

Unitary

CONTROLLER

INSTALLATION INSTRUCTIONS

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GENERAL

Trademark Information

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

Product Description

Honeywell Unitary BACnet™ IP WiFi, BACnet™ RJ45 (IP), BACnet™ MS/TP and BACnet™ T1L (IP), 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. Operating control for HVAC systems to control blower fan, thermostats. Independently mounted control.

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™ IP WiFi, BACnet™ RJ45 (IP), BACnet™ T1L (IP), or BACnet™ MS/TP as a backbone interface and Sylk™ and Modbus RTU as sub interface, flexible universal input/output (UIO) points, and DO Chopper output (DO CHP).

These BACnet™ IP or BACnet™ MS/TP based Unitary controllers utilize smart engineering, commissioning tools, and Sylk™ 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.

BACnet™ MS/TP models of controller communicate via a TIA/EIA 485 BACnet™ MS/TP communication network, capable of baud rates between 9.6 and 76.8 kbps. BACnet™ RJ45 (IP) models communicate over a wired standard network cable and BACnet™ T1L (IP) communicate via a 2-wire twisted pair cable.

Table 1 Part Numbers

Part Number	Housing	UIO	Relay	DO Chopper Output (DO CHP)	Communication	Sylk	Bluetooth
UN-RS0844ES230NMC / D	Small	8	4	4	BACnet™ IP	Yes	No
UN-RS0844ESB230NMC / D	Small	8	4	4	BACnet™ IP	Yes	Yes
UN-RS0844MS230NMC / D	Small	8	4	4	BACnet™ MS/TP	Yes	No
UN-RS0844MSB230NMC / D	Small	8	4	4	BACnet™ MS/TP	Yes	Yes
UN-RS0844TS230NMC / D	Small	8	4	4	BACnet™ T1L	Yes	No
UN-RS0844TSB230NMC / D	Small	8	4	4	BACnet™ T1L	Yes	Yes
UN-RS0844WASB230NMC / D	Small	8	4	4	BACnet™ WiFi	Yes	No
UN-RS0844WBS230NMC / D	Small	8	4	4	BACnet™ WiFi	Yes	Yes
UN-RL1644ES230NMC / D	Large	16	4	4	BACnet™ IP	Yes	No
UN-RL1644ESB230NMC / D	Large	16	4	4	BACnet™ IP	Yes	Yes
UN-RL1644MS230NMC / D	Large	16	4	4	BACnet™ MS/TP	Yes	No
UN-RL1644MSB230NMC / D	Large	16	4	4	BACnet™ MS/TP	Yes	Yes
UN-RL1644TS230NMC / D	Large	16	4	4	BACnet™ T1L	Yes	No
UN-RL1644TSB230NMC / D	Large	16	4	4	BACnet™ T1L	Yes	Yes
UN-RL1644WAS230NMC / D	Large	16	4	4	BACnet™ WiFi	Yes	Yes
UN-RL1644WBS230NMC / D	Large	16	4	4	BACnet™ WiFi	Yes	Yes

Note: WiFi SKUs with WA: Compliant with FCC standards (North America). WiFi SKUs with WB: Compliant with ETSI standards (Europe). For more information, please contact your regional sales office.

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 models of Unitary controllers
IO-JUMPER-4-10	4-pin relay output Jumper Bar to connect 4 relays IN terminals (sold in pack of 10)

Controller Part Numbers

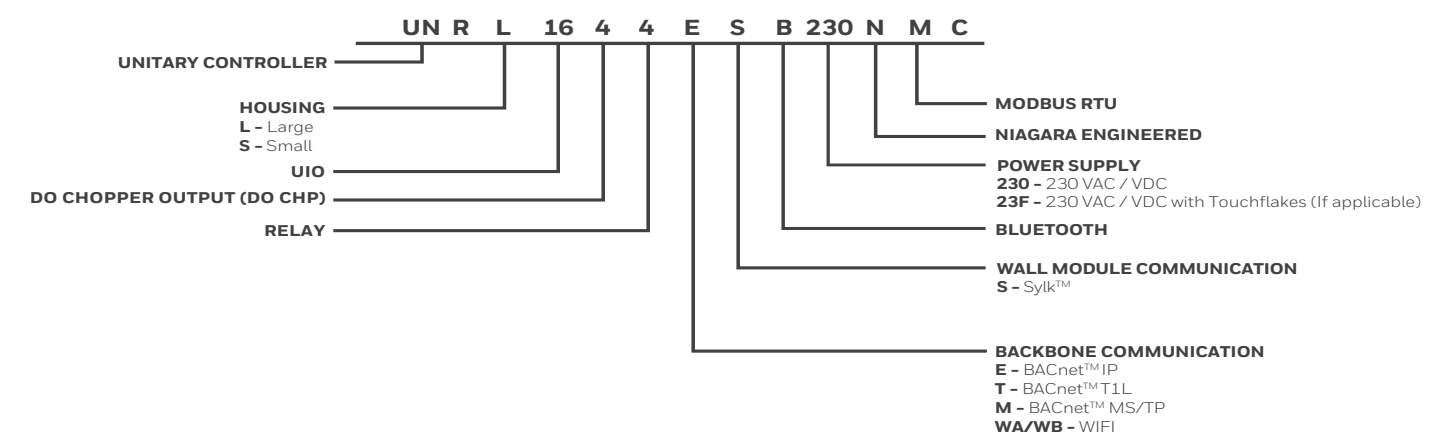


Fig. 1 Controller Part Numbers

Dimensions

Unitary Controller Large

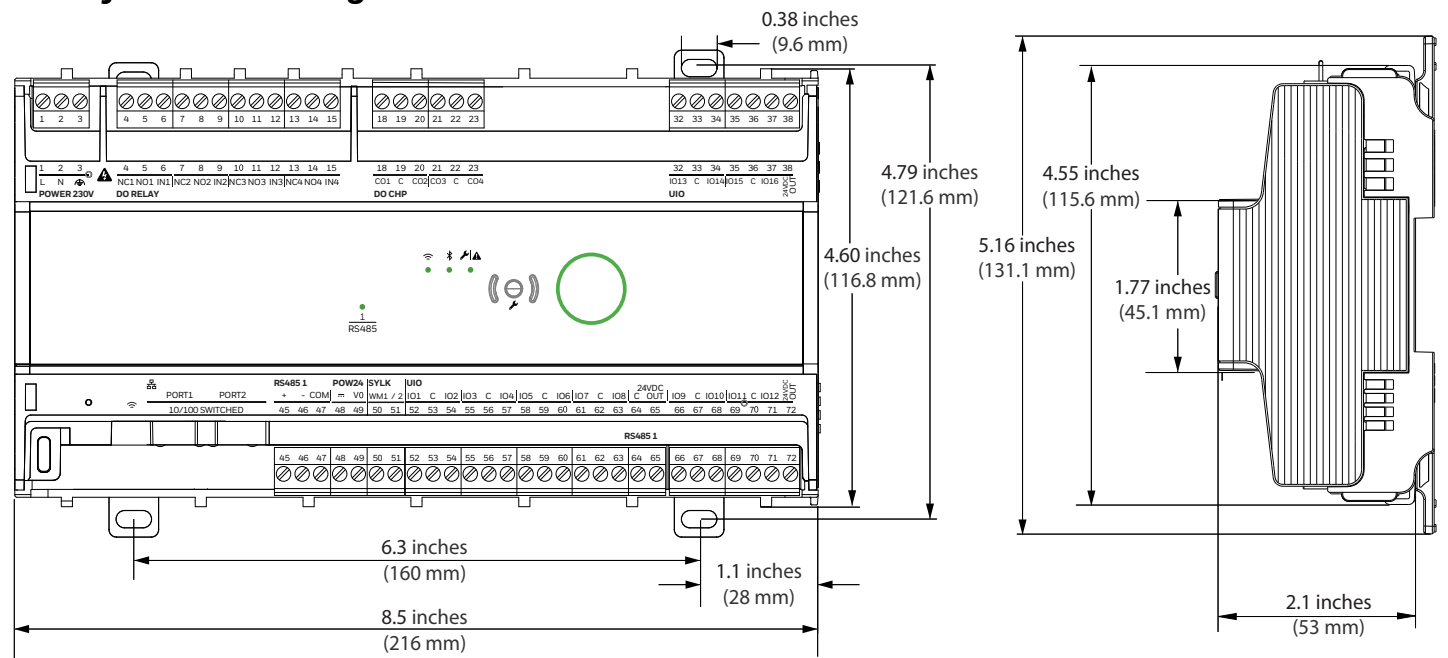


Fig. 2 Unitary controller large dimensions

Unitary Controller Small

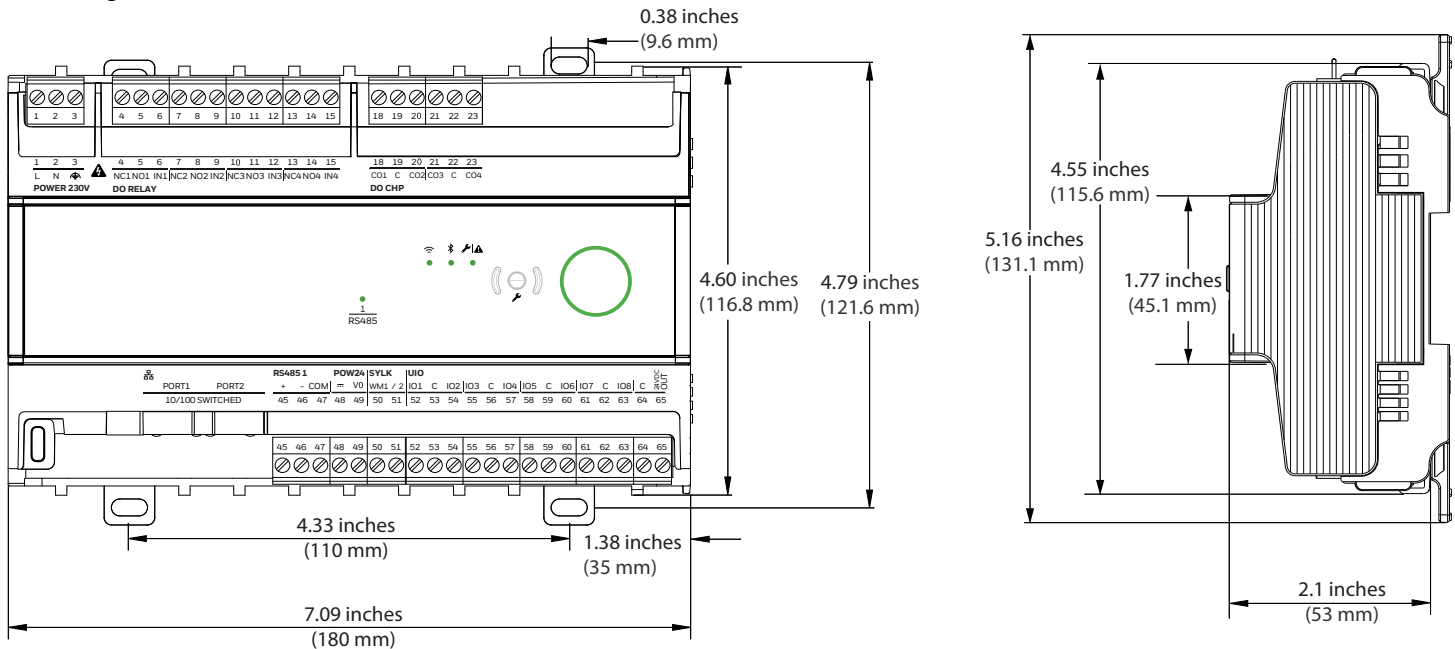


Fig. 3 Unitary controller small dimensions

NETWORK SECURITY

WARNING

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

- Before installing or dismantling the system, disconnect the power supply by either removing the power terminal block from the controller or through local isolation.



CAUTION

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

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 third-party manufacturers.

GENERAL SAFETY INSTRUCTIONS

Follow the safety instructions provided by Honeywell in this manual while doing any operation such installation, mounting, or starting.

- The Honeywell Unitary controllers must be installed and mounted by authorized and trained personnel.
- In the case of any modification, except by Honeywell, the operation and safety warranties become void.
- Observe all applicable local standards and regulations.
- Use only Honeywell supplied or approved accessories.

