NELSON
HEAT TRACE

NELSON™
CM-2201/CM-2202
HEAT TRACE CONTROLLERS
Installation and Operating Instructions

EMERSON™

1.1 Introduction

The Nelson Heat Trace CM-2201 is designed to monitor and control one heating circuit in ordinary and Class I, Division 2, Class I, Zone 2, and Zone 2 hazardous locations.

The CM-2202 can monitor/control two heating circuits in those same locations.

This manual provides information pertaining to the installation, operation, testing, communications and maintenance of these controllers. See Appendix A for detailed specifications

1.2 Getting Started

The CM-2201/CM-2202 is typically connected to external RTDs, power or communication based on Appendix B and C. Detailed set-up of the operating/control/monitoring program is entered throughout the following sections.

For addition help, call Nelson technical support or follow the Troubleshooting section.

2.0 General Application Information

The CM-2201/CM-2202 are designed to operate on input voltages between 100 and 277 Vac and 50/60 Hz. Load switching is handled by a 2-Pole solid-state relay and can control resistive loads of 30A continuous @ 40°C ambient.

The CM-2201/CM-2202 are designed to control heating circuits by monitoring one or two temperature inputs for each circuit via industry standard 3-wire, 100Ω, Platinum RTDs. The two separate RTDs for each circuit may be utilized to customize the temperature control inputs. Several different modes are user selectable as well as the sensor failure operational mode.

The CM-2201 and CM-2202 can be operated in temperatures of -40°F to +104°F (-40°C to +40°C).

3.1 Installation

The CM-2201/CM-2202 must be installed only in areas for which it has been approved and in accordance with all applicable electrical codes and ordinances. All conduit entry holes must be appropriately installed and sealed to maintain ingress protection rating.

Do not install this unit prior to functional testing if shipping container or internal packaging shows signs of damage. Notify the appropriate individuals immediately if damage is suspected.

3.2 Selecting Installation Location

The CM-2201/CM-2202 should be installed in an area protected from the elements as much as possible. It is possible to install the unit in unprotected areas but such often limits maintenance/access. Further, installation in unprotected areas must be carefully considered to ensure it is always in operating conditions consistent with specifications. See Appendix A for additional details.

3.3 Mounting

The CM-2201/CM-2202 should be mounted at a convenient height to suit operator interaction. Conduit entries should be made in the bottom of the enclosure to prevent damage to the internal electronics from moisture intrusion. Conduit entries should be drilled and the use of suitable bushings is required to maintain the environmental ratings.

3.4 Wiring

Electrical wiring diagrams and schematics are provided in Appendix B and C of this manual. Ensure that all wiring and connections are in accordance with applicable wiring codes. Enclosure grounding must be in accordance with applicable wiring codes for non-metallic devices.

The power supply for the CM-2201 is derived from the power provided for the load. However, the power supply for the CM-2202 can be provided independent of the power supply for the loads being controlled. For example, the power supply for the CM-2202 can be 120 VAC while the loads being controlled can be 277 VAC. Further, the power supply for the CM-2202 may also be derived from either of the loads being controlled – this is implemented by connecting appropriate jumpers. Refer to Wiring Diagram in Appendix B for details.

4.1 Initial Set-Up

Upon initial power-up, the CM-2201/CM-2202 display will run self-check, display the software version and then start the main program.

4.2 Display Modes

This feature determines what messages and functions are displayed during normal operations. If set to "normal user," only basic information is displayed. If set to "advanced user," all controller information is displayed. Each parameter shown in this manual will list the Display Mode required to view information and access each function during programming.

4.3 Password Protection

The CM-2201/CM-2202 may have password protection enabled to ensure that sensitive operating parameters are not inadvertently adjusted. If password protection is enabled, the user will be prompted to enter a valid value to access any protected features. The user may also replace the default password value (1234) with their own unique value for greater protection of operational parameters.

4.4 Security Levels

CM-2201/CM-2202 has two levels of security. The high level (Advanced Display) requires password protection. Disabling the password from the Password Enable/Disable menu will keep the password disabled indefinitely – any parameter can be changed without the use of a password. At this level all the functions and monitoring parameters are open. The low level (Normal Level) does not give access to parameters settings, but is open for few parameters monitoring like temperature, current, GFI, etc.

If the password is "Enabled", when going directly to the parameter to be changed, after the 'up' or 'down' arrow is pressed, the controlled will ask for the password, and then the parameter can be changed and saved. The password will stay disabled for 15 min, then be automatically re-enabled. During the 15 min period when the password is disabled, other parameters can be changed and saved.

5.1 General Operation

5.2 Display

The CM-2201/CM-2202 utilizes a 2 line x 16 character alphanumeric display viewable from the front keypad. The top line is reserved for the function or operation and the bottom line displays the value range.

5.2.1 Navigation for CM2201

The CM2201 monitors one heating circuit consisting of load (typically a heating cable) and controls the load based on the temperature of the item being heated (typically a pipe) as provided via one or two RTD's attached to the pipe and connected to the controller.
To monitor the load, press **Actual** until "Operating Values" is displayed, then press **Right** or **Left** arrow to scroll through the various values.
To review the statistics that have been collected, press **Actual** until "Statistics" is displayed then press **Right** or **Left** arrow to scroll through the various statistics.

To change the control and monitoring settings (including alarm settings), press the **Program** key and then **Right** or **Left** arrow to scroll through the various settings. Any setting can be altered by pressing the **Up** or **Down** arrow. Note that a 4-digit password may be required to change certain settings – when required, the cursor will flash on the leftmost digit – use the **Up** arrow to increase this digit value or the **Down** arrow to decrease it. Move the cursor to the second leftmost digit using the **Right** or **Left** arrow and it will flash until adjusted using **Up/Down** arrows. When the last digit has been selected, press **Enter** and then changes will be allowed to the setting. Once the setting is adjusted, press the **Enter** key to store it.

To view alarms, press the **Alarms** key and then **Right** or **Left** arrow to scroll through the various alarms. Alarms that are not active can be erased by pressing the **Reset** key.

5.2.2 Navigation for CM2202

The CM2202 can monitor/control two separate heating circuits (channels). The controller defaults to Channel 1 upon first start-up. All parameters for Channel 1 can be displayed and modified using standard techniques as described for the CM2201 in Section 5.2.1.

To change to Channel 2, simply press the "**Actual**" key and then **right** arrow – the active channel will be displayed. To change the channel, press the **Up** arrow.

In general, when the active channel is displayed (eg. "CH.2"), the channel can be changed by pressing the **Up** or **Down** arrow.

5.3 Keypad

The keypad is "capacitive" touch sensitive and keys are activated by simply touching the area of the desired key with a finger, even when wearing gloves. Note that a stylus or other item used to touch the keypad will usually not activate the keys.

5.4 LED Functions

LED indicators will show the status of the respective functions. The power LED will be illuminated when the controller is connected to a source voltage. The heater LED will be illuminated when voltage is applied to any heater. The system LED will illuminate if there is an internal hardware issue with the controller. The comm LED will illuminate when the controller is sending data through external communication. The alarm LED will flash when there is a current active alarm condition or any circuit; the alarm LED will illuminate solid when an alarm was previously present but is not currently active.

5.5 Monitoring

By touching the "**Actual"** button follow the arrow and the controller will scroll through all the active parameters.

5.6 Alarm Management

All the alarm(s) will be saved in the alarm log. If no alarms are active (alarm LED solid red) the Alarm LED can be turned off by touching "Reset" once for every alarm that previously occured. If any alarm is active (alarm LED flashing red) the user cannot reset the alarm.

5.7 Soft-Start Feature

The Soft-Start feature enables self-regulating cables to be energized at low temperatures without causing excessive load on the electrical system and extending cable life by reducing cable internal heating due to inrush currents. The resistance of self-regulating cables decreases as these cables get colder, which results in higher current draw and can result in breaker trips if temperatures are very cold and the installed length of cable is long. The Soft-Start feature operates by initially only energizing the cable for a very short period of time – while the current draw may be high during this period, the period is usually short enough to reduce average load on the electrical system.

This short energization period is repeated and eventually increased; after a few minutes, the cable is usually warm enough such that the resistance has increased and the current decreased to the point where it can be continuously energized.

5.7 Current-Limiting Feature

The Current-Limiting feature operates similarly to the Soft-Start in that it restricts the amount of time the cable is energized during any given period thereby reducing the average current draw of the cable during that period. For example, if a cable normally draws 8 Amps, but current limit is set to 6 Amps, then the cable would be energized only 75% of the time.

5.8 Ground Faults

Ground faults typically are the result of damaged or improperly installed cables which allow current-carrying conductors/surfaces/parts to be in contact with grounded objects. For example, if a heating cable has been secured to a pipe with a clamp, and if the clamp has been overtightened, then the ground braid and/or the pipe may come in contact with current carrying parts within the cable. This would result in current leakage to ground through the ground braid of the cable and/or the pipe itself. This type of fault can eventually become serious, resulting in overheating/fire/shock hazards. Current leakage to ground can be monitored by electronic circuitry and the SPC can be programmed to either alarm or trip when leakage current exceeds the specified maximum allowable amount.

6.1 Control Modes

The CM-2201/CM-2202 allows the user to select different control modes based on their individual process control parameters.

6.2 On-Off Control

This control method simply energizes the cable until the actual monitored temperature rises to the setpoint value plus half the deadband value (upper limit). The cable is then de-energized until the actual monitored temperature drops to the setpoint value minus half the deadband value. Note that this type of control can result in some temperature "overshoot;" this is because the cable is de-energized when the monitored temperature reaches the upper limit. However, the residual heat in the cable continues to transfer to the pipe, and this will cause the pipe temperature to increase slightly above the upper limit. Similarly, there can be some temperature "undershoot."

6.3 Proportional Control

This control method uses the typical proportional control algorithm wherein the cable is cycled on and off at a rate proportional to the difference between the setpoint value and the actual monitored temperature. As the difference between the setpoint value and the actual monitored temperature increases, the amount of time the cable is energized increases proportionately. This helps reduce the "overshoot" and "undershoot" commonly associated with On/Off control.

6.4 Forced Control Feature

This control method simply allows the user to force the cable on or off as desired.

7.0 Programming

7.1 Program - Setpoints

7.1.1 Setpoint Value

This message displays the name of the sub-menu when entered.

1. Display Mode: All
2. Range: N/A
3. Default: N/A

7.1.2 Maintain Temp

This value sets the control setpoint temperature for all operating modes. For On-Off control, the circuit is energized if the control temperature is less than the maintain temperature minus the deadband. The circuit is de-energized if the control temperature is greater than the maintain temperature plus the deadband. If maintain temp is set to None then the heater circuit will have temperature monitoring with no control temperature. If the maintain temp is set to Off then the heater circuit will have no temperature monitoring or control.

1. Display Mode: All
2. Range: -50 to 500°C, none or -58°F to 932°F, none, Off
3. Default: 10° or 50°F

7.1.3 Low Temp Alarm

This value sets the Low Temperature Alarm setpoint. It must be less than the maintain temperature minus the Deadband. To disable this alarm set the value to "Off'. When the measured temperature of either RTD A or RTD B (if activated) is less than or equal to this setpoint, the Low Temperature Alarm is activated and a "LOW TEMP ALARM" message is added to the alarm stack. This alarm deactivates when the temperature rises above the alarm setpoint value.

1. Display Mode: All
2. Range: -50C to Maintain Temperature, Off, -58°F to Maintain Temperature, Off
3. Default: 5°C or 41°F
4. Restrictions: Message does not exist if Maintain Temperature is set to Off.

7.1.4 High Temp Alarm

This value sets the High Temperature Alarm setpoint. It must be greater than the maintain temperature plus deadband. To disable this alarm set the value to "Off". When the measured temperature of either RTD A or RTD B (if activated) is greater than or equal to this setpoint, the High Temperature Alarm is activated and a "HIGH TEMP ALARM" message is added to the alarm stack. The alarm deactivates when the temperature falls below this alarm setpoint.

1. Display Mode: All
2. Range: Maintain Temperature to +500°C, Off, Maintain Temperature to +932°F, Off
3. Default: Off
4. Restrictions: Message does not exist if Maintain Temperature is set to Off.

7.1.5 Low Current Alarm

This value sets the Low Current Alarm setpoint. It must be less than the high current alarm setpoint. To disable this alarm set the value to "Off'. When the heater current is less than or equal to this setpoint, the Low Current Alarm is activated and a "LOW CURRENT ALARM" message is added to the alarm stack. The alarm deactivates when the Heater Current rises above this alarm setpoint. Note: This setpoint is based on the heater at 100% power. If Proportional Control or Current Limiting is enabled, all current measurements will be scaled to 100% power, based on a constant resistive load, before being compared to the alarm setpoint.

1. Display Mode: All
2. Range: 0.1A to High Current Alarm, Off
3. Default: Off

7.1.6 High Current Alarm

This value sets the High Current Alarm setpoint. It must be greater than the low current alarm setpoint. To disable this alarm set the value to "Off'. When the heater current is greater than or equal to this setpoint, the High Current Alarm is activated and a "HIGH CURRENT ALARM" message is added to the alarm stack. The alarm deactivates when the heater current falls below this alarm setpoint. This setpoint is based on the heater at 100% power.

7.1.6 High Current Alarm Continued

If Proportional Control or Current Limiting is enabled, all current measurements will be scaled to 100% power, based on a constant resistive load, before being compared to the alarm setpoint.

