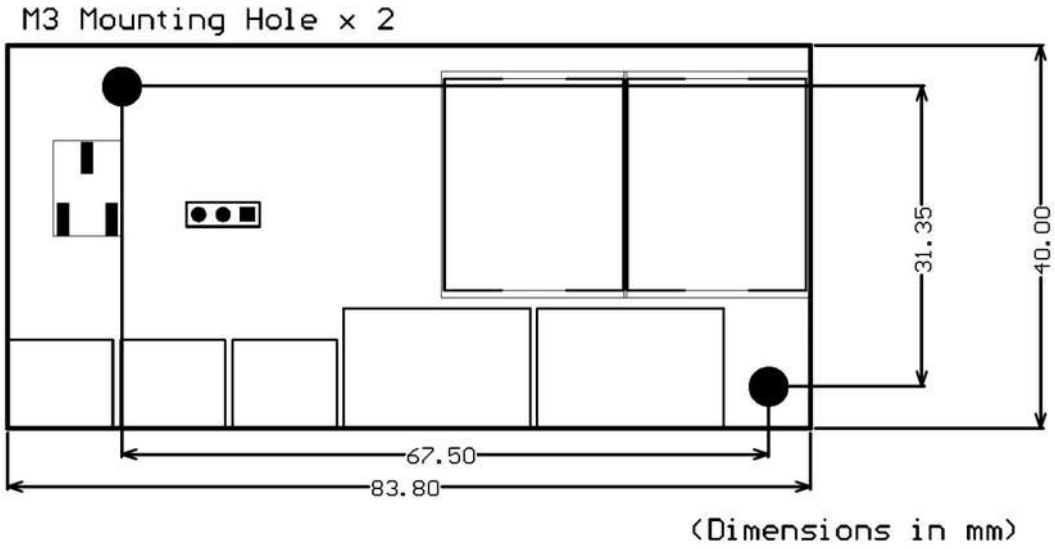


Figure 5. PCB assembly dimensions (top view)

Height and clearance information is shown in Table 4.

Component height on the bottom side	3mm
PCB substrate thickness	1.6mm
Component height on the top side	22mm
Total height	26.6mm
Recommended minimum clearance around the board	5mm
Micro USB connector protrusion	1.5mm

Table 4. Board height information and clearance

2. Software

2.1. Introduction

All Adaptive products have a simple text based serial interface available for configuring and setting the various internal registers used to control the device. This is straightforward when the device is simple to configure or needs only initial setup and occasional monitoring, however for more complicated configurations, monitoring or ease of use the Adaptive HMI can be used. The HMI is compatible with all the Adaptive products providing one common graphical interface that adjusts to the product it is connected to. The HMI provides easy setup and configuration but also basic plotting and data log capabilities. This document describes the Adaptive HMI and how it can be used with the Adaptive CyCLO.

2.2. Minimum PC System Requirements

The Adaptive Controller HMI has been designed for use with Microsoft Windows versions 7,8 & 10. It has not been tested or verified with Windows Vista. Windows XP is not supported as XP does not meet the minimum .Net requirements.

The application requires .Net support and during installation will check and prompt if necessary the installation of the required Microsoft .Net framework (size of the installation is approx. 50MB)

Depending on the Adaptive product being used the PC will require either 1 free USB or RS232 serial port. Note if the PC does not have a serial port a USB to serial port adapter may be used.

2.3. Installing the Software

To install the software, you must have admin rights for the user account. Locate the installation package, unzip if necessary to a temporary location and run the setup.exe installation file. Follow the on-screen instructions provided, note if the Microsoft .Net version needs to be upgraded you will be prompted to download or obtain it before continuing. Once installed a new Adaptive HMI icon will be placed on the desktop and in the All Programs menu.

2.4. CyCLO Quick Setup Guide

The user is encouraged to read this manual fully to familiarise themselves with the operation, however for those already familiar with the Adaptive HMI and CyCLO operation this section serves as a quick reminder for setting up a new CyCLO controller.