SPECIFICATIONS

Electrical

Table 3 Electrical Specification

Parameter	Specification
Rated input voltage	230 VAC $\pm$ 10 %
Maximum Nominal Power Consumption (for IP, MS/TP, T1L and WiFi models)	Small: IP and T1L: 45 VA MS/TP and WiFi: 60 VA Large: IP and T1L: 60 VA MS/TP and WiFi: 75 VA
Full Load Power Consumption (Maximum load including external loads, Sylk™, Communication, Bluetooth, Universal IO output, 24 VDC output, and load on the DO CHPs) for IP, MS/TP, T1L and WiFi.	Small: IP: 170 VA MS/TP, T1L and WiFi: 200 VA Large: IP: 200 VA MS/TP and T1L: 210 VA WiFi: 220 VA
Frequency Range	50/60 Hz
Auxiliary Output	24 VDC at 75 mA (terminal 38,48,65 and 72 shared)
Type of loads	Different types of sensors
Impulse Voltage	4000 V (4 kV)
Material Group	IIIb
Period of electric stress across insulating parts	Long
Classes of control function	Class A control
Type of Output Waveform	Rectangle

Operational Environment

Table 4 Operational Environment

Parameter	Specification
Storage Temperature	-40 °F to 150 °F (-40 °C to 66 °C)
Operation Temperature	-40 °F to 149 °F (-40 °C to 65 °C) with 0.6 A cumulated across all chopper outputs. -40 °F to 122 °F (-40 °C to 50 °C) with 1.5 A cumulated across all chopper outputs.
Humidity	5 % to 95 % RH, non-condensing

Table 4 Operational Environment

Protection	IP20, NEMA-1
Pollution degree	2
Pass	Ball Pressure and Glow wire test

Hardware

Table 5 Hardware Specification

Parameter	Specification
CPU	Crossover processor i.MXRT ARM CORTEX-M7
Memory Capacity	16 MB QSPI Flash, 16 MB SDRAM
Ethernet	BACnet™ IP (RJ45): 2 x RJ-45 Ethernet ports with a protection that allows loop topology to continue the communication with other controllers even if one node fails, when used with an RSTP supporting device.
Real Time Clock	24 hours backup after power failure. After 24 hours, the time will reset to factory default time until the user performs a BACnet™ Time Sync
Small LED	Transmission or reception of communication signal (green)
Large LED	Controller status (Green, Yellow, and Red)

Communications

Table 6 Communication Specification

Parameter	Specification
Protocol supported	• BACnet™ IP (RJ45 or T1L) • BACnet™ MS/TP* • BACnet™ WiFi • Modbus RTU (Modbus client only)
IP Addressing Modes	• Dynamic: DHCP and Link Local • Static: Assigned
Sylk™ bus	2-wire, polarity-insensitive, 18VDC, 96mA, wall module
*Auto Baud rate detection is provided for the BACnet™ MS/TP controllers.	

Table 7 Wire Gauge Range

Parameter	Specification
Chopper/Auxiliary output	26-18 AWG
Relay	18-14 AWG
 NOTE: The range will depend on the current supplied.	

T1L Communication

Table 8 T1L Specifications

Parameter	Specification
10BASE-T1L Standard	802.3cg-2019
Connection	Screw terminal, auto MDI-X
Cable Type	Single twisted pair, 18AWG, shielded or unshielded.
Distance	Maximum 660 ft. (200 m) to Honeywell T1L controller in daisy chain. Maximum 2,950 ft. (900 m) to any other T1L device without a daisy chain.
Transmission Mode	10 Mbps

Supported Devices*

Table 9 Supported Devices

Parameter	Specification
Sylk™ wall Modules	TR40, TR40-H, TR40-CO2, TR40-H-CO2, TR42, TR42-H, TR42-CO2, TR42-H-CO2, TR50 (emulation mode only), TR71, TR71-H, TR75, TR75-H, TR75-HE, TR120 (TR75-E), and TR120-H (emulation mode only).
Sylk™ sensor	C7400S
Sylk™ Actuator	MS3103, MS3105, MS3110, and MS3120
Non Sylk™ Actuators	MS4103, MS4105, MS7403, MS7405, MS7503, MS7505, MS8103, and MS8105
Hardwired Wall Modules	T7460 A, B, C, D, E, F and T7770 A, B, C, D, E, F, G

Table 9 Supported Devices

Modbus devices	Modbus RTU devices from any manufacturer (including Honeywell Modbus devices, for example DALI64MODPSUF/S, TR50, and TR80) can be used.
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Weight And Dimensions

Table 10 Weight And Dimensions

Parameter	Specification
Dimension (L x W x H)	Large - 8.5 x 4.79 x 2.1 inches (216 x 121.6 x 53 mm). Small - 7.1 x 4.7 x 2.1 inches (180 x 121.6 x 53 mm).
Weight	Large - 1.54 lbs. (700 grams) Small - 1.32 lbs. (600 grams)
Mounting	Mounting in fuse boxes (DIN43880), on DIN rails or surface mounted with optional protection covers.

Universal IO*

Table 11 Universal IO Specification

Parameter	Specification
AI	16-bit A/D resolution
UI	0 to 10 V or 0 to 20 mA input. - Sensors: 10K Ohm NTC Type II, 10K Ohm NTC Type III, 10K3A1, 20K Ohm NTC, PT100, PT1000, NI1000TK5000, NI1000 Class B DIN43760, PT3000, 100 Ohm to 100K Ohm resistive (custom characteristic). - Hardwired wall modules*: space temperature, space temperature setpoint, 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 SO* interface for pulse counters.
AO	- Voltage output 0 to 11 V with 25 mA (short circuit sourcing) and 3 mA (short circuit sinking). - Current output with 0(4)...20 mA direct/reverse. - Hardwired wall modules*: LED Control.

Table 11 Universal IO Specification

Parameter	Specification
DO	Dry contact binary output with direct/reverse.

* Devices subject to local availability. Contact your local sales representative for information on available devices in your region.

Chopper Output (CHP)

Table 12 Chopper Output (CHP)

Parameter	Specification
	Chopper works with maximum 24 VAC
	1.5 A constant for 4 DO CHP's combined or 1.5 A each on stand-alone. 3.5 A inrush current for 0.1 seconds.
Type of load	Resistive and Inductive
	24 VAC, 50/60 Hz, 1.5 A (at 50 °C) or 24 VAC, 50/60 Hz, 0.6 A (at 65 °C)
	Type 1

Relays

Table 13 Relays

Parameter	Specification
Contact Rating	Up to 240/277 VAC or 24 VDC
	3 contacts per relay (Normally open (NO), Normally closed (NC), Common (IN)).
	10 A constant current on normally open contact 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.
Type of Load	Resistive and Inductive
Output	240/277 VAC, 50/60 Hz, or 24 VDC, 12 A Max. total common (10 A Max. per Relay)
Number of Automatic Cycles	40000 cycles for contact A (NO) 6000 cycles for contact C (CO)

Table 13 Relays

Type of disconnection or interruption provided by each circuit
Type 1.C

Table 14 Fuse for Relays

Input	Fuse Part Number	Current Rate [A]	Voltage Rate [A]	Holder Part Number
Relay	021812.5 MXP	12.5	250	01500520 H
	0505012.MX P	12	250	150603
	FCD-12.5A	12	250	01500520 H

WiFi Communication

Table 15 WiFi Communication

Parameter	Specification
WiFi Client connection type	- Open - WPA2 Personal - WPA2 Enterprise
Frequency	2.4 GHz Note: The Unitary controller does not support 5 GHz frequency.
Protocols supported	IPv4

HARDWARE OVERVIEW

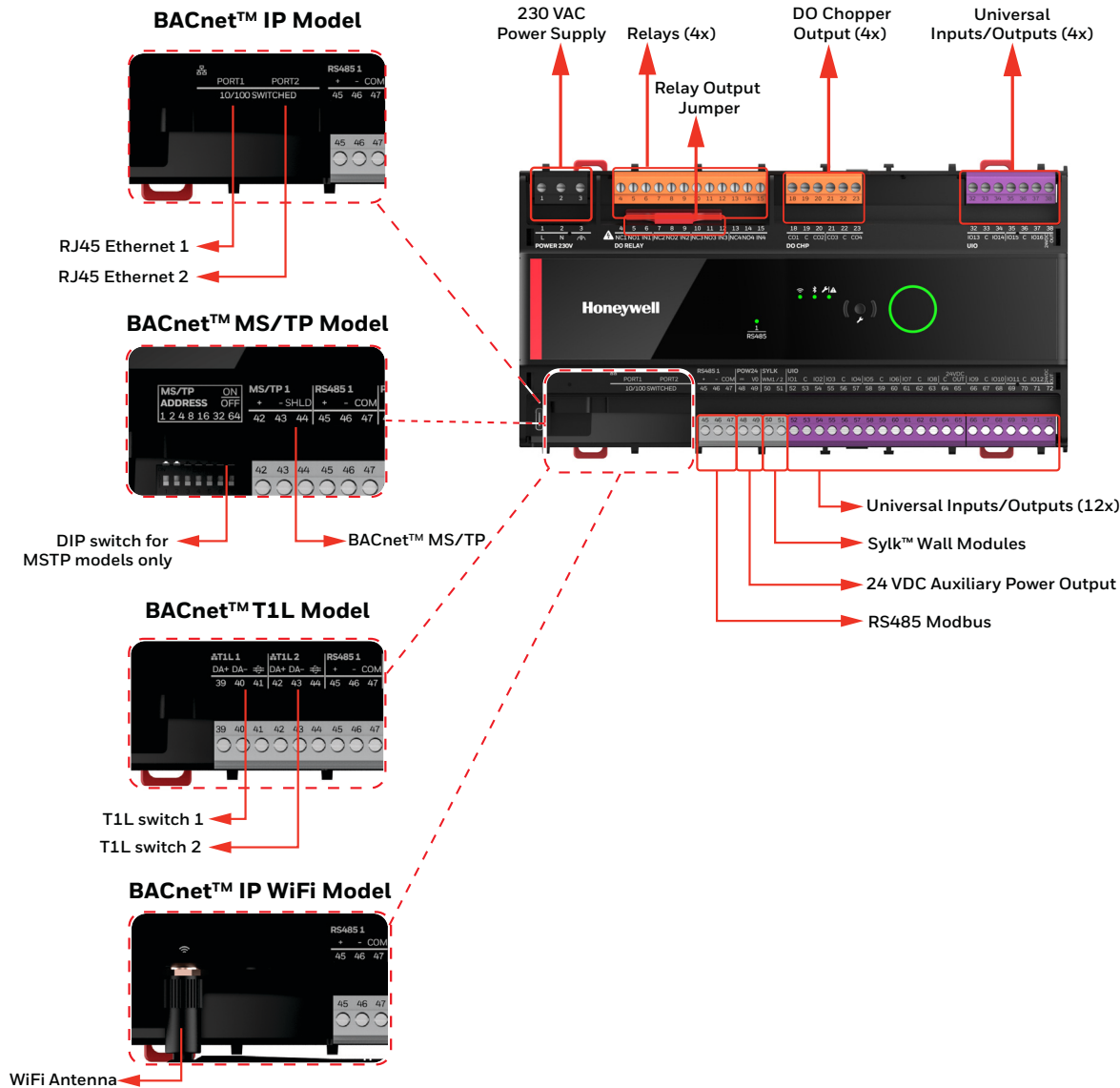


Fig. 4 Hardware Overview

System Overview

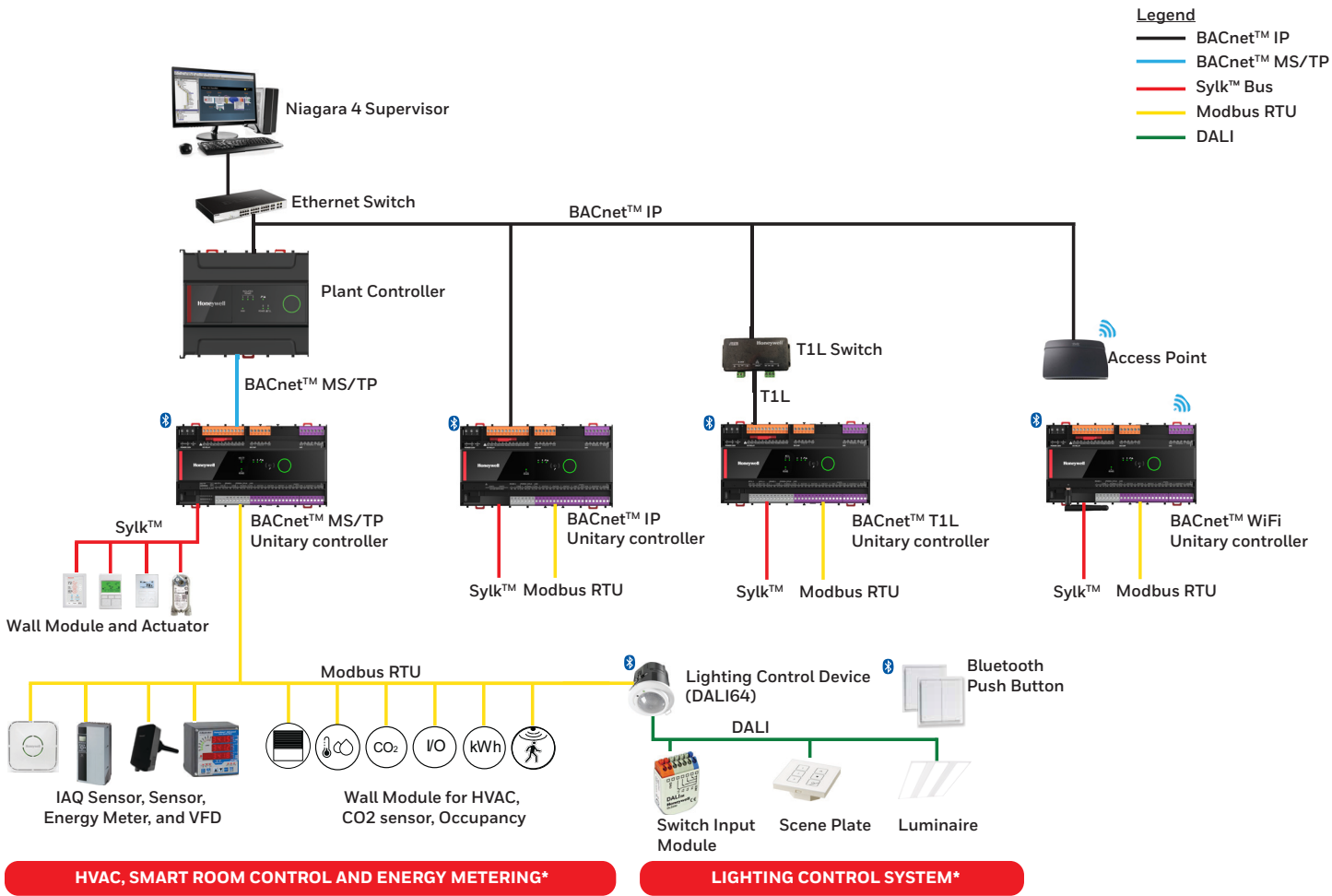


Fig. 5 System Overview

* Devices subject to local availability. Contact your local sales representative for information on available devices in your region.

