Sensei Infrastructure Manual – EX Model
Intrinsically Safe for Hazardous Locations

31826 – Sensei - Intrinsically Safe - Repeater
31827 – Sensei - Intrinsically Safe – Gateway

Revision Level	Affected Pages	Description of Change	Effective Date	Approval
A	All	Initial Release	12/23/2020	Justin Kolterman
	8,12	Updated Ambient Temperature Specification	6/15/2021	Justin Kolterman
		Updated Installation Instructions to include equipotential bonding instructions	6/15/2021	Justin Kolterman
		Updated Note instructing that the field wiring by a minimum of 14 AWG	6/15/2021	Justin Kolterman
		Added requirement for Ex Cable Gland and conduit	6/15/2021	Justin Kolterman
B		Added Certification and special conditions information	6/15/2021	Justin Kolterman
C	Multiple	Updated documentation to remove AC/DC power supply from the design.	6/28/2021	Justin Kolterman
D	8,12	Update Equipotential Bonding Figure removing power supply from image	8/4/2021	Justin Kolterman
E		Added Certification #s	8/12/2021	Justin Kolterman

Contents

OVERVIEW of the SENSEI RELIABILITY SOLUTION

Trico Corporation's first release of the Sensei Platform of wireless, cloud based, analytic sensing equipment provides real time monitoring of your constant level oiling devices. This product utilizes infrared technology to continuously monitor the oil level in your original Trico Opto-

Matic Oiler or Closed System Opto-Matic Oiler. A two-piece clam shell assembly affixes directly to the world recognized Trico glass reservoir in any new applications and most existing installations. Simply replace the reservoir with this product. Welcome to the next level of practical monitoring.

Why would I want it? The number one issue facing reliability and maintenance personnel is the lack of time and resources to complete everyday tasks. Our goal is to help our customers utilize their resources more efficiently by providing them the tools necessary to retrieve instant data related to the operation of their critical equipment without having to be there.

- Instead of wasting countless hours per week running lube routes topping off your oil applications, this product will communicate to you which machines need attention and when.
- Instead of finding out the pump you checked just yesterday failed because a leak developed and starved the bearing of lubrication, your team can be alerted immediately that there is an issue to attend to.
- Instead of checking a bad actor in some remote location every day, allow this product to monitor the asset lubrication requirements for you, allowing travel only when necessary.

EASY CONFIGURATION and INSTALLATION

The solution was designed from the ground up to ensure that the system would be easy to implement and maintain. The minimum hardware requirement to get Sensei up and running is a Sensei Gateway connected to the internet. Depending on the number of devices and the physical size of your plant, the installation of repeaters may be required. Repeaters will either connect directly to the Sensei Gateway or they will connect to other repeaters in a wireless mesh.

SENSEI INFRASTRUCTURE COMPONENTS

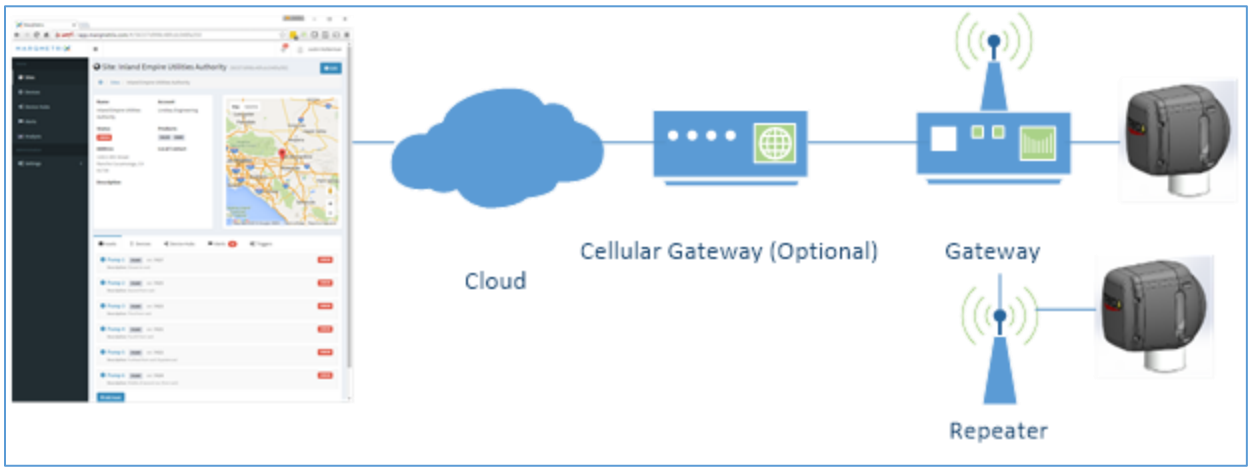

Figure 1: Major infrastructure components of the Sensei system

INFRASTRUCTURE NOTES:

- Repeaters are **not** required. They are used if there are more than 64 devices connected to the network and/or the distance from the Sensei Gateway to the end point is greater than 100m or the signal strength is low i.e. interference from noisy equipment, metal etc.
- The absolute maximum distance between a repeater and Sensei Gateway or a repeater to a repeater is untested but based on testing that we performed with end points the distance should at a minimum be 300'.
- Repeaters can connect to other repeaters or directly to the Sensei Gateway.
- The maximum number of devices on the network is variable but the system works reliably at 250 devices. If an installation is too large for the network, which would be determined by performance, an additional gateway can be added.
- The Sensei Gateway can be connected to a customer's IP Ethernet network or cellular gateway. The requirement is a path to the internet to access https://sensei.tricocorp.com on port 1883.

SENSEI Repeater and Gateway – EX HAZARDOUS LOCATIONS INFORMATION

ATEX Directive Compliance

Trico complies with ATEX directive 2014/34/EU to ensure a safe working environment when working with equipment in potentially explosive atmospheres. The Sensei Repeater and Gateway–Ex device is compliant to the ATEX Directive under Certification ITS-I21ATEX30452X and is suitable for use in II 3G Ex ec nC IIC T4 Gc or Non-Hazardous locations only.

Special conditions for safe use

The product contains non-metallic material as part of the enclosure. Caution must be used when handling or cleaning the product so there is no static charge buildup. Do not wipe off the enclosure with a dry cloth. Use only water damp cloth and allow to air dry for cleaning of the product.

All cable entries into the enclosure shall be fitted with IECEx/ATEX certified cable glands that have a minimum ingress protection of IP54. The cable glands shall have an operating temperature range equal to or greater than the ambient operating temperature.

Class I, Division 2 Groups A, B, C, D Hazardous Location Statement

The Sensei Smart Oiler – EX is suitable for use in Class I, Division 2 Groups A, B, C, D, T4 -20°C ≤ TAMB ≤ +40°C or Non-Hazardous locations only.

Marking and Certification information

North America and Canada CSA Cert#. ETL21CA104506851X
Class I, Division 2, Groups A,B,C, and D, T4
Ex ec nC IIC t4 Gc
-20°C ≤ Ta ≤ +40°Ch

IECEx Cert# IECEx ETL 21.0050X
Ex ec nC IIC t4 Gc

ATEX Cert#: ITS-I21ATEX30452X
(Atex Symbol) II 3 G Ex ec nC IIC T4 Gc
-20°C ≤ Ta ≤ +40°C

UKEX Cert#: ITS21UKEX0325X
(Atex Symbol) II 3 G Ex ec nC IIC T4 Gc
-20°C ≤ Ta ≤ +40°C

Ingress Protection: IP54
Electrical Input: 5-30 VDC
Contains FCC ID: 2SJWF-Metrix01
Contains IC: 21890-Metrix01

Comforms to:
EN IEC 60079-0, 60079-7, 60079-15

The SENSEI GATEWAY

The gateway provides the connection to the outside world for the smart sensor system and is required for every smart sensor system. It requires an internet connection either provided by the customer through their internal systems or packaged with a cellular repeater. The gateway can connect to 64 smart devices at a range of 100m. To extend the range and number of devices repeaters can be added to the system.

Power	5 – 30 VDC 1 Amp Minimum
Mechanical	
Dimensions	203mm x 254mm x 152mm
Enclosure Material	Powder Coated Steel
Network	
Ethernet	10/100 Mbps
Wireless	2.4 GHz 802.15.4
Range	100m line of sight minimum
Connections Supported	Able to support a network of 250 devices
Data Protocols	MQTT
Feedback	LEDs provides feedback regarding network connectivity

Environmental	
Installation	Indoor or outdoor
Operating Temperature	-4 to 104 F (-20 to 40 C)
Ingress Protection Rating	IP54
Wireless Security	
Device Level Authentication	AES-128 encrypted network joining scheme
	Pre-shared key and rotating session key
	AES-128 encrypted secure data transmission

Table 1 Sensei Gateway Specifications

SPECIFICATIONS

REGISTER SENSEI GATEWAY ON YOUR CLOUD ACCOUNT

1. Connect the Sensei Gateway to your site via the Platform Wizard.
    - Navigate and login to https://sensei.tricocorp.com
    - On your site click the gear icon to the right and select "Add a Gateway"

