CEG and TMR Technical Bulletin

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Contents

Introduction

This document describes technical details of the Connected Equipment Gateway (CEG) and its use with the Transparent MS/TP Router (TMR) Series Wireless System and the BACnet® MS/TP controllers that the CEG manages.

Use this document for additional information about how to install, commission, maintain, and troubleshoot the CEG and the TMR Wireless System. Also included is a brief technical background on the wireless technology that the system uses.

Table 1: CEG and TMR related documentation

For information about	Document title and number
Locating, mounting, and wiring the TMR	*TMR Series Wireless Router Installation Guide (Part No. 24-11461-00020)*
Locating, mounting, and wiring the CEG	*CEG Installation Guide (Part No. 24-11460-00034)*
Locating, mounting, and wiring the CEG Panel	*CEG Panel Installation Guide (Part No. 24-11460-00050)*
The local user interface for the CEG	*CEG and TMR User Guide (LIT-12013890)*
Detailed information about the CEG and TMR	*CEG and TMR Technical Bulletin (LIT-12013900)*
Correctly applying wireless	*TMR Wireless Best Practices (LIT-12013954)*
Detailed information about cybersecurity practices	*Smart Connected Chillers Hardening Requirements (Part No. GPS0030-CE-20220429-EN)*

Table 2: Related wireless documentation

For information about	Document title and number
Testing the wireless signal strength between the TMRs	*ZFR-HPSST-0 High Power Wireless Sensing System Installation Guide (Part No. 24-11461-00012)*
Understanding MS/TP communications	*MS/TP Communications Bus Technical Bulletin (LIT-12011034)*
Installation and setup of the SC-EQUIP (SC-EQ)	*SC-EQ COMMUNICATION CARD 035-25087-000, Form 450.50-N1 (1220)*

Applications

You can use the following methods to stream chiller data through the CEG to the Connected Equipment Portal (CEP):

- Wireless by adding the TMR wireless router to the chiller's BACnet MS/TP port
- Directly, or wired, by connecting to the same BACnet MS/TP trunk as the chiller

Note: The CEG supports BACnet MS/TP devices at BACnet protocol revision 4 or later. However, for optimal network performance, use devices at BACnet protocol revision 15 or later.

CEG and TMR System overview

The CEG uses BACnet MS/TP open protocol to monitor chiller operation. The gateway can communicate either through hardwired RS-485 or wirelessly, using mesh network technology with self-healing capabilities. The CEG then aggregates, packages, and transmits the data to the Johnson

Controls® cloud over an encrypted, secure connection where the data is run through several rules to present chiller performance and health indices on the CEP web UI.

The CEG follows the same guidance for MS/TP rules as other Johnson Controls devices, including a limitation of number of devices on a Field Controller (FC) bus when third-party devices are present. Refer to the *MS/TP Communication Bus Technical Bulletin (LIT-12011034)* for the most up-to-date guidance. In addition to MS/TP rules, the CEG can support up to eight chillers hardwired, and four chillers wirelessly for each TMR coordinator connected to the CEG. You can add an additional TMR coordinator to the CEG to support up to eight wireless chillers.

The TMR enables a wireless connection between the CEG and BACnet compatible devices. The router is called transparent because it does not require any code changes on the BACnet compatible device. The router acts as a wired BACnet MS/TP to wireless BACnet mesh converter.

The TMR Wireless Field Bus System uses a low-power 802.15.4 mesh technology to wirelessly connect HVAC equipment that uses the BACnet MS/TP protocol. The system creates a wireless mesh network that automatically updates transmission paths for the data.

The supervisory and equipment controllers equipped with the TMR require no special configuration to operate in the system. You can connect segments of wired and wireless BACnet MS/TP controllers to form a single MS/TP bus.

Important: The wireless networks (PANs) formed by the TMR, ZFR183x, ZFR182x, and ZFR181x systems are not compatible with each other and cannot be mixed on the same wireless network.

Figure 1: SC-EQ and CEG wired connected system overview

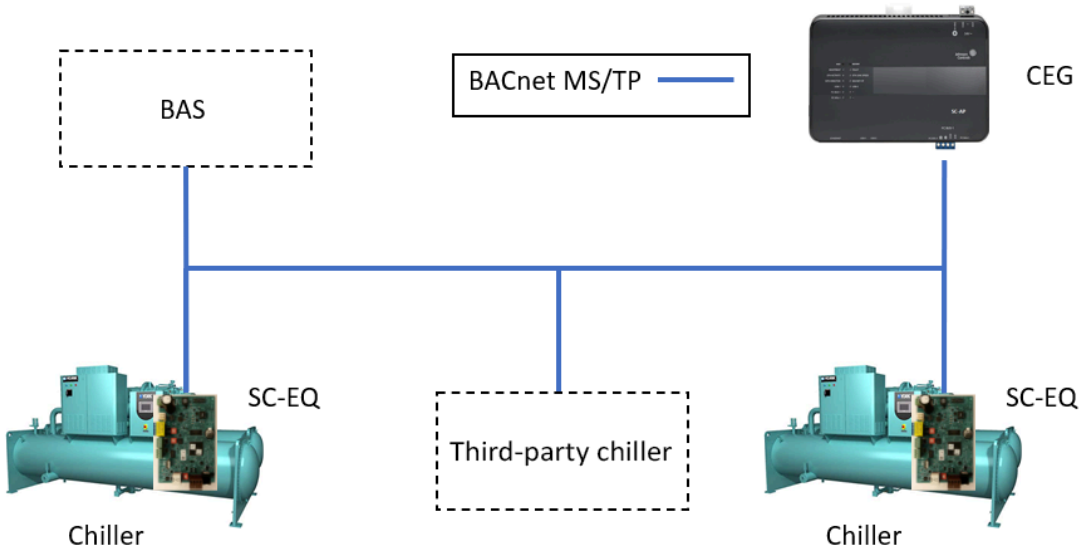


Figure 2: TMR and CEG wireless connected system overview

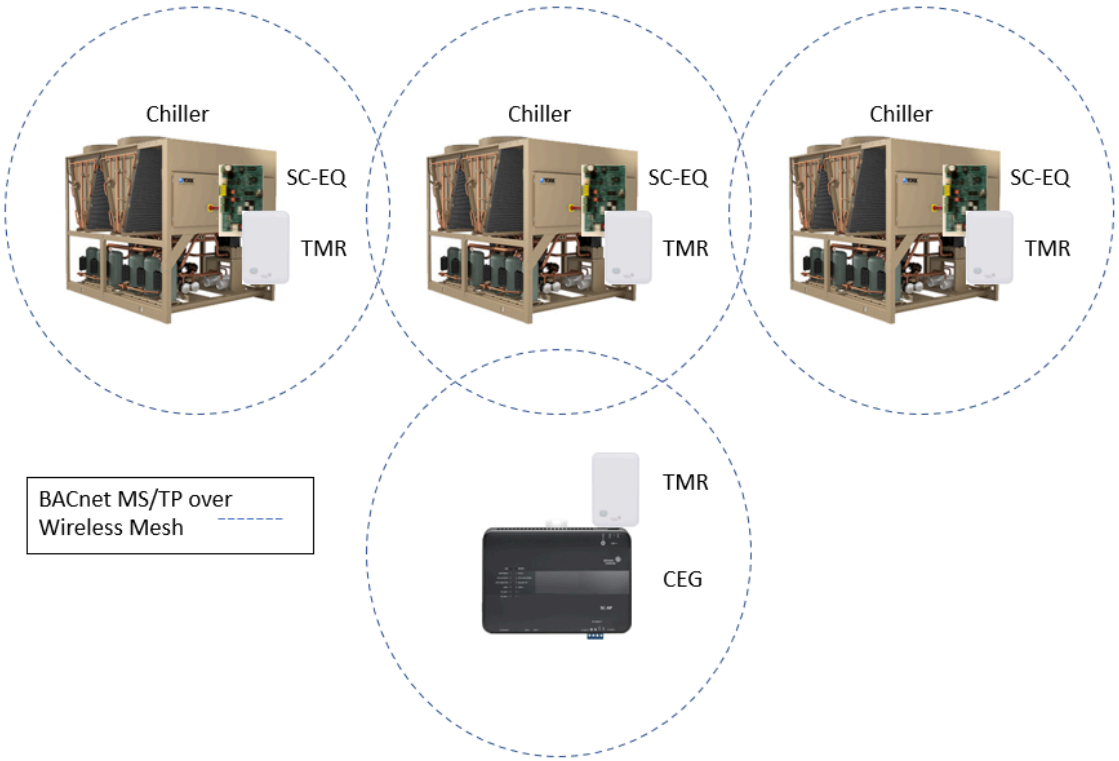
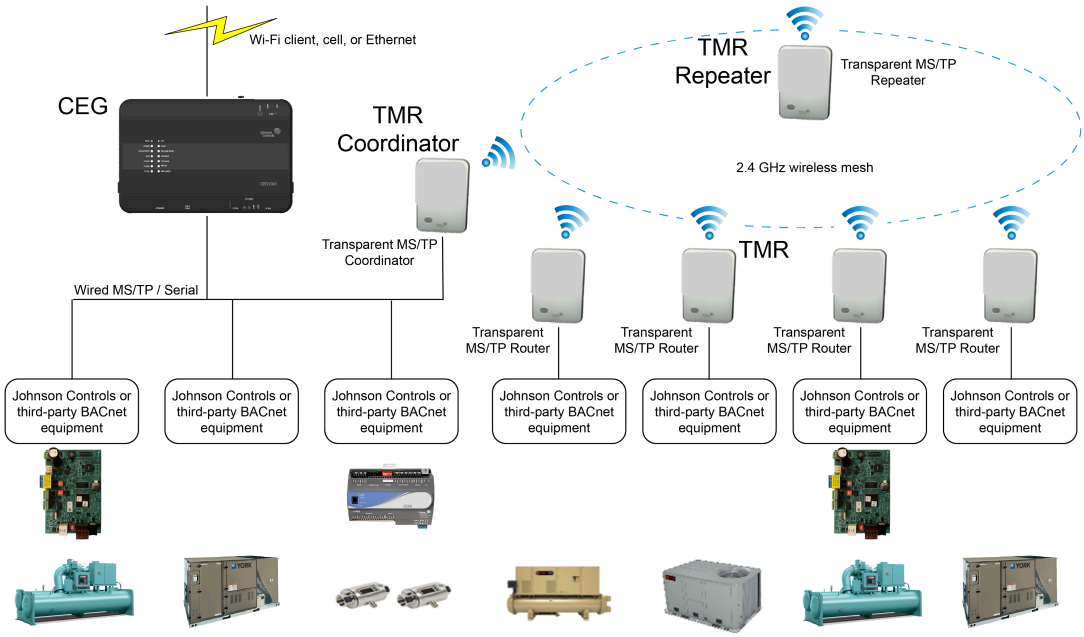


