Honeywell

UNITARY
CONTROLLER

INSTALLATION INSTRUCTIONS

GENERAL

Trademark Information

Sylk™ is a trademark of Honeywell International Inc.
BACnet™ is a registered trademark of ASHRAE Inc.

Product Description

Honeywell Unitary T1L (IP), RJ45 (IP), and MSTP controllers provide flexible, freely programmable, demand-led control that delivers tangible benefits to reduce energy spending while driving new levels of functionality and efficiency in today's buildings.

They offer performance-based engineering with Niagara 4 and enable Single-Tool-Engineering throughout the whole Building Management System with cost-effective installation. These controllers contain integrated Bluetooth, which allows easy connection to a Commissioning App.

These new generation controllers offer BACnet™ RJ45 (IP), T1L (IP), or MSTP as a backbone interface and Sylk™ and Modbus RTU as sub interface, flexible universal input/output (UIO) points, and solid-state relays (SSR) and normal relays.

These scalable and freely programmable BACnet™ IP or BACnet™ MSTP based universal unitary controllers utilize smart engineering, commissioning tools, and Sylk™ bus technology. These controllers can achieve multiple flexible configurations to address specific applications with the Niagara Engineering tool.

The controllers can stand-alone operation; however, they can achieve optimum functional benefits when they use network communication capabilities.

MSTP variant of controller communicates via a TIA/EIA 485 BACnet™ MSTP network communications network, capable of baud rates between 9.6 and 76.8 kb. BACnet™ IP (RJ45) variants communicate over a wired standard network cable and BACnet™ IP (T1L) communicates via a 2-wire twisted pair cable.

Table 1. Ordering Part Numbers

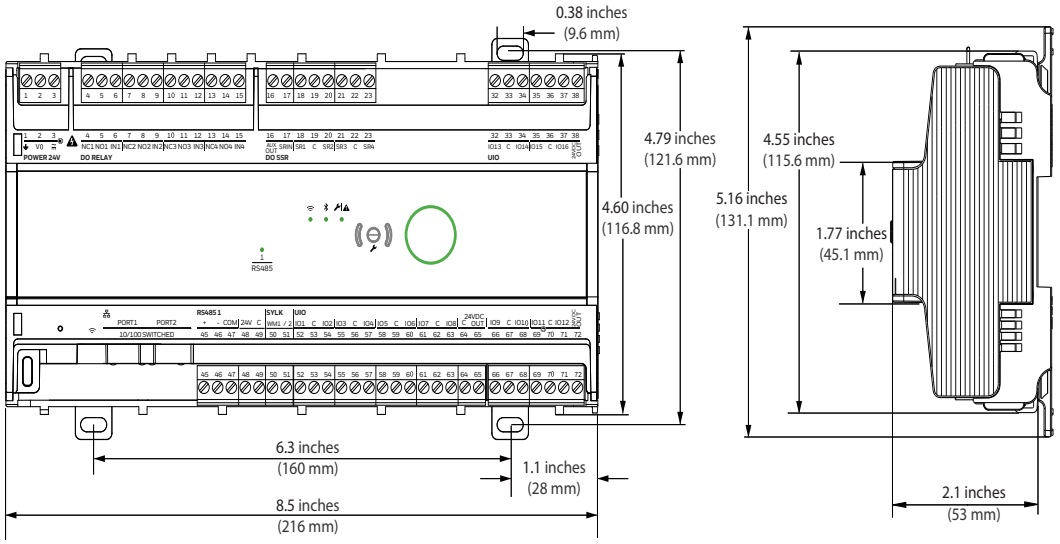
Part Numbers	Housing	UIO	Relay	Solid State Relay (SSR)	Communication	Sylk™ Bus	Bluetooth
UN-RS0844ES24NMC / D	Small	8	4	4	IP	Yes	No
UN-RS0844ESB24NMC / D	Small	8	4	4	IP	Yes	Yes
UN-RS0844MS24NMC / D	Small	8	4	4	MSTP	Yes	No
UN-RS0844MSB24NMC / D	Small	8	4	4	MSTP	Yes	Yes
UN-RS0844TS24NMC / D	Small	8	4	4	T1L	Yes	No
UN-RS0844TSB24NMC / D	Small	8	4	4	T1L	Yes	Yes
UN-RL1644ES24NMC / D	Large	16	4	4	IP	Yes	No
UN-RL1644ESB24NMC / D	Large	16	4	4	IP	Yes	Yes
UN-RL1644MS24NMC / D	Large	16	4	4	MSTP	Yes	No
UN-RL1644MSB24NMC / D	Large	16	4	4	MSTP	Yes	Yes
UN-RL1644TS24NMC / D	Large	16	4	4	T1L	Yes	No
UN-RL1644TSB24NMC / D	Large	16	4	4	T1L	Yes	Yes

Table 2. Accessories/Replacement Parts

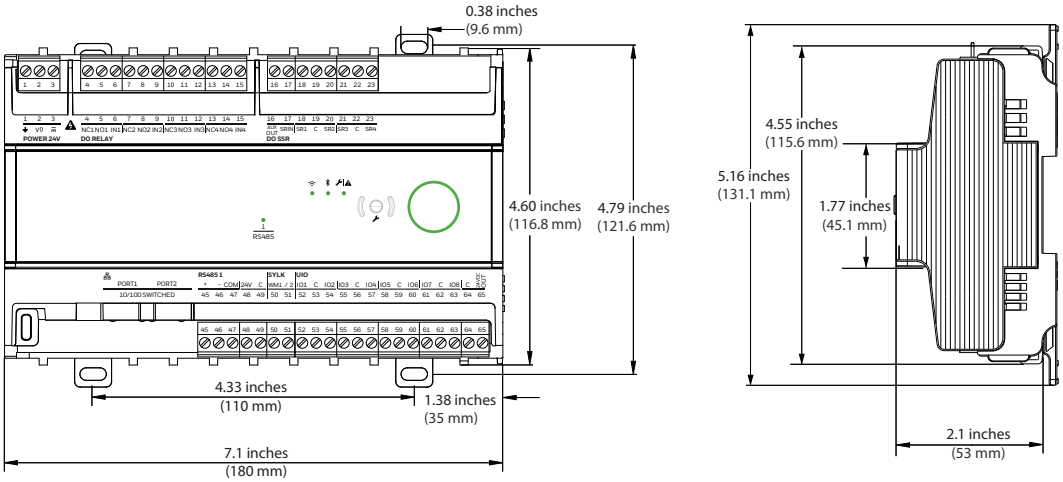
Part Number	Description
CW-Cov-L-Unitary	Terminal cover for the L-version of the unitary controller (sold in pack of 10)
CW-Cov-S-Unitary	Terminal cover for the S-version of the unitary controller (sold in pack of 10)
10BASE-T1L-ADAPT	IP-T1L single pair media adapter that allows converting 10BASE-T traffic to 10BASE-T1L
SCRW-TB-UNI-L	Set of removable terminal blocks covering all variants of Unitary controllers
IO-JUMPER-4-10	4-pin relay output jumper to connect 4 relay in terminals (sold in pack of 10)

Dimensions

Large Housing Controllers



Small Housing Controllers



All the dimensions are in inches (mm).

Weight and Dimensions

Parameter	Housing	Specifications
Dimension (L x W x H)	Small	7.1 inches x 4.7 inches x 2.1 inches (180 mm x 121.6 mm x 53 mm)
	Large	8.5 inches x 4.7 inches x 2.1 inches (216 mm x 121.6 mm x 53 mm)
Weight	Small	1.064 lbs. (483 grams)
	Large	1.256 lbs. (570 grams)
Mounting	Both	Mounting on DIN rails or walls.

NETWORK SECURITY

⚠ WARNING

Honeywell expressly states that Honeywell Unitary T1L (IP), RJ45 (IP), and MSTP controllers will not protect against all cyber security risks from the internet. Therefore use the controllers in private and protected networks.

To ensure a safe and reliable operation, take necessary protective measures, such as locating BMS controls behind a firewall and using a VPN connection. Suitable VPN routers are available from numerous third-party manufacturers.

GENERAL SAFETY INSTRUCTIONS

While performing any work (installation, mounting, or startup), follow all instructions given by Honeywell and the safety instructions provided in this document.

- The Honeywell Unitary controllers must be installed and mounted by trained personnel.
- In the case of any modification, except by Honeywell, the operation and safety warranties become void.
- Observe the applicable local standards and regulations.
- Use only Honeywell supplied or approved accessories.
- Before installing or dismantling the system, disconnect the power supply by either removing the power terminal block from the controller or using local isolation. Read the following caution note carefully.

⚠ CAUTION

Disconnect the power before installing, removing, or replacing the Honeywell Unitary. Switch off the power before you install any jumpers.

SPECIFICATIONS

Electrical

Parameter	Specifications
Rated Input Voltage	24 - 30 VDC/20 - 30 VAC
Nominal Current Consumption	• **IP model:** 8 VA • **MSTP model:** 8 VA • **T1L model:** 8 VA
Full Load Current Consumption (Maximum load including external loads, Sylk™, Communication, Bluetooth, Universal IO output, and 24 VDC output, excluding the load on the SSRs) **Note:** For the current consumption of SSR, refer SSR section table.	• **IP model:** 100 VA • **MSTP model:** 100 VA • **T1L model:** 100 VA
Frequency Range	50-60 Hz
Auxiliary Power Output	24 VAC/VDC at 75 mA
Impulse Voltage	330 V

Hardware

Parameter	Specifications
CPU	Crossover processor NXP I.MRT, Cortex M7
Memory capacity	16 MB QSPI Flash, 16 MB SDRAM
Ethernet	2 X RJ-45 Ethernet ports with integrated fail-safe for daisy-chain.
Real Time Clock	24 hours backup after power failure. The controller includes a super capacitor to power the built-in real-time clock for 24 hours. After 24 hours, the time will reset to default factory time until the user performs BACnet™ Time Sync.
Small LEDs	Transmission or Reception of communication signal (green)
Large LED	Controller status (Green, Yellow or Red)

Communication

Communication	Specifications
Protocol supported	• BACnet™ IP (RJ45 or T1L) • BACnet™ MSTP • Sylk™ • Modbus RTU (Modbus client only) • Bluetooth (optional)
IP Addressing Modes	1. Dynamic: DHCP and Link-local 2. Static

Solid State Relay

Description
SSR works with maximum 24 VAC/VDC.
1.5 A constant; 3.5 A in rush for 0.1 seconds per SSR output.
Factory installed jumper between 24 VAC supply and SSR input shared by all SSRs.
Type 1

Relays

Description
Up to 277 VAC.
3 contacts per relay (Normally open (NO), Normally closed (NC), Common (IN)).
10 A continuous current on NO contact (e.g., electric reheat) and 100 A inrush for 100 ms.
Total current across all relays is limited to 12 A if all commons are connected via a relay jumper bar.
Type 1.C

Universal IO

Parameter	Specifications
AO	• Voltage output with 0-11 V direct/reverse with -3 mA ...+20 mA. • Current output with 0(4)...20 mA direct/reverse. • **Hardwired wall modules*:** LED control.
UI	• 0(2)...10 V direct/reverse or 0(4)...20 mA input. • **Sensors:** NTC10k(Type 2), NTC10K3, 10K3A1, NTC20k, PT100,PT1000,NI1000TK500, NI1000 Class B DIN43760, PT3000, JOHNSON A99, 100 Ohm to 100 k Ohm resistive (custom characteristic). • **Hardwired wall modules*:** space temperature, space temperature set point, fan speed override, occupancy mode override. • Dry contact binary input with direct/reverse. • Pulse input with maximum frequency 100 Hz, minimum pulse width 5 ms. Compatible with the S0 interface for pulse counters.

Operational Environment

Parameter	Specifications
Storage	-40 °F to 150 °F (-40 °C to 66 °C)
Operation	-40 °F to 122 °F (-40 °C to 50 °C)
Humidity	5% to 95% RH., non-condensing
Protection	IP20, NEMA -1
Pollution Level	2

Supported Devices*

Parameter	Specifications
Sylk™ Wall Modules	TR40, TR40-H, TR40-CO2, TR40-H CO2, TR42, TR42-H, TR42-CO2, TR42 H-CO2, TR71, TR71-H, TR75, TR75-H, TR120 (TR75-E), and TR120-H TR75 HE (emulation mode only).
Sensors	C7400S Sylk™ Sensor
Actuators	MS3103, MS3105, MS4103, MS4105, MS7403, MS7405, MS7503, MS7505, MS8103, MS8105 spring return Direct Coupled Actuators (DCA).
Hardwired wall modules	T7460 A,B,C,D,E,F and T7770 A,B, C,D,E,F,G
Modbus Devices	Modbus can be freely programmed: Modbus devices from any manufacturer (Example: Including Honeywell Modbus device - DALI64MODPSUF/S and TR80) can be used.

"*" Devices subject to regional availability.

