JOHNSON CONTROLS

System 350™
A350E Electronic Cooling Control

The A350E is an on/off, electronic, cooling-only control with Single-Pole, Double-Throw (SPDT) relay output and Light-Emitting Diode (LED) relay status indication. A cooling-only control, the A350E has two features that differentiate it from the A350A/B Series Electronic Temperature Controls: a selectable minimum setpoint and short/open sensor detection. The A350E also has an adjustable differential and an interchangeable temperature sensor.

As are all System 350™ products, the A350E is housed in a NEMA 1, high-impact plastic enclosure. The modular design provides easy, plug-together connections for quick installation and future expandability.

Figure 1: A350E Electronic Cooling Control

Features and Benefits	
❑ **Modular Design**	Enables stage, display, and power modules to be purchased and installed as necessary
❑ **Minimum Setpoint Selections**	Allows the selection of a minimum setpoint at which the equipment can be set to control
❑ **Reacts to Short or Open Sensor Condition**	Deenergizes output relay if the sensor or sensor wiring fail
❑ **Wide Adjustable Differential of 1 to 30F° (0.6 to 16.7C°)**	Enables the user to match equipment cycle rate and/or sequencing for a given application
❑ **Plug-together Connectors and 35 mm DIN Rail Mounting**	Eliminates wiring between modules and reduces installation costs
❑ **One Dual-scale Model Covers a Temperature Range of 10 to 65°F (-12 to 18°C)**	Supports the majority of Fahrenheit and Celsius cooling applications
❑ **Interchangeable Temperature Sensors**	Increases versatility and serviceability

Part No. 24-7664-400, Rev. B
Code No. LIT-930015

Application

The A350E Cooling Control can be used as a standalone device or in conjunction with other System 350 plug-together accessory modules to control a wide variety of single or multiple-stage equipment. Typical applications include:

- frozen/refrigerated food cases
- cooling tower control
- beverage/milk coolers
- chiller staging
- space temperature control (cooling only)

A typical cooling control scheme includes the following:

- A350E Cooling Control
- One or more S350 Stage Modules
- D350 Digital Temperature Sensor/Setpoint Display Module
- Y350R Power Module (or 24 VAC Class 2 transformer)
- A99B Temperature Sensor

Operation

The A350E Cooling Control operates on 24 VAC and provides an SPDT relay output. A front-panel LED lights to indicate when the relay is energized. Adjustable features include:

- setpoint
- differential
- minimum setpoint

IMPORTANT:	All System 350 controls are designed for use **only** as operating controls. Where an operating control failure would result in personal injury and/or loss of property, it is the responsibility of the installer to add devices (safety, limit controls) that protect against, or systems (alarm, supervisory systems) that warn of, control failure.

Setpoint Adjustment

Setpoint is defined as the temperature at which the A350E's relay will de-energize. Refer to Figure 3**.** Use the Setpoint Dial on the front of the A350E to adjust setpoint. See Figure 2.

Minimum Setpoint Jumper

Four possible settings are available: 20°F (-7°C), 30°F (-1°C), 40°F (4°C), and Off. Refer to Figure 2 and use the jumper to select the desired minimum setpoint.

The minimum setpoint function overrides any knob-selected setpoint that is lower than the minimum setpoint. For example, if a minimum setpoint of 40°F is selected and the dial is set at 32°F (0°C), then the control setpoint will be 40°F (4°C). The external knob will change the control setpoint only when it is adjusted between 40 and 65°F (4 to 18°C).

When the minimum setpoint jumper is removed or the Off position is selected, the setpoint can be adjusted over the full range of 10 to 65°F (-12 to 18°C).