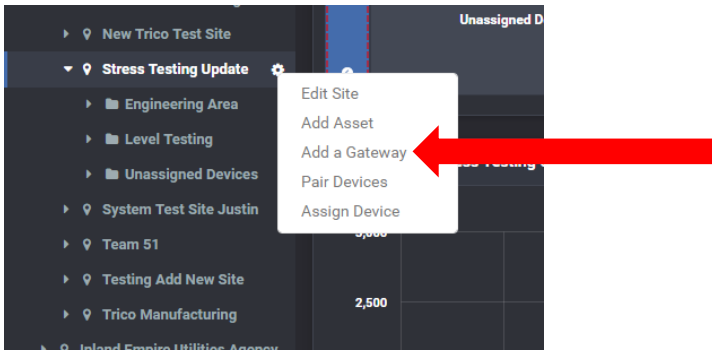

Figure 2 Add a Gateway by right clicking a site in the left menu

2. Enter the 4 digits of your Gateway found on circuit board in the case.

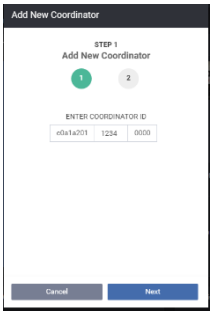

Figure 3 Application window used to enter the ID of the Gateway.

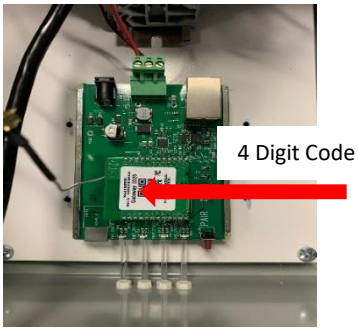

Figure 4 The Gateway serial number can be found on the circuit board.

SENSEI GATEWAY HARDWARE INSTALLATION

MOUNTING

The selection of the mounting location for the device, its controls and the routing of the wiring is to be accomplished under the direction of the facilities and the safety engineer. The gateway is intended to be mounted on any relatively flat and rigid surface. Hardware for mounting the gateway to the surface is left up to the installer. This unit is heavy and should be mounted on a rigid surface capable of supporting the weight of the gateway. The gateway housing has two tabs on top.

ELECTRICAL AND DATA CONNECTIONS

Warning: Do not connect wires when power is applied.

Avertissement : Ne connectez pas les fils lorsque l'alimentation est appliquée.

Note: Requires an equipotential bonding cable

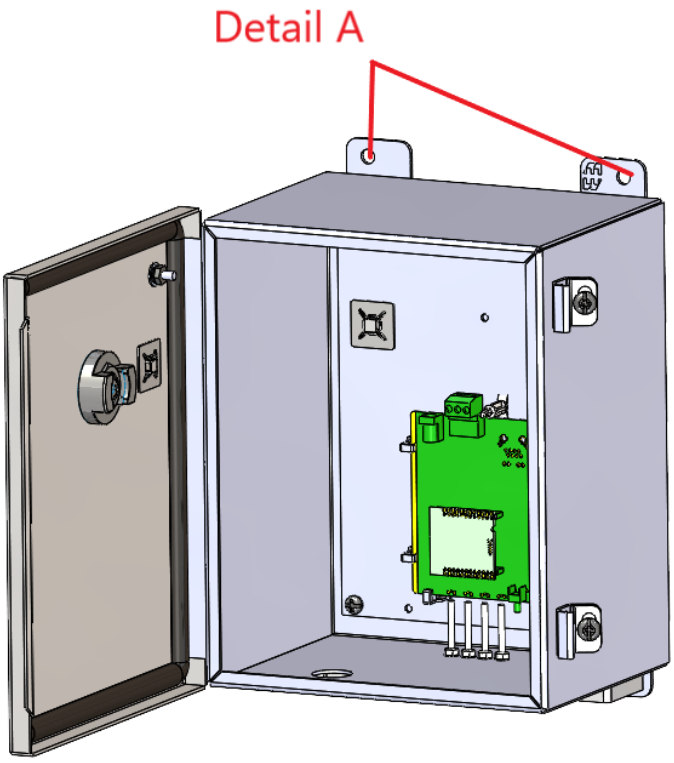

Figure 5 Equipotential (EP) Bonding

Equipotential (EP) Bonding

- Refer to Fig. 5 Detail "A" for allowable EP connections points
- EP Conductor 12AWG (4mm²) minimum
- EP Lug 40A rated minimum, sized for M7 fastener
- Use paint-piercing washer between lug and connection point
- Torque M7 fastener to 4.5N-m

Note: Ensure that the power circuit is connected via a switch or breaker that can be locked out properly in the event the enclosure needs to be opened.