INTERFACE – IP, MSTP AND T1L MODEL

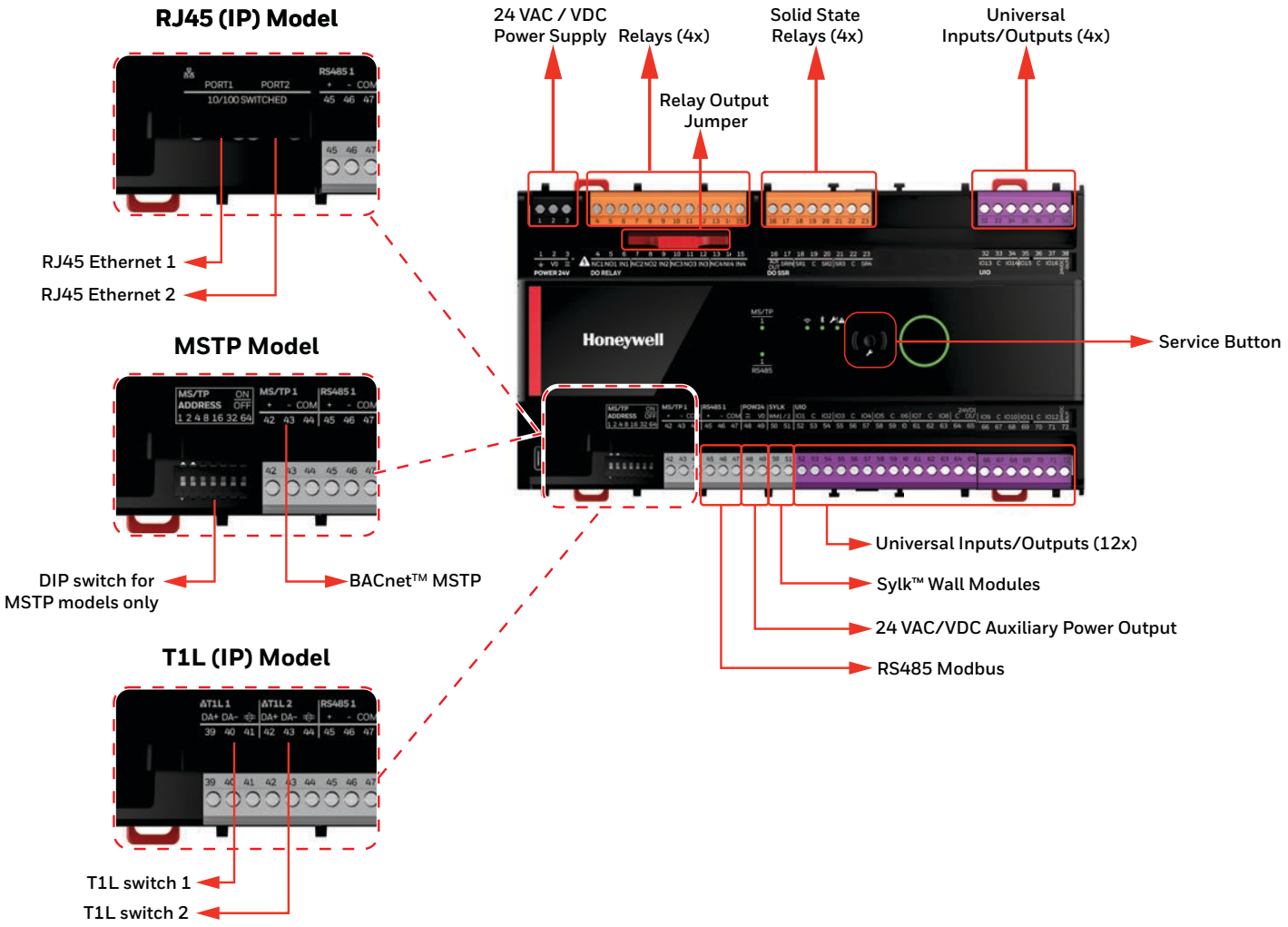


Figure 1. Interface

SYSTEM OVERVIEW – IP, MSTP AND T1L MODEL

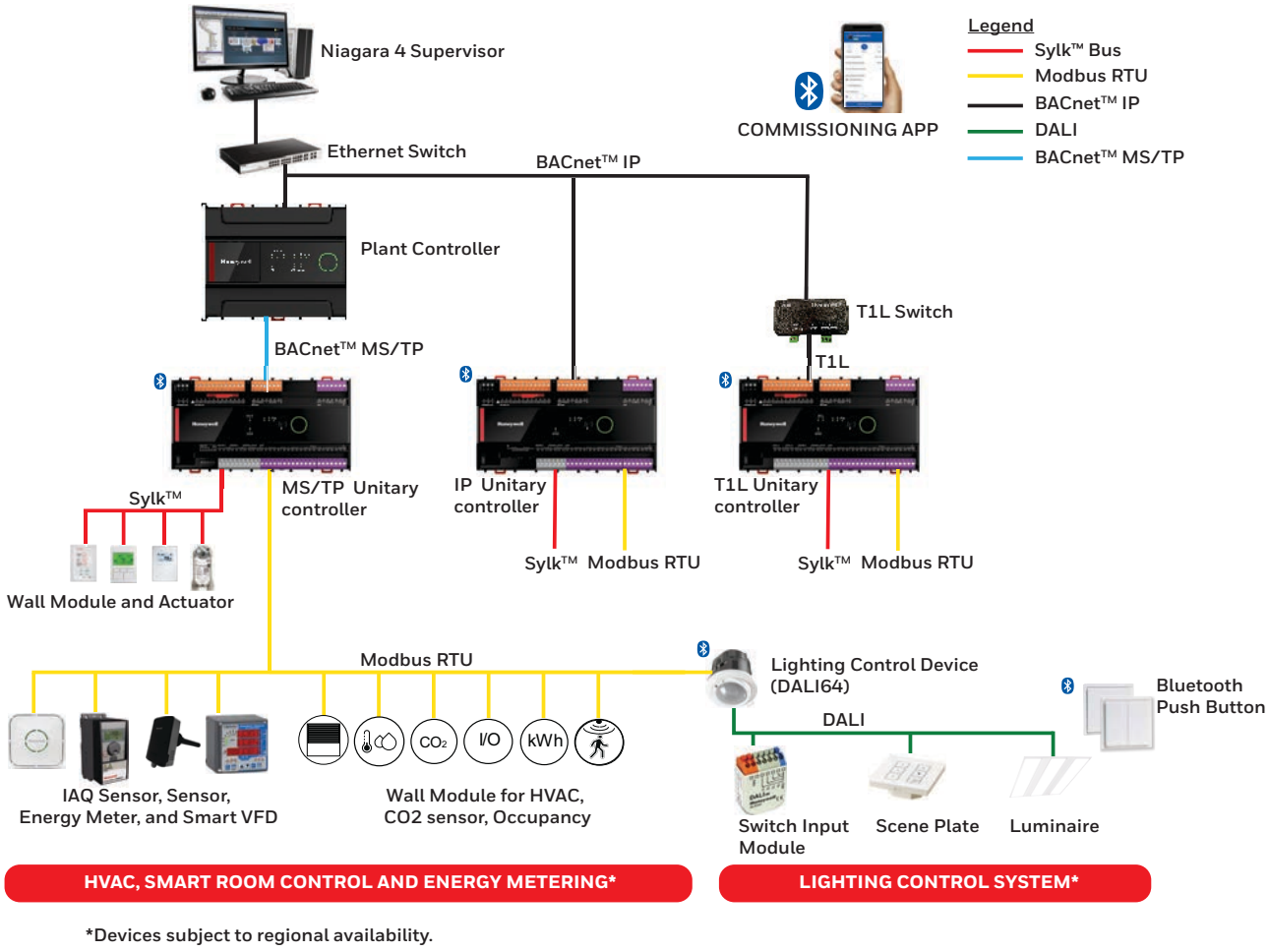


Figure 2. System Overview

SERVICE BUTTON

The Service Button (refer Figure. 1 on page 5) is used to trigger dedicated events. It is important to distinguish different controller behaviors elicited depending upon whether the Service Button is pressed when the controller is powering up or in normal operation. See the following dedicated events.

Pressing Service Button during Power-Up

If the service pin is pressed and the controller is switched on (while the service pin is still pressed), a reset to factory delivery is performed. The service button must be pressed until the green power LED goes out at least twice and is switched on again. Factory defaults are as follows.

- The application is cleared from the controller.
- The MAC address will be set to 0 x FF, meaning that the controller will now search for a new MAC address (Auto-MAC will be automatically triggered after controller power-up).
- The maxMaster setting will revert to its default value of 127.
- The Max info frames will revert to 10.
- The device instance will revert to its default of 4194302.
- The device name will revert to [Model Name].
- The values of Auto MAC, Min MAC and Max MAC will be reset to 1 and 127, respectively.

Pressing Service Button during Normal Operation

During normal operation of the controller, a short press (< 1 sec) of the Service Button will cause a Service Pin Message (BACnet™ Who Am I as a Private Transfer (Serial No. = 130)) to be sent.

MOUNTING

Before Installation

IMPORTANT:

Keep the room temperature for at least 24 hours before evaporating any condensation resulting from low shipping or storage temperatures.

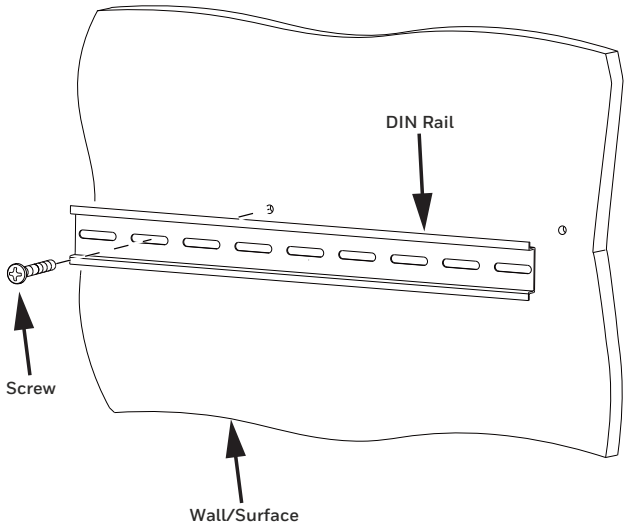
Avoid mounting in areas where acid fumes or other corrosive vapors can harm the metal parts of the controller or in areas where escaping gas or other explosive vapors are present.

CAUTION

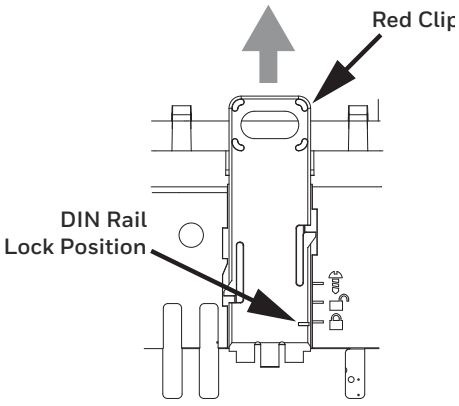
To avoid electrical shock or equipment damage, you must switch OFF the power supply before attaching or removing connections to or from any terminals.

DIN Rail Mounting

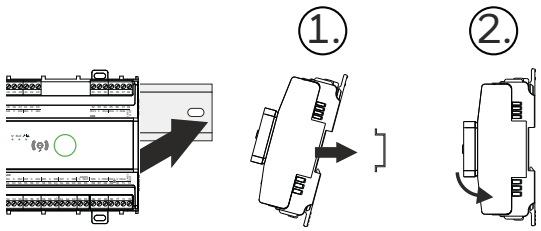
1. Mount the DIN rail on the wall/surface by using screws.



2. Extend all red mounting clips to the unlock position as shown in the below figure.



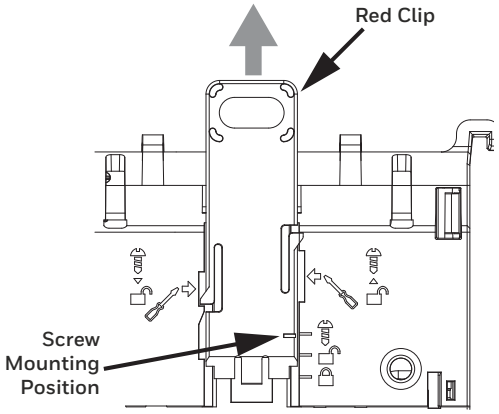
3. Hold the controller as shown in below image and Mount the controller onto the DIN rail.



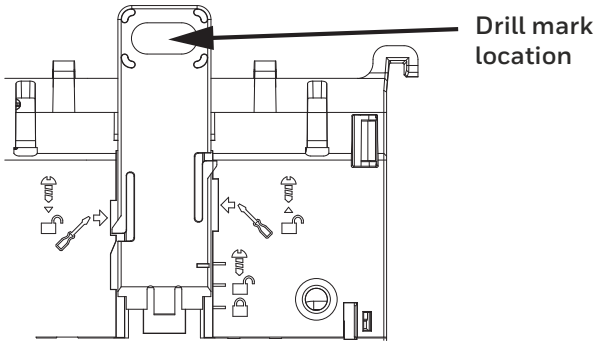
4. Push all red clips in to secure it in place.

Wall Mounting

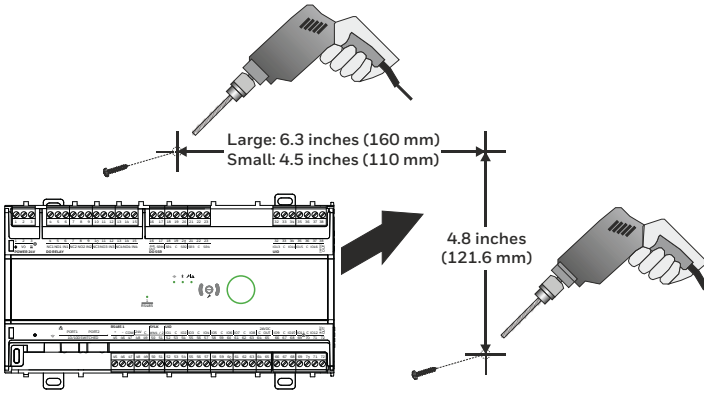
1. Extend all red clips to the screw mounting position by inserting the flat blade screwdriver at a marked location and move up the nod from the lower slot to the upper slot as shown in the below figure.



2. Hold the controller along the wall and mark drilling locations through the screw red clip slots, as shown in the below figure.



3. Remove the controller from the wall and drill four holes at the marked locations.



4. Insert anchors into the four mounting screw holes.
5. Place the controller on the wall/panel so that the holes are aligned. Insert the screws into the topside holes first and fasten them with a screwdriver.
6. Insert the screws into the bottom hole and fasten them with a screwdriver.

NOTE:

It is recommended to use the 6/18 1-inch pan head Phillips tapping screws.

WIRING

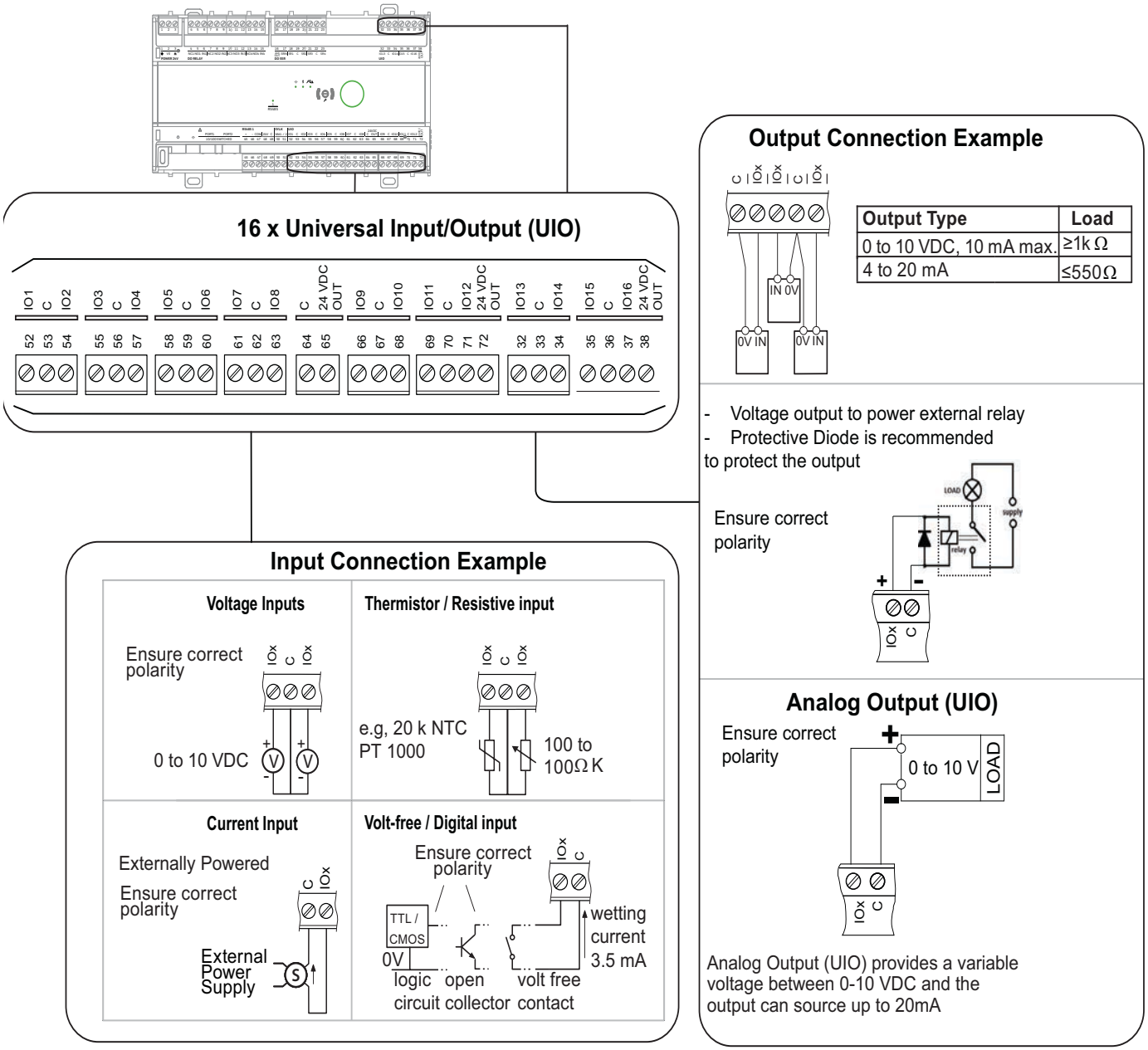
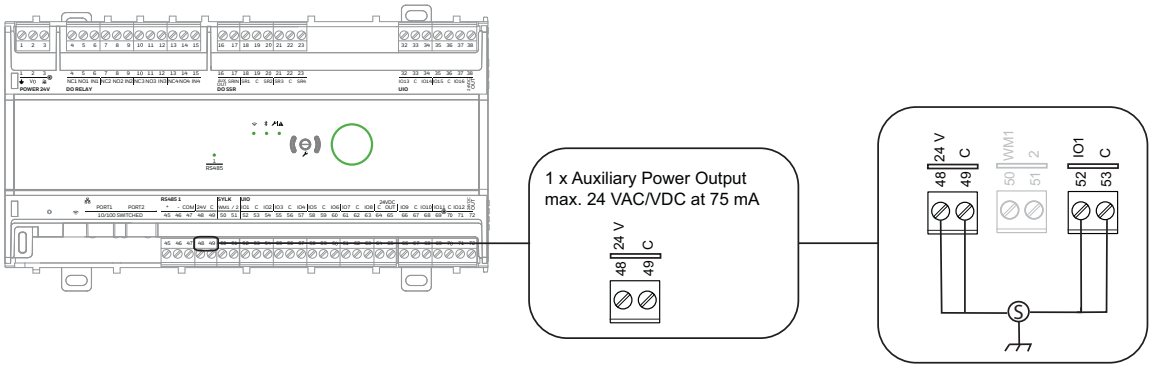


Figure 3. Universal IO Wring

NOTE:

- UL Standards recommend all wiring connections for the IO, SSR, 24 VAC/VDC circuits are restricted to the same room.
- Use a protective diode for any circuit that allows the current to flow forward because the current will not flow in the reverse direction. The diode protects the components responsive to the current flow through them in the wrong direction.