Figure 3: TMR and CEG mixed connection system overview



Note: The TMR wireless mesh network is independent of any building IT systems and does not require any preexisting wireless infrastructure.

The TMR Wireless Field Bus System is similar to the legacy Johnson Controls® ZFR1830, ZFR1820, and ZFR1810 Series wireless systems, but there are several important differences. The following list shows an overview of those differences:

- The TMR connects directly to the MS/TP bus of the controller with the controller running in MS/TP mode.
- The TMR can support any Johnson Controls or third-party BACnet MS/TP controller. The ZFR18xx radios only work with select Johnson Controls field controllers.
- The TMR system does not support Johnson Controls WRZ Series Wireless Sensors.
- Multiple MS/TP controllers can connect to a single TMR. The ZFR18xx radios can only connect to a single controller.

Use the TMR wireless routers in the following applications:

- Indoor, intra-building applications
- Outdoor rooftop applications in a weather-appropriate, outdoor-rated enclosure

CEG and TMR System components

The CEG and TMR Wireless Field Bus System contains a CEG, TMR routers, and various BACnet MS/TP equipment. One of the TMR routers in the system is configured as coordinator. See the following table for component details.

Table 3: CEG and TMR System components

Product code number	Component description	Reference names
SE-CEG1001-0	Connected Equipment Gateway, North America	CEG
SE-CEG1001-1	Connected Equipment Gateway, International	
SE-CEG1001-E	Connected Equipment Gateway, Europe	
SE-CEG1001-C	Connected Equipment Gateway, China	
SE-CEG1001-T	Connected Equipment Gateway, Taiwan	
CEGPNL1001-0	Connected Equipment Gateway Panel	CEG panel
CEGPNL1002-0	Connected Equipment Gateway Panel and TMR	
JC-TMR2400-0	Transparent Wireless Router, 100mW (20dBm), North America	TMR coordinator, TMR router, TMR repeater ⓘ **Note:** The JC-TMR2400-x operates in all three modes.
JC-TMR2400-0E	TMR Wireless Router, 10mW, (10dBm) Europe and Japan	
JC-TMR2400-0C	TMR Wireless Router, 10mW (10dBm), China	
JC-TMR2400-0T	TMR Wireless Router, 100mW (20dBm), Taiwan	

You can connect the TMR to YORK® or third-party party chiller controllers to make them wireless enabled field controllers (WEFC). The TMRs are transparent to the WEFCs and the CEG, and no

special setup procedure is required to discover, map, and integrate the WEFCs. The following list contains the supported devices:

- York chillers through an SC-EQ gateway
- Third-party chillers with an MS/TP connection.

Note: Some chillers require a separate option to be installed or enabled to provide MS/TP.

Connected Equipment Gateway

The CEG is a supervisory device that monitors BACnet MS/TP equipment and sends data to cloud-based services. The CEG supports Johnson Controls and third-party chillers.

When you use the CEG with a TMR, you can connect the wireless enabled BACnet MS/TP controllers over the TMR wireless mesh network.

The CEG includes a local, browser-based user interface so that technicians can configure and monitor the TMR wireless devices and all the BACnet devices that connect over the wireless mesh network.

TMR Wireless Router

The TMR router provides a wireless interface between BACnet MS/TP controllers. The TMR performs different operations depending on how and where you use it. The following list describes different uses of the TMR.

- When you wire the TMR to a CEG, the TMR acts as the wireless network coordinator. The wireless network requires exactly one network coordinator. The TMR coordinator starts the wireless network, acts as the wireless network's security trust center, collects diagnostic information, and passes through MS/TP requests and responses from the WEFCs.
- When you wire the TMR to a BACnet MS/TP equipment controller, the TMR acts as a network router. A router transparently connects the BACnet MS/TP controller to other BACnet MS/TP controllers and to the CEG in the wireless network. The TMRs that act as routers join the wireless network through the TMR coordinator.
- The TMR can also act as a stand-alone repeater to fill in gaps in the mesh network and to extend the range of the wireless devices.

You can power the TMR directly from the connected chillers 15 VDC output through the FC bus RJ-12 connector. When the TMR connects to third-party equipment, you can hard-wire the TMR to receive power from any 15 to 24 VAC or VDC source.

CEG and TMR installation guidance

The CEG Panel comes with a preconfigured cellular modem connected to the CEG and is ready to transmit data. Due to the nature of wireless communications and its susceptibility to metal and interference, not all mounting locations for the panel are suitable to obtain optimal signal strength.

Before installation

Before you mount and install the panel, take the following considerations into account:

- Easy accessibility to power. The panel requires 120 VAC to 240 VAC power to operate.
- Access to the communication trunk. Determine if an existing BACnet MS/TP network already exists and how to easily tap into the same trunk.

- If you use TMR wireless options, consider where you can place the panel to limit the number of hops and distance between wireless endpoints.
- Cellular communication for streaming out data. You can use your own cellular device as a rudimentary gauge to test the available signal. If your cellular device is unable to get a signal, a cellular modem may also have trouble getting a signal.
- If you connect the CEG to York chillers with Smart Connected Equipment boards (SC-EQ), ensure the SC-EQ all run on version 3.5.x.x or higher to ensure compatibility with CEG.

Performance considerations for third-party BACnet devices

Network performance can degrade when you add third-party devices on the same MS/TP trunk if those devices do not meet the minimum requirements in Table 4. Actual job experience has shown as few as five devices can create significant performance issues; although other variables can affect performance, such as the number of objects per device. To improve network performance, ensure that third-party devices also meet the preferred requirements.

Table 4: Third-Party BACnet device performance requirements

MS/TP trunk and BACnet services		Requirement
Devices on MS/TP trunk	MS/TP master device	Required
	Baud rate 38,400 bps	Minimum
	Application Layer Protocol Data Unit (APDU) size 480 bytes	Acceptable
	APDU size 200 bytes	Preferred
	Segmentation on MS/TP	Acceptable
BACnet services	BACnet version 1 revision 4 or later	Minimum
	BACnet version 1 revision 15 or later	Preferred
	Device profile of B-SA or B-SS	Minimum
	BACnet certified	Minimum
	+ Read Property Multiple, Execute	Preferred
	+ Subscribe COV, Execute	Preferred
	+ Write Property Multiple, Execute	Preferred

Installing the CEG Panel

Refer to the *CEG Panel Installation Guide (Part No. 24-11460-00050)* and the *TMR Installation Guide (Part No. 24-11461-00020)* for details about how to install the CEG.

Important: If you use TMR wireless with more than four chillers, install a second TMR coordinator in the panel and configure the AREA and Personal Area Network (PAN) OFFSET to be unique between the two networks.

Installing the TMR

About this task:
Refer to the *TMR Installation Guide (Part No. 24-11461-00020)* for the full details about how to install the TMR.

Important: Do not connect the TMR to the chiller controller before you set the PAN OFFSET and AREA switches to match the TMR that is installed in the CEG Panel.

1. Set the TMR PAN OFFSET and AREA switches based on site design documents.
2. Connect the TMR to the chiller controller.
   a. For York chillers with SC-EQ boards, connect an RJ-12 cable from the TMR to the SC-EQ's Connected Services (CS) RJ-12 port, which supplies both the communication and power.
   b. For third-party chillers or legacy York chillers, use the screw terminals on the TMR to connect both the MS/TP communication and power.

CEG wired network installation

The following section describes the required steps to set up the CEG wired network.

Airwall requirements for CEG version 2.0 or earlier

The Tempered Airwall 110E gateway device is a security solution that blocks all incoming traffic to the CEG from unknown sources. The Tempered Airwall 110E takes outgoing data from the CEG through a Host Identity Protocol (HIP) tunnel to a gateway hosted in Azure® and then to their respective destinations.

Install the physical Tempered Airwall 110E gateway device when you use the CEG at firmware version 2.0 or earlier. If your CEG is at firmware version 2.1 or later, you do not need to install the physical Tempered Airwall 110E gateway device, because version 2.1 includes Tempered Airwall zero-trust technology embedded within the CEG device.