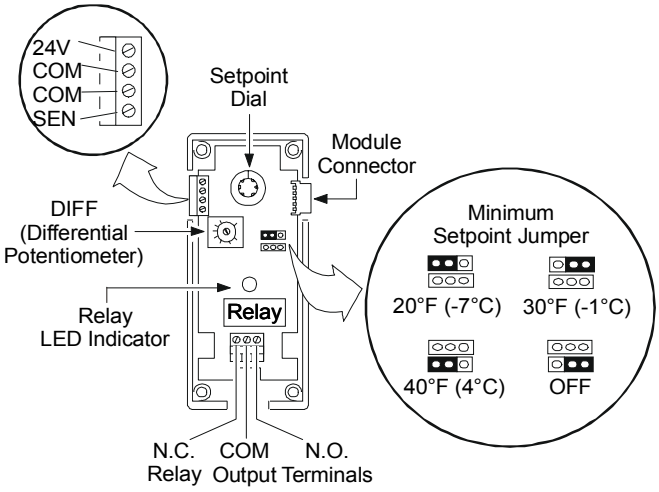

Figure 2: A350E Electronic Cooling Control Board Layout and Terminal Locations

Differential Adjustment

Differential is defined as the change in sensor temperature between the energization and de-energization of the relay. (See Figure 3.) The differential can be adjusted between 1 and 30F° (0.6 and 16.7C°). Adjustment is made using the differential potentiometer, marked DIFF. (See Figure 2 for location.)

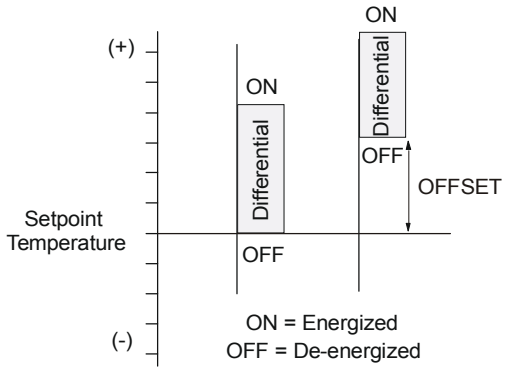

Figure 3: Relationship Between Differential Setpoint and Offset

Add-On Modules

The S350 Stage Modules, D350 Digital Temperature Display Module, and Y350R Power Module connect together and plug into a connector on the right side of the A350E. The maximum number of add-on modules is listed in Table 1.

Table 1: Maximum Number of S350 Stage Modules per A350E

Power Source	Number of S350A or S350C Modules Allowed	Number of S350A or S350C Modules (with 1 S350P) Allowed	Number of S350A or S350C Modules (with 2 S350Ps) Allowed
Y350R	9	6	4
External Class 2 Transformer	9	8	7

S350A On/Off Stage Modules

S350A On/Off Stage Modules receive power, setpoint, and sensor input from the A350E control. S350A Stage Modules perform switching functions based upon the A350E's setpoint, sensor information, with the offset and differential selected at the S350A. For more information on these modules, refer to the *System 350™ S350 Temperature, S351 Humidity, and S352 Pressure On/Off Stage Modules Product/Technical Bulletin (LIT-930080).*

S350C Slave Stage Modules

S350C Slave Stage Modules receive power and sensor input from the A350E control. S350C Slave Stage Modules perform switching functions based upon the A350E's sensor information, with the setpoint and differential selected at the S350C. For more information on these modules, refer to the *System 350™ S350C Temperature Slave Stage Module Product/Technical Bulletin (LIT-930084).*

S350P Proportional Stage Modules

S350P Proportional Stage Modules receive power, setpoint, and sensor input from the A350E control. The S350P responds with an analog 0 to 10 VDC and 0 to 20 mA output signal. This is based upon the A350E's setpoint and sensor information, with the offset, throttling range, and minimum output selected at the S350P.

For more information on these modules, refer to the *System 350™ S350P Proportional Plus Integral Temperature Stage Module Product/Technical Bulletin (LIT-930086).*

D350 Temperature Sensor/Setpoint Display Module

The D350 receives its power, sensor, and setpoint information from the A350E. A 3-digit Liquid Crystal Display (LCD) gives a continuous read-out of the sensed temperature. The setpoint of the adjoining A350E is displayed when the PRESS FOR SETPOINT button on the front of the D350 is pushed.

Y350R Power Module

The Y350R provides a convenient method of powering System 350 Modules from a 120 or 240 VAC power source. See Figure 5 for a typical wiring diagram where a Y350R is used to power the A350E. Up to nine S350A/C stage modules and one D350 can be operated from a Y350R.

