

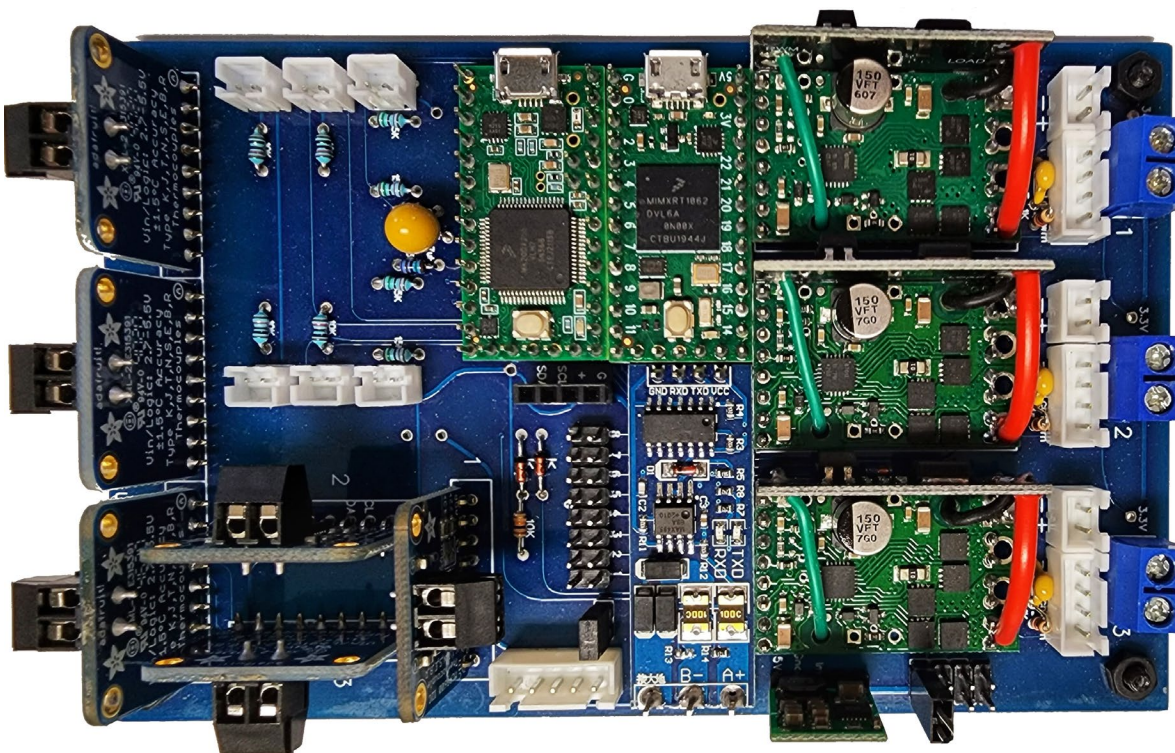
NWCS Temperature Measurement and Control Board

This board consists of a temperature sensing sub-module, with 6 thermistor inputs (10K thermistor), up to 6 thermocouple inputs (type K, J, T, N, S, E, B, or R), up to 6 IR (touchless) sensors, and a control sub-module, capable of driving TEC's, resistive heaters, and PWM controlled ovens. There are up to 3 control channels, each capable of driving devices up to 400W (17A, 24V). Three fan control channels are provided; both speed-controlled fans and simple DC power-controlled fans can be used. Speed-controlled fans can be configured for PID controlled cooling of resistive heaters if desired.

Control algorithms include both classical PID control for analog controllable devices such as TEC's and resistive heaters as well as thermostatic (On/Off) control for ovens that have only an "on" and an "off" state. Any of the control channels can be configured to automatically run at power-up.

Extensive safety features are included. Any temperature sensor can be used for monitoring and alerting if temperature exceeds defined bounds; optionally, power to heating devices can be cut if defined safe conditions are exceeded.

The system is designed for ease of scripted control and comes with script examples and with a dedicated Windows utility application to configure and run the system. Please see application screenshots at the end of this document for an application overview.



Protocols and Commands

Command protocol is compatible with the Cavro/Kloehn/Tricontinent protocol, both electrically and in software.

