S1 IoT Heater Controller Operating Manual

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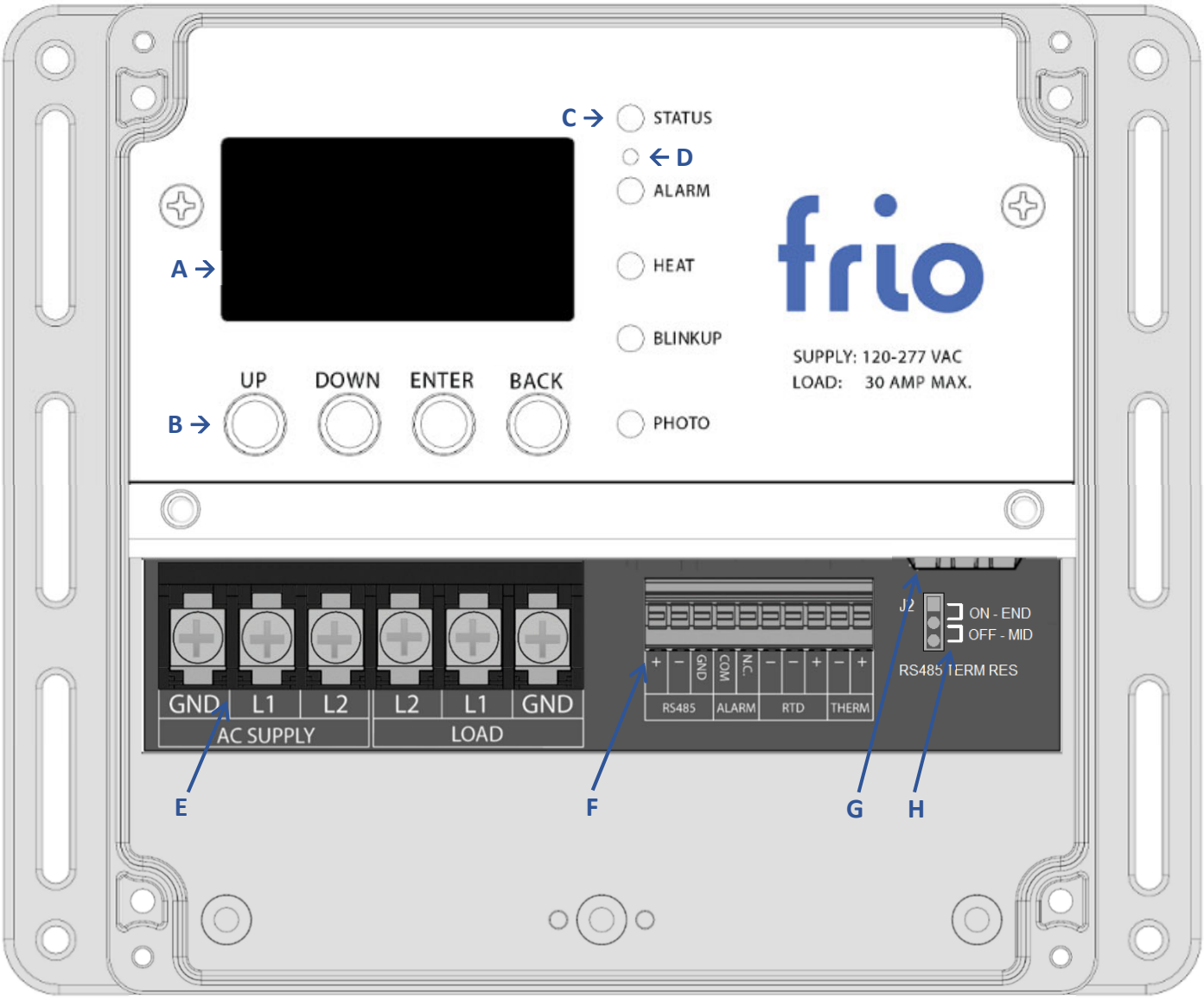
1 Device Diagram



HMI (Human Machine Interface)

A. Screen
B. Buttons
C. LEDs
D. Device Reset

Wiring Area

E. High Voltage Connections
F. Low Voltage Connections
G. Ethernet Connection
H. RS485 Termination Resistor Jumper (S1-A)

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2 INTRODUCTION

This operating manual provides a complete overview of the S1 IoT Heating Controller, including an installation guide and all relevant information required to use the controller. The Frio S1 shall only be used for the purposes described in this manual and must be installed by a trained service professional in compliance with all applicable local electrical codes, according to the instructions contained herein. For more information, including device terms and conditions and limited warranty information, please visit www.frio.co.

2.1 OVERVIEW

The S1 is a single-circuit IoT controller for snow melting, freeze protection, and temperature maintenance applications. The device can drive up to a 30A resistive load to control heating systems operating between 100 VAC and 277 VAC. The S1 comes in an outdoor-rated enclosure certified to IP67 standards and NEMA 4X.

Wi-Fi and Ethernet capability allows the S1 to connect to the Frio cloud platform via the internet, enabling smart, cloud-based control. When connected to the cloud, the S1 will upload system status and receive operational commands. The Frio cloud platform integrates weather data, system feedback, and proprietary control algorithms to automatically maximize system effectiveness and efficiency. Multiple S1 devices can be joined together in the Frio cloud platform, allowing centralized control of multiple heating systems.

The Frio cloud connection enables advanced monitoring and notification of your heating system. Data on key performance characteristics are monitored over time, and anomalies or excursions are flagged and reported. The Frio cloud platform offers customizable SMS and email notifications so that the user can be alerted immediately if there are any issues with the system. Users can access their S1 device remotely via the Frio cloud platform to check status, activate the system, or run a diagnostic test, eliminating the need to physically check the heating system. If an internet connection is not available, the S1 can operate in an offline configuration.

2.2 INSTALLATION AND INTENDED USE

> ⚠ **NOTE: THE CONTROLLER MUST BE INSTALLED BY A LICENSED ELECTRICIAN OR QUALIFIED PROFESSIONAL IN ACCORDANCE WITH LOCAL AND NATIONAL ELECTRICAL CODES. THE CONTROLLER MUST BE CONNECTED TO A CERTIFIED CIRCUIT BREAKER RATED FOR 30 A OR LESS, WITH NO OTHER DEVICES ON THE CIRCUIT BREAKER.**

The S1 controller may be used for temperature control with self-regulating heat trace, mineral insulated (MI) heat trace, constant wattage heat trace, or any other type of UL recognized heating system.

2.3 DISCLAIMER

Frio makes absolutely no representations or warranties, either expressed or implied, with respect to the contents of this manual or the products described herein. Frio specifically disclaims any implied warranties of merchantability or fitness for a particular purpose. Frio does not warrant the products described herein will meet the user's requirements nor does it give any warranty about the results that may be obtained by using the products. Frio reserves the right to make changes or improvements to the products described in this manual and to revise this publication at any time. Frio is under no obligation to notify any person or organization of such changes, improvements, or revisions.

2.4 CONTACT INFORMATION

Please send all inquiries to info@frio.co or to the address below:

141 Flushing Ave.
Building 77 Unit 1111C
Brooklyn, NY 11205

3 S1 System Overview

The following sections describe the features available on the Frio S1-A-0002 and S1-B-2002 when operating with Firmware Version 4. For Frio S1 devices operating with different firmware versions or with model numbers S1-A-0001 or S1-A-2001, please visit www.frio.co/resources to download the appropriate operating manual. The model number is shown on the label on the right side of the device, and the device firmware version can be found under **Device Info** on the **Main Menu**.

3.1 Hardware Variants

The Frio S1 device is available under two different models, the S1-A and the S1-B. The S1-A includes all features, and the S1-B which does not include RS485 local communications or RTD sensing capabilities. Both versions have Wi-Fi and Ethernet communication. To check which device you have, look at the model number located on the product label.

3.1.1 Wi-Fi and Ethernet

Both the Frio S1-A and S1-B models can connect to the Frio cloud platform via Wi-Fi 802.11 Dual Band 2.4GHz & 5GHz or wired ethernet connection using a Cat 5 or Cat 6 cable. The devices use an FCC certified Wi-Fi Module and have been tested to the requirements laid out in FCC Part 15 Subpart B. Frio does have an option for devices with internet capabilities disabled, please contact info@frio.co for more information.

3.2 Control Modes

The S1 device operating on Firmware Version 4 has eight available control modes:

- Freeze Protection
- Dual Temperature Freeze Protection
- Temperature Maintenance
- Local Snow Melting
- Manual Control
- Cloud Control (Snow/gutter melting)
- Hybrid Freeze Protection
- Temperature Maintenance Scheduler

3.2.1 Freeze Protection

Freeze protection mode can be used to prevent water in pipe systems from freezing. In freeze protection mode, the S1 will activate the heating circuit when the active temperature sensor reads a value below the temperature set point. The S1 will then turn off the heat tracing circuit when the temperature sensor reads a value above the setpoint plus the dead-band. The dead-band is used to prevent the system from turning on and off rapidly if the temperature hovers near the setpoint. Both the temperature setpoint and the dead-band of the system can be set by the user. The dead-band is added to the temperature setpoint such that the system will turn on when the temperature falls below the setpoint and will turn off again once the temperature rises above the setpoint plus the dead-band.

The Freeze protection control mode requires at least one temperature sensor to be connected. On the S1-A and S1-B, the user may set the thermistor to either Pipe or Ambient. On the S1-A only, the user may use an RTD that is set to Pipe or Ambient as the control sensor. If a user configures both the thermistor and RTD as control sensors (pipe, ambient, or slab) on an S1-A, the device will use the lower of the two temperature readings as the control signal. If a sensor is set to High Limit, it will not be used for control.

Freeze protection mode can be used in either an Ambient sensing configuration or a Pipe sensing configuration. In the Ambient configuration, the active temperature sensor must be placed in a location such that it will accurately detect the lowest ambient temperature the system will see. Do not place the temperature sensor in direct sunlight or near a source of artificial heat such as a vent. In the Pipe sensing configuration, the active temperature sensor should be placed on the coldest part of the pipe on the opposite side from the heat trace.

3.2.2 Dual Temperature Freeze Protection

Dual Temperature Freeze Protection mode is available on the S1-A controller and utilizes both the RTD and the Thermistor to improve reliability and energy efficiency. One sensor (typically the thermistor) is set up as an ambient temperature sensor, while the second sensor (typically the RTD) is set up as a pipe temperature sensor. The controller will turn on when both sensors are below their respective setpoints. The ambient setpoint is 40°F (4°C), and the pipe setpoint is programmed by the user. If the ambient temperature sensor is lost, the system will send an alarm and act as a pipe sensing system. If the pipe temperature sensor is lost, the system will send an alarm and act as an ambient sensing system. This provides redundancy allowing the system to continue operating if either sensor is damaged or disconnected.

In a typical single-temperature pipe sensing freeze protection system there is only one setpoint to turn on the system. If a user wants to maintain their pipes at 50°F (10°C) to provide a margin of safety, they must program the setpoint to 50°F (10°C). This will mean the system may turn on even if the ambient temperature is 45°F (7°C) and there is no possible way for the system to freeze. With Dual Temperature Freeze Protection, the user can set the pipe maintain temperature to 50°F (10°C) without worrying that the system will run when freezing conditions are not possible. This allows users to improve reliability by including a larger margin of safety in their setpoint.

When the ambient sensor reads a temperature below the ambient setpoint, freezing conditions may be present. However, in many situations the pipe may be warm and does not require heat. Since Dual Temperature Freeze Protection requires both sensors to be below their respective setpoints, it only operates when freezing conditions are present, and the pipe is not already warm. When the ambient temperature warms up, well-insulated pipes will often stay colder longer, which can result in a pipe sensing system calling for heat when freezing conditions are not present. Dual Temperature freeze Protection mode eliminates unnecessary operation in both scenarios to reduce overall energy usage.

3.2.3 Temperature Maintenance

Temperature maintenance mode can be used to control a heating system within a set temperature range. In temperature maintenance mode, the S1 will activate the heating circuit when the active temperature sensor reads a value below the temperature set point. The S1 will then turn off the heat tracing circuit when the active temperature sensor reads a value above the temperature setpoint plus the dead-band. The dead-band is used to prevent the system from turning on and off rapidly if the temperature hovers near the setpoint. Both the temperature setpoint and the dead-band of the system can be set by the user. The dead-band is added to the temperature setpoint such that the system will turn on when the temperature falls below the setpoint and will turn off again once the temperature rises above the setpoint plus the dead-band.

The Temperature Maintenance control mode requires at least one temperature sensor to be connected. On the S1-A and S1-B, the user may set the thermistor to either Pipe or Ambient. On the S1-A only, the user may use an RTD that is set to Pipe or Ambient as the control sensor. If a user configures both the thermistor and RTD as control sensors (pipe, ambient, or slab) on an S1-A, the device will use the lower of the two temperature readings as the control signal. If a sensor is set to High Limit, it will not be used for control. The active temperature sensor must be placed in a location where it can accurately read the temperature of the system.

3.2.4 Local Snow Melting

The Frio S1-A works with Frio's snow and ice sensors to provide a complete control solution for surface snow melting, roof snow melting, and gutter melting systems. Frio offers multiple methods and configurations to meet your snow melt project needs, including local snow sensors and online weather forecast control. Configurations include:

- Single circuit operation for small systems
- Satellite contactor mode to control multiple circuits from one set of sensors (See section 3.2.10)
- Pilot duty mode to use the Frio S1 controller to drive a contactor panel (See section 3.2.9)

A complete snow melting Product and Design Guide is available at www.frio.co/resources. For questions, please contact us at info@frio.co.

⚠ ***NOTE: When a device is configured for Local Snow Melt mode, it is not possible to communicate using Modbus.***

3.2.4.1 Local Snow Melting Operations Summary

Local snow sensors detect if moisture is present, then send this information via Modbus to the Frio S1-A controller. The Aerial Sensor (AER-1) and Gutter Sensor (GUT-1) also send temperature to the Frio S1-A, while the Pavement Sensor (PVT-1) requires the use of a separate ambient temperature sensor which can be the thermistor that come with the S1-A. When moisture and freezing temps are detected, the heating system is activated. The sensors are connected to a junction box (SM-JB-1) via a 30 foot (10 m.), 24V 4-wire cable (can be extended up to 1000 ft. with 4-wire shielded cable, 18-AWG or larger). The SM-JB-1 junction box includes a 24VAC power supply to provide power to the sensors. Each Frio S1-A can accept any combination of up to (6) total snow sensors and will activate when any single sensor detects snow or ice. Frio offers a gutter sensor (GUT-1), an aerial sensor (AER-1) and a pavement sensor (PVT-1). For more information on the Frio snow and ice sensors please see section 3.3.2.