For more information on this module, refer to *System 350™ Y350R Power Module Product/Technical Bulletin (LIT-930090).*

Dimensions

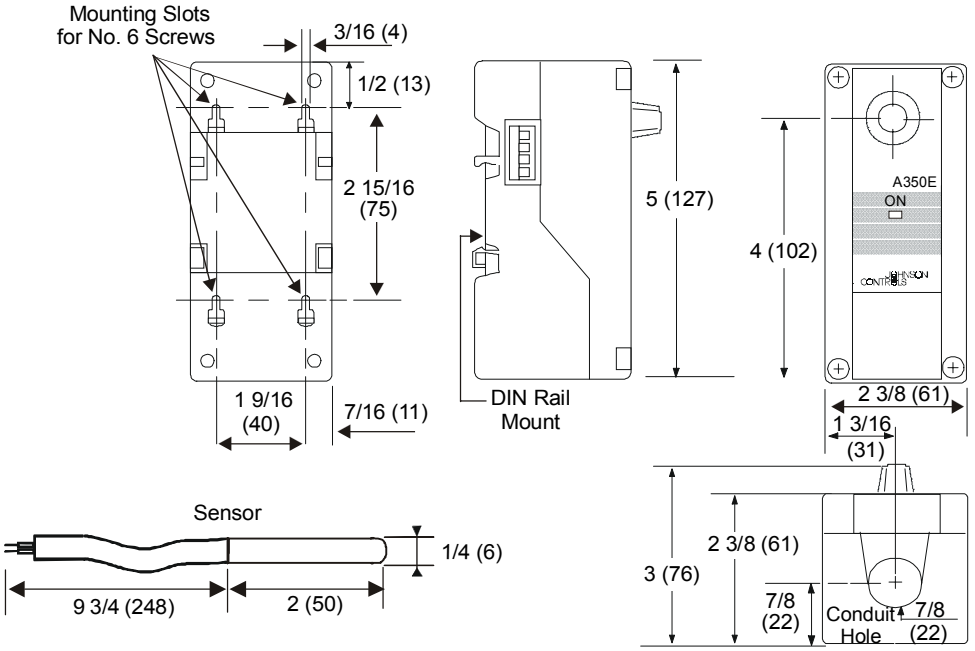

Figure 4: A350E and Sensor Dimensions, in. (mm)

Installation and Wiring

The A350E Cooling Control is housed in a compact NEMA 1 plastic enclosure designed for standard 35 mm DIN rail mounting. Four key-slot mounting holes on the back of the control case are provided if surface mounting is required. The A350E may be connected to a Y350R, as well as other control modules. Refer to Figures 5 and 6 for proper arrangement.

Note: When mounting any System 350 module to rigid conduit, attach the hub to the conduit before securing the hub to the control enclosure.

> WARNING: **Risk of Electrical Shock.** Disconnect power supply before making electrical connections to avoid possible electrical shock or equipment damage.

Note: For maximum electrical ratings of control, see the *Specifications* section or the label inside the control cover. Use adequate gauge copper conductors only.

Consult Figures 2, 5, and 6 for proper wiring configurations and terminal designations.

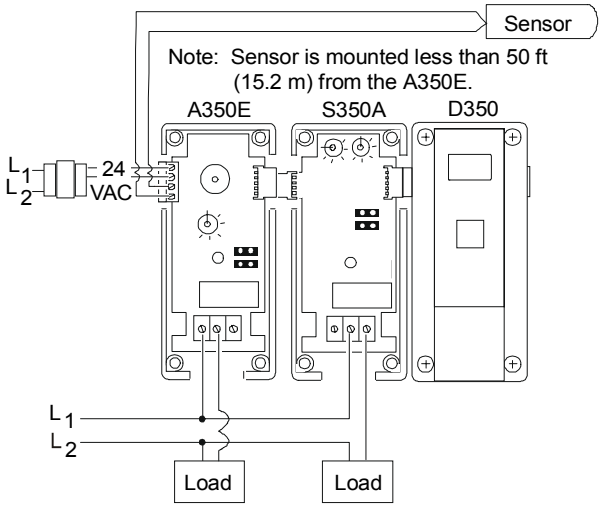

Figure 5: Typical Wiring Diagram for an A350E Powered by an External Class 2 Transformer

Sensor Connection

Shielded cable is not generally required for sensor wiring on runs of less than 50 ft (15.2 m), but is recommended for lengths greater than 50 ft (15.2 m). Connect the shield to the COM sensor terminal on the A350E. (See Figure 2 for terminal location.) Sensor A99BA-200, which includes a shielded cable, is available if needed.

Note: At the maximum cable lengths listed in Table 2, no more than 1F° (0.6C°) error in the sensed temperature will result due to wire resistance.

Table 2: Recommended Maximum Sensor Cable Lengths

Wire Gauge	Shielded Cable Length*	
	Feet	Meters
14 AWG	800	244
16 AWG	500	152
18 AWG	310	94
20 AWG	200	61
22 AWG	124	38

* Values provided are for 2-wire stranded cable.