Service Button

The service button is used to trigger dedicated events as shown in Fig. 4. It is important to distinguish different controller behaviors elicited depending on 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 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 0xFF, 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 Auto MAC is by default true and Min MAC, 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 button message (BACnet™ WhoAmI as a Private Transfer (SerialNo. = 130)) to be sent.

MOUNTING

Before Installation



IMPORTANT:

It is recommended that the unit be kept at room temperature for at least 24 hours before applying power. This is to allow the evaporation of any condensation resulting from low shipping / storage temperatures.



NOTE:

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.



IMPORTANT:

US requirement, only: This device must be installed in a UL-listed enclosure offering adequate space to maintain the segregation of the line voltage field wiring and Class 2 field wiring.



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.

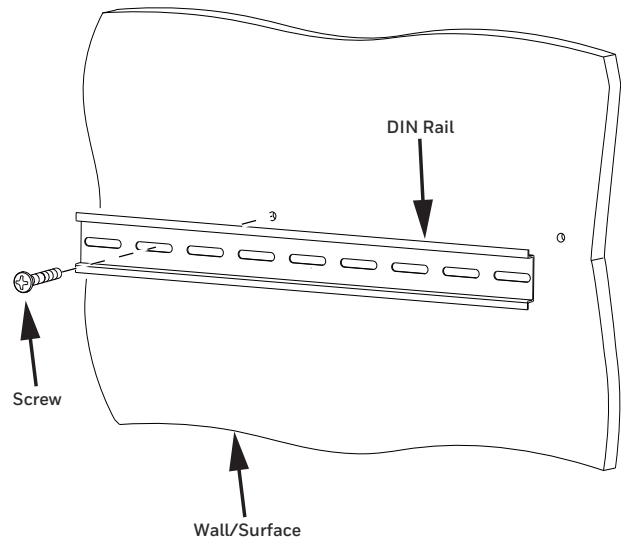


Fig. 6 DIN Rail Wall/Surface

2. Extend all red mounting clips to the unlock position as shown in figure 7.

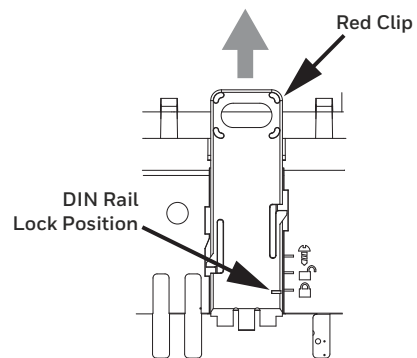


Fig. 7 Lock Position

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

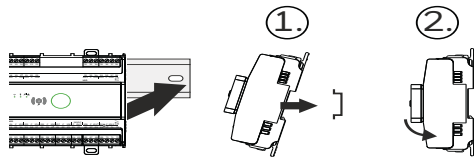


Fig. 8 Controller mounting on DIN Rail

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 figure 9.

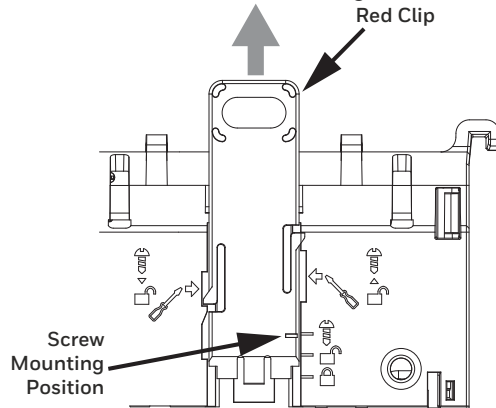


Fig. 9 Screw Mounting Position

2. Hold the controller along the wall and mark drilling locations through the screw red clip slots, as shown in figure 10.

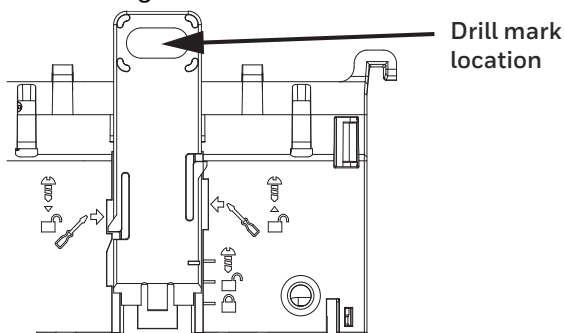


Fig. 10 Drill mark location

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

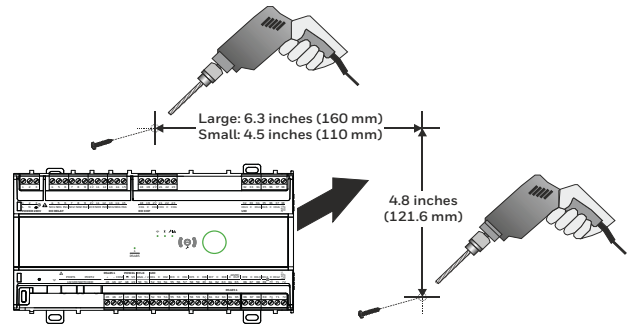


Fig. 11 Mounting and Dismounting

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 top-side 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.

POWER SUPPLY

General Information

To prevent a risk of injury due to electrical shock and/or damage to the device due to short-circuiting, low voltage and high-voltage lines must be kept physically separate. To prevent a risk of short-circuiting and damage to your Honeywell Unitary controllers, do not reverse the polarity of the power connection cables and avoid ground loops (connecting one field device to several controllers).

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, other input and output devices, and create wiring diagrams for illustrations of 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 as a whole. Usually, some variables must be passed between the controllers that are required for optimum system-wide operation. Typical examples are the TOD, occupied, unoccupied, outdoor air temperature, and demand limit control signal. Understanding these interrelationships early in the job engineering process is vital for proper implementation while configuring the controllers.



NOTE:

All wiring must comply with applicable electrical codes and ordinances. Refer to the job or manufacturers' drawings for details. Local wiring guidelines (for example, IEC 364-6-61 or VDE 0100) may take precedence over recommendations provide 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 disconnecting from the power supply must have the means of disconnect incorporated in the fixed wiring. This type of disconnect must have a contact separation of at least 1/8 in. (3 mm) at all poles.

Chopper Wiring

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



NOTE:

A The 230 VAC power supply must include a dedicated 3 A fuse or a circuit breaker in conjunction with a switch as a disconnecting safety device for the controller.

Chopper Wiring Example

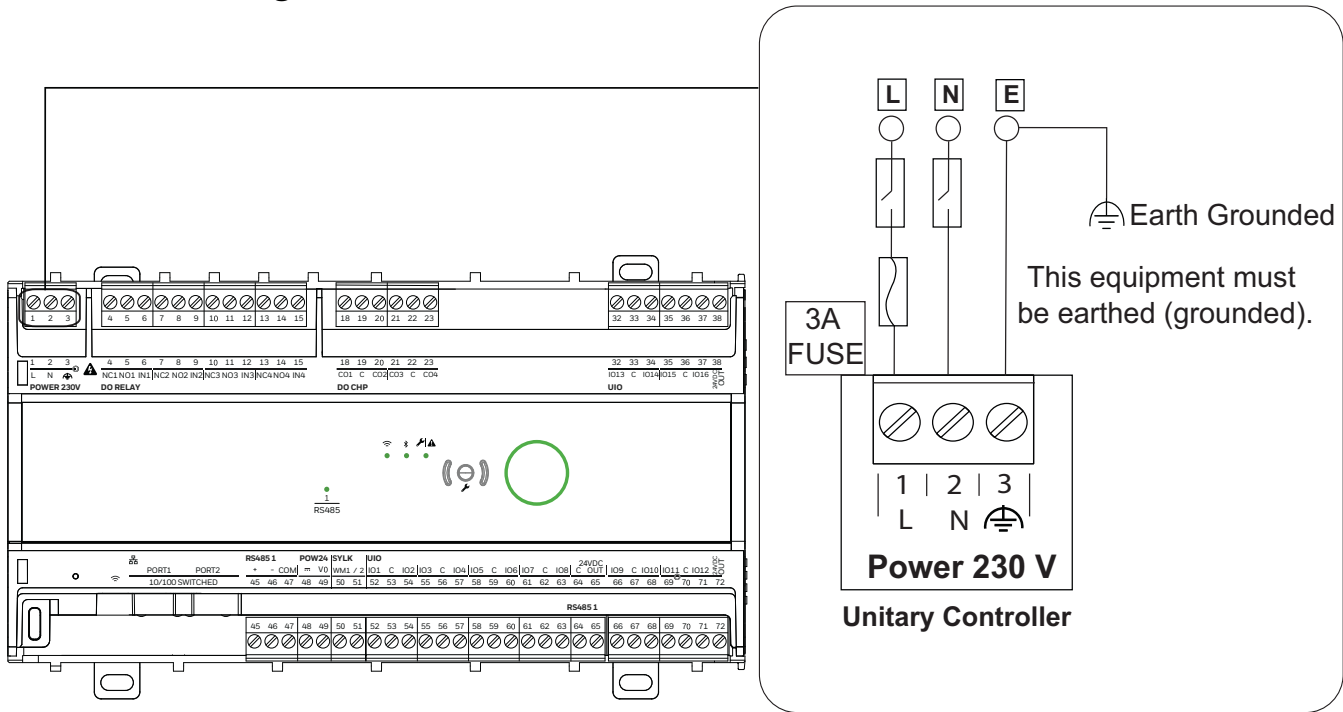


Fig. 12 Power Wiring Examples



DO NOT SWITCH ON POWER

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



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

Building earth ground (⏏) is a functional grounding, and it does not offer shock protection from a hazardous voltage. Connect the building earth ground (⏏) terminal to the panel ground using the proper cable as shown above. Ensure that the panel ground connects to a known earth ground.

INPUT / OUTPUT WIRING

Wiring Requirements



NOTE:

When attaching two or more wires to the same terminal, other than 14 AWG (2.0 mm²), 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 mm²) to 18 AWG (1 mm²) solid or stranded
- **Multiple wires:** Up to two 18 AWG (1 mm²) stranded, with 1/4 watt wire-wound resistor
 - Prepare wiring for the terminal blocks, as follows:
 - Strip 1/2 in. (13 mm) insulation from the conductor.
 - Cut a single wire to 3/16 in. (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 in. (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).