You require the physical Tempered Airwall 110E device for the following use cases:

- Connecting the CEG at firmware version 2.0, or earlier, to a BAS system through the BACnet MS/TP trunk
- Connecting the CEG at firmware version 2.0, or earlier, to a third-party chiller

You do not require the Airwall 110E gateway device for chillers connected through the Connected Services (CS) port on the SC-Equip communication card. This includes third-party chillers retrofitted with York® Optiview™ panels that connect through the CS port on the SC-Equip communication card.

Note: Optionally, if your CEG is at version 2.0, or earlier, you can use the Airwall 110E device to provide another layer of security for many other networking scenarios, including connecting the CEG to the SC-EQ controller's CS RJ port.

Refer to the *Smart Connected Chillers Hardening Requirements (Part No. GPS0030-CE-20220429-EN)* for detailed information about how to install and configure the Airwall 110E gateway device. Contact the Connected Offering Support Team at BE-ConnectedOfferingsSupport@jci.com for details about purchasing the Airwall 110E gateway.

Airwall configuration for CEG v2.1

The CEG, from version 2.1, includes Tempered Airwall zero-trust software, which removes the requirement for the installation of the Tempered Airwall 110E gateway device, see Airwall requirements for CEG version 2.0 or earlier.

The Tempered Airwall zero-trust software uses Host Identity Protocol to secure network communication between the CEG and the cloud. In addition, it secures communication for any remote access requirements.

Configure the CEG to use the following DNS settings:

- Auto DNS = Off
- Primary DNS = 9.9.9.9
- Secondary DNS = 149.112.112.112

For China, use the following DNS settings:

- Primary DNS = 223.5.5.5
- Secondary DNS = 223.6.6.6

The CEG needs to be able to communicate outbound to the Internet on the following ports:

- UDP 53 for the DNS servers
- TCP 8096 for encrypted TLS traffic
- UDP 10500 for encrypted HIP traffic

Refer to the *Smart Connected Chillers Hardening Requirements (Part No. GPS0030-CE-20220429-EN)* for detailed information about how to configure the Tempered Airwall zero-trust software.

Using the Airwall Bypass

About this task:
The CEG, from version 2.1, includes Tempered Airwall zero-trust software. In order to troubleshoot internet connection problems, you may want to bypass the Airwall protection temporarily. To configure the Airwall Bypass complete the following steps:

1. Log on to the CEG local UI.
2. Click **Settings** > **Airwall Bypass**.
3. From the **Airwall Bypass** list, select **On**.
4. In the **Bypass Interval** area, select the length of time that you want to bypass the Airwall protection.
5. Click **Save**.

Connecting wired SC-EQ controllers (preferred connection for all York equipment)

About this task:
When connecting the CEG to SC-EQ controllers, it is best practice to connect to the SC-EQ controller's CS RJ port J1 to the CEG FC Bus 6-pin RJ-12 connector for the most secure connection. To monitor third-party equipment on the BAS bus, you can connect the CEG' FC Bus to the SC-EQ controller BAS RJ port J2, however this connection exposes the CEG to the other equipment on the BAS bus and requires the use of the Airwall 110E gateway device.

- Connect the RJ-12 cable between the SC-EQ CS RJ port J1 and the CEG FC Bus 6-pin RJ-12 connector as shown in the following figure.

Figure 4: Connecting the SC-EQ controller to the CEG

Important: Plugging the RJ-12 cable into the SC-EQ BAS RJ Port J2 can expose other equipment on the BAS network to the CEG. When connecting the CEG's FC Bus to the SC-EQ's BAS RJ port J2, use the Airwall 110E gateway device. Refer to the *Smart Connected Chillers Hardening Requirements (Part No. GPS0030-CE-20220429-EN)* for detailed information about how to install and configure the Airwall 110E gateway device.

Connecting wired BACnet MS/TP network equipment

About this task:
Use the 4-pin FC bus on the CEG to connect your BACnet MS/TP network equipment. Wire between the CEG and MS/TP controllers in a daisy chain wiring configuration.

- Wire the RS485 +, -, and COM pins. Do not connect to the PWR pin.

Important: If the CEG is at the end of an MS/TP bus segment, set the End-of-Line (FC EOL) switch to ON. If the CEG is not at the end of an MS/TP bus segment, set the End-of-Line (FC EOL) switch to OFF. If you use a shielded cable, do not connect the shield wire to the CEG. To daisy chain the CEG, connect the shields using a wire nut or similar connector.

CEG address on the network

Each BACnet device on the MS/TP network requires a device address to coordinate communication. The device address on the network must be unique from all other devices on the network. The default address of the CEG is 116.

The CEG discovers what is on the bus and uses those devices accurately.

Note: Device addresses on a bus do not require the devices on the bus to be wired in sequential order.

BACnet MS/TP settings

You must set the following BACnet MS/TP parameters when you join the CEG to an existing network. You can adjust all the parameters listed in the following table in the CEG UI in the Settings > BACnet Settings menu.

Table 5: BACnet MS/TP settings

Parameter	Setting
Device Object Identifier	Identifies the CEG on a BACnet network and must be unique on the network. The CEG attempts to generate a unique value, but that does not guarantee it is unique. If it is not unique, adjust the value manually. Adjustable: 0 to 4194302
Network Number	Sets the routing address for devices under the CEG. If you plug into an existing BAS network, set the network number to the same as the BAS. If you do not plug into an existing BAS, keep the network number at the default value. Adjustable: 1 to 65534
Baud Rate	This is the communication speed of the BACnet MS/TP network. Set the baud rate to the same value as other controllers on the network. If no existing network exists, set the baud rate of the controllers manually. The recommended baud is 38.4 kbps. Available Enum options: 1.2 kbps, 9.6 kbps, 19.2 kbps, 38.4 kbps, and 76.8 kbps
Max Master	This is the highest master MS/TP node number used on the BAS. Set the max master to the same number as the BAS for optimal network performance. If no BAS exists, set this value to the highest MAC address that is present on the MS/TP network for optimal performance. Additionally, the MAC address of both the CEG and TMR must be lower than the max master of the BAS. If you use wireless, the max master of the BAS must be set to 127, or the highest MAC address in use by a TMR. ⓘ **Note:** All devices on the networks must use the same Max Master setting. Adjustable: 4 to 127
Max Info Frames	This allows the transmission of MS/TP frame packets. Set the max info frames value to the same value as the BAS, if a BAS is present on the network. If no BAS is present, leave it at the default value which is 50. Adjustable: 1 to 255

TMR wireless network characteristics

TMR wireless network characteristics include the wireless transmission ranges and the device limits on the wireless network.

Wireless transmission range

The effective transmission range and signal quality can vary for each application because of wireless signal absorption and reflection due to metal obstructions, walls, floors, and furniture in building interiors. An increased number of hops that a message takes through the mesh can result in a higher probability of errors and decrease reliability of the wireless network.

ⓘ **Note:** The default and maximum Tx power setting depends on the model and regional regulatory agencies.

Important: Transmission ranges between products can be less than the maximum distances in the following table.

Table 6: Wireless transmission range

Range type	Tx power setting	Transmission range	
		TMR to TMR	TMR coordinator to furthest TMR through multiple hops on the mesh
Best practice	20 dBm	250 ft (75 m)	1,000 ft (305 m)
	14 dBm	125 ft (38 m)	500 ft (150 m)
	10 dBm	50 ft (15 m)	200 ft (60 m)
Maximum line of sight	20 dBm	1,000 ft (305 m)	4,000 ft (1220 m)
	14 dBm	500 ft (150 m)	2,000 ft (610 m)
	10 dBm	250 ft (75 m)	1,000 ft (305 m)

Wireless network device limits

The maximum number of wireless devices on a PAN or managed by a single supervisory controller is dependent on site requirements and general construction variables conducive to supporting wireless networks. A typical CEG wireless system consists of the following limits:

- Up to 2 TMR coordinators for each CEG FC bus
- Up to 4 MS/TP controllers for each TMR coordinator/PAN
- Up to 4 MS/TP controllers for each TMR
- Up to 8 MS/TP controllers for each CEG, requires two TMR coordinators if all MS/TP controllers are connected as WEFCs

TMR network installation

Select the mounting locations based on the guidance provided in *TMR Wireless Best Practices (LIT-12013954)*. After the installation of the devices in the wireless network, you must connect the different components to create the wireless mesh network.

Applications to avoid for wireless

Locations or applications that prohibit cellular telephones or Wi-Fi systems are unsuitable for the wireless products.

Do not use wireless products in applications that cannot tolerate intermittent interference, for example, where the following would happen in the case of signal disturbances:

- Critical control features would affect life safety or result in large monetary loss, including secondary (backup) life-safety applications.
- Data centers, production lines, or critical areas would be shut down.
- Loss of critical control would result from loss of data from humidity or temperature sensor communications.
- Operation of exhaust fans or air handling units (AHUs) would impair a purge or pressurization mode.

- Missing data would invalidate reporting required by the monitored customer security points.

AREA and PAN OFFSET setting for a wireless network

When you select the AREA and PAN OFFSET for a wireless network, observe the following guidelines:

- Set all devices in a single wireless mesh network to the same AREA and PAN OFFSET.
- Select PAN OFFSETS that are unique for the site.

  Important: To avoid interference, assign a unique PAN OFFSET to each wireless network in a building. A unique PAN OFFSET is particularly important if PANs exists on adjacent floors of a building. Do not use the same PAN OFFSET on multiple wireless networks in a building, even if the transmit distances do not appear to overlap.
- Select an AREA setting that is unique for each group of TMRs that connect to the same CEG.