A sensor is connected to the 24V DC Auxiliary Power Output. The sensor has a voltage output connected to IO1.

Figure 4. VDC Auxiliary Wiring

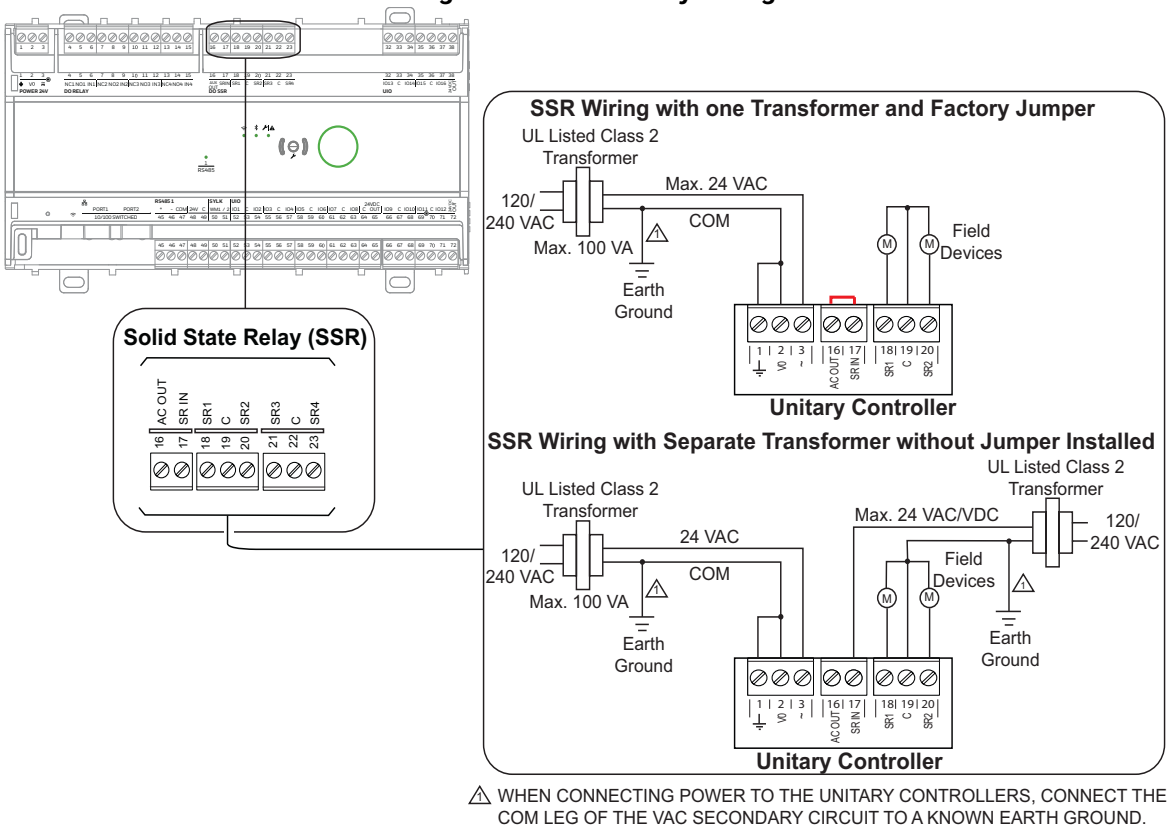


Figure 5. SSR Wiring

NOTE:

- SR IN (terminal 17, SSR power input) is connected to AC OUT (terminal 16, 24 VAC~ output) by a jumper wire provided by the factory.
- Remove the jumper if you want to power field devices with their own 24 VAC/VDC transformer or 20 VDC.
- All terminals are protected against short circuit and 24 VAC.
- Use Copper Conductor only.

CAUTION

Risk of Electric Shock - More than one disconnect switch may be required to de-energize the equipment before servicing.

POWER SUPPLY

General Information

Low and high voltage lines must be kept physically separate to prevent injury due to electric shock or short-circuiting. Avoid connecting one field device to several controllers as there is a risk of short circuits and damage to the Unitary Controller IP and MSTP.

Before wiring the controller, determine the input and output device requirements for each controller used in the system. Select input and output devices compatible with the controller and the application. Consider the operating range, wiring requirements, and environmental conditions while selecting input and output devices.

Determine the location of controllers, sensors, actuators, and other input/output devices and create wiring diagrams to illustrate typical controller wiring for various configurations.

The application engineer must review the control job requirements. This includes the sequences of operation for the controller and the system. Usually, press some variables between the controllers required for optimum system-wide operation. For Example, TOD, occupied, unoccupied, outdoor air temperature, demand limit control signal, and the smoke control mode signal.

Understanding these interrelationships early in the job engineering process is important for proper implementation while configuring the controllers.

NOTE:

All wiring must comply with applicable electrical codes and ordinances. Refer to job or manufacturers' drawings for details. Local wiring guidelines (for example, IEC 364-6-61 or VDE 0100) may take precedence over recommendations provided in these installation instructions.

To comply with CE requirements, devices having a voltage of 50-1000 VAC or 75-1500 VDC but lacking a supply cord, plug, or other means for disconnect from the power supply must have the means of disconnection incorporated in the fixed wiring. This type of disconnect must have a contact separation of at least 1/8-inches (3 mm) at all poles.

Power Wiring

All wiring must comply with applicable electrical codes and ordinances specified on installation wiring diagrams. Controller wiring is terminated to the screw terminal blocks located on the device.

NOTE:

For multiple controllers operating from a single transformer, connect the same transformer secondary side to each controller's power input terminal.

Energy limited class 2 power source must provide 24 VAC/VDC power to the controller. To confirm this, the transformer must not be larger than 100 VA.

NOTE:

Power must be off before connecting or removing connections from the 24 VAC VDC power (24 V~/24 V0) and 24 VDC power terminals.

Use the heaviest gauge wire available, up to 18 AWG (1 mm^2), with a minimum of 22 AWG (0.3 mm^2), for all power wiring.

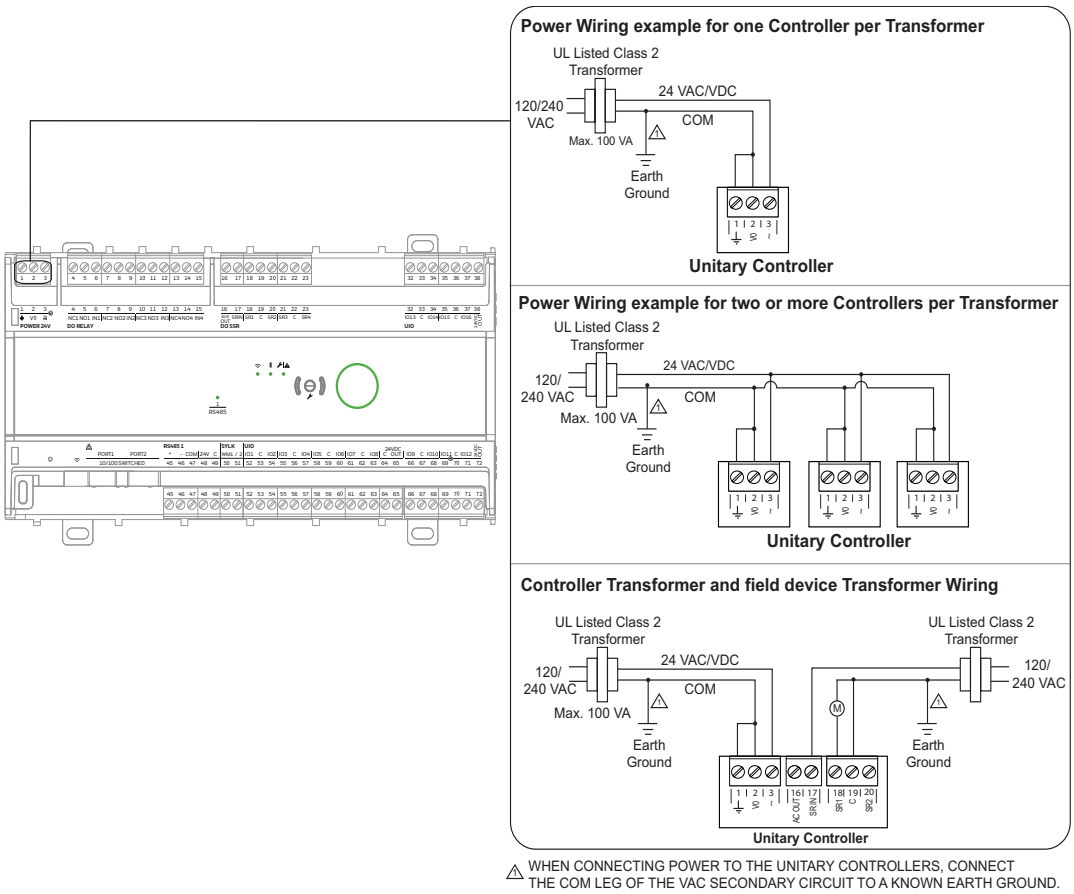


Figure 6. Power Wiring

Supply Voltage: 24 VAC/VDC. 50/60 Hz

IMPORTANT:
Power multiple controllers from a single transformer, and connect the same transformer secondary side to each device same power input terminal. When connecting power, ensure that one leg of the 24 VAC/VDC secondary circuit and the grounded terminal on the device connects to known earth ground at the panel or enclosure. Limit the distance of the power wire running between the device and the transformer to 15 feet (4.5 meters and restricted for same room installation). The transformer must be UL Listed for smoke control. The transformer also needs to be mounted and installed in an enclosure. Use a 15407287 series power supply.

⚠ CAUTION
Risk of Electric Shock - More than one disconnect switch may be required to de-energize the equipment before servicing. To Reduce the Risk of Fire or Electric Shock, Do Not Interconnect the Outputs of Different Class 2 Circuits.

Grounding:

EGND is a functional and it doesn't offer shock protection from a hazardous voltage. Connect the EGND terminal to the panel ground using the proper cable as shown above. Ensure that the panel ground connects to a known earth ground.

The RS-485 Standard

According to the RS-485 standard (TIA/EIA 485: "Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multi point Systems"), only one driver communicating via an RS-485 interface may transmit data at a time. Further, each RS-485 interface may be loaded with 32 unit loads according to U.L. requirements. For example, if a controller utilizes as little as 1/8-unit load each, 256 devices can be connected.

BACnet™ connections to the RS-485 interfaces must comply with the RS-485 standard. Thus, it is recommended that each end of every bus be equipped with a termination resistor (not included in shipment) with a resistance equal to the cable impedance (120 Ω; the wattage should be in the range of 0.25 – 0.5 W).

RS-485 systems frequently lack a separate signal ground wire. However, the laws of physics still require that a solid ground connection be provided to ensure error-free communication between drivers and receivers unless all of the devices are electrically isolated, and no earth grounding exists.

⚠ CAUTION

A separate signal ground wire must be used. Failing to obey this requirement can lead to unpredictable behavior if other electrically non-isolated devices are connected, and the potential difference is too high.

TIA/EIA 485 Cable Specifications

The following cable specification is valid for BACnet™ MSTP EIA 485 buses.

Table 3. TIA/EIA 485 cable specifications

Maximum length	1312 yards (1200 meters)
Cable type	Twisted shielded pair (foil or braided shields are acceptable)
Characteristic impedance	100-130 Ω
Distributed capacitance between conductors	Less than 30 pF per foot (100 pF per meter)
Distributed cap. between conductors and shield	Less than 200 pF per foot (60 pF per meter)

The Honeywell tested and recommended MSTP cable is Honeywell Cable 3322 (18 AWG, 1-Pair, Shielded, Plenum cable). Alternatively, Honeywell Cable 3251 (22 AWG, 1-Pair, Shielded, Plenum cable) is available and meets the BACnet™ Standard requirements.

Wiring Method

NOTE:

When attaching two or more wires to the same terminal, other than 14 AWG (2.0 mm^2), be sure to twist them together. Deviation from this rule can result in improper electrical contact,

Each terminal can accommodate the following gauge of wire:

- **Single wire**: From 22 AWG (0.3 mm^2) to 18 AWG (1 mm^2) solid or stranded
- **Multiple wires**: Up to two 18 AWG (1 mm^2) stranded, with 1/4-watt wire-wound resistor
  - Prepare wiring for the terminal blocks, as follows:
  - Strip 1/2 inches (13 mm) insulation from the conductor.
  - Cut a single wire to 3/16 inches (5 mm). Insert the wire in the required terminal location and tighten the screw.
  - If two or more wires are being inserted into one terminal location, twist the wires together with a minimum of three turns before inserting them.
  - Cut the twisted end of the wires to 3/16 inches (5 mm) before inserting them into the terminal and tightening the screw.
  - Pull-on each wire in all terminals to check for good mechanical connection.

NOTE:

Do not over-tighten the terminal screws to avoid deformation and damage to the terminal block—the maximum torque for the terminal screws is 4.4 in-lb (0.5 Nm).

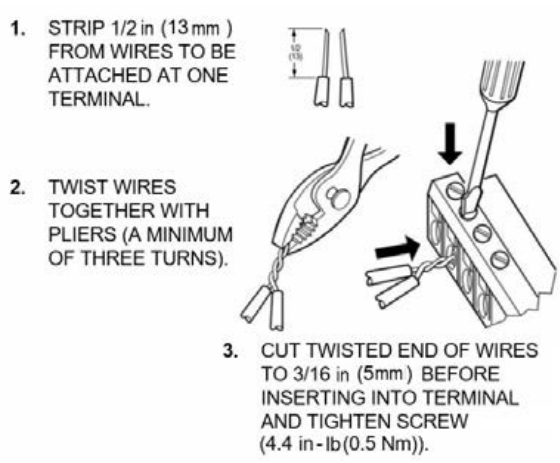


Figure 7. Attaching two or more wires at terminal block

BACnet™ MSTP Model

The MSTP variants of the Honeywell Unitary Controller use the BACnet™ MSTP communication protocol. The controller's data is presented to other controllers over a twisted-pair MSTP network, using the TIA/EIA 485 signal standard capable of the following baud rates: 9.6, 19.2, 38.4, 57.6, and 76.8 kb/s. The Honeywell Unitary Controller BACnet™ MSTP controllers are server devices on the MSTP network. Each Honeywell Unitary Controller BACnet™ controller uses a high-quality TIA/EIA 485 transceiver and exerts 1/8-unit load on the MSTP network. The controller features a 2-wire non-isolated RS-485 interface (terminals 45, 46, and 47) suitable for BACnet™ MSTP communication. The terminal block containing it is grey. The cable length affects the baud rate.

Table 4. Baud rate vs Maximum cable length

Baud rate	Maximum cable length (L)
9.6, 19.2, 38.4, 57.6, and 76.8 kbps	4000 feet (1200 meters)

NOTE:
The maximum BACnet™ MSTP network bus segment is 4,000 feet (1200 meters) using recommended wiring. Repeaters must be used when making runs longer than 4,000 feet (1200 meters). A maximum of three repeaters can be used between any two devices.

Auto Baudrate Functionality

Each time the supply voltage to the controller is switched on, the MSTP network is listened up to 4 minutes to determine a baud rate. As soon as a correct baud rate has been determined, this is used and stored in the controller as a successful baud rate, and the auto baud detection is terminated.

If no baud rate is determined after 4 minutes, the controller will switch to the baud rate successfully used before the controller was powered up. However, if the controller is new from the factory and has yet to communicate successfully then a default baud rate is used but not stored as a successful baud rate in the controller. This causes the same process to start again next time the supply voltage is switched on.

BACnet™ MSTP Limitations

There are two limitations regarding the number of controllers per BACnet™ MSTP network:

Physical Limitation:

One Beats IP & MSTP FCU represents 1/8 load (32 loads per TIA/EIA-485 standard). The physical limitation is important if 3rd party devices representing a full load are connected.

AutoMAC limitation:

For the default max master value see Table 5 AutoMAC Limitation.
A maxMaster of 127 means we can support a maximum of 125 BACnet™ MSTP FCU controllers, one supervisor, and one BACnet™ client (tool) per BACnet™ MSTP network.

Table 5 . AutoMAC limitation

Default maxMaster	Default MinMAC	Default MaxMAC	Default Baud rate
127	1	127	76800

NOTE:
0 and 127 are special MAC address reserved for auto MAC addressing.

Depending on the actual performance needs and required communication rates, connecting a smaller number of BACnet™ MSTP devices per network is recommended.

NOTE:
It is recommended not to have more than 62 controllers on single MSTP channel.

Automatic MAC Addressing

In contrast to other controllers, the Honeywell Unitary Controller features automatic MAC addressing.