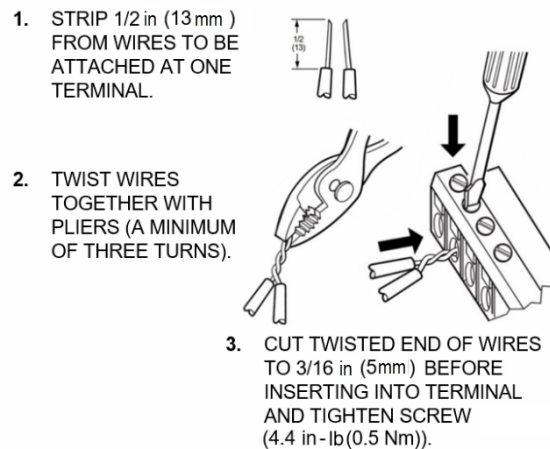


Fig. 13 Attaching Two or More Wires at Terminal Block

Internal Wiring Example

Internal Wiring Large controller

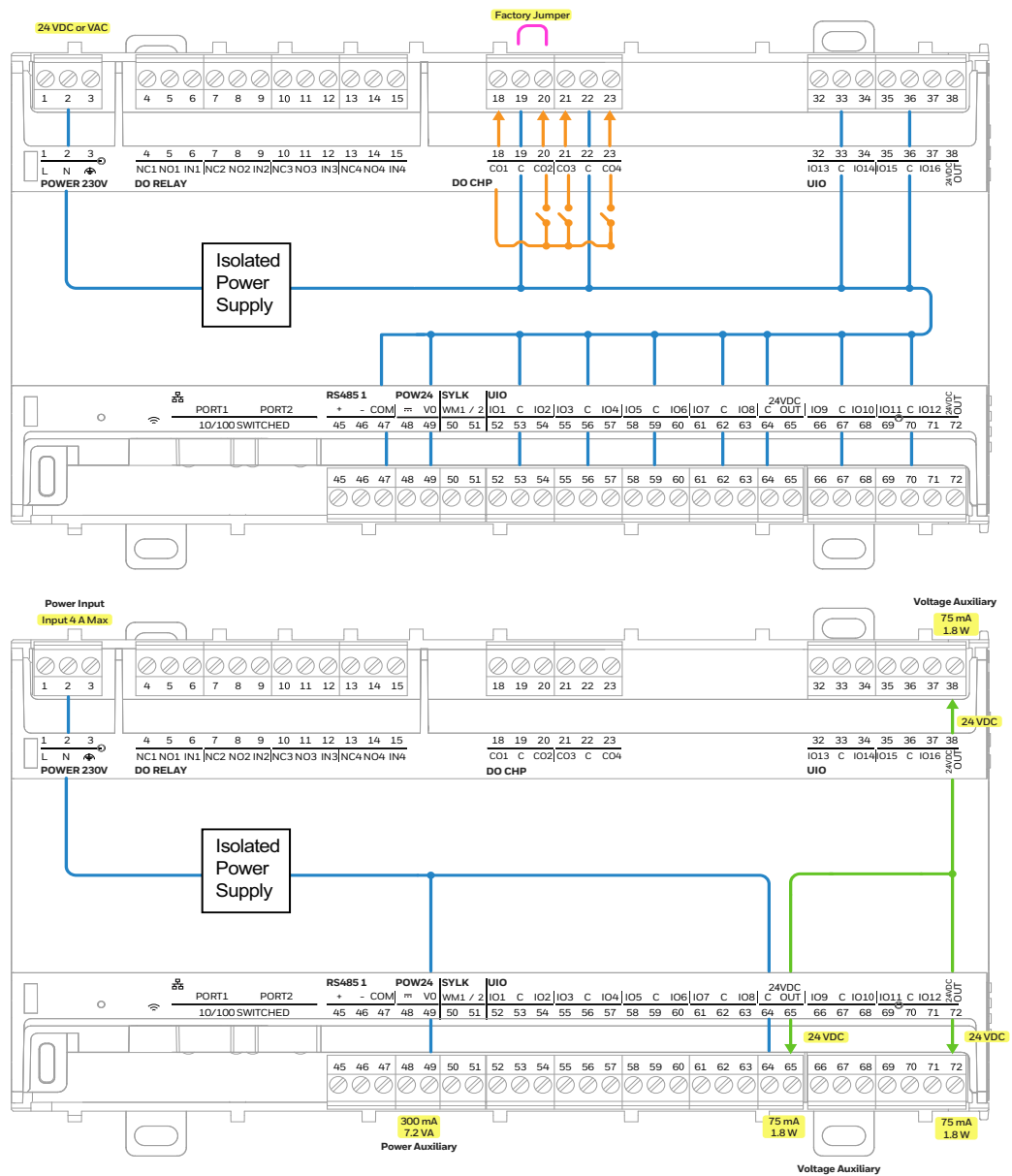


Fig. 14 Internal Wiring Large controller

Internal Wiring Small controller

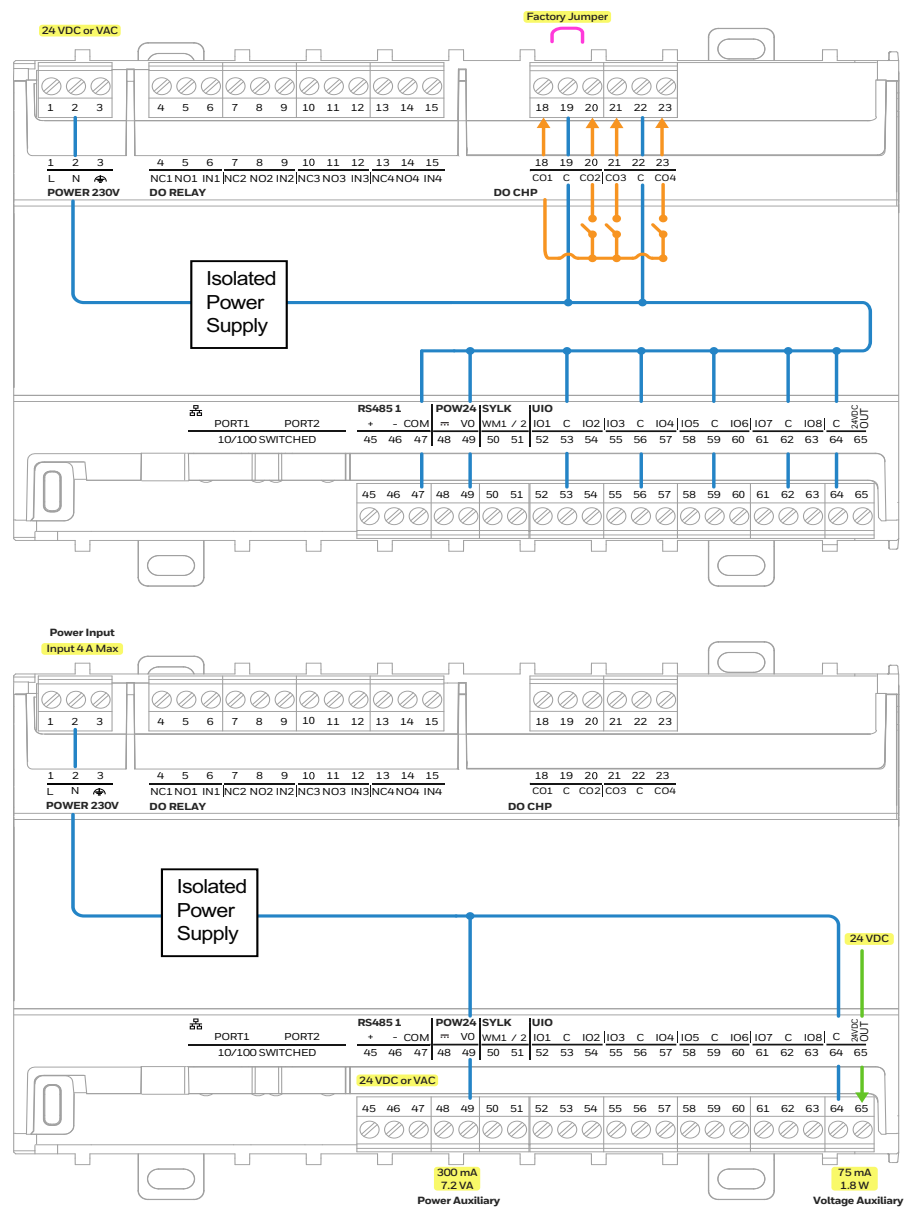


Fig. 15 Internal Wiring Small controller

Terminal Connections

Table 16 Terminal Connections

Terminal	Label	Description
Power 24V		
1	L	
2	N	Neutral
3		Earth ground (connected to building earth ground)
DO Relay		
4	NC1	Normally Closed 1
5	NO1	Normally Open 1
6	IN1	Universal signal input / output 1
7	NC2	Normally Closed 2
8	NO2	Normally Open 2
9	IN2	Universal signal input / output 2
10	NC3	Normally Closed 3
11	NO3	Normally Open 3
12	IN3	Universal signal input / output 3
13	NC4	Normally Closed 4
14	NO4	Normally Open 4
15	IN4	Universal signal input / output 4
DO CHP		
18	CO1	CO1 chopper output
19	C	Common
20	CO2	CO2 chopper output
21	CO3	CO3 chopper output
22	C	Common
23	CO4	CO4 chopper output
UIO		
32	IO13	Universal signal input / output 13
33	C	Common
34	IO14	Universal signal input / output 14
35	IO15	Universal signal input / output 15
36	C	Common
37	IO16	Universal signal input / output 16
38	24 VDC OUT	Power Output
RS485 - 1		
45	+	RS-485 bus + (for Modbus only)
46	-	RS-485 bus - (for Modbus only)
47	COM	Common
Power 24		
48		Power supply voltage (connected to 24 VDC)
49	V0	Power supply voltage (connected to 24 V0)
SYLK™		
50	+	Sylk™ Bus
51	-	Sylk™ Bus

Table 16 Terminal Connections

Terminal	Label	Description
UIO		
52	IO1	Universal signal input / output 1
53	C	Common
54	IO2	Universal signal input / output 2
55	IO3	Universal signal input / output 3
56	C	Common
57	IO4	Universal signal input / output 4
58	IO5	Universal signal input / output 5
59	C	Common
60	IO6	Universal signal input / output 6
61	IO7	Universal signal input / output 7
62	C	Common
63	IO8	Universal signal input / output 8
64	C	Common + 24 VDC
65	OUT	Power Output + 24 VDC
66	IO9	Universal signal input / output 9
67	C	Common
68	IO10	Universal signal input / output 10
69	IO11	Universal signal input / output 11
70	C	Common
71	IO12	Universal signal input / output 12
BACnet™ RJ45 (IP) Model		
Port 1	Port 1	RJ45 Ethernet 1
Port 2	Port 2	RJ45 Ethernet 2
BACnet™ MS/TP Model		
42	+	RS-485 bus + (for MS/TP only)
43	-	RS-485 bus - (for MS/TP only)
44	SHD	Shield
BACnet™ T1L Model		
39	DA+	T1L Switch 1 +
40	DA-	T1L Switch 1 -
41		T1L Switch 1 Common
42	DA+	T1L Switch 2 +
43	DA-	T1L Switch 2 -
44		T1L Switch 2 Common

UIO Wiring Examples

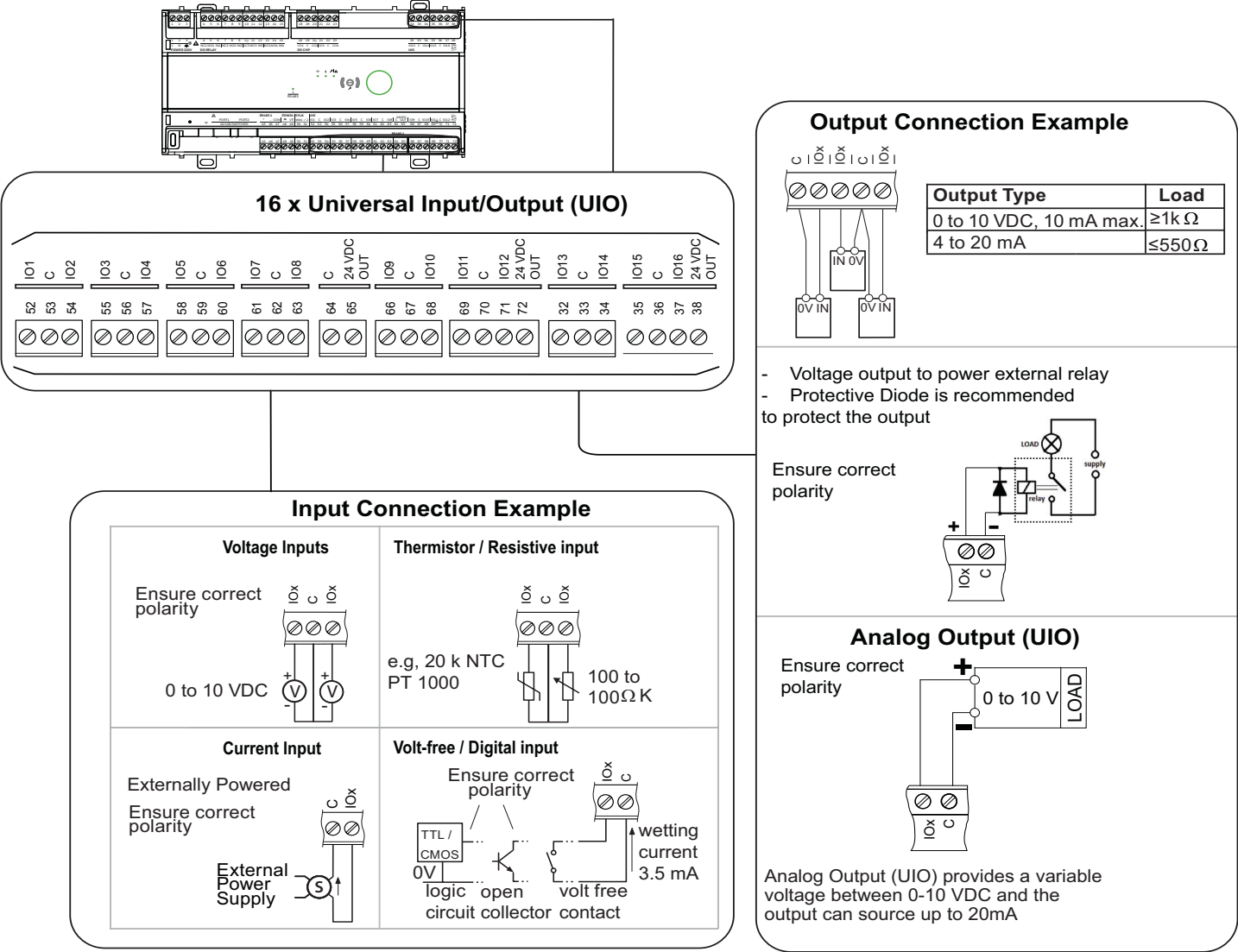


Fig. 16 Universal IO Wiring Examples

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.

