Wireless Temperature Sensing System

The Wireless Temperature Sensing System consists of three discrete types of components: (multiple) temperature transmitters, a single receiver, and a single communication board. Together, the system monitors temperature at multiple points within a facility and transmits intermittent digital temperature messages to a Johnson Controls/PENN refrigeration or convenience store system controller at predefined intervals. The system and uses a 900 MHz spread-spectrum, frequency-hopping, radio frequency communications

By positioning temperature transmitters in a facility's refrigerated (or heated) equipment and conditioned spaces, the Wireless Temperature Sensing System can monitor and transmit the sensed temperature at up to 255 unique points in a facility to the system controller.

The Wireless Temperature Sensing System allows fast, economical, and low-maintenance installation; provides great versatility when re-positioning refrigerated equipment; and facilitates remote temperature monitoring of self-contained and portable equipment.

Figure 1: Wireless Sensing System

Features and Benefits

❑ **Small, Lightweight Transmitters and Sensors with Wire Leads**	Installs easily and quickly, reducing time and cost over hardwire installations – especially in retrofit applications
❑ **Frequency-hopping, 900 MHz, Spread-spectrum Radio Frequency Technology**	Provides proven performance, with over a decade of use in commercial and industrial wireless applications
❑ **Temperature Monitoring of Portable Equipment**	Allows centralized, local, or remote temperature monitoring of portable refrigerated equipment in a facility
❑ **Competitive with Installed Cost of Hardwired Sensors**	Provides an alternative to hardwired sensor systems with reliable, state-of-the-art technology at a reasonable cost

Operation and Application Overview

IMPORTANT:	The Wireless Temperature Sensing System is intended to provide an input to equipment under normal operating conditions. Where failure or malfunction of the Wireless Temperature Sensing System could lead to an abnormal operating condition that could cause personal injury or damage to the equipment or other property, other devices (limit or safety controls) or systems (alarm or supervisory) intended to warn of, or protect against, failure or malfunction of the Wireless Temperature Sensing System must be incorporated into and maintained as part of the control system.

FCC Compliance Statement

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 that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class A digital device pursuant to Part 15 of FCC Rules. These limits are designed to provide reasonable protection against harmful interference when this 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 or her own expense.

System Operation

The Wireless Temperature Sensing System (WTSS) was developed to work in conjunction with Johnson Controls/PENN refrigeration system controllers and convenience store system controllers to monitor temperature at a variety of refrigerated (or heated) pieces of equipment or conditioned spaces within a facility.

A basic WTSS consists of three types of components: (multiple) temperature transmitters, a receiver, and a communications board. An optional high-powered repeater is also available to amplify and re-send transmitter messages in applications where the standard transmitter signal is not strong enough to reach the receiver.

The temperature transmitter consists of a small, stainless-steel-clad, thermistor-type, temperature sensor with a two wire cable and a small, lightweight, battery-powered transmitter, which may be easily mounted at the monitored equipment or space with screws or double-sided tape. Up to 256 transmitters may be used in a facility.

The sensor responds to temperature changes by changing resistance. The transmitter checks the sensor resistance at short (sampling) intervals and interprets the resistance changes, then issues intermittent temperature messages using 900 MHz spread-spectrum, frequency-hopping, radio frequency communications.

Along with temperature information, the transmitted messages also include unique transmitter identifier (ID) codes. Each unique message is sent multiple times in very rapid succession on different radio frequencies. These quick bursts of redundant messages are issued by each transmitter in the facility at predefined transmission (time) intervals.

In addition to regular transmission intervals, the transmitter may be set to issue a temperature-change (Delta T) message that is triggered when a pre-determined temperature change is detected at the sensor. See *Transmitter Settings*.

The receiver scans for and gathers the messages from all of the specified transmitters in the facility. The receiver then filters out incomplete, redundant, or bad messages and interference, identifies the unique temperature messages, converts them to RS-232 serial data protocol, and passes them along (via a hardwire connection) to the communication board.

The communication board converts the serial data stream of messages into RS-485 digital protocol that can be understood by the refrigeration or convenience store controller, and then routes the digital messages on to the controller (and the specified input addresses) via a two wire network connection. See Figure 9.

The controller monitors temperature changes at the various pieces of equipment and conditioned spaces, and may be programmed to initiate responses to temperature changes, such as turning a compressor on or off, or issuing a high or low temperature alarm.

Applying a Wireless System

The WTSS is a custom-built system.
Johnson Controls/PENN provides a transmitter and sensor for each transmission point required by the specified application, as well as a single receiver and a single communication board.

Each refrigeration or convenience store controller uses one (and only one) communication board and receiver. Each receiver can monitor up to 255 transmitters.