The MAC addresses which the individual controllers in the BACnet™ MSTP channel assign to themselves is not assigned in sequential order. Rather, they assign the MAC Addresses in the range of min MAC to max MAC (these are exposed as the proprietary properties ID 1028 (min MAC) and 1029 (max MAC) under device object) currently not in use by another device in the BACnet™ MSTP channel (the MAC Address of "0" is reserved by default for the router/plant controller, itself).

All Honeywell Unitary Controllers are BACnet™ MSTP clients. Every client performs periodic polling for the possible appearance of new clients. Each client "knows" the identity of the "next" master (for example, that Honeywell Unitary Controller with the next-highest MAC Address) on the BACnet™ MSTP bus and to which it must therefore pass the token. The polling process

includes a search for new masters which might have MAC addresses lying between its own MAC address and that of the “next” master.

The property maxMaster specifies the highest-allowable address for master nodes. The maxMaster is set to 127 by default, thus guaranteeing that, on a BACnet™ MSTP bus. Following properties are writeable and can be changed:

- maxMaster
- min MAC
- max MAC
- MAC address.

NOTE:
It would help if you did not attempt to program a MAC address outside the range of min MAC and max MAC.

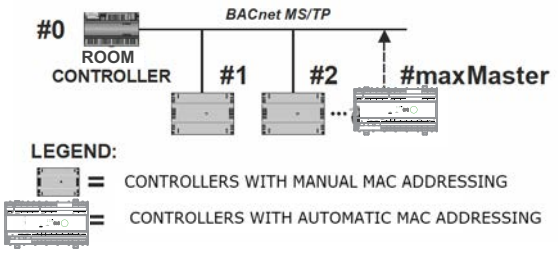


Figure 8. Automatic MAC addressing

In the scenario depicted, some of the BACnet™ MSTP channel controllers do not feature automatic MAC addressing; instead, their MAC addresses were assigned manually. Thus, when a new device is added to the channel and its automatic MAC addressing function is triggered, it will set itself an available (unused) MAC address within the range of min MAC and max MAC values.

Setting the MSTP MAC Address

The MSTP MAC address for each device must be set to a unique value in the range of 1-126 on an MSTP network segment (addresses 1, 2, & 3 should be avoided as they are commonly used for the router, diagnostic tools, and as spare addresses). A seven-position DIP switch on the MSTP BACnet™ controller sets the controller's MAC address.

NOTE:
DIP setting of all-ON (Mac address will be 127) or all-OFF (Mac address will be 0) will enable the Auto MAC mode in the controller. The dip switches will not be used for MAC addressing.

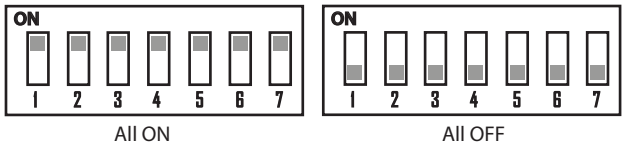


Figure 9. MSTP MAC Address Details

To set the MAC address of a BACnet™ MSTP Honeywell Unitary Controller:

1. Find an unused MAC address on the BACnet™ MSTP network to which the Honeywell Unitary Controller connects.
2. Locate the DIP switch bank on the Honeywell Unitary Controller for addressing.
3. Power off the Honeywell Unitary Controller BACnet™ and set the DIP switches for the MAC address you want.
4. Add the value of DIP switches set to ON to determine the MAC address. See Table 6 below.

Table 6. DIP Switch values for MSTP MAC Address

DIP	1	2	3	4	5	6	7
VALUE	1	2	4	8	16	32	64

For example, if only DIP switches 1, 3, 5, and 7 are on, the MAC address would be 85 (1 + 4 + 16 + 64 = 85).

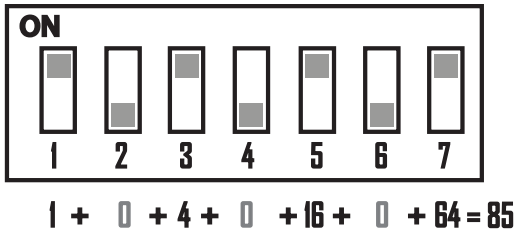


Figure 10. Calculating the MAC address

Setting the Device Instance Number

The Device Instance number must be unique across the entire BACnet™ MSTP network because it is used to identify the BACnet™ devices uniquely. It may be used to identify the BACnet™ device from other devices during installation conveniently. The BACnet™ MSTP Device Instance number is automatically set when added to a Niagara station. The user can change the Device Instance number.

Termination Resistors

Matched terminating resistors are required at each end of a segmented bus wired across (+) and (-). Use matched precision resistors rated ¼ W ±1% or 80 - 130 Ω.

Ideally, the value of the terminating resistors should match the rated characteristic impedance of the installed cable. For example, if the installed MSTP cable has a listed characteristic impedance of 120 Ω, install 120 Ω matched precision resistors.

Shield Termination

Following proper MSTP cabling shield grounding procedures is important to minimize the risk of communication problems and equipment damage caused by capacitive coupling. Capacitive coupling is caused by placing MSTP cabling close to higher voltage lines. If shielding is used, the shielding of each bus segment should be separately connected at one end to the earth.

NOTE:

If any of the devices are electrically isolated, it is recommended that those devices be connected to a single ground.

The controller communicates via its BACnet™ MSTP interface with other BACnet™ MSTP capable devices (for example, other room controllers or MSTP controllers). In doing so, the following considerations should be taken into account.

- Maximum BACnet™ MSTP bus length.
- Twisted-pair cable, for example,
  1. AWG 18 (1 mm^2)
  2. J-Y(ST)Y 4 x 2 x 0.8 mm2 or a special RS-485 cable.
  3. CAT 5,6,7 cable: use only one single pair for one bus.
  4. Belden 9842 or 9842NH
  5. Daisy chain topology.
  6. Must conform to TIA/EIA RS-485 cabling guidelines and ANSI/ASHRAE Standard 135-2010.

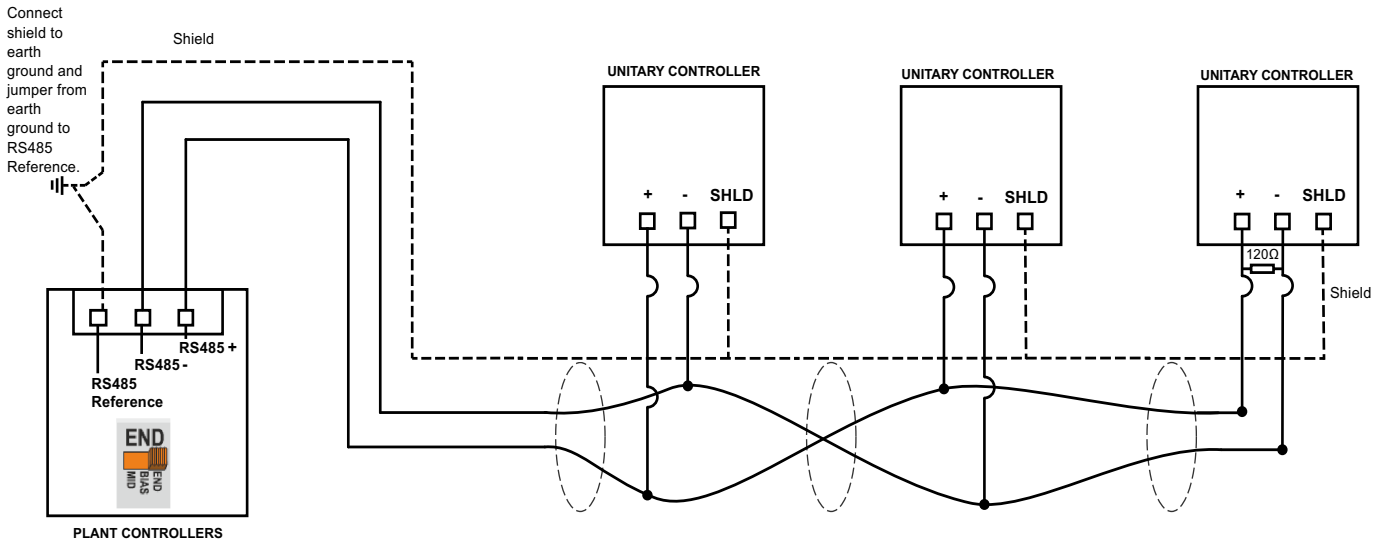


Figure 11. Connection to a BACnet™ MSTP Bus

NOTE:

- Suppose any of the devices are electrically isolated. It is recommended that those devices be connected to the ground terminal (GND), if available. See TIA/EIA 485 Cable Specifications.
- The 120 Ω termination resistor must be inserted directly into the terminals of both end devices.
- If shielding is used, the shielding of each individual bus segment should be separately connected at one end to earth.
- Always power each controller and the connected slaves via separate transformers.
- Between devices equipped with non-isolated RS-485 bus interfaces, potential differences of max. ±7 V are allowed. Further, this bus should not extend beyond a single building.

BACnet™ MSTP connection with non-isolated RS485 Interfaces

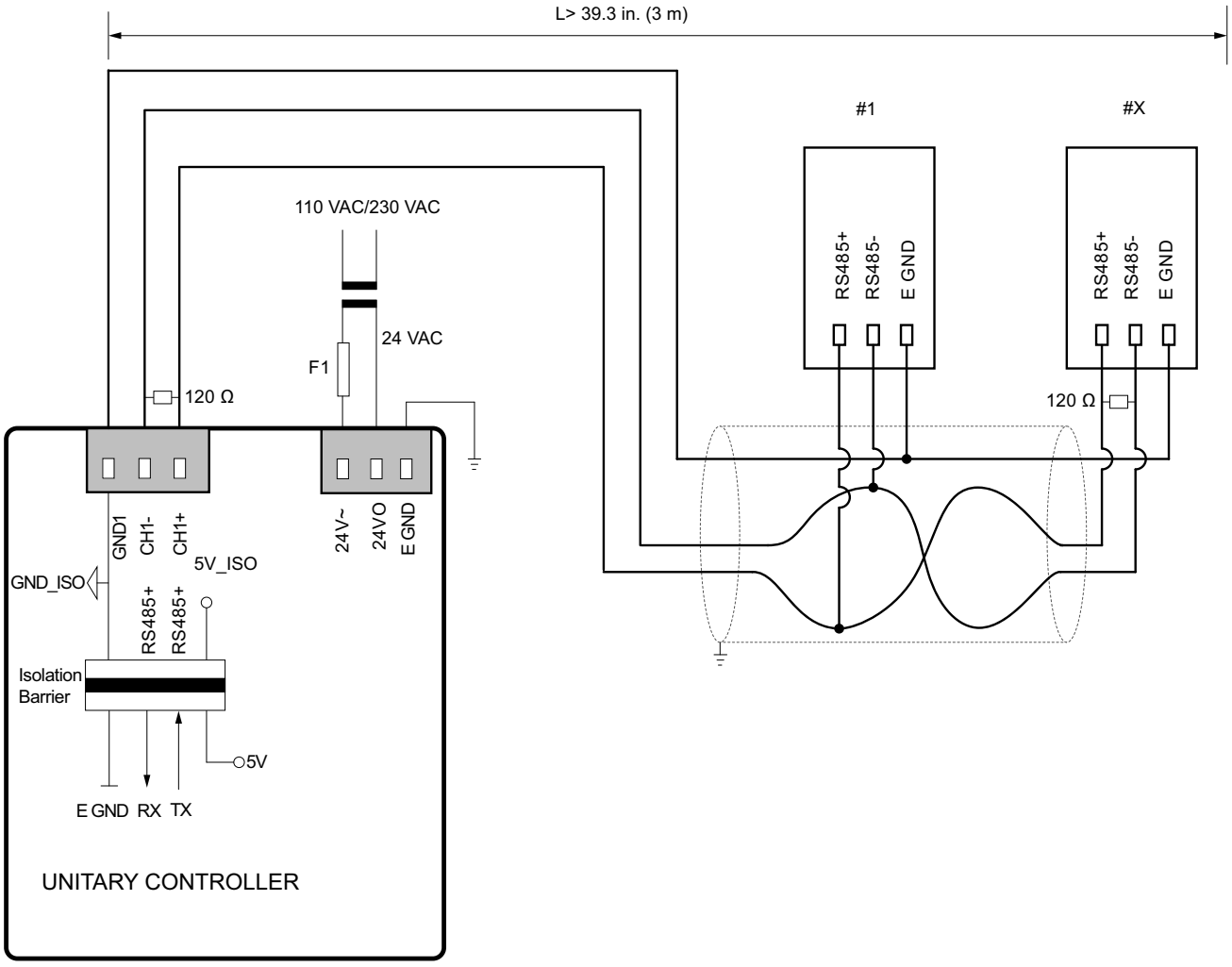


Figure 12. Connection of RS485 interfaces 1, 2, or 3 (RS485 interface 1 shown) on a BACnet™ Bus

NOTE:

- Always power the Unitary Controller with a separate transformer.
- X = max. 62 controllers.
- Single ground (single reference) connection is recommended if not all devices are electrically isolated.

BACNET™ IP MODEL

Table 7. Default IP Address

IP Address	169.254.x.x
Gateway	0.0.0.0
Subnet Mask	255.255.0.0

Connecting to an IP network

Unitary Controller communicates over wired IPV4 network using Ethernet connection via two RJ45 ports.

DHCP IP Configuration

If DHCP mode is enabled:

- For the first 15 seconds, the controller will search for a DHCP server to acquire an IP address on power-up.
- Suppose the DHCP server Ethernet switch is unavailable. In that case, the controller will switch to Auto IP mode. It follows Link-Local Addressing for address resolution.
- The controller acquires an IP address in range 169.254.1.0 - 169.254.254.254. It uses the last two (2) numbers of its serial number as the last octet for starting address search. For example, if the serial number ends with “36” (decimal value = 54), the IP address is set to 169.254.1.54.

Static IP Configuration

Static IP address can be configured using Niagara 4 workbench.

1. Navigate to IP configuration under IP settings.
2. Select the IP address as **Static.**
3. Select **Enabled** as True.
4. Configure a valid **IP address**.

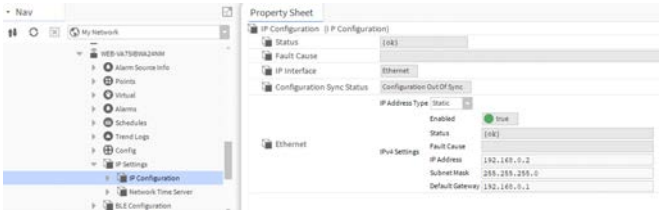


Figure 13. Static IP Configuration

Refer to the *Unitary Controller System Engineering Guide* for more information on configuring the IP address.

Network Topologies

- Recommended cable: Cat5/Cat6
- Maximum distance between two controllers or controller, and switch should be less than 328 ft. (100 meters)

Non-Failover (Daisy Chain)

In non-failover, that is the daisy chain connection type. If any of the devices in the network fails, the devices next to the failed device also fail.

For example, there are 10 devices in a network, and device number 1 is the master device, which is connected to device 2, and device 2 is connected to 3, and so on. If device 5 fails to function then 6, 7, 8, 9, and 10 also fail to communicate with the master device.

Maximum number of controllers that can be connected in a daisy chain is 100.

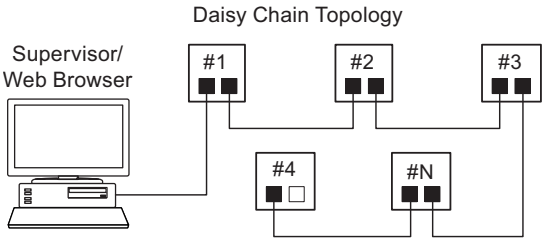


Figure 14. Daisy chain topology

Spanning Tree Protocol (RSTP)

Suppose the Unitary Controller are connected in a redundant ring. In that case, you must have one spanning tree protocol supported Ethernet switch as a part of the ring. Beats IP MSTP FCU supports an Ethernet switch for 10/100 Mbps IP connection.

The switch will connect Unitary Controller ring with the IP network. The loop-free topology ensures that there aren’t any broadcast storms or duplicate frame transmissions. The maximum number of controllers connected in the STP loop is 40.
A switch manages the connection of a loop.

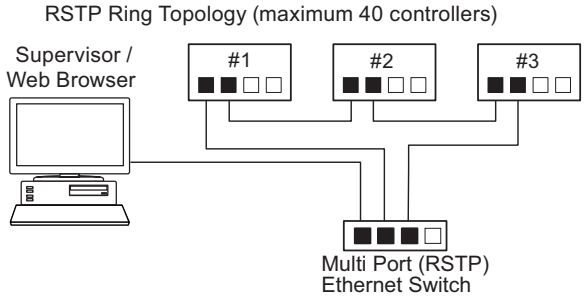


Figure 15. STP wiring

T1L COMMUNICATION AND STANDARD

The standard Ethernet, 4-wire solution has evolved into a 2-wire solution known as 10BASE-T1L, consisting of a single pair of twisted cables or single-pair Ethernet (SPE).

