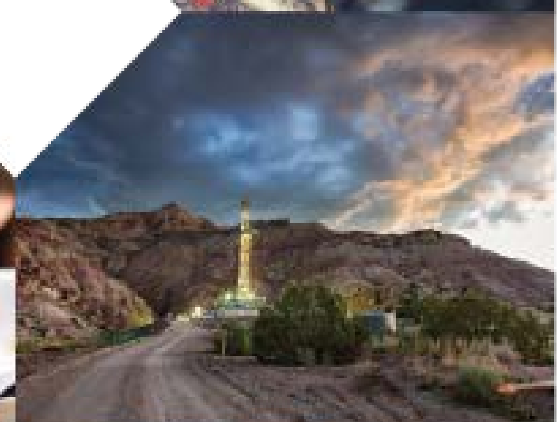

User Guide

cnReach™ N500

System Release: 01-40

(900 MHz, 700 MHz, 450 MHz, 220 MHz)

Quick Start One-Page Reference

Current Software Version

This user guide reflects system release 01-40 containing the following software versions which can be downloaded from the Cambium Networks support website:
https://support.cambiumnetworks.com/files/n500/

OS firmware: cn-EBX.5.2.18c_update (radios in enclosures)
cn-EMA.5.2.18c_update (for board-level radios)

Radio firmware:
rf_1.52.19110-400jumbo (for both 450 MHz FCC and 450 MHz ETSI RED models)
rf_1.52.19110-700g2 (for 700 MHz radios)
rf_1.52.19110-900jumbo (for all 900 MHz radios)

For 220 MHz, the radio firmware is:
rf_1.51. 18494-200

Optional Software Modules:

cs-5.2.18c_module	(for high-availability 1+1 station)
wr-5.2.18c_module	(for wire replacement feature)
plc-5.2.18c_module	(for local PLC feature)
dc-5.2.18c_module	(for data concentrator feature)

Caution

The optional software modules MUST have the same version number of the OS firmware. A mixture of version numbers between the OS firmware and optional software modules will results in radio melfuntioning.

Caution

Note that there are different radio firmware files depending on the band of the radio. The band is denoted in the filename (eg. 450 = 450 MHz radios; 900 = 900 MHz).

Default Login Information

Default IP address: 192.168.0.3
Default Username: admin
Default Password: admin

Please refer to the Obtaining an Unknown IP Address section in the Quick Start Guide if you cannot access the User Interface.

Accessing the User Interface

The User Interface is accessed by initiating a secure HTTPS connection (or HTTP connection depending on the radio's configuration) from a Web Browser, via direct Ethernet port connection or active radio link.

- Ensure that your laptop is configured with an IP address on the same subnet as the default IP address.
- Type **https://<IP ADDRESS>** in the URL box; i.e. **https://192.168.0.3**

- If this is the first time attempting to connect via https the browser may prompt you regarding privacy. Certificates are usually associated with fully-qualified domain names and not individual IP addresses, so this prompt is completely normal.

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Cambium and its supplier(s) specifically disclaim any express or implied warranty of fitness for any high risk activities or uses of its products including, but not limited to, the operation of nuclear facilities, aircraft navigation or aircraft communication systems, air traffic control, life support, or weapons systems ("High Risk Use"). Any High Risk is unauthorized, is made at your own risk and you shall be responsible for any and all losses, damage or claims arising out of any High Risk Use.

Contents

About This User Guide

This guide contains the following chapters:

- Chapter 1: Product Description
    - An overview of cnReach with model numbers, descriptions of accessories, etc.
- Chapter 2: System Configuration
    - A page-by-page walkthrough of the GUI with explanations and recommendations for each setting.
- Chapter 3: Technical Reference
    - Detailed descriptions of the technologies and techniques used by cnReach. Also reference tables for capacity, link budgets and payload sizes.
- Chapter 4: Tasks and Best Practices Network Deployments
    - Recommendations for performing common tasks associated with designing, deploying and maintaining cnReach networks.
- Chapter 5: Legal and Regulatory

Contacting Cambium Networks

Support website:	http://support.cambiumnetworks.com/
Main website:	http://www.cambiumnetworks.com
Sales enquiries:	solutions@cambiumnetworks.com
Telephone number list:	http://www.cambiumnetworks.com/contact
Address:	Cambium Networks Suite 360 3800 Golf Road Rolling Meadows, IL 60008

Purpose

Cambium Networks cnReach N500 documents are intended to instruct and assist personnel in the operation, installation and maintenance of cnReach equipment and ancillary devices. It is recommended that all personnel engaged in such activities be properly trained.

Cambium Networks disclaims all liability whatsoever, implied or express, for any risk of damage, loss or reduction in system performance arising directly or indirectly out of the failure of the customer, or anyone acting on the customer's behalf, to abide by the instructions, system parameters, or recommendations made in this document.

Cross references

References to external publications are shown in italics. Other cross references, emphasized in blue text in electronic versions, are active links to the references.

This document is divided into numbered chapters that are divided into sections. Sections are not numbered, but are individually named at the top of each page, and are listed in the table of contents.

Feedback

We appreciate feedback from the users of our documents. This includes feedback on the structure, content, accuracy, or completeness of our documents. Send feedback to solutions@cambiumnetworks.com .

Important regulatory information

Refer to Chapter 5: Legal and Regulatory Information

Problems and warranty

Reporting problems

If any problems are encountered when installing or operating this equipment, follow this procedure to investigate and report:

- Search this document and the software release notes of supported releases.
- Visit the support website. (http://support.cambiumnetworks.com)
- Ask for assistance from your Cambium Networks channel partner.
- Gather information from affected units, such as any available diagnostic downloads.
- Escalate the problem by emailing or telephoning support
- Make a post on the Cambium Networks community forum: http://community.cambiumnetworks.com

Repair and service

If unit failure is suspected, obtain details of the Return Material Authorization (RMA) process from the support website.

Hardware warranty

Cambium's standard hardware warranty is for one (1) year from date of shipment from Cambium Networks or a Cambium distributor. Cambium Networks warrants that hardware will conform to the relevant published specifications and will be free from material defects in material and workmanship under normal use and service. Cambium shall within this time, at its own option, either repair or replace the defective product within thirty (30) days of receipt of the defective product. Repaired or replaced product will be subject to the original warranty period but not less than thirty (30) days.

To register products or activate warranties, visit the Cambium Networks support website. For warranty assistance, contact the reseller or distributor.

Cambium offers extended warranties on cnReach hardware. The following model numbers are available for ordering from your Cambium channel partner. Extended warranties can be added to provide a total of up to 5 years. In addition, an All Risks Advanced Replacement option is available that covers all but negligent or intentional damages and provides for a replacement to be sent to you prior to the return of the damaged device.

Part Number	Description
EW-E1NBN51-WW	cnReach N500 Single Radio Extended Warranty, 1 Additional Year
EW-E2NBN51-WW	cnReach N500 Single Radio Extended Warranty, 2 Additional Years
EW-E1NBN52-WW	cnReach N500 Dual Radio Extended Warranty, 1 Additional Year

EW-E2NBN52-WW	cnReach N500 Dual Radio Extended Warranty, 2 Additional Years
AR-E0NBN51-WW	cnReach N500 Single Radio - Upgrade to All Risks Advanced Replacement Program during 1st Year warranty
AR-E1NBN51-WW	cnReach N500 Single Radio - Extended Warranty and All Risks Advanced Replacement Program, 1 Additional Year
AR-E2NBN51-WW	cnReach N500 Single Radio - Extended Warranty and All Risks Advanced Replacement Program, 2 Additional Years
AR-E0NBN52-WW	cnReach N500 Dual Radio - Upgrade to All Risks Advanced Replacement Program during 1st Year warranty
AR-E1NBN52-WW	cnReach N500 Dual Radio - Extended Warranty and All Risks Advanced Replacement Program, 1 Additional Year
AR-E2NBN52-WW	cnReach N500 Dual Radio - Extended Warranty and All Risks Advanced Replacement Program, 2 Additional Years

Caution

Using non-Cambium parts for repair could damage the equipment or void warranty. Contact Cambium for service and repair instructions.

Portions of Cambium equipment may be damaged from exposure to electrostatic discharge. Use precautions to prevent damage.

Security advice

Cambium Networks systems and equipment provide security parameters that can be configured by the operator based on their particular operating environment. Cambium recommends setting and using these parameters following industry recognized security practices. Security aspects to be considered are protecting the confidentiality, integrity, and availability of information and assets. Assets include the ability to communicate, information about the nature of the communications, and information about the parties involved.

In certain instances, Cambium makes specific recommendations regarding security practices, however the implementation of these recommendations and final responsibility for the security of the system lies with the operator of the system.

To report a potential vulnerability in Cambium Networks products or report an incident involving the Cambium Networks corporate network please email us at security@cambiumnetworks.com.

If you'd like to receive e-mail notifications of known vulnerabilities and security advisories visit our website at https://www.cambiumnetworks.com/security/ to sign up.

Warnings, cautions, and notes

The following describes how warnings and cautions are used in this document and in all documents of the Cambium Networks document set.

Warnings

Warnings precede instructions that contain potentially hazardous situations. Warnings are used to alert the reader to possible hazards that could cause loss of life or physical injury. A warning has the following format:

Warning

Warning text and consequence for not following the instructions in the warning.

Cautions

Cautions precede instructions and are used when there is a possibility of damage to systems, software, or individual items of equipment within a system. However, this damage presents no danger to personnel. A caution has the following format:

Attention

Caution text and consequence for not following the instructions in the caution.

Notes

A note means that there is a possibility of an undesirable situation or provides additional information to help the reader understand a topic or concept. A note has the following format:

Note

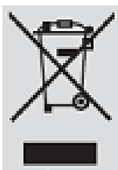
Note text.

Caring for the environment

The following information describes national or regional requirements for the disposal of Cambium Networks supplied equipment and for the approved disposal of surplus packaging.

In EU countries

The following information is provided to enable regulatory compliance with the European Union (EU) directives identified and any amendments made to these directives when using Cambium equipment in EU countries.



Disposal of Cambium Networks equipment

European Union (EU) Directive 2002/96/EC Waste Electrical and Electronic Equipment (WEEE)

Do not dispose of Cambium equipment in landfill sites. For disposal instructions, refer to http://www.cambiumnetworks.com/support

Disposal of surplus packaging

Do not dispose of surplus packaging in landfill sites. In the EU, it is the individual recipient's responsibility to ensure that packaging materials are collected and recycled according to the requirements of EU environmental law.

In non-EU countries

In non-EU countries, dispose of Cambium equipment and all surplus packaging in accordance with national and regional regulations.

Chapter 1: Product Description

cnReach N500 Radio Module

cnReach System

For outdoor critical infrastructure operations, *cn*Reach solutions transport process monitoring and control data from the remote sensor back to the operations center supporting real-time automated decision making and on-going analytics. Covering large geographic areas, hard to reach terrain and challenging spectrum environments, *cn*Reach delivers reliable, secure connectivity to the petrochemical, electric utility, water/wastewater/stormwater and transportation industries. *cn*Reach eases the migration to modern networks by combining legacy serial and analog/digital I/O with TCP/IP and Ethernet connectivity. Fully integrated into a 'single pane-of-glass' management platform (*cn*Maestro™) *cn*Reach helps bridge the IT/OT sides of complex organizations. Combining *cn*Reach's licensed and unlicensed narrow-band radios with Cambium Networks' broadband technologies, industrial organizations are delivering end-to-end Industrial "Internet of Things" solutions today.

A cnReach system consists of the following components:

- Radio modules available in multiple frequency bands; access to spectrum depends on geographic location and your access to the spectrum to be used:
    - Frequencies
        - Licensed and unlicensed 900 MHz
            - FCC models
            - Australia models
        - Licensed 757-758 and 787-788 MHz for United States only
        - Licensed 450 MHz
            - ETSI RED models (covers 406 MHz to 470 MHz)
            - US/FCC models (covers 406-430 AND 450-470 MHz)
        - Licensed 220 MHz (217 to 222 MHz) for United States and New Zealand only
    - Single or dual radio modules
    - With or without built-in analog/digital I/O
- Accessories
    - 24 VDC Power supplies (AC input 'bricks' or DIN-rail mount AC supplies)
    - Yagi, Omni and 'whip' antennas
    - Yagi and Omni antennas can be purchased with or without an installation kit that includes cabling, surge suppression, grounding and weather-proofing
    - DIN-Rail mounts
    - DB-9 to RJ-45 adaptor for accessing the serial port on the radio
    - Spare power and I/O connectors
- LINKPlanner
    - A planning and deployment tool made available by Cambium Networks
    - Easy-to-use graphical interface that integrates with Google Earth or Google Maps
    - Provides predictions of link performance and reliability
    - Provides a bill of materials

  - Provides an installation report to simplify the installation and alignment of cnReach radios
  - LINKPlanner can be downloaded at no cost from the Cambium Networks website at http://www.cambiumnetworks.com/linkplanner
- cnMaestro
  - Full life-cycle network management solution for networks based on Cambium Networks equipment.
  - Supports on-boarding, performance, fault and configuration management in a single pane-of-glass
  - Available in both cloud and on-premises versions.
- cnReach radios are often installed in NEMA enclosures as cnReach radios and power supplies are not designed for deployment in water or dust environments.

cnReach N500 Radio Modules

An overview of the cnReach N500 Radio Modules is provided in this section. More details are available in the technical reference section of Chapter 3.

The N500 is available in 900 MHz with the same radio supporting both MAS licensed and ISM unlicensed spectrum. cnReach is also available in additional licensed bands 700 MHz, 406-430 and 450-470 MHz and 217-222 MHz. In 900 MHz unlicensed operation, the radio operates in a frequency hopping spread spectrum mode which hops on various frequencing never dwelling on the same channel for very long. In licensed mode operation, the radio operates solely on the channel or channel-pair allocated. In all cases, cnReach operates as a TDD radio.

The N500 series has a flexible set of I/O options including two serial ports, two Ethernet ports and optional integrated I/O.

In 900 MHz unlicensed band, the radio can be deployed in point-to-point (PTP), point-to-multipoint PMP) store-and-forward and back-to-back repeater modes.

In licensed bands, the radio can be deployed in point-to-point (PTP), point-to-multipoint PMP) and back-to-back repeater modes.

Key Features include:

- Layer 2 Bridging and Layer 3 Routing
- Adaptive Modulation
- Single and Dual Radio options for advanced relay and store-and-forward applications
- AP Synchronization
- Secure communications with AES 128/256-bit encryption with password authentication
- Extensive I/O capabilities easing the transition from serial to all-IP networks with multiple serial ports, Ethernet ports and analog/digital I/O built-in

cnReach radios all have the same design with front access to communication ports and side access to RF and I/O connections. The radio may or may not be DIN rail mounted with an optional DIN-rail mount connector. The top of the radio enclosure is a heat sink needed for high-power dual-radio applications – the finned heat sink surface should be kept clear of any materials. The practice of stacking radios on top of each other is not recommended as a gap should always be maintained between radios to aid with heat dissipation.

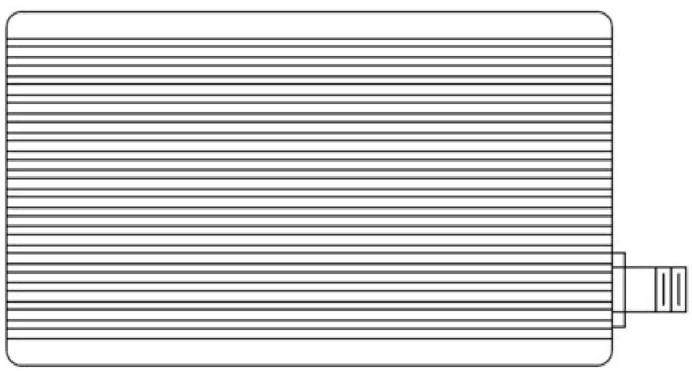
The front of the radio includes (from left to right) a 10-32VDC power connector, two RJ-45 serial port connectors, two RJ-45 Ethernet port connectors, a USB connector (not currently used), and two sets of indicator lights for up to two radio modules.

The left side of the radio may have I/O connectivity as an option. The radio can be ordered with or without analog/digital I/O. For radios without integrated I/O the left-side connector is used for synchronization.

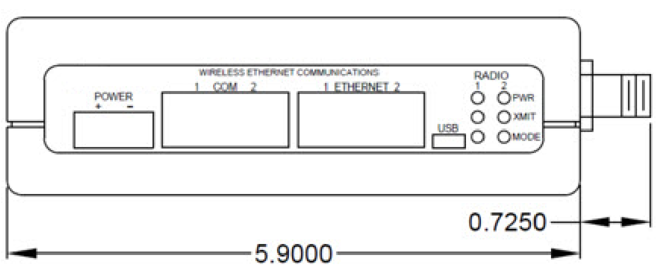
Figure 1: Front of cnReach N500

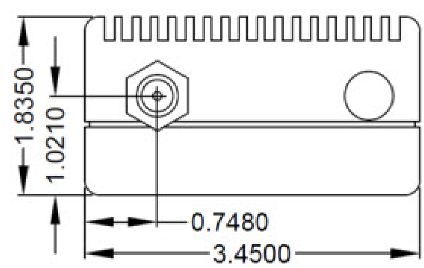
Depending on model, the right side of the enclosure will have either one or two female TNC connectors…

- 1 x TNC; cnReach Single Radios.
- 2 x TNC; cnReach Dual Radios.



Measurements in Inches





The table below lists the available radio modules (note the presence of single and dual modules as well as regulatory regions).

Model #	Model Description
NB-N500910B-US	N500 900 MHz Single
NB-N500911B-US	N500 900 MHz Single with IO
NB-N500920B-US	N500 900 MHz Dual
NB-N500921B-US	N500 900 MHz Dual with IO
NB-N500910B-AU	N500 900 MHz Single - Australia
NB-N500911B-AU	N500 900 MHz Single with IO - Australia
NB-N500920B-AU	N500 900 MHz Dual - Australia
NB-N500921B-AU	N500 900 MHz Dual with IO - Australia
NB-N500710A-US	N500 700 MHz Single
NB-N500711A-US	N500 700 MHz Single with IO
NB-N500720A-US	N500 700 MHz Dual
NB-N500721A-US	N500 700 MHz Dual with IO
NB-N500410B-US	N500 450 MHz Single
NB-N500411B-US	N500 450 MHz Single with IO
NB-N500420B-US	N500 450 MHz Dual
NB-N500421B-US	N500 450 MHz Dual with IO
NB-N500430A-EU	N500 450 MHz Single - ETSI RED
NB-N500431A-EU	N500 450 MHz Single with IO - ETSI RED
NB-N500440A-EU	N500 450 MHz Dual - ETSI RED
NB-N500441A-EU	N500 450 MHz Dual with IO - ETSI RED
NB-N500210B-US	N500 220 MHz Single
NB-N500211B-US	N500 220 MHz Single with IO
NB-N500220B-US	N500 220 MHz Dual
NB-N500221B-US	N500 220 MHz Dual with IO

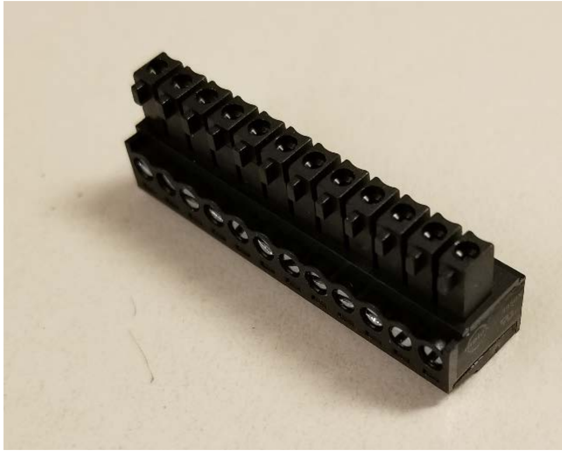
Accessories

Several accessories are available for cnReach deployments.