Note: At sites with more than one controller, the total number of transmitters at the site cannot exceed 255.

Each transmitter is shipped with a temperature sensor that has an 8 ft (2.4m) two wire lead. The sensor lead may be lengthened to 40 ft (12m) using Belden 9408 cable (or an equivalent 20 AWG stranded two wire, twisted-pair cable).

Johnson Control/PENN programs the transmitters at the factory to the required transmission characteristics (for each piece of equipment in the specified application), including:

- a unique transmitter ID code number
- controller ID number
- the site ID number
- the temperature sampling time interval
- the transmission time interval based on the application requirements
- the change in temperature (Delta T, **ΔT**) required to generate a temperature message between regular transmission time intervals

These programmed settings are recorded on the label on the back of the transmitter. For more information, see *Transmitter Settings* and Figure 3.

Some communication board settings are established when the system is commissioned in the field. See *Commissioning Communication Boards.*

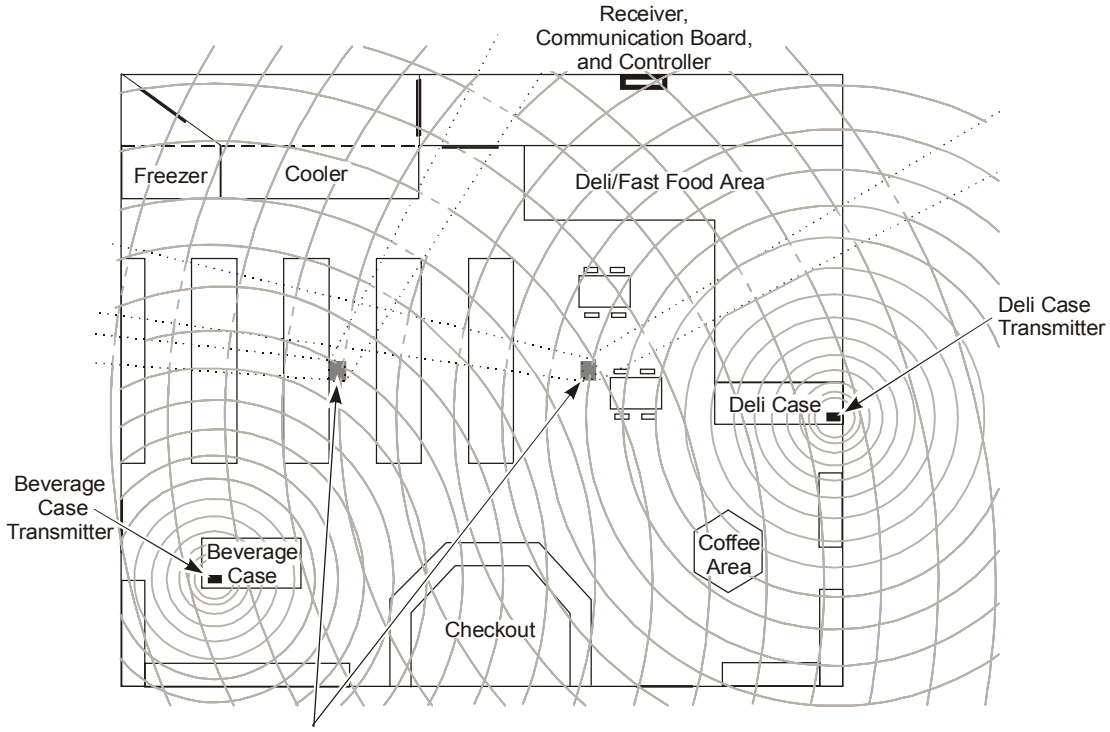

Figure 2: Illustration of Wireless Temperature Transmission in a Convenience Store

Transmitter Settings

The following transmitter settings are determined by the specified application requirements, and are programmed by Johnson Controls/PENN at the factory according to those requirements.

Transmitter ID code identifies the transmitter and message, so that messages may be routed to the proper input address on the refrigeration controller.

Site and Controller ID numbers identify the specific site location and the controller that the transmitter is sending messages to.

Sampling Interval is the amount of time between subsequent checks (by the transmitter) of the temperature (thermistor resistance) at the sensor, and may be set at 10 seconds, 30 seconds, 1 minute, or at the transmission interval.

Transmission Interval is the amount of time between regular temperature message transmissions. A 5-minute transmission interval is recommended for most applications. The transmission interval affects battery life. See the *Battery Life* section.

Delta T Transmission Value (ΔT) is the change in temperature (detected during sampling) that triggers an immediate transmission regardless of the programmed transmission interval. The ΔT transmission allows the WTSS system to notify the controller if a significant temperature change is detected between regular time interval transmissions.