1) Wire up the supply and thermistor to the CyCLO, connect the USB cable to the PC, switch on and start the HMI.
2) Determine the thermistor parameters (beta and 25°C resistance) from the manufacturers data sheet and enter the values into the temperature configuration page, see Temperature Configuration page
3) Configure and enable any desired alarms, see Alarm Configuration page
4) Set the control operating mode and setpoint, see Control page
   Note: Ensure the jumper on the CyCLO board is set for the correct mode
5) Switch off the CyCLO, connect to the thermoelectric cooler module (TEC), hot and cold side fans, reapply power and start the HMI
6) Reconnect the HMI to the CyCLO and monitor the temperature control to confirm correct operation

3. Overview of HMI Display

The HMI display is split into three main sections as detailed in the table and diagram below;

The live display is visible at all times and shows the important operating variables. The menu buttons are used to swap the configuration area between the various pages that can be used to view alarms, status, allow settings to be configured or the operating mode to be changed. On connection the HMI detects the connected product and automatically configures the displays and menu options to suit allowing easy connection to different products and firmware versions.

Live Display	This shows the current values of the device such as temperature, drive voltage and current, mode and status. This is typically updated every second.
Menu Buttons	These buttons select the various configuration and alarm pages available for the device. The number and type will vary according to the device that is connected.
Configuration	This area shows the available configuration or alarm parameters that can be changed.

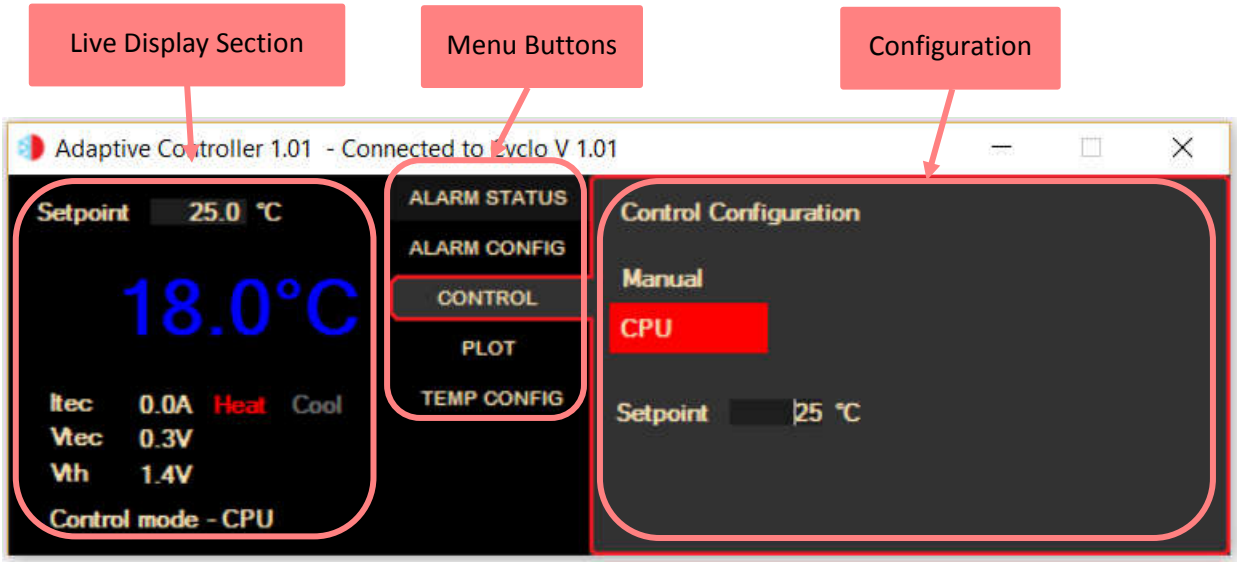
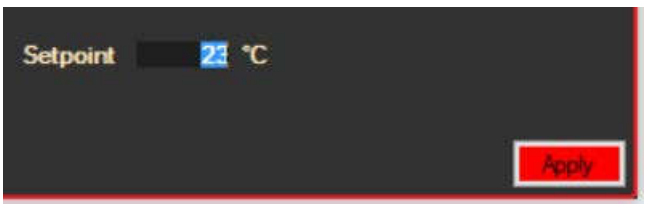


Figure 6 Example HMI display layout

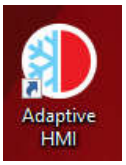
Whenever an item has been edited or changed on the HMI an 'Apply' button appears, click to apply the new values or flip to a different page and back to ignore and restore the original value. If a value is entered that exceeds the limit for the item in question it will simply revert to the previous value.



4. Using the Software

4.1. Starting the Software and Connecting the Controller

The CyCLO implements a USB serial port for its communication. The USB cable must be plugged in and the CyCLO powered on **before** the HMI is started, so that its sees the CyCLO serial port. If the port is not visible in the drop-down list double check the connection and power.