3.2.4.2 Snow Melt Hold-on Time

Frio's Snow Melting modes include a user-settable hold-on time which keeps the heating system active after snow is no longer detected. The hold-on time will depend on the system installation and type. It is best to experiment with your system to determine the best hold-on on time.

Longer Hold-on Time (6-10 hrs.)

- Critical egress and busy walkways
- Systems in high-snow areas
- Lower powered systems or embedded systems that are buried deep

Shorter Hold-on Time (2-6 hrs.)

- Energy conscious users (i.e. residential driveway)
- High powered systems with quick melt times

3.2.4.3 Snow Melt Fallback Mode

All snow melt control methods offer two fallback modes in case the sensor of internet connection is lost:

Ambient Fallback (Recommended): When the system is configured with an ambient temperature sensor, it will automatically fall back to ambient control if the sensors or internet connection is lost. This ensures that the system will continue to operate if freezing conditions are present but will prevent the system from operating during warm weather. This fallback mode provides users with time to troubleshoot and fix their system while ensuring the system operates with relative efficiency. The Frio S1-A and S1-B controllers include a thermistor which can be used as the ambient sensor to provide this fallback mode.

ON/OFF Fallback: For systems without an ambient temperature sensor, or in the case where all sensors have failed, users can set a fallback mode of Heater ON or Heater OFF. For critical systems such as egress and gutters, Frio recommends setting this mode to Heater ON. For large, high-power systems such as driveways, Frio recommends this be set to Heater OFF.

3.2.4.4 Slab Temperature Control

Slab temperature control allows users to maintain the snow melting surface at a constat temperature. This configuration requires a sensor embedded in the slab. The optimal slab temperature setting for your system will depend on heater power, slab depth, and sensor placement. Higher slab temperatures will result in quicker melt out, while lower slab temperatures will result in less energy use and lower operating costs.

To configure Slab Temperature Control, set the control mode to “Local Snow Melt”, then set one of the temperature sensors to “Slab”. The system will then control the slab using the Setpoint and Deadband values set by the user.

For surface melting systems using just an aerial sensor, the thermistor that comes with the Frio S1 can be used as the slab sensor. For systems using the pavement sensor, the thermistor is used as an ambient temperature sensor and an RTD must be included to be used as the slab temperature sensor.

3.2.5 Manual Control

Manual control means directly turning the heating circuit on or off on command. The Frio S1 can be controlled manually directly from the device, remotely via Modbus/BACnet, or remotely via the Frio Cloud platform.

From the device there are two options for manual control: setting the control mode to Always On or Always Off, and setting a heater override using the Force On feature. In Always On mode, the device will remain on indefinitely. In Always Off mode, the device will not turn on unless the user activates the manual override feature. To manually activate the device using the Force On feature, select **Force System On** from the **Main Menu**, then choose the time that you would like the device to be on. The device may be forced on for 5 minutes, 1 hour, or 24 hours. To cancel the Force On command, select **Cancel Force On** from the Main **Menu**. The Force On feature may also be used with any of the other control modes selected.

If the device is connected via Modbus or BACnet, users may force the device on or off by setting the Force On/Off point. The Force On/Off point has three options; 0=DO_NOTHING, 1=FORCE_ON, and 2=FORCE_OFF. The point should be set to DO_NOTHING for the controller to run as intended without an override. For more information on available Modbus and BACnet points please see section 3.5.2.

When the Frio S1 device is connected to the internet then a user with access to the device may set an override on or off via the Frio Cloud platform. To set an override on the Frio Cloud platform, navigate to the device page and select OVERRIDE. Set the time of the override and confirm your selection to set the override. Overrides may be set for up to 21 days. If a device loses power during the override period, then subsequently regains power, the override will continue until the end of the set override period. An override that was set from the HMI will reset on power loss. As an alternative method of manual control, users may also set the control mode to Always On or Always Off from by clicking settings on the device page.

An override set from the cloud will survive power loss once the device reconnects and will continue as an override until the end time set by the user is reached.

3.2.6 Cloud Control

Frio S1 devices that are connected to the internet can take advantage of the Frio cloud platform, including Online Weather Forecast Control. The cloud platform allows users to view device status and operational logs remotely, including information on the connection, heater state, and active and past alarms. Users can perform a remote test/reset from the cloud platform to clear active alarms. Users can also view and adjust device settings from the cloud platform. For additional information on Frio Cloud features please visit www.frio.co.

3.2.6.1 Online Weather Forecast Control

Frio's Online Weather Forecast Control uses NOAA forecast data which is analyzed by Frio's proprietary control algorithms to provide accurate and robust control. Frio offers three different control algorithms and programable hold-on times to allow users to customize control of their system. To use Online Weather Forecast Control, users must connect their device to the internet and provide an address with zip code.

- Efficient Control Algorithm: This algorithm is intended for snow melt systems and looks at temperature, precipitation type, and precipitation intensity to activate the system only when falling snow or ice is present and may accumulate. This system is up to 45% more efficient than a standard aerial snow sensor.
- Conservative Control Algorithm: This algorithm is intended for snow melt systems and works like the efficient algorithm with a different precipitation intensity threshold to activate for all precipitation under 39°F (3°C) and operates much like a standard aerial snow sensor.
- Ambient Freeze Protection: This algorithm is intended for gutters and freeze protection applications. It turns the heater on when the ambient temperature drops below 38°F (3°C).

Online Weather Forecast Control eliminates the need for local sensors, which can reduce project cost and simplify installation. Web-based control is an excellent option for surface melting systems, systems designed to keep ledges clear of ice and snow, and systems where users want additional control.

3.2.7 Hybrid Freeze Protection

Hybrid Freeze Protection offers an energy efficient option for freeze protection users looking to reduce unnecessary operation. The control mode requires a local temperature sensor (pipe or ambient), an internet connection, and an address with zip code. The device operates like a normal sensor-controlled thermostat as described in section 3.2.1 while the Frio Cloud platform monitors a 6-hour temperature forecast at the controller's location. If the forecast shows temperatures will be above 35°F (2°C) for the next 6 hours, the cloud platform will send an override off command to the system. This approach prevents the system from heating during transition periods where freezing conditions are not present, but the heater would otherwise be calling for heat. This approach can reduce energy usage by up to 40% while ensuring complete reliability. If the internet connection is lost at any point, the device reverts to normal freeze protection control.

3.2.8 Temperature Maintenance Scheduler

When connected to the internet, the Frio S1 can be placed in Temperature Maintenance Scheduler control mode which will enable or disable Temperature Maintenance mode on the controller based on a pre-defined schedule selected by the user. When a Frio S1 is in Temperature Maintenance mode, the controller uses a local sensor and a user-defined setpoint to maintain the temperature of the system. During ON periods, the schedule will enable Temperature Maintenance mode on the controller, where the controller will heat when the system temperature is below the setpoint. During OFF periods, the scheduler will disable Temperature Maintenance mode and override the heater off. While this is happening, the controller will not heat the system, regardless of system temperature. If the Frio S1 controller loses its online connection to the Frio Cloud for any reason, it will enter Offline Fallback mode. In

Offline Fallback mode, the controller will run in constant Temperature Maintenance mode, without regard for any ON or OFF periods based on time and day. Available Schedules include:

- Nursing Home
- Apartments
- Family Home
- Prison
- Hospital

3.2.9 Pilot Duty Mode

Pilot Duty Mode allows the Frio S1 controller to provide a 120 V control signal to a contactor or control panel and can be used with any control mode. This configuration allows a single Frio S1 to provide control for a large number of heating circuits. To activate Pilot Duty Mode, select **Settings** from the **Main Menu**, then select **Advanced Settings** from the **Settings Menu**. Select **Pilot Duty** from the **Advanced Settings Menu,** and set it to ON. Selecting Pilot Duty Mode will disable GFEP functionality. While in pilot duty mode, GFEP can be re-enabled manually by the user from the GFEP menu in advanced settings. Do not use pilot duty if you are directly controlling a heater from the Frio S1. For questions about contactor or control panel compatibility. Please contact Frio at info@frio.co.

3.2.10 Satellite Contactors

Multiple Frio S1-A controls may be tied together using the Modbus network to allow for one controller to act as the primary controller that will then activate up to 20 satellite contactor controllers. This configuration works with Frio snow sensors but is not available if the Modbus network is being used to communicate with a Gateway or BMS system. To configure the satellite contactors, follow the instructions below.

Step 1: Install the Primary S1-A controller and the S1-A satellite contactors. (Read the Frio S1 installation Instructions which can be found in section 4). Make the 3-wire Modbus RS485 connection between all S1-A controllers.

Step 2: Program the S1-A Controllers as satellite contactors

1. Turn on the supply power to all S1-A satellite contactors.
2. Select **Settings** from the **Main Menu**, then select **Advanced Settings** from the **Settings Menu**. Select **Modbus** from the **Advanced Settings Menu**. Program the Modbus settings as follows:
    a. MODE: “Server”
    b. DEVICE ADDRESS: Assign the device a unique Modbus address in the range of 1-20, inclusive
    c. BAUD RATE: “38400”
    d. PARITY: “None”
    e. STOP BITS: “1”
3. Navigate back to the **Main Menu** and select **Settings**.
    a. From the **Settings Menu** set the control mode to “Always ON”.
4. Repeat these steps for each S1-A satellite contactor.

⚠ ***NOTE: Ensure all satellite contactors that are connected to a single S1-A have a unique Device Address.***

Step 3: Program the Primary S1-A Controller

1. Turn on the supply power to the Primary S1-A Controller. Configure snow sensors prior to the next step.
2. Select **Settings** from the **Main Menu**, then select **Advanced Settings** from the **Settings Menu**. Select **Satellite Contactors** from the **Advanced Settings Menu**.

3. Select **Auto-Detect S1's** and press **Enter**. The device will scan for all available satellite contactors. The scan takes approximately 20 seconds.
    a. If S1s are detected, the screen will display the number of S1s detected. A list of S1s and device addresses will be visible on the Satellite Contactors menu.
    b. If no S1s are detected, the screen will display "zero (0) S1s detected."

To test the system, select **Force System On** from the **Main Menu** and select "5 MIN" to override the heaters on. Confirm that the satellite contactors turn on.

3.3 SENSORS

The Frio S1 device includes internal sensors that monitor supply voltage, operating current, and ground fault current. Information from these sensors is used for control of the system, system monitoring, alarms, and GFEP. The Frio S1-B is compatible with a thermistor that is included with the unit. The Frio S1-A works with two external temperature sensors, the thermistor (included) and a PT100 RTD. The Frio S1-A is also compatible with Frio's snow and ice sensors.

3.3.1 Temperature Sensors

Temperature sensors are used with the Frio S1 to provide input(s) for control, monitoring, and – when configured – the high-limit cutout. To configure the sensors, select **Settings** from the **Main Menu**, then select the sensor you would like to configure. Depending on the control mode you have selected you will see a list of options for each sensor.

- **None**: The sensor is not configured. The Sensor Loss alarm will be disabled for that sensor.
- **Ambient**: The sensor is used to sense ambient temperature. Make sure ambient sensors are installed outdoors away from any heat source and not in direct sunlight. If two sensors are configured and only one sensor is set to ambient, the ambient sensor will not be used for the Low Temperature Alarm.
- **Pipe**: The sensor is located on the pipe or vessel that is being heated.
- **Slab**: The sensor is located in the slab. If the device is in Local Snow Melt mode, configuring a slab sensor will enable the slab control thermostat mode (see section 3.2.4.4).
- **High Limit**: The sensor is being used as a high-limit cutout and will not be used as an input to the control algorithm. This feature is available on the S1-A only. See section 3.6.1.3 for more details.

At least one temperature sensor is required for Freeze Protection, Temperature Maintenance, Hybrid Freeze Protection, Cloud Scheduler, and Local Snow Melt with a pavement sensor. If no sensors are selected and the device is placed in a control mode that requires a temperature sensor, the thermistor will be automatically set to "Ambient". At least one temperature sensor is required if either the High or Low temperature alarms are enabled. Both sensors are required for Dual Temperature Freeze Protection; if none are selected the thermistor will default to "Ambient" and the RTD will default to "Pipe".

3.3.1.1 Thermistor

The Frio S1 should only be used with the Frio thermistor. The Frio thermistor is a 10k NTC thermistor with ± 1% accuracy. The Frio thermistor has an operating range of -40°C to 105°C, an IP68 rating and is RoHS Compatible. Each Frio thermistor comes with a 20 ft. (6 m) lead, which may be extended as required using twisted shielded pair 24 AWG wire. The lead wire is black TPE, and the thermistor tip is encapsulated using black TPE. The thermistor leads may be extended up to 500 ft. using 18 AWG shielded wires and up to 1000 ft. using 12 AWG shielded wires.

3.3.1.2 RTD (Available on the S1-A Only)

The Frio S1-A is compatible with all 3 wire pt100 RTDs. RTD lead wires must be 18-24 AWG shielded twisted pair. The Frio S1-B does not accept RTD input.

3.3.2 Snow and Ice Sensors

Frio Snow and Ice sensors detect if moisture is present, then send this information via Modbus to the Frio S1-A controller. The Aerial Sensor (AER-1) and Gutter Sensor (GUT-1) also send temperature to the Frio S1-A, while the Pavement Sensor (PVT-1) requires the use of a separate ambient temperature sensor which can be the thermistor that comes with the S1-A. When moisture and freezing temps are detected, the heating system is activated. The sensors are connected to a junction box (SM-JB-1) with a 30 foot (10 m.), 24V 4 wires cable (can be extended up to 1000 ft. with 4-wire shielded cable, 18-AWG or larger). The SM-JB-1 junction box includes a 24VAC power supply to provide power to the sensors. Each Frio S1-A can accept any combination of up to (6) total snow sensors and will activate when any single sensor detects snow or ice.

For more information on Frio Snow and Ice sensors and how to use the Frio S1-A to control snow melt systems, please reference the Snow Melt Design Guide which can be found at www.frio.co/resources.