The ΔT parameter is based on the percentage of change in thermistor resistance, relative to the resistance detected at the previous regular (interval) transmission. Each transmitter may be factory set to issue no ΔT transmissions, or to initiate ΔT transmissions at one of three different settings (based on percent change of thermistor resistance). See Table 1 to determine the best ΔT setting for each transmitter in the specified application.

Table 1: Determining the ΔT Transmission Temperature Value

ΔT Setting (% of sensor resistance that initiates a ΔT transmission)	**Resulting Temperature Change (at Sensor) That Initiates a ΔT Transmission** (Approximate °F change over typical operating range of -20 to 100°F)
No Percent Set	No ΔT Transmissions Initiated
3.1%	1.5 to 2.5 F° (≈ 2 F°)
6.25%	3 to 5.5 F° (≈ 4 F°)
12.5%	6.5 to 11 F° (≈ 8 F°)

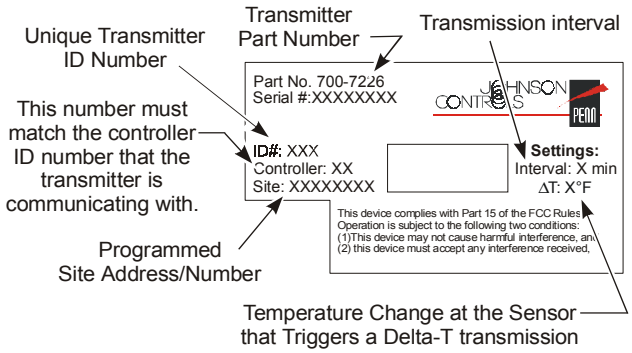

Figure 3: Sample Transmitter Label

Battery Life

The 3 VDC lithium (2/3 A size) battery that powers the transmitter must be replaced periodically. Battery life is primarily dependent on the transmission interval, although ambient temperatures below 60°F (16°C) shortens battery life.

Typical battery life is 2-1/2 to 3 years when the transmission interval is 5 minutes. See Table 2.

Table 2: Transmitter Battery Life

Transmission Interval	**Estimated Battery Life**
60 minutes	7 to 8 years
30 minutes	6 to 8 years
15 minutes	4-1/2 to 8 years
5 minutes	2-1/2 to 3 years
60 seconds	8 months
30 seconds	4 months
10 seconds	42 days
5 seconds	21 days

Low Battery Notification

The transmitter battery is checked (by the transmitter) every 18 hours. When a low-battery condition is detected, a low-battery message is included with each (subsequent) transmission. Johnson Controls/PENN refrigeration system and convenience store controllers interpret and display this low battery message as a shorted-sensor condition.

Note: Press the reset button after replacing the transmitter battery to restart transmissions.

Mounting the Wireless System

Transmitter Location Considerations

Refer to Figure 2 and the guidelines below when positioning the transmitters and sensors.

- Locate the transmitter so that it is easily accessible to facilitate battery replacement and resetting the transmitter.
- To minimize interference, mount the transmitter as high as possible and in “line of sight” with the receiver. Make sure no solid metal, concrete, or stone objects block the signal path to the receiver. See Figure 2.
- Mount the transmitter outside of the controlled space if the space temperature is below 60°F (16°C). (Cold temperatures shorten battery life.)
- Locate the temperature sensor within 40 ft (12.0m) of the transmitter.
- Place the temperature sensor in a location that accurately represents the temperature in the controlled space.
- Do not mount transmitters in areas exposed to condensation.

Mounting the Bracket and Transmitter

The mounting bracket can be mounted using the double-sided tape or the mounting screws and anchors provided. (Mounting with screws is recommended.)

To mount the bracket using screws and anchors:

1. Mark the holes using the mounting bracket as a template.
2. Drill two 5/32 in. mounting holes.
3. Insert the anchors into the mounting holes.
4. Place the bracket over the mounting holes with the smooth side to the mounting surface, and tighten the screws

To mount the bracket using the double sided tape:

1. Clean and dry the mounting surface and the bracket.
2. Peel and stick one side of the tape to the smooth surface of the mounting bracket.
3. Peel and stick the mounting bracket to the desired mounting surface.

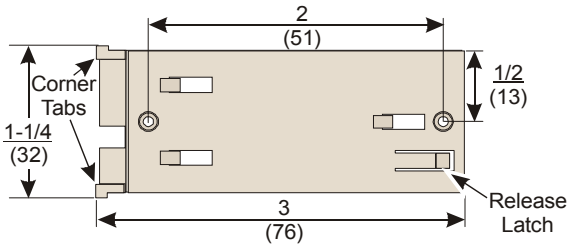

Figure 4: Transmitter Mounting Bracket, in. (mm)

After attaching the mounting bracket:

1. Place the transmitter over the mounting bracket and slide toward corner tabs to lock.
2. Mount the sensor in the normal location, using the same criteria as with a hardwired sensor.
3. Pull the sensor wire to the transmitter. Use Belden 9408 (or equivalent 20 AWG stranded, two wire cable) to extend the 8 ft (2.4m) sensor leads up to 40 ft (12.0m).
4. Remove the transmitter cover by inserting a small screwdriver in the slot between the cover and base on the side of the case.
5. Connect the sensor wires to the sensor wiring terminal block shown in Figure 5. (Sensor wiring is not polarity sensitive.)