To start the HMI, double click on the Adaptive HMI shortcut icon 

or select it from the start menu Adaptive group. This will bring up the connection window where the serial port being used can be selected. Select the port from the available port list and click the connect button. If the connection is OK after a brief pause the main display will show. If there are communication problems a message box will be displayed. If this appears double check the connection cables and power and that you have selected the correct port connected to the CyCLO.

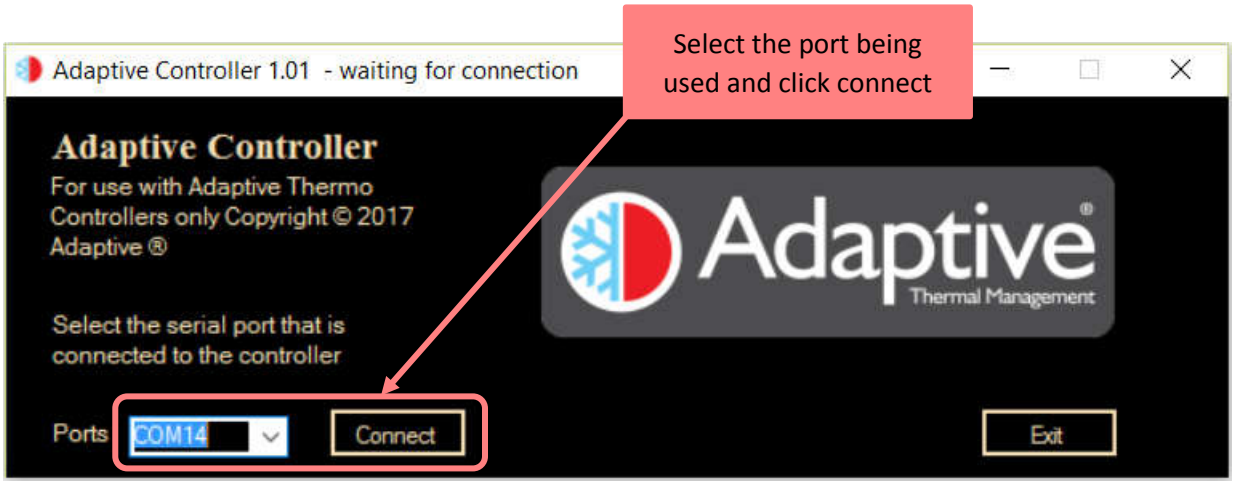


Figure 7 HMI connection screen

4.2. Software Flow

The HMI software provides four main options depending on the product that it is connected to; live monitoring of the variables and alarm status, configuration of the alarm limits and enables, selection of the control mode, and configuration / calibration of the connected temperature sensors and fans[1]. A plotting page is also provided to view trends and allow logging to file.

The menu section of the display is arranged so that the most used pages are shown at the top and the least at the bottom. When configuring a device for the first time the menu is normally worked in reverse upwards as the configuration of the sensors should be completed before attempting to use the device in an operational mode. The menu items may vary according to the product but the Alarm Status button will always be at the top see Figure 6. If the alarm page has not been selected or another page is on display and an alarm is present in the system the Alarm Status menu button will flash to indicate the presence of an alarm which the user should investigate.

When the HMI successfully connects to a device the Alarm Status page is automatically displayed.

[1] Options depend on product being used e.g. Fans available on JUNIOR

4.3. Alarm Configuration Page

There are four configurable alarms available for the CyCLO. Each alarm has individual trip thresholds and separate enable and shutdown options. When shutdown is enabled for an alarm, and it trips, the output drive is switched off and remains off until the operating mode or power is cycled.

There is also a hard-current limit implemented that cannot be disabled, which enters a shutdown state when tripped.

Note: The configurable alarm limits cannot be set beyond the limits as specified in the CyCLO datasheet.