1. Display Mode: All
2. Range: Low Current Alarm to 30.0A, Off
3. Default: Off

7.1.7 Ground Fault Alarm

This value sets the Ground Fault Alarm setpoint. It must be less than the ground fault trip setpoint. To disable this alarm set the value to "Off'. When the Ground Fault Current is greater than or equal to this setpoint, the Ground Fault Alarm is activated and a "GROUND FAULT ALARM" message is added to the alarm stack. The alarm deactivates when the Ground Fault Current falls below this alarm setpoint.

1. Display Mode: All
2. Range: 10 to Ground Fault Trip, Off
3. Default: 30mA

7.1.8 Ground Fault Trip

This value sets the Ground Fault Trip setpoint. It must be greater than the ground fault alarm setpoint. To disable this trip alarm set the value to "Off'. When the Ground Fault Current is greater than or equal to this setpoint, the heater circuit is de-energized, the Ground Fault Trip Alarm is activated and a "GROUND FAULT TRIP" message is added to the alarm stack. This is a latching alarm and trip. When the cause of the alarm has been corrected, the circuit may be energized by the manual reset function.

1. Display Mode: All
2. Range: Ground Fault Alarm to 500mA, Off
3. Default: 50mA

7.1.9 Low Voltage Alarm

This value sets the Low Voltage Alarm setpoint. It must be less than the high voltage alarm setpoint. To disable this alarm set the value to "Off'. When the Line Voltage is less than or equal to this setpoint, the Low Voltage Alarm is activated and a "LOW VOLTAGE ALARM" message is added to the alarm stack. The alarm deactivates when the Line Voltage rises above this alarm setpoint.

7.1.9 Low Voltage Alarm Continued

1. Display Mode: All
2. Range: 85VAC to High Voltage Alarm, Off
3. Default: Off

7.1.10 High Voltage Alarm

This value sets the High Voltage Alarm setpoint. It must be greater than the Low Voltage Alarm setpoint. To disable this alarm set the value to "Off'. When the Heater Voltage is greater than or equal to this setpoint, the High Voltage Alarm is activated and a "HIGH VOLTAGE ALARM" message is added to the alarm stack messages. The alarm deactivates when the Heater Voltage drops below this alarm setpoint.

1. Display Mode: All
2. Range: Low Voltage Alarm to 280VAC, Off
3. Default: Off

7.2 Program - Heater Setup

7.2.1 Heater Setup

This message displays the name of the sub-menu when entered.

1. Display Mode: Advanced
2. Range: N/A
3. Default: N/A

7.2.2 Enable Heater

This selection enables control and monitoring of the heater circuit. Setpoints and measured value messages cannot be accessed unless the heater is enabled. Select "No" if the circuit is not used.

1. Display Mode: All
2. Range: yes, no
3. Default: yes

7.2.3 Heater ID

This selection allows for user defined Heater Identification. It provides a unique, identifiable tag or label for each heater circuit. The Heater Name allows up to 20 alphanumeric characters which are entered one at a time from left to right. The cursor indicates which character is being selected. Press the [SELECT UP/DOWN] arrow keys to change the character. Move to the next character by pressing [NEXT] arrow. Press [ENTER] in the last character position to save the Heater ID.

1. Display Mode: Advanced
2. Range: 20 Characters
3. Default: Blank

7.2.4 Manual Override

This selection sets the response of the heater circuit to the Override inputs. The Override inputs respond to contact closure. If the Override is set to "Off", the override inputs are ignored and control of the heater circuit operates normally based on the measured temperature and maintain temperature setpoint. If the Override is set to "On", an open contact on the override inputs forces the heater Off. When the contact on the override input is closed, the heater control resumes in normal manner.

1. Display Mode: Advanced
2. Range: On, Off
3. Default: Off

7.2.5 Deadband

The Deadband is defined as the difference between the setpoint temperature and the actual maximum temperature that is ideally allowed in excess of the setpoint temperature. Decreasing the deadband increases the temperature control accuracy but also increases the heater switching frequency.

1. Display Mode: Advanced
2. Range: 1 C° to 5 C°, 1 F° to 10 F°
3. Default: 2 C° or 5 F°
4. Note: Deadband is disabled for Proportional Control mode.

7.2.6 Control Type

This selection determines the type of control method used by the controller, either On-Off (Deadband) or Proportional Control. The On-Off control mode is available for all heating devices. Proportional Control mode is only available for series type heating devices.

Warning: Proportional Control should never be selected for use with self-regulating heating cable types due to the constantly changing characteristics of self-regulating cables – this will cause the control to be unstable. Further, the continual cycling associated with Proportional Control can result in internal heating of the cable and lead to reduced life expectancy.

1. Display Mode: Advanced
2. Range: On-Off, Proportional
3. Default: On-Off
4. Selection does not exist if Maintain Temperature is set to Off.

7.2.7 Current Limiting

This selection sets the maximum average current limit allowed for the heater circuit. It is useful for reducing the power output of constant wattage heaters. The load will be turned on for a period of time and then turned off for a period of time to maintain the average current draw to the value set.

1. Display Mode: Advanced
2. Range: 0.5 to 30.0 A, Off
3. Default: Off
4. Note: The value range is in 0.5A increments.

7.2.8 Soft Start Mode

This function ramps the heater output from Off to nominal current of the heater over the set softstart cycle time. It is useful for reducing inrush currents of self-regulating heaters. At the end of the soft start cycle time, the load will no longer be controlled by the soft start function.

1. Display: Advanced
2. Range: 10 to 999 seconds, Off
3. Default: Off

7.2.9 Auto Test Cycle

This value sets the frequency at which the Auto Test Cycle is activated. Auto Test is a feature that exercises the system by automatically applying power to the heater at specified time intervals. If an alarm condition is detected during this period the Auto Test Alarm is activated and an "ALARM DURING AUTO TEST" message is added to the System Status messages. This is a latching alarm. To clear the alarm, locate the alarm message in the Alarm Menu and press [ENTER]. To disable this feature, set the value to "Off". The Auto Test Cycle does not operate if heater is forced off for any reason, including ground fault trip. Auto Test decreases maintenance by providing an early warning of problems that would otherwise go undetected until the heater was needed.

1. Display Mode: Advanced
2. Range: 1 to 720 hours, Off
3. Default: 24 hours

7.2.10 RTD Operation

This selection determines how the control temperature is utilized by the RTD inputs.

In One RTD Mode, the temperature is based on the measured temperature from RTD-A.

In Backup Mode, control temperature is based on RTD-A. If for any reason RTD-A fails, then RTD-B takes over.

In Average Mode, the control temperature is based on the average of RTD-A and RTD-B measured temperatures.

In Lowest Mode, control temperature is based on the lowest of the two temperature measurements.

In Highest Mode, control temperature is based on the highest of the two temperature measurements.

In High Temperature Cutoff Mode, control temperature is based on RTD-A, but if the temperature from RTD-B exceeds the high temperature alarm, the heater is turned Off and a high temperature alarm is activated. The High Temperature cutoff mode will operate in one RTD mode if the high temperature alarm is turned Off.

7.2.10 RTD Operation Continued

Functions requiring two RTDs to operate, such as Average, Lowest, Highest and High Temperature Cutoff, will operate in One RTD mode if one of the two RTDs fail.

1. Display Mode: Advanced
2. Range: One RTD, Backup, Average, Lowest, Highest, High Temperature Cutoff
3. Default: One RTD
4. Restrictions: Message does not exist if Maintain Temperature is set to Off.

7.2.11 RTD Failure Mode

This selection sets the controllers fail-safe mode. The controller detects if RTD-A has failed and will use RTD-B if available. If RTD-B is not installed or has also failed, the heater will be set to its fail-safe state as selected in this mode. For freeze protection where there is no hazard from overheating, you may select "On" to operate the heater continuously and prevent freeze up.

For processes where there is a potential hazard from overheating, you may select "Off", to de-energize the circuit until one of the RTD's becomes available.

1. Display Mode: Advanced
2. Range: On, Off
3. Default: Off
4. Restrictions: Message does not exist if Maintain Temperature is set to Off.

7.3 Program – System Setup

7.3.1 System Setup

This message displays the name of the sub-menu when entered.

1. Display Mode: Advanced
2. Range: N/A
3. Default: N/A

7.3.2 Password

This selection determines if password protection is required for programming changes. The display will show "disable" if program access is currently enabled and show "enable" if program access is currently disabled.

1. Display Mode: All
2. Range: Enable or Disable
3. Default: Enable

7.3.3 Change Password

This selection allows the user to change the default password. The user is prompt to enter the old password, press [ENTER]. If verified the user is then enter the new password, press [ENTER). The user is prompt to re-enter the new password. By not entering a password and pressing [ENTER], the controller assumes no password.

1. Display Mode: Advance
2. Range: Any combination of 2 to 16 characters 0–9, A–Z.
3. Default: 1234

7.3.4 Units

This selection determines the unit of measure for temperature values. All temperatures are displayed in the selected units of either Celsius degrees (C°) or Fahrenheit degrees (F°).

1. Display Mode: Advance
2. Range: Celsius, Fahrenheit
3. Default: Celsius

7.3.5 Operational Costs

This value sets the cost per kWh of electrical power. This is used to calculate energy costs for operating this control circuit.

1. Display Mode: Advance
2. Range: $0.01 to 1.00
3. Default: $0.05

7.3.6 Display Mode

This selection determines what messages are displayed by the controller for operations personnel. If set to "advanced user." all messages are displayed. If set to "normal user," only the basic messages are displayed. Each message listed throughout this manual shows the Display Mode required to see the message. "Advanced only" indicates that the display mode must be set to "advanced user" to view the message.

1. Display Mode: All
2. Range: Normal, Advance
3. Default: Advance

7.3.7 Default Display

This function specifies the information that will be displayed when no key has been pressed for the Display Timeout interval as described below.

VALUE	INFORMATION DISPLAYED
System status	Alarm status of all the heaters
Heater status	Alarm status of the heater
Heater temp	Temperature of the heater

1. Display Mode: Advance
2. Range: System Status, Heater Status, Heater Temp
3. Default: system status
4. Restrictions: Temperature messages are not displayed if Maintain Temperature is set to Off.

7.3.8 Display Timeout

This function sets the length of time from the last key press, to automatically return to the Default Display information. Selecting "Off' disables this function.

1. Display Mode: Advance
2. Range: 5 to 600 seconds, Off
3. Default: 120 seconds

7.3.9 Modbus Address

This selection sets a unique address to ensure only one CM-2201 attempts communications with the master unit at any time. See Section 8.0 for complete information on Modbus communications.

1. Display Mode: Advance
2. Range: 1 to 255 to accommodate multiple devices on same network.
3. Default: 1

7.3.10 Baud Rate

Sets the communication baud rate for the RS485 serial port. All controllers connected to the same data highway must operate on the same baud rate.

1. Display Mode: Advance
2. Range: 1200, 2400, 4800, 9600, 19200
3. Default: 9600

7.3.11 Reset Module

This selection resets controller memory parameters to factory default values. If the controllers memory becomes corrupt, resetting the module will force the controller to overwrite each register and may correct any problems that exist.

1. Display Mode: Advance
2. Range: yes, no
3. Default: no

7.4 Program - System Test

7.4.1 System Test

This message displays the name of the sub-menu when entered.

1. Display Mode: Advanced
2. Range: N/A
3. Default: N/A

7.4.2 Alarm Output Test

This function is used for testing and commissioning purposes allowing the alarm output to be forced On either for a short period of time or continuously. At the end of the specified time duration, the testing option is automatically disabled. The alarm test function will not operate if the alarm configuration is set to disable and the message "ALARM DISABLED" will appear.

1. Display Mode: Advanced
2. Range: 1-24 hours, Disabled, Continuously
3. Default: disabled

7.4.3 Heater Test

This function overrides heater control for maintenance purposes. For normal operation, set to "disable". If a period of time is selected, the heater is forced On or Off for the selected interval. If "continuous" is selected the heater is forced On or Off until "disable is selected.

1. Display Mode: Advanced
2. Range: 1-24 hours, Disabled, On Continuously
3. Default: disabled

7.4.4 Ground Fault Test

This function will test the ground fault trip function of the controller to ensure proper operation. When selected, the controller will generate an artificial ground fault current; if the ground fault current is sensed as being greater than 30 mA, the test passes. The GF test function will verify actual ground fault current and heater trip. Status of the test will be displayed as pass or fail. If this test has been invoked by the "Now" option and it passes, the user is prompted to reset the ground fault trip, at which time the load is capable of being re-energized as required. If this test has been invoked by the "Autotest" option and it passes, the load is allowed to be reenergized as required. If this test has been invoked by the Autotest cycle and it fails, an Autotest alarm is generated but the load is allowed to be reenergized as required.

1. Display Mode: Advanced
2. Range: Autotest cycle, Now, Disabled
3. Default: Disabled

8.0 Communications

The Nelson Heat Trace CM-2201 supports a subset of the Modbus® RTU protocol format that provides monitoring, programming, and control functions using Read (03) and Write (05-06) register commands.

8.1 General Information

Serial Port:	Select the serial port that corresponds to your RS-485 adapter. USB to Serial adapter may be used for devices without serial connections.
Baud Rate:	User Defined at 1200, 2400, 4800, 9600 or 19200
Data Bits:	8
Stop Bits:	1
Parity:	None
Device Address:	User Defined between 1 and 255

8.2 Modbus Registers

For all Modbus registers, see Appendix D.