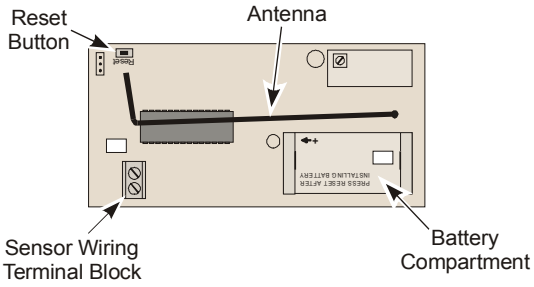

Figure 5: Transmitter Circuit Board

6. Install the battery in the battery compartment. Note the battery polarity indicated in the transmitter battery compartment.
7. Press the reset button to start transmitting and replace the transmitter cover.

To remove the transmitter, open the cover, take the battery out and depress the release latch while sliding the housing off the mounting plate.

Receiver Location Considerations

- Mount the receiver for easy access and removal of side cover screws.
- Mount the receiver within 100 ft (30m) of the communication board.
- Mount the receiver within 200 ft (60m) of the farthest transmitter.

Mounting the Receiver

To mount the receiver:

1. Attach the two antennas to the receiver by carefully screwing them to the top of the receiver.
2. Remove the receiver cover by loosening the two Phillips head screws on either side of the receiver box and lifting the cover plate.
3. Mark mounting holes, using the receiver backplate as a template.
4. Drill two 5/32 in. mounting holes.
5. Insert the wall anchors into the mounting holes.
6. Mount the receiver backplate and circuit board.
7. Replace the cover plate and tighten the two Phillips-head screws on the side of the box.

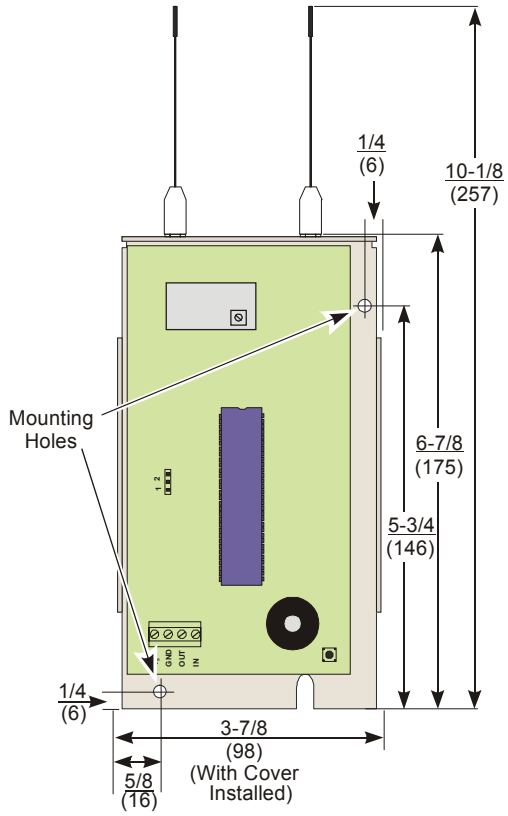

Figure 6: WTSS Receiver Dimensions, in. (mm)

Communication Board Location Considerations

- Mount the communication board for easy access and removal of cover.
- Mount the communication board within 100 ft (30m) of the receiver.
- Mount and wire the communication board in series with the other devices in the controller's RS-485 network connection. The total network cable length (between devices at either end of the RS-485 network) must not exceed 1000 ft. (305m). See Figure 9.

Mounting the Communication Board

To mount the board:

1. Mark mounting holes, using the holes in the top and bottom tabs on the receiver backplate as a template.
2. Drill two mounting holes.
3. Insert wall anchors, if needed.
4. Mount the communications board.