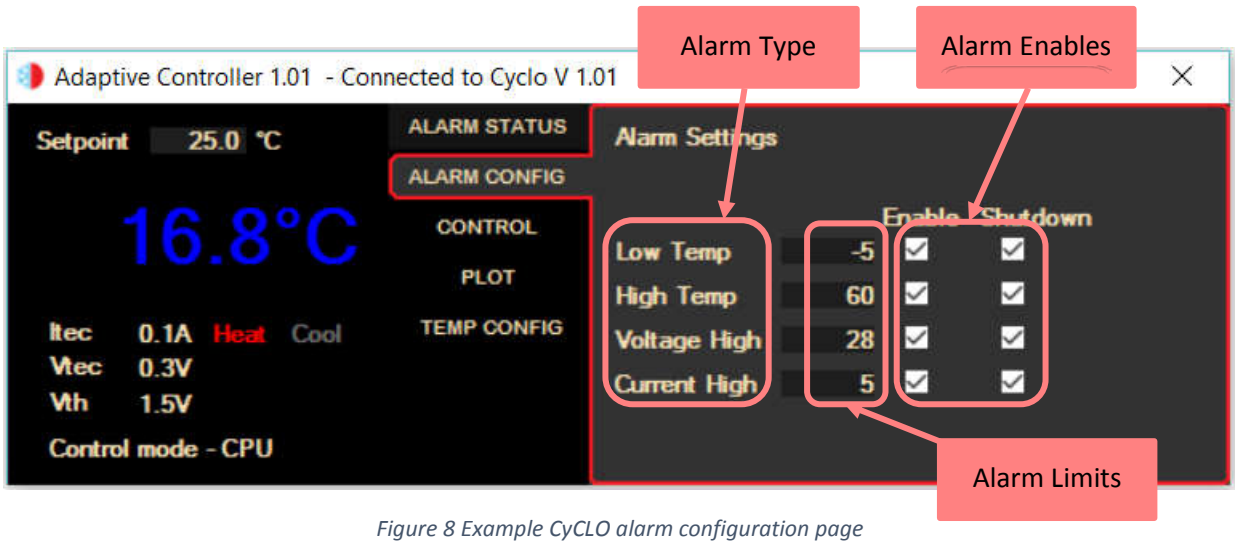


Figure 8 Example CyCLO alarm configuration page

Alarm Settings

Alarm Type	Description / Cause
Low Temp	Sets lower temperature limit. Alarm trips when the measured temperature falls below this value.
High Temp	Sets upper temperature limit. Alarm trips when the measured temperature rises above this value.
Voltage High	Sets the maximum bridge voltage. Alarm trips when the bridge voltage exceeds this value.
Current High	Sets the maximum bridge current. Alarm trips when the average bridge current exceed this value.

Alarm Enables	Result
Enable	Enables checking of the associated alarm limit, if active set the alarm state
Shutdown	When alarm trips the output drive is switched off and shutdown state latched.

4.4. Alarm Status Page

Figure 4 shows a typical alarm page for CyCLO. It displays the current status of the alarms. Any alarm that is active is highlighted in red.

The alarms are updated once every second and clear automatically when the alarm condition clears except the shutdown or hardware shutdown which have to be cleared by changing the operating mode or power cycling the product[2].