3.3.2.1 AER-1 Aerial Snow Sensor

Designed to detect falling snow, the AER-1 can be mounted on a vertical piece of conduit or by using the optional wall mount bracket (AER-WM). The AER-1 includes anti-nesting spikes to protect the sensor from birds. This sensor includes an ambient temperature sensor and operates on 24VAC from the SM-JB-1.

3.3.2.2 GUT-1 Gutter Snow Sensor

The robust rust-proof gutter sensor is designed to lay flat in a gutter to detect moisture, meltwater, or snow accumulations. This sensor includes an ambient temperature sensor and operates on 24VAC from the SM-JB-1.

3.3.2.3 PVT-1 Pavement Snow Sensor

The pavement sensor can be installed in the ground and is designed to detect moisture or snow accumulation. The sensor is mounted via four screws to a standard PVC 4" diameter round junction box, allowing easy removal for service. The PVT-1 requires a thermistor to be connected to the S1-A to sense ambient temperature. The PVT-1 operates on 24VAC from the SM-JB-1.

3.3.2.4 SM-JB-1 Snow Sensor Power Supply and Junction Box

Each moisture sensor includes a small heater to ensure the sensing surface does not freeze. The SM-JB-1 includes a power supply which runs these heaters and serves as a junction box to tie together the Modbus signals from each sensor. At least one SM-JB-1 is required for each S1-A acting as a primary controller using snow sensors. The SM-JB-1 can power up to (6) AER-1 or GUT-1 sensors and up to (2) PVT-1 sensors and can be wired to accept input voltage 120 – 277VAC. For systems using multiple pavement sensors, additional SM-JB-1 junction boxes may be required as shown in the below:

Combinations with (1) SM-JB-1

- (6) Mix of AER-1 or GUT-1
- (2) PVT-1
- (1) PVT-1 and (1) AER-1

Combinations with (2) SM-JB-1

- (4) PVT-1
- (3) PVT-1 and (1) AER-1

Combinations with (3) SM-JB-1

- (6) PVT-1
- (5) PVT-1 and (1) AER-1

3.3.2.5 Configuring Local Snow Sensors

Step 1: Install Sensors and Controller

1. Install the snow sensors in a suitable location.
2. Install the SM-JB-1 and make all wiring connections.
    a. Connect all snow sensors to the SM-JB-1.
    b. Make the 3-wire Modbus RS485 connection between the SM-JB-1 and the S1-A.

c. Connect supply power to the SM-JB-1.

3. Install the S1-A (Read the Frio S1 installation Instructions which can be found at www.frio.co/resources).
    a. Connect supply power to the S1-A.
    b. [Optional] Connect the Thermistor or RTD if you plan to use a temperature sensor as the primary fallback option. Ensure the sensor is located outdoors where it will read the ambient temperature.
    c. [Optional] Connect the dry-contact alarm output to your Building Management System (BMS).

Step 2: Program the Primary S1-A Controller

1. Turn on the supply power to the SM-JB-1.
2. Turn on the supply power to the S1-A and wait for the device to boot up.
3. Navigate to **Snow Sensors** on the **Main Menu**.
    a. Select **+Auto-Detect Sensors** and start the sensors scan. The device will scan for any connected sensors for ~20 seconds.
    b. If sensors are detected, they will be displayed on the screen along with the sensor type and address.
    c. If no sensors are found, the screen will display "(0) sensors detected".
4. Navigate back to the **Main Menu** and select **Settings**.
    a. From the **Settings Menu** set the control mode to "Local Snow Melt".
5. There are two available fallback modes if the snow sensor connection is lost described in section 3.3.2.6 below.
    a. [Optional] To set up the device with an ambient temperature sensor as the fallback mode, connect either a Thermistor or RTD and set at least one sensor to **Ambient.** Set the **Setpoint** to a temperature between 35F - 40F. If the connection to all configured snow sensors is lost, the system will turn on the heater when the temperature sensor reads below the **Setpoint**.
    b. If you do not connect a temperature sensor, the system will fall back into the **Failure State** if the connection to the snow sensor is lost. If you connected a temperature sensor in the step above, the device would go into the **Failure State** if both the snow sensor and the temperature sensor are lost. Set the **Failure State** to ON or OFF.

3.3.2.6 Snow Sensor Fallback Mode

All snow melt control methods offer two fallback modes in case the sensor of internet connection is lost:

- **Ambient Fallback (Recommended):** When the system is configured with an ambient temperature sensor, it will automatically fall back to ambient control if the sensors or internet connection is lost. This ensures that the system will continue to operate if freezing conditions are present but will prevent the system from operating during warm weather. This fallback mode provides users with time to troubleshoot and fix their system while ensuring the system operates with relative efficiency. The Frio S1-A and S1-B controllers include a thermistor which can be used as the ambient sensor to provide this fallback mode.

- **ON/OFF Fallback:** For systems without an ambient temperature sensor, or in the case where all sensors have failed, users can set a **Failure State** of Heater ON or Heater OFF. For critical systems such as egress and gutters, Frio recommends setting this mode to Heater ON. For large, high-power systems such as driveways, Frio recommends this be set to Heater OFF.

3.4 Ground Fault Equipment Protection (GFEP)

The Frio S1 device includes integrated Ground Fault Equipment Protection (GFEP) and had been tested by UL to the UL 1053 end product standard. Ground Fault Equipment Protection is designed to shut off power to the heater in the event of leakage current in excess of the GFEP threshold.

3.4.1 GFEP Overview

The GFEP circuit measures the sum of the current on the two conductors feeding the heater and compares this value to a set trip level. If the value exceeds the set trip level, the controller will open the relay, shutting off the heating circuit. Since the current flowing out to the heater should equal current flowing back from the heater, measured ground fault current should be near 0 mA. If the value is greater than 0 mA, that is an indication that leakage current is flowing to some other part of the system. Some leakage current can be expected with heating systems, including self-regulating heat trace; however, systems with high leakage current are dangerous and should not be used. The default setting for the GFEP Trip Level is 30 mA.

3.4.2 Adjusting the GFEP Trip Level

The GFEP Trip Level on the Frio S1 controller is adjustable from 30 mA to 300mA. Frio does not recommend setting the GFEP threshold above 30 mA. In limited circumstances and always under the guidance of a licensed electrician, the GFEP threshold may be set to a value above 30 mA. To do this, select **Settings** from the **Main Menu**, then select **Advanced Settings** from the **Settings Menu**. Select **Ground Fault Protection** from the **Advanced Settings Menu**, then select **GFEP Trip Level**. Enter the desired trip level, then confirm to set the GFEP Trip Level.

> ⚠ **NOTE: FRIO DOES NOT RECOMMEND SETTING THE GFEP THRESHOLD ABOVE 30 mA.**

3.4.3 Disabling GFEP

To disable GFEP, select **Settings** from the **Main Menu**, then select **Advanced Settings** from the **Settings Menu**. Select **Ground Fault Protection** from the **Advanced Settings Menu**, then select **GFEP Trip** and change the setting to OFF. When the GFEP Trip setting is turned OFF the system WILL NOT turn off the heating circuit in the event of a ground-fault but will trigger a *GF Current High* alarm.

> ⚠ **NOTE: FRIO DOES NOT RECOMMEND DISABLING THE GROUND FAULT EQUIPMENT PROTECTION CIRCUIT AS IT MAY RESULT IN DAMAGE TO THE CABLE OR SURROUNDING EQUIPMENT.**

3.4.4 Testing the GFEP circuit

To test the GFEP circuit, follow the step-by-step instructions in section 4.7 of this manual.

Periodic testing of the GFEP circuit is required in most settings. The results of the test are to be recorded on a test form such as the one provided with the S1 Installation Instructions in section 4. The tester shall record on the form the date the test was performed and the results and shall ensure the form is retained by those in charge of the building's electrical installation to be available to the authority having jurisdiction.

3.5 COMMUNICATION

Frio S1-A and S1-B devices are capable of communication with the Frio cloud platform when an internet connection is available. The S1-A device also supports Modbus communications via a three-wire RS 485 connection and BACnet communications via IP or MS/TP using a Frio Gateway.

3.5.1 Internet Connection

All Frio S1 devices can connect securely to the internet via a Wi-Fi connection or a wired ethernet connection, as described in sections 3.5.1.1 and 3.5.1.2. Ethernet and Wi-Fi network connections may be disabled via the HMI. To disable the network connection, select **Networking** from the **Main Menu**, then select **Turn Off Networking**. You will be asked if you want to **Disable** networking**?** Select **Yes** to disable the network. To reenable the network connection, follow the same directions and select **Yes** when asked if you want to **Enable** networking.

3.5.1.1 *Ethernet*

The S1 can connect to the Frio cloud platform via an ethernet connection and supports 10Mbps and 100Mbps operation. For firewall requirements, please review section 3.5.1.4 below. Use the Frio Mobile App to configure a Frio S1 device connected to ethernet via the BlinkUp process.

3.5.1.2 *Wi-Fi*

The Frio S1 is designed to use 802.11n Wi-Fi operating in the 2.4GHz band or the 5GHz band. It is also compatible with older 2.4GHz 802.11b, 802.11g, and 802.11a networks.

To connect a Frio S1 device to a Wi-Fi Network use the Frio Mobile App. The mobile app will allow you to configure the device via the BlinkUp process and connect to a Wi-Fi network. BlinkUp will be active for 5 minutes when the device is powered on and will be disabled 10 seconds after the device connects to the network. To manually activate BlinkUp select **Networking** from the **Main Menu**, then select **Rerun BlinkUp**. To clear the Wi-Fi credentials from the device, select **Networking** from the **Main Menu,** then select **Clear Network Credentials**. You will be asked if you want to **Clear All Credentials?** Select **Yes** to clear the Wi-Fi credentials and restart the BlinkUp process.

For security reasons, Frio S1 devices cannot be configured to operate as a Wi-Fi hotspot (access point). The Frio S1 is capable of determining what kind of security — WEP, WPA, or WPA2 — is being used by the network it is attempting to connect to. It supports all of these 'consumer' security mechanisms.

If you configure a Frio S1 device to connect to your password-protected Wi-Fi network but subsequently downgrade the security of the network by removing the password, the device will no longer connect to the network. To re-connect, the device must be reconfigured with a blank password. This is by design. It is intended to prevent your device (and other devices on the network) from being 'captured' by a rogue Wi-Fi access point masquerading as your network router. It can do this by transmitting the same SSID as your network but at a higher signal strength, but without the password, which the assailant does not know.

The Frio S1 does not currently support enterprise-level Wi-Fi authentication, 802.1x, which requires that you log in with a username and password as well as the customary SSID. An end-user will not be able to connect a Frio S1 device in such an environment at this time. There are ways to use the Frio S1 in enterprise environments, however. Many enterprises provide WPA2 Personal-based networks for guest access and to support other devices, such as network printers, which do not support WPA2 Enterprise. Please check with your IT department.

The Frio S1 does not support networks that present an HTML form in which the user enters login details before network access is granted. Some consumer routers use this approach, but it is most commonly encountered with public hotspots and some guest networks in corporate environments.

3.5.1.3 *Static Network Configuration*

The Frio S1 supports static network configurations and access through proxy servers on both Wi-Fi and Ethernet connections. To configure a static network configuration or proxy server, select the appropriate option while setting up your device using the Frio mobile app. The 'Static IP' section requires the entry of an IP address, netmask, gateway address and at the address of at least one DNS server, all in quad numeric form, e.g. 192.168.0.1. If the connection is not working, try including both the primary and secondary DNS servers. The 'Proxy' settings page requires a server address and a port number at minimum.

3.5.1.4 *Firewall Requirements*

The Frio S1 is a Wi-Fi and Ethernet compatible device that only makes outbound connections. Firewall configuration is required if the firewall stops outbound connections. This is rarely the case with consumer routers but commonplace

in corporate environments. The device communication makes use of the ports shown in the table below, which need to be open through a firewall.

Port	TCP	UDP	Usage
31314	✓		Initial device-server connection
993	✓		Fallback device-server connection #1
443	✓		Fallback device-server connection #2
80	✓		Fetch device firmware
53		✓	Allow DNS look-ups — Systems with non-default DNS settings

The S1 will attempt to connect via TCP port 31314. If this fails, it will attempt to use TCP port 993, which is typically open by default for email traffic. Should both 31314 and 993 be closed, it will try 443. The S1 does not use UDP. Port 80 is used to request and transfer impOS™ updates. This port is typically open by default for HTTP/HTTPS communications.

3.5.1.5 BlinkUp Codes

The Frio S1 provides users with information on the internet connection via the BlinkUp LED. The table below includes status codes that can be shown via the BlinkUp LED.

Ready for activation	500ms	500ms	Repeat									
BlinkUp Successful	For three seconds											
Device waiting for Ethernet	500ms	500ms	250ms	250ms	Repeat							
Searching for Wi-Fi network	500ms	500ms	500ms	250ms	250ms	250ms	Repeat					
Joining Wi-Fi network	500ms	500ms	500ms	250ms	250ms	250ms	250ms	250ms	Repeat			
Getting IP address	500ms	250ms	250ms	Repeat								
Resolving server name	500ms	250ms	250ms	Repeat								
Connecting to server	500ms	500ms	500ms	250ms	Repeat							
Connected to server	500ms	500ms	Repeat									
Proxy address or port incorrect	500ms	500ms	250ms	250ms	250ms	250ms	Repeat					
Proxy credentials rejected	500ms	500ms	250ms	250ms	250ms	250ms	250ms					
Device lost connection	500ms	500ms	Repeat									
Device deliberately offline	500ms	250ms	250ms	250ms	Repeat							
Updating Firmware	Continuous for duration of update											
Normal operation	LED not illuminated											

3.5.2 Modbus and BACnet

The Frio S1-A Heating Controller is capable of BACnet IP and BACnet MS/TP communication via an MSA Gateway. The device features a Modbus RTU Slave Interface to allow communication to the MSA Gateway. Up to 10 S1-A controllers can be serially connected to one MSA Gateway. A list of BACnet objects available for each Frio S1-A controller is included in the table below. Note, the S1-B is not capable of Modbus or BACnet communications. For more information on Modbus and BACnet including a Modbus points list go to www.frio.co/resources.