The IO expander is a cnReach module with no radios. It can be used to add Serial or Analog/Digital I/O to a broadband network or additional I/O to a narrowband network. It is managed and configured in the same way as a cnReach radio from a networking and management perspective.

NB-N500001A-US	N500 IO Expander
NB-N500002A-US	N500 Power Connector, Spare
NB-N500003A-US	N500 IO Connector, Spare
NB-N500004A-US	N500 DIN Rail Mount
NB-N500005A-US	N500 RJ45-DB9 Adaptor
NB-N500013A-GL	Power Supply, AC to 24VDC, DIN RAIL MOUNT
NB-N500006B-US	N500 AC to 24 VDC Power Supply with US line cord
NB-N500011B-GL	N500 AC to 24 VDC Power Supply (no line cord)

Each cnReach radio module ships with a power connector and an I/O connector. The model listed here are for spares purposes to replace lost or damaged connectors. Pictured below are the spare power connector and spare I/O connector.



The DIN Rail Mount allows for mounting the cnReach module on a standard DIN rail.

Cambium offers two power supplies for cnReach. The first is an AC brick useful for bench testing or temperature controlled environments. The second is a DIN rail supply that covers a wide temperature range and is mountable in a NEMA enclosure next to a cnReach DIN mounted radio.

Attention

The DIN-rail supply does NOT come with a line cord. Also note the availability of the 'brick' supply without a line cord for import into countries using a non-U.S. style cord..

NB-N500006B-US

N500 AC to 24 VDC Power Supply with US line cord

NB-N500011B-GL

N500 AC to 24 VDC Power Supply (no line cord)

NB-N500013A-GL

Power Supply, AC to 24VDC, DIN RAIL MOUNT

Antennas

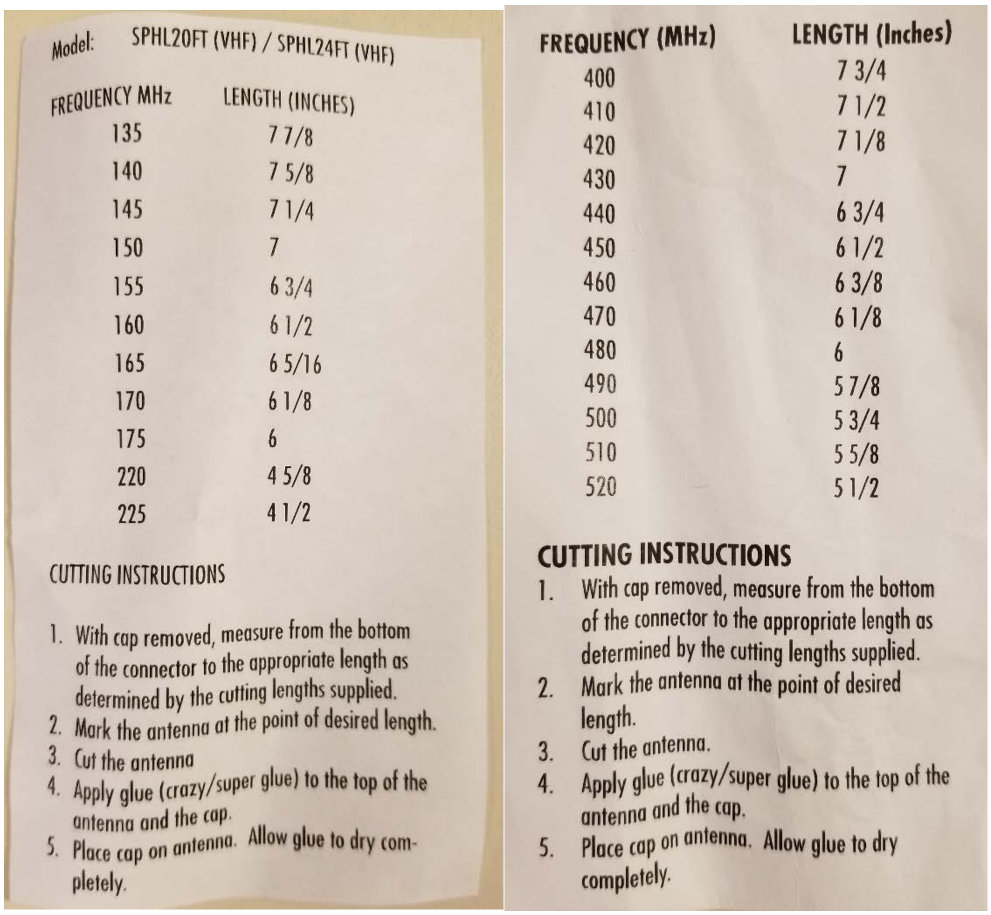
Cambium Networks offers a range of antenna options and installation kits to assist in the deployment of a complete system.

For bench testing and trials, a series of 'whip' low-gain omni antennas is available for each band.

NB-N500008A-US	N500 900 MHz Whip Antenna
NB-N500009A-US	N500 700 MHz Whip Antenna
NB-N500010A-US	N500 450 MHz Whip Antenna
NB-N500012A-US	N500 220 MHz Whip Antenna

These whip antennas generally net out to unity gain or close to 0dB. Picture below are the whip antennas from left to right (220 MHz, 450 MHz, 700 MHz and 900 MHz)

Note that the 220 MHz and 450 MHz whip antennas need to be trimmed to the correct length for optimal frequency matching. An instruction sheet is included with each antenna to indicate the correct length. Those instruction sheets are pictured below:


Model: SPHL20FT (VHF) / SPHL24FT (VHF)

FREQUENCY MHz	LENGTH (INCHES)
135	7 7/8
140	7 5/8
145	7 1/4
150	7
155	6 3/4
160	6 1/2
165	6 5/16
170	6 1/8
175	6
220	4 5/8
225	4 1/2

CUTTING INSTRUCTIONS

1. With cap removed, measure from the bottom of the connector to the appropriate length as determined by the cutting lengths supplied.
2. Mark the antenna at the point of desired length.
3. Cut the antenna
4. Apply glue (crazy/super glue) to the top of the antenna and the cap.
5. Place cap on antenna. Allow glue to dry completely.

FREQUENCY (MHz)	LENGTH (Inches)
400	7 3/4
410	7 1/2
420	7 1/8
430	7
440	6 3/4
450	6 1/2
460	6 3/8
470	6 1/8
480	6
490	5 7/8
500	5 3/4
510	5 5/8
520	5 1/2

CUTTING INSTRUCTIONS

1. With cap removed, measure from the bottom of the connector to the appropriate length as determined by the cutting lengths supplied.
2. Mark the antenna at the point of desired length.
3. Cut the antenna.
4. Apply glue (crazy/super glue) to the top of the antenna and the cap.
5. Place cap on antenna. Allow glue to dry completely.

In addition to the whip antennas, Cambium provides aelection of Yagi antennas and an omni antenna for field deployments. Specification sheets for these antennas are available on the Cambium website.

Model #	Cambium Description
NB-N500020A-GL	Yagi Antenna, 900 MHz 6.5 dBd, Single Pol
NB-N500021A-GL	Yagi Antenna, 900 MHz 10 dBd, Single Pol
NB-N500022A-GL	Yagi Antenna, 700 MHz 10 dBd, Single Pol
NB-N500024A-GL	Yagi Antenna, 406-430 MHz 6.5 dBd, Single Pol
NB-N500025A-GL	Yagi Antenna, 406-430 MHz 10 dBd, Single Pol
NB-N500026A-GL	Yagi Antenna, 450-470 MHz 6 dBd, Single Pol
NB-N500027A-GL	Yagi Antenna, 450-470 MHz 10 dBd, Single Pol

NB-N500042A-GL	Yagi Antenna, 215-225 MHz, 6.5 dBd, Single Pol
NB-N500029A-GL	NB-N500029A-GL
NB-N500044A-GL	NB-N500044A-GL
NB-N500045A-GL	NB-N500045A-GL
NB-N500053A-GL	NB-N500053A-GL
NB-N500046A-GL	NB-N500046A-GL

NB-N500030A-GL	Yagi Antenna with Install Kit, 900 MHz 6.5 dBd, Single Pol
NB-N500031A-GL	Yagi Antenna with Install Kit, 900 MHz 10 dBd, Single Pol
NB-N500032A-GL	Yagi Antenna with Install Kit, 700 MHz 10 dBd, Single Pol
NB-N500034A-GL	Yagi Antenna with Install Kit, 406-430 MHz 6.5 dBd, Single Pol
NB-N500035A-GL	Yagi Antenna with Install Kit, 406-430 MHz 10 dBd, Single Pol
NB-N500036A-GL	Yagi Antenna with Install Kit, 450-470 MHz 6 dBd, Single Pol
NB-N500037A-GL	Yagi Antenna with Install Kit, 450-470 MHz 10 dBd, Single Pol
NB-N500052A-GL	Yagi Antenna with Install Kit, 215-225 MHz, 6.5 dBd, Single Pol

NB-N500041A-GL	Antenna Installation Kit, 50 foot

The Yagi antennas are available either stand-alone with a two foot lead or with an integrated installation kit. For Yagis purchased with an installation kit, the antenna comes with the following items as shown in the picture below:

- Attached 25' cable
- Grounding kit
- Weatherproofing kit
- Bulk-head mount RF surge suppressor
- Extra N-type connector (used in case installer wishes to shorten the 25 or 50 ft. drop cable.
- A two foot jumper cable (N-Type to TNC)
- Zip ties

The omni antenna is available stand-alone. The NB-N500041A-GL installation kit has a fifty foot cable which is compatible with the omni for a more turn-key installation.

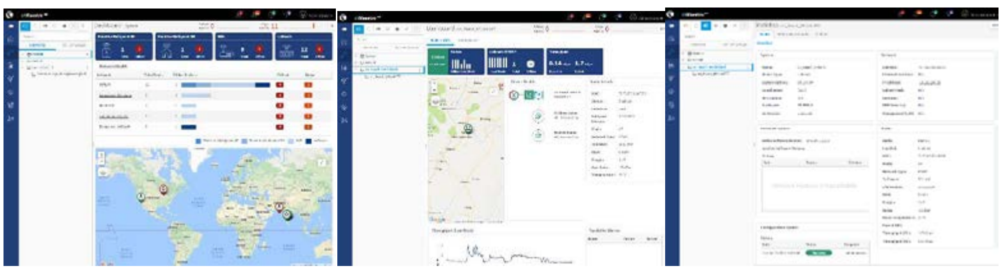
cnMaestro

cnReach can be managed by cnMaestro. cnMaestro is available in either an on-premises version or a cloud-based version. cnMaestro requires that all the radios be upgraded to 5.2.18c or later.

cnMaestro is designed to handle radio management of narrowband network even with very low data throughput.

More information about cnMaestro and software downloads are available on the Cambium Networks website at http://www.cambiumnetworks.com/linkplanner

Refer the cnMaestro documentation for installing and configuring the server. For configuring cnReach devices to interact with cnMaestro refer to Chapter 2: System Configuration.



Some of the features available with cnMaestro specifically for use with cnReach are listed below:

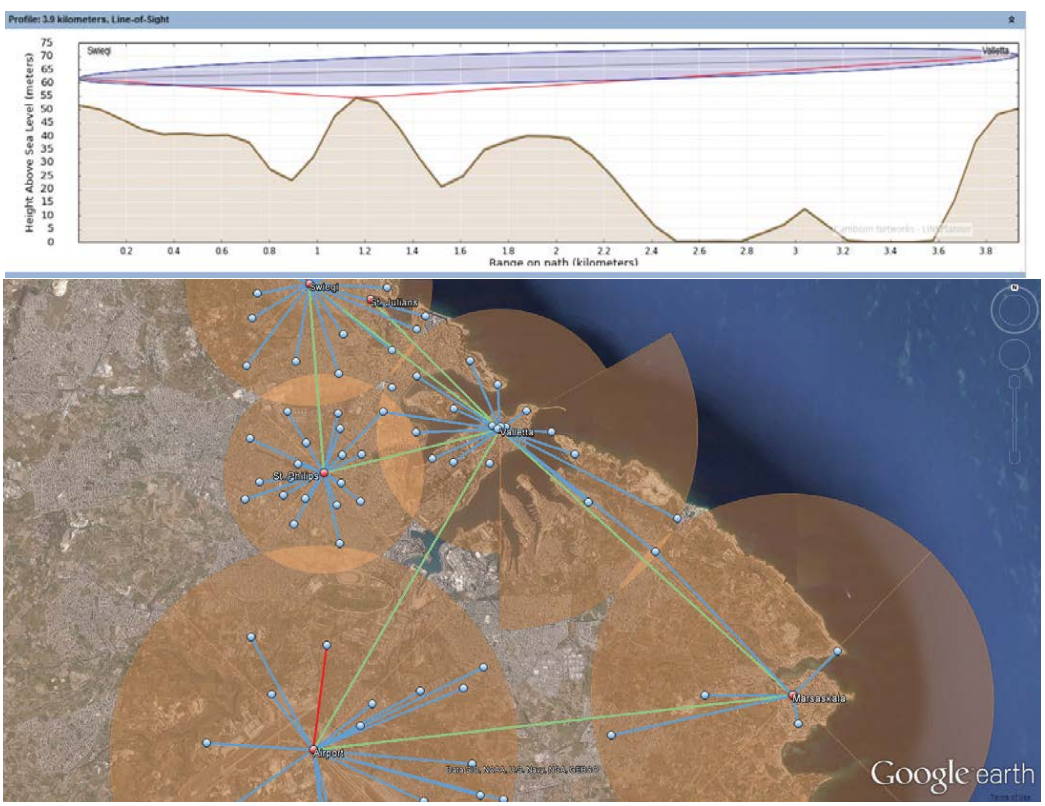
Deployment	Cloud-Hosted Web Portal Customer-Hosted VMware OVA Browser-Based Web UI
Visualization	Full Visibility Across Network Supports ePMP™, cnPilot™, PMP, cnReach™ Multiple Product Views Access and Backhaul View Wireless LAN View IIoT View (for cnReach) Hierarchical Device Tree Google Maps Integration Device Aggregations Network, Tower, Site, AP Group
Monitoring	Inventory Table Dedicated Device Dashboards Maps and Map Modes Statistics and Trending
Data and Reporting	Statistics Reports Exported in CSV RESTful Monitoring API

	Export Tables in CSV or PDF Graphical Reports (Q4/17) Email Alarms (Q3/17) WebHooks API (Q4/17)
Administration	Multiple Administrators (up to 10) Role-Based Access Administrator Session Visibility
Onboarding and Provisioning	Zero-Touch Onboarding Template Configuration (Q4/17) Bulk Software Distribution (Q4/17) Software Update (Q4/17)
Troubleshooting and Forensics	Tower-to-Edge View Stateful Alarms, Events Alarm History
Security	Communication over SSL No Inbound Internet Access Placed Outside of Traffic Path Firewall and NAT Friendly

LINKPlanner

Designed for use with our point-to-point and point-to-multipoint solutions, LINKPlanner allows you to easily and quickly design networks for optimal deployment and cost effectiveness. LINKPlanner is a free, easy to use link-design tool that can be downloaded from the Cambium Networks support site. Some features available for supporting cnReach deployments include:

- Engineer a highly reliable wireless link even in challenging environments
- Plan and optimize a single link or multiple links simultaneously
- Plan an entire project including PTP and PMP products
- Perform calculations for both licensed and unlicensed products
- Automatically load path terrain profiles and environmental factors such as rain fade
- Display a comprehensive overview of your entire point-to-point wireless network via Google™ Earth
- Conduct "what if" scenarios based on geography, distance, antenna height and transmit power and instantly see the effects on performance
- Generate reports that validate projected performance and serve astime-saving deployment guidelines
- Create a bill of materials for PMP and PTP networks including accessories



Chapter 2: System Configuration

The system configuration chapter covers an introduction to navigating the cnReach graphical user interface. It also provides a screen-by-screen summary of each field and setting with explanations and recommendations for each setting.

Keep in mind that chapter 3 provides more detailed technical reference information for some of the settings and techniques/technologies being used and chapter 4 provides some example configurations for simple example networks.

User Interface Overview

cnReach radios can be configured using a web-based User Interface (UI). The preferred browsers are Google Chrome or Mozilla Firefox to access the user interface, but most modern browsers should work. However, due to slightly different behaviour among web-browsers it may occasionally be necessary to manually clear the cache or refresh a page or click on the link on the left navigation bar to reload a page.

The PC/Laptop must have an IP address on the same subnet as the radio in order to communicate.

Attention

cnReach radios can be configured to use a (secure) HTTPS connection, therefore use of https://<IP ADDRESS> is required only when configured to operate with https.

Default IP Address

The factory default **IP address** of all radios is **192.168.0.3**

Please refer to the Obtaining an Unknown IP Address section in the Quick Start Guide if you cannot access the User Interface.

Accessing the User Interface

The User Interface is accessed by initiating a secure HTTPS connection (or HTTP connection depending on the radio's configuration) from a Web Browser, via direct Ethernet port connection or active radio link.

Type **https://<IP ADDRESS>** in the URL box; i.e. **https://192.168.0.3**

If this is the first time attempting to connect via https the browser may prompt you regarding privacy. Certificates are usually associated with fully-qualified domain names and not individual IP addresses, so this prompt is completely normal.

Note

This prompt only occurs the first time you connect to the Web Interface or after the browser history is cleared. Subsequent login attempts will not prompt in this way. Access will be granted once the username and password have been successfully entered.

Troubleshooting Access to the User Interface

If the connection times out, there are a few common issues.

1. Computer is on a different subnet.
2. The radios IP address has been changed.
3. The radios IP address is duplicated with other devices (e.g. a radio was configured with the IP address that had already been previously allocated/used).

4. The HTTPS protocol may be required to connect to the radio.

To troubleshoot these issues, open a Command Prompt Window and type **ipconfig**.

This will give you the IP address of your computer, which should be in the same subnet (192.168.0.X) as the radio in order to communicate with the radio. On Windows-based machines, this is typically done by setting a static IP address on the Network interface being used to connect to the radio.

```
Command Prompt
H:\>ipconfig

Windows IP Configuration


Ethernet adapter VirtualBox Host-Only Network #2:

   Connection-specific DNS Suffix  . :
   Link-local IPv6 Address . . . . . : fe80::e8f8:9244:39a2:72f7%3
   IPv4 Address. . . . . . . . . . . : 192.168.56.1
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . :
```

The computer and radio should have unique IP addresses.

Note

If you are using a routed network, make sure that the port on your managed switch/router is configured to the correct subnet.

Navigating the User Interface

After connecting the IP address of the radio, the user will be prompted to login with a username and password. The defaults are:

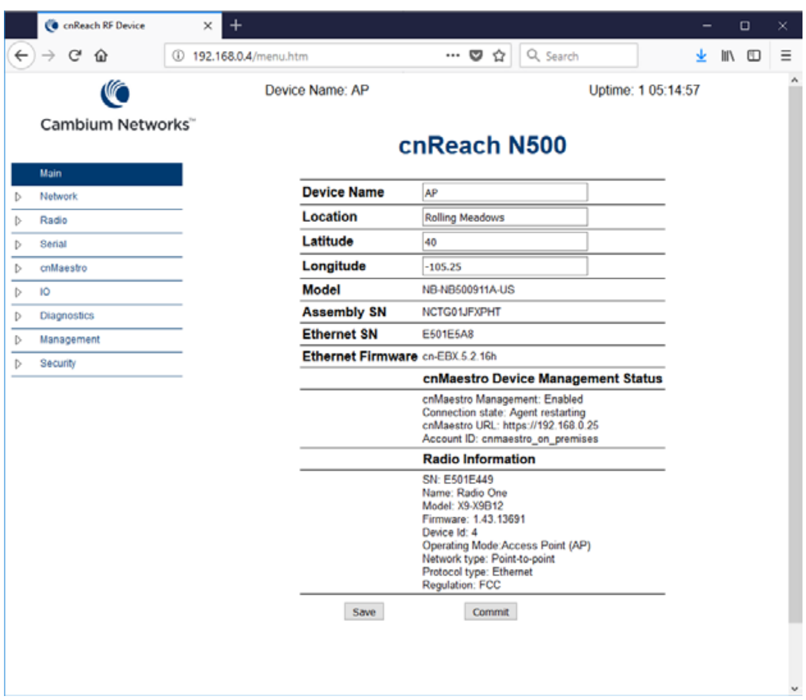
Username: admin

Password: admin

After successfully login, the home page will be displayed similar to the example below. The navigation bar is on the left and is used to connect to all of the different configuration and troubleshooting features on the radio. The remainder of this chapter follows the navigation bar in order with sample screens of a typical 900 Mhz licensed Point to Multipoint network. Where significant differences exist between band (900, 700, 450, 200) or in licensed vs. unlicensed, they will be called out. Otherwise, the GUI and features are the same for each band.