There are 2 ports on the bottom of the enclosure used to supply power and a data connection. Work with the engineering staff in order to determine the proper method of supplying power based on the rating of the area the device is installed in. This will require rated cable glands as well as conduit as determined by the specific electrical codes.

Note: Minimum ratings for cable glands and conduit are as follows:

- (<Ex> II 3G) Ex ec IIC T4 Gc and IP54
- Class I, Zone 2, AEx ecIIC T4 Gc and IP54
- Class I, Division 2, Groups A, B, C, and D, T4 and IP54

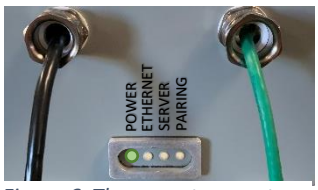

Figure 6 There are two ports on the bottom of the enclosure used to pass power and data into the enclosure. In this figure Ex rated cable glands are being used.

The cable glands in Figure 6 are examples of the type of pass-through connector that should be used.

All wiring to the gateway is terminated to the terminal block within the enclosure. The terminals should be tightened to 0.55 N-m of torque not to exceed .60 N-m. See Figure 7 for detailed installation wiring diagram.

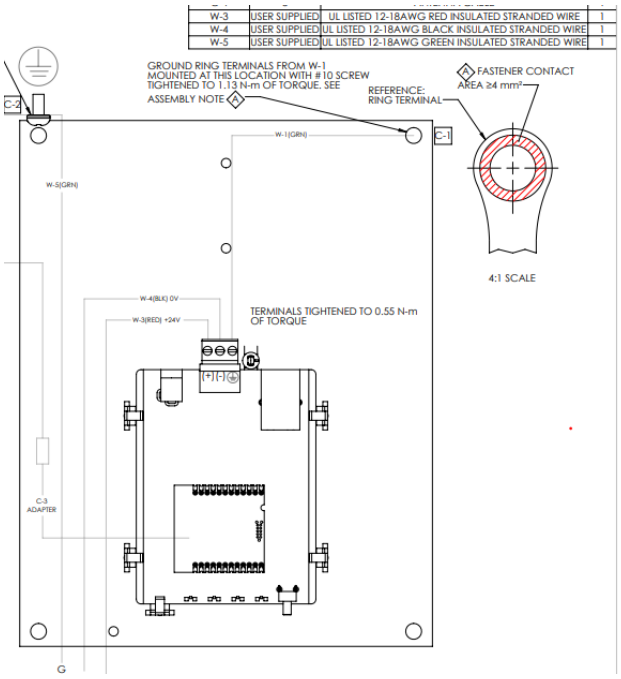

Figure 7 W-3, W-4, and W-5 are all user supplied and should meet the requirements as listed in the table and be wired according to the diagram.

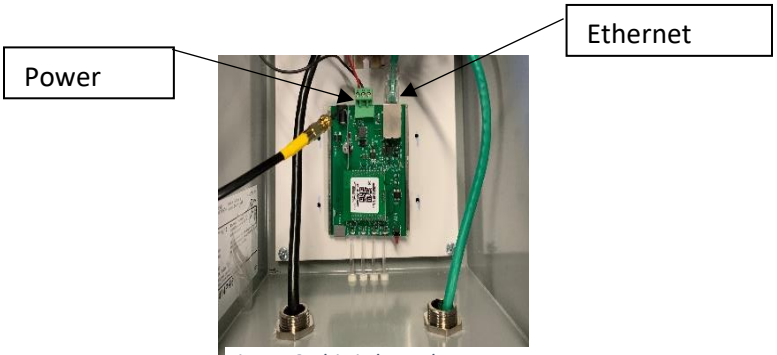

Figure 8 This is how the connections should look after it's completed.

1. Close Enclosure Cover with the (2x) ¼-28 screws and lip bracket (Figure 9). Torque = 3.3895 Nm (30 ft./lb-in.)

Figure 9 Be sure to close the cover properly by tightening the 2 1/4-28 screws to the proper Torque rating.

2. The power source can now be connected. Verify that the Sensei gateway power, network, and server status lights are all green (Figure 10).

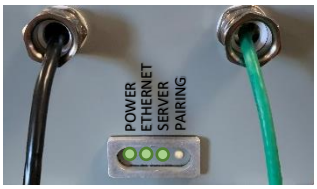

Figure 10 Sensei Gateway status lights. The Power, Ethernet, and Server lights will all turn green if the gateway is configured properly.