Object	Name	Type	Units	Range/Options	Read/ Write	Description
AI1	Current	Analog Input	Amps	0-50 A	R	Current consumption of connected heaters. *NOTE: The controller is only rated to 30 A*
AI2	Voltage	Analog Input	Volts AC	0-300 V	R	Voltage measurement from power supply to controller. *NOTE: The controller is only rated to 277 V*
AI3	RTD Temp C	Analog Input	°C	-100°C to 7500°C	R	Temperature reading from RTD in Celsius, if connected. *NOTE: If RTD is not connected the read value will be 65535.*
AI4	Thermistor Temp C	Analog Input	°C	-40°C to 105°C	R	Temperature reading from thermistor in Celsius, if connected. *NOTE: If Thermistor is not connected the read value will be 65535.*
AI5	RTD Temp F	Analog Input	°F	-148°F to 13822°F	R	Temperature reading from RTD in Fahrenheit, if connected. *NOTE: If RTD is not connected the read value will be 65535.*
AI6	Thermistor Temp F	Analog Input	°F	-40°F to 221°F	R	Temperature reading from thermistor in Fahrenheit, if connected. *NOTE: If Thermistor is not connected the read value will be 65535.*
AI7	Controller Mode	Analog Input	No Units	0 = ALWAYS_OFF 1 = ALWAYS_ON 2 = THERMOSTAT_FP 3 = THERMOSTAT_TM 4 = CLOUD_CONTROL 5 = HYBRID_ CLOUD_FP 6 = CLOUD_ SCHEDULER _TM 8 = DUAL_TEMP_FP	R	Current controller setting. • ALWAYS_OFF = Local manual control heater is always OFF. • ALWAYS_ON = Local manual control heater is always ON. • THERMOSTAT_FP = Local thermostat control for freeze protection • THERMOSTAT_TM = Local thermostat control for temperature maintenance • CLOUD_CONTROL = Cloud-based control for all smart control modes • HYBRID_CLOUD_FP = Freeze protection thermostat with weather forecast data input for efficiency improvements • CLOUD_SCHEDULER_TM = Cloud-based scheduler • DUAL_TEMP_FP = Dual temperature Freeze Protection
AI8	State	Analog Input	No Units	0 = CLOUD_CONTROL 1 = LOCAL_CONTROL 2 = OVERRIDE 3 = CRITICAL_ERROR 4 = MODBUS_ CONTROL 5 = HYBRID_CONTROL 6 = SPOTCHECK 7 = CLOUD_ SCHEDULER	R	Current operational state of the control state machine. See the table on the following page for possible State/Sub-state combinations.
AI9	Sub-state	Analog Input	No Units	0 = THERMOSTAT_FP 1 = THERMOSTAT_TM 2 = ALWAYS_ON 3 = ALWAYS_OFF 4 = CLOUD_CONTROL 5 = HYBRID_ THERMOSTAT	R	Current operational sub-state of the control state machine. See the box on the following page for possible State/Sub-state combinations.
AI10	Network Connection	Analog Input	No Units	0 = CONNECTING 1 = CONNECTED 2 = DISCONNECTED 3 = DISABLED	R	Current network connection status of the S1. The states apply for both ethernet and Wi-Fi connection types.
BI11	Alarm	Binary Input	No Units	0 = No Alarms 1 = One or more alarms present	R	Alarm summary indicating whether any alarms are present on the device.
BI12	Heater Relay State	Binary Input	No Units	0 = Relay is open, heater is OFF 1 = Relay is closed, heater is ON	R	Current state of the heater.
AO13	Force On/Off	Analog Output	No Units	0=DO_NOTHING 1=FORCE_ON 2=FORCE_OFF	R/W	Forces relay into On/Off state, ignoring the device's control mode. • DO_NOTHING = Device will operate according to the control mode in settings • FORCE_ON = Device will enter MODBUS_CONTROL/ALWAYS_ON • FORCE_OFF = Device will enter MODBUS_CONTROL/ALWAYS_OFF *NOTE: Modbus override takes priority over local and cloud override.*

BACnet Points List Continued

Object	Name	Type	Units	Range/Options	Read/ Write	Description
BI14	Alarms - GFEP Trip	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Ground fault trip alarm
BI15	Alarms - GFEP System	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Ground fault system alarm
BI16	Alarms - Low Temperature	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Low temperature alarm
BI17	Alarms - High Temperature	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	High temperature alarm or high temperature cutout alarm
BI18	Alarms - Low Current	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Low current alarm
BI19	Alarms - High Current	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	High current alarm
BI20	Alarms -Thermistor	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Temperature sensor alarm - thermistor
BI21	Alarms -RTD	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Temperature sensor alarm - RTD
BI22	Alarms - Power Loss	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Power loss alarm
BI23	Alarms -Network	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Internet network connection loss alarm
BI24	Alarms -GF High Current	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Ground fault high current alarm
BI25	Alarms -Power Monitor	Binary Input	No Units	0 = No Alarm 1 = Alarm Active	R	Power monitor system alarm

3.5.2.1 Device State/Substate Table

State	Sub-State	Description
CLOUD_CONTROL	CLOUD_CONTROL	Device online and controlled by the Frio Cloud Platform
	THERMOSTAT_FP	Offline fallback to thermostat control for freeze protection
	THERMOSTAT_TM	Offline fallback to thermostat control for temperature maintenance
	ALWAYS_ON	Offline fallback to always ON
	ALWAYS_OFF	Offline fallback to always OFF.
LOCAL_CONTROL	THERMOSTAT_FP	Local thermostat control for freeze protection
	THERMOSTAT_TM	Local thermostat control for temperature maintenance
	ALWAYS_ON	Local manual control heater is always ON.
	ALWAYS_OFF	Local manual control heater is always OFF
	DUAL_TEMP_THERMOSTAT_FP	Local dual temperature thermostat control
OVERRIDE	ALWAYS_ON	Heater ON due to Local or Cloud override command
	ALWAYS_OFF	Heater OFF due to Local or Cloud override command
CRITICAL_ERROR	ALWAYS_OFF	The system has a critical error, and the heater is OFF NOTE: User must perform a manual test/reset cycle to exit the critical error state.
MODBUS_CONTROL	ALWAYS_ON	Heater is ON due to Modbus force on command
	ALWAYS_OFF	Heater is OFF due to Modbus force off command
HYBRID_CONTROL	HYBRID_THERMOSTAT	Weather data indicates that heater operation can be suspended.
	THERMOSTAT_FP	Operating as local freeze protection thermostat
SPOTCHECK	ALWAYS_ON	Checking S1 status with heater ON
	ALWAYS_OFF	Checking S1 status with heater OFF
CLOUD_SCHEDULER	THHERMOSTAT_TM	Controller is on local thermostat mode due to selected schedule
	ALWAYS_OFF	Heater is OFF due to selected schedule

3.5.3 Dry Contact

The Frio S1 is equipped with a dry contact to provide users with a low voltage alarm output option. The dry contact is normally closed and opens when the Frio S1 has an alarm signal or loses power. The contacts are rated for 2 A maximum at 250 VAC and are compatible with 14-24 AWG wires. Users can set which alarms are enabled as described in the following section. All enabled alarms will activate the dry contact.

3.6 ALARMS

The Frio S1 has nine alarms described in the following sections. If an alarm is present the Alarm LED will light up, and the normally closed dry contact will open. There are five user-settable alarms: *High Current*, *Low Current*, *Low Temperature*, *High Temperature and High Temperature Cutout (S1-A only)*. There are three system alarms which are automatically enabled and cannot be configured by the user: *Sensor Failure*, *Power Loss*, and *Network Loss*. Lastly there is the Ground Fault Equipment Protection alarm (*GFEP Alarm*). Online systems may be configured to notify users of alarm conditions through the Frio cloud platform. Users may also use the cloud platform to view information about each alarm. All alarms must be reset at the device via the HMI. A summary of alarms is shown in the table below.

Alarm	Type	Enabled by Default	Default Threshold	Range	Increment	Delay	Default Delay
Low Current	User-Settable	No	0.1 A	0-30 A	0.1 A	0-500 s	5 s
High Current	User-Settable	Yes	30 A	0-30 A	0.1 A	0-500 s	300 s
Low Temperature	User-Settable	No	28 °F	S1-A: -40 °F to 1292 °F S1-B: -40 °F to 212 °F	1 °F	0-500 s	300 s
High Temperature	User-Settable	No	140 °F	S1-A: -40 °F to 1292 °F S1-B: -40 °F to 212 °F	1 °F	0-500 s	300 s
High Temperature Cutout	User-Settable	No	185 °F	S1-A: -40 °F to 1292 °F	1 °F	0-500 s	5 s
Sensor Failure	System Alarm	Yes	False	-	-	No	-
Power Loss	System Alarm	Yes	False	<50 VAC	-	3s	3s
Network Loss	System Alarm	Yes	False	-	-	1 hr	1 hr
GFEP Trip	GFEP	Yes	30 mA	30-300 mA	5 mA	No	-

3.6.1 User-Settable Alarms

User-settable alarms are designed to provide the user with a method to monitor their system and to understand if the system is operating outside of normal bounds. These alarms may be enabled or disabled via the HMI and include *High Current*, *Low Current*, *Low Temperature*, *High Temperature and High Temperature Cutout (S1-A Only)*. Enabled alarms will open the dry contact when set. With the exception of *High Current*, user-settable alarms are not enabled by default and must be enabled by the user. To configure all user-settable alarms except for the High Temperature Cutout, select **Settings** from the **Main Menu**, then select **Advanced Settings** from the **Settings Menu**. Select **Alarms** from the **Advanced Settings Menu**, then select the alarm you would like to adjust. For each user-settable alarm, you will be able to enable the alarm, set the threshold, and set the delay. The delay is provided to reduce nuisance alarms. Non-critical user-settable alarms (*Low Current, High Temperature*, and *Low Temperature*) may be set to Latching or Non-latching in the alarm settings. This setting will apply to all enabled non-critical alarms. Non-latching alarms are automatically reset when the alarm condition is resolved.

3.6.1.1 High and Low Current Alarms

When using the *High Current* alarm with self-regulating heat trace, it is highly recommended to use a delay of at least 300s to avoid alarming due to inrush current when the heat trace is activated. The *High Current* alarm is a critical alarm and will shut off the heater automatically if the alarm is enabled. It is also a latching alarm and must be reset via the HMI.

The Low Current alarm is a non-critical alarm that may be used to determine whether or not adequate power is being used by the heater. The low current alarm can be used to identify situations where the heating circuit has been disconnected.

3.6.1.2 High and Low Temperature Alarms

The High and Low Temperature alarms may be used to identify situations where the system is out of the typical operating temperature range. Frio does not recommend using temperature alarms on ambient systems. These temperature alarms will trigger an alarm, but will not shut off the heater. If multiple temperature sensors are configured, the High Temperature Alarm will use the highest temperature reading and the Low Temperature Alarm will use the lowest temperature reading. If two sensors are configured and only one sensor is set to ambient, the ambient sensor will not be used for the Low Temperature Alarm. At least one temperature sensor is required to be configured if using temperature alarms.

3.6.1.3 High Temperature Cutout

The High Temperature Cutout will trigger an alarm and shut off the heater if the temperature reading from the High Limit sensor exceeds the High Limit Threshold. The High Temperature Cutout is available on the S1-A and is not available on the S1-B. To configure the High Temperature Cutout, select **Settings** from the **Main Menu**, then set one or both of the temperature sensors to High Temp. Once one of the temperature sensors is set to High Temp, the **High Limit Cutout** option will be available under **Settings**. Select **High Limit Cutout** to enter the **High Limit Cutout Menu** to set the threshold and delay. When a temperature sensor is configured as the High Limit, it will not be used for control.

3.6.2 Sensor Failure Alarms

If a temperature sensor is configured and has failed or is disconnected, the device will indicate either a Thermistor Alarm or RTD Alarm. If the device is in a control mode that requires a temperature sensor and all configured control sensors fail, the device will enter the failure state. To configure the failure state for thermostat devices, select **Settings** from the **Main Menu**, then select **Failure State** from the **Settings Menu**. The failure state may be set to ON or OFF. The default setting for the failure state is ON. If the sensor returns to normal operation, the system will revert from the failure state and resume using the sensor for control. However, the Sensor Failure alarm is latching, so the alarm will remain present until it is reset via the HMI. If the device is set to use two temperature sensors and one sensor fails, the device will use the other sensor and display a Sensor Failure Alarm. If both sensors fail, the device will enter the failure state.

For Snow Melt systems a Snow Sensors Alarm will be displayed if the control mode is set to Local Snow Melt and no snow sensors are communicating with the Frio S1. The device will enter the Fallback Mode as described in section 3.3.2.5. When a snow sensor is configured and communication with that sensor is lost, the device will display an alarm showing the sensor type and ID. If a ground sensor is connected and the ambient temperature sensor is lost, the ground sensor will be considered lost.

If a satellite contactor is configured and communication with the satellite contactor is lost, the device will display a Sat. Cont. Alarm with the ID of the lost contactor.

3.6.3 Power Loss Alarm

In the event of a power loss, or if the supply voltage drops below 50 VAC for more than 3 seconds, the device will enter power loss mode. In power loss mode, the normally closed dry contact will open, and the HMI will display “POWER LOSS” until the onboard supercapacitor empties. A “last gasp” communication is sent to the cloud platform on connected systems. This enables the device to tell the cloud that it has lost power. When the device is reconnected to power, the power loss alarm is automatically reset. For more information on power loss mode, see section 5.6.

3.6.4 Network Loss Alarm

If the device has been through BlinkUp and networking is enabled, the network loss alarm will be enabled, and a loss of network will trigger an alarm. There is a one-hour delay to prevent nuisance alarming if the network drops momentarily. If the device is in a cloud control mode and the network is lost, it will revert to a preselected local control mode.

3.6.5 GFEP Alarm

When the ground fault current exceeds the GFEP Trip Level, the GFEP system will alarm, open the dry contact, and shut off the heating system. The GFEP alarm is a critical alarm that is latching and must be reset by the user via the HMI where it will show under Active Alarms as GFEP Trip. When the alarm is reset by a user, the device will automatically run a GFEP test and must pass in order to clear a GFEP alarm.

When GFEP Trip is disabled, the system will not turn off the heating system when the ground fault current exceeds the GFEP Trip Level, but the system will still activate the GFEP alarm and open the alarm dry contact. In this case, the GFEP alarm will be latching and must be cleared via the HMI where it will show under Active Alarms as GF High Current.