9.0 Troubleshooting

9.1 Operator Checks

Upon receipt of the controller, or to check the controller for an indication of normal operation, follow the operational procedures shown below. These procedures are designed to familiarize the operator with the controller and to provide an understanding of its operation.

In order to determine if a fault is associated with the heat tracing, wiring or the controller, it will be necessary to troubleshoot the wiring and tracer circuit. If the fault remains, remove power from the controller and exchange it with another controller. This may require some reprogramming of the new CM2201/CM-2202. Refer to the following sections for the appropriate topic.

9.1.1 RTDs

RTD failures after installation can generally be attributed to incorrect wiring or improper installation of the sensor. Troubleshooting of these failures is a very simple procedure if the proper steps are undertaken in the correct order. Some specific RTD problems and the correct methods for troubleshooting are outlined as follows.

1. RTD Failure Alarm(s)

If the CM2201/CM-2202 controller indicates a failure of an RTD:

a) Ensure that the RTD is a 3-wire 100 (Platinum Type). **TURN THE POWER TO THE CONTROLLER OFF BEFORE PROCEEDING!**
b) Disconnect the RTD wiring from the input terminals.
c) Measure the RTD's resistance between the source (RED) and sense (RED) leads at the controller (it should not exceed 40 Ω). Excessive lead resistance will cause a RTD FAILURE ALARM and must be corrected. Look for loose terminals, excessive lead length, or insufficient wire gauge and correct as necessary.
d) Measures the RTD's resistance between the source (RED) or sense (RED) lead and the common (WHT) lead of the RTD at the controller (should be between 60 and 330 Ω depending on the temperature and the lead resistance. Verify that the RTD is wired correctly—the heat tracing controllers will always be terminated in the order: source (RED), common (WHT), sense (RED). When wiring to the CM2201/CM2202, the terminals are marked as follows:

Terminal No.	Description
GND Bus	Shield
RA	RTD A Source (RED)
WA	RTD A Common (WHT)
RA	RTD A Sense (RED)
GND Bus	Shield
RB	RTD B Source (RED)
WB	RTD B Common (WHT)
RB	RTD B Sense (RED)

The RTD manufacturer will typically color code the leads with the source and sense being the same color, and the common a different color. Ensure that the RTD extension wire shield is terminated at one end only, normally using the terminal block provided at the terminal board.

Note: Some manufacturers use the common Black-White-Red triad color code for the RTD connections. Usually, the RED lead is the common connection (same as the White-White-Red color scheme) and the White and Black connections may be used interchangeably.

2. Temperature Verification

If you consider that the indicated or displayed temperature is not correct, the controller and the RTD can be quickly checked for correct operation. To verify the RTD:
TURN THE POWER TO THE CONTROLLER OFF BEFORE PROCEEDING!

a) Disconnect the RTD wiring from the input terminals.
b) To calculate the temperature indicated by the RTD, measure the resistance from source (red wire) or sense (red wire) to common (white wire) and subtract the resistance measured between source and sense. This will give a compensated resistance value that can be cross-referenced to one of the RTD tables found in Appendix E or Appendix F. Compare the measured resistance and cross-referenced temperature value obtained from the RTD table to the indicated or displayed value. These should agree to within the accuracy standards of the CM2201/CM2202 and the RTD.

Note: Ensure you refer to the correct RTD table for the type of RTD you are using.

2. Temperature Verification (Continued)

To verify the Controller:

TURN THE POWER TO THE CONTROLLER OFF BEFORE PROCEEDING!

a) Disconnect the RTD wiring from the input terminals.
b) Connect a 100 Ω resistor across the source or sense terminal and common. Insert a jumper between the source and sense terminals.
c) Apply power to the controller. The indicated or displayed temperature should be about 32°F (0°C) depending on the actual resistance of the test resistor if RTD TYPE is set to 100 Ω Platinum. Any resistor may have a +/- 10% tolerance.

3. Unstable Temperature

An erratic indication of temperature can be caused by several factors external to the controller. The controller's accuracy and resolution will result in an indicated temperature change of a couple of degrees if the measured resistance temperature falls between two discrete values (this is sometimes referred to as quantization error).

If the instability is excessive, check:

a) Wire used for extension of the RTD should be three-wire, twisted and shielded with the shield grounded at the controller only. Each of the three lead wires must be of the same gauge.
b) The ideal installation has a separate conduit for the RTD leads (if they have been extended). It is not usually a problem to run low signal levels in the same conduit as the power leads even in high power applications, as long as the RTD wire is a twisted, shielded type with an insulation rating equal to or greater than the highest voltage in the conduit. Follow the proper Electrical Code requirements for your particular installation.
c) Check the specifications for the particular cable being used to ensure that it does not have excessive capacitance when used in long lengths. This can cause a temperature offset between what the controller reads and what the RTD actually measures. This again is normally not a problem since the controller compensates for all but the worst cases of this.

3. Unstable Temperature (Continued)

d) Check one by one if the all RTD leads are connected to the connector.
e) Lastly, it is possible for the RTD itself to fail on an intermittent basis but this failure mode should be considered unusual. This kind of failure is probably the most difficult to find but fortunately it is also the least likely as a failure mechanism.

9.2 Ground Fault

Ground fault warning / alarms can be caused by incorrect installation as well as current leakage resulting from wet system components or damaged cables.

The CM2201/CM2202 Controller detects ground faults by summing the outgoing and return trace currents through an internal current transformer. Under normal operating conditions (no ground fault condition) this current will be zero. When there is a flow of current from one of the trace supply wires to ground, a ground fault condition occurs.

If a ground fault alarm is present on start-up of a new installation it is likely due to a wiring error or damaged cable. To verify this condition:

a) Check that the heating circuit neutrals return to the controller and are not connected directly to the distribution panel. This can be a common problem if the installation is a retrofit situation.
b) On paralleled circuits, be certain that ALL neutrals return. The late addition of a circuit may not be obvious.

Note: The controller monitors the integrity of the ground fault (GF) detection. If a fault is detected, the controller will generate a GFI warning / alarm depend of the settings.

9.3 Common Warnings/Alarms - What to Look for

The CM-2201/CM-2202 has a wide range of warning and alarming features that may be selectively enabled or disabled to allow the monitoring and indication of trouble conditions. Described below are the different warming and alarm conditions available on the CM-2201/CM-2202, their meanings, and possible causes. The warning settings must be below alarm settings. If an alarm will be activated the two SSR low power will be activated.

9.3.1 High RTD A/ RTD B Temperature Reading

This warning/alarm appear when the temperature exceeds the HIGH RTD WARNING/ALARM temperature setting.

Cause of Warning/Alarm:
- Warning/Alarm temperature setting too close to maintain temperature
- Flow of hot product
- Steaming out lines
- Incorrect tracer wiring

9.3.2 Low RTD A/ RTD B Temperature Reading

This warning/alarm appears when the temperature decreases below the LOW RTD WARNING/ALARM temperature setting.

Cause of Warning/Alarm:
- Warning/Alarm temperature setting too close to maintain temperature
- Flow of cold product
- Empty pipe
- Damaged, wet, or missing insulation
- Heating cable not sized properly for the application

9.3.3 RTD A/ RTD B Failure

This alarm indicates a sensor is not operating properly. The temperature sensor may fail due to an "open" or "shorted" condition.

Cause of Alarm:
- Incorrect or damaged field wiring - open leads or excess resistance (either intermittent or continuous) may be due to broken or damaged wires or loose terminals.
- Damaged or inoperative temperature sensors

9.3.4 High Current Warning/Alarm

This Warning/alarms current levels that are greater than the HIGH CURRENT WARNING/ALARM setting for the application.

9.3.4 High Current Warning/Alarm (Continued)

Cause of Warning/Alarm:
- Warning/Alarm setting too close to normal operating current
- High in-rush current from "cold start" of self regulating cable
- Damaged or partially shorted heating cable
- "As built" cable length is greater than design value

9.3.5 Low Current Warning/Alarm

This alarms current levels which are less than the LOW CURRENT WARNING/ALARM setting.

Cause of Warnings/Alarm:
- Warning/Alarm setting too close to normal operating current
- Low source voltage
- Damaged or inoperative heating cable
- Open connection—wiring problem
- SSR or contactor failed open

9.3.6 High GFI Warning

This warning ground fault current levels which are greater than the HIGH GFI WARNING setting.

Cause of Warning:
- Warning setting too close to normal leakage current
- Damaged cable insulation and/or moisture present
- Moisture in junction box
- Poor splice or termination
- Moisture provides conductive ground path which allows ground fault current

9.3.7 GFI Alarm

This value sets the upper limit of allowable ground fault leakage. Exceeding this limit will result in the output switch being latched off and the alarm activated to indicate a ground fault condition.

9.3.7 GFI Alarm (Continued)

Cause of Alarm:
- Trip setting too close to normal leakage current
- Damaged cable insulation and/or moisture present
- Moisture in junction box
- Poor splice or termination
- Moisture provides conductive ground path which allows ground fault current

9.3.8 High Voltage Warning/Alarm

This warning/alarms voltage levels that are greater than the HIGH VOLTAGE WARNING/ALARM setting.

Cause of Warning/Alarm:
- Warning/Alarm setting too close to normal operating voltage
- Incorrect wiring
- Power surge

9.3.9 Low Voltage Warning/Alarm

This warning/alarms voltage levels are less than the LOW VOLTAGE WARNING/ALARM setting.

Cause of Warning/Alarm:
- Warning/Alarm setting too close to normal operating voltage
- Damaged power cable
- Incorrect VOLTAGE TURNS RATIO
- "Brown-out" conditions
- Loss of power to the circuit

9.3.10 Overcurrent Trip

If the controller is unable to start the cable due to high current or after attempting to soft start it, the controller will trip its output switch off.

Cause of Alarm:
- Excessive in-rush current
- Incorrect CM-2201/CM2202 settings
- Incorrect wiring
- Damaged cable

9.3.11 Switch Failure

This alarm indicates that the controller senses current flow when the output switch should be off.

Cause of Alarm
- Some other device energized heat trace
- Output switch has failed "closed"

9.3.12 Power Limiting (Current Limiting)

This alarm indicates that the solid state relay is limiting the average amount of power that is applied to the trace circuit as defined by the MAXIMUM POWER setting.

Cause of Alarm:
- Power applied to trace circuit is being limited to the MAXIMUM POWER setting

9.3.13 EEPROM Data Failure

This alarm indicates that the controller has detected a failure in its non-volatile memory (this is where all of the controller's configuration and calibration settings are stored). This indicates an internal problem and the CM2201/CM2202 should be replaced and returned to the factory for repair.

Cause of Alarm:
- The CM-2201/CM2202 cannot bypass the failed area of its memory and has loaded factory defaults into this failed area.

10.0 Maintenance

The CM-2201/CM-2202 should be regularly maintained as follows:

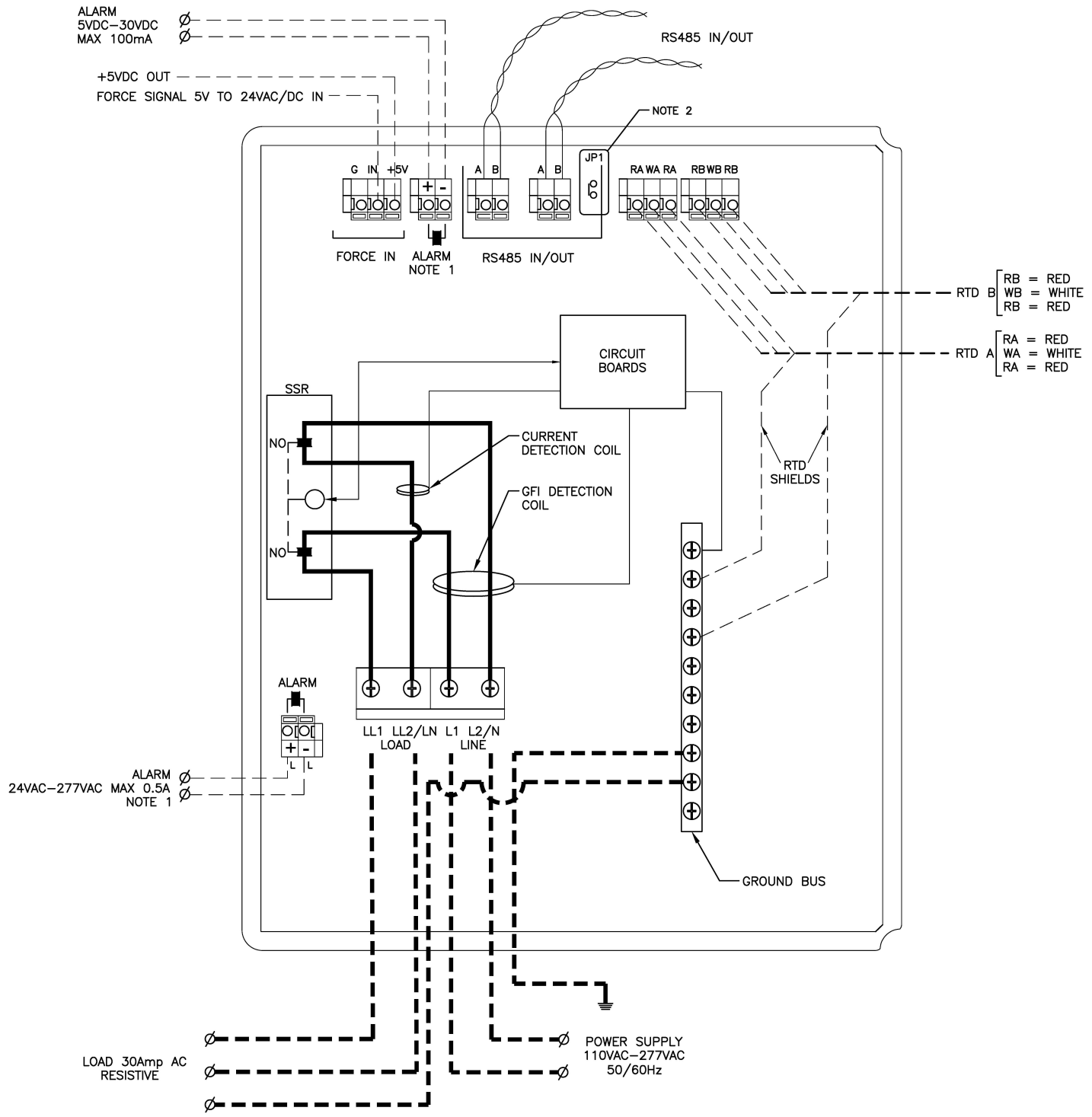
a) Check fit of door gasket and adjust as required. Clean door gasket.
b) Verify that moisture is not entering enclosure; repair as required.
c) Check terminals to ensure connections are secure.
d) Check wiring for any signs of overheating.
e) Clean front panel with mild soap on damp cloth.