SENSEI GATEWAY STATUS INDICATORS

Label	Color	Description
Power	Green	Sufficient Power Supplied
	Red	Insufficient Power from Board
Ethernet	Green	The device was able to get an IP address
	Red	Unable to get an IP address from DHCP
Server	Green	Connected to data platform and ready to send/receive data
	Red	Unable to connect to the data platform
Pairing	Green	Gateway is in pairing mode
	Green Flash	New device added
	Off	Gateway is not in pairing mode
	Red	Gateway failed to enter pairing mode

The SENSEI REPEATER

The repeater provides a mechanism to cover larger areas and systems that have more than 64 oilers. The repeater requires a power supply and should be mounted as high up as possible and away from any large metallic pieces of equipment. The repeater can connect to 64 smart devices at a range of 100m.

REPEATER SPECIFICATIONS

Power	5-30 VDC 1 Amp minimum
Mechanical	
Dimensions	203mm x 254mm x 152mm
Enclosure Material	Powder Coated Steel
Network	
Wireless	2.4 GHz 802.15.4
Range	100m line of sight minimum
Connections Supported	64 devices
Data Protocols	MQTT
Feedback	LEDs provides feedback regarding network connectivity
Environmental	
Installation	Indoor or outdoor
Operating Temperature	-4 to 104 F (-20 to 40 C)
Ingress Protection Rating	IP 54
Wireless Security	
Device Level Authentication	AES-128 encrypted network joining scheme
	Pre-shared key and rotating session key
	AES-128 encrypted secure data transmission

REPEATER INSTALLATION

MOUNTING

The selection of the mounting location for the device, its controls and the routing of the wiring is to be accomplished under the direction of the facilities and the safety engineer. The gateway is intended to be mounted on any relatively flat and rigid surface. Hardware for mounting the gateway to the surface is left up to the installer. This unit is heavy and should be mounted on a rigid surface capable of supporting the weight of the gateway. The gateway housing has two tabs on top.

ELECTRICAL AND DATA CONNECTIONS

Warning: Do not connect wires when power is applied.

Avertissement : Ne connectez pas les fils lorsque l'alimentation est appliquée.

Note: Requires an equipotential bonding cable

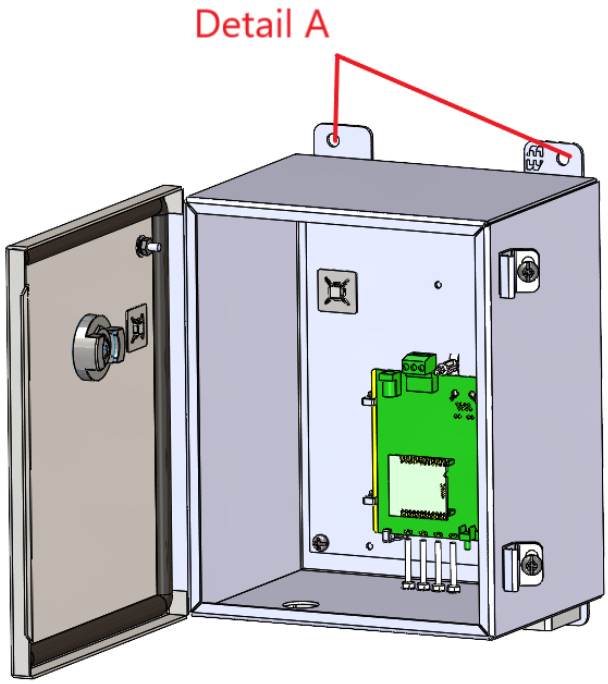

Figure 11 Equipotential (EP) Bonding

Equipotential (EP) Bonding

- Refer to Fig. 11 Detail "A" for allowable EP connections points
- EP Conductor 12AWG (4mm²) minimum
- EP Lug 40A rated minimum, sized for M7 fastener
- Use paint-piercing washer between lug and connection point
- Torque M7 fastener to 4.5N-m

Note: Ensure that the power circuit is connected via a switch or breaker that can be locked out properly in the event the enclosure needs to be opened.

Note: Field connection wiring should be a minimum of 14 AWG.

- (<Ex> II 3G) Ex ec IIC T4 Gc and IP54
- Class I, Zone 2, AEx ecIIC T4 Gc and IP54
- Class I, Division 2, Groups A, B, C, and D, T4 and IP54

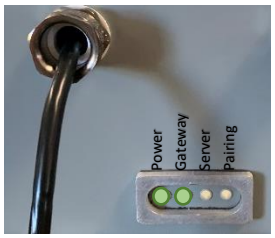

Figure 12 There is a single port on the bottom of the enclosure where the power cable will enter the enclosure. The cable gland used should be rated for the operating environment the repeater is installed.

There is a single port on the bottom of the enclosure used to supply power for the repeater. Work with the engineering staff to determine the proper method of supplying power based on the rating of the area the device is installed in. This will require a rated cable gland as well as conduit as determined by the specific electrical codes. The cable gland in Figure 12 is an example of the type of pass-through connector that should be used.