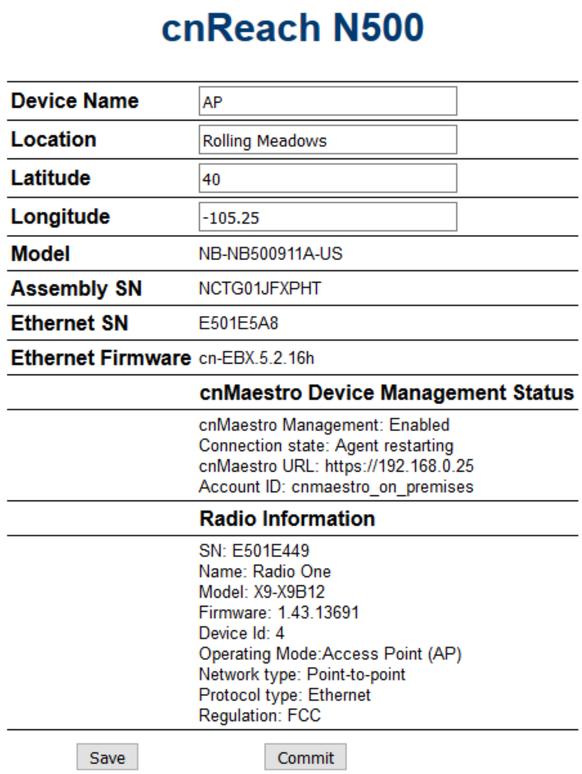
Attention

At the bottom of pages that allow for configuration changes there is both a ‘Save’ button and a ‘Commit’ button. The user MUST click save on each page after making a change and BEFORE navigating to a new page. Clicking COMMIT will commit all changes to memory and initiate a re-boot of the unit if necessary.



Main Menu

The main page is mostly used for status and configuration summary. The first four fields are free text editable by the user. Make sure to click SAVE before moving to a different page and then to click COMMIT to actually make the change take effect.



Main Menu Fields

Device Name – user-definable name to permit easier user identification with the device. When "*Save*" is clicked, the new value is immediately saved in the internal flash.

Location – a free text field to identify where the unit is physically located

Latitude/Longitude – a text field allowing the manually entry of the Lat/Long coordinates in degrees. Note: this is NOT automatically populated but must be entered by the user. The Lat/Long is collected by cnMaestro and can be used to plot the locations of radios on a map view.

Model – a read-only field indicating the model name of the unit.

Assembly SN - this unique identifier is used by Cambium support to identify the manufacturing date and to track warranty status

Ethernet SN: this unique identifier is the same as the right most four bytes of the device's MAC address.

Ethernet Firmware – displays the installed Ethernet firmware version (also referred to as the OS file in the files page)

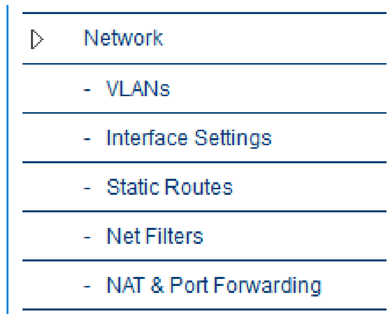
Radio Information – For modules with dual radios the information will appear as Radio 1 and Radio 2.Radio1 / Radio2 (cnReach Single/Dual 700/900 MHz radios).

Radio 1/2 – displays RF Module information:

- Serial Number – same as the right most four bytes of the RF Module MAC address.
- Name – user-definable name to permit further identification with the device.
- Model – Model # / version of installed RF Module;
- Radio Firmware – displays the installed Radio firmware version
- Device ID – user-configurable parameter used to uniquely identify radio nodes in a cnReach RF network.
- Operating Mode – Access Point (AP), Repeating End Point (REP), End Point (EP).
- Network Type – Point to Point (PTP), Point to Multipoint (PMP)
- Protocol Type – always Ethernet
- Regulation – cnReach is a global product. Options here may include FCC, ETSI, and Australia

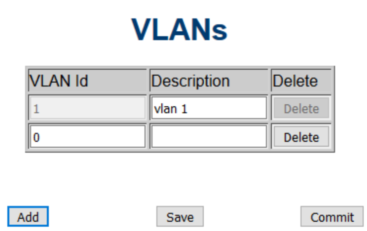
Network Menu

The network menu contains features related to how the cnReach interfaces to external networking equipment and how it processes incoming packets.



Network/VLANs

Add and remove additional VLANs.. The description is free-text for reference and will also appear/be editable on the Network/Interface Settings page.



Network/Interface Settings

cnReach radios can be configured as either layer 2 bridges or with layer 3 statics routes. VLAN's can also be used to determine which packets are accepted and passed at each interface. Refer to chapter 3 for more information about cnReach routing. For purposes of configuration, cnReach treats each Ethernet port and each Radio port as a separate network interface. This page configures settings related to each of these interfaces.

Interface Settings

Interface	Mode	Description	IP address	IP Mask	MAC Address	PVID	Allowed VLANs	VLAN port tagging	Bounce	Speed/Duplex	DHCP
eth1	bridged	port 1			000456009D1F	1	1	None		auto	☐
eth2	bridged	port 2			000456009D1F	1	1	None		auto	☐
rad1	bridged	radio 1			70F1E501B364	1	1	All	...		☐
rad2	bridged	radio 2			70F1E501B385	1	1	All	...		☐
vlan1	routed	vlan 1	192.168.0.3	255.255.255.0	70F1E501B364						☐

Default IP Gateway	none
DNS Server	none

Save Commit

Attention

To establish Ethernet communications, it is critical that these settings are correctly configured and compatible with other radios and devices on the network.

The Laptop/PC should be given a fixed IP address on the same subnet as the physical interface it is connected to.

Mode

Each interface can be configured as bridged or routed. Vlan1 is the interface allocated for local Ethernet access and should be left as routed.

Bridged

In the example above using bridged traffic, the Web Interface can be accessed via the VLAN IP address of the interface PVID. A Bridged interface defaults to the Management VLAN (VLAN1 unless otherwise reconfigured). Bridged mode passes all Broadcast traffic through every Bridged interface. Built in forwarding ensures addressed traffic is only passed via the appropriate interfaces, which translates to more efficient bandwidth use of the RF link.

Attention

Connecting a cnReach radio in bridge mode to an active Enterprise LAN with a lot of broadcast traffic can cause cnReach links to become overloaded. Care should be taken in designing the network to isolate bridged narrow-band connections.

Routed

In this example the web interface can be accessed via the IP address of the connected interface. Routed interfaces can be assigned unique IP addresses and are required to be on different subnets (one or multiple IP addresses can be assigned to the same routed interface. Static routes must be configured both in the radio and any connected Host for Ethernet traffic to be passed between subnets. A Routed interface will block Broadcast traffic and only pass addressed traffic routed across that interface.

Interface Settings

Interface	Mode	Description	IP address / IP Mask	MAC Address	PVID	Allowed VLANs	VLAN port tagging	Bounce	Speed / Duplex	DHCP	txqueuelen	MTU
eth1	routed	port 1	10.120.109.101 / 255.255.255.0 +	00045600AA03					auto	☐	0	1500
eth2	bridge	port 2		00045600AA03	1	1	None		auto		0	1500
rad1	bridge	radio 1		70F1E50215FF	1	1	All	...			25	1500
vlan1	routed	vlan 1	10.120.100.101 / 255.255.255.0 192.168.0.3 / Delete +	70F1E50215FF						☐	0	1500

Default IP Gateway	10.120.100.254
DNS Server	10.120.100.166

Description

The Description can be renamed alphanumerically up to a 30-character maximum. VLAN descriptions may also be edited on the Network/VLANs page.

IPv4

IPV4 address used to communicate with or connect to the radio. The address specified is used to access the Web Interface and establish communications with serial devices through the radio's built-in terminal server capabilities.

IP Mask

Mask applied to the IPV4 address to identify the network segment containing the Radio and when forwarding traffic to the default gateway is required.

MAC Address

Enclosed Radio; Ethernet ports list the Ethernet carrier board MAC. Radio1 and VLAN1 list the RF1 Module MAC unless Eth1 or Eth2 are set to Routed, then VLAN1 will list the Ethernet carrier board MAC. Radio2 lists the RF2 Module MAC.

PVID

Primary VLAN ID; default setting is **1** for **VLAN1** (Management VLAN). Additional VLANs can also be set as the PVID for any interface.

Note

Care should be taken when changing PVID so that Ethernet Communications are not interrupted.

ALLOWED VLANS

This value defines which VLANs are allowed to enter or leave an Interface. The default setting is 1 for VLAN1. Additional VLANs can also be allowed.

VLAN Port Tagging

This value controls the VLAN tagging behaviour for an Interface;

NONE

VLAN tags are not added to any frame leaving the Ethernet port and only untagged frames are allowed to enter the RF Module.

Note

One exception to this rule is that tagged frames belonging to the native VLAN are accepted by the RF Module, which means all packets entering and leaving the RF Module are associated with VLAN1.

EXCLUDE NATIVE

The interface acts as a VLAN trunk and will tag all frames leaving the interface except those belonging to the Native/Management VLAN. Traffic entering the port can be tagged or untagged with all untagged frames automatically being associated with a port's native VLAN.

ALL

The interface acts as a VLAN trunk and will tag all frames leaving the port including those belonging to the Native/Management VLAN. Traffic entering the port must be tagged. Any untagged frames entering a port are dropped.

Interface	Mode	Description	IP address	IP Mask	MAC Address	PVID	Allowed VLANs	VLAN port tagging	Bounce	Speed/Duplex
eth1	bridged	port 1			70F1E5015CD1	1	1	None		auto
eth2	bridged	port 2			70F1E5015CD1	2	1,2	All		auto
rad1	bridged	radio 1			70F1E5013AF2	1	1,2,3	All	1,3	
vlan1	routed	vlan 1	192.168.0.3	255.255.255.0	70F1E5013AF2					
vlan2	routed	SCADA	192.168.1.3	255.255.255.0						
vlan3	routed	Security	192.168.2.3	255.255.255.0						

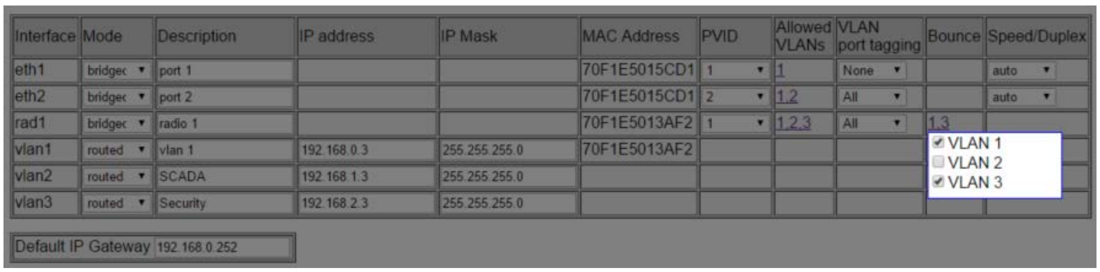
Default IP Gateway	192.168.0.252

Bounce

This setting allows Bridged End Points to communicate with each other via the upstream Access Point / Repeater. Although Bounce is not a true peer-to-peer setting it does allow communication from End Point to End Point.

> **Note:**
> Bounce should only be set on the AP or REP and becomes available when the radio is configured as a "Bridge".

Multiple VLANs can be added to the Bounce setup;



Interface	Mode	Description	IP address	IP Mask	MAC Address	PVID	Allowed VLANs	VLAN port tagging	Bounce	Speed/Duplex
eth1	bridgec	port 1			70F1E5015CD1	1	1	None		auto
eth2	bridgec	port 2			70F1E5015CD1	2	1,2	All		auto
rad1	bridgec	radio 1			70F1E5013AF2	1	1,2,3	All	1,3	
vlan1	routed	vlan 1	192.168.0.3	255.255.255.0	70F1E5013AF2					
vlan2	routed	SCADA	192.168.1.3	255.255.255.0						
vlan3	routed	Security	192.168.2.3	255.255.255.0						

VLAN 1 (checked), VLAN 2 (unchecked), VLAN 3 (checked)

Default IP Gateway 192.168.0.252

Speed/Duplex

Speeds of 10 Mbps, 100 Mbps or auto-negotiation (speed and duplex) can be set.

Default Gateway

If a Default Gateway is configured, the Radio will periodically attempt to resolve the MAC address of the default gateway via ARP. Once the MAC address of the default-gateway is acquired, the radio will periodically re-ARP for the gateway to ensure connectivity is maintained.

DNS Server

The IP address of a DNS server can be configured to resolve domain names to IP addresses

Network/Static Routes

The Static Routing feature allows for multiple subnets to be created so that only traffic destined for those subnets is Routed to those subnets, thereby eliminating unneccessary traffic on the RF links.

With a Routed configuration every interface is required to be on a separate subnet.

Interface	Mode	Description	IP address	IP Mask	MAC Address	PVID	Allowed VLANs	VLAN port tagging	Bounce	Speed/Duplex
eth1	routed	port 1	192.168.1.3	255.255.255.0	70F1E5015CD1					auto
eth2	bridgec	port 2			70F1E5015CD1	1	1	None		auto
rad1	routed	radio 1	10.10.10.1	255.255.255.0	70F1E5013AF2				1	
vlan1	routed	vlan 1	192.168.0.3	255.255.255.0	70F1E5015CD1					

Default IP Gateway	192.168.1.252

Static Routes should be configured in the Access Point for all downstream subnets in order to establish Ethernet communications between the various subnets.

If the network contains multiple cnReach dual radio modules, it may also be necessary to configure Static Routes on each of these radios.

To configure a Static Route the destination Network ID (Subnet), IP Mask and Gateway IP are required to be entered.

The Gateway IP will be the IP address of the downstream radio interface.

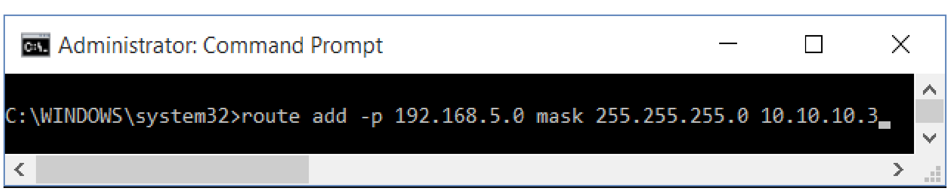
Network Id	Network Mask	Gateway IP	Delete
192.168.2.0	255.255.255.0	10.10.10.2	Delete

Add Save Apply

- Click Add to create a new Static Route.
- Click Save to add the Static Route to the radio configuration without enabling it.
- Click Apply to add the Static Route to the radio configuration and/or enable it.

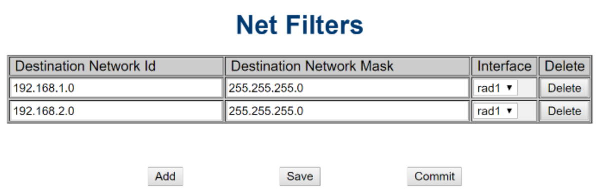
Static Routes should also be configured in any host that is connected to the Access Point. This can be done by opening the Command Prompt Window as Administrator and entering each route in the following format, where <Gateway IP> is the address of the Ethernet port the Host is connected to:

route add –p <Subnet IP> mask 255.255.255.0 <Gateway IP>



Network/Net Filters

cnReach supports an IP filtering feature used to allow only traffic coming from an approved source. The IP filter feature behaves like a 'white list' where

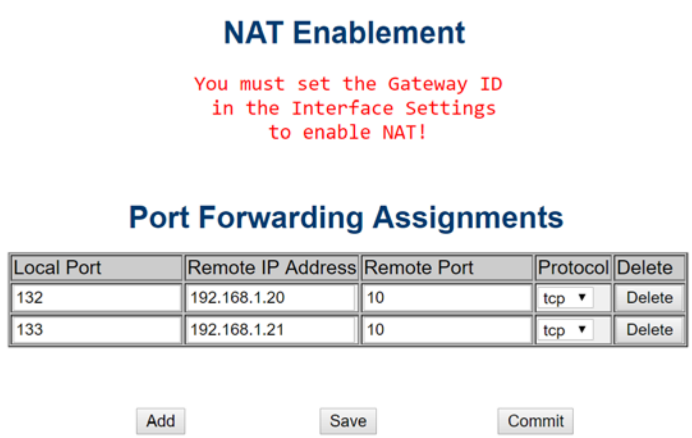


Destination Network Id	Destination Network Mask	Interface	Delete
192.168.1.0	255.255.255.0	rad1	Delete
192.168.2.0	255.255.255.0	rad1	Delete

The filters take action on the radio port egress traffic. In case of IP address based filtering, e.g. use 255.255.255.255 network mask, broadcast ARP messages for the IP addresses that are in the whitelist will still be passed.

Network/NAT & Port Forwarding

Network address translation (NAT) allows the radio to remap all routed traffic passed by the radio's default interface so that the traffic uses the IP address of the interface instead of the source's original IP address. This ability lets you reroute traffic without re-addressing every host. (This process is also known as NAPT or IP masquerading.) In contrast to NAT, port forwarding rewrites the destination port and IP address. For example, inbound traffic on a specific local port is forwarded to a remote IP address and port. This can be useful for allowing the radio to communicate with a specific computer (such as a central controller) or a service within a private local-area network (LAN).



Local Port	Remote IP Address	Remote Port	Protocol	Delete
132	192.168.1.20	10	tcp	Delete
133	192.168.1.21	10	tcp	Delete

Radio Menu

The Radio menu contains all configuration parameters associated with the radio / air interface. This includes physical layer parameters like transmit power and frequency but also network topology and addressing for the air interface protocols.

Radio/Band Settings (Full Configuration Mode)

This page provides information on the installed radio modules. If you are configuring a dual radio you'll see Radio 1 and Radio 2 as shown below. For single radios you will only see Radio 1.

For 900 MHz radios, this page sets whether the unit will be operating in ISM/Unlicensed band or MAS/Licensed band.

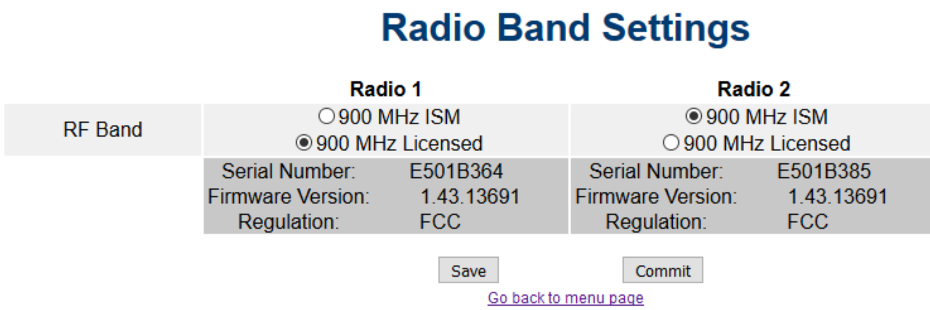
- ISM band (902-928MHz) - Unlicensed- a range of frequencies is used and the radio may hop between RF channels within the band.

- MAS band (928-960MHz) – Licensed - specific frequencies are used for transmit and receive and the radio maintains those frequencies at all times.