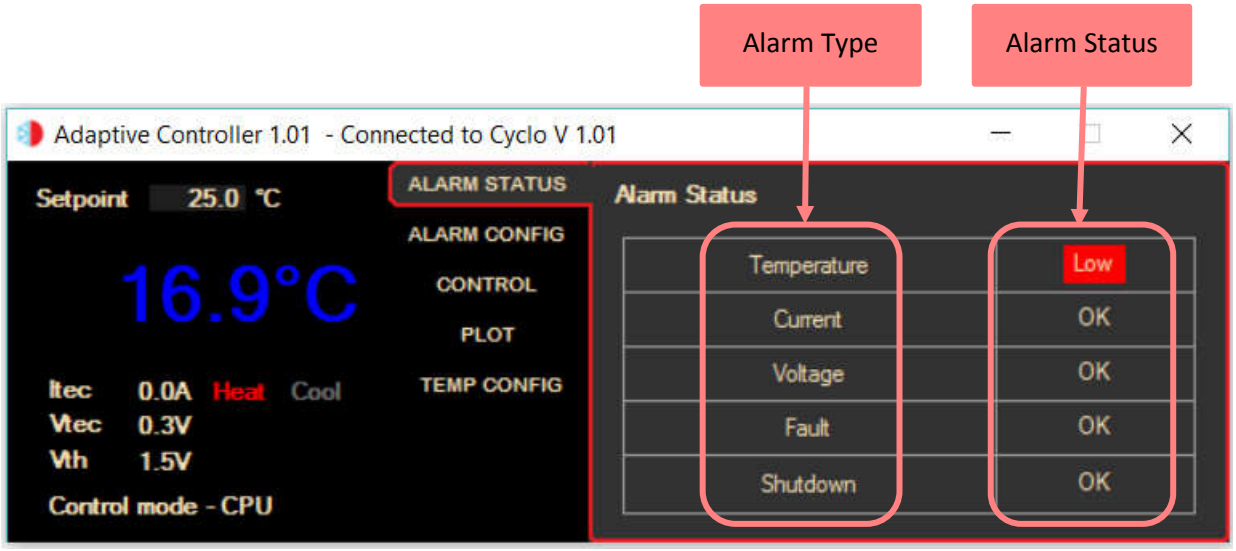


Figure 9 Example CyCLO alarm status page

Alarm Status

Alarm Type	Alarm Status	Reason
Temperature	Low	The measured temperature value has fallen below the Low Temp limit value
	High	The measured temperature value has risen above the High Temp limit value
Current	Fault	The average bridge current exceeds the current high limit value
Voltage	Fault	The maximum bridge voltage exceeds the voltage high limit value
Fault	Fault	This indicates that the controller hardware has detected a fault, this could be that the bridge current is over 19A or the NTC thermistor is open or short circuit
Shutdown	Fault	This occurs when the fault alarm is raised to indicate the drive is off, or when the software has detected an internal fault.

[2] Some hardware alarms are cleared by cycling the operating mode between auto and manual i.e. CyCLO or by power cycling the unit. See specific product manual for details.

4.5. Control Page

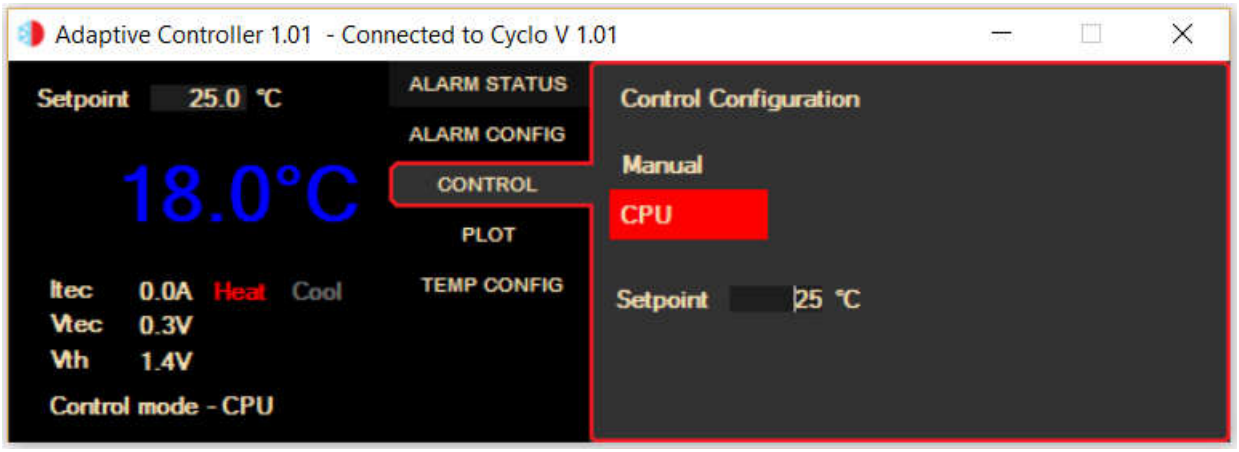


Figure 10 Operating mode page - CyCLO

The control page provides access to the operating mode of the unit. The number of modes available varies according to the product but as CyCLO is designed to be a simple standalone controller only two modes are available, manual or auto (CPU).

The CyCLO has two methods of providing a setpoint value to control the temperature;

1) Manual setpoint adjustment using the onboard potentiometer.
2) Software adjustable setpoint using onboard digital to analogue converter.

The setpoint that is used is determined by the 3-pin jumper setting on the CyCLO board NOT by the HMI setting.

This jumper allows the CyCLO to be used without any software[3] for quick and simple temperature control applications. To use the HMI to adjust the setpoint, the jumper must be set to CPU mode and the operating mode changed on this page to CPU.

When set to CPU mode the value in the Setpoint box can be changed. Any change to the setpoint will be reflected in the setpoint setting on the live display section and the unit will start to move towards the setpoint. If the indicated temperature is below the setpoint it will be shown in blue indicating it is too cold and when the temperature is above it, it will be in red. The reading will turn green when the temperature is within 0.5 of the setpoint.

[3] Although CyCLO can be used without software the configurable alarms are still active if enabled when used in manual mode and can be useful for providing limits below the default values.