10BASE-T1L offers the existing 2-wire infrastructure to realize line lengths of up to 1000 m at a transmission speed of 10 Mbps (see below table).

The T1L communication protocol allows devices to communicate on low-cost single twisted pair cable within an IP network. It reduces the cost of the installation of these devices. Through the Honeywell T1L media adaptor, T1L networks can be connected to main IP networks by converting one media type to another. An RJ-45 connector connects the 10BASE-T network cable to a switch or host device, and a three-way screw terminal connects the downstream T1L devices with the twisted pair cable. The two ports exchange data packets in both directions. The adaptor does not require an IP or MAC address and works out of the box with no configuration.

Daisy Chain Topology

The maximum number of T1L controllers which can be connected in a daisy chain is 100 with some limitations over few operations.

Spanning Tree Protocol (RSTP)

The maximum number of T1L controllers which can be connected in the STP loop is 40 with some limitations.

Table 8. T1L specifications

10BASE-T1L Standard	802.3cg-2019
Connection	Screw terminal, auto MDI-X
Cable Type	Single twisted pair
Distance	• 1000 feet (300 meters) maximum to Honeywell controller with failure-tolerant daisy chain. • 3300 feet (1000 meters) maximum to any other T1L device without a daisy chain.
Bus speed	10 Mbs/s

SYLK BUS™

Sylk™ Bus compatible wall modules such as TR120 can be connected to the controller's Sylk™ (terminals 50 and 51).

- The Sylk™ bus is single pair and polarity insensitive.
- Maximum current provided at the Sylk™ bus interface: 96 mA.
- The maximum number of wall modules depends on the following wall module specific information:
  - Sylk™ bus power consumption
  - Number of parameters used
  - Total config file size

The Niagara software has a built-in resource calculator to calculate the number of Sylk™ wall modules.

Following are the Sylk™ devices and Sylk™ actuator supported by the Honeywell Unitary Controller.

Supported Sylk™ Bus Devices

Sylk™ Wall Modules

TR40, TR40-H, TR40-CO2, TR40-H-CO2, TR42, TR42-H, TR42-CO2, TR42-H-CO2, TR71, TR71-H, TR75, TR75-H, TR120 (TR120_TR75E), and TR120-H (TR120H_TR75E) emulation mode only.

Sylk™ Actuator

MS3103, MS3105, MS4103, MS4105, MS7403, MS7405, MS7503, MS7505, MS8103, MS8105 spring return direct-coupled actuators (DCA) are used within heating, ventilating, and air-conditioning (HVAC) systems. They can drive a variety of quarter-turn, final control elements requiring spring return fail-safe operation.

Sylk™ Sensors

C7400S Sylk™ Sensor

NOTE:
- TR42x wall module must be firmware version 1.3 or higher.
- TR70 wall modules are not supported.

Table 9. Recommended maximum distances from controller to TR40x/T42x wall modules

Single twisted pair, non-shielded, stranded or solid[a)]		**Standard non-twisted thermostat wire shielded or non-shielded, stranded or solid[b)]**
18 - 22 AWG (0.3 to 1 mm^2)	24 AWG (0.20 mm^2)	18 - 24 AWG (0.20 to 1 mm^2)
500 ft (150 m)	400 ft (120 m)	100 ft (30 m)

a) As a rule of thumb, single twisted pair (two wires per cable, only), thicker gauge, non-shielded cable yields the best results for longer runs.

b) The standard thermostat wire's 100 ft (30 m) distance is conservative. Still, it is meant to reduce the impact of any sources of electrical noise (incl. but not limited to VFDs, electronic ballasts, etc.).

NOTE:
- Shielded cable is recommended if there is a need to reduce the effect of electrical noise.
- These distances also apply to shielded pair.

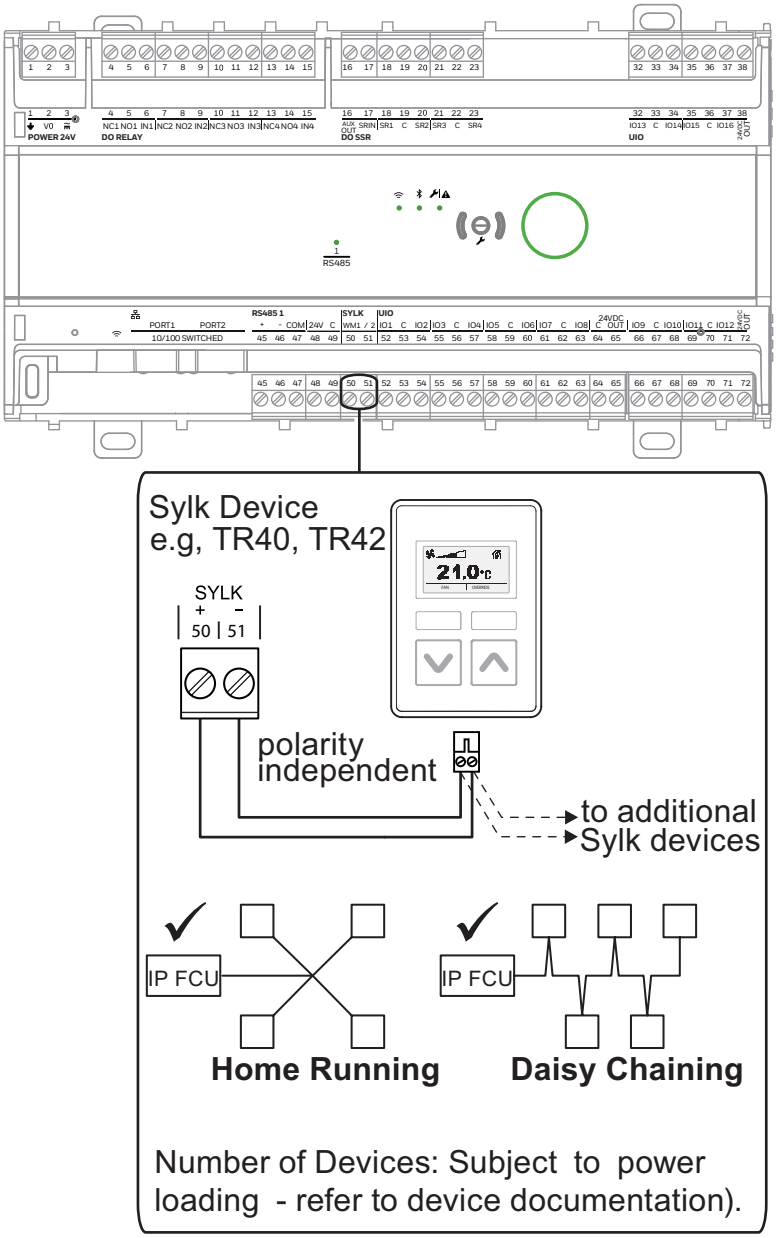


Figure 16. Sylk™ Wiring Topologies

MODBUS RTU

The controller features a removable 2-wire with shield, non-isolated, RS-485 interface suitable for Modbus communication (terminals 16, 17, and 18). The terminal block containing it is gray. The controller can function only as a Modbus server. In general, the TIA/EIA 485 wiring rules must be followed.

Wiring Topology

Only daisy chain wiring topology is allowed.

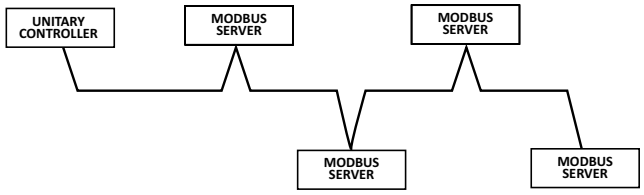


Figure 17. Modbus Wiring Topology

Other wiring topologies (such as star wiring and mixed star wiring) are prohibited. This is to avoid communication problems in the physical layer.

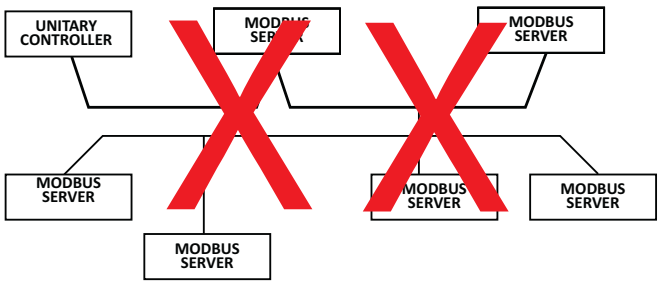


Figure 18. Prohibited Wiring Topology (example)

Cables and Shielding

Use shielded twisted pair cable J-Y-(St)-Y 4 x 2 x 0.8 and connect the Modbus shield to a noise-free earth ground (only once per Modbus network).

Shielding is primarily recommended when the Modbus cable is installed in areas with expected or actual electromagnetic noise. Prefer avoiding such areas.

You must use three wires:

- One wire for Modbus +
- One wire for Modbus –
- One wire for the signal common

When using one pair for Modbus (+) and Modbus (-) and one wire of another pair for the signal common, CAT 5 cable may also be used.

RS-485 Repeaters

RS-485 repeaters are possible but have not been tested by Honeywell, Therefore, it is the responsibility of the installing and/or commissioning person to ensure proper function.

NOTE:
Each Modbus segment will require its own line polarization and line termination (120 Ω; the wattage should be in the range of 0.25 – 0.5 W).

Modbus Client Specifications

Table 10. Modbus Client Specifications

Specification	Description
Physical Layer	2-wire serial line (TIA/EIA-485) (with additional common)
Communication rates	9.6, 19.2, 38.4, 57.6, and 76.8 kb/s supported.
Maximum numbers of devices	32, It is recommended to connect a smaller number of devices for better Modbus performance.
Cable and wiring specifications	Check cable and specifications in power wiring section.
Communication Mode	Modbus Master only.
Transmission Mode	RTU (Remote Terminal Unit).
Address Range	Modbus client can have an address between 1 and 247. Discrete inputs, coils, input registers and holding registers can have an address between 1 and 65534.

Modbus Compliance

As per the Modbus standard, the Unitary Controller is a conditionally compliant “regular” Modbus device.

The controller differs from an unconditionally compliant “regular” Modbus device in that it does not support communication rates of 1.2, 2.4, and 4.8 kb/s (because these communication rates are not market-relevant).

The baudrate (1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 115200), parity (Even/Odd, None) and the number of stop bits (1 or 2) can be selected under Controller - IRM Program - Control Manager.

Modbus Considerations

The RS-485 interface suitable for Modbus communication is 2-wire with shield non-isolated, hence the following considerations apply:

- Maximum Modbus length (“L”):
  4000 feet (1200 meters) for 9.6 – 78.8 kbps or
  2600 feet (790 meters) for 115.2 kbps. It is recommended that you select a low baud rate (for example, 19.2 kbps) for reliable operation.
- Use only shielded, twisted pair of cables and daisy chain topology.
- Ground noise should not exceed the EIA-485 common mode voltage limit.
- Must conform to TIA/EIA 485 cabling guidelines.
- Should not extend beyond a single building.

TROUBLESHOOTING

Honeywell Unitary Controller feature a Service Button, Status LED, Power LED, and two additional LEDs (T1 and R1) for commissioning and troubleshooting.

Check if the Status LED's behavior is changed if you switch the power OFF/ON. If this does not solve the problem, contact your Reseller. If you purchased the product directly from Honeywell or have been instructed by your Reseller to contact Honeywell Safety and Productivity Solutions directly, call the Customer Service Department.

Further, the test function (online debugging) of Niagara Workbench can also be used to carry out a general application and wiring checks. Niagara Workbench also features a BACnet™ device manager who can prove very helpful in analyzing the controller's function and communication.

OPERATOR INTERFACE LEDS

The controller features the following LEDs.

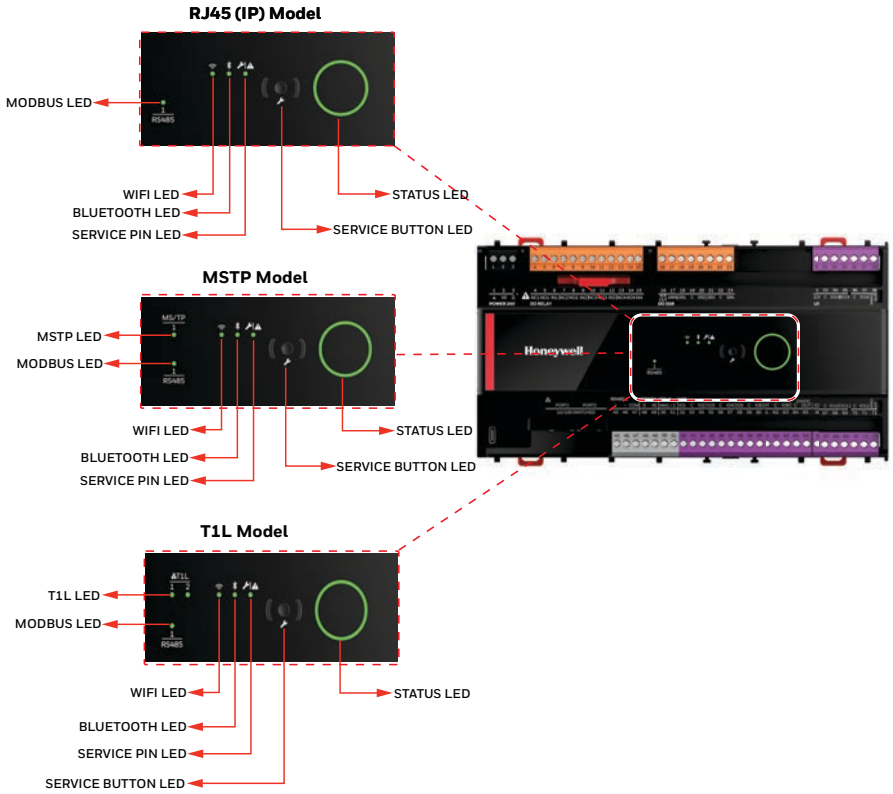


Figure 19. LED interface

Table 11. STATUS LED Details

LED Status	Visual	Mode
Green LED permanent ON		Normal operation
Green LED blinks every 2 seconds		Auto MAC
Green LED blinks every 200 ms.		Firmware download
Yellow LED permanent ON		No Valid Mac
Yellow LED blinks every 2 seconds		Un Ack Alarm
Red LED permanent ON		Broken sensor
		Short circuit
Red LED blinks every 200 ms.		Communication error
Red, Green, Yellow LED blinks every 1 second		No application

Table 12. Modbus LED STATUS

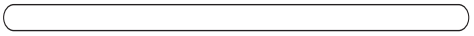
LED Status	Visual	Mode
Green LED permanent ON		Modbus Communication is healthy - Successful to read/write all of Modbus registers configured in the application.
Yellow LED permanent ON		Modbus Communication is not healthy - failure to read/write some of Modbus registers configured in the application.
Red LED permanent ON		Modbus Communication failure - failure to read/write all of Modbus registers configured in the application.
LED OFF		No Modbus Communication - Application don't have any Modbus read/write registers.

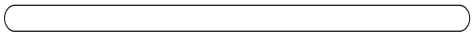
Table 13. BACnet® MSTP LED STATUS

LED Status	Visual	Mode
Green LED permanent ON		Controller MSTP BACnet communication is normal.
Yellow LED permanent ON		Controller is sending MSTP BACnet packets but not receiving any response.
Red LED permanent ON		No communication from MSTP BACnet. The controller is not in the MSTP network.

Table 14. T1L LED STATUS

LED Status	Visual	Mode
Green LED permanent OFF		Link is up, Valid IP address is configured. Communication is healthy.
Yellow LED permanent OFF		Link is up, No valid IP address is configured.
LED OFF		Link is down.

Table 15. Service Pin LED STATUS

LED Status	Visual	Mode
Green LED permanent ON		On Service PIN button Press
LED OFF		On release of Service PIN button

NOTE:
The communication error mode on the LED status reacts only on Modbus communication RS485-1.

REGULATORY INFORMATION

FCC Regulation

This device complies 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:

This equipment has 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.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

However, there is no guarantee that interference will not occur in a particular installation.