Once the band is set, the Radio/RF settings page will display only information relevant to the chosen band.

For 220/450/700 MHz radios there is nothing to set on this page.

Additional information about radio firmware, serial number and regulation region is shown here.



Radio/RF Settings

This section describes the configuration of frequencies, transmit power, hop pattern, and transmit rates.

Note

cnReach radios can be used in full configuration mode or auto-configuration mode. In full configuration mode, all settings are made on all radios (APs and EPs). In auto-configuration model, the EP automatically detects many of the air interface settings from APs beacon signals. This can dramatically simplify the configuration, modification and maintenance of cnReach networks.

This section refers to the full configuration mode. See the following section which repeats this information but for those using auto configuration mode.

For new installations, we recommend using auto configuration mode.

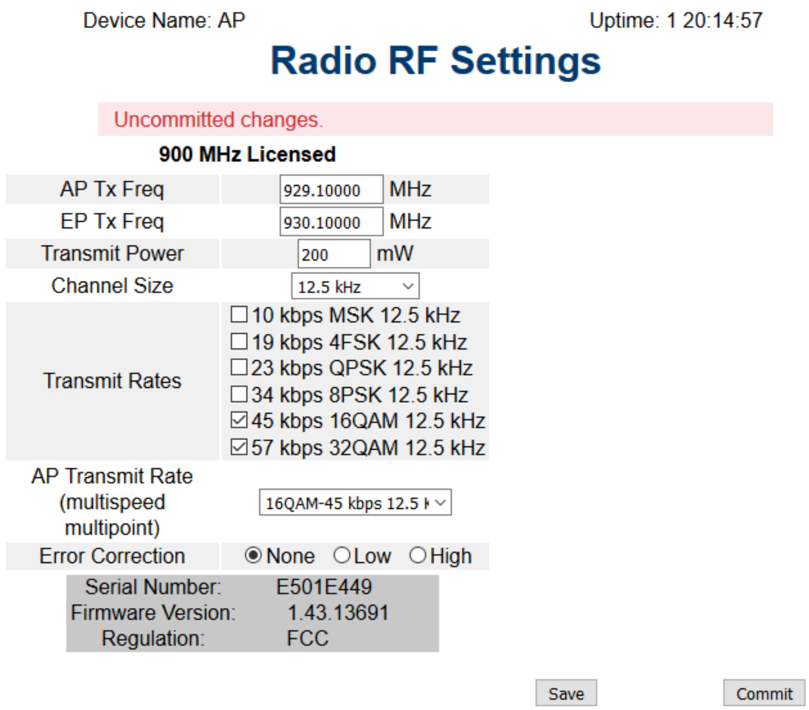
Attention

The following radio settings that affect transmission timing must be the SAME in ALL radios within ALL sub-networks in the system;

- AP/EP Tx Frequency (and for ISM the start/stop and excluded frequencies)
- For ISM, Hop Pattern
- Access Point Transmit Rate
- End Point Transmit Rate(s)
- Max Payload Bytes
- Network Type; PTP or PMP
- Network Radius

Licensed Band Settings (900/MAS, 700, 450, 220)

If a licensed band is selected in **Radio/Band** settings, the following parameters are configurable:



Access Point and End Point Transmit Frequencies

Licensed Operation requires both the **AP Tx Freq** and **EP Tx Freq** to be manually entered. The frequencies should correspond to the frequencies and channel size issued on the FCC or other jurisdiction license.

> **Attention**
> MAS is a licensed band requiring an appropriate FCC license to be in compliance. Outside of the U.S. consult local regulatory agencies to confirm compliance to license/band plan.

Transmit Power

Transmit Power is set in milli-Watts from 100 to the maximum available for the radio/band (eg. 4W = 4000).

> **Note**
> Some older 900 MHz MAS radios have a software limit set to 3W. If your radio limits you to setting 3000 mW maximum, contact support for a patch to increase this to 4000 mW maximum.

mW can be converted to **dBm** using this online calculator.

> **Attention**
> RF performance is often more problematic at higher RSSI levels. When the Transmit Power is set too high, the receiving radio RSSI may be too high and the overall noise floor in the area will increase.
>
> Transmit Power should be tuned to provide enough SNR on the receiving Radio.
> Please refer to the RSSI and Sensitivity & Minimum SNR per Modulation sections.
> When lab testing with an optional 0 dBi whip antenna it is recommended to install 20 dB coaxial attenuators and adjust the transmit power to 100 mW.

Channel Sizes

As a software defined radio, cnReach supports a wide variety of channel bandwidths. From 6.25 kHz up to 250 KHz depending on the band and regulatory requirements. Refer to Chapter 3: Technical Reference and individual specification sheets to determine which channel bandwidths are available for each band. LINKPlanner is also a good resource when planning networks.

In addition the FCC or other regulatory body license will state what channel size can be utilized.

Transmit Rates

Transmit Rates (or modulations) are configured by selecting one or more modes from the available list.

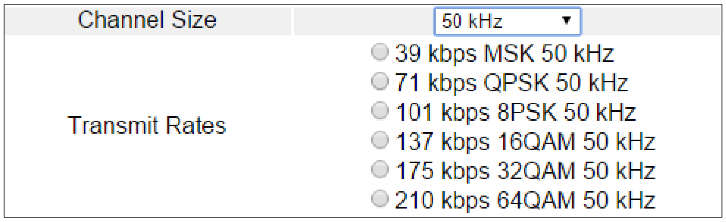
The faster the speed the more complex the modulation but the more complex the modulation the higher the signal level needs to be relative to the noise floor of the link. Therefore, the network design should select modulations that deliver the necessary capacity but with enough fade margin to ensure a reliable link. LINKPlanner is an excellent tool for designing cnReach networks based on need for capacity and availability.

The lists below are representative of 900 MHz. Other bands will have different channel sizes and different modulations.

There are several rules to keep in mind when selecting these modulations. Primarily they are:

1. Don't select more than four modulations
2. All selected modulations should be adjacent in the table. For example, if you select 10kbps MSK and 23 kbps QPSK below, don't skip 19 kbps 4FSK.
3. The exact same set of modulations must be selected for all radios in the same network (PTP or PMP cluster)

The following figure showed example of a modulation modes with 50 KHz channel size. Please notice that actual modes could vary depending on firmware release.50 kHz



For multi-point networks, cnReach supports multiple speeds in the EP to AP direction as selected above with transmit rates. In PMP networks, the AP to EP direction is always done at the same speed.

For point-to-point networks, cnReach supports multiple speeds in both the EP to AP and AP to EP direction.

The transmit rate of the AP to EP direction is configured here. Ensure that the modulation mode selected here is adequate to reach all EP's. Setting this too high can potentially strand an EP.

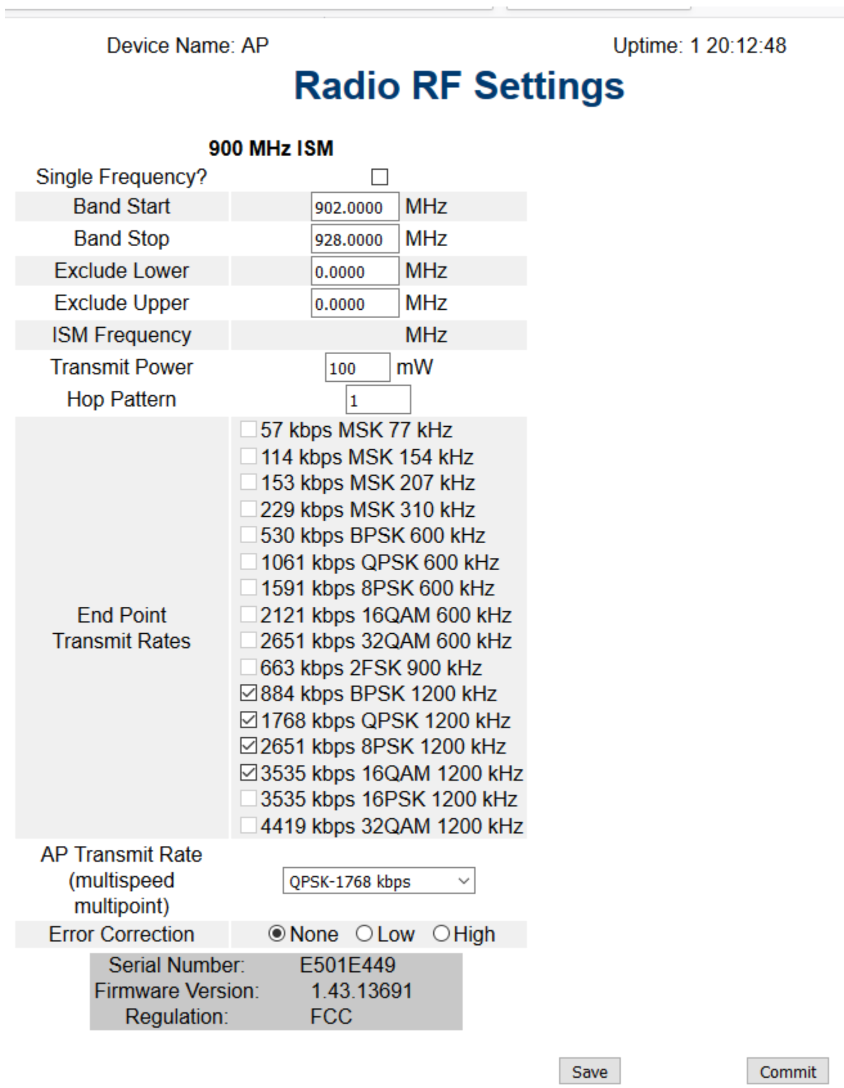
Error Correction

Error correction can be set to either none, low or high. There is a trade-off in capacity and reliability in each of these settings.

- Setting error correction to none does not apply any additional forward error correction.
- Setting error correction to low adds 2 bytes of correction to each 24 byte block. This increases receive sensitivity by ~1 dB at a cost of ~8-30% of capacity depending on packet length.
- Setting error correction to high adds 12 bits of correction to every 12 bits of data or fraction thereof. This increases receive sensitivity by 2-3 dB at a cost of ~50% of capacity.

Un-licensed/ISM Band Settings (900 MHz only)

There are a few settings on this page that are unique to 900 MHz / ISM only. All other settings are similar to the licensed band operations above.



Band Start/Band Stop/Exclude Lower/Exclude Upper

Band Start and **Band Stop** frequencies are limited to a minimum of 902MHz and a maximum of 928MHz though this may vary depending on local regulatory requirements. The frequencies in use within the ISM band may be reduced by adjusting these settings to clip off the band extremities.

Additionally, a range of frequencies within the band may be excluded using the **Exclude Lower** and **Exclude Upper** settings.

> Note
>
> Care must be taken to ensure enough frequencies are available for the radio to hop within the required regulations.

In particular, under FHSS rules (less than 663 Kbps) the radio must have enough frequency bandwidth as required under FCC rules;

– For FHSS systems operating in the 902-928 MHz band, if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

– If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period.

– The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

– Under DTS rules (greater than or equal to 663kbps) there is no limit on the minimum bandwidth for the Radio as it may operate on one frequency, therefore the lower and upper edge of the band may be reduced if the full 902 to 928MHz ISM range is not required.

– ISM start/stop frequency: These parameters specify the beginning and end of the RF band allocated for hopping.

– ISM exclude frequency: These parameters specify the beginning and end of an excluded band within the band specified by “ISM start/stop frequency”. If an excluded band is specified, the hop pattern avoids hopping with the excluded band.

Single Frequency?

o When selected, the radio will operate on a single frequency (tx and rx)

Hop Pattern

A Hop Pattern of 0 fixes the frequency to a single channel (DTS Modulations ONLY).

A Hop Pattern of 1 creates a pseudo random hopping sequence through the available channels.

A Hop Pattern of 2 - 9 is a uniform step through the defined channels as follows:

2: Every other available channel

3: Every 3rd available channel

4: Every 4th available channel

And so on.

For FHSS (less than 633kbps) the Hop Pattern should be set to 1.

For DTS (633kbps and above) the Hop Pattern may be set anywhere from 0 – 9.

Radio/Network Settings (Full Configuration Mode)

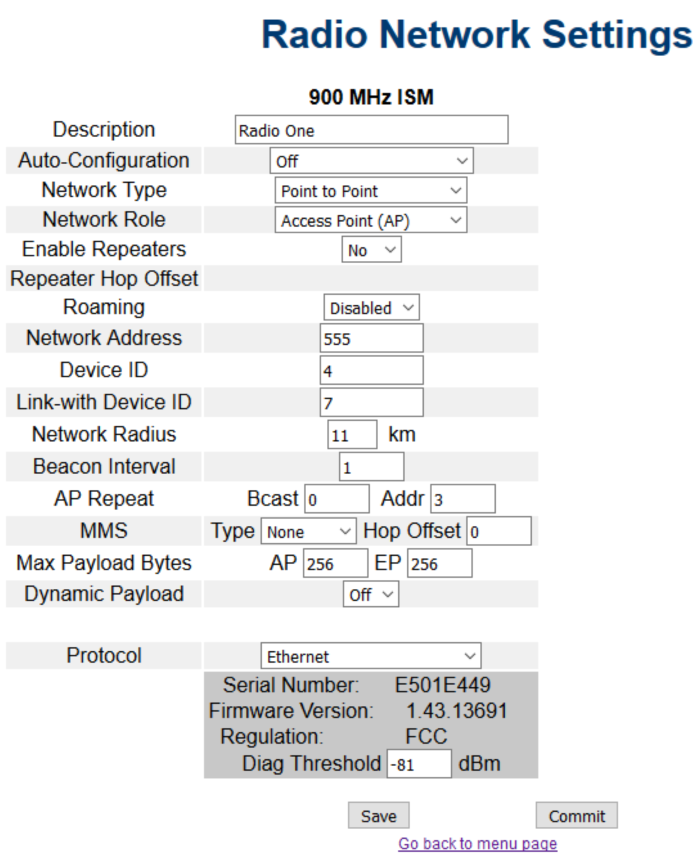
Note

cnReach radios can be used in full configuration mode or auto-configuration mode. In full configuration mode, all settings are made on all radios (APs and EPs). In auto-configuration model, the EP automatically detects many of the air interface settings from APs beacon signals. This can dramatically simplify the configuration, modification and maintenance of cnReach networks.

This section refers to the full configuration mode. See the following section which repeats this information but for those using auto configuration mode.

For new installations, we recommend using auto configuration mode.

This page configures more parameters related to the topology of the radios and how the air interface identifies and treats each device.



Description

Description is a user-definable name to permit easier identification with the RF Module frequency, network segment or RF Link.

Auto-Configuration

See following section on using Auto-Configuration for more details. When set to **Off**, the radio requires all parameters to be set on APs, EPs and REPs.

Network Type

Network Type defines the network topology; Point to Point or Point to Multi-Point.

Network Role

Select whether the module will operate as an Access Point, End Point or Repeating End Point. Note that 'Enable Repeaters' must be set to Yes in order to see the Repeating End Point option.

Enable Repeaters (Unlicensed 900 MHz operation only)

This setting creates a timeslot in the transmission frame for Store & Forward Repeater mode. Enable Repeaters must be identical in **ALL radios in the Network**; either YES or NO.

Enabling store-and-forward repeaters in a network reduces overall capacity of the network by 50%.

Store and Forward repeater functionality is only available in 900 MHz unlicensed band operation at this time. In licensed networks, this setting should always be set to No.

This should ONLY be enabled if there are any store&forward repeaters in the network.

Note
If this setting is mismatched between radios, communication will be lost.
Store and Forward repeater mode is only allowed in

Roaming

Roaming allows a mobile or fixed EP radio to seamlessly switch association between upstream radios as necessary to maintain the best possible link. Roaming is only supported with ISM band. Please refer to Roaming section for more detail.

Network Address

Network Address is a unique identifier that defines a group of communicating radios.

The Network Address can range from 1 to 65535. All devices within a PTP link or within a PMP cluster (AP and it's EP's and REP's) must have the same network address. A mismatch here will cause radios to NOT connect.

Device ID

Device ID is a unique number that identifies the radio on the RF network. Each radio on a network, as defined by the network address, is required to have a unique ID in a similar way to IP addresses on an Ethernet network. The Device ID settings allows for configuration of data paths throughout the network and is integral to troubleshooting with the RF Ping and RF Throughput utilities.

The Device ID can range from 1 to 65534 and may be reused on different networks.

One best practice is to use the last octet of the IP address as the device id. It isn't necessary but can be helpful when troubleshooting and working with networks.

Link-with Device ID

For both PTP and PMP networks, the **Link-with Device ID** on the End Point radio must be the Device ID of the Access Point radio that the End Point is required to communicate with.

For PTP networks only, the **Link-with Device ID** should be the Device ID of the remote radio that the radio is required to communicate with.

On a PMP network, the AP's Link-with Device ID must be a valid number 1 to 65534 but it isn't used and can be set to any value. A best practice is to simply use the device ID of the AP in this case.

The Link-with Device ID can range from 1 to 65534.

Network Radius

Network Radius is the physical line-of-sight distance between two radios. It can be configured in Miles (miles) or Kilometers (km) and has an effect on transmission timing.

- Setting the Network Radius larger than the actual link is acceptable.
- Setting the Network Radius smaller than the actual link may cause the radios to stop operating.
- Network Radius must be identical in ALL radios within a network;
    - o PTP network; set the Network Radius in both radios as the link distance.
    - o PMP network; set the Network Radius in ALL radios to the longest link in the network.
    - o MMS network; set the Network Radius in ALL radios to longest link within the entire network.

Beacon Interval

Beacon Rate sets the number of transmission slots the Access Point radio may skip if it has nothing to transmit/acknowledge. The setting can range from 1 to 15. When set to 1, if there is no data to send after a successful transmit and if there is no End Point remote data to acknowledge, the Access Point will not transmit for that time slot and will resume transmitting the second time slot. This feature helps to reduce the amount of RF noise in an environment when there is no benefit of the transmission.

As the Beacon Rate is increased, several things happen…

- – The XMIT LED on the Access Point and the RCV LED on the End Point start to blink. The higher the Beacon Rate the slower the blinking.
- – Traffic on the link slows down; a basic ping test at various settings shows increased turnaround time as the Beacon Rate is increased.
- – With slower modulations, if the Beacon Rate is increased too much the link will go down.

AP Repeat

Access Point Repeat sets the maximum number of times the Access Point will repeat a transmit packet in the absence of an acknowledgement from the remote unit. This is only applicable for a Point-to-Multi-Point network.

If set to 3 the Access Point will repeat a packet up to three times unless the remote unit acknowledges receipt at which time the Access Point will move to the next packet.

The default setting is 0.

Broadcast

Broadcast defines the AP Repeat for Broadcast traffic.

Addressed

Addressed defines the AP Repeat for Addressed traffic.

MMS

Refer to Chapter 3 Technical Reference for examples and background on multiple master synchronization (MMS)

	Attention For ISM bands, MMS should be configured with FHSS modulations 57 MSK, 114 MSK, 153 MSK & 229 MSK OR DTS modulations 884 BPSK, 1768 QPSK, 2651 8PSK, 3535 16QAM and 3535 16PSK. It is not recommended to mix FHSS and DTS modulations.