Figure 5: AREA and PAN OFFSET switches

When you analyze over-the-air communications traffic with a wireless sniffer and a software tool, such as Wireshark, it is useful to know the actual PAN ID. The actual PAN ID of the wireless network is a combination of the AREA and PAN OFFSET settings, as follows:

Actual PAN ID = 1000 + 100 * AREA setting + PAN OFFSET

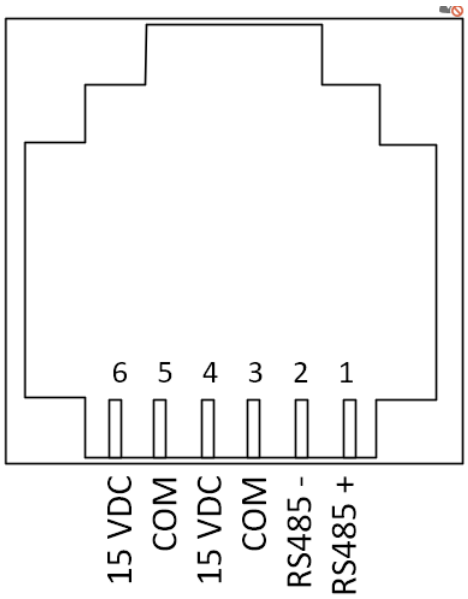
Connecting the TMR coordinator to a CEG

About this task:
The CEG Panel ships with a TMR coordinator preinstalled. If not, then you can install it in the field. The CEG Panel also accommodates a second TMR when needed.

1. Wire the TMR coordinator to the FC bus of the CEG. Use either the RJ-12 jack or the terminal block on the TMR and CEG. If you use the terminal block, the SA PWR can be 15 to 24 VAC/VDC. For the details, refer to the TMR and CEG installation documentation.

Figure 6: Terminal block

Figure 7: RJ-12 jack



2. Set the AREA and PAN OFFSET to the same value on the TMR coordinator and all routers assigned to the same PAN.

   ⓘ **Note:** The factory default setting is 0 for AREA and 00 for PAN OFFSET. If another CEG Panel is installed at the same site, set the PAN OFFSET to a unique value.

   ⓘ **Note:** If you install a second TMR in an existing CEG Panel, set the AREA to a unique value.

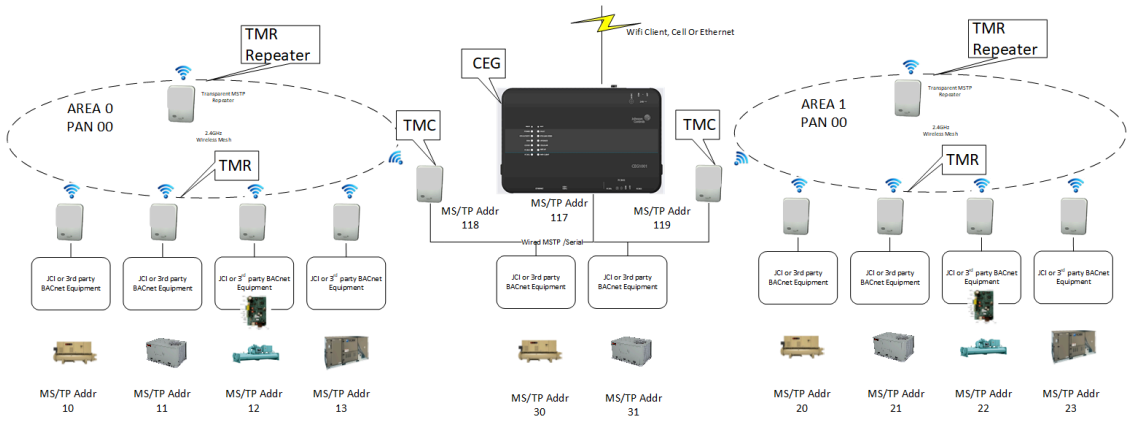
3. Ensure that the MS/TP address setting on all WEFCs is unique across the entire FC bus for both wired and wireless connections.

Connecting multiple TMR coordinators to a CEG

About this task:
In a CEG system, it is best practice to connect a maximum of four controllers in each PAN. To expand the total number of WEFCs, add multiple TMR coordinators to a single FC bus.

The standard CEG Panel provides space to install a second TMR coordinator. You can also mount an additional TMR coordinator external to the CEG Panel, if the equipment is located in separate areas where it is not recommended to extend the mesh, for example, floors, wings, buildings.

Figure 8: Multiple TMR coordinators (TMC) connected to a CEG



1. Wire the additional TMR coordinator to the FC bus of the CEG. Because the CEG contains only one RJ-12 jack, use daisy-chain wiring for the terminal blocks on the CEG and the TMRs. For the details, refer to the TMR and CEG installation documentation.
2. Set the AREA switch on each TMR coordinator to a unique number. This ensures that they have a unique MS/TP address on the FC bus.
3. Set the PAN OFFSET. This can be the same on each TMR coordinator if you install no other CEG Panels in the same area.
4. Set the AREA and PAN OFFSET to the same value on all the TMRs assigned to the same PAN.
5. Ensure that the MS/TP address setting on all WEFCs is unique across the entire FC bus for both wired and wireless connections.

Connecting the TMR wireless router to a BACnet device

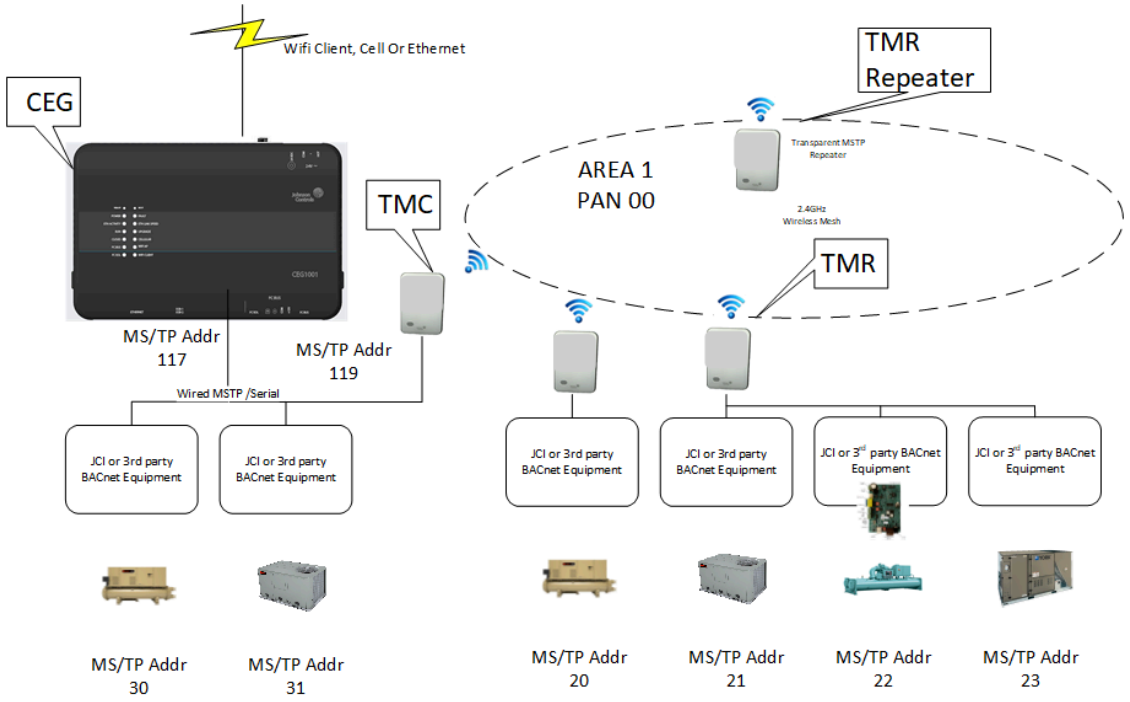
To connect the TMR wireless router to a chiller, complete the following steps:

1. Wire the TMR to the chiller according to the *TMR Installation Guide (Part No. 24-11461-00020)*.
2. Set the AREA and PAN OFFSET switches on the TMR router according to the same positions as the TMR coordinator that is connected to the CEG.
3. At each WEFC, set the chiller MS/TP address switch according to the job plans.
4. Ensure that the MS/TP address setting on all WEFCs is unique across the entire FC bus for both wired and wireless connections.

Connecting a TMR wireless router to multiple BACnet devices

About this task:
You can connect multiple MS/TP controllers to the same TMR router. This is useful if you install the controllers in the same control panel, or in close proximity, so that it is more economical to hard wire the controllers together, rather than to connect a separate TMR to each controller.

Figure 9: Multiple BACnet devices connected to a TMR



1. Use daisy-chain wiring for the FC bus terminal blocks on the TMRs and the MS/TP controllers. For details, refer to the TMR and CEG installation documentation. See Table 1
2. Set the AREA switch and PAN OFFSET switch to the same value on all the TMRs assigned to the same PAN.
3. Ensure that the MS/TP address setting on all WEFCs is unique across the entire FC bus for both wired and wireless connections.

Installing the TMR as a wireless repeater

To install the TMR as a repeater, complete the following steps:

1. Set the AREA and PAN OFFSET switch on the TMR according to the job plans.
2. Connect the TMR to a 24 VAC power source.
3. Follow the steps in Adding new wireless devices to a running network to add the TMR repeater to the network.