4.6. Plot Window

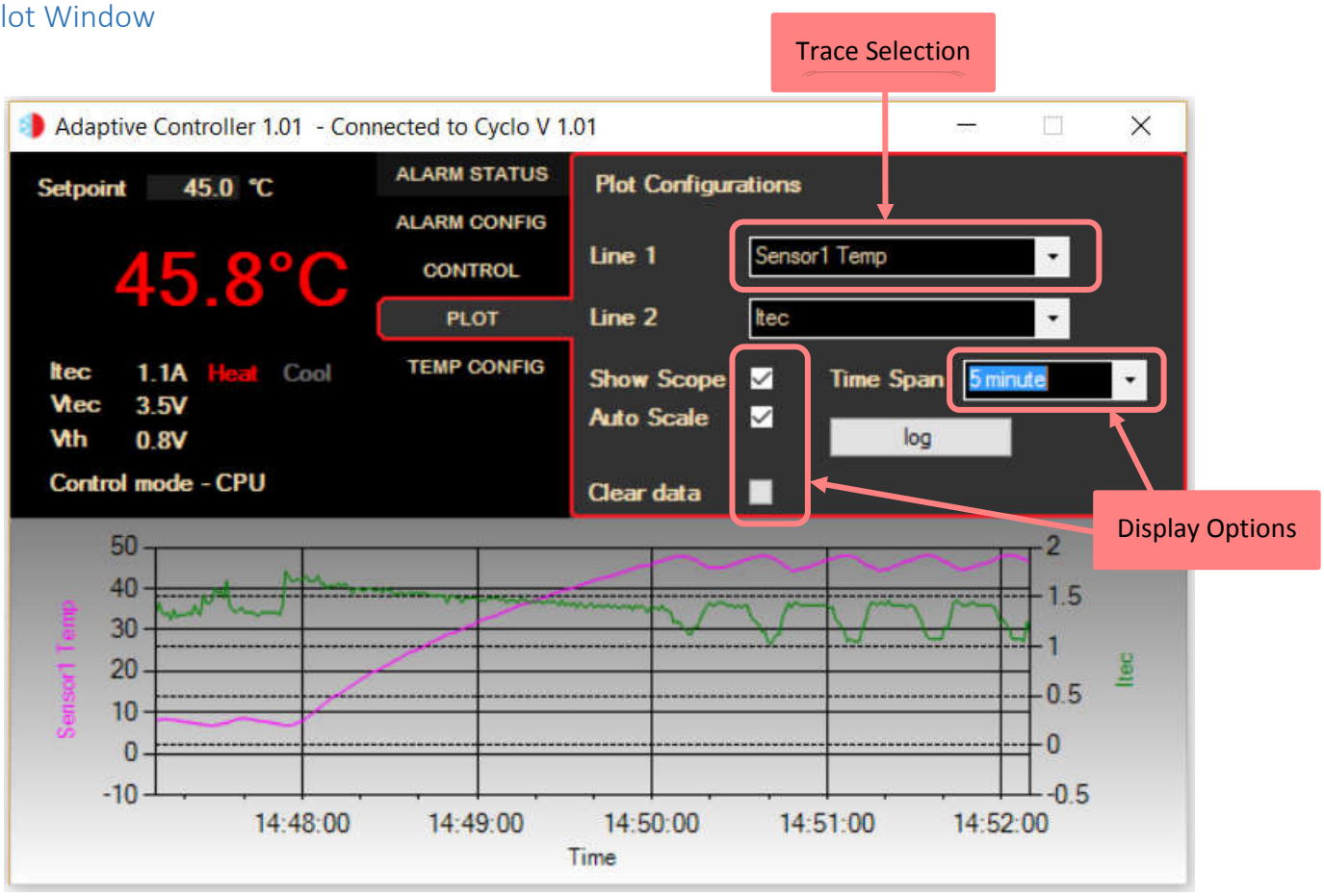


Figure 11 Realtime plotting and logging

The HMI provides basic plotting and logging facilities that can be used to check the operation of the system or monitor the performance. It is not intended for production or extended logging as the log is maintained in one plain text file with minimum validation.

Up to two traces can be selected using the drop-down lists Line 1 & 2. The items are sampled once a second and added to the trace. If logging has been selected they are also recorded to the text file that was selected. The items selected can be changed at any point, but on doing so the trace is cleared before plotting resumes with the new items. If the items are changed whilst logging to a file is in progress the logging simply carries forward with the new items being logged, causing a discontinuity in the log file.

The display options settings effect how the scope data is displayed (has no effect on logging)

Display Option	Effect
Show Scope	Displays the scope in a window below the main application display.
Auto Scale	Increases or decreases the Y axis range so that all the recorded Y values fit within the axis.
Clear Data	Erases the current data from the trace, using this when Auto Scale is selected causes the axis to expand the range to fit
Time Span	This can be used to adjust the plots X axis from 1 minute to 24 hours, this can be done at any point and does not cause any loss of data as the data is stored in a rolling 24-hour buffer.