Target address is a single Hexadecimal character.

Each command is a single ASCII character, optionally followed by a parameter.

The firmware allows for a maximum of 3 TEC controllers, 3 speed controlled fans, 6 thermocouples (any type), and 6 thermistors (10K).

The temperature sensor subsystem can be used independently of the controller or can be a slave to the controller.

Default temperature controller address is "3".

If the temperature sensor is acting as a slave to the controller, it must be set to address "4" and system communication must then be directed to the controller.

The temperature controller can run either TEC's or resistive heaters.

If resistive heaters are used, speed controlled fans can be used for cooling (under PID control); see the "h" command.

There are three communication channels:

- 1) USB port (appears on the PC as a serial port).
- 2) RS485 port (appears on the PC as a serial port).
- 3) Serial2 port -- temperature sensor to temperature controller channel (used for communication between the subsystems).

The USB port is used for initial setup and the RS485 port is used for normal communications.

Commands are targeted to either the temperature sensor or the temperature controller (use the appropriate target address).

Command sets are as follows:

Common Commands

Set device address. Note that 0 is reserved for master node and 15 (F) is reserved as universal device address

& Get firmware version

E Save settings to EEPROM

e Get current settings

Temperature Sensor Commands

- X** Set thermistor input channel for subsequent thermistor commands (expect param); zero based
- Y** Set thermocouple input channel for subsequent thermocouple commands (expect param); zero based
- `** Set IR input channel for subsequent thermocouple commands (expect param); zero based
- ^** Get IR reading, current channel
- A** Get thermistor reading, current channel
- B** Get thermocouple reading, current channel
- a** Get all thermistor readings, space separated
- b** Get all thermocouple readings, space separated
- C** Use simple thermistor model, current channel
- D** Use full SH thermistor model, current channel
- G** Set offset for current thermistor
- H** Set offset for current thermocouple
- J** stream thermistor reading for current thermistor
- K** stream thermocouple reading for current thermocouple
- L** Set TRCoeffA, current channel
- M** Set TRCoeffB, current channel
- O** Set TRCoeffC, current channel
- S** Set SimpBCoeff, current channel
- T** Set Thermocouple type, current channel

Temperature Controller Commands

- N** Specify temperature control channel # to use (expect param); zero based
- I** Set control type for current control channel, PID or Bang-bang
- %** Set Bang-bang PWM value for current control channel
- *** Set Bang-bang control band value for current control channel
- !** Set current control channel to auto-run
- F** Set current fan channel for subsequent fan commands (expect param)
- P** Set fan power (FET), current fan channel
- s** Read fan speed (RPM), current fan channel
- V** Set fan speed (PWM), current fan channel
- ~** Set fan rpm multiplier (to correct tach reading to true rpm)
- {** Get voltage of power input; (expect channel param, ones based)
- }** Get current power output; (expect channel param ones based) NOT IMPLEMENTED
- W** Directly set power, current control channel
- p** Set P value, current control channel
- i** Set I value, current control channel
- d** Set D value, current control channel
- o** Transmit current PID values to pid object
- t** Set target temperature, current control channel
- h** Set pid control direction, current control channel
 - "0" means a positive signal results in a positive response (TEC)
 - "1" means a negative signal results in a positive response (TEC)
 - "2" means a negative signal results in no response (Resistive)
 - "3" means a negative signal results in a Fan response (Resistive)
- Z** Start controlling, current control channel
- x** Stop controlling, current control channel
- q** Set Rapid Approach Band, current control channel
- r** Set Rapid Approach Power, current control channel
- v** Enable Rapid Approach, current control channel
- c** Set output lower limit, current control channel (with TEC, negative values are allowed)
- l** Set output upper limit, current control channel
- w** Send limits to PID object, current control channel
- U** Set specified thermistor number for current control channel (0 to 5)
- u** Set specified thermocouple number for current control channel (0 to 5)
- +** Set specified IR sensor number for current control channel (0 to 5)
- \$** Set sample time for current control channel
- m** Get current control power, current control channel
- n** Get current control temp, current control channel
- :** Request notification of when target temperature reached, current control channel
- ;** Set notification threshold for notification of when target temperature reached, current control channel
- y** Set Alert temperature value, current thermocouple channel
- z** Set Alert temperature value, current thermistor channel
- (** Set Alert temperature value, current IR channel
- f** Enable or disable alerting, current thermocouple channel
- g** Enable or disable alerting, current thermistor channel
-)** Enable or disable alerting, current IR channel
- k** Enable/disable Stop control if thermistor alerts, current thermistor ch, specified control ch (bit pattern)
- j** Enable/disable Stop control if t-couple alerts, current t-couple ch, specified control ch (bit pattern)
- <** Enable/disable Stop control if IR alerts, current IR ch, specified control ch (bit pattern)