Do not use any cloth from synthetic material or similar. On the cleaning process the front label may charge electrostatic and by touching the front panel may generate sparks.

Appendix A – Specifications

Model:	CM-2201/CM-2202
Rating:	110–277Vac, 30Amps (Solid State Relays)
Maximum Current:	30 Amps per Channel
Frequency:	50 or 60 Hz
Switching:	Solid State Relay (DPST) Normally Open (NO)
Enclosure:	NEMA 4X
Alarm Outputs:	1. 24 VAC to 277 VAC @ Max. 0.5 Amps (Solid State Relay - requires Min. 100mA load) 2. 30VDC @ Max. 0.1 Amps (Solid State Relay - requires Min. 50mA load)
Agency Approval for Hazardous Locations:	cCSAus Class1, DIV.2, Groups A, B, C, D Class 1, Zone 2: IIC
Temperature Code:	T4 (135 °C)

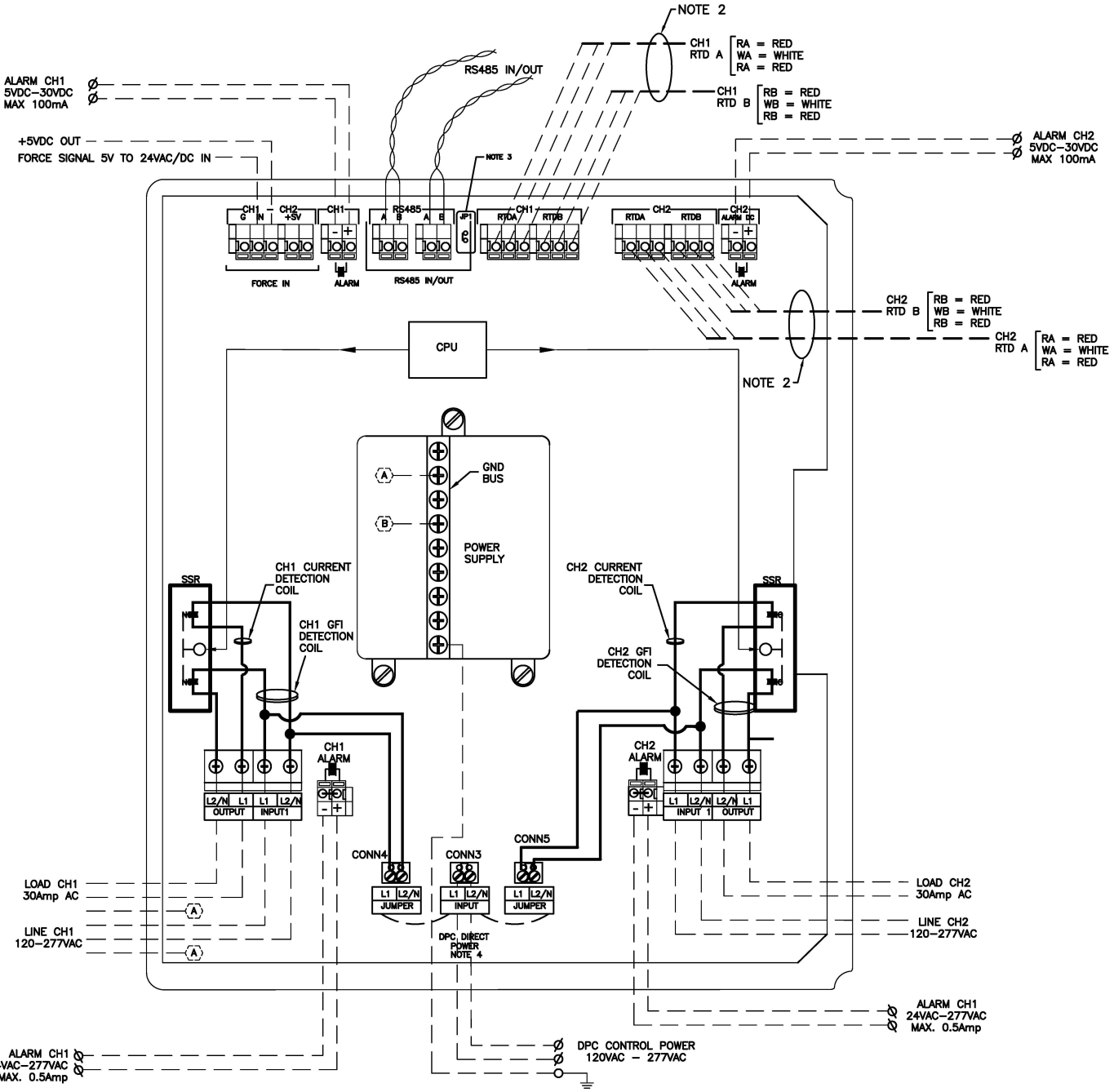
Appendix B - Wiring Diagram: CM-2201



Notes:

1. Solid State Contact
2. Install Jumper at JP1 (120 OHM Resistor) on both terminals if CM-2201 is last device on network. Else install jumper on one terminal only of JP1.
3. If "Force " feature is activated by external "dry contact", use "+5V" and "IN" terminals; Ground connection is not required. If activated by external voltage signal, use "IN" and "G" (Ground) terminals as noted.

Appendix B - Wiring Diagram: CM-2202

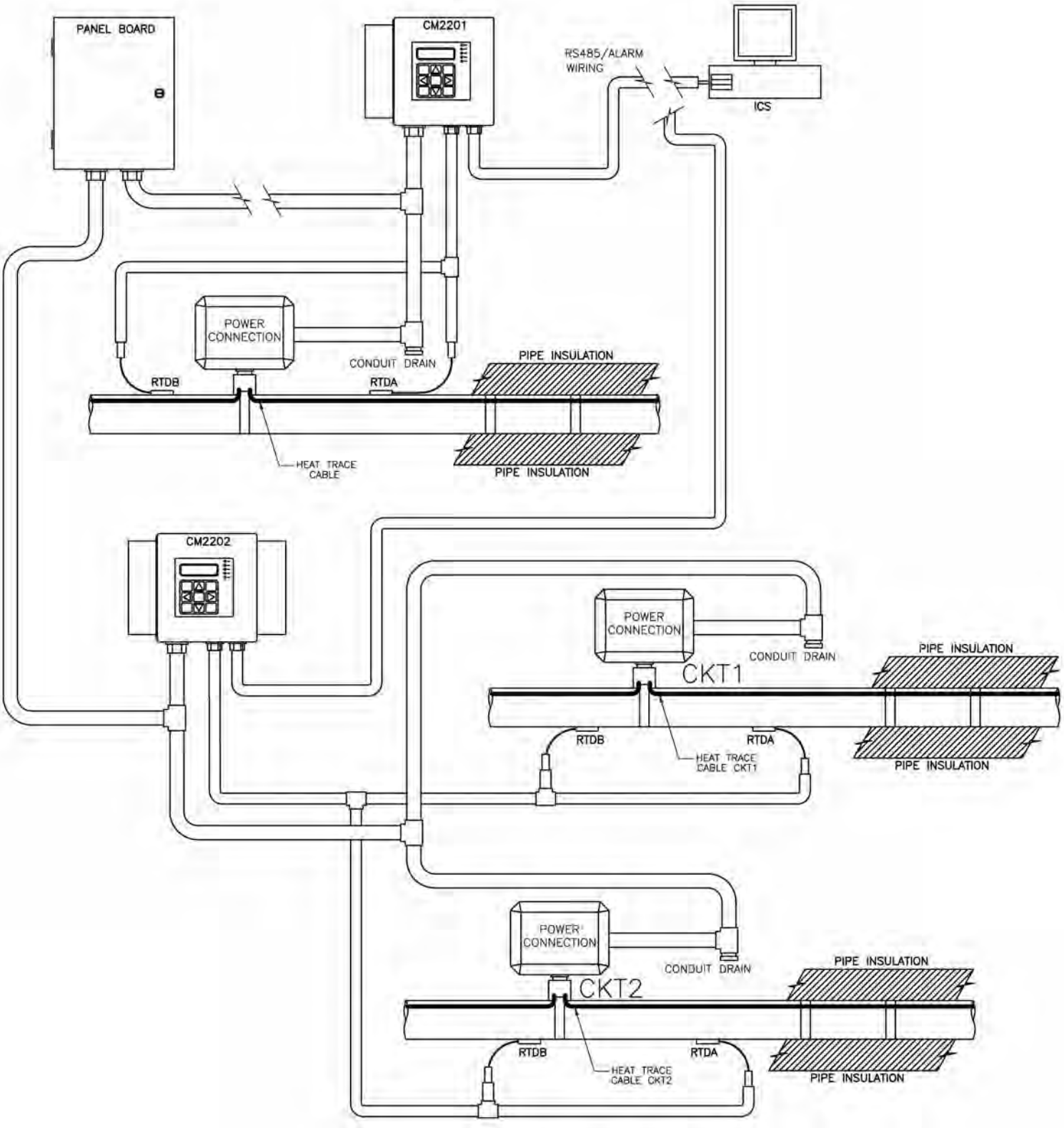


Notes:

1. All Alarms Output are SSR N.O.
2. All RTD's must have the Shield connected to Ground Bus.
3. Remove Jumper JP1 only if the controller is in RS485 Network AND is not the last unit on the Network.
4. Connect Power Supply Jumpers PJ1 & PJ2 as follows;

CONTROL POWER SOURCE	PJ1 (L1 - CONN3)	PJ2 (L2/N - CONN3)
INDEPENDENT	NO CONNECTION	
CH.1	L1 - CONN4	L2/N - CONN4
CH.2	L1 - CONN5	L2/N - CONN5

Appendix C - Typical Installation Diagram



Appendix D

D.1 Module Setup Group (Read/Write) Addresses for SPC and DPC				
Note: Shaded items are unique to DPC				
Modbus Register	Index Value	Length Bytes	Variable Name	Description/Value Range
40001	0	2	Maintain Temp in °F	= x per 1°F (-58 to +932) = 32766 if Set to None = 32767 if Set to Off
40002	1	2	Maintain Temp in °C	= x per 1°C (-50 to +500) = 32766 if Set to None = 32767 if Set to Off
40003	2	2	Low Temp Alarm in °F	= x per 1°F (-58 to +932) = 32767 if Set to Off
40004	3	2	Low Temp Alarm in °C	= x per 1°C (-50 to +500) = 32767 if Set to Off
40005	4	2	High Temp Alarm in °F	= x per 1°F (-58 to +932) = 32767 if Set to Off
40006	5	2	High Temp Alarm in °C	= x per 1°C (-50 to +500) = 32767 if Set to Off
40007	6	2	Deadband in °F	= x per 1°F (1 to 10)
40008	7	2	Deadband in °C	= x per 1°C (1 to 5)
40009	8	2	Low Current Alarm	= x per 0.1A (1 to 300) = 32767 if Set to Off
40010	9	2	High Current Alarm	= x per 0.1A (1 to 300) = 32767 if Set to Off
40011	10	2	Ground Fault Alarm	= x per 1mA (10 to 500) = 32767 if Set to Off
40012	11	2	Ground Fault Trip	= x per 1mA (10 to 500) = 32767 if Set to Off
40013	12	2	Low Voltage Alarm	= x per 1V (85 to 280) = 32767 if Set to Off
40014	13	2	High Voltage Alarm	= x per 1V (85 to 280) = 32767 if Set to Off
40015	14	2	Power Control	= x per 10% (1 to 10) = 32767 if Set to Off
40016	15	2	SoftStart	= x per 1 Second (10 to 999) = 32767 if Set to Off
40017	16	2	Auto Test Time	= x per 1 Hour (1 to 720) = 32767 if Set to Off