The data being plotted can also be logged to a file, this is achieved by clicking on the log button and entering a file name. The data is recorded in a comma separated format, which if the file name ends with the extension '.csv' can easily be opened in Microsoft Excel. When logging is in progress the button changes to 'Stop logging'.

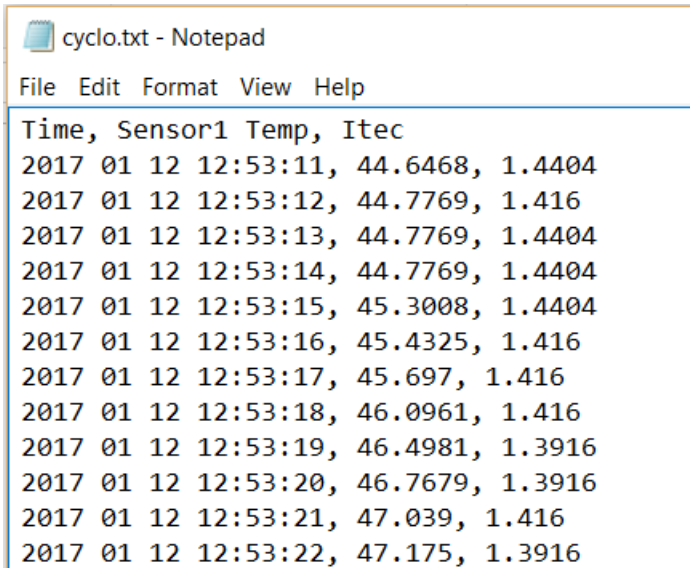


Figure 12 Sample log file showing CSV data format

4.7. Temperature Configuration Page

The CyCLO uses a single NTC thermistor for sensing the temperature and providing feedback for the control. This page is used to configure the CyCLO to the particular NTC sensor it is being used with and will only be required the first time the CyCLO is setup or if the NTC sensor is replaced.

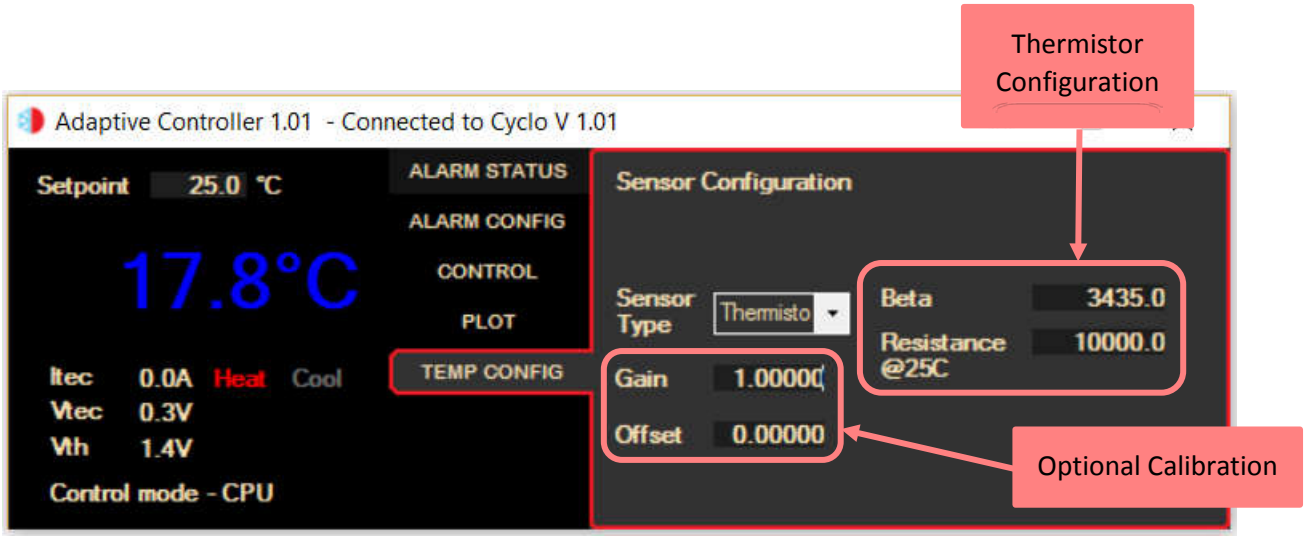


Figure 13 Sensor configuration for CyCLO

The resistance of a thermistor changes with temperature which is highly dependent on the materials used for its manufacture. Manufacturers therefore provide constants for use in the conversion between resistance and temperature. The thermistor datasheet will usually provide a beta constant (sometimes referred to as 25/85 value) and resistance value at 25°C (normally), specified over a given operating temperature range. The values for beta and 25°C resistance should be entered into the spaces provided.