Powering the TMR wireless router

About this task:
To power the TMR Wireless Router, complete the following steps:

1. Apply power to each WEFC and TMR.
2. Verify that the WEFC has MS/TP connectivity. York chillers have connectivity when the CS bus LED blinks at 1 Hz.
3. If the PAN is closed for joining, the TMR LED is on steady blue with a green blink to indicate that it is attempting to join the selected PAN.

4. If the PAN is open for joining, verify that the TMR LED turns red and indicates a good signal strength in approximately 10 seconds. If the LED shows poor signal strength or does not flash, see Troubleshooting.

   ⓘ **Note:** The LED can transition through multiple colors before it settles on the color of its current state. See Table 8 for LED states information.

Adding new wireless devices to a running network

About this task:
After you plan and install the wireless system, complete the following steps to commission the system and to let new devices join the network:

1. Apply power to the CEG and the connected TMR coordinator, and verify that the TMR yellow LED is on.
2. Apply power to the TMR routers and repeaters, and verify that their LED is on steady blue with a green blink.
3. For security reasons, the PAN is locked and new devices cannot join the network. Open the network in one of the following ways:

   - Press the **Join** button on the side of the TMR coordinator.
   - Log on to the CEG local UI, select the TMR coordinator from the device list, and set **Commissioning** > **Join Enable** to **Enabled**.

   When the PAN is open for joining, the LEDs on all the TMRs that are already in the network turn red. The new TMRs join the PAN automatically.
4. Verify that in approximately a minute, the LED on the newly joined TMRs blinks in red. The number of blinks indicate the signal strength.

   ⓘ **Note:** After joining the PAN, the TMR LED may turn aqua. This indicates that the download of new firmware is in progress. Download of firmware happens in the background and does not interfere with operation.
5. Verify that after the join time duration expires, the LED on each TMR turns green. This indicates that the network locks down again.

   ⓘ **Note:** You can configure the join time duration to up to eight hours on the CEG local UI. The default is one hour.

Verifying wireless operation

About this task:

ⓘ **Note:** When you first apply power to the wireless network devices, some WEFCs can toggle online and offline at the CEG for a short period until the entire trunk finished its startup procedure. This is normal operation.

To verify wireless operation, complete the following steps:

1. Log on to the CEG local UI, and verify that the connected TMR coordinators and all the WEFCs appear in the device list.

   ⓘ **Note:** For the CEG to fully discover the points available in each WEFC can take up to 5 minutes. During this time, the WEFC may display a **Not Supported** indication.
2. Navigate to the **Diagnostics** page on the CEG local UI to check the performance of the wireless mesh network, including online status and wireless signal strength.

3. **Required:** before you leave the site, ensure that you disable the **Join** button.

TMR BACnet MS/TP operation

TMR address on the MS/TP network

The TMR is an MS/TP manager device on the BACnet MS/TP segment that it is directly wired to. The TMRs address on the ring is determined by adding 118 to the AREA switch position. This gives a range of 118 to 127.

MS/TP address = 118 + AREA switch

Important: Select the AREA so that the MS/TP address does not conflict with any other controller on the MS/TP network.

Note: The MS/TP address of each TMR on the same wireless PAN is the same MS/TP address on their respective wired segment. This does not cause a conflict, because the remote TMR routers are not directly visible to the local MS/TP network segment.

Baud rate determination

The TMR supports an auto-baud scheme and automatically synchronizes to an active MS/TP bus at the following baud rates: 9600, 19200, 38400, or 76800.

Note: You might need to configure some third-party devices to support the 38.4k baud rate.

If the TMR in router mode does not detect any MS/TP activity, it times out after approximately 10 seconds after power-up, and starts the MS/TP ring at the 38.4k baud rate. Other controllers that are also in an auto-baud mode can synchronize to this baud rate and join the MS/TP ring.

The TMR in coordinator mode also supports auto-baud. However, it does not attempt to start the MS/TP token ring if it detects no other devices.

The TMR in router or coordinator mode also indicates an auto-baud warning when it does not detect any other devices, and its LED becomes dim purple. However, the TMR in stand-alone repeater mode does not indicate a warning when it does not detect any other devices.

Required setup for cloud operation

The following section describes the required actions you must take to set up the cloud for correct operation.

Editing the equipment description for the Connected Equipment Portal

About this task:
To ensure the Connected Equipment Portal (CEP) identifies your equipment correctly, from the CEG local UI, edit the equipment description in the Device List page as specified in the email sent to you from the CEP onboarding team. To edit the name and description of your equipment on the device list page, complete the following steps:

1. Log on to the CEG local UI.
2. From the **Device List** page, click **Edit Device Details**.
3. In the **Name** field, enter a unique name for your equipment.
4. In the **Description** field, enter the description sent to you from the CEP onboarding team.

   Note: Even if the CEP did not provide a description, you must enter a unique description for all monitored and non-monitored devices.

5. Click **Save Device Details**.

Configuring the SC-Equip connected services port MAC address

About this task:
To configure the SC-Equip connected services port MAC address, complete the following steps:

1. Log on to the CEG local UI.
2. From the Device list, select the equipment that is using a SQ-Equip interface.
3. Click **SC-Equip Data**.
4. Click the **CONNECTED SERVICES PORT MAC ADDRESS** field.
5. In the pop-up window, enter the MAC address and click **Save**.

   ⓘ **Note:** It is best practice to use a MAC address between 5-155.

Configuring the remote services connection

About this task:
Each CEG device uses an account ID to send telemetry data to the cloud. Use the CEP Account ID emailed to you from the CEP onboarding team. To configure the account ID for the device, complete the following steps:

1. Log on to the CEG local UI.
2. Click **Settings** > **Remote Services Connection**.
3. Click **Edit Account ID**.
4. In the pop-up window, enter the new account ID and click **Save**.

What to do next:
To view the status of the CEG connection to the cloud, click **Remote Diagnostic**.

TMR network maintenance

Network maintenance includes the following tasks:

- Replacing an existing TMR wireless coordinator, router, or repeater
- Advanced operations:
  - Upgrading firmware
  - Changing the active wireless channel
  - Changing the transmit power
  - Disabling the token proxy feature

Replacing an existing TMR coordinator

About this task:

Important: Replace a TMR coordinator only if necessary. The TMR coordinator is the network's security trust center. The TMR coordinator selects a random network key and securely distributes this key to other devices as they join the PAN and also keeps a record of all of the devices that are allowed to be on the network. When you replace a TMR coordinator, this persistent information is lost, and you need to factory reset all existing TMR routers and repeaters, and add them to the network again.

1. Prepare the new TMR coordinator by setting its AREA and PAN OFFSET switches according to the site plans.
2. Unplug the existing TMR coordinator from the CEG and the power source.
3. Wire the new TMR coordinator to the CEG and apply power.
   The CEG automatically sets the TMR into coordinator mode when it discovers the TMR. Verify that the LED turns yellow to indicate coordinator mode.
4. When the new coordinator is active, enable joining:
   a. Use the CEG local UI or the **Join** button, start the join timer so that the TMR routers are able to join the PAN.
   b. Verify that the TMR coordinator LED turns red to indicate that the network is open for joining.
5. Reset the TMR routers and repeaters so that they can join the new network that the new TMR coordinator formed. To reset a TMR, complete the following steps:
   Option 1: Factory Reset
   a. Verify that the TMR is turned on, and press and hold the **Join** button until the LED sequences to red.
   b. Release the **Join** button.
   c. While the LED is rapidly blinking red, press the **Join** button again.
   d. Wait until the TMR resets and the LED blinks blue and green.

   Option 2: Toggle PAN setting
   a. Verify that the TMR is powered on, and change any of the rotary switches to a new value.
   b. Wait until the TMR resets and the LED blinks blue and green.
   c. Change the rotary switch back to the original setting.
   d. Wait until the TMR resets and the LED blinks blue and green.

Adding or replacing a TMR router or repeater

About this task:
Use this procedure when you want to add new wireless MS/TP devices to an existing PAN or a new repeater to strengthen the mesh.

To add or replace a TMR router or repeater, complete the following steps:

1. Prepare the new TMR router or repeater by setting its AREA and PAN OFFSET switch according to the site plans.
2. If you want to replace a TMR, unplug it from the chiller or the power source.
3. Use the CEG local UI or the **Join** button to start the join timer so that the new TMR can join the PAN. The TMR coordinator LED turns red.
4. Install the new TMR router or repeater and wire it to the chiller or power source.
5. The new TMR joins the network and its signal strength LED blinks in red.
6. Wait for up to 5 minutes for the CEG to recognize that the TMR is added or replaced.

7. Verify that the chiller appears as online in the CEG device list. If this device is not online, see Troubleshooting for more information.

   Note: If you replace a TMR that connects to an MS/TP controller, the TMR coordinator LED can turn purple for up to 5 minutes to indicate an MS/TP address conflict warning. This warning clears when the TMR coordinator learns that the old TMR is removed.

Advanced operations

Advanced operations include changing the advanced settings of the TMR wireless system.

Important: Exercise caution when you make changes to any of the advanced settings, because they may cause a disruption in the wireless network and you may need to perform additional steps to revert the changes.

Refer to the *TMR advanced setup* section of the *CEG and TMR User Guide (LIT-12013890)* for more information.