Suppose this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on. In that case, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Wireless Connectivity

Table 16. Connectivity Frequency Range

Parameter	Specification
Connectivity	Bluetooth
Frequency Range	2.4 GHz
E.I.R.P for CE (Effective Isotropic Radiated Power)	20 mW
E.I.R.P for FCC/IC (Effective Isotropic Radiated Power)	20 mW

The BLE (Nordic) chip is used for the secure application of BLE communication and wiring verification. It works at a frequency of ~2400 MHZ. A mobile app is used to establish a secure BLE connection to the controller via BLE. After establishing a secure connection with the controller's mobile app, the controller will exchange cable verification data over BLE in an encrypted format.

Canadian Regulatory Statement

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:
(1) this device may not cause interference, and
(2) this device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

(1) L'appareil ne doit pas produire de brouillage;

(2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

CE Statement: The WLAN function for this device is restricted to indoor use only when operating in the 5150 to 5350 MHz frequency range.

Figure 20. CE Statement

EMF Statement: To comply with the RF exposure requirement, a separation distance of 20 cm between the device and the human should be maintained.

Déclaration EMF: Pour se conformer à l'exigence d'exposition RF, une distance de séparation de 20 cm entre l'appareil et l'humain doit être maintenue.

RESTRICTIONS IN THE 5 GHZ BAND

Within the 5.15 to 5.25 GHz band, UNII devices will be restricted to indoor operations to reduce any potential for harmful interference to co-channel Mobile Satellite System (MSS) operations.

Professional Installation Warning

- This device must be professionally installed, this should be noted on grantee.
- To maintain compliance, only the antenna types that have been tested shall be used.
- This device requires significant technology engineering expertise to understand the tools and relevant technology unavailable to the average consumer. Only a person professionally trained in the technology is competent.
- This device is not directly marketed or sold to general public.

Detachable Antenna Warning (IC)

Transmitter Antenna (From Section 6.8 RSS-GEN, Issue 5, April 2018):

Innovation, Science has approved this radio transmitter, and Economic Development Canada operates with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list with a gain greater than the maximum gain indicated for any type listed are strictly prohibited from using this device.

Table 17. Bluetooth Certification Numbers

FCC ID	IC ID
2A8LT-24NM001	12252A-24NM001

Standards and Compliance

- CE mark
- UL916
- UL/ULC 60730-1
- FCC/IC Product Class B,
- UL2043
- BACnet™ BTL®-Listed

Approvals and Certifications

- UL 60730-1, Standard for Automatic Electric Controls for Household and Similar Use, Part 1: General Requirements
- CAN/CSA-E60730-1:02, Standard for Automatic
- Electrical Controls for Household and Similar Use, Part 1: General Requirements
- Complementary listing for UL916, CSA C22.2 No. 205.
- BACnet™ BTL®-Listed; BACnet™ Advanced Application Controller
- (B-AAC) certification pending, expected in 2023.
- Advanced Application Controller (B-AAC) as per ANSI/ASHRAE 135.
- CE-approved
- FCC part 15B-compliant.
- RoHS Conformity

WEEE Directive 2012/19/EC Waste Electrical and Electronic Equipment directive

At the end of the product life, dispose of the packaging and product in an appropriate recycling center. Do not dispose of the device with the usual domestic refuse.Do not burn the device.

Article 33 Communication

REGULATION (EC) No 1907/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006

Concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)

Honeywell takes compliance with REACH very seriously.

According to Article 33 “Duty to communicate information on substances in articles”:

- Any supplier of an article containing a substance meeting the criteria in Article 57 and identified under Article 59(1) in a concentration above 0,1% weight by weight (w/w) shall provide the recipient of the article with sufficient information available to the supplier, to allow safe use of the report including, as a minimum, the name of that substance.

- On request by a consumer, any supplier of an article containing a substance meeting the criteria in Article 57 and identified under Article 59(1) in a concentration above 0,1% weight by weight (w/w) shall provide the consumer with sufficient information, available to the supplier, to allow safe use of the article including, as a minimum, the name of that substance. We have to inform you that the substance(s) listed below may be contained in these products above the threshold level of 0.1% by weight of the listed article.

Table 18. Honeywell Unitary containing Lead (Pb)

Product/Part Name	Substance Name
UN-RS0844ES24NMC / D UN-RS0844ESB24NMC / D UN-RS0844MS24NMC / D UN-RS0844MSB24NMC / D UN-RS0844TS24NMC / D UN-RS0844TSB24NMC / D UN-RL1644ES24NMC / D UN-RL1644ESB24NMC / D UN-RL1644MS24NMC / D UN-RL1644MSB24NMC / D UN-RL1644TS24NMC / D UN-RL1644TSB24NMC / D	Lead (Pb)

- We confirm that our products do not use any other REACH restricted materials during the manufacturing, storage or handling process.

APPENDIX

Sensor Input Accuracy

The controller's internal sensor inputs support both 10 K NTC Ω and 20 K NTC Ω sensors. The following table lists the typical minimum accuracies of the hardware and software for these temperature sensors.

Table 19. Sensor accuracies

Range	Measurement error (excluding sensor characteristics)			
	10 kΩ NTC [a)]	**20 k NTC**	**PT3000**	**NI1000TK5000 [b)]**
-58 °F to -4 °F (-50 °C to -20 °C)	≤ 5.0 K	≤ 5.0 K	≤ 1.2 K	≤ 1.2 K
-4 °F to +32 °F (-20 °C to 0 °C)	≤ 1.0 K	≤ 1.0 K	≤ 0.7 K	≤ 0.7 K
32 °F to 86 °F (0 °C to 30 °C)	≤ 0.5 K	≤ 0.3 K	≤ 0.5 K	≤ 0.5 K
86 °F to 158 °F (30 °C to 70 °C)	≤ 0.5 K	≤ 0.5 K	≤ 0.7 K	≤ 0.7 K
158 °F to 212 °F (70 °C to 100 °C)	≤ 1.0 K	≤ 1.0 K	≤ 1.2 K	≤ 1.2 K
212 °F to 266 °F (100 °C to 130 °C)	--	≤ 3.0 K	≤ 1.2 K	≤ 1.2 K
266 °F to 302 °F (130 °C to 150 °C)	--	≤ 5.5 K	≤ 1.2 K	--
302 °F to 752 °F (150 °C to 400 °C)	--	--	--	--

a) 10 k NTC Ω specified for -22 °F to 212 °F (-30 °C to +100 °C) only.

b)NI1000TK5000 specified for -22 °F to +266 °F (-30 °C to +130 °C) only.

NOTE:

This is the internal sensor input (hardware + software [linearization]) only. This table does not include the characteristics of the sensors themselves (see section “Sensor Characteristics below). Recognition of sensor failure for sensor inputs.

Recognition of Sensor Failure of Sensor Inputs

The thresholds at which the sensor fails, that is, sensor breaks (SB) and short-circuits (SC), are recognized, depending upon the given sensor type. In the event of a recognized sensor failure, the sensor assumes the safety values configured. It lists the measurement ranges and the corresponding thresholds for the recognized sensor failure for the various types of sensor:

Table 20. Thresholds for short-circuit (SC) and sensor-break (SB) recognition

I/O configuration	Measurement range	Recognition thresholds
2 to 10 V	2 to 10 VDC 4 to 20 mA (without pull-up)	SC: < 1.5 VDC 3 mA SB: no recognition
10 k NTC Ω (Type II)	-22 °F to +212 °F (-30 °C to +100 °C)	SC: < 20 Ω SB: < -94 °F (-70 °C)
20 k NTC Ω	-58 °F to +302 °F (-50 °C to +150 °C)	SC: < 20 Ω SB: < -94 °F (-70 °C)
PT1000	-58 °F to +752 °F (-50 °C to + 400 °C)	SC: < 775 Ω SB: < -58 °F (-50 °C)
NI1000TK5000	-22 °F to +266 °F (-30 °C to +130 °C)	SC: < 850 Ω SB: < -58 °F (-30 °C)
PT100	-58 °F to +752 °F (-50 °C to +400 °C)	-
PT3000	-58 °F to +302 °F (-50 °C to +150 °C)	-
10K3A1	-40 °F to +257 °F (-40 °C to +125 °C)	-
Nickel Class B DIN 43760 sensors	-76 °F to +752 °F (-60 °C to +169 °C)	-

NOTE:
In the case of temperatures lying outside the ranges shown in table, the lowest and highest value within the range, will be communicated. Thus, a temperature of -51 °F will be communicated as “-50 °F.”

Sensor Characteristics

The sensors' characteristics (resistance with temperature) and the resultant voltage are listed on the following pages. The stated values do not include:

- Sensor failures.
- Wiring resistance or wiring failures.
- The meter shows incorrect reading, when it is connected to measure voltage or resistance at the input.

PT1000

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
-58	-50	803	0.312
-56.2	-49	807	0.314
-54.4	-48	811	0.315
-52.6	-47	815	0.317
-50.8	-46	819	0.318
-49	-45	823	0.32
-47.2	-44	827	0.321
-45.4	-43	831	0.323
-43.6	-42	835	0.324
-41.8	-41	839	0.326
-40	-40	843	0.327
-38.2	-39	847	0.329
-36.4	-38	851	0.33
-34.6	-37	855	0.332
-32.8	-36	859	0.333
-31	-35	862	0.335
-29.2	-34	866	0.336
-27.4	-33	870	0.338
-25.6	-32	874	0.339
-23.8	-31	878	0.341
-22	-30	882	0.342
-20.2	-29	886	0.344
-18.4	-28	890	0.345
-16.6	-27	894	0.347
-14.8	-26	898	0.348
-13	-25	902	0.35
-11.2	-24	906	0.351
-9.4	-23	910	0.353
-7.6	-22	914	0.354
-5.8	-21	918	0.356
-4	-20	922	0.357
-2.2	-19	926	0.359
-0.4	-18	929	0.36
1.4	-17	933	0.361
3.2	-16	937	0.363
5	-15	941	0.364
6.8	-14	945	0.366
8.6	-13	949	0.367
10.4	-12	953	0.369
12.2	-11	957	0.37
14	-10	961	0.372
15.8	-9	965	0.373

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
17.6	-8	969	0.375
19.4	-7	973	0.376
21.2	-6	977	0.378
23	-5	980	0.379
24.8	-4	984	0.38
26.6	-3	988	0.382
28.4	-2	992	0.383
30.2	-1	996	0.385
32	0	1000	0.386
33.8	1	1004	0.388
35.6	2	1008	0.389
37.4	3	1012	0.391
39.2	4	1016	0.392
41	5	1020	0.394
42.8	6	1023	0.395
44.6	7	1027	0.396
46.4	8	1031	0.398
48.2	9	1035	0.399
50	10	1039	0.401
51.8	11	1043	0.402
53.6	12	1047	0.404
55.4	13	1051	0.405
57.2	14	1055	0.406
59	15	1058	0.408
60.8	16	1062	0.409
62.6	17	1066	0.411
64.4	18	1070	0.412
66.2	19	1074	0.413
68	20	1078	0.415
69.8	21	1082	0.416
71.6	22	1086	0.418
73.4	23	1090	0.419
75.2	24	1093	0.42
77	25	1097	0.422
78.8	26	1101	0.423
80.6	27	1105	0.425
82.4	28	1109	0.426
84.2	29	1113	0.428
86	30	1117	0.429
87.8	31	1121	0.431
89.6	32	1124	0.432
91.4	33	1128	0.433
93.2	34	1132	0.435

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
95	35	1136	0.436
96.8	36	1140	0.438
98.6	37	1144	0.439
100.4	38	1148	0.441
102.2	39	1152	0.442
104	40	1155	0.443
105.8	41	1159	0.445
107.6	42	1163	0.446
109.4	43	1167	0.448
111.2	44	1171	0.449
113	45	1175	0.451
114.8	46	1179	0.452
116.6	47	1182	0.453
118.4	48	1186	0.455
120.2	49	1190	0.456
122	50	1194	0.458
123.8	51	1198	0.459
125.6	52	1202	0.461
127.4	53	1205	0.462
129.2	54	1209	0.463
131	55	1213	0.465
132.8	56	1217	0.466
134.6	57	1221	0.467
136.4	58	1225	0.469
138.2	59	1229	0.47
140	60	1232	0.471
141.8	61	1236	0.473
143.6	62	1240	0.474
145.4	63	1244	0.476
147.2	64	1248	0.477
149	65	1252	0.479
150.8	66	1255	0.48
152.6	67	1259	0.481
154.4	68	1263	0.483
156.2	69	1267	0.484
158	70	1271	0.486
159.8	71	1275	0.487
161.6	72	1278	0.488
163.4	73	1282	0.49
165.2	74	1286	0.491
167	75	1290	0.493
168.8	76	1294	0.494
170.6	77	1297	0.495

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
172.4	78	1301	0.497
174.2	79	1305	0.498
176	80	1309	0.499
177.8	81	1313	0.501
179.6	82	1317	0.502
181.4	83	1320	0.503
183.2	84	1324	0.505
185	85	1328	0.506
186.8	86	1332	0.508
188.6	87	1336	0.509
190.4	88	1339	0.51
192.2	89	1343	0.512
194	90	1347	0.513
195.8	91	1351	0.515
197.6	92	1355	0.516
199.4	93	1358	0.517
201.2	94	1362	0.519
203	95	1366	0.52
204.8	96	1370	0.522
206.6	97	1374	0.523
208.4	98	1377	0.524
210.2	99	1381	0.525
212	100	1385	0.527
213.8	101	1389	0.528
215.6	102	1393	0.53
217.4	103	1396	0.531
219.2	104	1400	0.532
221	105	1404	0.534
222.8	106	1408	0.535
224.6	107	1412	0.537
226.4	108	1415	0.538
228.2	109	1419	0.539
230	110	1423	0.541
231.8	111	1427	0.542
233.6	112	1430	0.543
235.4	113	1434	0.545
237.2	114	1438	0.546
239	115	1442	0.547
240.8	116	1446	0.549
242.6	117	1449	0.55
244.4	118	1453	0.551
246.2	119	1457	0.553
248	120	1461	0.554

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
249.8	121	1464	0.555
251.6	122	1468	0.557
253.4	123	1472	0.558
255.2	124	1476	0.56
257	125	1479	0.561
258.8	126	1483	0.562
260.6	127	1487	0.564
262.4	128	1491	0.565
264.2	129	1494	0.566
266	130	1498	0.567
267.8	131	1502	0.569
269.6	132	1506	0.57
271.4	133	1510	0.572
273.2	134	1513	0.573
275	135	1517	0.574
276.8	136	1521	0.576
278.6	137	1525	0.577
280.4	138	1528	0.578
282.2	139	1532	0.58
284	140	1536	0.581
285.8	141	1539	0.582
287.6	142	1543	0.584
289.4	143	1547	0.585
291.2	144	1551	0.586
293	145	1554	0.587
294.8	146	1558	0.589
296.6	147	1562	0.59
298.4	148	1566	0.592
300.2	149	1569	0.593
302	150	1573	0.594
303.8	151	1577	0.596
305.6	152	1581	0.597
307.4	153	1584	0.598
309.2	154	1588	0.6
311	155	1592	0.601
312.8	156	1596	0.602
314.6	157	1599	0.603
316.4	158	1603	0.605
318.2	159	1607	0.606
320	160	1610	0.607
321.8	161	1614	0.609
323.6	162	1618	0.61
325.4	163	1622	0.612

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
327.2	164	1625	0.613
329	165	1629	0.614
330.8	166	1633	0.615
332.6	167	1636	0.617
334.4	168	1640	0.618
336.2	169	1644	0.619
338	170	1648	0.621
339.8	171	1651	0.622
341.6	172	1655	0.623
343.4	173	1659	0.625
345.2	174	1662	0.626
347	175	1666	0.627
348.8	176	1670	0.629
350.6	177	1674	0.63
352.4	178	1677	0.631
354.2	179	1681	0.632
356	180	1685	0.634
357.8	181	1688	0.635
359.6	182	1692	0.636
361.4	183	1696	0.638
363.2	184	1699	0.639
365	185	1703	0.64
366.8	186	1707	0.642
368.6	187	1711	0.643
370.4	188	1714	0.644
372.2	189	1718	0.645
374	190	1722	0.647
375.8	191	1725	0.648
377.6	192	1729	0.649
379.4	193	1733	0.651
381.2	194	1736	0.652
383	195	1740	0.653
384.8	196	1744	0.655
386.6	197	1747	0.656
388.4	198	1751	0.657
390.2	199	1755	0.658
392	200	1758	0.659
393.8	201	1762	0.661
395.6	202	1766	0.662
397.4	203	1769	0.663
399.2	204	1773	0.665
401	205	1777	0.666
402.8	206	1780	0.667