40018	17	2	Display Time	= x per 1 Second (5 to 600) = 32767 if Set to Off
40019	18	2	Cost per kwh	= x per $0.01 (1 to 100)
40020	19	2	Reserved	
40021	20	2	Reserved	
40022	21	2	Reserved	
40023	22	2	Alarm Test	= x per 1 Hour (1 to 24) = 32764 if Set to Disable =32765 if Set to Continuously
40024	23	2	Heater Test	= x per 1 Hour (1 to 24) = 32764 if Set to Disable =32765 if Set to Continuously
40025	24	2	Reserved	
40026	25	16	Heater Name	
40043	42	4	Heater Settings	b0:Units 0 = Fahrenheit 1 = Celsius b1:Enable Heater 0 = No 1 = Yes b2:Manual Override 0 = Off 1 = On b3:Control Type 0 = On/Off 1 = Proportional b4-b6:RTD Operation 000 = Single RTD Mode 001 = Backup 010 = Average 011 = Lowest 100 = Highest 101 = High Temp Cutout b7:RTD Failure Mode 0 = Off 1 = On b8:Enable Password 0 = Disable 1 = Enable b9:Display Mode 0 = Normal 1 = Advanced b10-b11:Default Display 00 = System Status 01 = Heater Status

				10 = Heater Temp b12-b14:Baud Rate 000 = 1200 bps 001 = 2400 bps 010 = 4800 bps 011 = 9600 bps 100 = 19200 bps b15-b16:GF Test 00 = Auto Test Cycle 01 = Now 10 = Disable b17:Heater Type 0 = Fixed Resistance 1 = Self-Regulating
				b18:Enable Heater (ch2) 0 = No 1 = Yes b19:Manual Override (ch2) 0 = Off 1 = On b20:Control Type (ch2) 0 = On/Off 1 = Proportional b21-b23:RTD Operation (ch2) 000 = Single RTD Mode 001 = Backup 010 = Average 011 = Lowest 100 = Highest 101 = High Temp Cutout b24:RTD Failure Mode (ch2) 0 = Off 1 = On b25-b26:GF Test (ch2) 00 = Auto Test Cycle 01 = Now 10 = Disable b27:Heater Type (ch2) 0 = Fixed Resistance 1 = Self-Regulating
40091	119	2	Maintain Temp in °F (ch2)	= x per 1°F (-58 to +932) = 32766 if Set to None = 32767 if Set to Off

40092	120	2	Maintain Temp in °C (ch2)	= x per 1°C (-50 to +500) = 32766 if Set to None = 32767 if Set to Off
40093	121	2	Low Temp Alarm in °F (ch2)	= x per 1°F (-58 to +932) = 32767 if Set to Off
40094	122	2	Low Temp Alarm in °C (ch2)	= x per 1°C (-50 to +500) = 32767 if Set to Off
40095	123	2	High Temp Alarm in °F (ch2)	= x per 1°F (-58 to +932) = 32767 if Set to Off
40096	124	2	High Temp Alarm in °C (ch2)	= x per 1°C (-50 to +500) = 32767 if Set to Off
40097	125	2	Deadband in °F (ch2)	= x per 1°F (1 to 10)
40098	126	2	Deadband in °C (ch2)	= x per 1°C (1 to 5)
40099	127	2	Low Current Alarm (ch2)	= x per 0.1A (1 to 300) = 32767 if Set to Off
40100	128	2	High Current Alarm (ch2)	= x per 0.1A (1 to 300) = 32767 if Set to Off
40111	129	2	Ground Fault Alarm (ch2)	= x per 1mA (10 to 500) = 32767 if Set to Off
40112	130	2	Ground Fault Trip (ch2)	= x per 1mA (10 to 500) = 32767 if Set to Off
40113	131	2	Low Voltage Alarm (ch2)	= x per 1V (85 to 280) = 32767 if Set to Off
40114	132	2	High Voltage Alarm (ch2)	= x per 1V (85 to 280) = 32767 if Set to Off
40115	133	2	Power Control (ch2)	= x per 10% (1 to 10) = 32767 if Set to Off
40116	134	2	SoftStart (ch2)	= x per 1 Second (10 to 999) = 32767 if Set to Off
40117	135	2	Auto Test Time (ch2)	= x per 1 Hour (1 to 720) = 32767 if Set to Off
40118	136	2	Display Time	= x per 1 Second (5 to 600) = 32767 if Set to Off
40119	137	2	Cost per kwh	= x per $0.01 (1 to 100)
40120	138	2	Reserved	
40121	139	2	Reserved	
40122	140	2	Reserved	
40123	141	2	Alarm Test (ch2)	= x per 1 Hour (1 to 24) = 32764 if Set to Disable =32765 if Set to Continuously

40124	142	2	Heater Test (ch2)	= x per 1 Hour (1 to 24) = 32764 if Set to Disable =32765 if Set to Continuously
40125	143	2	Reserved	
40126	144	16	Heater Name (ch2)	

D.2 Module Monitoring Group (Read Only)				
40045	44	2	System Temp in °F	= x per °F = 32765 if RTD Open = 32767 if RTD Shorted
40046	45	2	System Temp in °C	= x per °C = 32765 if RTD Open = 32767 if RTD Shorted
40047	46	2	Low Temp Alarm in °F	= x per °F = 32765 if RTD Open = 32767 if RTD Shorted
40048	47	2	Low Temp Alarm in °C	= x per °C = 32765 if RTD Open = 32767 if RTD Shorted
40049	48	2	High Temp Alarm in °F	= x per °F = 32765 if RTD Open = 32767 if RTD Shorted
40050	49	2	High Temp Alarm in °C	= x per °C = 32765 if RTD Open = 32767 if RTD Shorted
40051	50	2	Heater Power	= x per 10%
40052	51	2	Reserved	
40053	52	2	Current	= x per 0.1A = 32766 as Out of Range
40054	53	2	GF Current	
40055	54	2	Voltage	= x per 1V = 32766 as Out of Range
40056	55	2	Heater status	= 1 on = 0 off
40057	56	2	Max Temp in °F	= x per °F = 32765 if RTD Open = 32767 if RTD Shorted
40058	57	2	Max Temp in °C	= x per °C = 32765 if RTD Open = 32767 if RTD Shorted
40059	58	2	Min Temp in °F	= x per °F = 32765 if RTD Open

				= 32767 if RTD Shorted
D.2 Module Monitoring Group (Read Only) Continued				
40060	59	2	Min Temp in °C	= x per E256°C = 32765 if RTD Open = 32767 if RTD Shorted
40061	60	2	Max Current	= x per 0.1A = 32766 as Out of Range
40062	61	2	Max GF Current	= x per 1mA = 32766 as Out of Range
40063	62	2	Max Volt	= x per 1V = 32766 as Out of Range
40064	63	2	Min Volt	= x per 1V = 32766 as Out of Range
40065	64	2	Energy	= x per 1MWh = 32766 as Out of Range
40066	65	4	Cost	= x per $0.01 = 0x7FFFFFFF as Out of Range
40067	66	2		
40068	67	4	Heater On Time	= x per 1 Hour = 1500000 as Out of Range
40069	68	0		
40070	69	2	Heater on %	= x per 1%
40071	70	2	Alarm Stack 01	0 = No Alarm 1 = Low Temp Alarm 2 = High Temp Alarm 4 = Low Current Alarm 8 = High Current Alarm 16 = GF Alarm 32 = GF Trip 64 = Low Voltage Alarm 128 = High Voltage Alarm 256 = Auto Test Alarm 512 = Continuity Failure Alarm 1024 = SSR Failed Shorted Alarm 2048 = RTD-A Open Alarm 4096 = RTD-A Shorted Alarm 8192 = RTD-B Open Alarm 16384 = RTD-B Shorted Alarm 32768 = Self Check Failure
40072	71	2	Alarm Stack 02	
40073	72	2	Alarm Stack 03	
40074	73	2	Alarm Stack 04	
40075	74	2	Alarm Stack 05	
40076	75	2	Alarm Stack 06	
40077	76	2	Alarm Stack 07	
40078	77	2	Alarm Stack 08	
40079	78	2	Alarm Stack 09	
40080	79	2	Alarm Stack 10	
40081	80	2	Alarm Stack 11	
40082	81	2	Alarm Stack 12	
40083	82	2	Alarm Stack 13	
40084	83	2	Alarm Stack 14	
40085	84	2	Alarm Stack 15	
40086	85	2	Alarm Stack 16	
40087	86	2	Alarm Stack 17	
40088	87	2	Alarm Stack 18	
40089	88	2	Alarm Stack 19	
40090	89	2	Alarm Stack 20	

40127	145	2	System Temp in °F (ch2)	= x per °F = 32765 if RTD Open = 32767 if RTD Shorted
40128	146	2	System Temp in °C (ch2)	= x per °C = 32765 if RTD Open = 32767 if RTD Shorted
40129	147	2	Low Temp Alarm in °F (ch2)	= x per °F = 32765 if RTD Open = 32767 if RTD Shorted
40130	148	2	Low Temp Alarm in °C (ch2)	= x per °C = 32765 if RTD Open = 32767 if RTD Shorted
40131	149	2	High Temp Alarm in °F (ch2)	= x per °F = 32765 if RTD Open = 32767 if RTD Shorted
40132	150	2	High Temp Alarm in °C (ch2)	= x per °C = 32765 if RTD Open = 32767 if RTD Shorted
40133	151	2	Heater Power (ch2)	= x per 10%
40134	152	2	Current (ch2)	= x per 0.1A = 32766 as Out of Range
40135	153	2	GF Current (ch2)	
40136	154	2	Voltage (ch2)	= x per 1V = 32766 as Out of Range
40137	155	1	Heater status (ch2)	= 1 on = 0 off
40138	160	2	Max Temp in °F (ch2)	= x per °F = 32765 if RTD Open = 32767 if RTD Shorted
40139	161	2	Max Temp in °C (ch2)	= x per °C = 32765 if RTD Open = 32767 if RTD Shorted
40140	162	2	Min Temp in °F (ch2)	= x per °F = 32765 if RTD Open = 32767 if RTD Shorted
40141	163	2	Min Temp in °C (ch2)	= x per °C = 32765 if RTD Open = 32767 if RTD Shorted
40142	164	2	Max Current (ch2)	= x per 0.1A = 32766 as Out of Range

40143	165	2	Max GF Current (ch2)	= x per 1mA = 32766 as Out of Range
40144	166	2	Max Volt (ch2)	= x per 1V = 32766 as Out of Range
40145	167	2	Min Volt (ch2)	= x per 1V = 32766 as Out of Range
40146	168	2	Energy (ch2)	= x per 1MWh = 32766 as Out of Range
40147	169	4	Cost (ch2)	= x per $0.01 = 0x7FFFFFFF as Out of Range
40148	171	4	Heater On Time (ch2)	= x per 1 Hour = 1500000 as Out of Range
40149	173	2	Heater on % (ch2)	= x per 1%
40150	174	2	Alarm Stack 01 (ch2)	0 = No Alarm 1 = Low Temp Alarm 2 = High Temp Alarm 4 = Low Current Alarm 8 = High Current Alarm 16 = GF Alarm 32 = GF Trip 64 = Low Voltage Alarm 128 = High Voltage Alarm 256 = Auto Test Alarm 512 = Continuity Failure Alarm 1024 = SSR Failed Shorted Alarm 2048 = RTD-A Open Alarm 4096 = RTD-A Shorted Alarm 8192 = RTD-B Open Alarm 16384 = RTD-B Shorted Alarm 32768 = Self Check Failure
40151	175	2	Alarm Stack 02 (ch2)	
40152	176	2	Alarm Stack 03 (ch2)	
40153	177	2	Alarm Stack 04 (ch2)	
40154	178	2	Alarm Stack 05 (ch2)	
40155	179	2	Alarm Stack 06 (ch2)	
40156	180	2	Alarm Stack 07 (ch2)	
40157	181	2	Alarm Stack 08 (ch2)	
40158	182	2	Alarm Stack 09 (ch2)	
40159	183	2	Alarm Stack 10 (ch2)	
40160	184	2	Alarm Stack 11 (ch2)	
40161	185	2	Alarm Stack 12 (ch2)	
40162	186	2	Alarm Stack 13 (ch2)	

40163	187	2	Alarm Stack 14 (ch2)	
40164	188	2	Alarm Stack 15 (ch2)	
40165	189	2	Alarm Stack 16 (ch2)	
40166	190	2	Alarm Stack 17 (ch2)	
40167	191	2	Alarm Stack 18 (ch2)	
40168	192	2	Alarm Stack 19 (ch2)	
40169	193	2	Alarm Stack 20 (ch2)	
D.3 Module Reset Group (Write Only)				
00092	91	2	Acknowledge All	= Set to 1 to Reset
00093	92	2	Reset Max Temp	= Set to 1 to Reset
00094	93	2	Reset Min Temp	= Set to 1 to Reset
00095	94	2	Reset Max Current	= Set to 1 to Reset
00096	95	2	Reset Max GF	= Set to 1 to Reset
00097	96	2	Reset Max Voltage	= Set to 1 to Reset
00098	97	2	Reset Min Voltage	= Set to 1 to Reset
00099	98	2	Reset Energy	= Set to 1 to Reset
00100	99	2	Reset Cost	= Set to 1 to Reset
00101	100	2	Reset Heater On Time (Hours)	= Set to 1 to Reset
00102	101	2	Reset Heater On Percentage	= Set to 1 to Reset
00103	102	2	Reset Statistics	= Set to 1 to Reset
00104	103	2	Reset Low Temp	= Set to 1 to Reset
00105	104	2	Reset High Temp	= Set to 1 to Reset
00106	105	2	Reset Low Current	= Set to 1 to Reset
00107	106	2	Reset High Current	= Set to 1 to Reset
00108	107	2	Reset GF	= Set to 1 to Reset
00109	108	2	Reset GF Trip	= Set to 1 to Reset
00110	109	2	Reset Low Voltage	= Set to 1 to Reset
00111	110	2	Reset High Voltage	= Set to 1 to Reset
00112	111	2	Reset Auto Test	= Set to 1 to Reset
00113	112	2	Reset Continuity Failure	= Set to 1 to Reset
00114	113	2	Reset SSR Shorted	= Set to 1 to Reset
00115	114	2	Reset RTD-A Open	= Set to 1 to Reset
00116	115	2	Reset RTD-A Shorted	= Set to 1 to Reset