Firmware update for the TMR

The software update package for the CEG also includes the latest compatible firmware for a TMR coordinator that connects to the CEG. The update for the TMR coordinator runs in the background, no manual intervention is required. After the TMR coordinator receives and validates the new firmware file, it resets automatically and starts with the new firmware image.

After the TMR coordinator completes its own software update, it automatically updates the firmware in each TMR router and repeater connected to its PAN. The coordinator updates one router or repeater at a time to reduce the load on the network. Updating each TMR can take up to 10 minutes.

Note: During the firmware update, network performance can degrade and WEFCs connected to TMRs where update is in progress can temporarily appear offline to the supervisory device.

Important: The LED on each TMR device turns aqua to indicate that a firmware update is in progress. Do not cycle power for the device during this time.

Changing the active wireless channel

When the TMR coordinator starts the PAN, it chooses a wireless channel that carries the least amount of noise and includes the least number of other networks. The TMR coordinator chooses from channels 15, 20, and 25, because these 802.4.15 channels lie between the standard Wi-Fi channels 1, 6, and 11. See Appendix B: TMR wireless basics for more details.

When the TMR coordinator selects the channel, the PAN remains on that channel. However, this channel can become over-crowded or otherwise unacceptable due to changes in the environment. When this happens, you can manually change the channel from the CEG.

When you change the channel, the TMR coordinator sends a command to the network so that all the TMR devices change at the same time. However, some TMRs might not receive the command from the TMR coordinator. These TMRs go into a lost coordinator warning state and their LED becomes purple. The MS/TP devices connected to these TMRs can also appear offline in the CEG local UI. These TMRs search for the TMR coordinator on the other channels until they find the new channel.

The process of locating the TMR coordinator and the MS/TP devices going back online can take up to 30 minutes depending on the RF environment.

Token proxy

The TMRs use a priority scheme to pass the token for other MS/TP devices detected on remote MS/TP segments. This scheme makes it possible for some Johnson Controls devices, for example

the CEG, to quickly discover active MS/TP devices without broadcasting BACnet `WHO-IS` requests. Broadcasts can be disruptive on a wireless mesh network.

This proprietary token proxy scheme may not be compatible with some third-party BACnet MS/TP devices. If this occurs, you can disable this feature from the CEG local UI or if you change the **Proxy Token** BACnet object **BV[2]** to **Disable (0)**.

Note: No devices have been found to be incompatible with this scheme.

Troubleshooting

The following section provides a general troubleshooting information for the CEG and the TMR Series Wireless Field Bus.

CEG LED status

The CEG uses status LEDs to indicate functional states according to the LED map shown in the following table:

Table 7: CEG LED designations and operation

LED name	Color	Status	Description
POWER	Blue	Off	The device has no power.
		On solid	Primary voltage supplies power.
	Purple	On solid	The operating system (OS) is initializing. Returns to blue when completed.
FAULT	Red	Off	The device is operating normally.
		On solid	Missing hardware or software, operating system is not yet initialized, or reset is in progress.
		Slow flashes then fast flashes	Reset button is being pressed.
		Two flashes per second	Start up sequence.
		Five flashes per second	Other fault.
ETHERNET ACTIVITY	Green	Off	Ethernet cable is not connected.
		Flashes	Data transmission.
ETH LINK SPEED	Yellow	Off	No network connection.
		On solid	10 Mbps
	Blue	On solid	100 Mbps
RUN	Green	Off	No power or waiting for processes to start.
		On solid	OS and all monitored processes have started and the device is ready to use.
UPGRADE	Green	Off	No upgrade is in progress.
		On solid	Upgrade is in progress.
FC BUS	Green	Off	Cable is not connected.
		Flashes with activity	Data is transferring.
Wi-Fi AP	Green	Off	Wi-Fi adapter is not connected.
		On solid	The Wi-Fi adapter is connected and client is connected.
		Flashes	Broadcasting SSID and no client is connected.
FC EOL	Yellow	Off	FC EOL is not switched on.
			The device is in the middle of the bus.
		Flashes	The device is starting up.
	Green	On solid	FC EOL is switched on.
			The device is the end of the line.
Wi-Fi CLIENT	Blue	Off	The Wi-Fi dongle is not detected or the Wi-Fi client interface is turned off.
		Flashes	The router is not authenticated.
		On solid	The router is authenticated.
CLOUD	n/a	n/a	Not currently supported.
CELLULAR	n/a	n/a	Not currently supported.

TMR LED status

You can use the multi-color LED on the TMR to determine the status of the TMR. This can be useful for making a quick evaluation of the state of the TMR during the commissioning and maintenance process.

The following table describes the LED states and the associated colors.

Table 8: TMR LED states

TMR state	Color	Description
Normal operation	Green or yellow blink at a rate according to the signal strength ⓘ **Note:** Blinking stops five minutes after reset.	Green: router or repeater mode Yellow: coordinator mode ⓘ **Note:** This LED state also indicates that the PAN is closed and new devices cannot join.
Off network	On steady blue with a green blink	Restarting, or attempting to join the PAN.
Commissioning state	Red blink at a rate according to the signal strength	The PAN is open, new devices can join.
Warning state	Purple	One of the following warning states: • Lost coordinator • Lost MS/TP connection • Duplicate MS/TP Address • Duplicate coordinator For more information, see TMR warning states.
	Dim purple	Warning: • MS/TP Auto Baud
Miscellaneous	Aqua	Firmware update in progress
	White blink at 1 Hz rate and stopping after 30 seconds	Response to a ping request from the CEG local UI

ⓘ **Note:** Blink rate is an indication of signal quality. 1 - Poor, 2 - Fair, 3 - Good.

TMR warning states

The LED on the TMR turns purple to indicate a warning condition. A warning condition can affect the performance of other devices on the network.

In some cases, the warning code appears in the CEG local UI. However, if the TMR router is not active on the wireless network, then you have no further indication of the issue. In this case, eliminate each possible cause.

ⓘ **Note:** One or more warnings can be active at one time.

Use the following table as a guide on what to check.

Table 9: TMR warning states

Warning state	Possible cause	Solutions
Auto-baud	TMR coordinator: the TMR coordinator waits for the CEG or other devices already active on the MS/TP ring to start the ring. TMR router or repeater: this is a temporary warning state that lasts approximately 10 seconds after power on.	TMR coordinator: • Verify the MS/TP RS485 connection. • Verify that the CEG is active. The CEG is active when its FC bus LED is on. TMR router: • Expected behavior. • Verify the MS/TP RS485 connection. TMR repeater: • Expected behavior.
Lost coordinator	TMR router: the router has not received a message from the coordinator in the last 15 minutes.	• Verify that the coordinator is online. • Verify that the router is in RF range of at least one other router that is in the range of the coordinator. • Verify that a repeater is not needed. • If the problem is intermittent, choose another channel or add a repeater. • If the channel was changed, wait 30 minutes for the entire network to switch over.
Lost MS/TP connection	The TMR lost connection to all other MS/TP devices on its wired segment.	• The MS/TP controllers are powered off. • Verify the MS/TP RS485 connection. • Verify that the end-of-line switches are on for the terminating devices at the ends of the MS/TP bus.
Duplicate MS/TP address	The TMR detected that an over-the-air message originated from an MS/TP address that is also wired to its own MS/TP bus. The TMR detected that an over-the-air message from two different TMRs originated from the same MS/TP address.	• Verify that each MS/TP controller has a unique MS/TP address setting. • If a TMR was replaced or moved to another MS/TP controller, wait for 5 minutes for the changes to propagate in the network. The warning disappears automatically.
Duplicate coordinator	TMR coordinator: before the TMR coordinator starts a new network, it detects that other devices are already using the same AREA and PAN setting.	• Choose a different PAN OFFSET for this new network. • If you replaced a defective coordinator with a new one, do a factory reset on all the existing TMR routers and reopen the network so that they can join.

Using the TMR join button

You can use the join button on the side of the TMR for several operations during installation, commissioning, and servicing.

Open the PAN for joining

If you enable the join button through the CEG local UI, you can open the network for new devices to join if you press the join button on any TMR in the network. The LED on all the TMRs already in the network turns red. Any TMR with the same AREA and PAN offset settings and their LED blinking in blue and green join the network automatically.

Close the PAN

When the PAN is open and you press the join button, the network closes.

ⓘ **Note:** It can take up to 3 minutes for all the TMRs on the network to indicate that the network is closed.

Set coordinator mode

You can set the TMR to coordinator mode by pressing and holding the join button until the LED cycles to yellow. Release the join button and press it again while it is rapidly blinking. This causes the TMR to restart as a coordinator, as indicated by its yellow LED. You can then press the join button again to open the network for new devices to join the PAN.

Set router mode

You can set the TMR to router mode by pressing and holding the join button until the LED cycles to green. Release the join button and press it again while it is rapidly blinking. This causes the TMR to restart as a router. The TMR attempts to join the network as indicated by its LED blinking in blue and green. If the coordinator is online and the network is open for joining, the TMR joins, and its LED blinks in red according to the signal strength.

Reset to factory defaults

You can reset the TMR to factory defaults by pressing and holding the join button until the LED cycles to red. Release the join button and press it again while it is rapidly blinking. This causes the TMR to clear all network and user configured settings. The TMR restarts as a router and attempts to join the network as indicated by its LED blinking in blue and green. If the coordinator is online and the network is open for joining, the TMR joins, and its LED blinks in red according to the signal strength.

ⓘ **Note:** If you do not press the join button a second time, the LED stops blinking after five seconds and the TMR returns to normal operation.