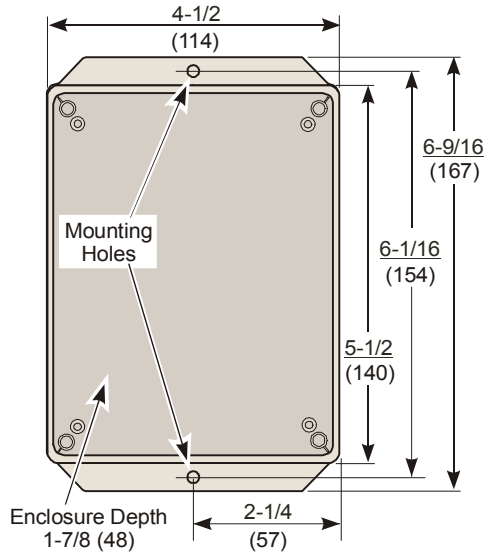

Figure 7: WTSS Communications Board Dimensions, in. (mm)

Wiring

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

> **IMPORTANT:** Make all wiring connections in accordance with the National Electrical Code and all local regulations. Use copper conductors only. Do not exceed the devices' electrical ratings.

The receiver is hardwired to the communication board with a three wire connection. The communication board is hardwired to the controller and other network devices with a two wire shielded cable.

Observe the following guidelines, and refer to Figures 8 and 9 when wiring the WTSS.

- Belden 9451 (or equivalent 22 AWG, stranded, two wire, twisted-pair, shielded cable) is recommended for RS-485 network communication wiring. The total network cable length (between the network devices at either end of the RS-485 network) must not exceed 1000 ft (305m). See Figure 9.
- The RS-485 network connections between the communications board, all input and output boards and the controller are polarity specific. Make sure to maintain proper polarity between each device. Refer to Figures 8 and 9.