DO CHP Wiring Example

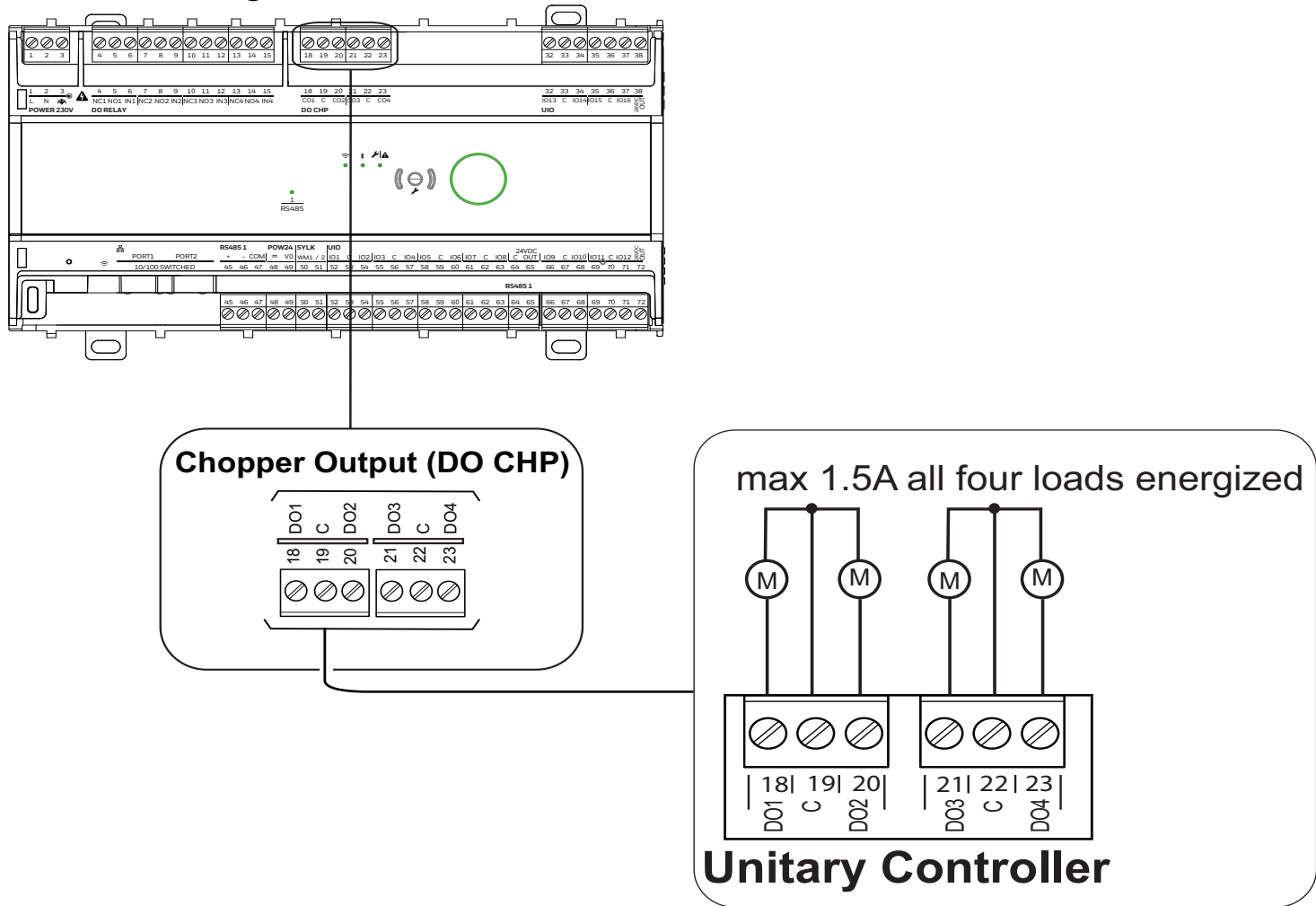


Fig. 17 DO (CHP) Wiring Example

NOTE:

- 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.

Auxiliary Wiring Examples

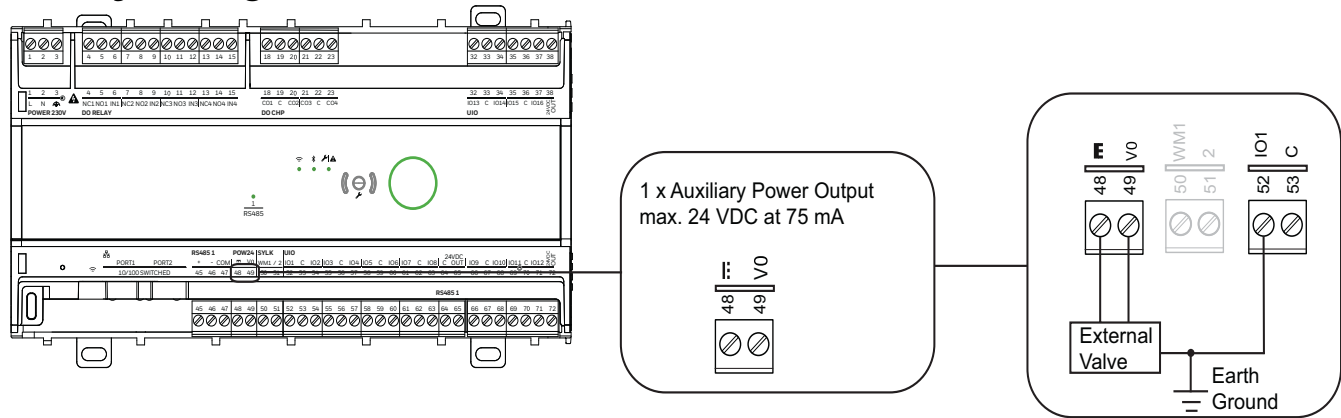


Fig. 18 Auxiliary Wiring Examples

NOTE:
The auxiliary power output (terminals 48, 49) is supplied from the controller input power supply (terminals 3, 2 respectively). The polarity of the external devices must be checked with the controller input power supply. If the polarity is reversed, external devices may be damaged.

DO Relay Wiring Examples

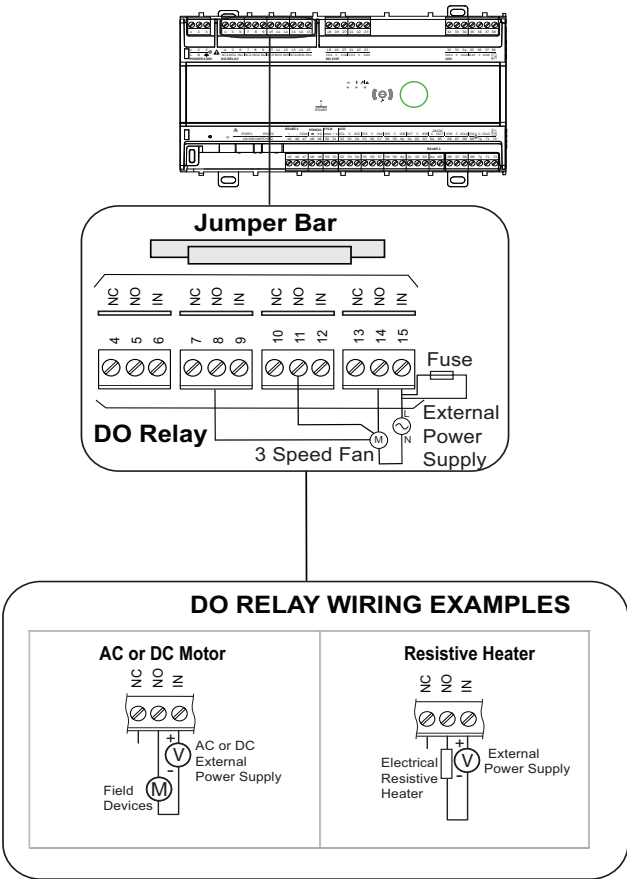


Fig. 19 DO Relay Wiring Examples

NETWORK CONCEPTS

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™ MS/TP EIA 485 buses.

Table 17. TIA/EIA 485 Cable Specifications

Maximum Length	3936 feet (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 MS/TP 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.

IP Network Topologies

- Recommended cable: CAT5, CAT6 etc.
- Maximum distance between two controllers or a controller and switch should be less than 328 ft (100 m).

Daisy Chain Topology

In traditional daisy chain topologies, if any of the devices in the network fails, the devices that are connected after that device, also fail.

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

Our IP ports include a protection for these scenarios so that a device having a logic failure will not interrupt the communication of others, for as long as the Ethernet switch continues to be powered and running.

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

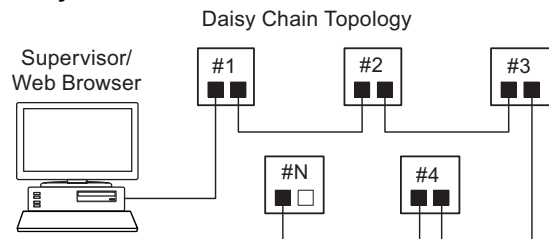


Fig. 20 Daisy Chain Topology

Ring Topology

If 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. Honeywell Unitary controllers 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 are not any broadcast storms or duplicate frame transmissions. The maximum number of controllers connected in the STP loop is 39 with one switch. A switch manages the connection of a loop.

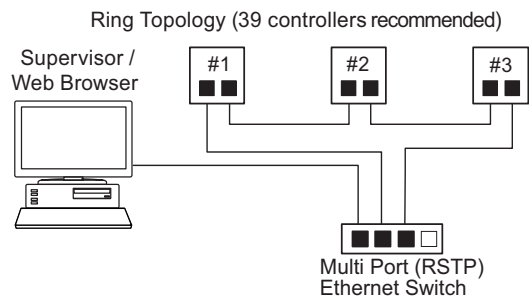


Fig. 21 Ring Topology

BACNET™ IP CONTROLLER

Every Unitary controller has a physical MAC address printed on the device. The physical MAC address of the controller is listed using the "arp -a" function on the command prompt of a Windows computer.

Connecting to an IP network

Honeywell Unitary controllers communicate over wired IPv4 network using Ethernet connection via two RJ45 ports.

DHCP IP Configuration

A new controller from the factory has DHCP enabled by default.

- For the first 15 seconds after powering the controller, a search for a DHCP server will be performed to acquire an IP address.

Link-local addressing

- If a DHCP server is not found, the controller will switch to Auto IP mode, in which it follows link-local addressing for address resolution.
- It will acquire an IP address in the range 169.254.1.0 - 169.254.254.254. The controller will use the last two characters of its serial number as the last octet for starting address search. For example, if the serial ends with "36" (decimal value= 54), the IP address is set to 169.254.1.54).
- The controller will periodically (every 1 minute) search for the DHCP server. If a server is found, the controller will acquire a new IP address from the server and start using it immediately.

BACNET™ MS/TP WIRING

The MS/TP models of the Honeywell Unitary controllers use the BACnet™ MS/TP communication protocol. The controller's data is presented to other controllers over a twisted-pair MS/TP 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 kbps. The Honeywell Unitary controller BACnet™ MS/TP are server devices on the MS/TP network. Each Honeywell Unitary controller BACnet™ controller uses a high-quality TIA/EIA 485 transceiver and exerts 1/8-unit load on the MS/TP network. The controller features a 2-wire non-isolated RS-485 interface (terminals 45, 46, and 47) suitable for BACnet™ MS/TP communication. The terminal block containing it is grey. The cable length affects the baud rate.

Table 18 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 ft (1200 m)



NOTE:

The maximum length of a BACnet™ MS/TP network bus segment with recommended wiring is 4,000 ft (1200 m). Repeaters must be used when making runs longer than 4,000 ft (1200 m). Between any two devices, a maximum of three repeaters can be used.

Auto Baud rate functionality

The MS/TP network is listened up to 4 minutes each time the supply voltage to the controller is turned on to establish a baud rate. Once the proper baud rate has been identified, the auto baud detection is stopped, and the new baud rate is used and saved in the controller as a successful baud rate.

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.

Termination Resistors

Matched terminating resistors are required at each end of a segment bus wired across (+) and (-). Use matched precision resistors rated $\frac{1}{4} W \pm 1 \% / 80 = 130 \Omega$.

Ideally, the value of the terminating resistors should match the rated characteristic impedance of the installed cable. For example, if the installed MS/TP cable has a listed characteristic impedance of 120 Ω , install a 120 Ω resistor.

Shield Termination

Following proper MS/TP 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 MS/TP cabling close to higher voltage lines. If shielding is used, the shielding of each bus segment should be separately connected at one end to a verified earth ground.



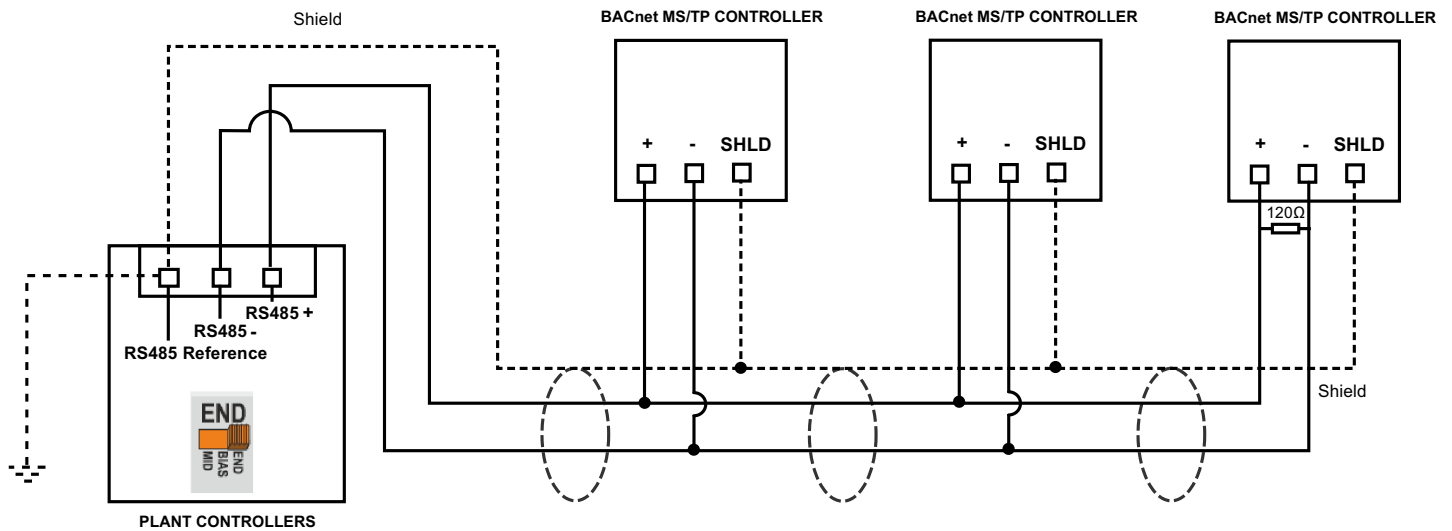
NOTE:

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™ MS/TP interface with other BACnet™ MS/TP capable devices. In doing so, the following considerations should be considered.

- Maximum BACnet™ MS/TP bus length.
- Twisted-pair cable, for example,
 1. AWG 18 (1 mm²)
 2. J-Y(ST)Y 4 x 2 x 0.8 mm² or a special RS-485 cable.
 3. CAT5,6,7 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.