General wireless network stability

Table 10: Troubleshooting wireless network stability issues

Symptom	Possible cause and solution
The TMR intermittently appears as offline in the CEG local UI.	Ensure that a wireless interference source, such as a microwave oven or a 2.4 GHz cordless phone, is not installed near any TMR radio. Confirm that the distance between devices on the TMR mesh are within range.
Chillers installed on the trunk have duplicate MS/TP addresses. ⓘ **Note:** An address conflict can exist between a coordinator and chillers within the address range of 4 through 119.	Each chiller monitored by the CEG on the FC bus must have a unique MS/TP address. This applies to devices wired to the FC bus or devices connected through the TMR wireless network.
The TMR does not join the wireless network.	• Ensure that the AREA and PAN offset setting is correct. • Ensure that network is open to add devices.

Troubleshooting issues with the CEG and the TMR coordinator

Table 11: Troubleshooting issues with the CEG and the TMR coordinator

Symptom	Possible cause and solution
Web browser cannot log on to CEG Local UI.	Some web browsers do not recognize the https://cegwy.jci.com address. Use the IP address 192.168.142.1 as an alternative to https://cegwy.jci.com.
The CEG cannot discover any TMR coordinators on the local MS/TP FC bus or the TMR coordinators appear offline in the CEG local UI.	• Confirm that the TMR coordinator is powered on and it is correctly wired to the FC bus port on the CEG using the RJ-12 port or the terminal block. • Confirm that the TMR LED is yellow, that is, the device is in coordinator mode. • If the TMR LED is purple, troubleshoot any issues that can cause the warning state.
The CEG cannot discover the WEFCs in the TMR networks.	• Confirm that the TMR routers and repeater have the same AREA and PAN setting as the TMR coordinator. • Confirm that the TMR routers are wired correctly to the MS/TP bus of the field equipment. • Confirm that the network is open for new devices to join. • Ensure that the address switch 128 is set to off for Johnson Controls FEC, FAC, IOM, or VMA.
The LED of a TMR coordinator connected to the CEG is green.	The CEG has not yet commanded the TMR into coordinator mode. The normal operating state color for the TMR coordinator is yellow.

Table 11: Troubleshooting issues with the CEG and the TMR coordinator

Symptom	Possible cause and solution
The LED of a TMR coordinator connected to the CEG is purple.	Lost MS/TP connection to equipment: • Verify that the MS/TP wiring to the equipment. • Verify that the MS/TP bus is not shorted.
	Duplicate active PAN detected: Verify that the AREA and PAN offset is unique to the site.
	Duplicate MS/TP address: • Verify that the MS/TP Address of the equipment is unique across the MS/TP network. • Verify that the AREA setting is unique if multiple TMR coordinators connect to the same CEG.
The LED of a TMR coordinator connected to the CEG is aqua.	Firmware update is in progress. The TMR coordinator receives a firmware update from the CEG or the TMR coordinator sends a firmware update to another TMR on the network. When the firmware update is complete for all TMRs, the TMR coordinator returns to normal operation. If additional TMRs require firmware updates, the firmware update sequence starts again.

Troubleshooting issues with the TMR routers and the WEFCs

Table 12: Troubleshooting issues with the TMR routers and the WEFCs

Symptom	Possible cause
The WEFC appears intermittently offline in the CEG local UI.	Ensure that a wireless interference source, such as a microwave oven or a 2.4 GHz cordless phone, is not installed near the TMR or the TMR coordinator radio.
The LED of a TMR connected to the MS/TP device blinks in blue and green.	The TMR is attempting to join the PAN. • Verify that the AREA and PAN offset setting matches the TMR coordinator. • Verify that the network is open for joining, that is, the TMR coordinator LED is red. • Verify that the TMR is within RF range of another TMR on the network and it shows open for joining, that is, its LED is red.
The LED of a TMR connected to the MS/TP device is yellow.	The TMR is set as coordinator. To recover the TMR as a router perform a factory reset. The normal operating state color for the TMR is green.

Table 12: Troubleshooting issues with the TMR routers and the WEFCs

Symptom	Possible cause
The LED of a TMR connected to the MS/TP device is purple.	Lost coordinator: • Verify that the associated TMR coordinator is online, that is, its LED is yellow. • Verify that other TMRs in the mesh path are online, that is, their LEDs are green.
	Lost MS/TP connection to equipment: • Verify the MS/TP wiring to the equipment. • Verify that the MS/TP bus is not shorted.
	Duplicate MS/TP address: verify that the MS/TP address of the equipment is unique across the MS/TP network.
The LED of a TMR connected to the MS/TP device is aqua.	Firmware update in progress. The update completes in approximately five minutes and then the TMR returns to normal operation.

Cellular signal strength

You can view the signal strength through the LEDs on the cell modem or through a connection with your PC.

Viewing the signal strength through LED

Table 13: LED colors on the cell modem case

LED color	Troubleshooting
Green	The modem is good, no need to do anything further
Yellow	Log on to the cell modem to get information about signal strength. See Viewing the signal strength from the modem for information about how to log on to the cell modem. Ensure the RSSI and RSRP/RSRQ values are either in excellent (green) or good (yellow) ranges according to the signal strength rubric, see Table 14. If signal strength RSSI and RSRP/RSRQ values are not in excellent or good range, try the following options to bring the cell modem signal under either good or excellent range: • Ensure both the primary and the aux antenna are installed, the left antenna is positioned 45 degree to the left and the right antenna positioned 45 degree to the right to make a 90-degree V-shape. • Relocate the CEG Panel to find a location with better cellular signal. • Remove the cell modem from the panel and find a location with better cellular signal. If none of the options generate a better signal strength, call Connected Offerings Technical Support on (+1 414) 524-5000 option 6, 1, 8, 6, for further options. Alternatively, you can contact Connected Offerings Technical Support through email on: BE-ConnectedOfferingsSupport@jci.com
The LED is off	• Confirm the cellular antennas are correctly connected. • Move the modem to a different location to get either a green or a yellow LED.

Table 14: RSRP and RSRQ signal strength rubric

Signal strength	RSRP value	RSRQ value
Excellent	> -90 dBm	> -9 dB
Good	-90 dBm to -105 dBm	-9 dB to -12 dB
Fair	-106 dBm to -120 dBm	n/a
Fair to poor	n/a	< -13 dB
Poor	< -120 dBm	n/a

Viewing the signal strength from the modem

About this task:
You must connect the cell modem to your PC or laptop to view the signal strength on the modem.

1. Disconnect the cell modem from the CEG Ethernet port.
2. Connect the cell modem to the Ethernet port on your PC or laptop.
   If your PC or laptop is configured to automatically retrieve an IP address, it can obtain the IP address from the device. Otherwise, ensure your PC or laptop can connect to network 192.168.1.0 (255.255.255.0).

3. Open your Internet browser and in the address bar of your browser enter `192.168.1.1`. The first page of the Getting Started wizard appears.
4. Enter the following logon credentials:

   - User name: admin
   - Password: the default password for the cell modem is included on the device label that is located in a packet attached to the inside sleeve of the door of the CEG Panel.

5. Open the **Cellular** window to view the signal strength.

Appendix A: TMR wireless security

The TMR Wireless Field Bus System is secure for the following reasons:

- The over-the-air mesh communication uses AES 128-bit encryption.
- The network coordinator manages when devices can be added to the network and can be software locked to prevent unauthorized access.
- The TMR Series Wireless Field Bus devices transmit data using several short proprietary messages that are collected and reconstructed at the destination. If a piece of the message is intercepted, it is indecipherable to the outside source.

Appendix B: TMR wireless basics

The following information provides a general understanding of Johnson Controls wireless solutions, how the technology works, things to watch out for to avoid issues, and ways to ensure the best performance.

Wireless spectrum basics

- The Johnson Controls wireless solution is based on the 802.15.4 standard operating at 2.4 GHz frequency.
- The 2.4 GHz spectrum is unlicensed and shared with Wi-Fi, streaming video, and Bluetooth.
- Wireless signal quality and reliability is similar to conversation between people in a crowd. The more people carrying on the conversation, it is harder and harder for two people to converse the farther they are from each other. This example illustrates the fundamental principle of signal to noise, where the signal is conversation between two people, and noise is all the other conversations in the crowd.

Building construction impacts

Within the 2.4 GHz spectrum, certain building characteristics can make wireless conversation more challenging.

- Metal within the path of the conversation can impact the quality of both the strength and decoding of the signal. Follow the recommended guidelines for installing the radio devices with respect to metal.