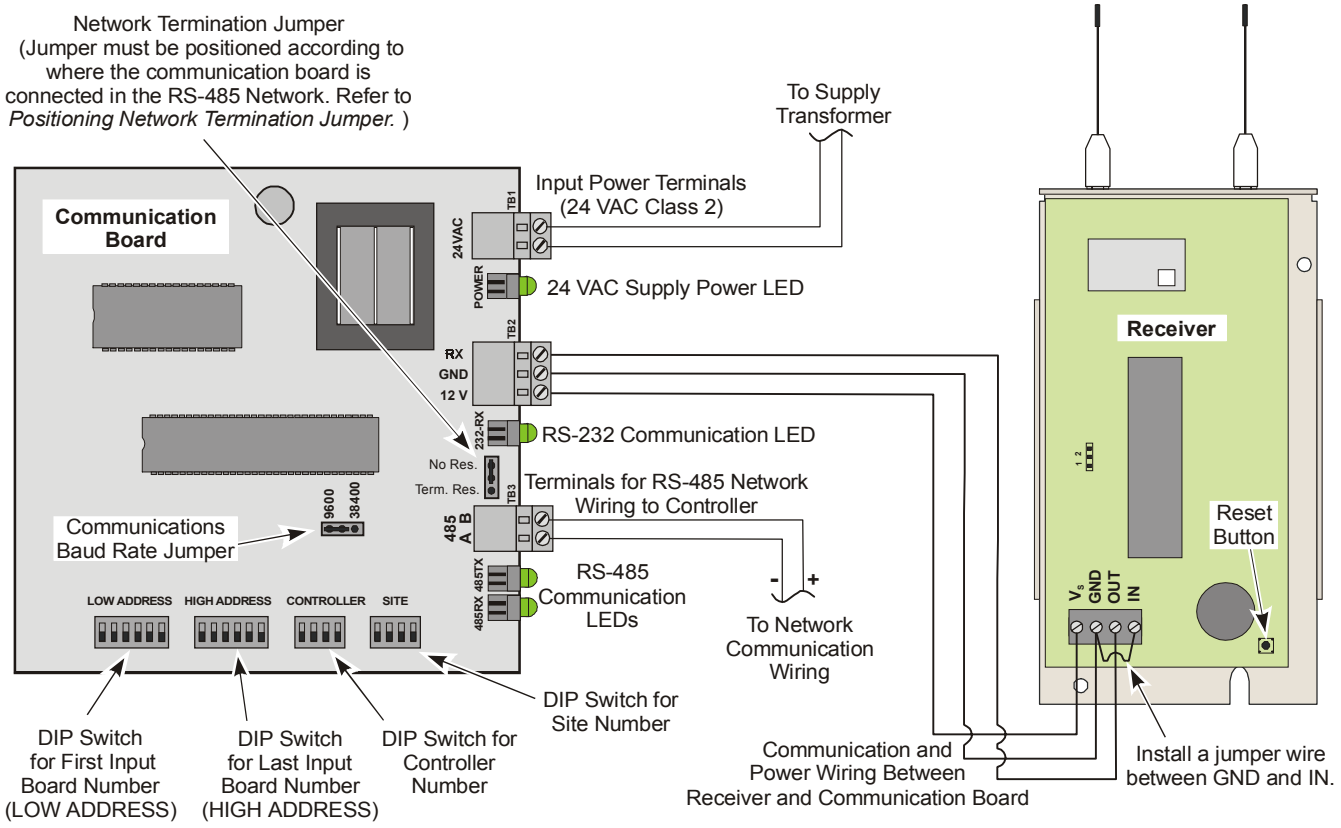

Figure 8: Wiring the Communication Board to the Receiver

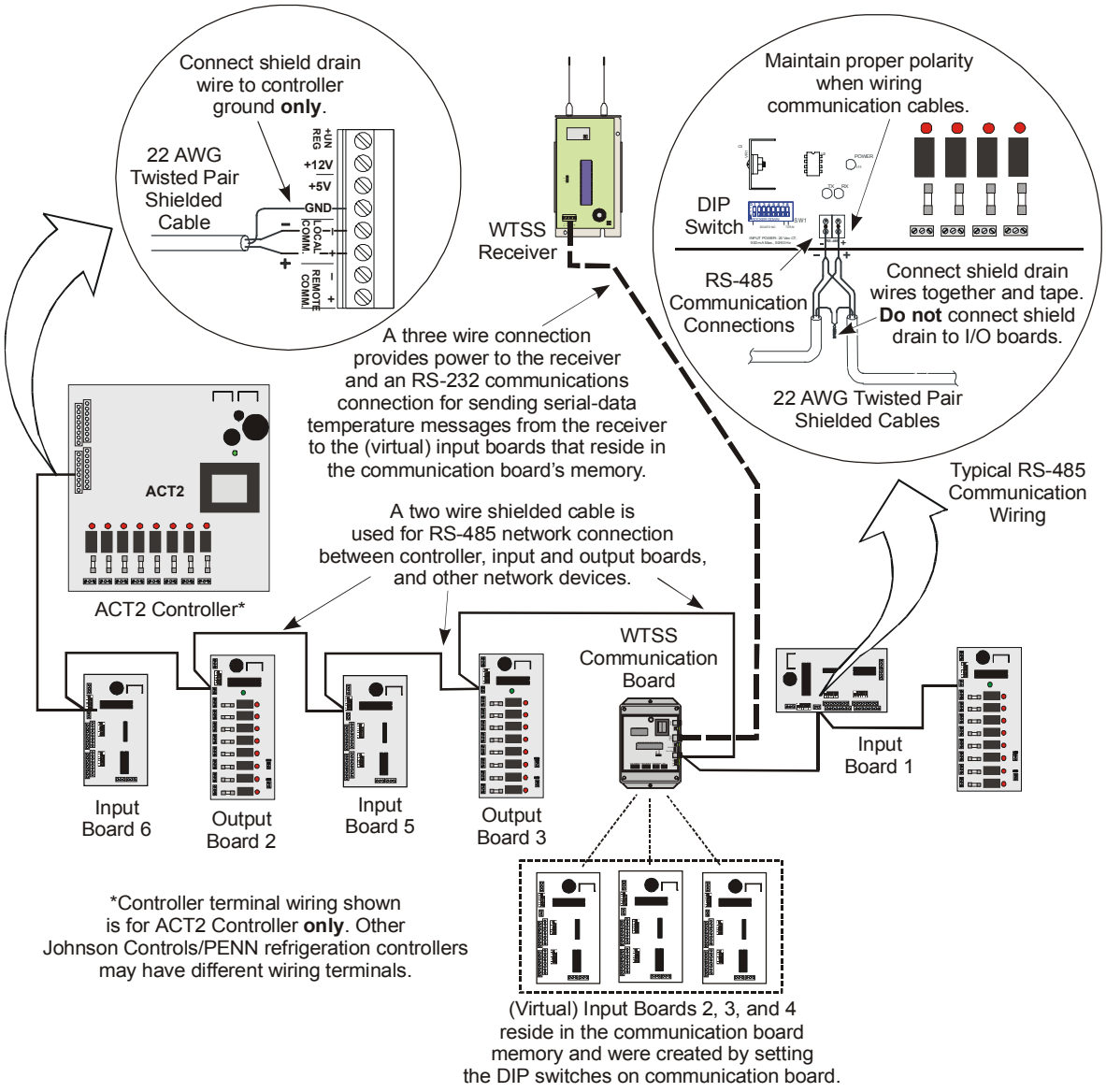

Figure 9: Wiring the WTSS Communication Board into an ACT2* Refrigeration System Controller

Commissioning the Wireless System

Once the WTSS is mounted, wired, and connected to power, the system must be setup to communicate with the controller.

Commissioning Transmitters

All transmitters are shipped completely programmed by Johnson Controls/PENN according to the specified application requirements. Insert the battery and press the reset button on the lower right of the transmitter circuit board to start transmissions. See Figure 5 and the *Applying a Wireless System* and *Transmitter Settings* sections.