All wiring to the repeater is terminated to the terminal block within the enclosure. The terminals should be tightened to 0.55 N-m of torque not to exceed .60 N-m. See Figure 13 for detailed installation wiring diagram.

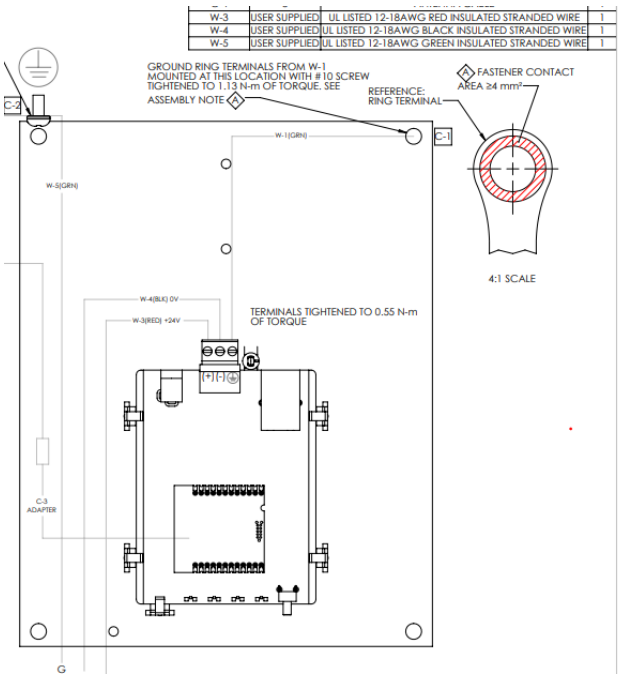

Figure 13 W-3, W-4, and W-5 are all user supplied and should meet the requirements as listed in the table and be wired according to the diagram.

Close Enclosure Cover with the (2x) ¼-28 screws and lip bracket (Figure 14). Torque = 3.3895 Nm (30 ft./lb-in.)

Figure 14 Be sure to close the cover properly by tightening the 2 1/4-28 screws to the proper Torque rating.

Once the enclosure has been sealed properly the power to the repeater can be connected.

Connect the Repeater to the Network

The Sensei Repeater is added to the network by setting the Sensei Gateway to pairing mode.

Set System to Pairing Mode via Pair Button on Gateway

This can be done by pushing the pair/reset button inside the Gateway on the circuit board (Figure 15).

******Warning this should only be performed when the Gateway is outside of a hazardous zone*

***** Cet avertissement ne doit être exécuté que lorsque la passerelle se trouve en dehors d'une zone dangereuse

Figure 15 Press the red pairing button on the Sensei Gateway to add Sensei Repeaters to the network.

Devices can be added to the network by pressing the pairing button on the Sensei Gateway. If the Gateway is installed in a hazardous location, you can set the system to pairing through the web application

Set System to Pairing Mode Online

Click on the gear icon next to site that you would like to set to pairing mode (Figure 16) and select “Pair Devices” from the menu options

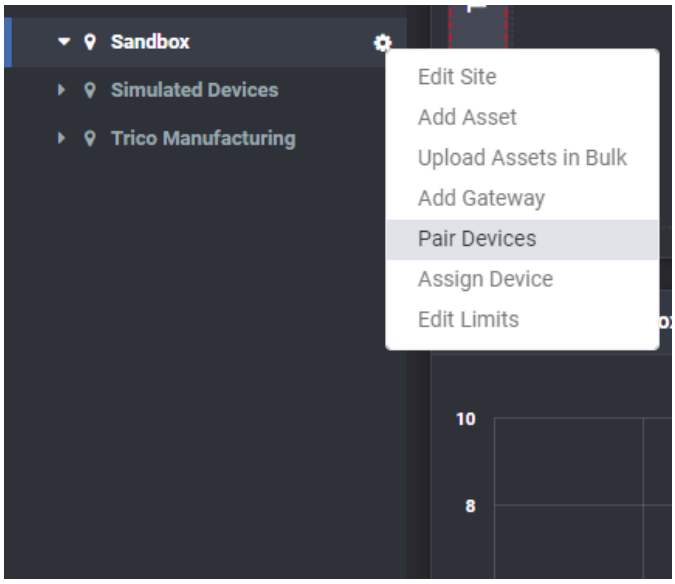

Figure 16 Access site options by clicking on the gear icon next to your site. Select pair devices to get a list of gateways available for your site.