00117	116	2	Reset RTD-B Open	= Set to 1 to Reset
00118	117	2	Reset RTD-B Open	= Set to 1 to Reset
00119	118	2	Reset Self-Check Failure	= Set to 1 to Reset
00120	200	2	Acknowledge All (ch2)	= Set to 1 to Reset
00121	201	2	Reset Max Temp (ch2)	= Set to 1 to Reset
00122	202	2	Reset Min Temp (ch2)	= Set to 1 to Reset
00123	203	2	Reset Max Current (ch2)	= Set to 1 to Reset
00124	204	2	Reset Max GF (ch2)	= Set to 1 to Reset
00125	205	2	Reset Max Voltage (ch2)	= Set to 1 to Reset
00126	206	2	Reset Min Voltage (ch2)	= Set to 1 to Reset
00127	207	2	Reset Energy (ch2)	= Set to 1 to Reset
00128	208	2	Reset Cost (ch2)	= Set to 1 to Reset
00129	209	2	Reset Heater On Time (Hours) (ch2)	= Set to 1 to Reset
00130	210	2	Reset Heater On Percentage (ch2)	= Set to 1 to Reset
00131	211	2	Reset Statistics (ch2)	= Set to 1 to Reset
00132	212	2	Reset Low Temp (ch2)	= Set to 1 to Reset
00133	213	2	Reset High Temp (ch2)	= Set to 1 to Reset
00134	214	2	Reset Low Current (ch2)	= Set to 1 to Reset
00135	215	2	Reset High Current (ch2)	= Set to 1 to Reset
00136	216	2	Reset GF (ch2)	= Set to 1 to Reset
00137	217	2	Reset GF Trip (ch2)	= Set to 1 to Reset
00138	218	2	Reset Low Voltage (ch2)	= Set to 1 to Reset

00139	219	2	Reset High Voltage (ch2)	= Set to 1 to Reset
00140	220	2	Reset Auto Test (ch2)	= Set to 1 to Reset
00141	221	2	Reset Continuity Failure (ch2)	= Set to 1 to Reset
00142	222	2	Reset SSR Shorted (ch2)	= Set to 1 to Reset
00143	223	2	Reset RTD-A Open (ch2)	= Set to 1 to Reset
00144	224	2	Reset RTD-A Shorted (ch2)	= Set to 1 to Reset
00145	225	2	Reset RTD-B Open (ch2)	= Set to 1 to Reset
00146	226	2	Reset RTD-B Open (ch2)	= Set to 1 to Reset
00147	227	2	Reset Self-Check Failure (ch2)	= Set to 1 to Reset

Appendix E - RTD Tables

Temperature Conversion
Platinum Resistance (-200°C to 239°C)
Temperature Coefficient - 0.00385 Ohms/Ohm/OC

°C	Ohms	°C	Ohms	C	Ohms	°C	Ohms	°C	Ohms	°C	Ohms
-200	18.49	-137	45.11	-74	70.73	-11	95.69	51	119.78	114	143.80
-199	18.93	-136	45.52	-73	71.13			52	120.16	115	144.17
-198	19.36	-135	45.94	-72	71.53	-10	96.09	53	120.55	116	144.55
-197	19.79	-134	46.35	-71	71.93	-9	96.48	54	120.93	117	144.93
-196	20.22	-133	46.76			-8	96.87	55	121.32	118	145.31
-195	20.65	-132	47.18	-70	72.33	-7	97.26	56	121.70	119	145.68
-194	21.08	-131	47.59	-69	72.73	-6	97.65	57	122.09		
-193	21.51			-68	73.13	-5	98.04	58	122.47	120	146.06
-192	21.94	-130	48.00	-67	73.53	-4	98.44	59	122.86	121	146.44
-191	22.37	-129	48.41	-66	73.93	-3	98.83			122	146.81
		-128	48.82	-65	74.33	-2	99.22	60	123.24	123	147.19
-190	22.80	-127	49.23	-64	74.73	-1	99.61	61	123.62	124	147.57
-189	23.23	-126	49.64	-63	75.13			62	124.01	125	147.94
-188	23.66	-125	50.06	-62	75.53	0	100.00	63	124.39	126	148.32
-187	24.09	-124	50.47	-61	75.93	1	100.39	64	124.77	127	148.70
-186	24.52	-123	50.88			2	100.78	65	125.16	128	149.07
-185	24.94	-122	51.29	-60	76.33	3	101.17	66	125.54	129	149.45
-184	25.37	-121	51.70	-59	76.73	4	101.56	67	125.92		
-183	25.80			-58	77.13	5	101.95	68	126.31	130	149.82
-182	26.23	-120	52.11	-57	77.52	6	102.34	69	126.69	131	150.20
-181	26.65	-119	52.52	-56	77.92	7	102.73			132	150.57
		-118	52.92	-55	78.32	8	103.12	70	127.07	133	150.95
-180	27.08	-117	53.33	-54	78.72	9	103.51	71	127.45	134	151.33
-179	27.50	-116	53.74	-53	79.11			72	127.84	135	151.70
-178	27.93	-115	54.15	-52	79.51	10	103.90	73	128.22	136	152.08
-177	28.35	-114	54.56	-51	79.91	11	104.29	74	128.60	137	152.45
-176	28.78	-113	54.97			12	104.68	75	128.98	138	152.83
-175	29.20	-112	55.38	-50	80.31	13	105.07	76	129.37	139	153.20
-174	29.63	-111	55.78	-49	80.70	14	105.46	77	129.75		
-173	30.05			-48	81.10	15	105.85	78	130.13	140	153.58
-172	30.47	-110	56.19	-47	81.50	16	106.24	79	130.51	141	153.95
-171	30.90	-109	56.60	-46	81.89	17	106.63			142	154.32
		-108	57.00	-45	82.29	18	107.02	80	130.89	143	154.70
-170	31.32	-107	57.41	-44	82.69	19	107.40	81	131.27	144	155.07
-169	31.74	-106	57.82	-43	83.08			82	131.66	145	155.45
-168	32.16	-105	58.22	-42	83.48	20	107.79	83	132.04	146	155.82
-167	32.59	-104	58.63	-41	83.88	21	108.18	84	132.42	147	156.19
-166	33.01	-103	59.04			22	108.57	85	132.80	148	156.57
-165	33.43	-102	59.44	-40	84.27	23	108.96	86	133.18	149	156.94
-164	33.85	-101	59.85	-39	84.67	24	109.35	87	133.56		

Appendix E - RTD Tables

Temperature Conversion
Platinum Resistance (-200°C to 239°C)
Temperature Coefficient - 0.00385 Ohms/Ohm/OC

-163	34.27			-38	85.06	25	109.73	88	133.94	150	157.31
-162	34.69	-100	60.25	-37	85.46	26	110.12	89	134.32	151	157.69
-161	35.11	-99	60.66	-36	85.85	27	110.51			152	158.06
		-98	61.06	-35	86.25	28	110.90	90	134.70	153	158.43
-160	35.53	-97	61.47	-34	86.64	29	111.28	91	135.08	154	158.81
-159	35.95	-96	61.87	-33	87.04			92	135.46	155	159.18
-158	36.37	-95	62.28	-32	87.43	30	111.67	93	135.84	156	159.55
-157	36.79	-94	62.68	-31	87.83	31	112.06	94	136.22	157	159.93
-156	37.21	-93	63.09			32	112.45	95	136.60	158	160.30
-155	37.63	-92	63.49	-30	88.22	33	112.83	96	136.98	159	160.67
-154	38.04	-91	63.90	-29	88.62	34	113.22	97	137.36		
-153	38.46			-28	89.01	35	113.61	98	137.74	160	161.04
-152	38.88	90	64.30	-27	89.40	36	113.99	99	138.12	161	161.42
-151	39.30	-89	64.70	-26	89.80	37	114.38			162	161.79
		-88	65.11	-25	90.19	38	114.77	100	138.50	163	162.16
-150	39.71	-87	65.51	-24	90.59	39	115.15	101	138.88	164	162.53
-149	40.13	-86	65.91	-23	90.98			102	139.26	165	162.90
-148	40.55	-85	66.31	-22	91.37	40	115.54	103	139.64	166	163.27
-147	40.96	-84	66.72	-21	91.77	41	115.93	104	140.02	167	163.65
-146	41.38	-83	67.12			42	116.31	105	140.39	168	164.02
-145	41.79	-82	67.52	-20	92.16	43	116.70	106	140.77	169	164.39
-144	42.21	-81	67.92	-19	92.55	44	117.08	107	141.15		
-143	42.63			-18	92.95	45	117.47	108	141.53	170	164.76
-142	43.04	-80	68.33	-17	93.34	46	117.85	109	141.91	171	165.13
-141	43.45	-79	68.73	-16	93.73	47	118.24			172	165.50
		-78	69.13	-15	94.12	48	118.62	110	142.29	173	165.87
-140	43.87	-77	69.53	-14	94.52	49	119.01	111	142.66	174	166.24
-139	44.28	-76	69.93	-13	94.91			112	143.04	175	166.61
-138	44.70	-75	70.33	-12	95.30	50	119.40	113	143.42	176	166.98

Temperature Conversion
Platinum Resistance (240°C to 629°C)
Temperature Coefficient - 0.00385 Ohms/Ohm/OC

°C	Ohms	°C	Ohms	C	Ohms	°C	Ohms	°C	Ohms	°C	Ohms
240	190.45	301	212.37	362	233.87	423	254.93	484	275.56	545	295.75
241	190.81	302	212.73	363	234.22	424	255.27	485	275.89	546	296.08
242	191.18	303	213.09	364	234.56	425	255.61	486	276.23	547	296.41
243	191.54	304	213.44	365	234.91	426	255.95	487	276.56	548	296.74
244	191.90	305	213.80	366	235.26	427	256.29	488	276.89	549	297.06
245	192.26	306	214.15	367	235.61	428	256.63	489	277.23		
246	192.63	307	214.51	368	235.96	429	258.98			550	297.39

Appendix E - RTD Tables

Temperature Conversion
Platinum Resistance (240°C to 629°C)
Temperature Coefficient - 0.00385 Ohms/Ohm/OC

247	192.99	308	214.86	369	236.31			490	277.56	551	297.72
248	193.35	309	215.22			430	257.32	491	277.90	552	298.04
249	193.71			370	236.65	431	257.66	492	278.23	553	298.37
		310	215.57	371	237.00	432	258.00	493	278.56	554	298.70
250	194.07	311	215.93	372	237.35	433	258.34	494	278.90	555	299.02
251	194.44	312	216.28	373	237.70	434	258.68	495	279.23	556	299.35
252	194.80	313	216.64	374	238.04	435	259.02	496	279.56	557	299.68
253	195.16	314	216.99	375	238.39	436	259.36	497	279.90	558	300.00
254	195.52	315	217.35	376	238.74	437	259.70	498	280.23	559	300.33
255	195.88	316	217.70	377	239.09	438	260.04	499	280.56		
256	196.24	317	218.05	378	239.43	439	260.38			560	300.65
257	196.60	318	218.41	379	239.78			500	280.90	561	300.98
258	196.96	319	218.76			440	260.72	501	281.23	562	301.31
259	197.33			380	240.13	441	261.06	502	281.56	563	301.63
		320	219.12	381	240.47	442	261.40	503	281.89	564	301.96
260	197.69	321	219.47	382	240.82	443	261.74	504	282.23	565	302.28
261	198.05	322	219.82	383	241.17	444	262.08	505	282.56	566	302.61
262	198.41	323	220.18	384	241.51	445	262.42	506	282.89	567	302.93
263	198.77	324	220.53	385	241.86	446	262.76	507	283.22	568	303.26
264	199.13	325	220.88	386	242.20	447	263.10	508	283.55	569	303.58
265	199.49	326	221.24	387	242.55	448	263.43	509	283.89		
266	199.85	327	221.59	388	242.90	449	236.77			570	303.91
267	200.21	328	221.94	389	243.24			510	284.22	571	304.23
268	200.57	329	222.29			450	264.11	511	284.55	572	304.56
269	200.93			390	243.59	451	264.45	512	284.88	573	304.88
		330	222.65	391	243.93	452	264.79	513	285.21	574	305.20
270	201.29	331	223.00	392	244.28	453	265.13	514	285.54	575	305.53
271	201.65	332	223.35	393	244.62	454	265.46	515	285.87	576	305.85
272	202.01	333	223.70	394	244.97	455	265.80	516	286.21	577	306.18
273	202.36	334	224.06	395	245.31	456	266.14	517	286.54	578	306.50
274	202.72	335	224.41	396	245.66	457	266.48	518	286.87	579	306.82
275	203.08	336	224.76	397	246.00	458	266.82	519	287.20		
276	203.44	337	225.11	398	246.35	459	267.15			580	307.15
277	203.80	338	225.46	399	246.69			520	287.53	581	307.47
278	204.16	339	225.81			460	267.49	521	287.86	582	307.79
279	204.52			400	247.04	461	267.83	522	288.19	583	308.12