3.6.6 Active Alarms

Active alarms can be viewed from the HMI by selecting **Active Alarms** from the **Main Menu**. The active alarm page will display all active alarms. The user may select an alarm to view: *Duration* (the time since the alarm condition started), *Returned?* (whether the alarm condition ceased/returned to normal).

3.6.7 Resetting Alarms

To reset the alarms, select **Active Alarms** from the **Main Menu**, then select **Reset All**. You will then be prompted to **Test/Reset Now**, select **Yes** to initiate a GFEP test and reset the alarm conditions. The GFEP test must be successful in order to reset the alarms.

3.7 Device Info

Device info can be viewed under **Device Info** on the **Main Menu**. Available information includes.

Device Info	Description
FW Version	Device firmware version
P/N	Device part/model number
S/N	Unique device serial number
Device ID	Unique device ID number
Networking	Displays the radio state (ON, OFF)
Enrolled	Displays whether the device is enrolled with the Frio Cloud platform (Yes, No)
Connection	Connection type, (Wi-Fi, Cellular, Ethernet, or None if not connected)
IP	Device IP address (Wi-Fi and Ethernet)
Gateway	Device gateway address
DHCP	The DHCP server's IP address (Wi-Fi and Ethernet)
Network	The network the devices is currently connected to (Wi-Fi only)
rssi	Received signal strength indicator, a negative value closer to 0 shows stronger signal (Wi-Fi only)
Channel –	The Wi-Fi channel on the router (Wi-Fi only)
Link	"10M" or "100M". Only present when link detected (Ethernet only)

3.8 System Ratings

Power Ratings
Supply Voltage: 120 to 277 Nominal VAC 50/60 Hz.
Single phase power only (Note: 277 VAC is phase-to-neutral in 480/277 VAC 3- phase)
Double-pole relay is safe for 240 VAC with two hot legs
Maximum Load: 30 A resistive
Wire size: 10-18 AWG
GFEP
Programable from 30 mA to 300 mA (default 30 mA)
Manual and automatic test
Option to disable GFEP
Sensor Inputs
S1-A & S1-B: Frio Thermistor - 2-Wire shielded pair 24 AWG leads, 10k NTC thermistor with ± 1% accuracy, operating range of -40°C to 105°C, leads and thermistor tip are black TPE, IP68, and RoHS)
S1-A ONLY: RTD - Compatible with 3-Wire pt100 RTD lead size 14-24 AWG
S1-A ONLY: Frio Snow Sensors – AER-1 Aerial Sensor, GUT-1 Gutter Sensor, and PVT-1 Pavement Sensor
Low Voltage Outputs
Dry Contact Alarm: Normally Closed, Open on Alarm (contacts rated for 2 A max at 250 VAC, 14-24 AWG)
Connectivity
S1-A & S1-B: WI-FI 802.11 Dual Band 2.4 GHz & 5 GHz and Ethernet (RJ45, Cat 5 or 6) See operating manual section 3.5.1.4 for firewall information
S1-A ONLY: TIA/EIA 485 (RS-485) Frio Modbus (Isolated 3-wire 2 x Signal w/ GND, 14-24 AWG)
S1-A ONLY: BACnet MS/TP or IP via Frio Gateway
Enclosure/Environment
Surface Mounted Enclosure rated to IP67 and NEMA 4X
Operating Temperature -30 °C to 60 °C
Dimensions with mounting feet: H: 6.29 in. D: 3.625 in. W: 7.55 in.
Agency Ratings
UL 1053, CSA Standard C22.2 No. 14 (Ground-Fault Sensing and Relaying Equipment) UL 60730-1 (Automatic Electric Controls)
Complies with FCC Part 15 Subpart B
User Interface
2.42 in. OLED display 128 x 64 pixels
Four button interface
Four LEDs with one phototransistor used for BlinkUp process during installation
Menus are in English only
Imperial or Metric units
Warranty
Two-year limited warranty – view more warranty information at www.frio.co/legal

3.9 AGENCY APPROVALS

Both the S1-A and S1-B controllers are certified to UL Standard 1053 and are certified to CSA Standard C22.2 No. 14 for Ground-Fault Sensing and Relaying Equipment. Both controllers are also certified to UL 60730-1 for Automatic Electric Controls. The S1-A and S1-B devices carry a UL listing in the US and Canada.

Both the S1-A and S1-B devices comply with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

⚠ **NOTE: THE S1-A AND S1-B HAVE BEEN TESTED AND FOUND TO COMPLY WITH THE LIMITS FOR A CLASS B DIGITAL DEVICE, PURSUANT TO PART 15 OF THE FCC RULES. THESE LIMITS ARE DESIGNED TO PROVIDE REASONABLE PROTECTION AGAINST HARMFUL INTERFERENCE WHEN THE EQUIPMENT IS OPERATED IN A COMMERCIAL ENVIRONMENT. THIS EQUIPMENT GENERATES, USES, AND CAN RADIATE RADIO FREQUENCY ENERGY AND, IF NOT INSTALLED AND USED IN ACCORDANCE WITH THE INSTRUCTION MANUAL, MAY CAUSE HARMFUL INTERFERENCE TO RADIO COMMUNICATIONS. OPERATION OF THIS EQUIPMENT IN A RESIDENTIAL AREA IS LIKELY TO CAUSE HARMFUL INTERFERENCE IN WHICH CASE THE USER WILL BE REQUIRED TO CORRECT THE INTERFERENCE AT HIS OWN EXPENSE.**

Purpose of control: ..... :	Heating Controller (Operating Control – Non-safety related) Ground Fault Sensing and Relay Equipment
Operating ambient temperature ..... :	-30°C to 60°C
Shipping and storage temperature ..... :	-40°C to 60°C
Method of Mounting the Control ..... :	Surface Mounting
Action ..... :	Type 1
Overvoltage category ..... :	III
Pollution degree ..... :	4 / 2 (2 refers to the environment within the outdoor enclosure)
Rated Impulse Voltage ..... :	4kV
Max phase to ground voltage of supply source .... :	277VAC
Protection against electric shock class ..... :	Class I Equipment
Environmental ..... :	Suitable for Indoor or Outdoor Applications (unit employs IP67 and 4X enclosure)
Terminals Suitable for External Conductors ..... :	J11: L1, L2, GND AC SUPPLY and LOAD J10: RS485, ALARM, RTD, THERM

Wiring compartment contains line voltage and Class 2 wiring terminals. All wiring for all circuits within the wiring compartment shall be wired with wire rated 300V minimum and should be installed in accordance with all local and national electrical codes.

4 INSTALLATION INSTRUCTIONS

NOTE: THE CONTROLLER MUST BE INSTALLED BY A LICENSED ELECTRICIAN OR QUALIFIED PROFESSIONAL IN ACCORDANCE WITH LOCAL AND NATIONAL ELECTRICAL CODES. THE CONTROLLER MUST BE CONNECTED TO A CERTIFIED CIRCUIT BREAKER RATED FOR 30 A OR LESS. NO OTHER TYPES OF DEVICES MAY BE PLACED ON THE CIRCUIT BREAKER.

STEP 1: INITIAL INSPECTION AND PLANNING

1. Inspect the Frio S1 controller for any damage that may have occurred during shipping.
2. Layout and plan the heat tracing system, including all sensors, wiring, conduit, and junction boxes.
3. Determine the controller location. The controller should be mounted on a fixed vertical surface. The controller may be mounted outside but should not be mounted in direct sunlight to reduce the chance of condensation forming in the controller.

STEP 2: ASSEMBLY AND MOUNTING

1. Once you have determined the wiring layout and conduit sizes, mark the bottom face of the controller for power and sensor connections. If the controller is mounted outside, use only NEMA Type 4X (or higher) liquid-tight conduit fittings and cable glands.
2. Drill holes on the bottom face of the controller (mount fittings inside of the dashed line shown in Figure 1) and mount your conduit and cable fittings. Do not drill holes within 0.5” of the edge of the enclosure. After drilling the holes, ensure that all plastic shavings have been removed from the controller.

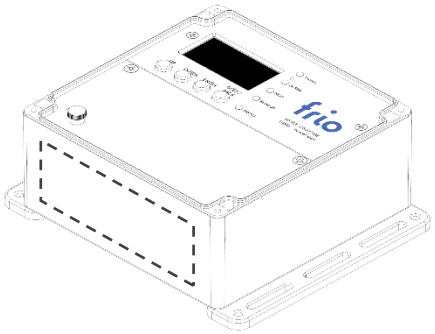


Figure 1: Frio S1 controller showing the bottom side where to drill wiring holes.

3. Mark hole locations on the vertical surface where you will mount the controller according to the dimensions shown in Figure 2. Ensure the mounting surface is flat, permanent, and the controller is protected from damage.
4. Mount the controller to the vertical surface.

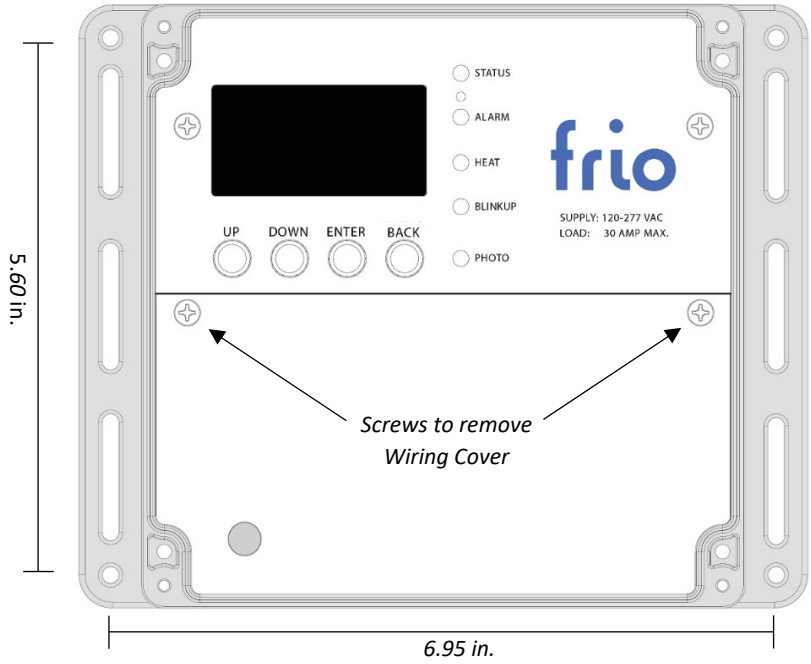


Figure 2: Top View of the Frio S1 controller showing mounting hole dimensions.

Step 3: Low Voltage Connections

1. Once the controller is mounted, you may remove the clear plastic enclosure cover and the white wiring cover. Always ensure that the wiring cover is in place before energizing the controller.
2. Connect low voltage sensor and communications wires according to the image in Figure 3.
3. For more information on sensor compatibility and setup, please consult the owner's manual.

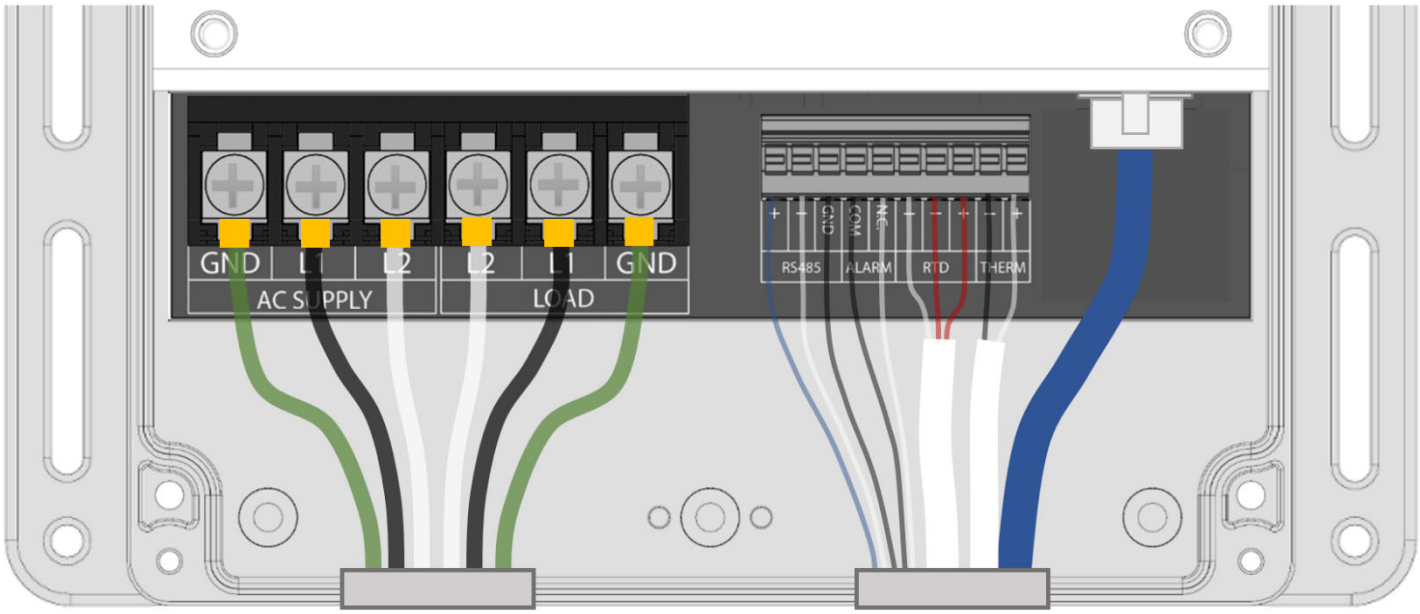


Figure 3: Top view of the Frio S1 controller with the wiring cover removed, showing all possible wiring connections.

NOTE: THE SYSTEM SHOULD NEVER BE ENERGIZED WHEN THE WIRING COVER IS NOT IN PLACE.

Step 4: Heat Trace and Power Connection

1. Ensure the circuit breaker connected to the controller is turned off.
2. Use an insulation tester resistance meter (Megger test) to check the integrity of the heat trace in accordance with the heat trace manufacturer's instructions.
3. Connect heat trace leads to the **LOAD** side as shown in Figure 3. The ground sheath of the heat trace must be connected to the ground terminal on the controller.
4. Connect the power leads to the **AC SUPPLY** as shown in Figure 3. The ground connection on the controller must be properly connected to ground in accordance with local and national electrical codes.
5. All power connections and wires should be installed in accordance with all local and national electrical codes. Use crimp connected spade terminals to ensure proper mounting in the power terminal blocks.