BACnet™ MS/TP Wiring Example



NOTE: Connect the shield to earth ground from the RS485 reference terminal as shown above.

Fig. 22 Connection to a BACnet™ MS/TP Bus

- NOTE:**
- Suppose any of the devices are electrically isolated. It is recommended that those devices be connected to the ground terminal (SHLD). 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 a verified earth ground.
 - 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 VDC are allowed. Further, this bus should not extend beyond a single building.

BACNET™ MS/TP CONTROLLER

BACnet™ MS/TP Limitations

There are two limitations regarding the number of controllers per BACnet™ MS/TP network:

Physical Limitation

One Honeywell Unitary controller represents 1/8 load (32 loads per TIA/EIA-485 standard). The physical limitation is important if third party devices representing a full load are connected.

AutoMAC limitation

A maxMaster of 127 means we can support a maximum of 125 BACnet™ MS/TP Unitary controllers, one supervisor, and one BACnet™ client (tool) per BACnet™ MS/TP network.

Table 19 Default Values

Default Max Master	Default MinMAC	Default MaxMAC	Default Baud Rate
127	1	127	38400



NOTE:

1 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™ MS/TP devices per network is recommended.



NOTE:

It is recommended not to have more than 62 controllers on single MS/TP 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™ MS/TP 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™ MS/TP channel (the MAC Address of "0" is reserved by default for the router/plant controller, itself).

All Honeywell Unitary controllers are BACnet™ MS/TP clients. Every client performs periodic polling for the possible appearance of new clients. Each client “knows” the identity of the “next” client (for example, that Honeywell Unitary controller with the next-highest MAC Address) on the BACnet™ MS/TP bus and to which it must therefore pass the token. The polling processes includes a search for new clients which might have MAC addresses lying between its own MAC address and that of the “next” controller.

The property maxMaster specifies the highest allowable address for controllers. The maxMaster is set to 127 by default, thus guaranteeing that, on a BACnet™ MS/TP bus the following properties are writeable and can be changed:

- maxMaster
- min MAC
- max MAC
- MAC address



NOTE:

Do not attempt to program a MAC address outside the range of min MAC and max MAC.

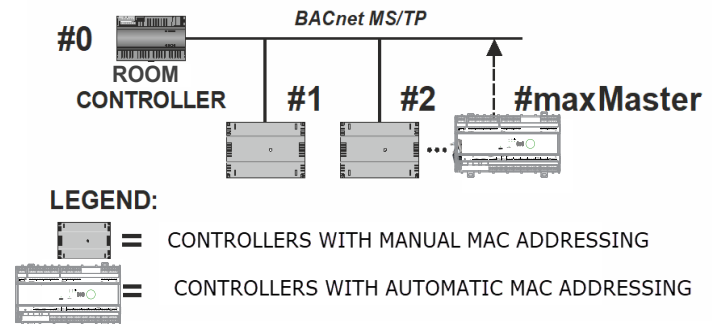


Fig. 23 Automatic MAC Addressing

Setting the MS/TP MAC Address

The MS/TP MAC address for each device must be set to a unique value in the range of 1-127 on an MS/TP 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 BACnet™ MS/TP controller sets the MAC address.



NOTE:

DIP setting of all-ON (MAC address will be 127) or all-OFF (MAC address will be 1) will enable the Auto MAC mode in the controller. The dip switches will not be used for MAC addressing.

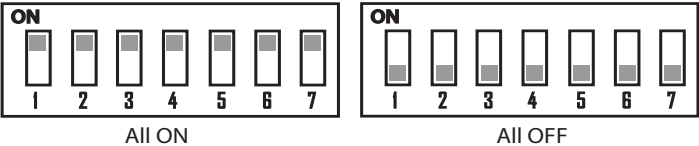


Fig. 24 MS/TP MAC Address Details

To set the MAC address of a Honeywell Unitary controller BACnet™ MS/TP:

- 1. Find an unused MAC address on the BACnet™ MS/TP 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 controllers BACnet™ MS/TP 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 20.

Table 20 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).

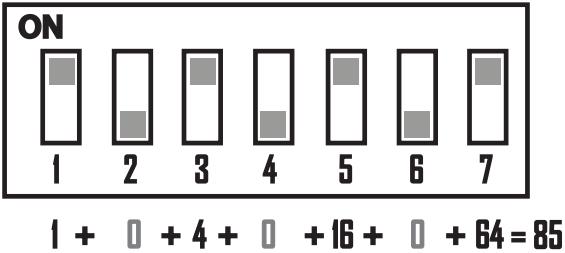


Fig. 25 Calculating the MAC Address

Setting the Device Instance Number

The Device Instance number must be unique across the entire BACnet™ MS/TP 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™ MS/TP Device Instance number is automatically set when added to a Niagara station. The user can change the Device Instance number.

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 3280 feet (1000 m) at a transmission speed of 10 Mbps.

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 RJ45 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

In T1L daisy chain topologies, if any two devices in the network fails/ or not communicating, the devices that are connected after that devices can communicate.

For example, if there are 10 devices in a network, device number 1 is the client device, which is connected to device 2, device 2 is connected to 3, and so on. if two sequential controllers lose power. If more than two sequential controllers lose power, the communication between the upstream controllers and the devices downstream may be compromised.

The maximum number of T1L controllers which can be connected in a daisy chain is 100.

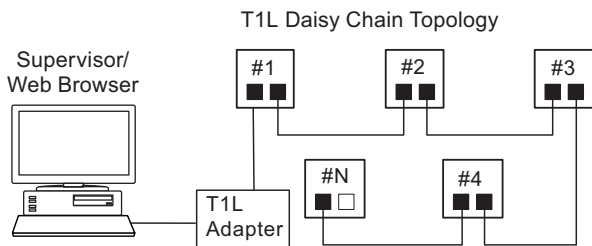


Fig. 26 T1L Daisy chain Topology

Ring Topology

If 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. The Honeywell Unitary controller 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 are not any broadcast storms or duplicate frame transmissions.

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

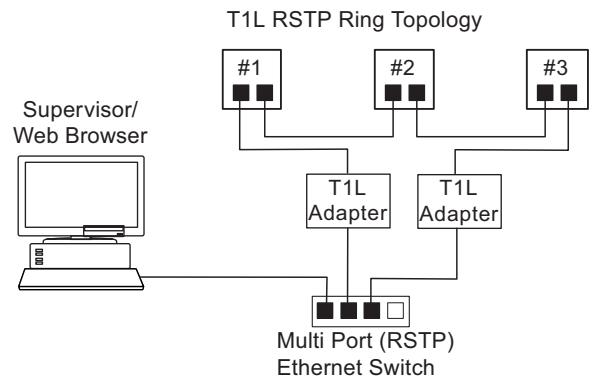


Fig. 27 T1L Ring Topology

WiFi Communication

The Unitary controllers ship with a WiFi antenna which connects directly on the controller without a cable extension. Use this antenna when mounting the Unitary controller in a non-metal enclosure. For metal enclosure applications, it is recommended to use a remote-mount antenna which mounts to the outside of the metal enclosure through an extension cable. If the antenna is mounted inside a metal enclosure or ductwork, the wireless signal will be attenuated, leading to unreliable wireless communications.

Install the Local Antenna

1. Insert local antenna terminal nut into the SMA (SubMiniature version A) connector.
2. Tighten by turning the base of the antenna clockwise.

Install the Remote Antenna

1. Uninstall the local antenna by turning the base of the antenna counterclockwise.
2. Place the remote antenna where the signal reception is good.
3. Safely route the remote antenna wire terminal nut to the Unitary controller.
4. Insert the wire terminal nut into the SMA (SubMiniature version A) connector.
5. Tighten the wire terminal nut by turning the nut clockwise. Do not over-tighten.

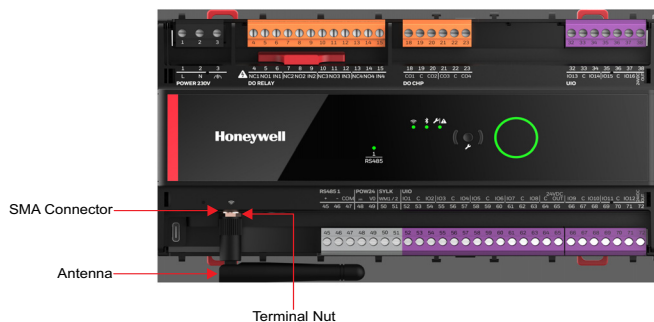


Fig. 28 Antenna

WiFi Access Point

The Unitary controller connects to access points via following connection methods:

- Open (SSID)
- WPA2 Personal (SSID, Password)
- WPA2 Enterprise

Factory Default Controller

The controller will search for a default access point (AP).

- SSID: **HON_Default_AP**
- Password: **Honeywell@123**

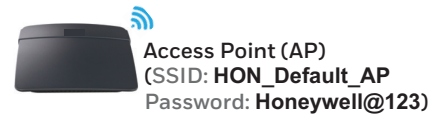


Fig. 29 Default access point



NOTE:

The default password is only for the initial connection when searching for a WiFi network. It is strongly advised to connect using secure WPA2 enterprise network and change the default password to a strong password or passphrase immediately after successful connection.



NOTE:

The following settings should be active, if the user attempts to connect to the controller via an Android or iPhone mobile hotspot:

- For Android, the frequency of the broadcast channel should be 2.4 GHz.
- For iPhone, maximize compatibility should always be enabled.

WiFi access point configuration

The Unitary controller functions as WiFi client only and can be connected to one access point. If a new access point is available and configured by the user, the controller will try connecting to the new one. For example, if the controller and the workstation are connected to an access point (AP1) and the user configures a new access point (AP2), the controller will try connecting to AP2. Once the AP2 connection is successful, then the controller will forget AP1. For failed case scenarios, refer WiFi Troubleshooting on page 37.

For more details on the access point connection refer WiFi Access Point Connection Process on page 32.

Remote Antenna Placement

Place and align the antenna in a way that the WiFi signal does not interfere with any obstacles.

Table 21 Types of building materials and range reduction

Wall Material	Range Reduction
Wood, drywall, glass	0-10 %
Brick, Particle board	5-25 %
Metal, steel-reinforced concrete wall	10-90 %

- Make sure that the antenna is installed perpendicular to the surface for a good WiFi signal.
- The antenna has a strong signal transmission and reception from the side. Position the sides of the antenna towards the device it is communicating with.

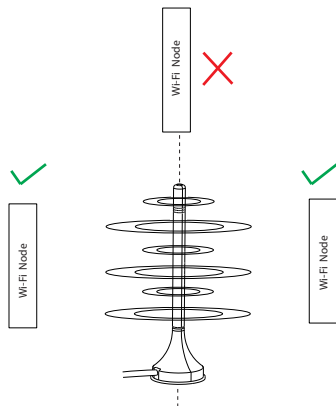


Fig. 30 Remote Antenna Placement

- Keep the antenna away from devices that cause wireless interference, such as other WiFi networks and telecommunications equipment.
- Do not install the antenna close to the floor.

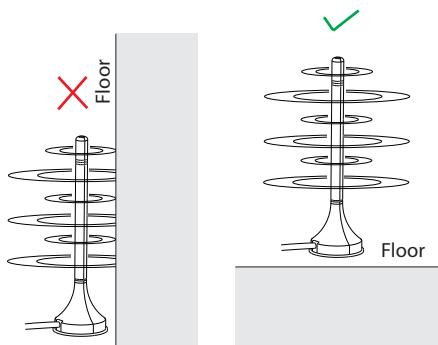


Fig. 31 Remote Antenna Placement

- The local antenna can be used when the Unitary controller is installed in a cabinet or enclosure.

Recommended WiFi Security Points

When connecting devices to a WiFi network, there are several security options users can follow to enhance the security of the devices and data.

- **Use strong and unique passwords:** Change the default passwords for the WiFi router and ensure to use a strong, complex password/passphrase that includes a mix of uppercase and lowercase letters, numbers, and special characters.
- **Enable network encryption:** Use WiFi Protected Access 2 (WPA2) on your WiFi network. Encryption helps protect the data from eavesdropping and unauthorized access. Avoid using WEP (Wired Equivalent Privacy) as it is not secure.
- **Keep firmware/software up to date:** Regularly update the firmware of your WiFi router and your devices' operating systems and software. These updates often include security patches that address known vulnerabilities.
- **Disable remote management:** Disable remote management of your WiFi router unless you specifically need it. Remote management can be a potential entry point for attackers.
- **Change default network and router names:** Modify your WiFi network's default network name (SSID) and change your router's default administrator username and password often. Using default settings makes it easier for attackers to identify your devices and launch attacks.
- **Use a guest network:** If your router supports it, set up a guest network for visitors. This separates your primary network from guest devices, limiting their access to your devices and data.
- **Disable WPS (WiFi Protected Setup):** WPS can be vulnerable to brute-force attacks. Disable WPS in your router settings to mitigate this risk.
- **Enable a firewall:** Use a firewall on your devices and network to monitor and control incoming and outgoing network traffic. Firewalls help protect against unauthorized access and malware.
- **Enable MAC address filtering:** Configure your router to only allow specific devices with known MAC addresses to connect to your network. Although MAC addresses can be spoofed, this measure adds an extra access control layer.
- **Disable unused network services:** Review the features and services enabled on your router and disable any you do not use or need. Reducing the attack surface minimizes potential vulnerabilities.
- **Be cautious with open network:** Avoid all sensitive activities apart from the initial connection to bring the device to the network. No other configurations, communications, etc., critical actions are performed in this open connection as these are susceptible to security attacks.