- A variety of A99B Series Temperature Sensors and mounting hardware are available for use with the A350E. Connect the sensor to the SEN terminal and one of the COM terminals on the four position terminal strip located at the top left of the printed circuit board, as shown in Figure 6. The sensor is not polarity sensitive.
- The sensor must be mounted so that it can accurately sense the temperature of the controlled medium.

Table 3: Sensor Included With A350E Controls

Control	Sensor Included
A350EA-4C	A99BB-25C; Range -40 to 212°F (-40 to 100°C) Lead length is 9-3/4 in. (0.25 m).
A350EB-1C	No Sensor Included
A350EB-1D	No Sensor Included
A350EB-2C	No Sensor Included

- For more information regarding sensor options and installation, refer to the *A99B Series Temperature Sensors Product/Technical Bulletin (LIT-125186)*.

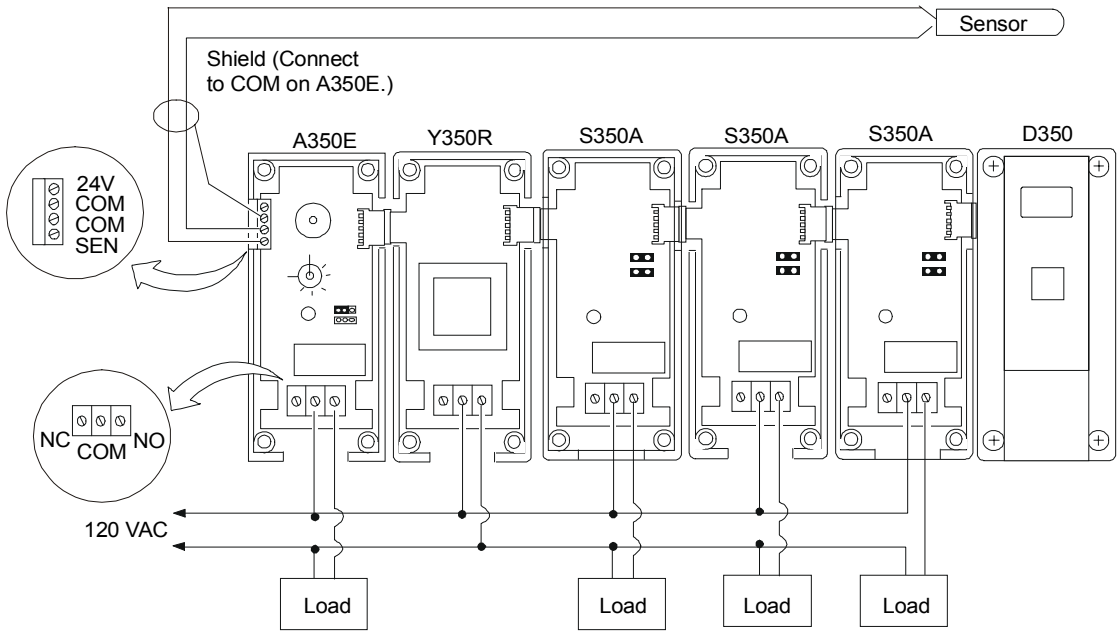

Figure 6: Typical Wiring Diagram for an A350E Powered by a Y350R Power Module

Adjustments

Follow this procedure to set up the A350E for the desired operation.

1. Remove the A350E's cover by loosening the four captive cover screws.
2. Adjust the differential potentiometer (DIFF) as desired (the number of degrees between relay energized and de-energized).

   Refer to Figure 7 for a sample multistage application. If a Celsius temperature reading is desired, place the included Celsius DIFF label over the Fahrenheit DIFF label (Punch out the tab in the center before affixing label to the board.)