Step 5: Start Up and Configuration

1. Close the wiring cover before energizing the system.
2. Energize the system by turning on the circuit breaker connected to the controller.
3. **Configure the settings for your system.** Once the device has finished booting up, press any button to access the **Main Menu**, then select **Settings** to configure the device. Refer to section 5.4 of the S1 Operating Manual for available settings and consult section 3.2 to determine the control mode and configuration that will best serve your purpose.

STEP 6: INTERNET CONNECTION (BLINKUP)

1. Download and Login to the Frio App.
2. Complete App Setup and enter all required information.
3. Connect to the S1 Controller via BlinkUp as directed in the Frio App.
4. Follow the in-app instructions to connect the Frio S1 controller to the internet and the Frio Cloud Platform.

STEP 7: GROUND FAULT TEST

The Frio S1 controller includes built-in Ground Fault Equipment Protection (GFEP). The GFEP circuit must be tested during installation. To test the GFEP circuit, follow the instructions below.

1. Press any button on the controller to enter the **Main Menu**.
2. Select **GFEP Test** and press enter.
3. You will be prompted to **Test GFEP now** to test the GFEP circuit, select **Yes**.
4. The controller will display **RUNNING GFEP TEST** during the test and **TEST SUCCESS** for a successful test. If the test is not successful, the device will display **TEST FAILED**. If the GFEP test fails, turn off the system at the breaker and disconnect the heat trace. Rerun the test with nothing connected to the load terminal blocks. If the test is successful with nothing connected, there is a wiring error or a fault with the heat trace.
5. If the test is successful with heat trace connected, record the test on the GFEP Test Form on the next page, and ensure that the GFEP Test Form is retained by those in charge of the building's electrical installation in order to be available to the authority having jurisdiction.

GFEP TEST FORM

DATE	GFEP TEST RESULT	TEST PERFORMED BY	COMPANY

NOTE: THIS TEST FORM MUST BE RETAINED BY THOSE IN CHARGE OF THE BUILDING'S ELECTRICAL INSTALLATION IN ORDER TO BE AVAILABLE TO THE AUTHORITY HAVING JURISDICTION.

5 MENUS, NAVIGATION AND OPERATION

Sections 5.1 through 5.4 provide a layout of all available information that can be accessed via the HMI. Press any button to enter the Main Menu and use the UP, DOWN, ENTER, and BACK buttons to navigate through the menus and change settings. For more information, please review the relevant section of the Operating Manual.

Sections 5.5 through 5.6 provide information on what the device does on start up or in the event of a power loss.

Sections 5.7, 5.8, and 5.9 cover rebooting the device, clearing device settings and offline devices.

5.1 LEDS

There are 5 LED light pipes on the front faceplate of the Frio S1.

- Status – LED will blink RED if there is an alarm regardless of network status. If there are no alarms present, the LED will be GREEN if the device is online, BLUE if the device is intentionally offline, and ORANGE if the device is trying to connect to the network.
- Alarm – LED will be RED when an alarm is present.
- Heat – LED will light up YELLOW when the heater output is active.
- BlinkUp – See sections 3.5.1.5 for BlinkUp Codes
- Photo – Phototransistor used for BlinkUp process and to wake the device from screensaver mode. Ensure phone screen covers this area during BlinkUp. To wake the device from screensaver mode, flash a light or wave your hand over the Photo transistor.

NOTE: During bootup, the status LED will show WHITE, and the heat LED will show YELLOW. This is only a part of the boot process and does not indicate heater activation.

5.2 MAIN SCREEN

The main screen displays information about the device based on the control configuration including:

- *Current* – Displays the current draw of the heating system (not shown in Pilot Duty Mode)
- *Temperature* – Displays the temperature sensor reading. If multiple sensors are configured the display will alternate between both temperatures.
- *Network Status* – Provides network connection status (Connected, Connecting, Disabled, or Error)
- *Snow Detected (Local Snow Melt Only)* – Displays whether or not the moistures sensors are currently sensing snow (alternates with Heater State when in Pilot Duty Mode)
- *Heater State (When in Pilot Duty Mode)* – Displays whether the heater is ON or OFF (alternates with Snow Detected when in Local Snow Melt Mode)

5.3 MAIN MENU

Press any button to enter the **Main Menu** and use the UP, DOWN, ENTER, and BACK buttons to navigate through the menus. Options on the main menu are:

- *Force System On* – Not available if the device is in Alarm
    - *Select ON time* – Select the force on period (5 min, 1 hour, 24 hours, Cancel)

  NOTE: When the device is forced on you will see the following: Cancel Force On
    - *Cancel?* – Cancel the force on (Yes, No)
- *GFEP Test* – Perform a test of the GFEP system
    - *Test GFEP Now?* – Select to test the GFEP system (Yes, Cancel)

- *Active Alarms* – Shows a list of active alarms, see section 3.6 for more details.
    - *Reset All* – Clears and resets all alarms, select Yes to initiate a GFEP test and reset the alarm conditions. The GFEP test must be successful in order to reset the alarms.
- *Device Info* – See section 3.7 for available device information.

- *Networking* – Adjust Network Settings
    - *Rerun BlinkUp* – Reruns the BlinkUp process to provision the device (YES, NO)
    - *Turn On/Off Networking* – Disables device networking (YES, NO). Network credentials are saved, such that when networking is re-enabled, the device should automatically reconnect to the network.
    - *Clear Network Credentials* – Clears the device's network credentials (YES, NO). A new BlinkUp will need to be performed in order to reconnect to any network.

⚠ **▪ NOTE: CLEARING NETWORK CREDENTIALS WILL CAUSE ALL NETWORK AND CONNECTION INFORMATION TO BE LOST, AND THE DEVICE WILL NEED TO BE CONFIGURED VIA BLINKUP AGAIN.**

- *Health Check* – Run and manage system diagnostic tests
    - *Run Spot Check* – Run a Spot Check to test the heating system and generate a PDF Spot Check Report (YES, CANCEL)
    - *Log* – View a log of prior Spot Checks organized by the date and time a check was run. Select a Spot Check in the log to view the Spot Check ID, Spot Check Version, Start Time, End Time, if the check was completed, and where the check was initiated (device or cloud).
- *Snow Sensors [S1-A Only]* – Scan for snow sensors and set hold on time
    - *Hold-ON Time* – Set the hold-on time for Local Snow Melt mode (0-10 Hours)
    - *+Auto-Detect Sensors* – Scans for local snow melt sensors on the Modbus network.
    - *Connected Sensors* – If sensors are connected, they will be shown here with Modbus address

5.4 SETTINGS

The following settings may be changed from the **Settings** page on the **Main Menu**.

- *Mode* – Select the desired control mode (Freeze Protection, Maintain Temperature, Always On, Always Off, TM Scheduler, Local Snow Melt, [Cloud Control & Hybrid FP if configured])
- *Thermistor*– Select the thermistor configuration (None, Ambient, Pipe, Slab, High Limit)
- *RTD [S1-A Only]* – Select the RTD configuration (None, Ambient, Pipe, Slab, High Limit)
- *Setpoint* – Select the desired temperature set point (0-300 °F)
- *Deadband* – Select the desired temperature dead-band (1-35 °F)
- *Failure State* – Select how the system should operate in the case of a sensor failure (ON, OFF)
- *High Limit Cutout [S1-A Only]* – Configure the High Temperature Limit if a sensor is configured.
    - *Enabled* – Determine if the alarm is enabled (NO, YES)
    - *Threshold* – Set the alarm threshold (-40 °F to 1292 °F)
    - *Delay* – Set the alarm delay (0-500 s)
- *Temp. Units* – Select the temperature units (°F, °C)

5.4.1 Advanced Settings

The following advanced settings may be changed from the **Advanced Settings** page on the **Settings** menu.

- *Ground Fault Protection* – The default and recommended GFEP Trip Level is 30 mA.
    - *GFEP Trip Level* – Select the desired GFEP Trip Level (30-300 mA)
    - *GFEP Trip* – Use this option to disable the GFEP circuit (ON, OFF)

> ⚠ **NOTE: IT IS NOT RECCOMENDED TO DISABLE GFEP OR TO SET THE GFEP TRIP LEVEL ABOVE 30 mA. IF GFEP IS DISABLED, THE DRY CONTACT ALARM SIGNAL IS REQUIRED TO ALERT THE SYSTEM OPERATOR TO A GROUND FAULT CONDITION.**

- *Pilot Duty* – Enable pilot duty mode, automatically disables GFEP (ON/OFF)
- *Modbus [S1-A Only]* – Configure Modbus communication. Must match gateway settings.
    - *Mode* – Configure the Modbus mode (Disabled, Server, Client)
    - *Device Address* – Sets the Modbus device address that corresponds to the gateway profile. Must be unique for each Frio S1 on a single gateway.
    - *Baud Rate* – Sets the baud rate for the Modbus network (9600, 19200, 38400, 57600)
    - *Parity* – Sets the Modbus parity bit (None, Even, Odd)
    - *Stop Bits* – Sets the number of stop bits (1, 2)
- *Satellite Contactors [S1-A Only]* - Configure Satellite Contactors
    - *+Auto-Detect S1s* – Scans for other S1-As on the Modbus network.
- *Screen Saver* – Configure the device screensaver
    - *Enabled* – Turns on the screensaver (ON, OFF)
    - *Delay* – The delay in minutes before the screensaver turns on (5-min intervals)
    - *Mode* – Sets the screensaver mode (Animation, Text, Screen Off)
- *Restore Default Settings* – Reset the device to the factory default settings (Cancel, Yes)

5.4.2 Alarm Settings

Alarm settings are available under Alarms on the **Advanced Settings** menu.

- *Latch All* – Select this option to set all non-critical alarms to latching (NO, YES)
- *High Current* – Configure the high current alarm
    - *Enabled* – Determine if the alarm is enabled (NO, YES)
    - *Threshold* – Set the alarm threshold (0-30 A)
    - *Delay* – Set the alarm delay. Frio recommends a delay of at least 300s with self-regulating heat trace to avoid alarming on inrush current (0-500 s)
- *Low Current* – Configure the low current alarm
    - *Enabled* – Determine if the alarm is enabled (NO, YES)
    - *Threshold* – Set the alarm threshold (0-30 A)
    - *Delay* – Set the alarm delay (0-500 s)
- *High Temperature* – Configure the high temperature alarm
    - *Enabled* – Determine if the alarm is enabled (NO, YES)
    - *Threshold* – Set the alarm threshold (S1-A: -40 °F to 1292 °F - S1-B: -40 °F to 212 °F)
    - *Delay* – Set the alarm delay (0-500 s)
- *Low Temperature* – Configure the low temperature alarm
    - *Enabled* – Determine if the alarm is enabled (NO, YES)
    - *Threshold* – Set the alarm threshold (S1-A: -40 °F to 1292 °F - S1-B: -40 °F to 212 °F)
    - *Delay* – Set the alarm delay (0-500 s)

5.4.3 Default Settings

Menu	Setting	Default	Range
Settings			
	Mode	Freeze Protection	
	Thermistor	Ambient	
	RTD [S1-A Only]	None	
	Setpoint	38 °F	S1-A: -40 °F to 1292 °F S1-B: -40 °F to 212 °F
	Deadband	2 °F	
	Failure State	ON	
	Temperature Units	°F	
Networking			
	Networking	ON	
Snow Sensors [S1-A Only]			
	Hold-On Time	04H 00M	0-10 H
High Limit Cutout [S1-A Only]			
	Enabled	NO	
	Threshold	185 °F	S1-A: -40 °F to 1292 °F
	Delay	5s	0-500 s
Advanced Settings (Ground Fault Protection)			
	GFEP Trip Level	30 mA	30 mA - 300 mA
	GFEP Trip	ON	
Advanced Settings (Alarms)			
	Latch All	NO	
	High Current Enabled	YES	
	High Current Threshold	30 A	0-30 A
	High Current Delay	300 s	0-500 s
	Low Current Enabled	NO	
	Low Current Threshold	0.1 A	0-30 A
	Low Current Delay	5 s	0-500 s
	High Temp. Enabled	NO	
	High Temp. Threshold	140 °F	S1-A: -40 °F to 1292 °F S1-B: -40 °F to 212 °F
	High Temp. Delay	300 s	0-500 s
	Low Temp. Enabled	NO	
	Low Temp. Threshold	28 °F	S1-A: -40 °F to 1292 °F S1-B: -40 °F to 212 °F
	Low Temp. Delay	300 s	0-500 s
Advanced Settings (Modbus)			
	Mode	Disabled	
	Device Address	1	
	Baud Rate	38400 bps	
	Parity	None	
	Stop Bits	1	
Advanced Settings (Screensaver)			
	Enabled	ON	
	Delay	15	5-60 min
	Mode	Animation	

5.5 Start Up

All S1 devices perform a network connection attempt immediately when power is connected. This process may take up to 30 seconds, during which the screen will be blank, the status LED white and the heat LED red, although the heater will not be turned on. The BlinkUp LED will blink according to the connection status codes listed in section 3.5.1.5. After the device checks for a connection, it will display the Frio logo on the main screen while loading device firmware from memory. Loading the firmware can take several seconds. When the firmware is loaded, the display will show the main screen, and the device is ready to use.

If the device has never been connected to a network or if the network credentials have been cleared, the BlinkUp LED will flash orange after power on. While the BlinkUp LED is flashing orange you may BlinkUp the device using the Frio mobile App. To initiate BlinkUp after the device has finished startup (i.e. after the BlinkUp LED has turned off), select **Networking** from the **Main Menu**, then select **Rerun BlinkUp**. You will be asked if you want to **Provision the device now?** Select **Yes** to rerun BlinkUp and provision the device.

5.6 Power Loss

The device includes an onboard backup power source to provide up to one minute of additional runtime in the case of a power loss. Connected devices will use this time to send a last gasp message to the cloud platform with information related to the power loss.

When the device is disconnected from power, the display will show “POWER LOSS”. When the screen goes blank the onboard power supply is exhausted and the device is completely turned off.