WiFi Access Point Connection Process

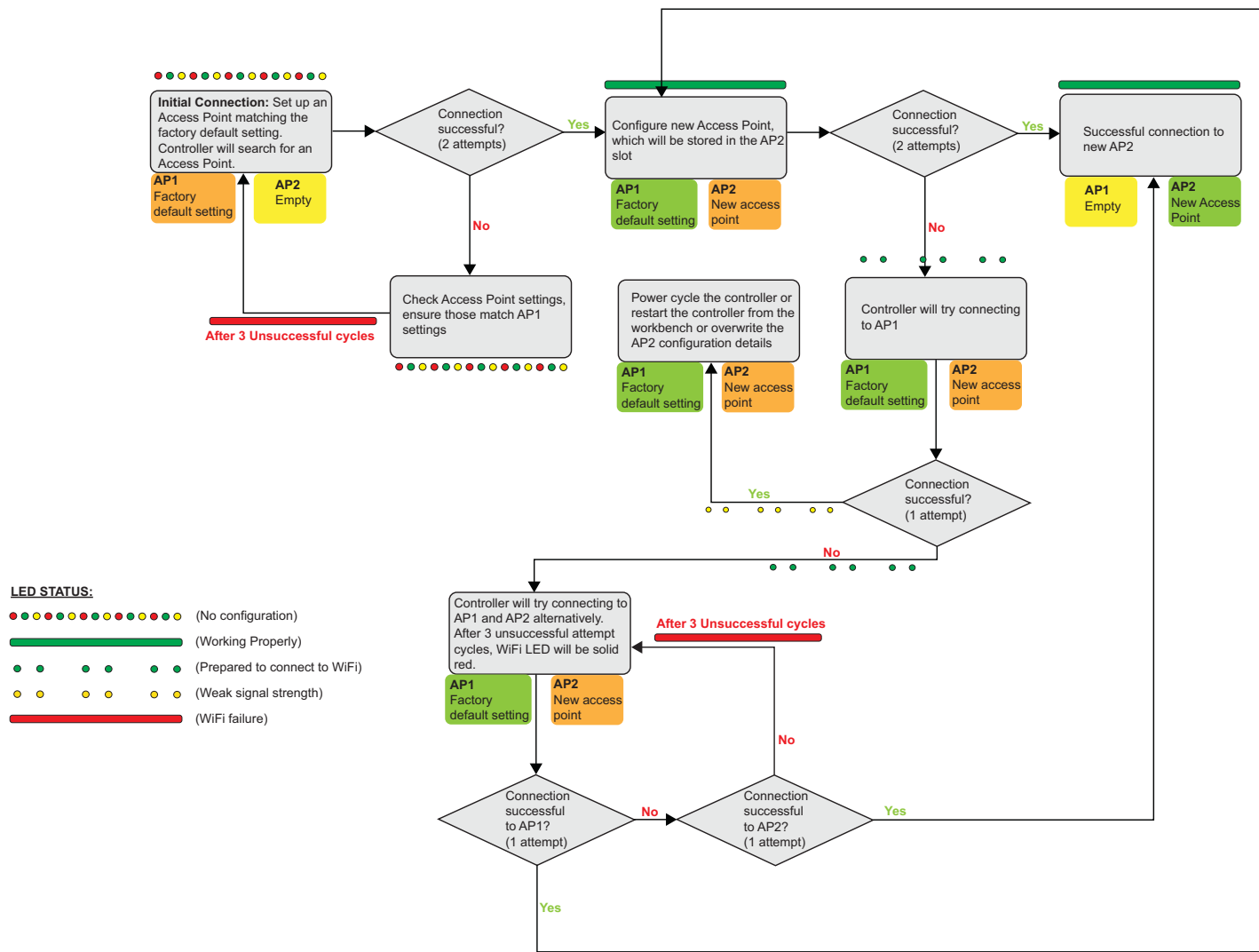


Fig. 32 WiFi Access Point Connection flow chart

MODBUS RTU

The controller features a removable 2-wire with shield, non-isolated, RS-485 interface suitable for Modbus communication (terminals 45, 46, and 47). The terminal block containing it is gray. The controller can function only as a Modbus client. In general, the TIA/EIA 485 wiring rules must be followed.

Wiring Topology

Only daisy chain wiring topology is allowed.

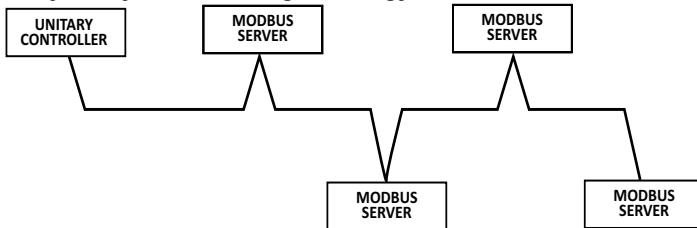


Fig. 33 Modbus Wiring Topology

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

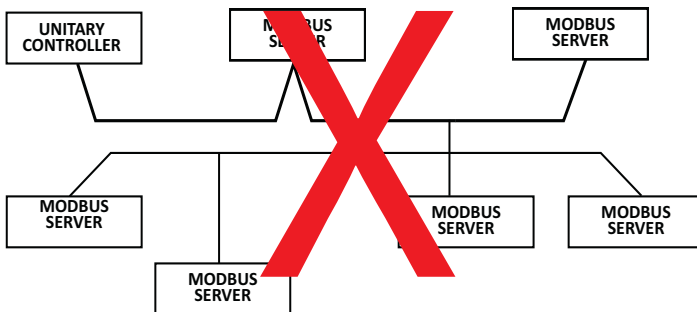


Fig. 34 Prohibited Wiring Topology (example)

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 especially 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 shield termination

When using one pair for Modbus (+) and Modbus (–) and one wire of another pair for the shield termination, CAT5 cable may also be used.

Modbus RS-485 Repeaters

RS-485 repeaters are possible but have not been tested by Honeywell; therefore, it is the installing or commissioning person's responsibility to ensure proper operation.



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 22 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 kbps 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 client.
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 kbps (because these communication rates are not market-relevant).

The baud rates (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.

SYLK™

Sylk™ 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™ interface: 96 mA.
- The maximum number of Sylk™ devices depends on the following Sylk™ devices specific information:
 - Sylk™ power consumption.
 - Number of parameters used.
 - Total config file size.

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

The following are the Sylk™ wall modules and Sylk™ actuators supported by the Honeywell Unitary controller.

Supported Sylk™ devices

- **Sylk™ wall modules:** TR40, TR40-H, TR40-CO2, TR40-HCO2, TR42, TR42-H, TR42-CO2, TR42-HCO2, TR50 (emulation mode only), TR71, TR71-H, TR75, TR75-H, TR75-HE, TR120 (TR75- E), and TR120-H emulation mode only.
- **Sylk™ actuators:** MS3103, MS3105, MS3110, and MS3120
- **Sylk™ Sensor:** C7400S



NOTE:

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

Table 23. Recommended maximum distances

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 (0.048 - 0.028 in) (0.3 to 1 mm ²)	24 AWG (0.022 in) (0.2 mm ²)	18 - 24 AWG (0.048 - 0.022 in) (0.2 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), thicker gauge, non-shielded cable yields the best results for longer runs.		
^{b)} The 100 ft (30 m) distance for standard thermostat wire is conservative but is meant to reduce the impact of any sources of electrical noise (including 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.



TROUBLESHOOTING

The Honeywell Unitary controller features 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.

The Unitary controller features a BACnet™ device manager that can be used to analyze the controller's function and communication for troubleshooting purposes.

WiFi Troubleshooting

Table 24 WiFi Troubleshooting

Issue	LED Mode	Action
- Access point (AP2) is not available. - Access point (AP2) configuration is incorrect.	Yellow LED blinks every 1 second and then pause for 2 seconds	Access point (AP2) connection fails, and the controller will fall back to the previously configured access point (AP1), and the connection is successful.
To make the controller retry connecting to access point (AP2).	-	- Power cycle the controller. - Restart the controller from workbench. - Rewrite the AP2 configuration details to the controller.
If controller fails to connect to an access point after several retries.	Red LED Permanent ON	Check the range of the access point configured in the controller where it is mounted.
How to recover if user lost SSID/PASS	-	Perform a factory reset, the controller will try connecting to default SSID/PASS

LED Interface

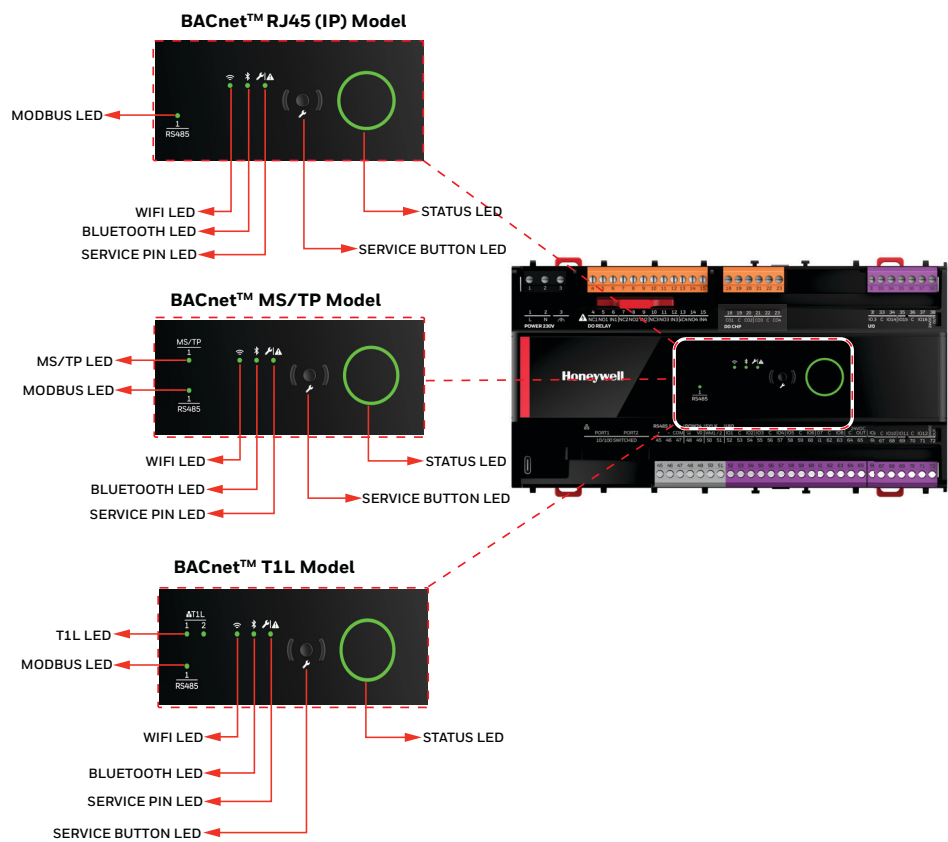


Fig. 36 LED Interface

Controller Status LED

Table 25 Controller Status LED

LED Status	Visual	Mode
Green LED permanent ON		Normal operation
Green LED blinks every 2 seconds		Auto MAC
Green LED blinks every 0.2 seconds		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 0.2 seconds		Communication error

LED Status	Visual	Mode
Red, Green, Yellow LED blinks every 1 second		No application

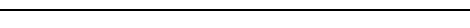
BACnet™ MS/TP LED Status

Table 26 BACnet™ MS/TP LED Status

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

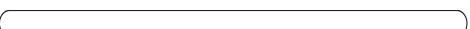
Modbus LED Status

Table 27 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.

T1L LED Status

Table 28 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.

WiFi LED Status

Table 29 WiFi LED Status

LED Status	Visual	Mode
LED OFF		WiFi disabled/Switched OFF
Red, Green, Yellow blinks every 1.5 second		Factory default, LED test (No application loaded/No configuration)
Green LED permanent ON		Working Properly
Green LED blinks every 1 second and then pause for 2 seconds		Prepared to connect to WiFi
Yellow LED permanent ON		Weak signal strength
Yellow LED blinks every 1 second and then pause for 2 seconds		New connection to access point fails, the controller will fall back to the previously configured access point, and the connection is successful.
Red LED permanent ON		WiFi failure

Service Pin LED Status

Table 30 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.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, 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 or TV technician for help.

ISED non-interference disclaimer

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence exempt RSS(s). Operation is subject to the following two conditions:

- (1) This device may not cause interference,

- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

This device complies with the Canadian ICES-003 Class A specifications. CAN ICES-003(B) / NMB-003 (B).

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 exempt 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.

Cet appareil numérique de la Canadian ICES-003. Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

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, which is listed in Table 2 on page 4.
- This device requires significant technology engineering expertise to understand the tools and relevant technology, which is not readily available 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.

Wireless Connectivity

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.

Table 31 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

CE Statement

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

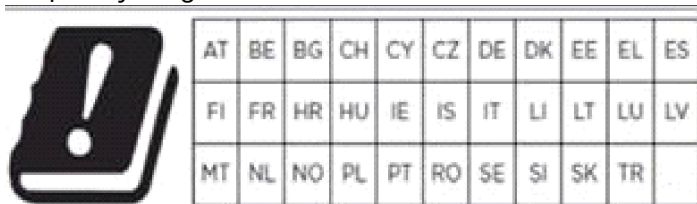


Fig. 37 CE Statement

RF Exposure (EMF) statement

This equipment complies with ISSED RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm (7.9 inches) between the radiator and any part of your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Cet équipement est conforme aux limites d'exposition aux radiations ISSED CNR-102 établies pour un environnement non contrôlé. Une distance de séparation d'au moins 20 cm doivent être maintenue entre l'antenne de cet appareil et toutes les personnes. Lanceurs ou ne peuvent pas coexister cette antenne ou capteurs avec d'autres.