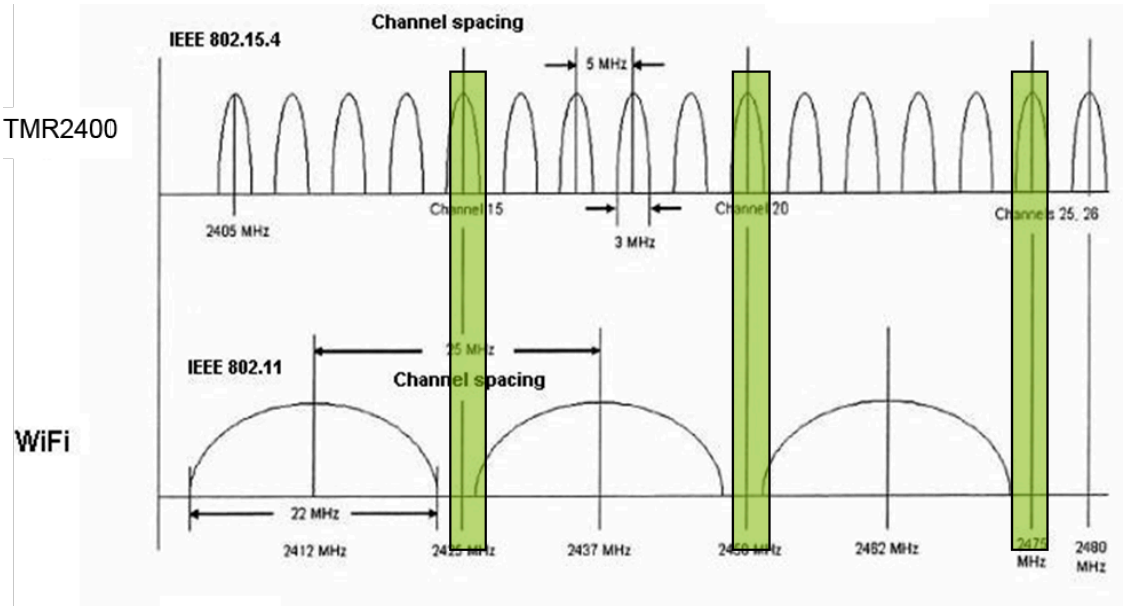
  ⓘ **Note:** Metal is used generically here, but typically refers to large duct runs, metal support structure, metal mesh in plaster walls, for example.

- Other building materials, such as concrete block or poured concrete wall can also create considerable loss to the signal strength.
- Fire walls or doors between building sections.
- Hurricane or tornado concrete construction.

Frequency band utilization

- TMR uses wireless channels between the main Wi-Fi channels.

Figure 10: IEE802.15.4 and IEE802.11 channels

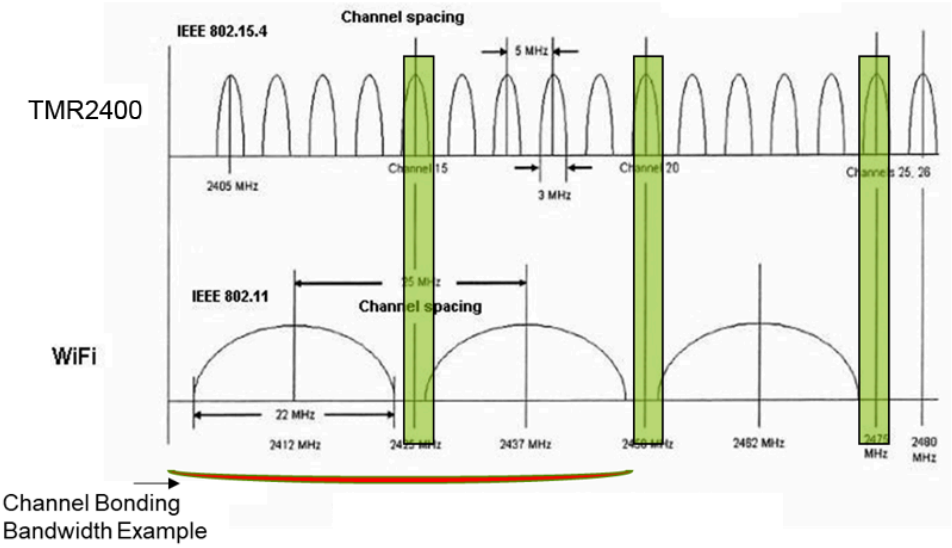


- Same frequency band as IEEE 802.11 (Wi-Fi), but different sized channels, the TMR system automatically selects non-overlapping, quiet channels such as 15, 20, or 25.
- Field-selectable channels for customer requests and custom applications.

Understanding interference

- Some sites may exhibit interference after the initial installation. Not all Wi-Fi is managed within the building, for example, channels are rotated or varied so that the same channel does not exist directly above or below a specific PAN.

Figure 11: IEEE802.15.4 and IEEE802.11 Channels



- IEEE 802.11 **A** and **N** enables channel bonding, which creates a 40 MHz channel and can potentially step on the IEEE 802.15.4 reserved space and cause potential for more communication errors.
- Knowledge of market-based Wi-Fi tools, for example, WiSpy, might be required to properly consider a site as a wireless candidate.

Appendix C: TMR wireless mesh network overview

The TMR wireless mesh network is based on a global open networking standard that defines a low-cost, low-power, two-way wireless communication system. Its development reference comes from the ZigBee Alliance, an organization of manufacturers devoted to providing a cost-effective wireless networking technology for use in commercial and residential applications. The primary advantages that this ZigBee Alliance technology brings to the marketplace include the following:

- High reliability and security
- Low power with multi-year battery life
- Low complexity at an economic cost

Communications technology

The TMR Series wireless network is a Personal Area Network (PAN) based on the Institute of Electrical and Electronic Engineers (IEEE) 802.15.4 standard for low power, low duty-cycle wireless transmitting systems. Devices on the network use Direct Sequence Spread Spectrum (DSSS) wireless technology and operate on the 2.4 GHz Industrial, Science, Medical (ISM) band.

Devices on the TMR Series wireless network are different from Bluetooth devices and wireless Universal System Bus (USB) devices in that they form a mesh network between nodes. Mesh networks are a type of daisy chaining from one device to another. This technique expands the typically short range of an individual node into a much larger, widespread network consisting of multiple nodes.

The Media Access Control (MAC) layer uses a Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) mechanism. This layer transmits beacon requests, synchronizations, and message retries. The physical layer of the ZFR Pro Series wireless network uses the 2.4 GHz radio band.

Network device types

The ZigBee Alliance specification defines three kinds of devices that are part of the mesh network: a coordinator, one or more routers, and one or more end devices.

Parent and child devices

In the TMR Series wireless network, a parent is a device that assigns unique network addresses to other child nodes as they join the network. Any coordinator or router can be a parent to other routers and end devices, but the coordinator is always a parent device.

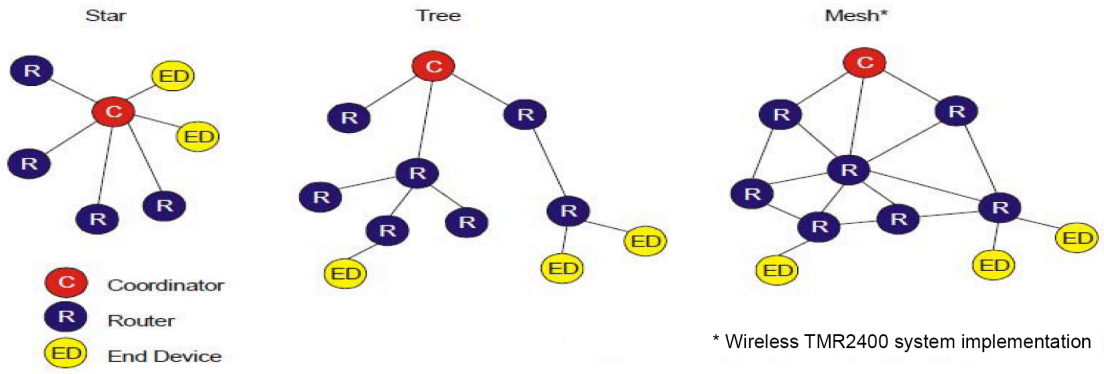
End devices, parent, and target routers

An end device communicates through its parent router. This parent can also be the target of the sensor end device data.

Wireless network topologies

The network topology defines how a message is routed from one node to another. A star network has a central node through which all messages pass. A tree network has a top node with a branch and leaf structure under it in which messages travel up and down the tree as necessary. A mesh network is a modified tree network in which some leaves are linked, enabling messages to travel across the tree when a suitable route is available. The TMR Wireless Field Bus System uses a mesh network.

Figure 12: Wireless network topologies



Self-healing, multi-hop network

The mesh network is further characterized as a self-healing, multi-hop network. If a wireless communication path experiences interference or drops out, the network automatically reroutes the message through an alternate path to form a new wireless communication path. Each message is received, then retransmitted as it hops along from node to node until it reaches its final destination. Within the mesh network, a single message is allowed to hop 30 times between the source and destination node.

TMR system mesh network technology implementation

The TMR Series Wireless Field Bus system implements mesh technology as follows:

- The CEG sets the TMR as the mesh coordinator. It does not accept end devices as child nodes. The coordinator is a parent to the TMR routers.
- The TMR router is a mesh router by default and when connected to MS/TP equipment. The TMR router connects to a wireless coordinator or other TMRs, and can be parent to other TMRs.
- The TMR system does not contain any end devices.

Physical layer channels

The TMR system is based on an Institute of Electrical and Electronic Engineers (IEEE) 802.15.4 ZigBee network definition.

This network has 16 channels available for use (channels 11 through 26). In North America, the TMR can use channels 11 through 25. By default, the TMR coordinator is configured for use in North America, and uses channels 15, 20, and 25.

These channels were selected for the TMR system because they do not overlap with channels used on an IEEE 802.11 Wi-Fi network, unless 802.11 A or N is used.

Appendix D: CEG security

The CEG is secure for the following reasons:

- The CEG requires authentication for user access with an audit log to track logons and commands.
- The CEG Wi-Fi functionality allows access to the CEG Local UI, but it does not create a Wi-Fi hotspot to the Internet.

For more information about CEG security, refer to *Smart Connected Chillers Hardening Requirements Part No. (GPS0030-CE-20220429-EN)*

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Contact information

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