Appendix E - RTD Tables

Temperature Conversion Platinum Resistance (240°C to 629°C) Temperature Coefficient - 0.00385 Ohms/Ohm/OC											
		340	226.17	401	247.38	462	268.17	523	288.52	584	308.44
280	204.88	341	226.52	402	247.72	463	268.50	524	288.85	585	308.76
281	205.23	342	226.87	403	248.07	464	268.84	525	289.18	586	309.09
282	205.59	343	227.22	404	248.41	465	269.18	526	289.51	587	309.41
283	205.95	344	227.57	405	248.76	466	269.51	527	289.84	588	309.73
284	206.31	345	227.92	406	249.10	467	269.85	528	290.17	589	310.05
285	206.67	346	228.27	407	249.45	468	270.19	529	290.50		
286	207.02	347	228.62	408	249.79	469	270.52			590	310.38
287	207.38	348	228.97	409	250.13			530	290.83	591	310.70
288	207.74	349	229.32			470	270.86	531	291.16	592	311.02
289	208.10			410	250.48	471	271.20	532	291.49	593	311.34
		350	229.67	411	250.82	472	271.53	533	291.81	594	311.66
290	208.45	351	230.02	412	251.16	473	271.87	534	292.14	595	311.99
291	208.81	352	230.37	413	251.50	474	272.20	535	292.47	596	312.31
292	209.17	353	230.72	414	251.85	475	272.54	536	292.80	597	312.63
293	209.52	354	231.07	415	252.19	476	272.88	537	293.13	598	312.95
294	209.88	355	231.42	416	252.53	477	273.21	538	293.46	599	313.27
295	210.24	356	231.77	417	252.87	478	273.55	539	293.79		
296	210.59	357	232.12	418	253.22	479	273.88			600	313.59
297	210.95	358	232.47	419	253.56			540	294.11	601	313.91
298	211.31	359	232.82			480	274.22	541	294.44	602	314.24
299	211.66			420	253.90	481	274.55	542	294.77	603	314.56
		360	233.17	421	254.24	482	274.89	543	295.10	604	314.88
300	212.02	361	233.52	422	254.59	483	275.22	544	295.43	605	315.20

Appendix E - RTD Tables

100W Platinum RTD Ω- 0.00385 coefficient												
°F	0	1	2	3	4	5	6	7	8	9	10	°F
Resistance in Ohms												
-320	20.44	20.20	19.96	19.72	19.48	19.24	19.00	18.76	18.52			-320
-310	22.83	22.59	22.35	22.11	21.87	21.63	21.39	21.16	20.92	20.68	20.44	-310
-300	25.20	24.97	24.73	24.49	24.25	24.02	23.78	23.54	23.30	23.06	22.83	-300
-290	27.57	27.33	27.10	26.86	26.62	26.39	26.15	25.91	25.68	25.44	25.20	-290
-280	29.93	29.69	29.46	29.22	28.98	28.75	28.51	28.28	28.04	27.81	27.57	-280
-270	32.27	32.04	31.80	31.57	31.34	31.10	30.87	30.63	30.40	30.16	29.93	-270
-260	34.61	34.38	34.14	33.91	33.68	33.44	33.21	32.98	32.74	32.51	32.27	-260
-250	36.94	36.71	36.47	36.24	36.01	35.78	35.54	35.31	35.08	34.84	34.61	-250
-240	39.26	39.03	38.80	38.56	38.33	38.10	37.87	37.64	37.40	37.17	36.94	-240
-230	41.57	41.34	41.11	40.88	40.65	40.42	40.19	39.95	39.72	39.49	39.26	-230
-220	43.88	43.65	43.42	43.19	42.96	42.73	42.49	42.26	42.03	41.80	41.57	-220
-210	46.17	45.94	45.71	45.48	45.26	45.03	44.80	44.57	44.34	44.11	43.88	-210
-200	48.46	48.23	48.00	47.78	47.55	47.32	47.09	46.86	46.63	46.40	46.17	-200
-190	50.74	50.52	50.29	50.06	49.83	49.60	49.38	49.15	48.92	48.69	48.46	-190
-180	53.02	52.79	52.56	52.34	52.11	51.88	51.65	51.43	51.20	50.97	50.74	-180
-170	55.29	55.06	54.83	54.61	54.38	54.15	53.93	53.70	53.47	53.25	53.02	-170
-160	57.55	57.32	57.10	56.87	56.65	56.42	56.19	55.97	55.74	55.51	55.29	-160
-150	59.81	59.58	59.35	59.13	58.90	58.68	58.45	58.23	58.00	57.78	57.55	-150
-140	62.06	61.83	61.61	61.38	61.16	60.93	60.71	60.48	60.26	60.03	59.81	-140
-130	64.30	64.08	63.85	63.63	63.40	63.18	62.95	62.73	62.50	62.28	62.06	-130
-120	66.54	66.31	66.09	65.87	65.64	65.42	65.20	64.97	64.75	64.52	64.30	-120
-110	68.77	68.55	68.33	68.10	67.88	67.66	67.43	67.21	66.99	66.76	66.54	-110
-100	71.00	70.78	70.55	70.33	70.11	69.89	69.66	69.44	69.22	68.99	68.77	-100
-90	73.22	73.00	72.78	72.56	72.33	72.11	71.89	71.67	71.45	71.22	71.00	-90
-80	75.44	75.22	75.00	74.78	74.55	74.33	74.11	73.89	73.67	73.45	73.22	-80
-70	77.66	77.43	77.21	76.99	76.77	76.55	76.33	76.11	75.88	75.66	75.44	-70
-60	79.86	79.64	79.42	79.20	78.98	78.76	78.54	78.32	78.10	77.88	77.66	-60
-50	82.07	81.85	81.63	81.41	81.19	80.97	80.75	80.53	80.31	80.09	79.86	-50
-40	84.27	84.05	83.83	83.61	83.39	83.17	82.95	82.73	82.51	82.29	82.07	-40
-30	86.47	86.25	86.03	85.81	85.59	85.37	85.15	84.93	84.71	84.49	84.27	-30
-20	88.66	88.44	88.22	88.00	87.78	87.56	87.34	87.13	86.91	86.69	86.47	-20
-10	90.85	90.63	90.41	90.19	89.97	89.75	89.54	89.32	89.10	88.88	88.66	-10

Appendix E - RTD Tables

100W Platinum RTD Ω- 0.00385 coefficient												
°F	0	1	2	3	4	5	6	7	8	9	10	°F
Resistance in Ohms												
0	93.03	92.82	92.60	92.38	92.16	91.94	91.72	91.50	91.29	91.07	90.85	0
0	93.03	93.25	93.47	93.69	93.91	94.12	94.34	94.56	94.78	95.00	95.21	0
10	95.21	95.43	95.65	95.87	96.09	96.30	96.52	96.74	96.96	97.17	97.39	10
20	97.39	97.61	97.83	98.04	98.26	98.48	98.70	98.91	99.13	99.35	99.57	20
30	99.57	99.78	100.00	100.22	100.43	100.65	100.87	101.09	101.30	101.52	101.74	30
40	101.74	101.95	102.17	102.39	102.60	102.82	103.04	103.25	103.47	103.69	103.90	40
50	103.90	104.12	104.34	104.55	104.77	104.98	105.20	105.42	105.63	105.85	106.07	50
60	106.07	106.28	106.50	106.71	106.93	107.15	107.36	107.58	107.79	108.01	108.23	60
70	108.23	108.44	108.66	108.87	109.09	109.30	109.52	109.73	109.95	110.17	110.38	70
80	110.38	110.60	110.81	111.03	111.24	111.46	111.67	111.89	112.10	112.32	112.53	80
90	112.53	112.75	112.96	113.18	113.39	113.61	113.82	114.04	114.25	114.47	114.68	90
100	114.68	114.90	115.11	115.33	115.54	115.76	115.97	116.18	116.40	116.61	116.83	100
110	116.83	117.04	117.26	117.47	117.68	117.90	118.11	118.33	118.54	118.76	118.97	110
120	118.97	119.18	119.40	119.61	119.82	120.04	120.25	120.47	120.68	120.89	121.11	120
130	121.11	121.32	121.53	121.75	121.96	122.18	122.39	122.60	122.82	123.03	123.24	130
140	123.24	123.46	123.67	123.88	124.09	124.31	124.52	124.73	124.95	125.16	125.37	140
150	125.37	125.59	125.80		126.22	126.44	126.65	126.86	127.08	127.29	127.50	150
160	127.50	127.71	127.93		128.35	128.56	128.78	128.99	129.20	129.41	129.62	160
170	129.62	129.84	130.05		130.47	130.68	130.90	131.11	131.32	131.53	131.74	170
180	131.74	131.96	132.17		132.59	132.80	133.01	133.23	133.44	133.65	133.86	180
190	133.86	134.07	134.28		134.71	134.92	135.13	135.34	135.55	135.76	135.97	190
200	135.97	136.19	136.40		136.82	137.03	137.24	137.45	137.66	137.87	138.08	200
210	138.08	138.29	138.51		138.93	139.14	139.35	139.56	139.77	139.98	140.19	210
220	140.19	140.40	140.61		141.03	141.24	141.45	141.66	141.87	142.08	142.29	220
230	142.29	142.50	142.71		143.13	143.34	143.55	143.76	143.97	144.18	144.39	230
240	144.39	144.60	144.81		145.23	145.44	145.65	145.86	146.07	146.28	146.49	240
250	146.49	146.70	146.91		147.32	147.53	147.74	147.95	148.16	148.37	148.58	250
260	148.58	148.79	149.00		149.41	149.62	149.83	150.04	150.25	150.46	150.67	260
270	150.67	150.88	151.08		151.50	151.71	151.92	152.13	152.33	152.54	152.75	270
280	152.75	152.96	153.17		153.58	153.79	154.00	154.21	154.42	154.62	154.83	280
290	154.83	155.04	155.25		155.66	155.87	156.08	156.29	156.49	156.70	156.91	290
300	156.91	157.12	157.33		157.74	157.95	158.15	158.36	158.57	158.78	158.98	300
310	158.98	159.19	159.40		159.81	160.02	160.23	160.43	160.64	160.85	161.05	310
320	161.05	161.26	161.47		161.88	162.09	162.29	162.50	162.71	162.91	163.12	320

Appendix E - RTD Tables

100W Platinum RTD Ω- 0.00385 coefficient												
°F	0	1	2	3	4	5	6	7	8	9	10	°F
Resistance in Ohms												
330	163.12	163.33	163.53	163.74	163.95	164.15	164.36	164.57	164.77	164.98	165.18	330
340	165.18	165.39	165.60	165.80	166.01	166.21	166.42	166.63	166.83	167.04	167.24	340
350	167.24	167.45	167.66	167.86	168.07	168.27	168.48	168.68	168.89	169.09	169.30	350
360	169.30	169.51	169.71	169.92	170.12	170.33	170.53	170.74	170.94	171.15	171.35	360
370	171.35	171.56	171.76	171.97	172.17	172.38	172.58	172.79	172.99	173.20	173.40	370
380	173.40	173.61	173.81	174.02	174.22	174.43	174.63	174.83	175.04	175.24	175.45	380
390	175.45	175.65	175.86	176.06	176.26	176.47	176.67	176.88	177.08	177.29	177.49	390
400	177.49	177.69	177.90	178.10	178.30	178.51	178.71	178.92	179.12	179.32	179.53	400
410	179.53	179.73	179.93	180.14	180.34	180.55	180.75	180.95	181.16	181.36	181.56	410
420	181.56	181.77	181.97	182.17	182.38	182.58	182.78	182.98	183.19	183.39	183.59	420
430	183.59	183.80	184.00	184.20	184.40	184.61	184.81	185.01	185.22	185.42	185.62	430
440	185.62	185.82	186.03	186.23	186.43	186.63	186.84	187.04	187.24	187.44	187.65	440
450	187.65	187.85	188.05	188.25	188.45	188.66	188.86	189.06	189.26	189.46	189.67	450
460	189.67	189.87	190.07	190.27	190.47	190.67	190.88	191.08	191.28	191.48	191.68	460
470	191.68	191.88	192.09	192.29	192.49	192.69	192.89	193.09	193.29	193.49	193.70	470
480	193.70	193.90	194.10	194.30	194.50	194.70	194.90	195.10	195.30	195.50	195.71	480
490	195.71	195.91	196.11	196.31	196.51	196.71	196.91	197.11	197.31	197.51	197.71	490
500	197.71	197.91	198.11	198.31	198.51	198.71	198.91	199.11	199.31	199.51	199.71	500
510	199.71	199.91	200.11	200.31	200.51	200.71	200.91	201.11	201.31	201.51	201.71	510
520	201.71	201.91	202.11	202.31	202.51	202.71	202.91	203.11	203.31	203.51	203.71	520
530	203.71	203.91	204.11	204.31	204.51	204.71	204.90	205.10	205.30	205.50	205.70	530
540	205.70	205.90	206.10	206.30	206.50	206.70	206.89	207.09	207.29	207.49	207.69	540
550	207.69	207.89	208.09	208.29	208.48	208.68	208.88	209.08	209.28	209.48	209.67	550
560	209.67	209.87	210.07	210.27	210.47	210.67	210.86	211.06	211.26	211.46	211.66	560
570	211.66	211.85	212.05	212.25	212.45	212.64	212.84	213.04	213.24	213.44	213.63	570
580	213.63	213.83	214.03	214.23	214.42	214.62	214.82	215.02	215.21	215.41	215.61	580
590	215.61	215.80	216.00	216.20	216.40	216.59	216.79	216.99	217.18	217.38	217.58	590
600	217.58	217.77	217.97	218.17	218.37	218.56	218.76	218.96	219.15	219.35	219.55	600
610	219.55	219.74	219.94	220.13	220.33	220.53	220.72	220.92	221.12	221.31	221.51	610
620	221.51	221.70	221.90	222.10	222.29	222.49	222.68	222.88	223.08	223.27	223.47	620
630	223.47	223.66	223.86	224.06	224.25	224.45	224.64	224.84	225.03	225.23	225.42	630
640	225.42	225.62	225.82	226.01	226.21	226.40	226.60	226.79	226.99	227.18	227.38	640
650	227.38	227.57	227.77	227.96	228.16	228.35	228.55	228.74	228.94	229.13	229.33	650
660	229.33	229.52	229.72	229.91	230.11	230.30	230.49	230.69	230.88	231.08	231.27	660