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
404.6	207	1784	0.669
406.4	208	1788	0.67
408.2	209	1791	0.671
410	210	1795	0.672
411.8	211	1799	0.674
413.6	212	1802	0.675
415.4	213	1806	0.676
417.2	214	1810	0.678
419	215	1813	0.679
420.8	216	1817	0.68
422.6	217	1821	0.681
424.4	218	1824	0.683
426.2	219	1828	0.684
428	220	1832	0.685
429.8	221	1835	0.686
431.6	222	1839	0.688
433.4	223	1843	0.689
435.2	224	1846	0.69
437	225	1850	0.692
438.8	226	1854	0.693
440.6	227	1857	0.694
442.4	228	1861	0.695
444.2	229	1865	0.697
446	230	1868	0.698
447.8	231	1872	0.699
449.6	232	1875	0.7
451.4	233	1879	0.702
453.2	234	1883	0.703
455	235	1886	0.704
456.8	236	1890	0.705
458.6	237	1894	0.707
460.4	238	1897	0.708
462.2	239	1901	0.709
464	240	1905	0.711
465.8	241	1908	0.712
467.6	242	1912	0.713
469.4	243	1915	0.714
471.2	244	1919	0.716
473	245	1923	0.717
474.8	246	1926	0.718
476.6	247	1930	0.719
478.4	248	1934	0.721
480.2	249	1937	0.722

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
482	250	1941	0.723
483.8	251	1944	0.724
485.6	252	1948	0.726
487.4	253	1952	0.727
489.2	254	1955	0.728
491	255	1959	0.729
492.8	256	1962	0.73
494.6	257	1966	0.732
496.4	258	1970	0.733
498.2	259	1973	0.734
500	260	1977	0.736
501.8	261	1980	0.737
503.6	262	1984	0.738
505.4	263	1988	0.739
507.2	264	1991	0.74
509	265	1995	0.742
510.8	266	1998	0.743
512.6	267	2002	0.744
514.4	268	2006	0.746
516.2	269	2009	0.747
518	270	2013	0.748
519.8	271	2016	0.749
521.6	272	2020	0.75
523.4	273	2024	0.752
525.2	274	2027	0.753
527	275	2031	0.754
528.8	276	2034	0.755
530.6	277	2038	0.757
532.4	278	2042	0.758
534.2	279	2045	0.759
536	280	2049	0.76
537.8	281	2052	0.761
539.6	282	2056	0.763
541.4	283	2060	0.764
543.2	284	2063	0.765
545	285	2067	0.766
546.8	286	2070	0.768
548.6	287	2074	0.769
550.4	288	2077	0.77
552.2	289	2081	0.771
554	290	2085	0.773
555.8	291	2088	0.774
557.6	292	2092	0.775

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
559.4	293	2095	0.776
561.2	294	2099	0.777
563	295	2102	0.778
564.8	296	2106	0.78
566.6	297	2110	0.781
568.4	298	2113	0.782
570.2	299	2117	0.784
572	300	2120	0.785
573.8	301	2124	0.786
575.6	302	2127	0.787
577.4	303	2131	0.788
579.2	304	2134	0.789
581	305	2138	0.791
582.8	306	2142	0.792
584.6	307	2145	0.793
586.4	308	2149	0.794
588.2	309	2152	0.796
590	310	2156	0.797
591.8	311	2159	0.798
593.6	312	2163	0.799
595.4	313	2166	0.8
597.2	314	2170	0.802
599	315	2173	0.803
600.8	316	2177	0.804
602.6	317	2181	0.805
604.4	318	2184	0.806
606.2	319	2188	0.808
608	320	2191	0.809
609.8	321	2195	0.81
611.6	322	2198	0.811
613.4	323	2202	0.812
615.2	324	2205	0.814
617	325	2209	0.815
618.8	326	2212	0.816
620.6	327	2216	0.817
622.4	328	2219	0.818
624.2	329	2223	0.82
626	330	2226	0.821
627.8	331	2230	0.822
629.6	332	2234	0.823
631.4	333	2237	0.824
633.2	334	2241	0.826
635	335	2244	0.827

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
636.8	336	2248	0.828
638.6	337	2251	0.829
640.4	338	2255	0.83
642.2	339	2258	0.831
644	340	2262	0.833
645.8	341	2265	0.834
647.6	342	2269	0.835
649.4	343	2272	0.836
651.2	344	2276	0.838
653	345	2279	0.839
654.8	346	2283	0.84
656.6	347	2286	0.841
658.4	348	2290	0.842
660.2	349	2293	0.843
662	350	2297	0.845
663.8	351	2300	0.846
665.6	352	2304	0.847
667.4	353	2307	0.848
669.2	354	2311	0.849
671	355	2314	0.85
672.8	356	2318	0.852
674.6	357	2321	0.853
676.4	358	2325	0.854
678.2	359	2328	0.855
680	360	2332	0.856
681.8	361	2335	0.857
683.6	362	2339	0.859
685.4	363	2342	0.86
687.2	364	2346	0.861
689	365	2349	0.862
690.8	366	2353	0.863
692.6	367	2356	0.864
694.4	368	2360	0.866
696.2	369	2363	0.867
698	370	2367	0.868
699.8	371	2370	0.869
701.6	372	2373	0.87
703.4	373	2377	0.871
705.2	374	2380	0.872
707	375	2384	0.874
708.8	376	2387	0.875
710.6	377	2391	0.876
712.4	378	2394	0.877

Table 21. PT1000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
714.2	379	2398	0.878
716	380	2401	0.879
717.8	381	2405	0.881
719.6	382	2408	0.882
721.4	383	2412	0.883
723.2	384	2415	0.884
725	385	2419	0.885
726.8	386	2422	0.886
728.6	387	2426	0.888
730.4	388	2429	0.889
732.2	389	2432	0.89
734	390	2436	0.891
735.8	391	2439	0.892
737.6	392	2443	0.893
739.4	393	2446	0.894
741.2	394	2450	0.896
743	395	2453	0.897
744.8	396	2457	0.898
746.6	397	2460	0.899
748.4	398	2463	0.9
750.2	399	2467	0.901
752	400	2470	0.902

PT3000

Table 22. PT3000 characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
-58	-50	2.82	1.02
-49	-45	2.87	1.03
-40	-40	2.91	1.05
-31	-35	2.96	1.06
-22	-30	3	1.08
-13	-25	3.05	1.09
-4	-20	3.09	1.1
5	-15	3.13	1.12
14	-10	3.18	1.13
23	-5	3.22	1.15
32	0	3.27	1.16
41	5	3.31	1.17
50	10	3.35	1.19
59	15	3.4	1.2
68	20	3.44	1.21
77	25	3.48	1.23
86	30	3.53	1.24
95	35	3.57	1.25
104	40	3.61	1.27
113	45	3.66	1.28
122	50	3.7	1.29
131	55	3.74	1.31
140	60	3.78	1.32
149	65	3.83	1.33
158	70	3.87	1.35
167	75	3.91	1.36
176	80	3.95	1.37
185	85	4	1.38
194	90	4.04	1.4
203	95	4.08	1.41
212	100	4.12	1.42
221	105	4.16	1.43
230	110	4.21	1.45
239	115	4.25	1.46
248	120	4.29	1.47
257	125	4.33	1.48
266	130	4.37	1.49
275	135	4.41	1.51
284	140	4.45	1.52
293	145	4.5	1.53
302	150	4.54	1.54

10 K NTC TYPE II

Table 23. 10 K NTC TYPE II characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
-22	-30	177	7.904
-20.2	-29	166.35	7.848
-18.4	-28	156.413	7.79
-16.6	-27	147.136	7.73
-14.8	-26	138.47	7.666
-13	-25	130.372	7.601
-11.2	-24	122.8	7.534
-9.4	-23	115.718	7.464
-7.6	-22	109.089	7.392
-5.8	-21	102.883	7.318
-4	-20	97.073	7.241
-2.2	-19	91.597	7.161
-0.4	-18	86.471	7.08
1.4	-17	81.667	6.996
3.2	-16	77.161	6.91
5	-15	72.932	6.821
6.8	-14	68.962	6.731
8.6	-13	65.231	6.639
10.4	-12	61.723	6.545
12.2	-11	58.424	6.448
14	-10	55.321	6.351
15.8	-9	52.399	6.251
17.6	-8	49.648	6.15
19.4	-7	47.058	6.047
21.2	-6	44.617	5.943
23	-5	42.317	5.838
24.8	-4	40.15	5.732
26.6	-3	38.106	5.624
28.4	-2	36.18	5.516
30.2	-1	34.363	5.408
32	0	32.65	5.299
33.8	1	31.027	5.189
35.6	2	29.494	5.079
37.4	3	28.047	4.969
39.2	4	26.68	4.859
41	5	25.388	4.75
42.8	6	24.166	4.641
44.6	7	23.01	4.532
46.4	8	21.916	4.423
48.2	9	20.88	4.316
50	10	19.898	4.209

Table 23. 10 K NTC TYPE II characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
51.8	11	18.968	4.103
53.6	12	18.087	3.998
55.4	13	17.252	3.894
57.2	14	16.46	3.792
59	15	15.708	3.69
60.8	16	14.995	3.591
62.6	17	14.319	3.492
64.4	18	13.678	3.396
66.2	19	13.068	3.3
68	20	12.49	3.207
69.8	21	11.94	3.115
71.6	22	11.418	3.025
73.4	23	10.921	2.937
75.2	24	10.449	2.85
77	25	10	2.767
78.8	26	9.572	2.684
80.6	27	9.165	2.603
82.4	28	8.777	2.524
84.2	29	8.408	2.447
86	30	8.057	2.372
87.8	31	7.722	2.299
89.6	32	7.402	2.228
91.4	33	7.098	2.159
93.2	34	6.808	2.091
95	35	6.531	2.025
96.8	36	6.267	1.962
98.6	37	6.015	1.9
100.4	38	5.775	1.84
102.2	39	5.546	1.781
104	40	5.327	1.724
105.8	41	5.117	1.669
107.6	42	4.917	1.616
109.4	43	4.726	1.564
111.2	44	4.543	1.514
113	45	4.369	1.465
114.8	46	4.202	1.418
116.6	47	4.042	1.373
118.4	48	3.889	1.329
120.2	49	3.743	1.286
122	50	3.603	1.244
123.8	51	3.469	1.204
125.6	52	3.34	1.166

Table 23. 10 K NTC TYPE II characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
127.4	53	3.217	1.128
129.2	54	3.099	1.092
131	55	2.986	1.057
132.8	56	2.878	1.023
134.6	57	2.774	0.99
136.4	58	2.675	0.959
138.2	59	2.579	0.928
140	60	2.488	0.898
141.8	61	2.4	0.87
143.6	62	2.316	0.842
145.4	63	2.235	0.815
147.2	64	2.158	0.79
149	65	2.083	0.765
150.8	66	2.011	0.74
152.6	67	1.943	0.718
154.4	68	1.877	0.695
156.2	69	1.813	0.673
158	70	1.752	0.652
159.8	71	1.694	0.632
161.6	72	1.637	0.612
163.4	73	1.583	0.593
165.2	74	1.531	0.575
167	75	1.481	0.557
168.8	76	1.433	0.541
170.6	77	1.387	0.524
172.4	78	1.342	0.508
174.2	79	1.299	0.493
176	80	1.258	0.478
177.8	81	1.218	0.464
179.6	82	1.179	0.45
181.4	83	1.142	0.436
183.2	84	1.107	0.423
185	85	1.072	0.411
186.8	86	1.039	0.399
188.6	87	1.007	0.387
190.4	88	0.976	0.375
192.2	89	0.947	0.365
194	90	0.918	0.354
195.8	91	0.89	0.344
197.6	92	0.863	0.334
199.4	93	0.838	0.324
201.2	94	0.813	0.315

Table 23. 10 K NTC TYPE II characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
203	95	0.789	0.306
204.8	96	0.765	0.297
206.6	97	0.743	0.289
208.4	98	0.721	0.28
210.2	99	0.7	0.276
212	100	0.68	0.265

10 K NTC TYPE III

Table 24. 10 K NTC TYPE II characteristics

Temp. [°F]	Temp.[°C]	Resistance [Ω]
-35	-37.2	203.6K
-30	-34.4	173.6K
-25	-31.7	148.3K
-20	-28.9	127.1K
-15	-26.1	109.2K
-10	-23.3	94.07K
-5	-20.6	81.23K
0	-17.8	70.32K
5	-15.0	61.02K
10	-12.2	53.07K
15	-9.4	46.27K
20	-6.7	40.42K
25	-3.9	35.39K
30	-1.1	31.06K
35	1.7	27.31K
40	4.4	24.06K
45	7.2	21.24K
50	10.0	18.79K
55	12.8	16.65K
60	15.6	14.78K
65	18.3	13.15K
70	21.1	11.72K
75	23.9	10.46K
80	26.7	9354
85	29.4	8378
90	32.2	7516
95	35.0	6754
100	37.8	6078
105	40.6	5479
110	43.3	4947
115	46.1	4472
120	48.9	4049
125	51.7	3671
130	54.4	3333
135	57.2	3031
140	60.0	2759
145	62.8	2515
150	65.6	2296
155	68.3	2098
160	71.1	1920
165	73.9	1759
170	76.7	1614

Table 24. 10 K NTC TYPE II characteristics

Temp. [°F]	Temp.[°C]	Resistance [Ω]
175	79.4	1482
180	82.2	1362
185	85.0	1254
190	87.8	1156
195	90.6	1066
200	93.3	984
205	96.1	909.8
210	98.9	841.9
215	101.7	779.8
220	104.4	723
225	107.2	671
230	110.0	623.3
235	112.8	579.5
240	115.6	539.4

PT100

Table 25. PT100 characteristics

Temp. [°F]	Temp.[°C]	Resistance [Ω]
-30	-34.44	86
-20	-28.89	89
-10	-23.33	91
0	-17.78	93
10	-12.22	95
20	-6.67	97
30	-1.11	100
32	0.00	100
40	4.44	102
50	10.00	104
60	15.56	106
70	21.11	108
77	25.00	110
80	26.67	110
90	32.22	113
100	37.78	115
110	43.33	117
120	48.89	119
130	54.44	121
140	60.00	123
150	65.56	125
160	71.11	127
170	76.67	130
180	82.22	132
190	87.78	134
200	93.33	136
210	98.89	138
220	104.44	140

20 K NTC

Table 26. 20 K NTC characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
-58	-50	1659	8.78
-56.2	-49	1541	8.77
-54.4	-48	1432	8.76
-52.6	-47	1331	8.75
-50.8	-46	1239	8.74
-49	-45	1153	8.72
-47.2	-44	1073	8.71
-45.4	-43	1000	8.7
-43.6	-42	932	8.69
-41.8	-41	869	8.67
-40	-40	811	8.66
-38.2	-39	757	8.64
-36.4	-38	706	8.62
-34.6	-37	660	8.6
-32.8	-36	617	8.58
-31	-35	577	8.56
-29.2	-34	539	8.54
-27.4	-33	505	8.52
-25.6	-32	473	8.49
-23.8	-31	443	8.47
-22	-30	415	8.44
-20.2	-29	389	8.41
-18.4	-28	364	8.38
-16.6	-27	342	8.35
-14.8	-26	321	8.32
-13	-25	301	8.28
-11.2	-24	283	8.25
-9.4	-23	266	8.21
-7.6	-22	250	8.17
-5.8	-21	235	8.13
-4	-20	221	8.08
-2.2	-19	208	8.04
-0.4	-18	196	7.99
1.4	-17	184	7.94
3.2	-16	174	7.89
5	-15	164	7.83
6.8	-14	154	7.78
8.6	-13	146	7.72
10.4	-12	137	7.66
12.2	-11	130	7.6
14	-10	122	7.53
15.8	-9	116	7.46
17.6	-8	109	7.39

Table 26. 20 K NTC characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
19.4	-7	103	7.32
21.2	-6	97.6	7.25
23	-5	92.3	7.17
24.8	-4	87.3	7.09
26.6	-3	82.6	7.01
28.4	-2	78.2	6.93
30.2	-1	74.1	6.85
32	0	70.2	6.76
33.8	1	66.5	6.67
35.6	2	63	6.58
37.4	3	59.8	6.49
39.2	4	56.7	6.4
41	5	53.8	6.3
42.8	6	51.1	6.2
44.6	7	48.5	6.1
46.4	8	46	6
48.2	9	43.7	5.9
50	10	41.6	5.8
51.8	11	39.5	5.7
53.6	12	37.6	5.59
55.4	13	35.7	5.49
57.2	14	34	5.38
59	15	32.3	5.28
60.8	16	30.8	5.17
62.6	17	29.3	5.07
64.4	18	27.9	4.96
66.2	19	26.6	4.85
68	20	25.3	4.75
69.8	21	24.2	4.64
71.6	22	23	4.53
73.4	23	22	4.43
75.2	24	21	4.32
77	25	20	4.22
78.8	26	19.1	4.12
80.6	27	18.2	4.01
82.4	28	17.4	3.91
84.2	29	16.6	3.81
86	30	15.9	3.71
87.8	31	15.2	3.62
89.6	32	14.5	3.52
91.4	33	13.9	3.43
93.2	34	13.3	3.33
95	35	12.7	3.24
96.8	36	12.1	3.15