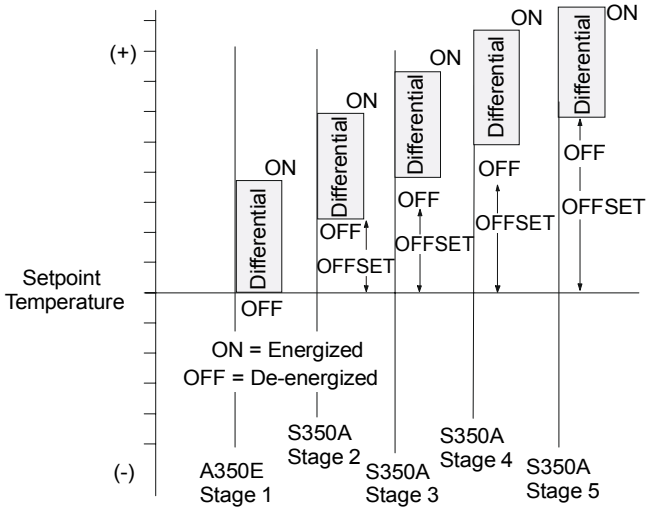

Figure 7: Typical Multistage Cooling Application

3. Replace the cover, fasten in place with the four captive screws, and move the setpoint dial to the desired setpoint.

Note: The A350E setpoint is factory calibrated at midscale to a tolerance of ± 1F° (0.6C°). The setpoint tolerance at the extreme ends of the setpoint range in relation to the printed scale plate can be ± 3F° (1.7C°). The D350 Display Module is unaffected by this tolerance shift. Use the D350 display for the most accurate setpoint selection.

Checkout Procedure

Follow this procedure to verify the A350E control is connected and functioning properly.

1. Make sure installation and wiring connections are according to job specifications before applying power. (Refer to Figure 7 for a sample multistage application if needed.)
2. Make the necessary adjustments and electrical connections.
3. Put the system in operation and observe at least three complete operating cycles before leaving the installation.

Troubleshooting

If the control system does not function properly, use the following procedures to determine the cause of the problem:

1. Check for proper voltage applied to the A350E.
   a. Connect a Digital Voltmeter (DVM) between the 24V (+) and COM (-) terminals located on the control's left side terminal block (Figure 2).
   - *If an external transformer is used*, select AC volts on the DVM and verify that the voltage is between 20 and 30 VAC.
   - *If a Y350R Power Module is used,* select DC volts on the DVM and verify that the voltage is between 16 and 38 VDC.

   b. If the DVM reading is within the indicated voltage range, proceed to Step 2.

   c. If the DVM reading is **not** within the indicated voltage range, correct the wiring, replace the Y350R, or replace the external transformer.
2. Check sensor for proper resistance at a given temperature. (The resistance across the sensor changes with the temperature of the sensor.)

   a. Disconnect power from the A350E control.

   b. Disconnect the sensor from the control and measure the resistance across sensor leads.

   c. When measuring the sensor's resistance, use an accurate thermometer to measure the temperature at the sensor.

   d. Refer to Figure 8 to determine the optimal resistance for the measured temperature.

   e. If the measured resistance varies substantially from the optimal resistance for that temperature, the sensor or wiring must be replaced.

f. If the sensor's resistance conforms to the chart in Figure 8, reconnect the sensor to the control.

g. Reconnect power to the control.

Note: Sensor reading indicated by the D350 may differ somewhat from thermometer readings due to sensor tolerances and time constants, thermometer accuracies, and other factors.

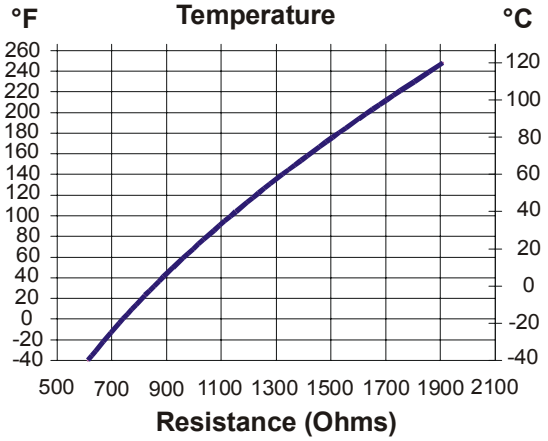

Figure 8: Temperature vs. Resistance Chart

3. Check the A350E for proper operation.

Note: Steps 1 and 2 must be performed first.

a. Set the minimum setpoint jumper to the Off position.

b. Set the DIFF range to 5F° (2.8C°).

c. Adjust the setpoint dial to at least 10°F (-12.2°C) above the sensor temperature (Ts) determined in Step 2 (relay and LED should be Off).

d. Slowly decrease the setpoint until the control relay and LED turn On, then slowly increase the setpoint until the relay and LED turn Off.

e. If the relay does **not** perform as indicated in Table 4, replace the A350E.