Select the Gateway that you would like the repeater to connect to and then click the "Toggle" button (Figure 17). *Note: Most locations will only have 1 option.*

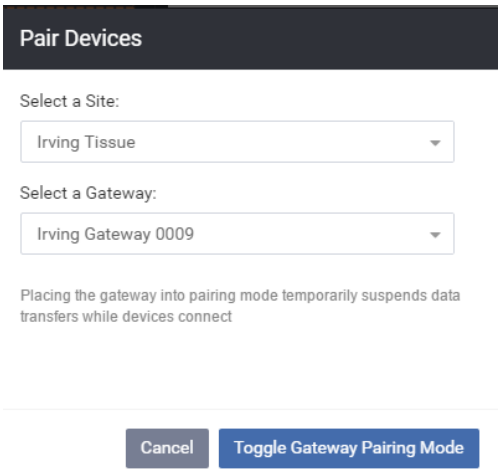

Figure 17 Select the Gateway that you would like to put into pairing mode.

The repeater “Gateway” light will turn green once it has successfully connected to the gateway (Figure 18). The system infrastructure is now set up and ready for smart devices to be added.

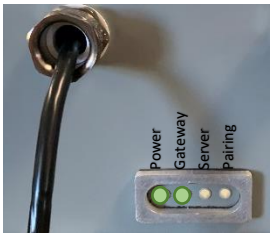

Figure 18 The "Gateway" status light will turn green once it has successfully connected to the network.

SECURITY ARCHITECTURE

WIRELESS ENCRYPTION

The Zigbee wireless network uses a custom security model. The gateway functions as a limited Zigbee Trust Center and manages connection/disconnection and key rotations. All network communications are encrypted using a session key. The session key is chosen at random by the repeater. This key is used in conjunction with a pre-shared key that is part of the device's firmware.

WIRELESS NETWORK JOIN

Each device joins the wireless network initially via a join. Joins are only allowed when the gateway is in pairing mode. The joining device joins using a pre-shared key that is programmed at the point of manufacturing. The gateway verifies that the joining device knows the pre-shared key and allows the device to join the network by sending the current session key. The device uses the session key to encrypt and decrypt traffic to and from, respectively, gateway.

WIRELESS NETWORK KEY ROTATION

The gateway changes the session key every 24 hours. The new key is sent to all devices encrypted using the current key. Later, after all devices should have received the new key, the repeater sends out a network key change message and the repeater and devices switch over to use the new key. If a device doesn't get the new key or see the network key change message, it disconnects to the network and performs a rejoin using the pre-shared key method that a normal join uses.

ETHERNET ENCRYPTION

The gateway performs server authentication by verifying that the server knows the pre-shared key. This key is a different key than the bootloader and Zigbee network pre-shared keys. The repeater opens a TCP/IP connection to the server on port 1883 (MQTT port). Once a TCP/IP connection has been established, the device makes an MQTT connection and subscribes to the server's general channel to

receive communication from the server. The repeater also exposes its general channel for use by the server.

After the TCP/IP and MQTT connections are established, the server and repeater start the authentication process. This process is meant as a simple way of authenticating the server and encrypting communication between the server and repeater.

After the authentication process is complete the repeater will only send messages encrypted by the session key. Session keys are chosen randomly once per connection. They exist if the connection between the server and repeater remains connected. Each time the repeater and server reconnect, a random session key is chosen.

ENCRYPTED FIRMWARE UPDATES

OTA (over-the-air) firmware upgrades are served by the repeater to the other devices on the radio network. These upgrade images are served via the repeater's OTA server. This server responds to firmware upgrade requests from devices in the system and provides the version of the available update and tells the device whether it should download the upgrade or not. If the device is told to upgrade, it downloads the OTA firmware image from the repeater. The download is broken up in too many individual packets. These packets are encrypted using the session key.

When a device has downloaded a complete OTA firmware upgrade image, it performs some preliminary validation (the reset is performed by the secure bootloader) and asks the OTA server on the repeater if it can upgrade. If the repeater indicates that it should upgrade, it does so immediately. If the repeater does not respond, the device will upgrade automatically after a few minutes. Devices start the upgrade by telling the bootloader to run. The bootloader checks for an image and, if one is present, validates it and performs the upgrade as described below.

BOOTLOADER ENCRYPTION

Each device has an encrypted bootloader. The bootloader software is responsible for verifying that the image is valid and was created using the correct bootloader key. The bootloader key is unique to each device type. All devices of the same type have the same pre-shared bootloader key.

When the bootloader is told to upgrade, the firmware using the encrypted image in flash, the following tests are performed on the image:

- Validate that the image was encrypted using the bootloader key for this device type
- Verify that the image can be decrypted using the bootloader key
- Verify that the image is for this device type
- Verify that the image contents match the image checksum

If all the above tests pass, the bootloader copies the decrypted firmware to the processor's internal flash and executes the new firmware image.