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.

Detachable Antenna Warning (IC)

Transmitter Antenna (From Section 6.8 RSS-GEN, Issue 5, April 2018): This radio transmitter See Table 32 on page 42 has been approved by Innovation, Science, and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Table 32 BLE Certification Numbers

FCC ID	IC ID
2A8LT-230NM001	12252A- 230NM001

Table 33 WiFi Certification Numbers

FCC ID	IC ID
COF-WMBACBM25	10293A-WMBACBM25

Standards and Compliance

- CE mark
- UL916 Energy Management Equipment
- UL/ULC 60730-1
- FCC/IC Product Class B
- BACnet™ BTL®-Listed
- Conforms to UL 2043

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 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 in accordance with 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 article 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 in accordance with 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. Our duty is 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 34 Honeywell Unitary Controllers Containing Lead (Pb)

Product / Part Name	Substance Name
UN-RS0844ES230NMC / D UN-RS0844ESB230NMC / D UN-RS0844MS230NMC / D UN-RS0844MSB230NMC / D UN-RS0844TS230NMC / D UN-RS0844TSB230NMC / D UN-RS0844WAS230NMC / D UN-RS0844WBS230NMC / D UN-RL1644ES230NMC / D UN-RL1644ESB230NMC / D UN-RL1644MS230NMC / D UN-RL1644MSB230NMC / D UN-RL1644TS230NMC / D UN-RL1644TSB230NMC / D UN-RL1644WAS230NMC / D UN-RL1644WBS230NMC / 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 35 Sensor Accuracies

Range	Measurement Error (Excluding Sensor Characteristics)			
	10 k Ω 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 accuracy of the internal sensor input (hardware + software [linearization]) only. This table does not include the characteristics of the sensors themselves, see Sensor Characteristics on page 46.

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 in Table 35 on page 44. It lists the measurement ranges and the corresponding thresholds for the recognized sensor failure for the various types of sensor:

Table 36 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, the lowest and highest value within the range, will be communicated. Thus, a temperature of -51 °F (-46 °C) will be communicated as -50 °F (-45 °C).

Sensor Characteristics

The characteristics (resistance in relation to temperature) of the sensors and the resultant voltage are listed on the following pages. The stated values do not include failures due to sensor failures, wiring resistance or wiring failures, mis readings due to a meter connected to measure resistance or voltage at the input.

10 K NTC TYPE II Characteristics

Table 37 10 K NTC TYPE II Characteristics

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]	Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
-22	-30	177	7.904	35.6	2	29.494	5.079
-20.2	-29	166.35	7.848	37.4	3	28.047	4.969
-18.4	-28	156.41	7.79	39.2	4	26.68	4.859
-16.6	-27	147.14	7.73	41	5	25.388	4.75
-14.8	-26	138.47	7.666	42.8	6	24.166	4.641
-13	-25	130.37	7.601	44.6	7	23.01	4.532
-11.2	-24	122.8	7.534	46.4	8	21.916	4.423
-9.4	-23	115.72	7.464	48.2	9	20.88	4.316
-7.6	-22	109.09	7.392	50	10	19.898	4.209
-5.8	-21	102.88	7.318	51.8	11	18.968	4.103
-4	-20	97.073	7.241	53.6	12	18.087	3.998
-2.2	-19	91.597	7.161	55.4	13	17.252	3.894
-0.4	-18	86.471	7.08	57.2	14	16.46	3.792
1.4	-17	81.667	6.996	59	15	15.708	3.69
3.2	-16	77.161	6.91	60.8	16	14.995	3.591
5	-15	72.932	6.821	62.6	17	14.319	3.492
6.8	-14	68.962	6.731	64.4	18	13.678	3.396
8.6	-13	65.231	6.639	66.2	19	13.068	3.3
10.4	-12	61.723	6.545	68	20	12.49	3.207
12.2	-11	58.424	6.448	69.8	21	11.94	3.115
14	-10	55.321	6.351	71.6	22	11.418	3.025
15.8	-9	52.399	6.251	73.4	23	10.921	2.937
17.6	-8	49.648	6.15	75.2	24	10.449	2.85
19.4	-7	47.058	6.047	77	25	10	2.767
21.2	-6	44.617	5.943	78.8	26	9.572	2.684
23	-5	42.317	5.838	80.6	27	9.165	2.603
24.8	-4	40.15	5.732	82.4	28	8.777	2.524
26.6	-3	38.106	5.624	84.2	29	8.408	2.447
28.4	-2	36.18	5.516	86	30	8.057	2.372
30.2	-1	34.363	5.408	87.8	31	7.722	2.299
32	0	32.65	5.299	89.6	32	7.402	2.228

Table 37 10 K NTC TYPE II Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
33.8	1	31.027	5.189
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
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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
91.4	33	7.098	2.159
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
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
156.2	69	1.813	0.673
158	70	1.752	0.652

10 K NTC TYPE III Characteristics**Table 38 10 K NTC TYPE III 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

Temp. [°F]	Temp. [°C]	Resistance [Ω]
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
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

10 K3A1 Characteristics**Table 39 10 K3A1 Characteristics**

Temp. [°F]	Temp. [°C]	Resistance [Ω]	Temp. [°F]	Temp. [°C]	Resistance [Ω]
-40	-40	336098	26.6	-3	38110
-38.2	-39	314553	28.4	-2	36184
-36.4	-38	294524	30.2	-1	34366
-34.6	-37	275897	32	0	32651
-32.8	-36	258563	33.8	1	31031
-31	-35	242427	35.6	2	29500
-29.2	-34	227398	37.4	3	28054
-27.4	-33	213394	39.2	4	26687
-25.6	-32	200339	41	5	25395
-23.8	-31	188163	42.8	6	24172
-22	-30	176803	44.6	7	23016
-20.2	-29	166198	46.4	8	21921
-18.4	-28	156294	48.2	9	20885
-16.6	-27	147042	50	10	19903
-14.8	-26	138393	51.8	11	18973
-13	-25	130306	53.6	12	18092
-11.2	-24	122741	55.4	13	17257
-9.4	-23	115661	57.2	14	16465
-7.6	-22	109032	59	15	15714
-5.8	-21	102824	60.8	16	15001
-4	-20	97006	62.6	17	14324
-2.2	-19	91553	64.4	18	13682
-0.4	-18	86439	66.2	19	13073
1.4	-17	81641	68	20	12493
3.2	-16	77138	69.8	21	11943
5	-15	72911	71.6	22	11420
6.8	-14	68940	73.4	23	10923
8.6	-13	65209	75.2	24	10450
10.4	-12	61703	77	25	10000
12.2	-11	58405	78.8	26	9572
14	-10	55304	80.6	27	9165
15.8	-9	52385	82.4	28	8777
17.6	-8	49638	84.2	29	8408
19.4	-7	47050	86	30	8056
21.2	-6	44613	87.8	31	7721

Table 39 10 K3A1 Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [Ω]	Temp. [°F]	Temp. [°C]	Resistance [Ω]
23	-5	42317	89.6	32	7402
24.8	-4	40151	91.4	33	7097
93.2	34	6807	159.8	71	1693
95	35	6530	161.6	72	1637
96.8	36	6266	163.4	73	1582
98.6	37	6014	165.2	74	1530
100.4	38	5774	167	75	1480
102.2	39	5544	168.8	76	1432
104	40	5325	170.6	77	1385
105.8	41	5116	172.4	78	1341
107.6	42	4916	174.2	79	1298
109.4	43	4724	176	80	1256
111.2	44	4542	177.8	81	1216
113	45	4367	179.6	82	1178
114.8	46	4200	181.4	83	1141
116.6	47	4040	183.2	84	1105
118.4	48	3887	185	85	1070
120.2	49	3741	186.8	86	1037
122	50	3601	188.6	87	1005
123.8	51	3467	190.4	88	974
125.6	52	3339	192.2	89	945
127.4	53	3216	194	90	916
129.2	54	3098	195.8	91	888
131	55	2985	197.6	92	862
132.8	56	2877	199.4	93	836
134.6	57	2773	201.2	94	811
136.4	58	2674	203	95	787
138.2	59	2579	204.8	96	764
140	60	2487	206.6	97	741
141.8	61	2399	208.4	98	720
143.6	62	2315	210.2	99	699
145.4	63	2234	212	100	678
147.2	64	2157	213.8	101	659
149	65	2082	215.6	102	640
150.8	66	2011	217.4	103	622
152.6	67	1942	219.2	104	604
154.4	68	1876	221	105	587

Table 39 10 K3A1 Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [Ω]
156.2	69	1813
158	70	1752
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

Temp. [°F]	Temp. [°C]	Resistance [Ω]
222.8	106	571
224.6	107	555
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

20 K NTC Characteristics**Table 40 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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
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
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

Table 40 20 K NTC Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
-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
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
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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
42.8	6	51.1	6.2
44.6	7	48.5	6.1
44.4	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
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
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

Table 40 20 K NTC Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
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
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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
174.2	79	2.24	0.818
176	80	2.17	0.792
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
251.6	122	0.57	0.225
253.4	123	0.56	0.219
255.2	124	0.54	0.213
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

Table 40 20 K NTC Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal voltage [V]
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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
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

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 RTD's. The electrical characteristic can be described by the following equation:

$$R(T) = R_0 (1 + aT + bT^2 + cT^4 + dT^6)$$

Coefficients:

- $a = 5.485 \times 10^{-3}$
- $b = 6.650 \times 10^{-6}$
- $c = 2.805 \times 10^{-11}$
- $d = -2.000 \times 10^{-17}$

$$T(R) = a' + b'(1 + c'R)^{1/2} + d'R^5 + e'R^7 \quad dT < 0.12 \text{ K (higher order equations on request)}$$

Coefficients:

- $a' = -412.6$
- $b' = 140.41$
- $c' = 0.00764$
- $d' = -6.25 \times 10^{-17}$
- $e' = -1.25 \times 10^{-24}$

Tolerances:

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

Table 41 Characteristic of the Nickel Temperature Sensor is Specified as per DIN 43760

Temp. [°F]	Temp. [°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 42 NI1000 TK5000 Sensor Specification

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

Table 43 R-T Characteristics (according to supplier's specifications and based on DIN 43760, resistance values in Ω)

Temp. [°F]	Temp. [°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
Temp. [°F]	Temp. [°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									

PT100 Characteristics**Table 44 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

PT1000 Characteristics**Table 45 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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
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
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

Table 45 PT1000 Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
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
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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
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
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

Table 45 PT1000 Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
143.6	62	1240	0.474
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
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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
213.8	101	1389	0.528
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
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

Table 45 PT1000 Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
282.2	139	1532	0.58
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
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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
350.6	177	1674	0.63
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
482	250	1941	0.723
483.8	251	1944	0.724
485.6	252	1948	0.726

Table 45 PT1000 Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]	Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
419	215	1813	0.679	487.4	253	1952	0.727
489.2	254	1955	0.728	557.6	292	2092	0.775
491	255	1959	0.729	559.4	293	2095	0.776
492.8	256	1962	0.73	561.2	294	2099	0.777
494.6	257	1966	0.732	563	295	2102	0.778
496.4	258	1970	0.733	564.8	296	2106	0.78
498.2	259	1973	0.734	566.6	297	2110	0.781
500	260	1977	0.736	568.4	298	2113	0.782
501.8	261	1980	0.737	570.2	299	2117	0.784
503.6	262	1984	0.738	572	300	2120	0.785
505.4	263	1988	0.739	573.8	301	2124	0.786
507.2	264	1991	0.74	575.6	302	2127	0.787
509	265	1995	0.742	577.4	303	2131	0.788
510.8	266	1998	0.743	579.2	304	2134	0.789
512.6	267	2002	0.744	581	305	2138	0.791
514.4	268	2006	0.746	582.8	306	2142	0.792
516.2	269	2009	0.747	584.6	307	2145	0.793
518	270	2013	0.748	586.4	308	2149	0.794
519.8	271	2016	0.749	588.2	309	2152	0.796
521.6	272	2020	0.75	590	310	2156	0.797
523.4	273	2024	0.752	591.8	311	2159	0.798
525.2	274	2027	0.753	593.6	312	2163	0.799
527	275	2031	0.754	595.4	313	2166	0.8
528.8	276	2034	0.755	597.2	314	2170	0.802
530.6	277	2038	0.757	599	315	2173	0.803
532.4	278	2042	0.758	600.8	316	2177	0.804
534.2	279	2045	0.759	602.6	317	2181	0.805
536	280	2049	0.76	604.4	318	2184	0.806
537.8	281	2052	0.761	606.2	319	2188	0.808
539.6	282	2056	0.763	608	320	2191	0.809
541.4	283	2060	0.764	609.8	321	2195	0.81
543.2	284	2063	0.765	611.6	322	2198	0.811
545	285	2067	0.766	613.4	323	2202	0.812
546.8	286	2070	0.768	615.2	324	2205	0.814
548.6	287	2074	0.769	617	325	2209	0.815
550.4	288	2077	0.77	618.8	326	2212	0.816
552.2	289	2081	0.771	620.6	327	2216	0.817
554	290	2085	0.773	622.4	328	2219	0.818

Table 45 PT1000 Characteristics (Continued)

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
555.8	291	2088	0.774
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
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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
624.2	329	2223	0.82
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
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 Characteristics**Table 46 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

Temp. [°F]	Temp. [°C]	Resistance [KΩ]	Terminal Voltage [V]
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

ABBREVIATIONS

Table 47 Abbreviations

Abbreviation	Definition
SSR	Solid State Relay
MS/TP	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 Version A
CMOS	Complementary Metal Oxide Semiconductor
TTL	Transistor Logic

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