MMS may operate in one of two modes;

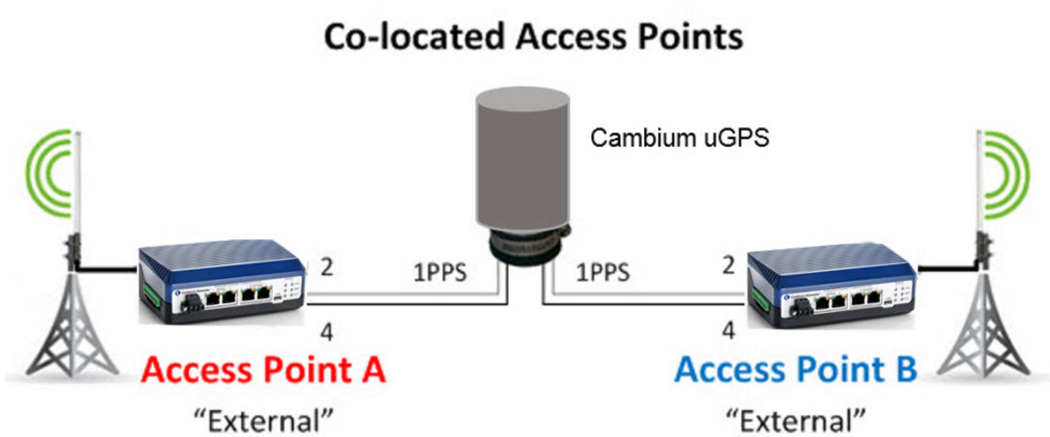
1. Generate; the system Access Point internally "generates" the 1Hz timing signal for all other radios in the network(s).
2. External; a 1PPS "external" trigger signal from a GPS receiver is used to synchronize the 1Hz timing signal for all other radios in the network(s). See IO Connections in Chapter 3 for wiring info. The Cambium Networks uGPS is an option for providing the 1PPS sync signal.

MMS Access Point Specific Settings

Generate

When the Access Point radio is set to Generate, it will internally generate a timing signal that can be used in two ways;

1. For timing downstream radios in any number of interconnected sub-networks.
2. For timing a co-located Access Point (and any number of interconnected sub-networks downstream of that Access Point).



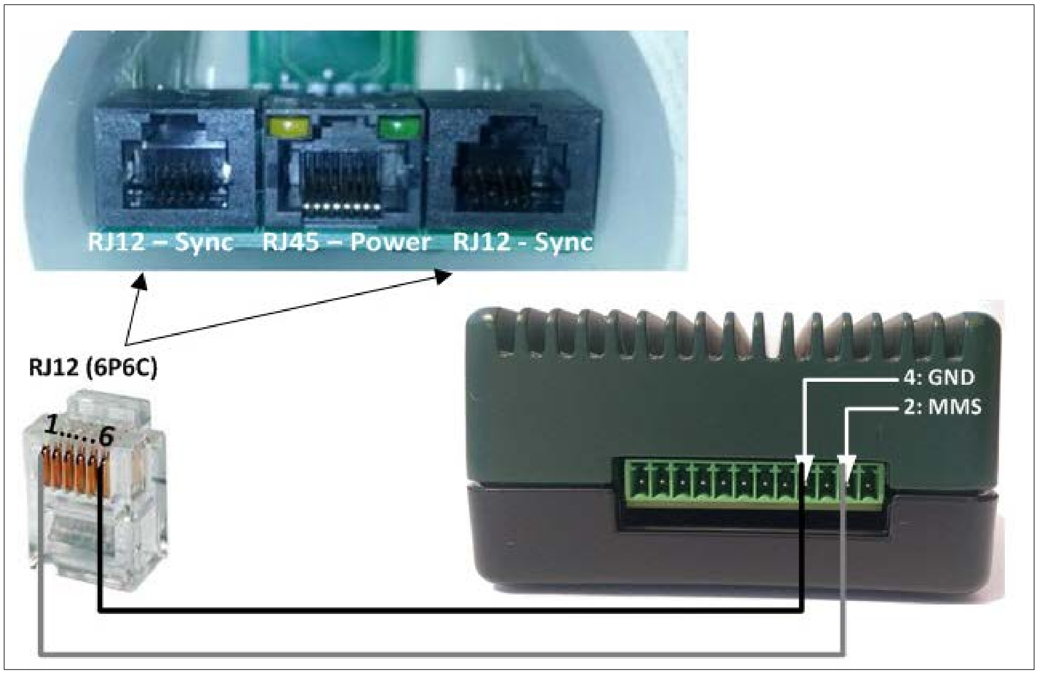
	Note If co-locating Access Points connect Pin2 – Pin2 and Pin4 – Pin4 so that one Access Point will "generate" the timing signal and the other will receive it on the MMS Pins of the External IO connector.

External

Use of a 1PPS (one pulse-per-second) external trigger for MMS requires a GPS receiver capable of providing a 1PPS signal to the IO connector on the side of the radio.

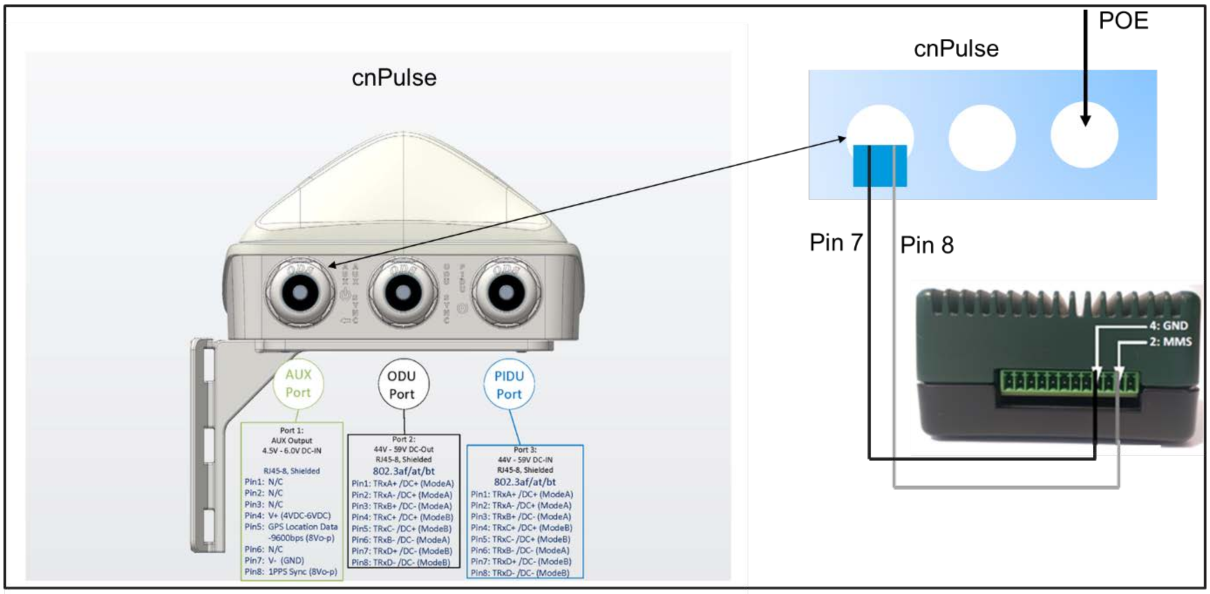
The Cambium Networks uGPS can be used for this purpose.

Either of the **RJ12 – Sync** ports can be used, with cable pinouts and wiring as follows;

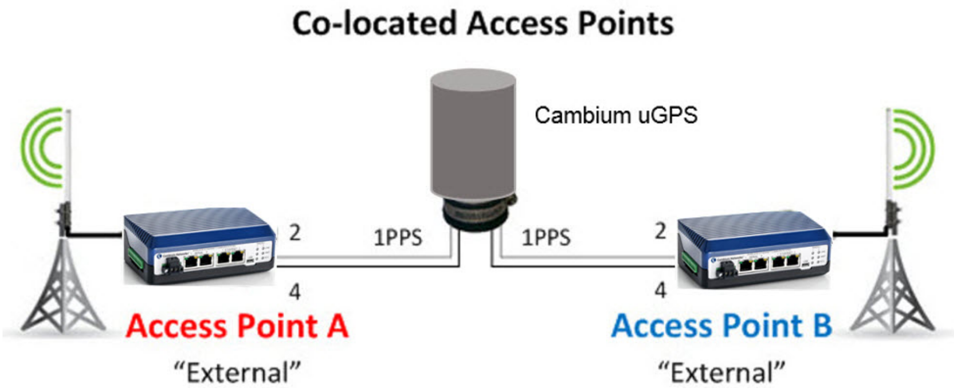


RJ12 Pin #	Signal Pinout	Connect to MMS Pin #
1	1PPS GPS Sync	2
2 - 4	Not connected	-
6	Ground	4

One can also use the cnPulse for the same purpose with a different pinout configuration. The following diagram shows how to connect cnPulse for providing 1PPS sync.


cnPulse
AUX Port
ODU Port
PIDU Port
Port 1:
AUX Output
4.5V - 6.0V DC-IN
RJ45-8, Shielded
Pin1: N/C
Pin2: N/C
Pin3: N/C
Pin4: V+ (4VDC-6VDC)
Pin5: GPS Location Data -9600bps (8Vo-p)
Pin6: N/C
Pin7: V- (GND)
Pin8: 1PPS Sync (8Vo-p)
Port 2:
44V - 59V DC-Out
RJ45-8, Shielded
802.3af/at/bt
Pin1: TRxA+ /DC+ (ModeA)
Pin2: TRxA- /DC+ (ModeA)
Pin3: TRxB+ /DC- (ModeA)
Pin4: TRxC+ /DC+ (ModeB)
Pin5: TRxC- /DC+ (ModeB)
Pin6: TRxB- /DC- (ModeA)
Pin7: TRxD+ /DC- (ModeB)
Pin8: TRxD- /DC- (ModeB)
Port 3:
44V - 59V DC-IN
RJ45-8, Shielded
802.3af/at/bt
Pin1: TRxA+ /DC+ (ModeA)
Pin2: TRxA- /DC+ (ModeA)
Pin3: TRxB+ /DC- (ModeA)
Pin4: TRxC+ /DC+ (ModeB)
Pin5: TRxC- /DC+ (ModeB)
Pin6: TRxB- /DC- (ModeA)
Pin7: TRxD+ /DC- (ModeB)
Pin8: TRxD- /DC- (ModeB)
POE
cnPulse
Pin 7
Pin 8
4: GND
2: MMS

With 2 x Sync Ports the uGPS can be used to precisely trigger two co-located Access Points.



Note

If using a GPS device with a single 1PPS port, it's possible to "daisy chain" the radios together Pin2 – Pin2 and Pin4 – Pin4 so that both radios are triggered simultaneously.

MMS-End Point Specific Settings

When using MMS the End Point radio should always be set to Generate, irrespective of the Access Point's MMS setting.

MMS-Dual Radio Specific Settings

When using MMS with a cnReach N500 Dual Radio, the End Point radio that connects to an upstream Access Point should be set to **Generate** and the Access Point that has downstream End Points connected should be set to **External**; *the cnReach dual radio configurations have internal MMS circuitry between RF Modules that propagates the timing signal.*

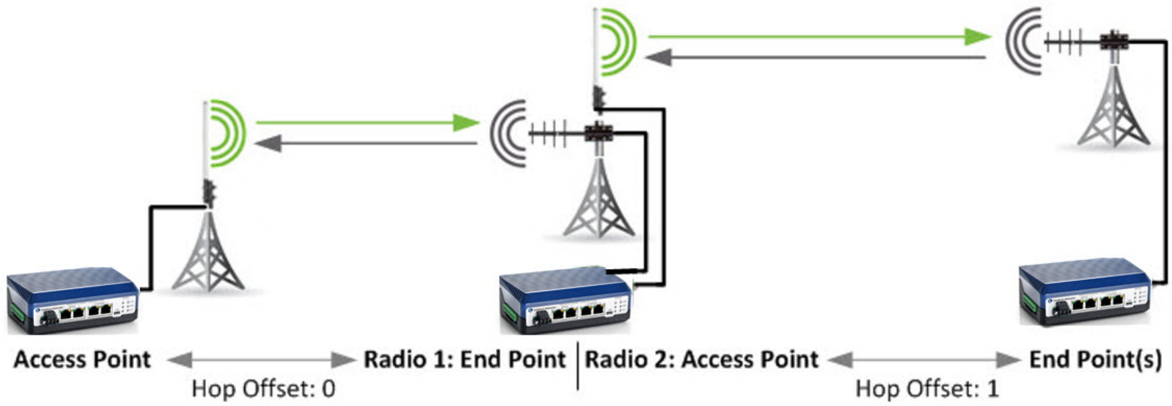
MMS Hop Offset (ISM only)

MMS Hop Offset is a crucial setting for MMS to operate effectively; it is this parameter that permits the frequency/channel separation between the radios in the MMS Network.

The MMS Hop Offset should be set so that each of the sub-networks operate on a different channel in the hop table. For example, if there are 20 channels in the hop table (DTS: 884 BPSK upwards), setting the first radio to "0" and the second radio to "1" results in the radios transmitting on separate channels in the pseudorandom hop pattern.

The MMS Hop Offset should match between each Access Point and their connected End Points.

- ISM hop offset: This parameter is used when multiple networks are synchronized via the multi-master synchronization option. When multi-master sync is enabled, hopping restarts at each sync pulse. Each network must set a different value for this parameter to ensure the synchronized radios transmit on different frequencies from each other at all times.
- When set to zero, the radio's hop pattern starts with the lowest-frequency channel.
    - o When set to a nonzero value, the radio's hop pattern starts the given number of hops into the hop pattern.



Max Payload Bytes

Max Payload Bytes for Access Point and End Point range from 64 to 1600 Bytes with a default setting of 256. These settings are also referred to as "packet sizes". To achieve high user data rates, larger packets and higher modulation levels are required. In one slot time, there are fixed delays that are not a function of packet size or data rate, so as more data is sent in a packet per slot time, the utilization increases.

In noisy RF environments, small packets with faster, more complex modulation will help the radio get on and off channels as quickly as possible to help mitigate bit error and packet loss.

If a targeted data rate is desired, there are multiple options of packet size and modulation that will result with a similar data rate. The choice of shorter packets with more complex modulation or longer packets with simpler modulation will be determined by the noise level in the environment.

Attention
Max Payload Bytes is one of the most commonly mis-configured parameters. Not only must the value match for all radios in a PTP link or PMP cluster but they must be compatible with the selected modulation or transmit modes. See the tables in Chapter 3: Technical Reference for the tables associated with the band you are using.

Here is one example of the table showing how to determine the appropriate value. Make sure to use the correct table as show in Chapter 3: Technical Reference.

ISM – Minimum Packet Sizes with Multi-Speed Multi-Point

The following table charts the smallest "Max Payload Bytes" setting when using multiple ISM End Point Transmit Rates.

		Fastest Modulation										
		MSK				2FSK	BPSK	QPSK	8PSK	16QAM	16PSK	32QAM
Slowest Modulation	Kbps	57	114	153	22	663	884	1768	2651	3535	3535	4419
MSK	57	64	165	229	35	1111	1492					
	114		64	95	15	530	718	1459				
	153			64	11	396	539	1101				
	229				64	260	357	737	1118	1498	1498	
2FSK	663					64	97	217	337	458	458	578
BPSK	884						64	152	240	328	328	416
QPSK	1768							64	108	152	152	196
8PSK	2651								64	94	94	122
16QAM	3535									64	64	86
16PSK	3535									64	64	86
32QAM	4419											64

1. Find the fastest desired modulation at the top of the chart.
   –
2. Find the slowest desired modulation on the left hand side of the chart.
   –
3. The box where the column and the row meet is the **smallest** packet size that must be used for **both** Access Point and End Point **Max Payload Bytes** to establish a connection.
   –
4. Multiple modulations can be enabled as long as the smallest packet size corresponds to the value where the fastest and slowest modulations meet.

Examples

Example 1: ISM

Fastest Modulation: 884Kbps (BPSK), Slowest Modulation 229Kbps (MSK).

Max Payload Bytes must be configured to 357 Bytes or larger.

Example 2: ISM

Modulations enabled: 2651 Kbps (8PSK), 884 Kbps (BPSK), 663 Kbps (2FSK).

Max Payload Bytes must be configured to 337 Bytes or larger.

Example 3: ISM

Fastest Modulation 2651 Kbps (8PSK), Slowest Modulation 153 Kbps (MSK).

This combination of modulation modes will not work.

Dynamic Payload

Dynamic payload is used to optimize the usage of the air interface. When there is no data to be sent in the uplink direction the AP can use the extra time to send more data in the downlink period. Refer to the technical reference section of this user guide for more information.

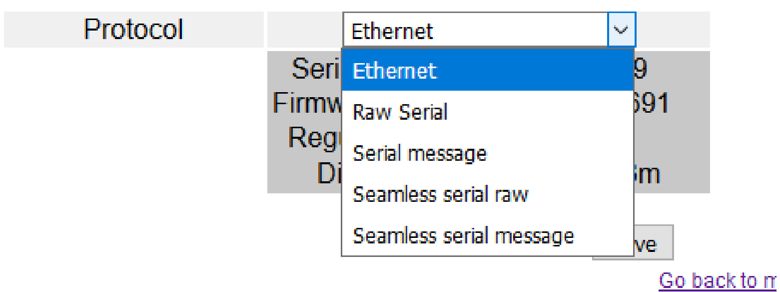
Protocol

cnReach radios can be configured to deliver Ethernet traffic only, a mixture of Ethernet and Serial data or only Serial data.

If you are planning to use Ethernet traffic (**including over-the-air management traffic**) at all this setting should be left as Ethernet.

The other modes are used when the goal is to send ONLY serial traffic. In **serial only** modes:

- No Ethernet traffic will be passed.
- User will be able to manage the radio only via the local Ethernet port
- This allows serial traffic to be sent over the radio link without TCP/IP overhead
- Serial data jitter is reduced significantly due to elimination of packetization and buffering



Raw modes send data as packets arrive. **Seamless serial modes** allow the radio to join a seamless serial group within an overall network that is sharing Ethernet and Serial-only radios. **Message modes** refer to the radio waiting for a pause in the traffic before sending the data.

Diag Threshold

This feature should only be used when contacting Cambium support. It is not typically used other than for detailed troubleshooting.

The **Diagnostic Threshold** is the level at which the user wishes to detect noise.

Auto-Configuration Mode

In Auto-configuration mode, EPs automatically retrieve many of the air interface parameters from the Access Point. In auto-configuration mode, APs send information about the air interface in the broadcast beacon. Using auto-configuration mode can dramatically reduce the complexity of configurating end points. This makes for fewer errors in configuration. More importantly, it is easier to make changes to the interface settings because the changes are only required to be made at the AP and not at every single EP.

An example: the administrator wishes to add a higher modulation mode or change the network radius or modify the max payload bytes to alter the uplink/downlink capacity of a sector.

With full configuration mode, the change must be made on each EP either over the air or by visiting the sites. Then the AP is changed and the administrator confirms that all settings were made correctly and the network is operational again. If a setting was made incorrectly on an EP, it may be necessary to roll a truck to that EP to recover it with the correct setting.

With auto-configuration mode, the change is only made once at the AP. All EP's then automatically update their configuration and re-connect. If a setting is made that prevents an EP from re-connecting automatically, the administrator can simply revert the setting on the AP and the network returns to its previous operation with no site visits necessary.

Auto-Configuration is enabled on the Radio/Network Settings Page.

Configuration

Auto-Configuration is enabled on the Radio/Network Settings Page. All AP's and EP's in a sector must have the same auto-configuration setting. Settings are one of:

Off:	full configuration mode
On, Fast Mode:	recommended for new installations
Off, Compatibility Mode:	recommended for migrating sectors to auto-configuration

Select On, Fast Mode and then hit save to apply the settings to both the Radio/Network Settings page and the Radio/RF Settings Page

In Unlicensed 900 MHz operation, the follow parameters are auto-configured and no longer have to be set at the EP as they are picked up automatically from the AP.