Commissioning Receivers

Receivers are also shipped completely programmed for the specified application and require no additional adjustments. After the communication board and receiver are wired and powered, push the reset button on the lower right corner of the receiver circuit board to start receiving transmissions and initiate RS-232 communications between the receiver and the communication board.

Commissioning Communication Boards

Before putting the WTSS into operation, the following settings must be established (on the communication board) by positioning two jumpers and setting three DIP switches. See Figure 8.

- the communication baud rate
- the communication board's position in the communication network
- the transmitter input addresses
- the controller ID number

Positioning Baud Rate Jumper

Communications baud rate is selected by positioning a jumper on the three pin Baud Rate terminal located just above the DIP switches. Most refrigeration system applications require a 9600 baud rate. See Figure 8.

Positioning Network Termination Jumper

If there are no input or output boards following the communication board in the refrigeration system's RS-485 communication network, the network termination jumper must be installed in the **TERM. RES.** position on the bottom two pins on the terminal block. If any inputs or output boards follow the communication board in the network (as illustrated in Figure 9), install the jumper in the **NO RES.** position on the top two pins on the terminal block. See Figure 8.

Establishing Transmitter Input Addresses and Controller and Site ID Numbers

All of the WTSS transmitters must be assigned an input address to communicate with the refrigeration system controller. **Input addresses consist of an input board number and an input point number**.

The input board numbers are established using the LOW ADDRESS and HIGH ADDRESS DIP switches on the bottom of the communication board. Refer to Figure 8. Once the board numbers are established, the communication board automatically assigns the input point numbers based on the transmitters' pre-programmed ID numbers.

On a **typical refrigeration controller input board**, the input board number is established by setting a DIP switch on the board. The input point number is established by where the input device is wired to the input board. Input boards have 16 sets of input terminals and the input points are numbered 1 through 16 on each board.

On the **WTSS communication board**, the input addresses are established by creating **virtual input boards** in the communication board's memory. Each virtual input board may accommodate up to 16 input points.

The virtual board addresses may be assigned any number between 1 and 32 that is not already assigned to a standard external input board. If there is more than one virtual input board, the virtual board must be numbered sequentially (i.e., 2, 3, 4, or 6, 7, 8, 9, etc.). To establish the virtual input board numbers, refer to Table 3 and set the LOW ADDRESS DIP switch and HIGH ADDRESS DIP switch.

Once the virtual input boards are established at the DIP switches, the communication board automatically assigns an input address (input board number and input point number) based on the unique transmitter ID number that is pre-programmed for each transmitter. The pre-programmed transmitter ID numbers are in numerical sequence and the communication board assigns transmitter addresses according to that sequence.

For example, on the refrigeration control system illustrated in Figure 9, three standard (external) input boards and 35 WTSS transmitters are used. Three virtual input boards must be created in the communication board memory to accommodate the 35 transmitters.

Since the standard input boards are assigned numbers 1, 5 and 6, the LOW ADDRESS DIP switch is set to 2 and the HIGH ADDRESS DIP switch is set to 4, creating Virtual Input Boards 2, 3, and 4.

- Virtual Input Board 2 automatically assigns point addresses for, and accommodates the first 16 transmitters according to the transmitter ID sequence at Virtual Input Board 2, Points 1-16.
- Virtual Input Board 3 assigns point addresses and accommodates Transmitters 17 through 32 at Virtual Input Board 3, Points 1-16.
- Virtual Input Board 4 assigns point addresses and accommodates the remaining three Transmitters 33 through 35 at the first three input point positions at Virtual Input Board 4, Points 1-3.

The site ID number and the controller ID number must also be set. These ID numbers are established at the CONTROLLER DIP switch and the SITE DIP switch. See Figure 8 for DIP switch locations. Refer to Table 3, Figure 10, and *Setting the DIP Switches.* Use the first four switch positions to set the controller ID and SITE number.