The firmware provides an optional calibration facility which can be used to either improve the accuracy of the thermistor being used or adjust thermal offsets present in the system. For example, a thermistor will be specified over a given temperature range for a specified accuracy, but this may be much larger than the required operating range. By calibrating it over a smaller range the accuracy can be increased. The calibration can also be used to minimise the error across the operating range caused by CyCLO's use of a fixed gain controller. In some applications this can be caused if the point being measured by the thermistor is not sufficiently close the source.

The gain and offset values are used to apply a straight-line adjustment to the temperature measurement. The values are typically calculated by taking two measurements of both the indicated temperature on the controller and that from a separate calibrated temperature indicator at the two extremes of the range being used. These four values are then used to calculate the gain and offset to apply, minimising the error across the range.

5. Appendix 1 CyCLO Communication Interface

5.1. Serial Protocol and Settings

The CyCLO USB connection provides a serial communication port with the following settings;

Baud rate	Data bits	Stop bits	Parity
115,200	8	1	None

Although this document describes the use of the Adaptive HMI with the CyCLO, any terminal program may be used to communicate and control the CyCLO as long as it adheres to the protocol outlined below.

All commands are sent using 8-bit ASCII characters starting with $ and terminated with carriage return, line feed. The characters can be upper case, lower case or mixed and with or without spaces.

Numeric values may be integer or real, however exponent forms are not accepted and will return an '`Error_6 unexpected data` <command that was sent>'

Some example commands are shown below note the < and > are not part of the command and are not typed.

Command	Result	Description
$ID<cr><lf>	ID=Cyclo V1.01 ETDYN (c) Oct 30 2017<cr><lf>	Reads the identification
$REG 1<cr><lf>	REG 1=320<cr><lf>	Reads the status register
$REG 3=25<cr><lf>	REG 3=25<cr><lf>	Writes to the setpoint register and returns the new value stored

5.2. Commands, Register Set and limits

The table below shows the commands available using the interface.

Command	Description	Notes
VER	Returns the version of firmware programmed	
ID	Returns the device identifier string	
REG	Provides access to the internal registers	Use REG n to read register n Use REG n = x.y to write value x.y to register n
RUN	Turns on the output drive	Unconditionally starts control
STOP	Turns off the output drive	Unconditionally stops control (uses shutdown)

The following tables lists the registers available in the CyCLO with a brief description and any restrictions.

Register Number	Type	Limits	Description
0	Integer	Read only	Firmware version number
1	Integer	See table	Status
2	Integer	0 or 1	Control mode 0 = Manual 1 = CPU
3	Integer	-5 to +60°C	Setpoint
4	Integer	-5 to +60°C	Temperature alarm low limit
5	Integer	-5 to +60°C	Temperature alarm high limit

6	Integer	0 to 50 Volts	Voltage high alarm limit
7	Integer	0 to 19 Amps	Current high alarm limit
8	Integer	See table	Alarm enables
9	Integer	See table	Shutdown enables
10	Floating point 32 bit	Read only	Temperature sensor value
11	Floating point 32 bit	Read only	Thermistor voltage
12	Floating point 32 bit	Read only	Bridge voltage (TEC)
13	Floating point 32 bit	Read only	Bridge current (TEC)
14	Floating point 32 bit		Calibration gain
15	Floating point 32 bit		Calibration offset
16	Integer	-10000 to +10000	Thermistor beta
17	Integer	10 to 100000 Ohms	Thermistor resistance (25C)

Status bits

Bit number	Meaning
0	Shutdown
6	Heat or cool
7	Fault alarm
8	Temperature low alarm
9	Temperature high alarm
10	Bridge voltage high alarm
11	Bridge current high alarm
13	Internal fault
14	Communications fault
15	Communications fault

Bit = 1 indicates alarm condition

Alarm Enable and Shutdown Registers

Register	Bit 3	Bit 2	Bit 1	Bit 0
Enable	Bridge current high	Bridge voltage high	Temperature high	Temperature low
Shutdown	Bridge current high	Bridge voltage high	Temperature high	Temperature low

Bit = 0 disabled, Bit = 1 enabled

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