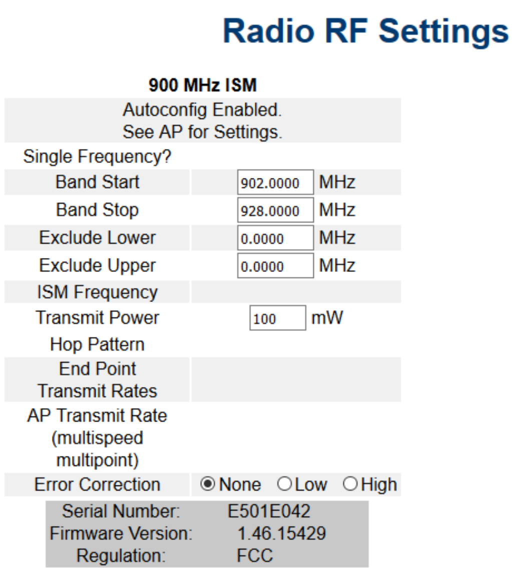
- Network type
- Roaming
- Network Radius
- Beacon Interval
- AP Repeat
- MMS
- Max Payload Bytes

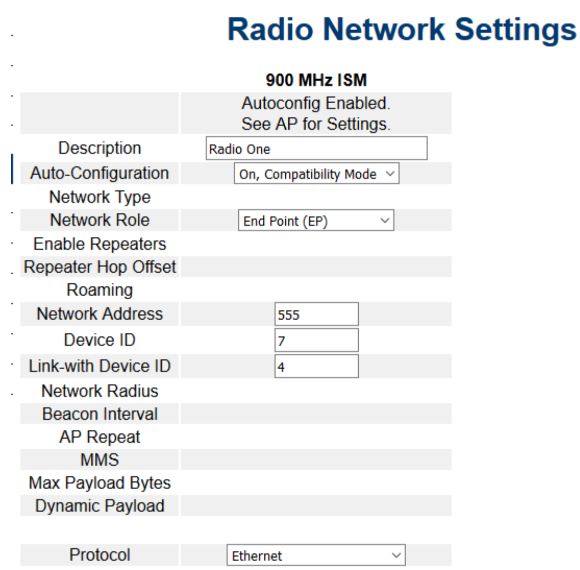
- Dynamic Payload
- Hop Pattern
- End Point Transmit Rates

The following must still be set at both AP and EP:

- Auto-configure mode
- Network Role
- Network Address
- Device ID
- Link-with Device ID
- Protocol
- Frequencies
- Transmit Power
- Error Correction

Note the fields removed from the settings pages below:





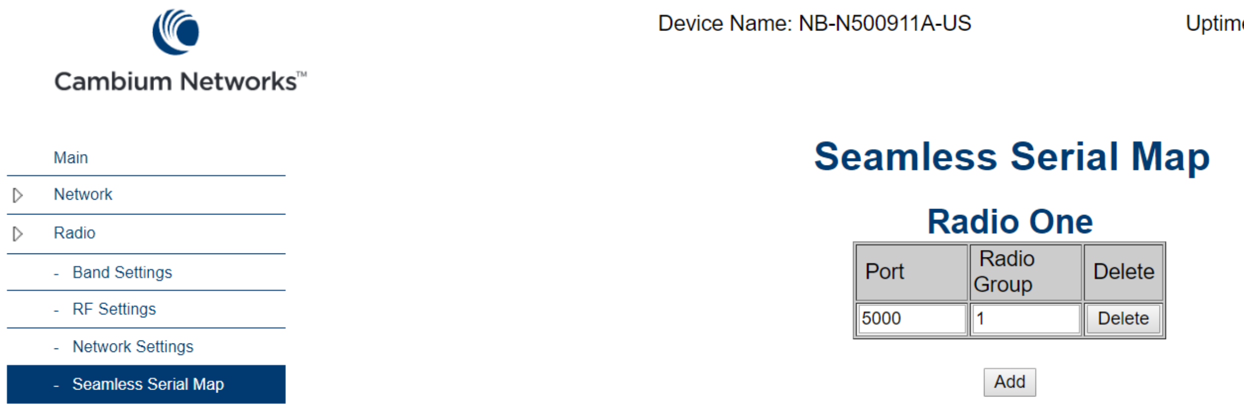
Notes on Auto-configure

- After making a change to any of these parameters, the AP will broadcast an auto-cfg beacon periodically to all EP's. When an EP receives this auto-cfg beacon, it will adjust its parameters and restart the radio interface. Depending on the change of the configuration parameters, it could take up to twenty(20) minutes for the EPs to reconnect to the AP.
- When an EP in auto-configuration mode first powers up or after a link is lost, the EP will be in 'search' mode waiting for the period auto-cfg packet. When if receives the packet it will set all values based on this packet.
- When encryption is enabled on a link, the encryption keys must also match as the auto-configure beacons are also encrypted.
- Auto-configure beacons are sent in every idle beacon. In a very busy network (with no idle frames), the AP will insert additional beacons to ensure they get through. So in a non fully-loaded network, there is no capacity impact.

- Auto configuration is not available in store-and-forward relay networks. (Nodes that are REP role).

Radio/Seamless Serial Map

Seamless Serial Map is used for configuring seamless serial services.



The Port number is the TCP port number for seamless serial service and the radio group number is used as the identifier of the seamless serial stream. For a radio that has two radio ports, you can choose to assign the seamless service to be sent over “Radio One” or “Radio Two”.

Please refer to serial service session for more detail.

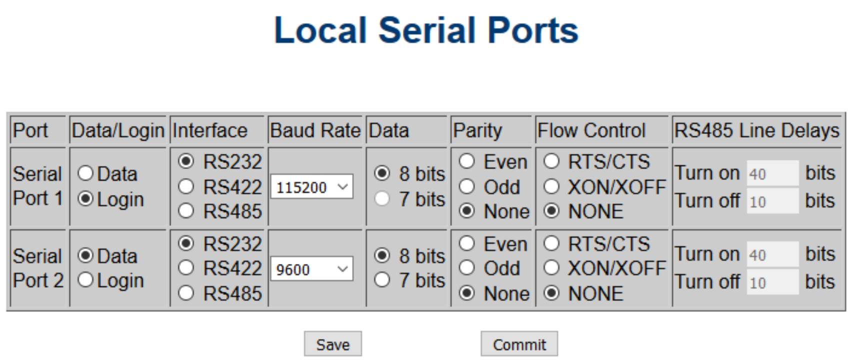
Serial Menu

The Serial menu options relate to setting up serial services on each of the built-in serial ports on a cnReach radio.

Serial/Local Serial Settings

This is where the physical connection to the Serial End Device is configured.

Interface type; RS232/422/485, Baud Rate, Data Bits, Parity, Stop Bits, Flow Control and RS485 Line Delays can be adjusted to suit the required application.



The default setting for Serial 2 is **Data**, which allows Serial Services to be configured.
The default setting for Serial 1 is **Login**, which allows access to the CLI for configuration.
Please refer to RJ-45 Serial Port Pin Assignments for cabling info.

Baud Rate is the speed at which the data is sent, in bits per second. Baud Rate must match between both Serial Devices in order for communications to be successful.

Data bits is the number of bits in each character. This can be 7 for ASCII or 8 for most other types of data. 8 data bits = 1 byte.

Parity can be used to detect errors in the data stream. Parity allows an extra data bit to be sent with each character. This extra parity bit is arranged so that the number of 1 bits in each character (including the parity bit), is always odd or always even. Errors are detected when a byte is received with the wrong number of 1's.

Stop Bits: cnReach always uses one stop bit and this is not adjustable.

Flow Control can be used when the serial devices require the transmission of data to be paused and then resumed.

RTS/CTS is hardware flow control using the RS-232 RTS/CTS lines, which are turned off and on from alternate ends to control the data flow.

XON/XOFF is software flow control which uses special characters to control the flow of data. The XON/XOFF characters are sent in the opposite direction to the data so the receiving device will send the characters to the sending device. XON/XOFF flow control information is sent over the same channel used for the data, therefore eliminating the requirement for extra lines in the serial connection.

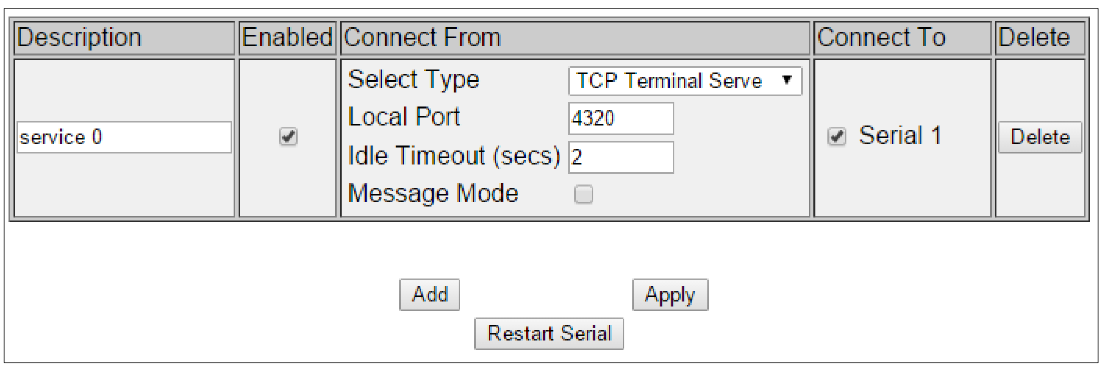
Serial/Serial Services

The Serial Services page is where various Serial Services can be configured and applied to the Serial Port(s). The settings here are typically tied back to the type of RTU/PLC that is being connected to the serial port and what type of protocol it is using.

cnReach radios support TCP Terminal Server, TCP Terminal Client and UDP terminal described in detail below.

(MODBUS RTU Server and Multicast Terminal are not currently supported)

Multiple Services can be added, but only one Service can be enabled at any given time.



Description – allows for user identification up to a 30-character maximum.

Enabled – used to select the desired service when multiple services are configured. Unchecking this setting disables the Service while retaining it in the radio configuration.

Connect From – defines the Ethernet configuration of the Serial Service and associated settings;

- TCP Terminal Server
- TCP Terminal Client
- UDP Terminal

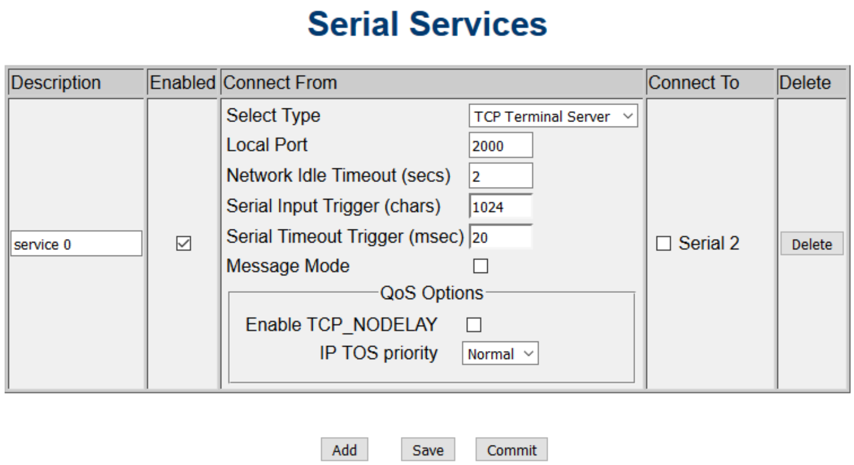
Connect To – this is the physical Serial Port that the Service will be applied to. Since Serial 2 is set to Login by default, only Serial 1 is available, unless Serial 2 is changed from Login to Data in Serial/Local Serial Settings.

Click **Add** to create a Serial Service.

Click **Apply** to save the Serial Service to the radio configuration.

Click **Restart Serial** to activate the Serial Service.

TCP Terminal Server



TCP Terminal Server permits TCP connections from a Host or TCP Terminal Client to terminate on the Serial Port interface of the radio, therefore allowing Serial End Devices to communicate over the Ethernet Radio System.

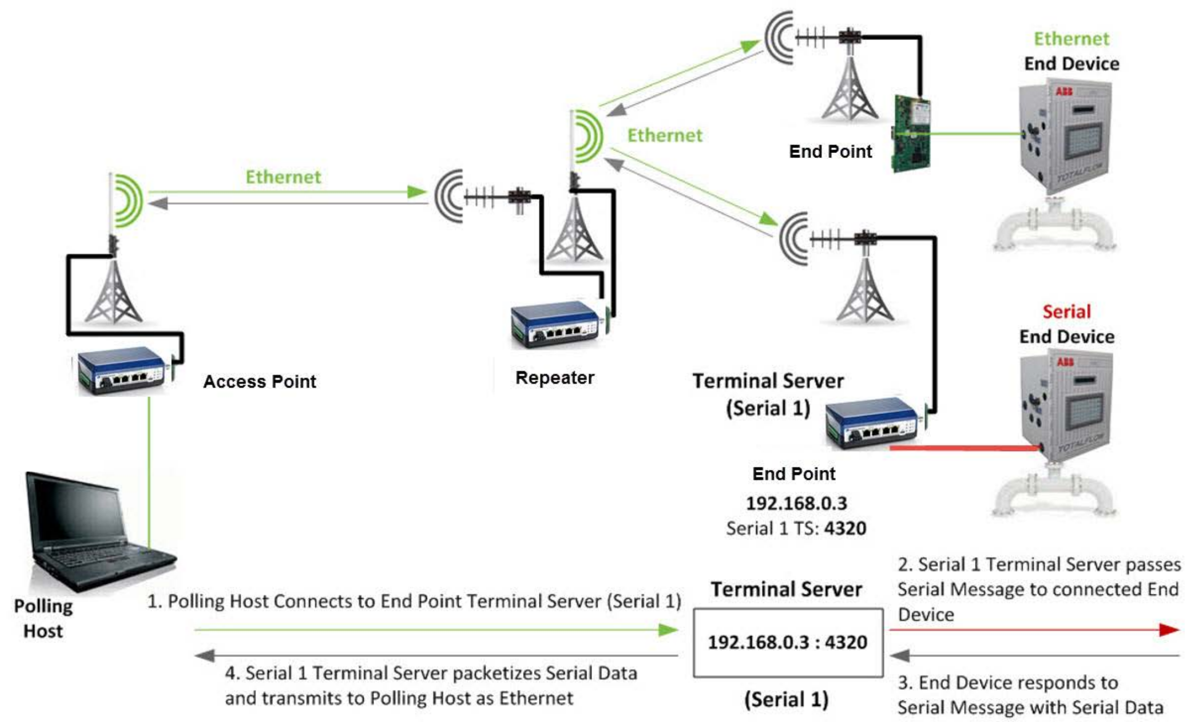
When set to Terminal Server, the user defined (TCP) **Local Port** number is monitored for incoming TCP connections. If the Terminal Server observes traffic on that TCP port it creates a session to open the Serial Port and pass data to the connected Serial End Device.

The session will end if the Host that initiated the session terminates it, or if the **Idle Timeout** is reached without any traffic present on the TCP port.

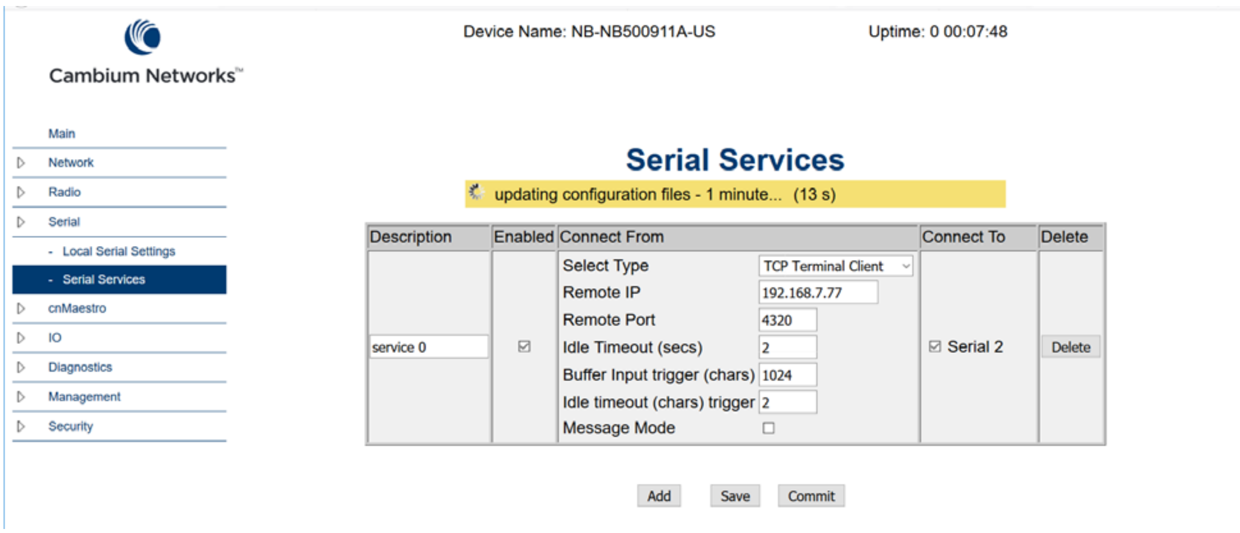
Message Mode should be used with Modbus, DNP3 or other message oriented Protocol. When set to Message Mode, the radio waits for a pause in the Serial Data being received on the Serial Port from the End Device, i.e. the radio waits for the End Device to finish communicating the message before transmitting the message as a whole. If the message cannot be transmitted as a whole, the radio will break it up between transmissions and the Master will reassemble upon demodulation. Some RTU's or recloser controls (such as those from Schweitzer Labs) can be sensitive to breaks in the messages. Message mode can reduce the incident of packet loss.

Enabling TCP_NODELAY disables Nagle's algorithm for TCP transmissions which can be helpful for large numbers of small packets on a low-bandwidth connection.

The QoS settings allow for prioritization of serial services traffic by applying TOS bit settings to generated packets.


Ethernet
End Device
Ethernet
End Point
Ethernet
Access Point
Repeater
Serial
End Device
Terminal Server
(Serial 1)
End Point
192.168.0.3
Serial 1 TS: 4320
Polling
Host
1. Polling Host Connects to End Point Terminal Server (Serial 1)
Terminal Server
192.168.0.3 : 4320
(Serial 1)
2. Serial 1 Terminal Server passes Serial Message to connected End Device
3. End Device responds to Serial Message with Serial Data
4. Serial 1 Terminal Server packetizes Serial Data and transmits to Polling Host as Ethernet

TCP Terminal Client



When set to **TCP Terminal Client**, activity on the Serial Port interface will initiate a TCP session to a Host or Terminal Server specified by the **Remote IP** address and **Remote Port** number in the configuration.

Data arriving on the Serial Port will be packetized and sent to the destination IP address and TCP port.

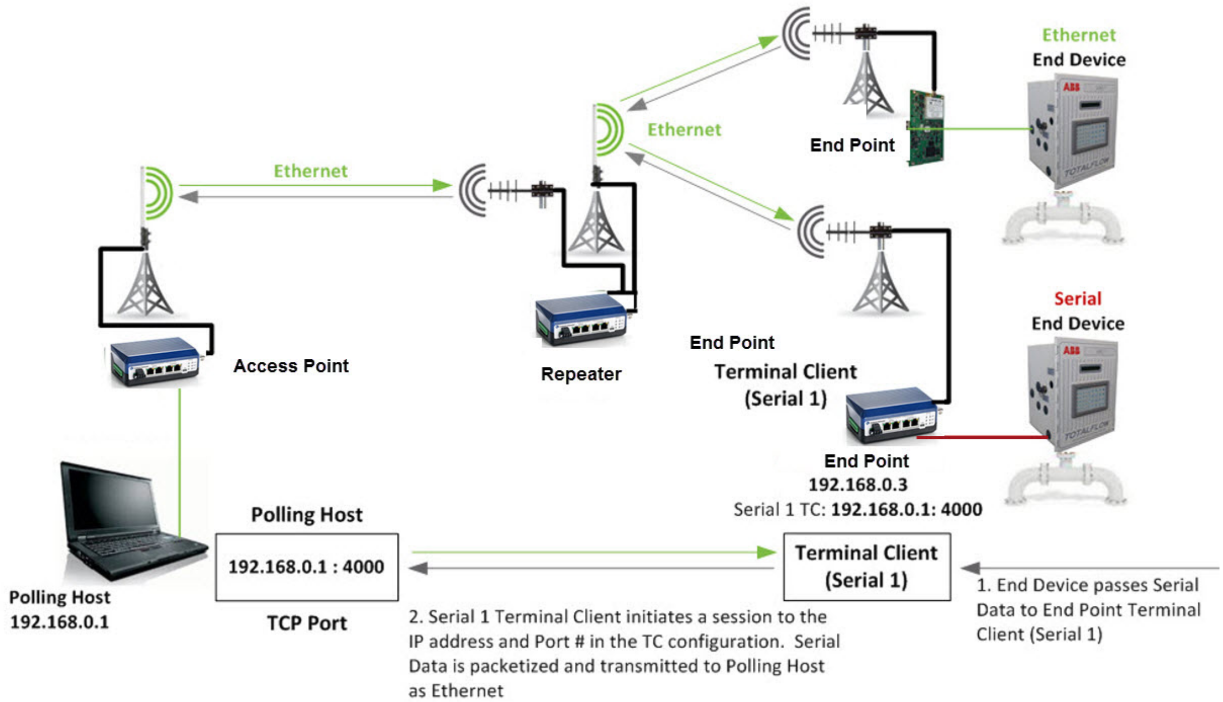
The session will end if the **Network Idle Timeout** is reached without any activity on the Serial Port interface.