Application Utility

In addition to the full Oven Control Software, the system comes with a utility/setup application to assist with hardware testing and calibration. When a full hardware/software system is purchased, this utility should not be required, since calibration is then done at the factory, but is very useful for testing and troubleshooting.

The following screenshot demonstrates the functionality available.

The screenshot displays the MAS Temperature Controller Test App interface, which is organized into several functional panels:

- Top Bar:** Includes an "Open" button, a "Port" dropdown menu set to "COM4", and a "Close" button.
- Read Temperature (°C) Panel:** Features a "Select Channel" section with radio buttons for channels 1 through 6. Below this, there are two sensor type options: "Thermistor" (selected) and "Thermocouple". Under "Thermistor", six temperature readings are listed: 20.38, 20.01, 22.37, 21.49, 21.49, and 23.28. "Read Selected" and "Read All" buttons are provided.
- Temperature Control Panel:** Contains a "Select Channel" section (channel 1 selected), a "Set Temperature Sensor for this Channel" button, and a "Start Controlling" button. It also includes a "Target Temp (°C)" input set to 24.0 with a "Set" button, a "Set Control Power (PWM)" input set to 0, and a "Stop Controlling" button. At the bottom, there are buttons for "Get Current Power (PWM)" and "Get Current Temp (°C)".
- Fan Control Panel:** Includes a "Sel Channel" section (channel 1 selected), buttons for "Set Fan Speed (RPM)", "Set Fan Pwr (FET)", and "Set Fan Speed (PWM)", each with a corresponding input field.
- Parameter Adjustment Panels:**
 - Thermistor Parameters:** Includes an "Update Calc Model" button, a "Simple" (selected) or "SH" radio button, an "Update Simple Coeff" input (3.9500 e 3), an "Update SH Coefficients" button, and three coefficient inputs (A: 1.39691800 e -3, B: 2.37825800 e -4, C: 9.37265300 e -8).
 - Thermocouple Parameters:** Includes an "Update TC Type *" button, radio buttons for types K, J, T, N, S, E, B, and R, a note about power cycling the board, and an "Update TC Offset" button with an input of 0.000 e 0.
- Regulator Parameters Panel:** Features an "Update Regulator Values" button, a "Control Type" section (PID selected, BB unselected), and a "Polarity" checkbox (Negative unselected). It lists several parameters with input fields: Upper Power Limit (PWM) at 255, Lower Power Limit (PWM) at 0, Bang Bang Power (PWM) at 128, Bang Bang Band (°C) at 1.0, Rapid Approach Band (°C) at 6.0, Rapid Approach Pwr (PWM) at 255, and a "Rapid Approach" checkbox (Enable unselected).
- Bottom Bar:** Includes a "Get FW Ver of Temperature Sensor" button showing version 1.1, and a "Save All To Non-Volatile Memory" button.

Control Regulator Parameters



Open Port: COM4 Close

Read Temperature (°C)

Select Channel: 1 2 3 4 5 6

Thermistor ① 20.38 ② 20.01 ③ 22.37
 Thermocouple ④ 21.49 ⑤ 21.49 ⑥ 23.28

Temperature Control

Select Channel: 1 2 3

 Target Temp (°C)

All settings shown here refer to selected channel in the panel above.