> ⚠ **NOTE: DO NOT OPEN THE WIRING COVER UNTIL THE SCREEN IS BLANK AND THE DEVICE IS COMPLETELY TURNED OFF.**

An override that was set from the HMI will be reset on power loss. An override set from the cloud will resume as soon as the device reconnects and will continue until the original end time set by the user.

5.7 Rebooting the Device

In the unlikely event that the device freezes up or has other issues, you can reboot the device in one of two ways.

First, you can power cycle the device by turning the power to the device off from the circuit breaker. Wait until the power loss screen goes blank and all lights on the device are off. Turn power to the device back on to restart.

Second, you can use a small diameter pin to press the reset button located in between the status and alarm LEDs. This will power cycle the processor and reboot the device.

Please contact Frio to notify us of any issues that cause the device to freeze up.

5.8 Clearing Device Settings

Users may reset the device to factory default settings and clear the network credentials from the device if needed. Restoring the factory default settings does not clear the network credentials. Clearing the network credentials does not reset any other device settings. To completely clear the device of all settings, the user should restore the factory default settings and then clear the network credentials.

5.8.1 Restore Factory Default Settings

To restore the factory default settings, select **Settings** from the **Main Menu**, then select **Advanced Settings** from the **Settings Menu**. Select **Restore Default Settings** from the **Advanced Settings Menu**. You will be asked if you want to **Reset and Reboot?** Select **Yes** to reset the device to the factory default settings.

5.8.2 Clear Network Credentials

To clear the Wi-Fi credentials from the device, select **Settings** from the **Main Menu**, then select **Advanced Settings** from the **Settings Menu**. Select **Network Settings** from the **Advanced Settings Menu,** then select **Clear Network Credentials**. You will be asked if you want to **Clear All Credentials?** Select **Yes** to clear the Wi-Fi credentials and restart the BlinkUp process. You will need to Blink Up the device again in order to connect to a network.

5.9 SCREENSAVER

The Frio S1 has a screensaver setting to limit "burn-in" and extend the lifetime of the OLED display. The screensaver will start after the delay period which can be set from the screensaver menu. To exit screensaver mode, the user either needs to wave a hand or light in front of the PHOTO sensor or press any button. There are three options for the screensaver: "Animation" which displays a moving Frio logo, "Text" which displays instructions on how to wake the device, and "Screen Off" which turns the screen completely off. For the longest screen life, Frio recommends the "Screen Off" setting.

5.10 OFFLINE DEVICES

To use the device offline without connecting to the internet, simply perform all setup steps except for network provisioning. Do not use the Frio App to give the device network credentials.

Frio recommends disabling networking on offline devices as this will disable the network connection alarm.

Offline devices will not have access to the Frio Cloud platform and will not be able to use any cloud features. Offline devices will not have access to any firmware updates.

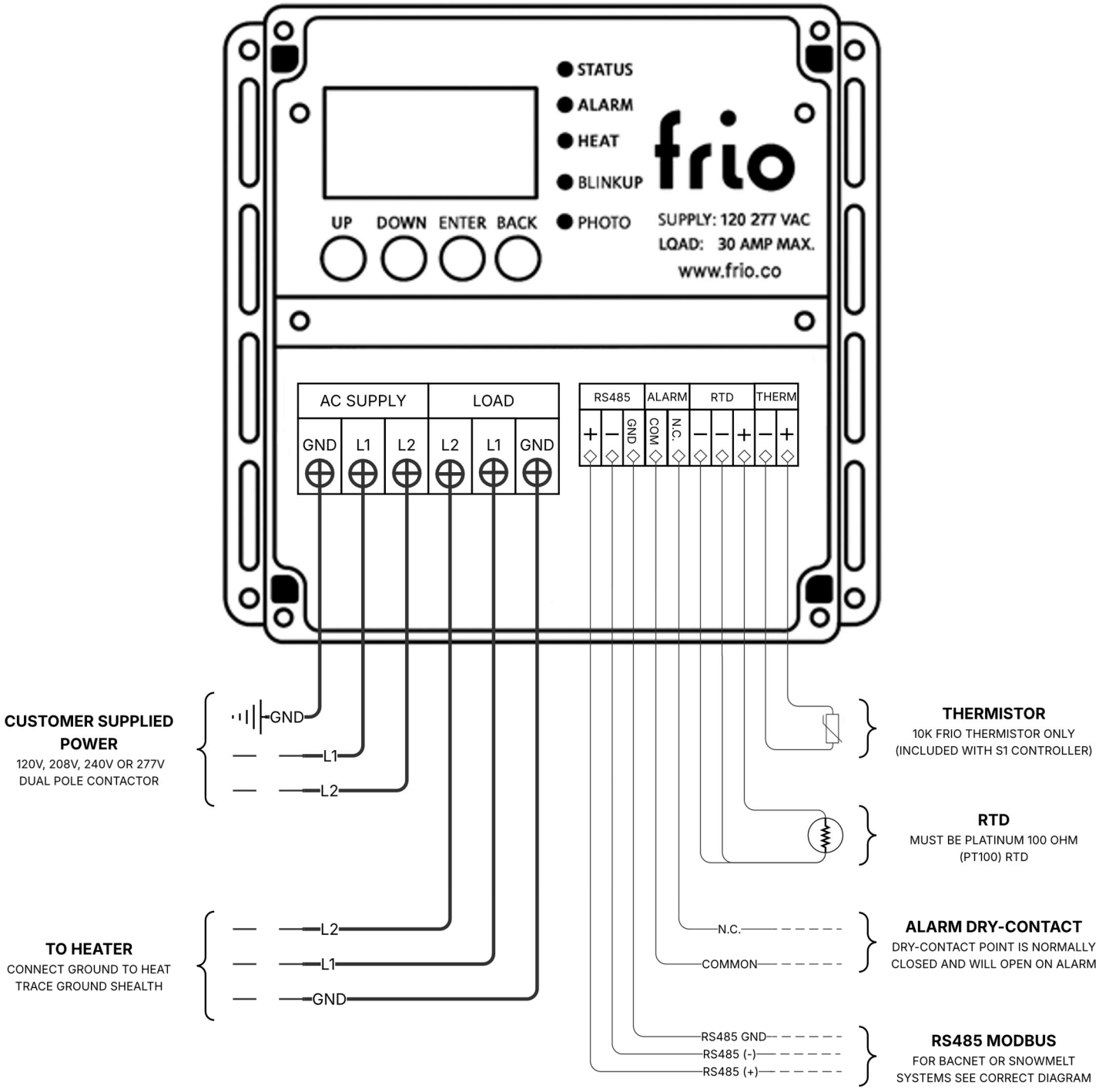
Frio has an option for devices with internet capabilities disabled, please contact info@frio.co for more information.

6 FIRMWARE UPGRADES

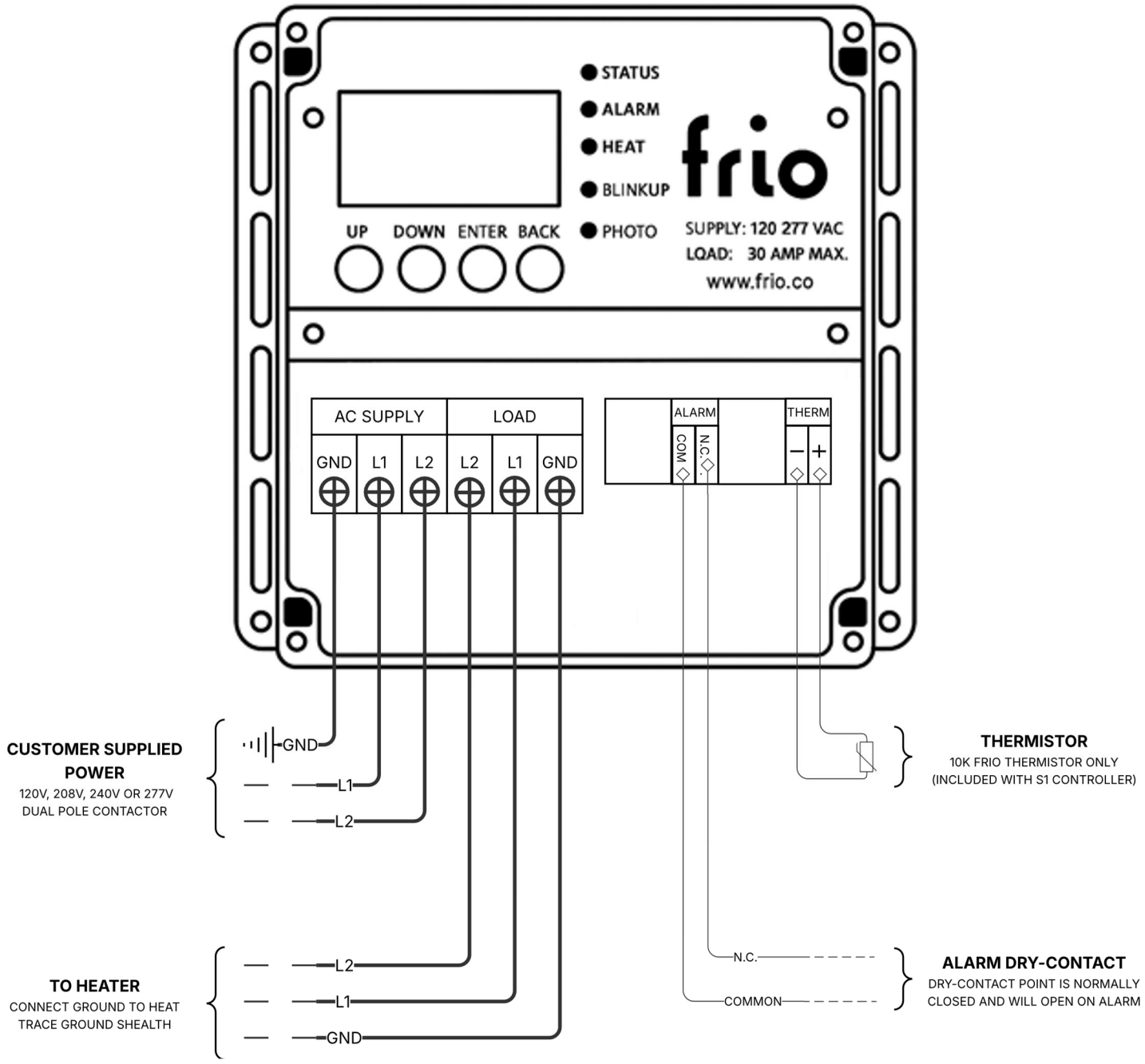
Firmware updates will occur automatically as long as the device is connected to the internet. Updates do not change device settings. A copy of the previous firmware version is retained on the device. If the update fails or the device is disconnected during the update, the previous firmware version will be reloaded until the device is able to retry the update at a later time. When an update occurs, the device will restart, shutting off the heating system if it is on. Once the update is complete, the device will resume normal operation. Updates typically take less than one minute to complete.