WARRANTY

Trico Corporation warrants each new product to be free from defects in materials and workmanship under normal use and service for a period of twelve (12) months from the date of sale to the original end user. If within the applicable warranty period any Trico Corporation product that shall be proved to Trico Corporation's satisfaction to be defective, shall be repaired or replaced at Trico Corporation's sole discretion.

Trico Corporation's warranty obligation shall be limited to repair or replacement of determined defective products. This obligation shall not include any of the user's costs of labor, whether for product removal, reinstallation or otherwise, and shall be conditioned upon Trico Corporation receiving written notice of any warranty claim within thirty (30) days after defect discovery. This remedy is exclusive and shall not be deemed to have failed of its essential purpose so long as Trico Corporation is willing and able to repair or replace the parts in question or issue a credit to the user within a reasonable time after the user has establish that a warranty claim exists.

EXCEPTIONS and EXCLUSIONS

This warranty shall not apply to products which have been subjected to unauthorized use, alteration or modification, user's negligence, an accident, damage due to shipper's handling, storage conditions or any neglect, breakage, unauthorized or improper modifications or tampering, use in an unsuitable physical environment, use with a marginal power supply, or use with other inadequate facilities or damage caused by circumstances beyond Trico Corporation's control. Reasonable care must be taken by the Customer to avoid such hazards. This warranty also shall not apply to products that are used or operated improperly, improperly maintained or improperly installed. There are no warranties which extend beyond the description contained within this document.

EXCLUSION OF CONSEQUENTIAL DAMAGES AND DISCLAIMER OF LIABILITY

Trico Corporation's liability with respect to breaches of warranty shall be limited as provided in the section "SENSEI PRODUCT WARRANTY" hereof. With respect to other breaches of contract, Trico Corporation's liability shall in no event exceed the purchase price of the subject goods that were purchased from Trico Corporation. Trico Corporation shall not be subject to and disclaims: (1) any other obligations or liabilities arising out of breach of contract or of warranty, (2) any obligations whatsoever arising from Tort claims to include without limitation, negligence and strict liability with respect to products sold by Trico Corporation, or any undertakings, acts or omissions relating thereof, and (3) any and all consequential, incidental and contingent damages of any nature. Without limiting the generality of the foregoing, Trico Corporation specifically disclaims any liability for penalties (including administrative penalties), special or punitive damages, damages for lost profits or revenues, damages for loss of use of products or any associated equipment, cost of capital, facilities or services, downtime, shut-down or slowdown costs, or for any other types of economic loss.

RETURN MATERIAL AUTHORIZATION

The customer must obtain a return material authorization (RMA) number from Trico Corporation before returning any products for repair or replacement. All customers are requested to contact the Customer Service department at Trico in advance for return authorization of any product for any reason. Contact can be made, using the contact information listed below, via mail, email, phone or fax. In order to expedite this process, please have the product serial number available. The serial number can be found on the top of the product. No products will be accepted by Trico Corporation which do not have an RMA number.

Trico Customer Service
1235 Hickory St.
Pewaukee, WI 53072
800-558-7008 or 262-691-9336
Fax: 262-691-2576
www.tricocorp.com

WARRANTY REPAIR

The customer may return a product that is covered by warranty for repair after obtaining an RMA number. Any product covered by warranty is repaired or replaced, free of charge. All repairs carry a 90-day warranty or the remainder of the initial warranty period, whichever is longer, which begins the day the repaired item is shipped back to the customer. Returned items must be accompanied by proof of purchase denoting purchase date, a written description of the defect, and the RMA number issued by Trico Corporation. The end-user shall return the defective product to Trico Corporation, at the above address, freight, customs and handling charges prepaid. End-user agrees to accept all liability for loss of or damages to the returned product during shipment. Trico Corporation shall repair or replace the returned product, at its option and return the repaired or replaced new product to the end-user, freight prepaid, via method to be determined by Trico Corporation. All returns must include a RMA # on the packaging. If the product is not defective, customer is responsible for outbound shipping costs. International customers are responsible for both inbound and outbound freight charges, customs and duties on returns.

NONWARRANTY REPAIR

The customer may return a product for repair that is not covered by warranty. A standard repair fee, specific to the product, is charged for any product that is repaired outside of the warranty period. Repairs performed on products out of warranty also carry a 90-day warranty, which begins the day the repaired item is shipped back to the customer. The customer will be charged for all repair costs, labor, diagnostic fees and shipping. A repair quote will be provided upon

request. If the customer chooses not to have the unit repaired after receiving the quote, a request can be made to have the unrepaired product shipped back. This request must be made within 30 days or returned products will be disposed of.