Thermistor Parameters

 Simple SH
 e

 Coeff A e
 Coeff B e
 Coeff C e
 e

Thermocouple Parameters

K J T N
 S E B R
 * Power cycle board after update & saving to non-volatile memory
 e

Fan Control

Sel Channel: 1 2 3

Reg Params PID Params Alerts *Settings for selected ctrl ch above*

Proportional (kP) $P = (kP * Te)$
 Integral (kI) $I = (kI * ts * Te) + I[-1]$
 Derivative (kD) $D = kD / ts * (Te - Te[-1])$
 Sample Time (ms)

Cooling Source TEC Fan None

[version]

PID Control Parameters



Port:

Read Temperature (°C)

Select Channel: 1 2 3 4 5 6

Thermistor ① 20.38 ② 20.01 ③ 22.37

Thermocouple ④ 21.49 ⑤ 21.49 ⑥ 23.28

Temperature Control

Select Channel: 1 2 3

Target Temp (°C)

All settings shown here refer to selected channel in the panel above.

Thermistor Parameters

Simple
 SH

e

Coeff A e
 Coeff B e
 Coeff C e

e

Thermocouple Parameters

K J T N
 S E B R

* Power cycle board after update & saving to non-volatile memory

e

Fan Control

Sel Channel: 1 2 3

Settings for selected ctrl ch above

All settings shown here refer to the temp sensor specified in the upper left panel.

Alert Temp (°C)