Table 3: Addresses Created by DIP Switch Settings

Address Number	Switch Position					
	Switch 1	Switch 2	Switch 3	Switch 4	Switch 5	Switch 6
1	On	Off	Off	Off	Off	Off
2	Off	On	Off	Off	Off	Off
3	On	On	Off	Off	Off	Off
4	Off	Off	On	Off	Off	Off
5	On	Off	On	Off	Off	Off
6	Off	On	On	Off	Off	Off
7	On	On	On	Off	Off	Off
8	Off	Off	Off	On	Off	Off
9	On	Off	Off	On	Off	Off
10	Off	On	Off	On	Off	Off
11	On	On	Off	On	Off	Off
12	Off	Off	On	On	Off	Off
13	On	Off	On	On	Off	Off
14	Off	On	On	On	Off	Off
15	On	On	On	On	Off	Off
16	Off	Off	Off	Off	On	Off
17	On	Off	Off	Off	On	Off
18	Off	On	Off	Off	On	Off
19	On	On	Off	Off	On	Off
20	Off	Off	On	Off	On	Off
21	On	Off	On	Off	On	Off
22	Off	On	On	Off	On	Off
23	On	On	On	Off	On	Off
24	Off	Off	Off	On	On	Off
25	On	Off	Off	On	On	Off
26	Off	On	Off	On	On	Off
27	On	On	Off	On	On	Off
28	Off	Off	On	On	On	Off
29	On	Off	On	On	On	Off
30	Off	On	On	On	On	Off
31	On	On	On	On	On	Off
32	Off	Off	Off	Off	Off	On

Setting the DIP Switches

Use Table 3 to set the LOW ADDRESS and HIGH ADDRESS DIP switches, as well as the SITE and CONTROLLER DIP switches. Refer to Figure 10.

To determine how many virtual input board are needed, divide the total number of transmitters in the application by 16, and round up to the next integer.

If 16 or fewer transmitters are used, set the LOW ADDRESS and HIGH ADDRESS to the same number. The virtual input board address numbers must not be used by any other input board in the system, and if there are two or more virtual boards, they must be numbered sequentially.

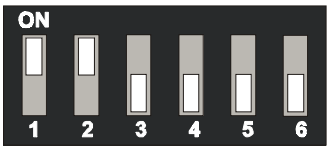

Figure 10: Address DIP Switch

When an individual switch (on the DIP switch block) is in the up position, that switch is On; in the down position, it is Off.

Troubleshooting

Table 4: Troubleshooting

Symptom	Possible Problem	Solution
Sensor Open error displayed at controller.	1. Transmitter out of receiver range. 2. No battery installed in transmitter. 3. Battery completely dead. 4. Sensor or sensor wire open.	1. Relocate the transmitter or receiver. 2. Install or replace battery. 3. Install or replace battery. 4. Replace sensor or repair sensor wire.
Sensor Short error displayed at controller.	1. Sensor or sensor wire short circuit. 2. Low transmitter battery conditon.	1. Replace sensor or repair sensor wire. 2. Replace the battery.
Tx or Rx lights at controller and/or communication board are not blinking.	RS-485 network communication has been lost.	Check communication network wiring and polarity.

Ordering Information

The Wireless Temperature Sensing System is a custom-built component system. Contact Johnson Controls/PENN Refrigeration Systems at (770) 427-9808 to obtain an Ordering Worksheet, which assists in determining what components and settings are required for your application. Refer to the Product Codes Numbers in Table 5 when ordering components for a WTSS.

Table 5: Ordering Information

Product Code Number	Description
800-7226	Transmitter with Temperature Sensor
700-7403	Receiver
700-7710	Communication Board
700-7226	Replacement Transmitter (no sensor)
700-6300	Temperature Sensor with 8 ft (2.4m) Leads

Specifications

Product	Wireless Temperature Sensing System	
Power Requirements	Transmitter:	3.0V lithium 2/3 A size (e.g., Duracell DL123A)
	Receiver:	12 VDC power provided by communication board
	Communication Board:	12 VDC 500 mA
Enclosure	Transmitter:	NEMA 1 Plastic
	Receiver:	NEMA 1 Metal
	Communication Board:	NEMA 1 Plastic
Ambient Operating Conditions	Transmitter:	-13 to 140°F; (-25 to 60°C) 95% RH, non-condensing
	Receiver:	32 to 140°F; (0 to 60°C) 95% RH, non-condensing
	Communication Board:	32 to 140°F; (0 to 60°C) 95% RH, non-condensing
Ambient Storage Conditions	-20 to 140°F; (-29 to 60°C) 95% RH, non-condensing	
Dimensions (H x W x D)	Transmitter:	3-1/2 x 1-3/4 x 15/16 in. (89 x 44 x 23 mm)
	Receiver:	10-3/8 x 3-7/8 x 1-1/4 in. (264 x 98 x 30 mm)
	Communication Board:	4-1/2 x 6-1/2 x 1-7/8 in. (114 x 167 x 48 mm)
Agency Listings	FCC/DOC Part 15	
Shipping Weight	Transmitter:	3 oz (84g)
	Receiver:	10.9 oz (308g)
	Communication Board and Transformer:	13.6 oz (386g)

The performance specifications are nominal and conform to acceptable industry standards. For application at conditions beyond these specifications, contact Johnson Controls/PENN Refrigeration Systems Application Engineering at (770) 427-9808. Johnson Controls, Inc. shall not be liable for damages resulting from misapplication or misuse of its products.

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