Table 26. 20 K NTC characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
98.6	37	11.6	3.06
100.4	38	11.1	2.97
102.2	39	10.7	2.89
104	40	10.2	2.81
105.8	41	9.78	2.72
107.6	42	9.37	2.64
109.4	43	8.98	2.57
111.2	44	8.61	2.49
113	45	8.26	2.42
114.8	46	7.92	2.34
116.6	47	7.6	2.27
118.4	48	7.29	2.2
120.2	49	7	2.14
122	50	6.72	2.07
123.8	51	6.45	2.01
125.6	52	6.19	1.94
127.4	53	5.95	1.88
129.2	54	5.72	1.82
131	55	5.49	1.77
132.8	56	5.28	1.71
134.6	57	5.08	1.66
136.4	58	4.88	1.61
138.2	59	4.69	1.56
140	60	4.52	1.51
141.8	61	4.35	1.46
143.6	62	4.18	1.41
145.4	63	4.03	1.37
147.2	64	3.88	1.32
149	65	3.73	1.28
150.8	66	3.59	1.24
152.6	67	3.46	1.2
154.4	68	3.34	1.16
156.2	69	3.21	1.13
158	70	3.1	1.09
159.8	71	2.99	1.06
161.6	72	2.88	1.02
163.4	73	2.78	0.991
165.2	74	2.68	0.96
167	75	2.58	0.929
168.8	76	2.49	0.9
170.6	77	2.41	0.872
172.4	78	2.32	0.844
174.2	79	2.24	0.818
176	80	2.17	0.792

Table 26. 20 K NTC characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
177.8	81	2.09	0.767
179.6	82	2.02	0.744
181.4	83	1.95	0.72
183.2	84	1.89	0.698
185	85	1.82	0.676
186.8	86	1.76	0.655
188.6	87	1.7	0.635
190.4	88	1.65	0.616
192.2	89	1.59	0.597
194	90	1.54	0.578
195.8	91	1.49	0.561
197.6	92	1.44	0.544
199.4	93	1.4	0.527
201.2	94	1.35	0.511
203	95	1.31	0.496
204.8	96	1.27	0.481
206.6	97	1.23	0.466
208.4	98	1.19	0.452
210.2	99	1.15	0.439
212	100	1.11	0.425
213.8	101	1.08	0.413
215.6	102	1.05	0.401
217.4	103	1.01	0.389
219.2	104	0.98	0.378
221	105	0.95	0.367
222.8	106	0.92	0.356
224.6	107	0.9	0.346
226.4	108	0.87	0.336
228.2	109	0.84	0.326
230	110	0.82	0.317
231.8	111	0.79	0.308
233.6	112	0.77	0.299
235.4	113	0.75	0.29
237.2	114	0.73	0.282
239	115	0.7	0.274
240.8	116	0.68	0.266
242.6	117	0.66	0.259
244.4	118	0.64	0.252
246.2	119	0.63	0.245
248	120	0.61	0.238
249.8	121	0.59	0.231
251.6	122	0.57	0.225
253.4	123	0.56	0.219
255.2	124	0.54	0.213

Table 26. 20 K NTC characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
257	125	0.53	0.207
258.8	126	0.51	0.201
260.6	127	0.5	0.196
262.4	128	0.49	0.191
264.2	129	0.47	0.186
266	130	0.46	0.181
267.8	131	0.45	0.176
269.6	132	0.43	0.171
271.4	133	0.42	0.167
273.2	134	0.41	0.162
275	135	0.4	0.158
276.8	136	0.39	0.154
278.6	137	0.38	0.15
280.4	138	0.37	0.146
282.2	139	0.36	0.142
284	140	0.35	0.139
285.8	141	0.34	0.135
287.6	142	0.33	0.132
289.4	143	0.32	0.128
291.2	144	0.32	0.125
293	145	0.31	0.122
294.8	146	0.3	0.119
296.6	147	0.29	0.116
298.4	148	0.29	0.113
300.2	149	0.28	0.11
302	150	0.27	0.107

10 K3A1

Table 27. 10 K3A1 characteristics

Temp. [°F]	Temp.[°C]	Resistance [Ω]
-40	-40	336098
-38.2	-39	314553
-36.4	-38	294524
-34.6	-37	275897
-32.8	-36	258563
-31	-35	242427
-29.2	-34	227398
-27.4	-33	213394
-25.6	-32	200339
-23.8	-31	188163
-22	-30	176803
-20.2	-29	166198
-18.4	-28	156294
-16.6	-27	147042
-14.8	-26	138393
-13	-25	130306
-11.2	-24	122741
-9.4	-23	115661
-7.6	-22	109032
-5.8	-21	102824
-4	-20	97006
-2.2	-19	91553
-0.4	-18	86439
1.4	-17	81641
3.2	-16	77138
5	-15	72911
6.8	-14	68940
8.6	-13	65209
10.4	-12	61703
12.2	-11	58405
14	-10	55304
15.8	-9	52385
17.6	-8	49638
19.4	-7	47050
21.2	-6	44613
23	-5	42317
24.8	-4	40151
26.6	-3	38110
28.4	-2	36184
30.2	-1	34366
32	0	32651
33.8	1	31031

Table 27. 10 K3A1 characteristics

Temp. [°F]	Temp.[°C]	Resistance [Ω]
35.6	2	29500
37.4	3	28054
39.2	4	26687
41	5	25395
42.8	6	24172
44.6	7	23016
46.4	8	21921
48.2	9	20885
50	10	19903
51.8	11	18973
53.6	12	18092
55.4	13	17257
57.2	14	16465
59	15	15714
60.8	16	15001
62.6	17	14324
64.4	18	13682
66.2	19	13073
68	20	12493
69.8	21	11943
71.6	22	11420
73.4	23	10923
75.2	24	10450
77	25	10000
78.8	26	9572
80.6	27	9165
82.4	28	8777
84.2	29	8408
86	30	8056
87.8	31	7721
89.6	32	7402
91.4	33	7097
93.2	34	6807
95	35	6530
96.8	36	6266
98.6	37	6014
100.4	38	5774
102.2	39	5544
104	40	5325
105.8	41	5116
107.6	42	4916
109.4	43	4724
111.2	44	4542
113	45	4367

Table 27. 10 K3A1 characteristics

Temp. [°F]	Temp.[°C]	Resistance [Ω]
114.8	46	4200
116.6	47	4040
118.4	48	3887
120.2	49	3741
122	50	3601
123.8	51	3467
125.6	52	3339
127.4	53	3216
129.2	54	3098
131	55	2985
132.8	56	2877
134.6	57	2773
136.4	58	2674
138.2	59	2579
140	60	2487
141.8	61	2399
143.6	62	2315
145.4	63	2234
147.2	64	2157
149	65	2082
150.8	66	2011
152.6	67	1942
154.4	68	1876
156.2	69	1813
158	70	1752
159.8	71	1693
161.6	72	1637
163.4	73	1582
165.2	74	1530
167	75	1480
168.8	76	1432
170.6	77	1385
172.4	78	1341
174.2	79	1298
176	80	1256
177.8	81	1216
179.6	82	1178
181.4	83	1141
183.2	84	1105
185	85	1070
186.8	86	1037
188.6	87	1005
190.4	88	974
192.2	89	945

Table 27. 10 K3A1 characteristics

Temp. [°F]	Temp.[°C]	Resistance [Ω]
194	90	916
195.8	91	888
197.6	92	862
199.4	93	836
201.2	94	811
203	95	787
204.8	96	764
206.6	97	741
208.4	98	720
210.2	99	699
212	100	678
213.8	101	659
215.6	102	640
217.4	103	622
219.2	104	604
221	105	587
222.8	106	571
224.6	107	555
226.4	108	539
228.2	109	524
230	110	510
231.8	111	496
233.6	112	482
235.4	113	469
237.2	114	457
239	115	444
240.8	116	432
242.6	117	421
244.4	118	410
246.2	119	399
248	120	388
249.8	121	378
251.6	122	368
253.4	123	359
255.2	124	350
257	125	341

Nickel Class B DIN 43760 sensors

The characteristic of the nickel temperature sensor is specified as per DIN 43760. The large Temperature Coefficient of Resistance (TCR) of the Ni-RTD, 6178 ppm/K, offers greater sensitivity than other types of RTDs. The electrical characteristic can be described by the following equation:

R(T) = R0 (1+aT+bT2+cT4+dT6)

Coefficients:

- a = 5.485 x 10-3
- b = 6.650 x 10-6
- c = 2.805 x 10-11
- d =-2.000 x 10-17

T(R) = a´+b´(1+c´R)½ +d´R5+e´R7 dT < 0.12 K (higher order equations on request)

Coefficients:

- a´= - 412.6
- b´= 140.41
- c´= 0.00764
- d´= - 6.25 x 10-17
- e´= -1.25 x 10-24

Tolerances:

- Class B (0.4+0.007 x |T|) in range from 32 °F (0 °C) to 320 °F (+160 °C) (0.4+0.028 x |T|) in range from -67 °F (-55 °C) to 32 °F (0 °C)

Table 28. Characteristic of the nickel temperature sensor is specified as per DIN 43760

T/°F	T/°C	0	1	2	3	4	5	6	7	8	9
-76	**-60**	695.2	699.9	704.6	709.3	714	718.7	723.4	728.2	733	737.8
-58	**-50**	742.6	747.4	752.2	757	761.9	766.8	771.6	776.5	781.4	786.4
-40	**-40**	791.3	796.3	801.2	806.2	811.2	816.2	821.2	826.3	831.3	836.4
-22	**-30**	841.5	846.5	851.7	856.8	861.9	867	872.2	877.4	882.6	887.8
-4	**-20**	893	898.2	903.4	908.7	913.9	919.2	924.5	929.8	935.1	940.5
14	**-10**	945.8	951.2	956.5	961.9	967.3	972.7	978.2	983.6	989.1	994.5
32	**0**	1000	1005.5	1011	1016.5	1022	1027.6	1033.1	1038.7	1044.3	1049.9
50	**10**	1055.5	1061.1	1066.8	1072.4	1078.1	1083.8	1089.5	1095.2	1100.9	1106.6
68	**20**	1112.4	1118.1	1123.9	1129.7	1135.5	1141.3	1147.1	1153	1158.8	1164.7
86	**30**	1170.6	1176.5	1182.4	1188.3	1194.2	1200.2	1206.1	1212.1	1218.1	1224.1
104	**40**	1230.1	1236.1	1242.2	1248.2	1254.3	1260.4	1266.5	1272.6	1278.8	1284.9
122	**50**	1291.1	1297.2	1303.4	1309.6	1315.8	1322	1328.3	1334.5	1340.8	1347.1
140	**60**	1353.4	1359.7	1366	1372.4	1378.7	1385.1	1391.5	1397.9	1404.3	1410.8
158	**70**	1417.2	1423.7	1430.1	1436.6	1443.1	1449.7	1456.2	1462.8	1469.3	1475.9
176	**80**	1482.5	1489.1	1495.7	1502.4	1509.1	1515.7	1522.4	1529.1	1535.9	1542.6
194	**90**	1549.3	1556.1	1562.9	1569.7	1576.5	1583.4	1590.2	1597.1	1604	1610.9
212	**100**	1617.8	1624.7	1631.7	1638.6	1645.6	1652.6	1659.6	1666.7	1673.7	1680.8
230	**110**	1687.9	1695	1702.1	1709.3	1716.4	1723.6	1730.8	1738	1745.2	1752.5
248	**120**	1759.7	1767	1774.3	1781.6	1788.9	1796.3	1803.7	1811.1	1818.5	1825.9
266	**130**	1833.3	1840.8	1848.3	1855.8	1863.3	1870.9	1878.4	1886	1893.6	1901.2
284	**140**	1908.9	1916.5	1924.2	1931.9	1939.6	1947.4	1955.1	1962.9	1970.7	1978.5
302	**150**	1986.3	1994.2	2002.1	2010	2017.9	2025.9	2033.8	2041.8	2049.8	2057.8
320	**160**	2065.9	2074	2082.1	2090.2	2098.3	2106.5	2114.6	2122.8	2131.1	2139.3

NI1000 TK5000 DIN B

R-T Characteristics of Ni1000 TK5000 DIN B.

Table 29. NI1000 TK5000 Sensor Specification

Sensor Type	Nominal Resistance	Sensitivity
Ni1000 TK5000 DIN B	R_0: 1000 Ω	TC: 5000 ppm/K

Table 30. R-T Characteristics (according to supplier's specifications and based on DIN 43760, resistance values in Ω)

°F	°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9
-58	**-50**	790.88									
-40	**-40**	830.84	826.8	822.78	818.76	814.75	810.75	806.76	802.78	798.8	794.84
-22	**-30**	871.69	867.57	863.45	859.34	855.24	851.15	847.07	843	838.94	834.88
-4	**-20**	913.48	909.26	905.05	900.85	896.65	892.47	888.3	884.13	879.98	875.83
14	**-10**	956.24	951.92	947.61	943.31	939.02	934.74	930.47	926.21	921.96	917.72
32	**0**	1000	995.58	991.17	986.77	982.37	977.99	973.62	969.26	964.91	960.57
°F	**°C**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
32	**0**	1000	1004.4	1008.9	1013.3	1017.8	1022.3	1026.8	1031.2	1035.8	1040.3
50	**10**	1044.8	1049.3	1053.9	1058.4	1063	1067.6	1072.2	1076.8	1081.4	1086
68	**20**	1090.7	1095.3	1100	1104.6	1109.3	1114	1118.7	1123.4	1128.1	1132.9
86	**30**	1137.6	1142.4	1147.1	1151.9	1156.7	1161.5	1166.3	1171.2	1176	1180.9
104	**40**	1185.7	1190.6	1195.5	1200.4	1205.3	1210.2	1215.1	1220.1	1225	1230
122	**50**	1235	1240	1245	1250	1255	1260.1	1265.1	1270.2	1275.3	1280.3
140	**60**	1285.5	1290.6	1295.7	1300.8	1306	1311.1	1316.3	1321.5	1326.7	1331.9
158	**70**	1337.2	1342.4	1347.6	1352.9	1358.2	1363.5	1368.8	1374.1	1379.4	1384.8
176	**80**	1390.1	1395.5	1400.9	1406.3	1411.7	1417.1	1422.5	1428	1433.4	1438.9
194	**90**	1444.4	1449.9	1455.4	1460.9	1466.5	1472	1477.6	1483.2	1488.8	1494.4
212	**100**	1500	1505.6	1511.3	1517	1522.6	1528.3	1534	1539.8	1545.5	1551.2
230	**110**	1557	1562.8	1568.6	1574.4	1580.2	1586	1591.8	1597.7	1603.6	1609.5
248	**120**	1615.4	1621.3	1627.2	1633.2	1639.1	1645.1	1651.1	1657.1	1663.1	1669.1
266	**130**	1675.2	1681.3	1687.3	1693.4	1699.5	1705.7	1711.8	1717.9	1724.1	1730.3
284	**140**	1736.5	1742.7	1748.9	1755.2	1761.4	1767.7	1774	1780.3	1786.6	1792.9
302	**150**	1799.3									

ABBREVIATIONS

Table 31. Abbreviations

Abbreviations	Definitions
SSR	Solid State Relay
MSTP	Multiple Spanning Tree Protocol
IP	Internet Protocol
RTU	Remote Terminal Unit
BMS	Building Management Solutions
FCU	Fan Coil Unit
UIO	Universal IO
NEMA	National Electrical Manufacturers Association
SDRAM	Synchronous dynamic random-access memory
QSPI	Quad Serial Peripheral Interface
DHCP	Dynamic Host Configuration Protocol
EIRP	Effective Isotropic Radiated Power
SMA	Sub Miniature Push

RELATED TECHNICAL LITERATURE

Table 32. Related Technical Literature

Title	Reference
Honeywell Unitary Controller Datasheet	31-00613
Honeywell Unitary Controller Mounting Instructions	31-00572
System Engineering Guide for brands	31-00282 EN2B-0414-GE51 EN2B 0426IE67
Function Block User Guide for brands	31-00364 EN2B 0415GE51 EN2B-0427IE67

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31-00614-01 I Rev. 03-23

Honeywell