Serial Timeout Trigger is the timeout for when data is sent to the network after the start of serial data (in non-message modes).

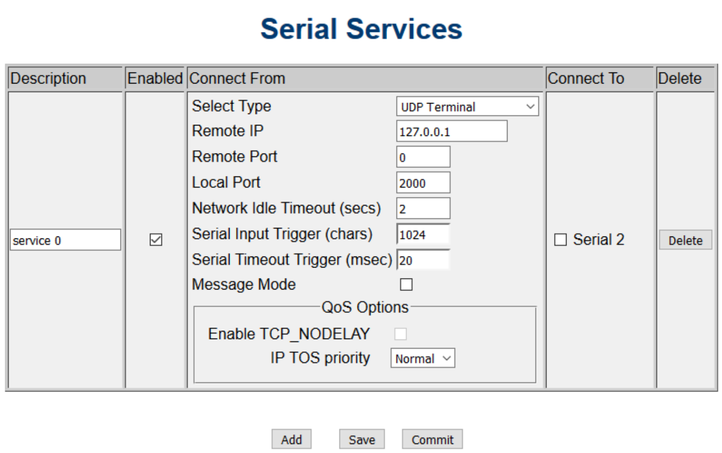
Serial Input Trigger defines the amount of data, in Bytes, that will be held in the buffer before being packetized and sent over the network. For example, if set to 1024, the radio sends the message after receiving 1024 characters. The default is 1024.

Message Mode should be used with Modbus, DNP3 or other message oriented protocol.

- Message Mode should be used with Modbus or other message oriented Protocol. When set to Message Mode, the radio waits for a **pause** in the Serial Data being received on the Serial Port from the End Device, i.e. the radio waits for the End Device to finish communicating the message before transmitting the message as a whole. If a pause is not received after 1024bytes, the radio just sends out the 1024 bytes. If the message cannot be transmitted as a whole, the radio will break it up between transmissions and the Master will reassemble upon demodulation.
- Message mode disables Serial Input trigger and Serial timeout trigger
- Example use of message mode:
    - Modbus RTU to Modbus TCP
    - Serial DNP3 to Terminal TCP client



UDP Terminal

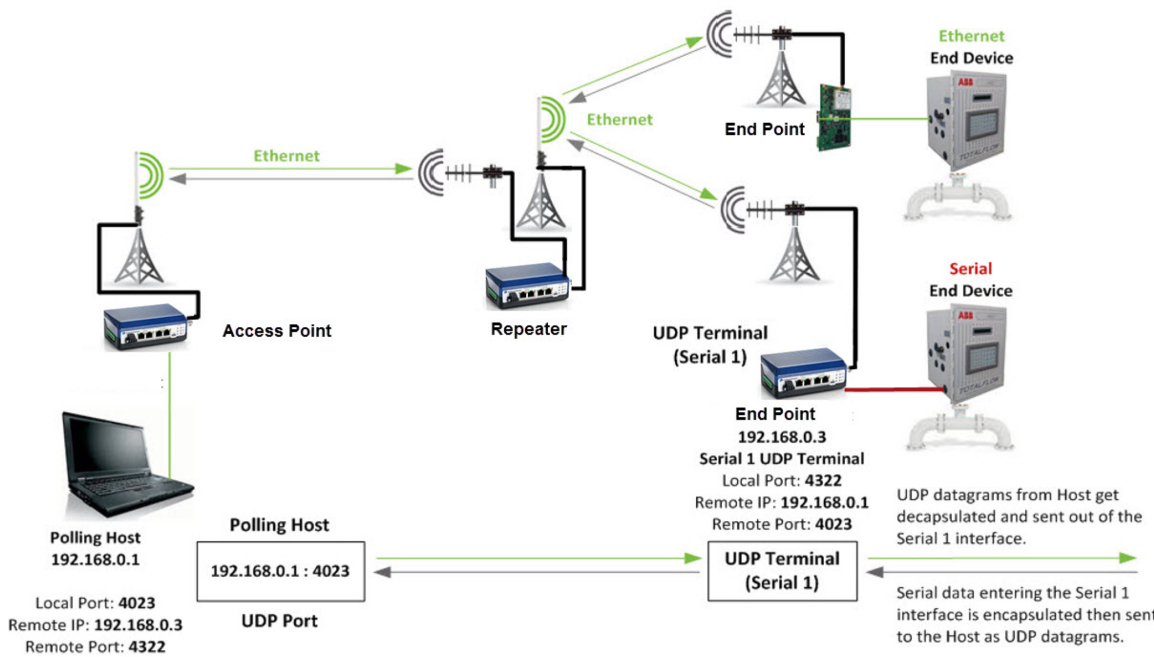


The User Datagram Protocol is a **connectionless** protocol with less overhead than TCP.
Unlike TCP, UDP does NOT guarantee delivery or delivery in order.

When set to **UDP Terminal**, activity on the Serial Port interface will instantly encapsulate the data into a UDP datagram and send to the Host or UDP Terminal specified by the **Remote IP** address and **Remote Port** number in the configuration.

Likewise, the UDP Terminal will “listen” for UDP datagrams on the specified Port number. This means a Host may also send UDP datagrams to the **Radio IP** and **Local Port** without any prior handshaking to establish a connection. UDP datagrams arriving will be decapsulated and converted to Serial data then sent out of the Serial Port interface.

The Host must be set up the same way; Remote IP, Port and also a Local Port.



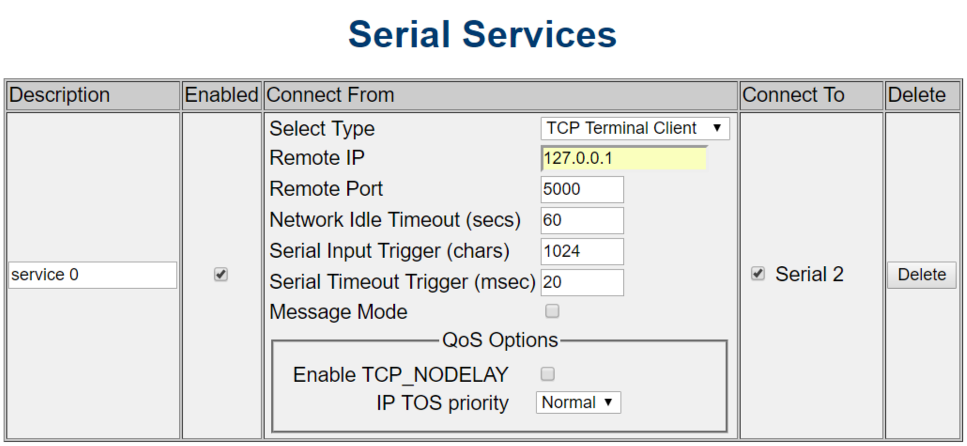
Seamless Serial Service

Seamless serial is a mechanism unique to cnReach allowing for serial-only to serial-only communications within a subset of a sector (AP to a subset of it's EPs) while sharing that same sector's air interfaces for Ethernet traffic. Using seamless serial, the administrator defines a series of seamless serial groups. Then when a serial service is set up it can be assigned to a seamless serial group. All serial ports within that seamless serial group now act as one joined serial port.

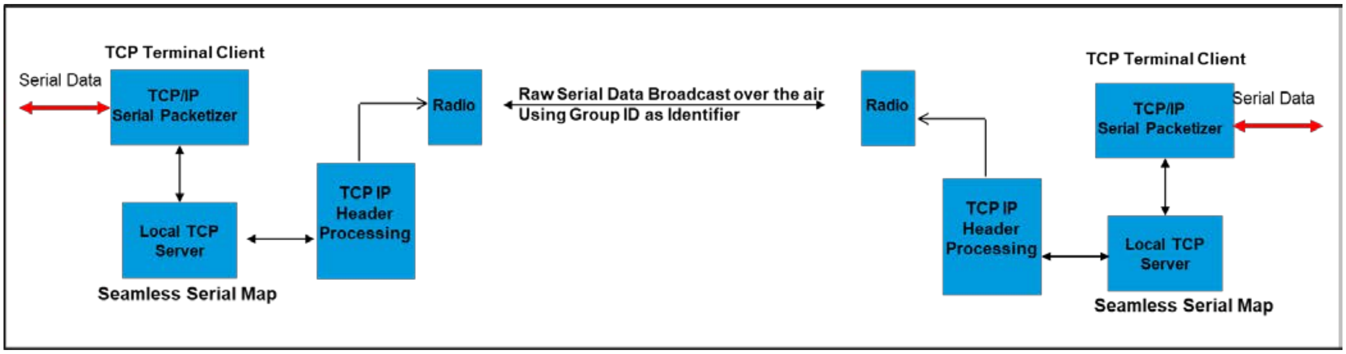
Seamless Serial allows you to use a hybrid network with some endpoints supporting full Ethernet bridging and routing while other endpoints are serial only (and possibly lowpower serial.) A major benefit of Seamless Serial is multi-point efficiency — you can broadcast the same data to a multi-point network without duplicating the data across multiple TCP sessions. A single Seamless Serial network requires a minimum of one AP and one EP. Seamless serial also significantly reduced overhead for transporting serial data over the air by eliminating Ethernet header and TCP/IP header, replacing these overheads with a radio group ID. The radio group ID should be the same for all radios sharing the same serial service.

Seamless serial traffic is sent at higher priority than Ethernet traffic as one of the main goals of seamless serial is to reduce overhead of TCP/IP communications, increasing efficiency and reducing jitter for serial services that are time/jitter sensitive.

To configure seamless serial, on a radio, configure a regular serial service TCP terminal client with the remote IP address as 127.0.0.1 and remote port number the same as the port number configured on the seamless serial map. For example, 5000 as shown on the screenshot of the seamless serial map. The following is a screenshot showing configuration of a serial service for seamless serial.



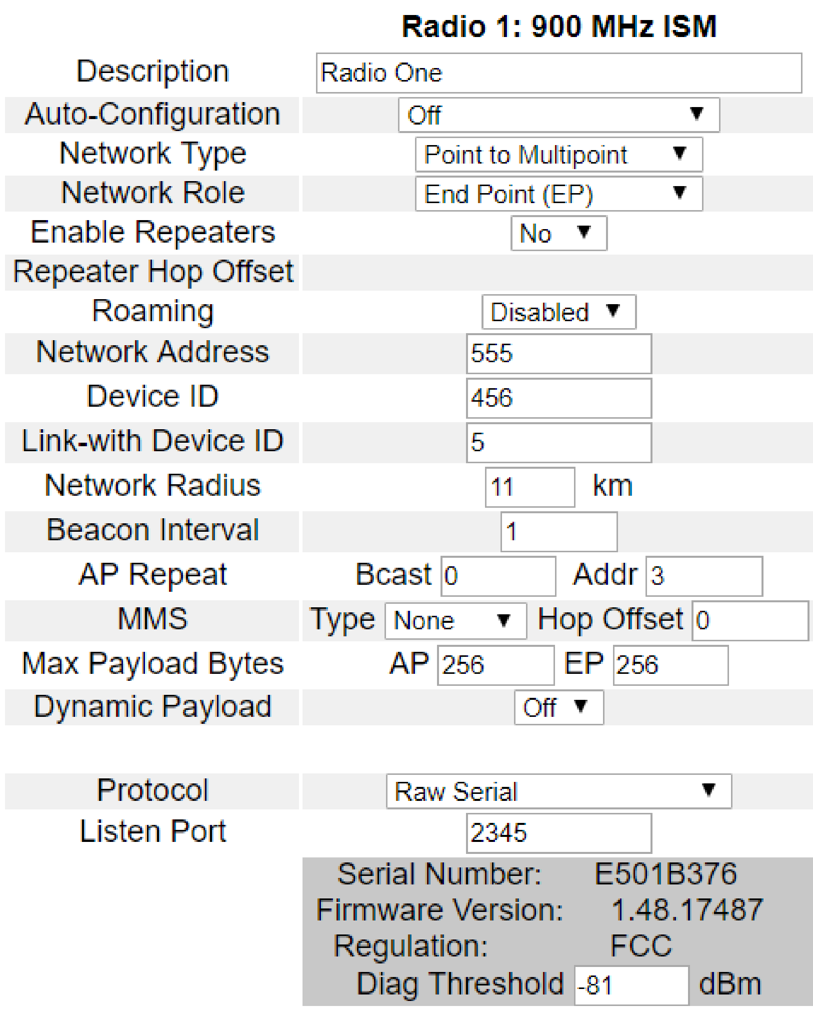
The following diagram shows how seamless serial service works.



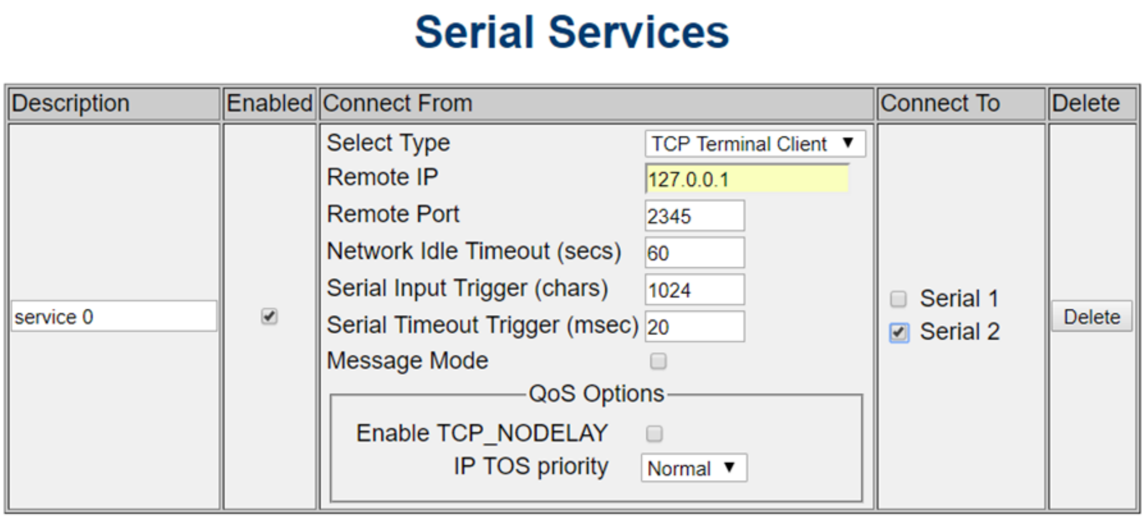
Serial Only Mode

Serial only mode dedicates the whole RF channel exclusively to serial traffic. No IP traffic will be allowed through the wireless link.

To configure serial only mode, in the Radio Network Setting, configure protocol to be raw serial. Also assign a TCP listening port for internal serial traffic processing.

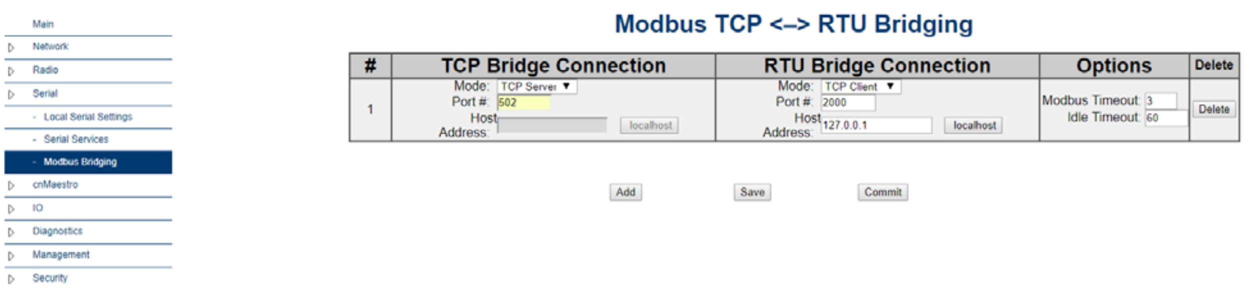


On the serial service configuration page, create a serial client service, with the remote listening port point to the one set in the radio network configuration, use 127.0.0.1 as remote IP address



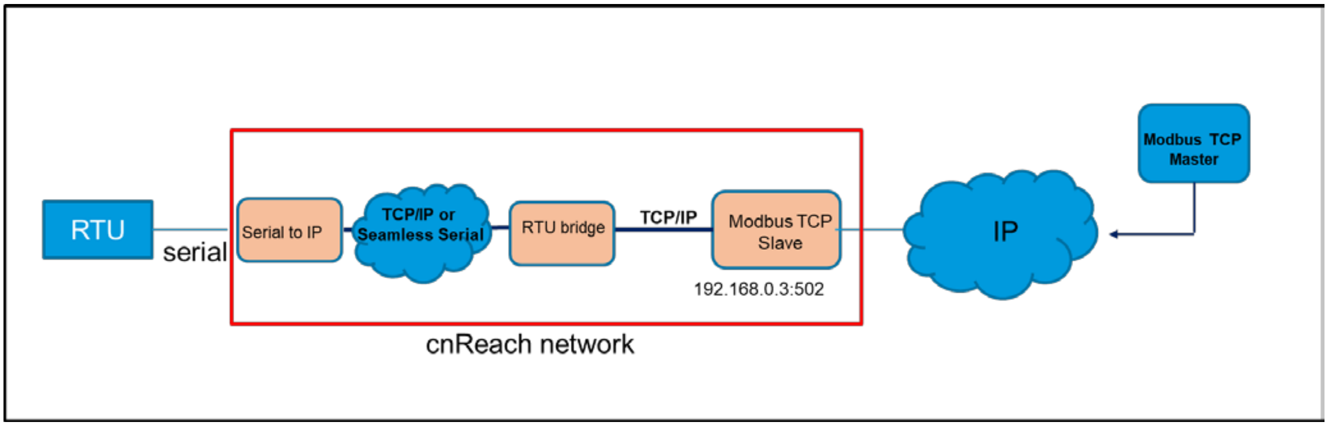
Serial/Modbus Bridging

The Modbus Bridging menu is used for setting up a protocol gateway between Modbus TCP (from the IP side) to Modbus RTU (at the serial side)



Modbus TCP and RTU bridging allow the cnReach radio to act as a protocol converter so that a TCP polling host (such as a SCADA master) can communicate with a device running an RTU terminal server (typically an RTU device often behind a repeater). The feature helps establish the TCP session on devices on both sides of the radio.