7 Wiring Diagrams

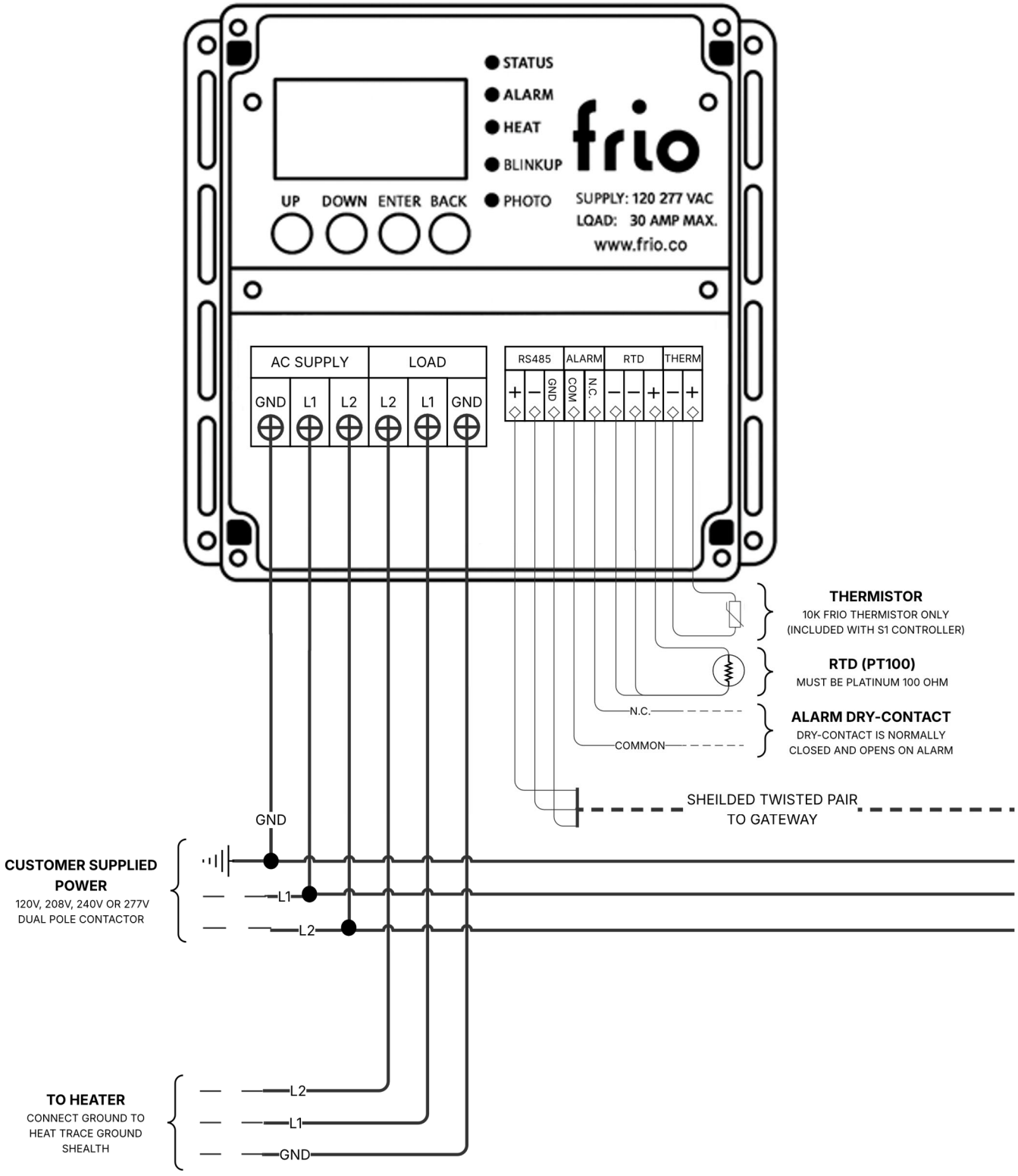
7.1 Frio S1-A Wiring Diagram

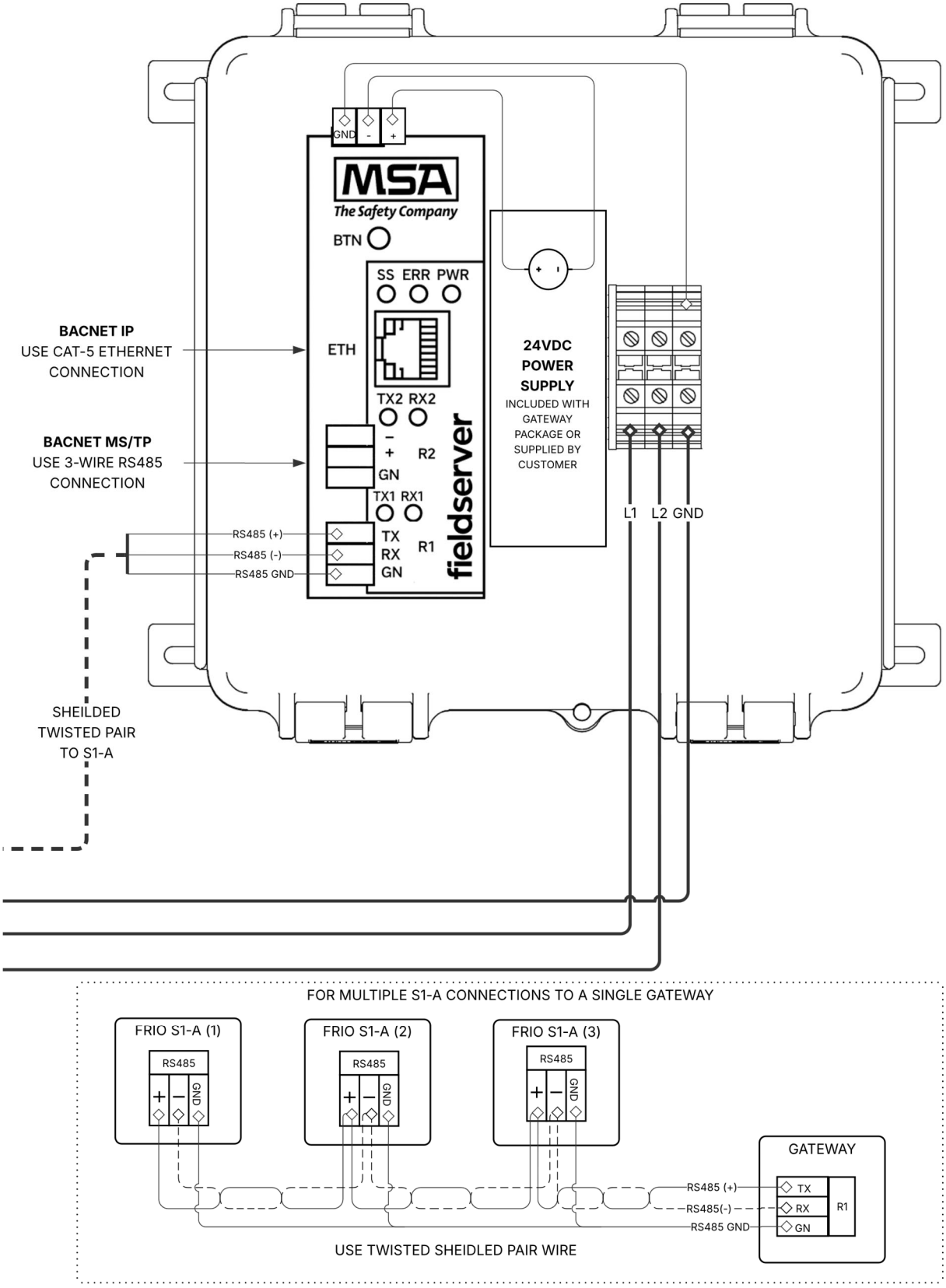


7.2 FRIO S1-B WIRING DIAGRAM

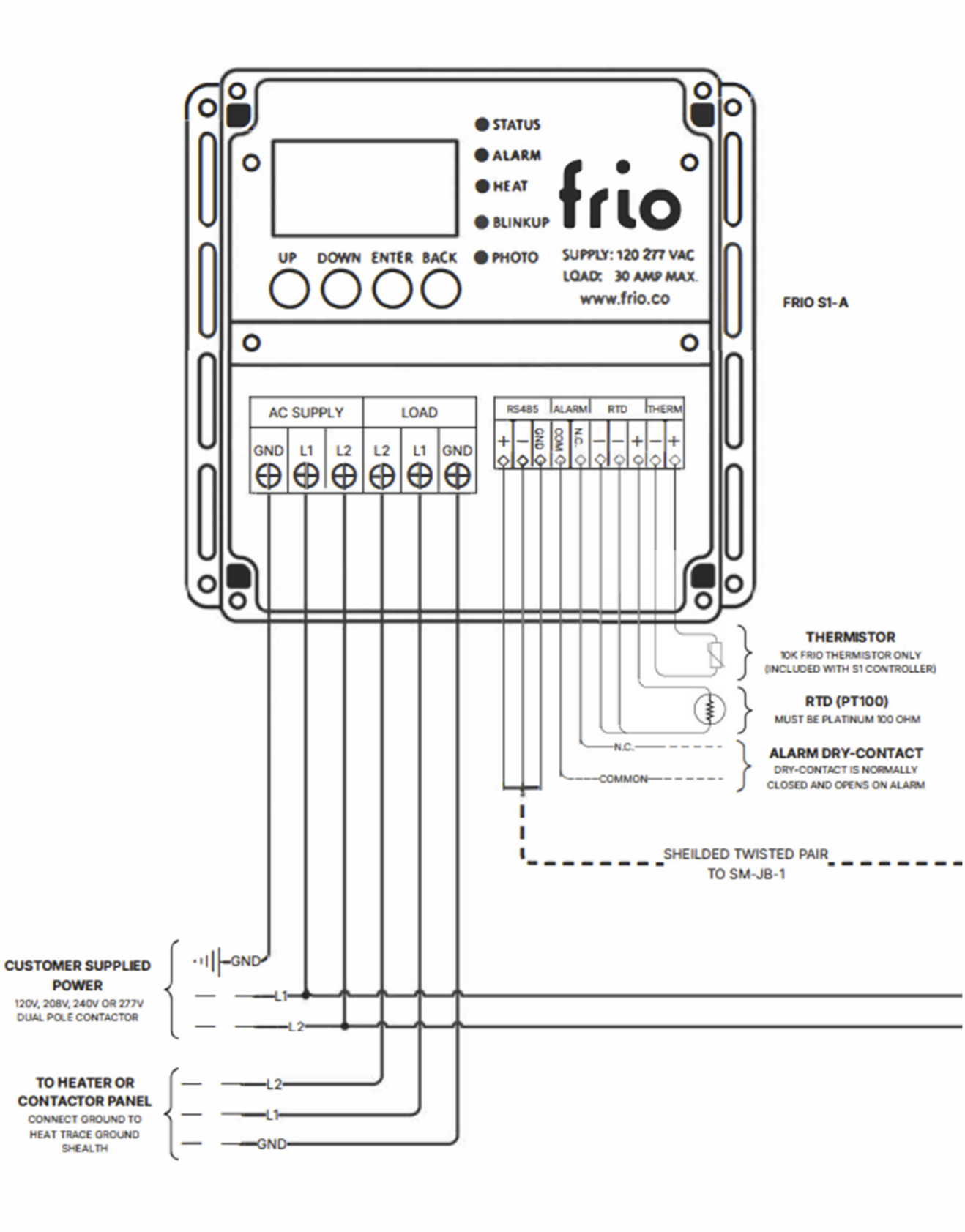


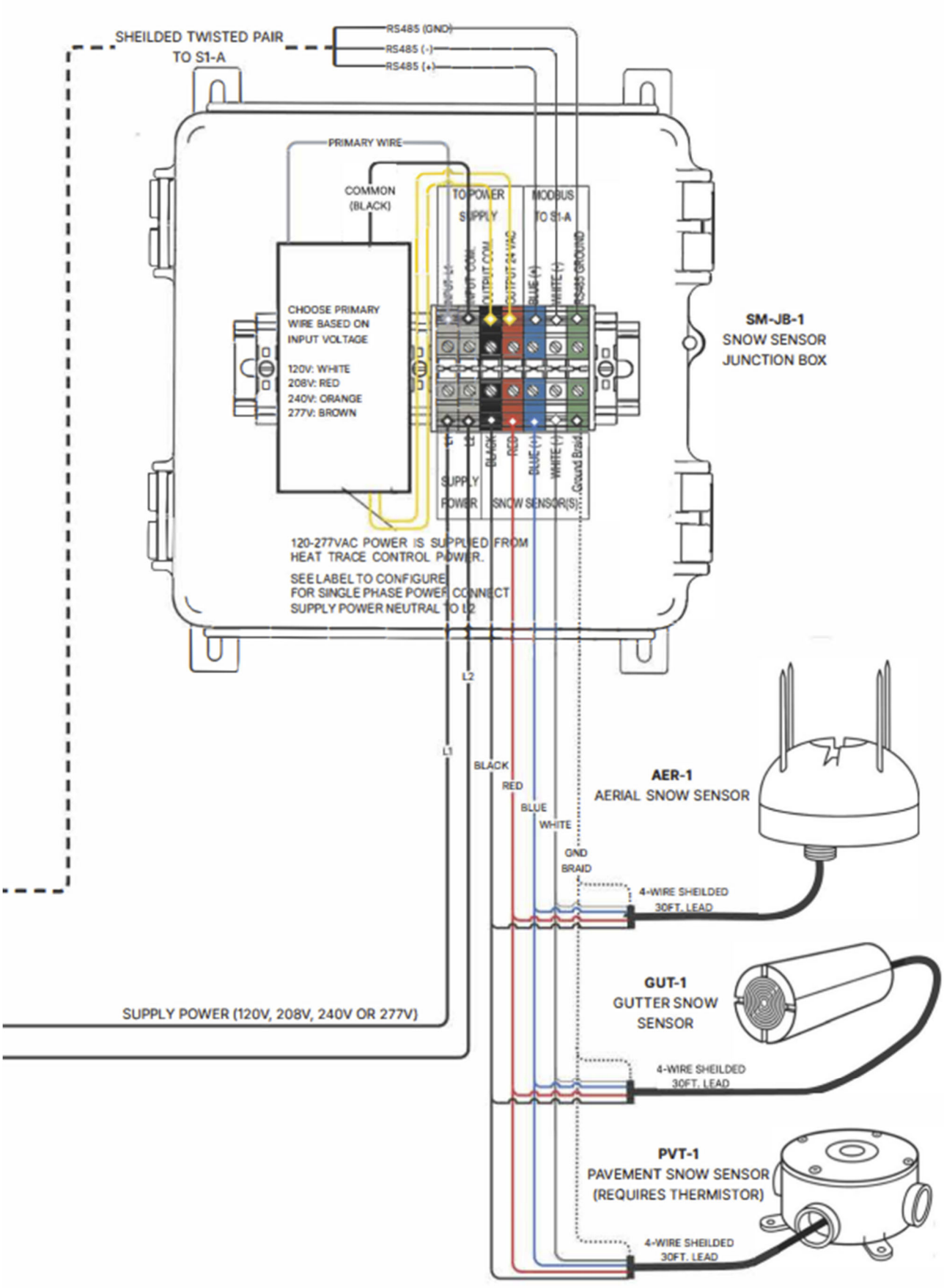
7.3 FRIO S1-A WITH BACNET GATEWAY WIRING DIAGRAM




GND
-
+
MSA
The Safety Company
BTN
SS ERR PWR
ETH
TX2 RX2
-
+ R2
GN
TX1 RX1
TX
RX R1
GN
fieldserver
BACNET IP
USE CAT-5 ETHERNET
CONNECTION
BACNET MS/TP
USE 3-WIRE RS485
CONNECTION
RS485 (+)
RS485 (-)
RS485 GND
SHEILDED
TWISTED PAIR
TO S1-A
24VDC
POWER
SUPPLY
INCLUDED WITH
GATEWAY
PACKAGE OR
SUPPLIED BY
CUSTOMER
L1 L2 GND
FOR MULTIPLE S1-A CONNECTIONS TO A SINGLE GATEWAY
FRIO S1-A (1)
RS485
+ - GND
FRIO S1-A (2)
RS485
+ - GND
FRIO S1-A (3)
RS485
+ - GND
GATEWAY
TX
RX
GN
R1
RS485 (+)
RS485(-)
RS485 GND
USE TWISTED SHEIDLED PAIR WIRE

7.4 FRIO S1-A WITH SNOW SENSORS WIRING DIAGRAM




SHEILDED TWISTED PAIR
TO S1-A
RS485 (GND)
RS485 (-)
RS485 (+)
PRIMARY WIRE
COMMON
(BLACK)
TO POWER
SUPPLY
MODBUS
TO S1-A
CHOOSE PRIMARY
WIRE BASED ON
INPUT VOLTAGE
120V: WHITE
208V: RED
240V: ORANGE
277V: BROWN
SUPPLY
POWER
SNOW SENSOR(S)
SM-JB-1
SNOW SENSOR
JUNCTION BOX
120-277VAC POWER IS SUPPLIED FROM
HEAT TRACE CONTROL POWER.
SEE LABEL TO CONFIGURE
FOR SINGLE PHASE POWER CONNECT
SUPPLY POWER NEUTRAL TO L2
L2
L1
BLACK
RED
BLUE
WHITE
GND
BRAID
AER-1
AERIAL SNOW SENSOR
4-WIRE SHEILDED
30FT. LEAD
GUT-1
GUTTER SNOW
SENSOR
4-WIRE SHEILDED
30FT. LEAD
PVT-1
PAVEMENT SNOW SENSOR
(REQUIRES THERMISTOR)
4-WIRE SHEILDED
30FT. LEAD
SUPPLY POWER (120V, 208V, 240V OR 277V)