Table 4: A350E Relay Troubleshooting

LED	N.O. Relay Status	Setpoint Dial Setting
On	Closed	(T_S)* - Differential
Off	Open	(T_S)*

* (Ts) is sensed temperature.

For example:
70°F (Ts)
- 5F° (Differential)
65°F (Setpoint Dial Setting)

Repairs and Replacement

Field repairs or calibration must not be made. A99B Series sensors and replacement controls are available through the nearest Johnson Controls representative. See Tables 5 and 6 for ordering information.

Ordering Information

Table 5: System 350 Products

Item	Product Code Number	Description
A350E Cooling Controls (A350EA-4C Includes the A99BB-25C Temperature Sensor)	A350EA-4C and A350EA-1C	Range: 10 to 65°F (-12 to 18°C) Adjustable differential: 1 to 30F° (0.6 to 16.7C°)
	A350EA-2C	Range: 10 to 65°F (-12 to 18°C) Differential: 2.5°F (1.5°C) fixed For applications above 65°F (18°C), contact your Johnson Controls representative.
Digital Temperature Sensor/ Setpoint Display Modules	D350AA-1C D350BA-1C	Fahrenheit scale Celsius scale
On/Off Stage Modules	S350AA-1C S350AB-1C	Fahrenheit Scale Celsius Scale
Slave Stage Module	S350CC-1C	Dual Scale (°F and °C)
Proportional Stage Module	S350PQ-1C	Dual Scale (°F and °C)
Power Module	Y350R-1C	120 or 240 VAC, 50 or 60 Hz input; Rectified Class 2, 24 VAC output

Table 6: System 350 Accessories

Item	Product Code Number	Description
Outdoor Enclosure	BOX10A-600R	PVC enclosure; includes wire nuts
Wall Mount Plate	TE-6001-4	Includes sensor mounting clip
Cover	T-4000-2644	For wall mount plate
Conduit Adaptor	ADP11A-600R	1/2 in. snap-fit EMT conduit adaptor (box of 10)
Immersion Well	WEL11A-601R	For liquid sensing applications
DIN Rail Sections	BKT287-1R BKT287-2R	12 in.(0.3 m) long 39-1/3 in.(1.0 m) long
DIN Rail End Clamps	PLT344-1R	Two end clamps
Cable for remote mounting of D350 Display Modules	WHA29A-600R* WHA29A-603R WHA29A-604R	3 ft (0.9 m) 25 ft (7.6 m) 50 ft (15.2 m)

* WHA29A-600R can also be used to remote mount S350 Stage Modules.

Specifications

Product	A350E Electronic Cooling Control		
Supply Voltage	Y350R Power Module:	Input:	120/240 VAC 50/60 Hz
		Output:	24 VDC, unfiltered, 10 VA, Class 2
	External Source:		24 VAC, 50/60 Hz Class 2 (20-30 VAC)
	Note: Only one supply voltage source may be used.		
Power Consumption	1.4 VA		
Adjustment Setpoint Range	10 to 65°F (-12 to 18°C)		
Differential Adjustment Range	1 to 30F° (0.6 to 16.7C°)		
SPDT Relay Output		**120V**	**208 to 240V**
	Horsepower:	1/2	1/2
	Full Load:	9.8A	4.9A
	Locked Rotor:	58.8A	29.4A
	Non-Inductive:	10A at 24 to 240 VAC	
	Pilot Duty:	125 VA at 24 to 240 VAC	
Ambient Temperatures	Operating: -30 to 150°F (-34 to 66°C)		
	Shipping: -40 to 185°F (-40 to 85°C)		
Humidity	0 to 95% RH non-condensing; maximum dew point: 85°F (29°C)		
Sensor	Replaceable positive temperature coefficient sensor		
	Reference resistance: 1035 ohms at 77°F (25°C)		
Material	Case and cover: NEMA 1, high-impact thermoplastic		
Minimum Setpoint	Four jumper-selectable settings: 20°F (-7°C), 30°F (-1°C), 40°F (4°C), and Off		
Short Circuit Detection	De-energizes the relay if the sensor shorts or opens		
Agency Listings	UL Listed, CCN XAPX, File E27734		
	UL Listed for Canada, CCN XAPX7, File E27734		

The performance specifications are nominal and conform to acceptable industry standards. For application at conditions beyond these specifications, consult Johnson Controls Application Engineering at (414) 274-5535. Johnson Controls, Inc. shall not be liable for damages resulting from misapplication or misuse of its products.

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