Alert Status Enable

Stop Controlling on Alert Enable

1.1

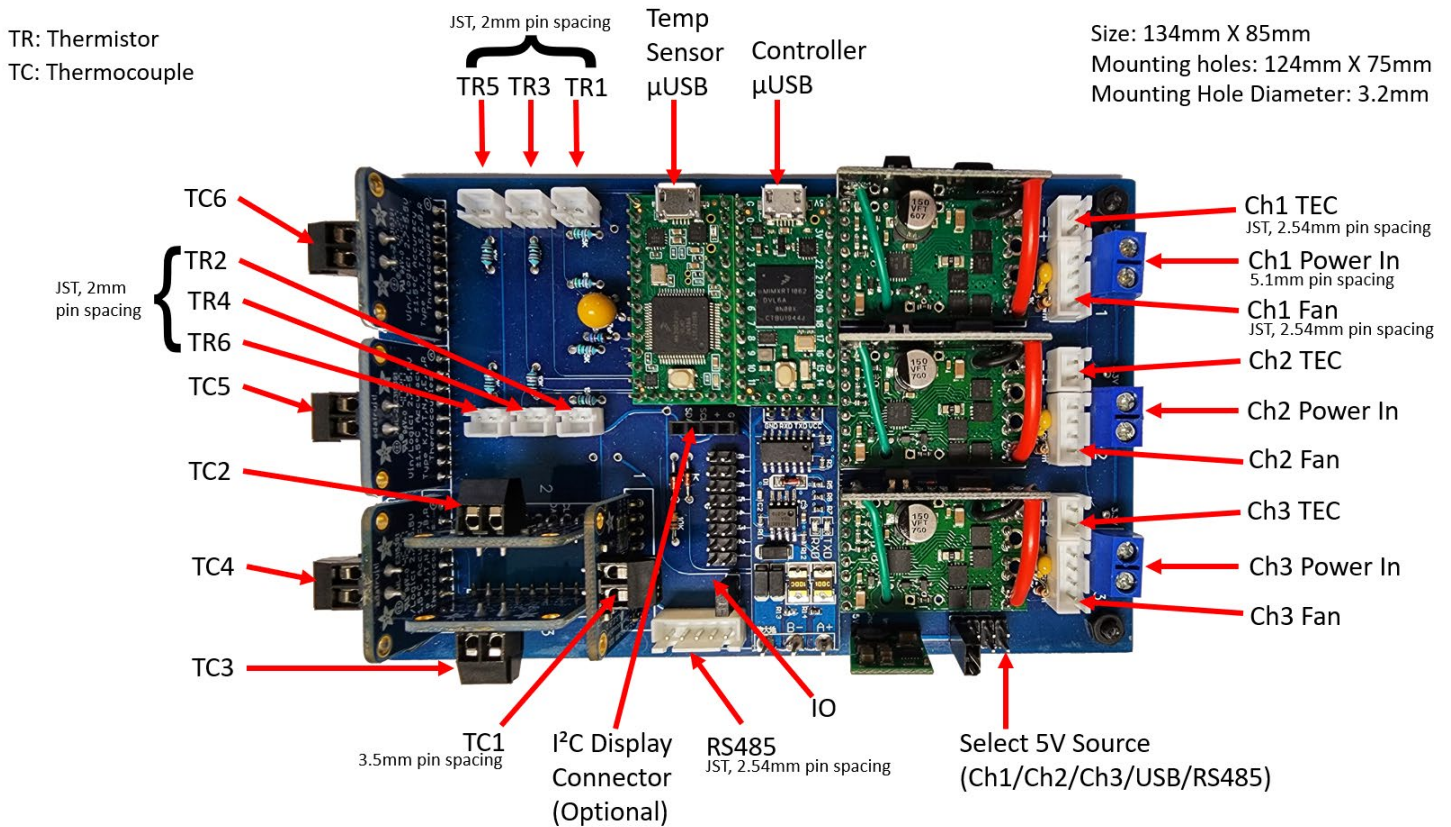
Alert Settings

Hardware

The Temperature Controller is offered in the following configurations:

- Two heating/cooling channels, two fan channels, six thermistor inputs, two thermocouple inputs. Footprint: 55mm x 133mm
- Three heating/cooling channels, three fan channels, six thermistor inputs, six thermocouple inputs. Footprint: 85mm x 133mm

The three-channel, 6-thermocouple version is shown below:

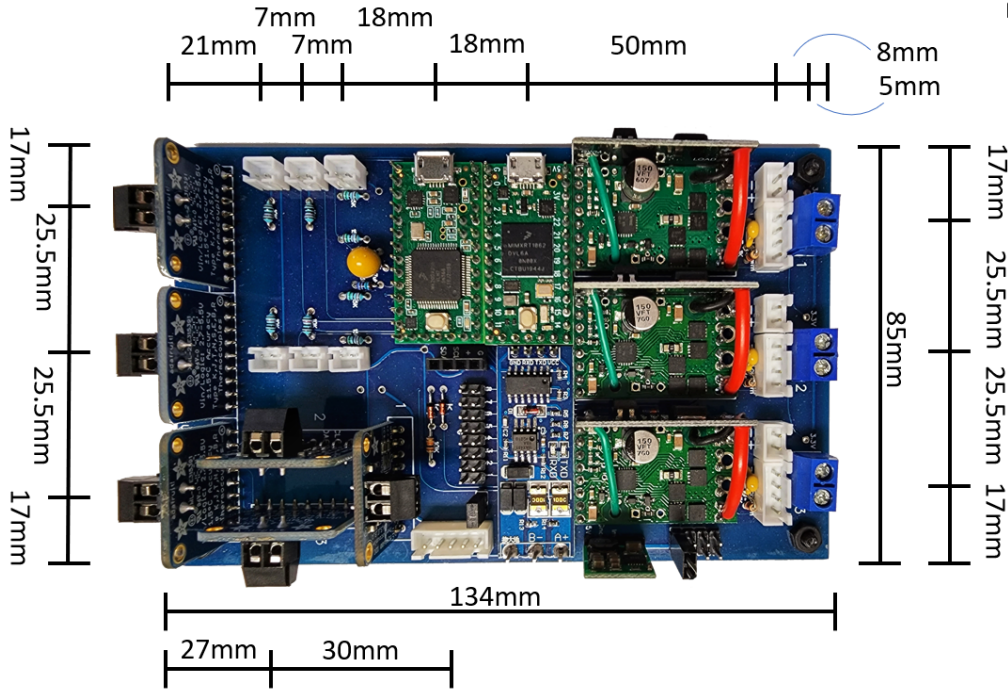


Power-in is typically either 12VDC or 24VDC.