Appendix E - RTD Tables

100W Platinum RTD Ω- 0.00385 coefficient												
°F	0	1	2	3	4	5	6	7	8	9	10	°F
Resistance in Ohms												
670	231.27	231.47	231.66	231.86	232.05	232.24	232.44	232.63	232.83	233.02	233.21	670
680	233.21	233.41	233.60	233.80	233.99	234.18	234.38	234.57	234.77	234.96	235.15	680
690	235.15	235.35	235.54	235.73	235.93	236.12	236.31	236.51	236.70	236.89	237.09	690
700	237.09	237.28	237.47	237.67	237.86	238.05	238.25	238.44	238.63	238.83	239.02	700
710	239.02	239.21	239.41	239.60	239.79	239.98	240.18	240.37	240.56	240.75	240.95	710
720	240.95	241.14	241.33	241.52	241.72	241.91	242.10	242.29	242.49	242.68	242.87	720
730	242.87	243.06	243.26	243.45	243.64	243.83	244.02	244.22	244.41	244.60	244.79	730
740	244.79	244.98	245.18	245.37	245.56	245.75	245.94	246.13	246.33	246.52	246.71	740
750	246.71	246.90	247.09	247.28	247.47	247.67	247.86	248.05	248.24	248.43	248.62	750
760	248.62	248.81	249.00	249.20	249.39	249.58	249.77	249.96	250.15	250.34	250.53	760
770	250.53	250.72	250.91	251.10	251.30	251.49	251.68	251.87	252.06	252.25	252.44	770
780	252.44	252.63	252.82	253.01	253.20	253.39	253.58	253.77	253.96	254.15	254.34	780
790	254.34	254.53	254.72	254.91	255.10	255.29	255.48	255.67	255.86	256.05	256.24	790
800	256.24	256.43	256.62	256.81	257.00	257.19	257.38	257.57	257.76	257.95	258.14	800
810	258.14	258.33	258.52	258.70	258.89	259.08	259.27	259.46	259.65	259.84	260.03	810
820	260.03	260.22	260.41	260.60	260.78	260.97	261.16	261.35	261.54	261.73	261.92	820
830	261.92	262.11	262.29	262.48	262.67	262.86	263.05	263.24	263.43	263.61	263.80	830
840	263.80	263.99	264.18	264.37	264.56	264.74	264.93	265.12	265.31	265.50	265.68	840
850	265.68	265.87	266.06	266.25	266.44	266.62	266.81	267.00	267.19	267.37	267.56	850
860	267.56	267.75	267.94	268.12	268.31	268.50	268.69	268.87	269.06	269.25	269.44	860
870	269.44	269.62	269.81	270.00	270.18	270.37	270.56	270.75	270.93	271.12	271.31	870
880	271.31	271.49	271.68	271.87	272.05	272.24	272.43	272.61	272.80	272.99	273.17	880
890	273.17	273.36	273.55	273.73	273.92	274.11	274.29	274.48	274.67	274.85	275.04	890
900	275.04	275.22	275.41	275.60	275.78	275.97	276.15	276.34	276.53	276.71	276.90	900
910	276.90	277.08	277.27	277.46	277.64	277.83	278.01	278.20	278.38	278.57	278.75	910
920	278.75	278.94	279.13	279.31	279.50	279.68	279.87	280.05	280.24	280.42	280.61	920
930	280.61	280.79	280.98	281.16	281.35	281.53	281.72	281.90	282.09	282.27	282.46	930
940	282.46	282.64	282.83	283.01	283.20	283.38	283.56	283.75	283.93	284.12	284.30	940
950	284.30	284.49	284.67	284.86	285.04	285.22	285.41	285.59	285.78	285.96	286.14	950
960	286.14	286.33	286.51	286.70	286.88	287.06	287.25	287.43	287.62	287.80	287.98	960
970	287.98	288.17	288.35	288.53	288.72	288.90	289.08	289.27	289.45	289.64	289.82	970
980	289.82	290.00	290.19	290.37	290.55	290.73	290.92	291.10	291.28	291.47	291.65	980
990	291.65	291.83	292.02	292.20	292.38	292.56	292.75	292.93	293.11	293.30	293.48	990

Appendix E - RTD Tables

100W Platinum RTD Ω- 0.00385 coefficient												
°F	0	1	2	3	4	5	6	7	8	9	10	°F
Resistance in Ohms												
1000	293.48	293.66	293.84	294.03	294.21	294.39	294.57	294.76	294.94	295.12	295.30	1000
1010	295.30	295.48	295.67	295.85	296.03	296.21	296.40	296.58	296.76	296.94	297.12	1010
1020	297.12	297.31	297.49	297.67	297.85	298.03	298.21	298.40	298.58	298.76	298.94	1020
1030	298.94	299.12	299.30	299.49	299.67	299.85	300.03	300.21	300.39	300.57	300.75	1030
1040	300.75	300.94	301.12	301.30	301.48	301.66	301.84	302.02	302.20	302.38	302.56	1040
1050	302.56	302.75	302.93	303.11	303.29	303.47	303.65	303.83	304.01	304.19	304.37	1050
1060	304.37	304.55	304.73	304.91	305.09	305.27	305.45	305.63	305.81	305.99	306.17	1060
1070	306.17	306.35	306.53	306.71	306.89	307.07	307.25	307.43	307.61	307.79	307.97	1070
1080	307.97	308.15	308.33	308.51	308.69	308.87	309.05	309.23	309.41	309.59	309.77	1080
1090	309.77	309.95	310.13	310.31	310.49	310.67	310.85	311.02	311.20	311.38	311.56	1090
1100	311.56	311.74	311.92	312.10	312.28	312.46	312.64	312.81	312.99	313.17	313.35	1100
1110	313.35	313.53	313.71	313.89	314.07	314.24	314.42	314.60	314.78	314.96	315.14	1110
1120	315.14	315.31	315.49	315.67	315.85	316.03	316.21	316.38	316.56	316.74	316.92	1120
1130	316.92	317.10	317.27	317.45	317.63	317.81	317.98	318.16	318.34	318.52	318.70	1130
1140	318.70	318.87	319.05	319.23	319.41	319.58	319.76	319.94	320.12	320.29	320.47	1140
1150	320.47	320.65	320.82	321.00	321.18	321.36	321.53	321.71	321.89	322.06	322.24	1150
1160	322.24	322.42	322.59	322.77	322.95	323.13	323.30	323.48	323.66	323.83	324.01	1160
1170	324.01	324.18	324.36	324.54	324.71	324.89	325.07	325.24	325.42	325.60	325.77	1170
1180	325.77	325.95	326.12	326.30	326.48	326.65	326.83	327.00	327.18	327.36	327.53	1180
1190	327.53	327.71	327.88	328.06	328.24	328.41	328.59	328.76	328.94	329.11	329.29	1190
1200	329.29	329.46	329.64	329.82	329.99	330.17	330.34	330.52	330.69	330.87	331.04	1200
1210	331.04	331.22	331.39	331.57	331.74	331.92	332.09	332.27	332.44	332.62	332.79	1210
1220	332.79											1220

Appendix F - Warranty

NelsonHeatTraceProducts
LIMITEDWARRANTYANDLIABILITY

AppletonGrp LLC - d/b/aAppletonGroupwarrantsthatiftherearеany defects in material or workmanship in any heating cable or accessory duringthefirst yearafterthedateofpurchase,wewillprovidenew productstoreplaceanydefectiveitems,orwewillrefundthepurchase pricepaidfortheaccessoryorcable, notincludinganylaborорother installationcosts. As an alternate, wemayelecttorepairthecableor accessory at our factory with all shipping and other removal costs borne bythepurchaser.

Wefurther warrant that, for a period of twelve (12) months after the date of performance, anyservices performedhereunderwillbeina good and skillful manner, based on our understanding of pertinent technical data as of the date of performance of such services. Appleton Group'ssole responsibility and liability in theeventofanydefect, error, omission, or failure in the services rendered hereunder shall be to providecorrectedservicesofthetypeprovidedforherein, designedto correct such defect, error, omissions, or failure, and in no event shall AppletonGroup'sliabilitywithrespecttosuchwarrantyexceedthe amount received by it from the Buyer on account of such services.

Ourobligationtoprovidecorrectedservices, newproducts, refundthe purchase price, orperformtherepairdescribedaboveis conditioned upon (a) the installation of the accessory or cable conforming to the directions set forth in our installation instructions and (b) the accessory or cable not having been damaged by mechanical or electrical activities unrelatedtotheoperationoftheaccessoryorcable.

Arefundofyourpurchaseprice, provision of replacementproducts, repair of the accessory or cable or provision of corrected services as described above, shall be your sole and exclusive remedy for a breach of this warranty. THESE ARE THE SOLE AND EXCLUSIVE WARRANTIES GIVEN BY APPLETON GROUP WITH RESPECT TO THE GOODS AND SERVICES AND ARE IN LIEU OF AND EXCLUDE ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, ARISING BY OPERATION OF LAW OR OTHERWISE, INCLUDING WITHOUT LIMITATION, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE WHETHER OR NOT THE PURPOSE OR USE HAS BEEN DISCLOSED TO NELSON IN SPECIFICATIONS, DRAWINGS OR OTHERWISE, AND WHETHER OR NOT APPLETON GROUP'S PRODUCTS ARE SPECIFICALLY DESIGNED AND/OR MANUFACTURED BY NELSON FOR YOUR USE OR PURPOSE.

This warranty does not extend to any losses or damages due to misuse, accident, abuse, neglect, normal wear and tear, negligence, unauthorizedmodificationoralteration,usebeyondratedcapacity,or improperinstallation, maintenanceor application. Tothe extent thatyou oryouragentshavesuppliedspecifications, information, representation of operating conditions or other data to Appleton Group in the selection or design of the Goods and the preparation of Appleton Group's quotation, and in the event that actual operating conditions or other conditions differ from those represented by you, any warranties or other provisions contained herein which are affected by such conditions shallbenullandvoid.

If within thirty (30) days after your discovery of any warranty defects within the warranty period, you notify Appleton Group thereof in writing. AppletonGroupshall, atitsoption, repair,correctorreplace F.O.B.point of manufacture, or refund the purchase price for, that portion of the Goodsfoundby Appleton Group to be defective. Failurebyyou togive such written notice within the applicable time period shall be deemed an absolute and unconditional waiver of your claim for such defects. Goods repaired or replaced during the warranty period shall be covered bytheforegoingwarrantyfortheremainderoftheoriginalwarranty period or ninety (90) days from the date of shipment of the repaired or replacedgoods, whicheverislonger.

This limited warranty does not cover any costs relating to the repair or replacement of any accessory or cable at the installation site. Our accessories and cables are not easily accessible. A failed accessory or cable usually cannot be easily repaired. Replacement of a failed accessory or cable will require that the materials under which it is installedberemovedtopermitreplacementoftheaccessoryorcable. We will not reimburse any costs relating to the repair or replacement of any accessory or cable at the installation site.

IN NO EVENT, REGARDLESS OF THE FORM OF THE CLAIM OR CAUSE OF ACTION(WHETHERBASEDINCONTRACT,INFRINGEMENT,NEGLIGENCE, STRICT LIABILITY, OTHERTORTOROTHERWISE), SHALL APPLETON GROUP'S LIABILITY TO YOU AND/OR YOUR CUSTOMERS EXCEED THE PRICE PAID BY YOU FOR THE SPECIFIC GOODS PROVIDED BY APPLETON GROUP GIVING RISE TO THE CLAIM OR CAUSE OF ACTION. YOU AGREE THAT WE SHALL NOT BE LIABLE TO YOU OR YOUR CUSTOMERS FOR ANY INCIDENTAL, SPECIAL OR CONSEQUENTIAL OR PUNITIVE DAMAGES. No agent, employee or representative of ours has authority to bind us to anyaffirmation, representationorwarrantyconcerningthegoodssold unlesssuch affirmation, representation or warranty isspecifically incorporated by written agreement.

Toobtain new products, arrange repair of existing product, or a refund under this warranty, please contact Appleton Group (800-621-1506) with a description of the defect and proof of purchase at the address noted herein.

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