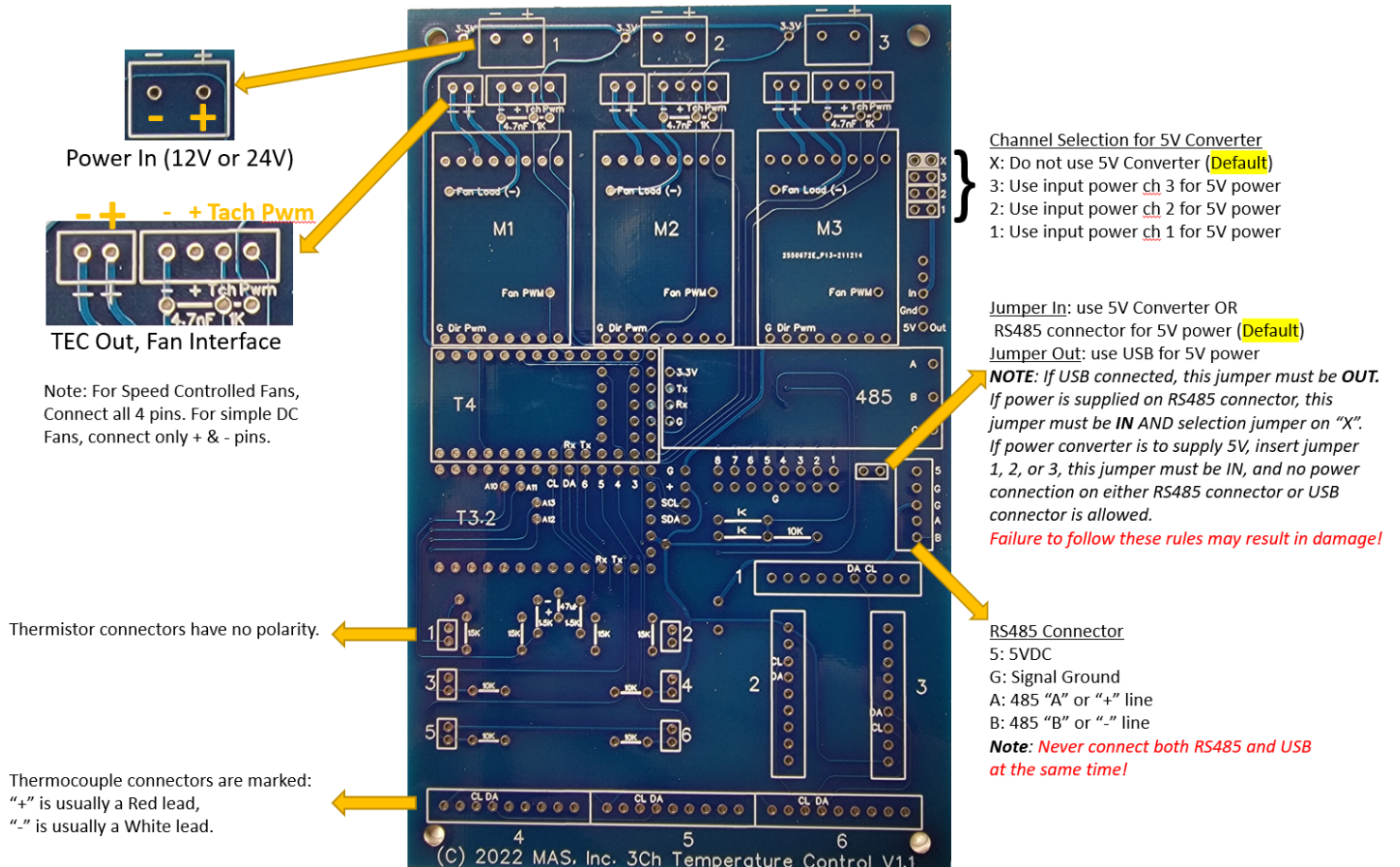
The primary system communication is via RS485, although USB ports are provided for testing and for firmware updates.

Physical dimensions are shown below:

Size: 134mm X 85mm
 Mounting holes: 124mm X 75mm
 Mounting Hole Diameter: 3.2mm
 Board Ht: 22mm
 Min. Mounting Ht: 4mm



Please note the following before use:



Contact information and part numbers



Northwest Control Systems LLC
133-25 Jylha Rd.
Rochester, WA 98579-8917

Phone 510-299-3453

Email sales@nwctrl.com

Part Numbers

2-Channel Temperature Controller: TEMP020-A1

3-Channel Temperature Controller: TEMP030-A2