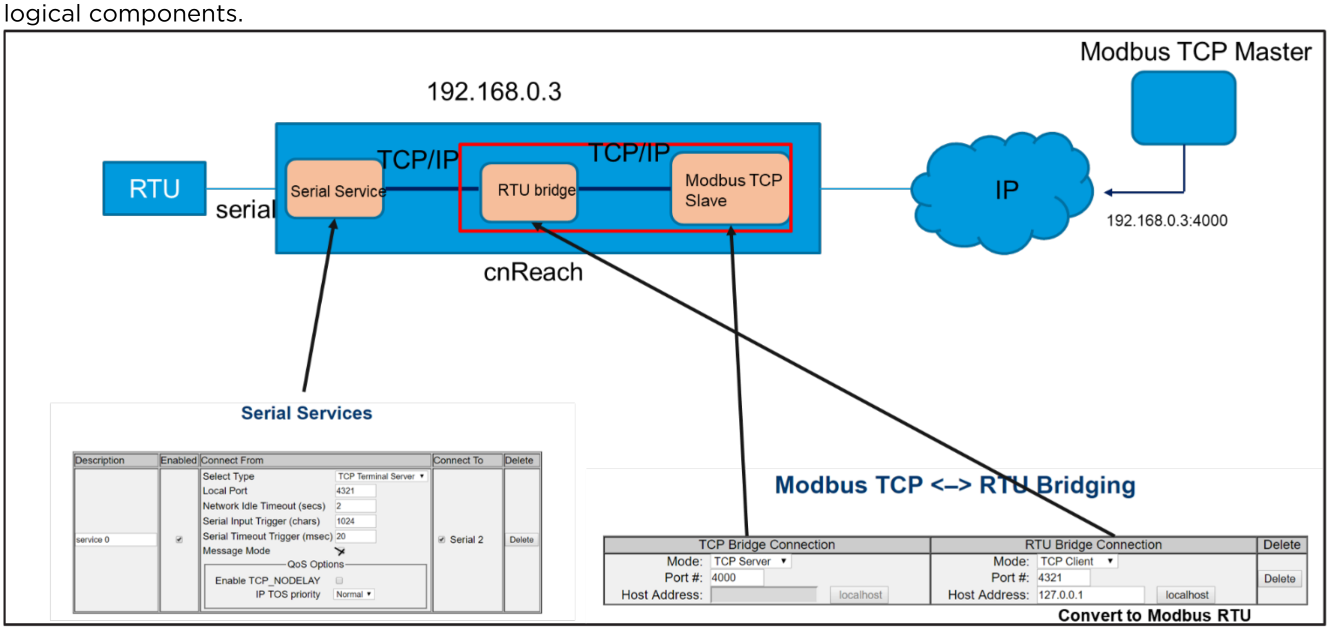
The following figure shows how this conversion is implemented by cnReach:



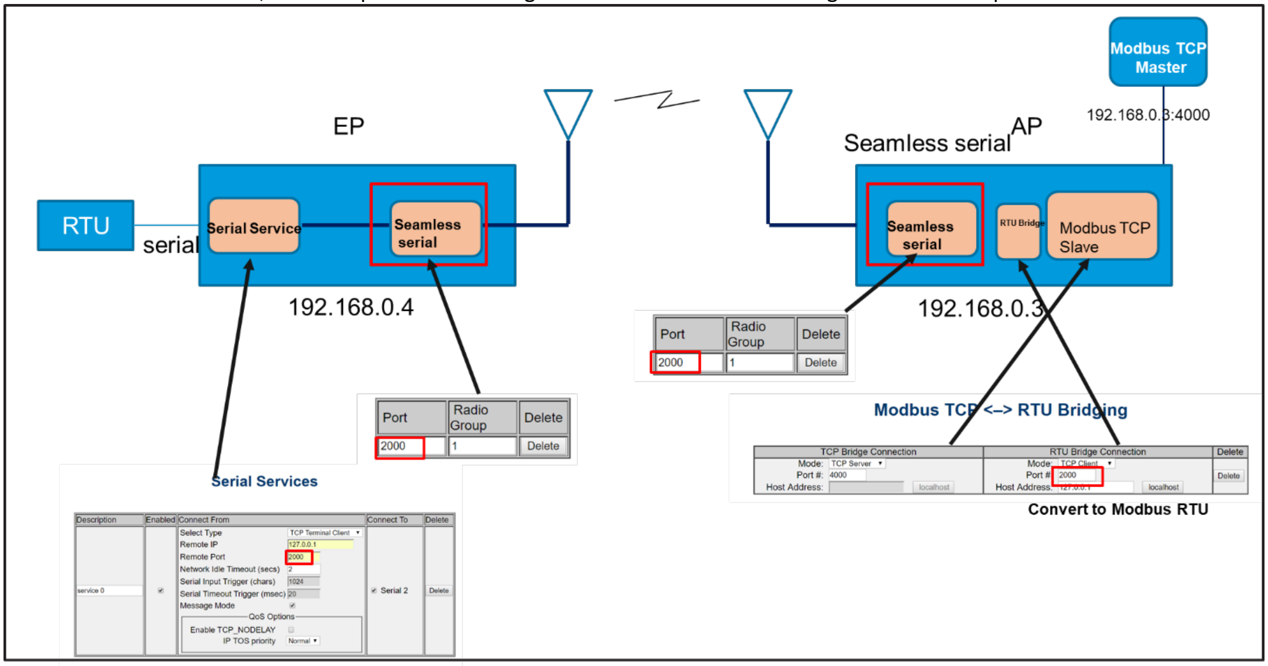
To create a new Modbus TCP to RTU bridge connection:

1. In the UI, go to Serial > Modbus Bridging.
2. Click Add to display the bridging settings.
3. Click the Mode list and select TCP Server or TCP Client for each part of the bridge connection. Typically, the TCP Bridge Connection is in TCP Server mode and the RTU Bridge Connection is in TCP Client mode. The Host Address field is enabled for TCP Clients only.
4. In Port#, enter the port number for the bridge. This is the port through which the bridge communicates.
5. For the TCP Client, enter the host IP address in Host Address. (You can automatically select the local host by clicking localhost.)
6. Click Commit to save the changes.

The following diagram shows configuration of a Modbus TCP/Modbus RTU service and their related logical components.



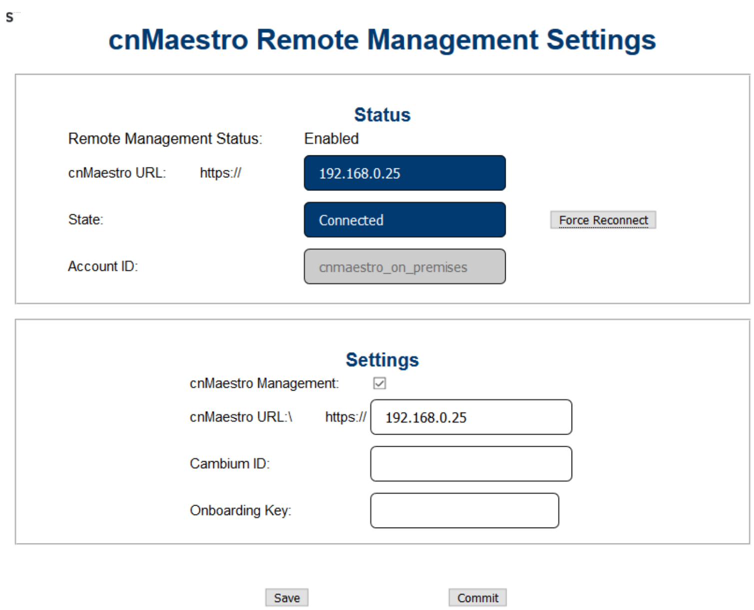
Please notice that Modbus TCP/Modbus RTU conversion can also be sent over seamless serial, because once Modbus TCP is converted to Modbus RTU, it can be processed like regular serial traffic. The following shows an example on how to do it.



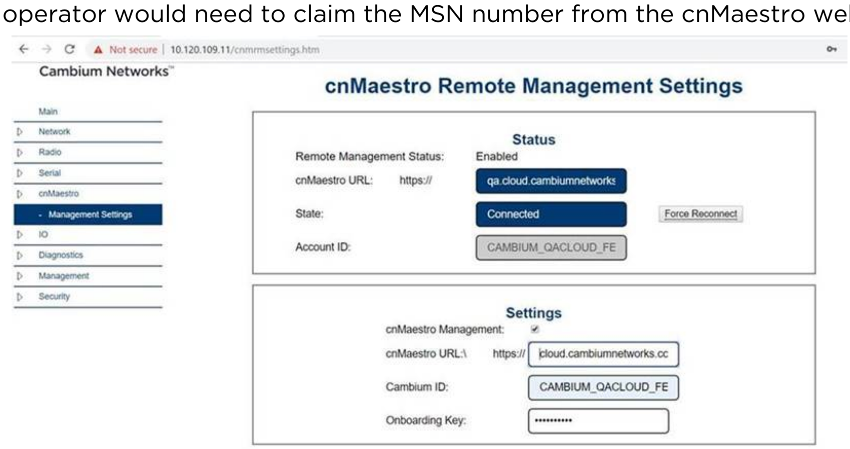
cnMaestro Menu

cnMaestro/Management Settings

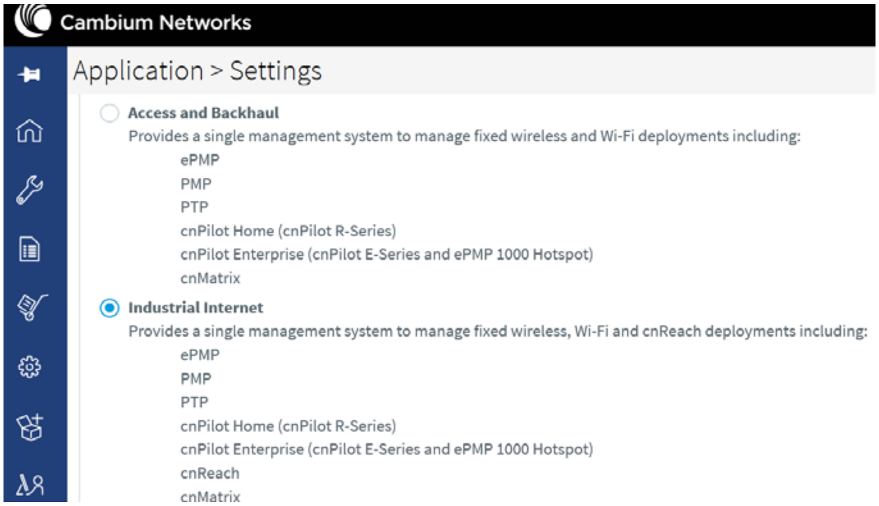
The settings on this page enable the cnReach device to be managed by the cnMaestro management system from Cambium Networks. Refer to cnMaestro documentation for setting up the server. To configure cnReach for NOC support, enter only the IP address of the cnMaestro at the cnMaestro URL input box and check the cnMaestro Management check box.



To configure cnReach to work with cnMaestro cloud, set the url to cloud.cambiumnetworks.com. The Cambium ID and Onboarding Key are not required if MSN of the radio is used for onboarding claiming. In that case, the operator would need to claim the MSN number from the cnMaestro website.



The cnMaestro (cloud or NOC) should have “Industrial Internet” selected in the application settings.



Settings

cnMaestro Management:	Enable this checkbox to active cnMaestro management
cnMaestro URL:	Enter the URL (or IP address) of the cnMaestro server
Cambium ID:	Enter the Cambium ID provided by your cnMaestro administrator. By default this is cnmaestro_on_premises
Onboarding Key:	Enter the Onboading Key provided by your cnMaestro administrator

Status

- cnMaestro URL: this is the URL either entered by the user below in setting or gathered from a DHCP server when using that option.
- State: State can be one of the following:
    - Connected (successfully connected to cnMaestro)
    - Connecting
    - Connecting in X minutes
    - Awaiting Authorization (cnMaestro Administrator needs to accept the module)
    - Failed to Resolve URL (cnReach radio can’t reach cnMaestro server; URL could be incorrect)
    - Initializing (~60 seconds)
- Account ID: equates to Cambium ID entered in Settings after the connection is successfully established.

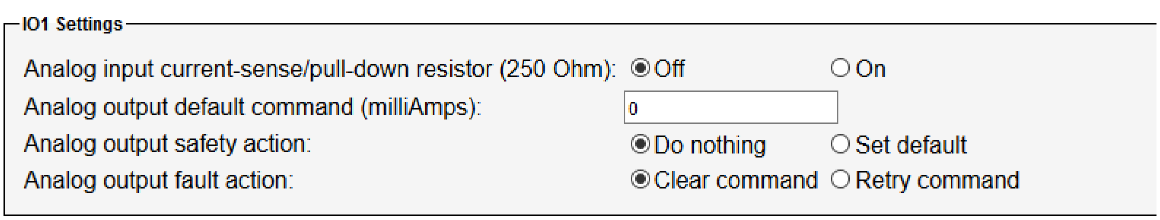
I/O Menu

I/O/Channel Settings

Built-in I/O is an optional hardware feature on cnReach models. See the product overview section for the sales models that include built-in I/O.   The built-in I/O can be used to interface directly to analog and digital service (inputs and outputs). Refer to the technical reference section for more details and wiring examples of the I/O interfaces.

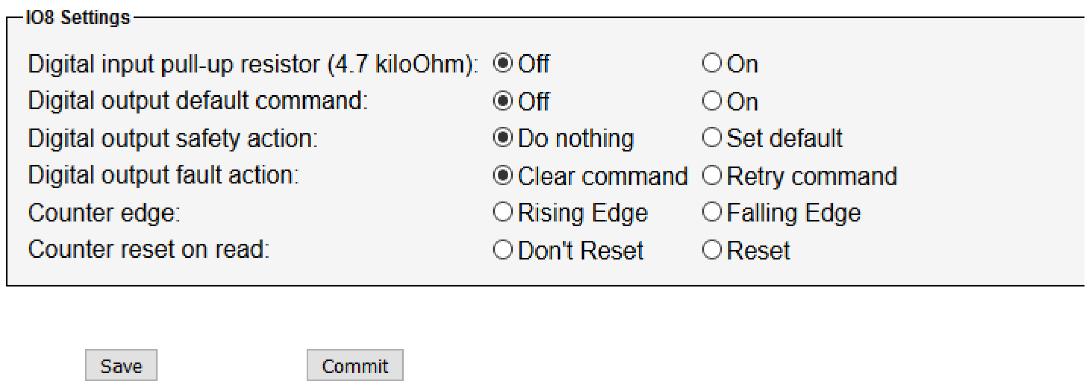
GUI settings for the IO1 to IO4 referencing Analog I/O:

- Analog input current-sense/pull-down resistor. Turning this on enables the pull-down resistor. See reference schematic in the technical reference section.
- The Analog default command sets the default amount of current to drive in an analog output application.
- The Analog safety action is what the cnReach radio will do if no Modbus command is received within the Modbus timeout setting (see the Modbus settings page).
- The Analog output fault action is what to do if the cnReach radio attempts to drive analog current into a short circuit or other fault condition. cnReach can either continue to retry or simply clear the command / Modbus register setting.



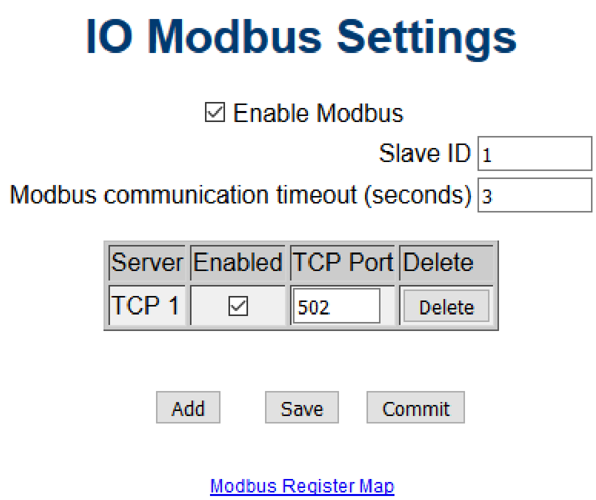
GUI settings for the IO5 to IO8 referencing Digital I/O:

- Digital input pull-up resistor. Turning this on enables the pull-up resistor which is commonly used with dry-contact switch applications. See reference schematic in the technical reference section.
- The Digital output default command sets the default state to drive.
- The Digital output safety action is what the cnReach radio will do if no Modbus command is received within the Modbus timeout setting (see the Modbus settings page).
- The Digital output fault action is what to do if the cnReach radio attempts to drive into a short circuit or other fault condition. cnReach can either continue to retry or simply clear the command / Modbus register setting.



I/O/Modbus Settings

The Modbus communication timeout is the time the cnReach radio will wait for a new Modbus command before reverting the IO ports to their safety action.



Clicking on the Modbus Register Map displays the entire register that can be read from the Modbus server. Refer to the IO application note on the Cambium website for more information and examples of using the register map to read/write the different IO pins.

Modbus Register Map

Holding Coils

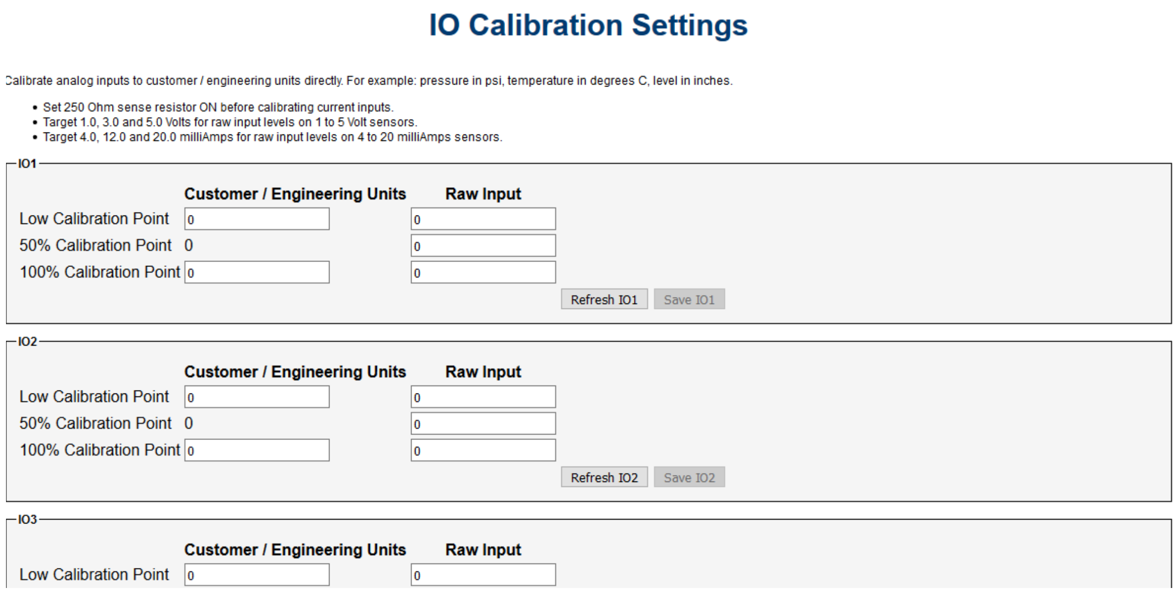
To read holding coil registers use Modbus commands **1 Read Coils**, **5 Write Single Coil**, and **15 Write Multiple Coils**.

Register	Address	Description	Channel	Units	Format
1 to 4	0 to 3	Reserved			
5	4	Digital Output Command	Ch4	"1" = On	Boolean
6	5	Digital Output Command	Ch5	"1" = On	Boolean
7	6	Digital Output Command	Ch6	"1" = On	Boolean
8	7	Digital Output Command	Ch7	"1" = On	Boolean
9 to 12	8 to 11	Reserved			
13	12	Pull-Up Resistor	Ch4	"1" = 4.7 kiloOhm to 4.3 Volts	Boolean
14	13	Pull-Up Resistor	Ch5	"1" = 4.7 kiloOhm to 4.3 Volts	Boolean
15	14	Pull-Up Resistor	Ch6	"1" = 4.7 kiloOhm to 4.3 Volts	Boolean
16	15	Pull-Up Resistor	Ch7	"1" = 4.7 kiloOhm to 4.3 Volts	Boolean
17	16	Current Sense/Pull-Down Resistor	Ch0	"1" = 250 Ohm to ground	Boolean
18	17	Current Sense/Pull-Down Resistor	Ch1	"1" = 250 Ohm to ground	Boolean
19	18	Current Sense/Pull-Down Resistor	Ch2	"1" = 250 Ohm to ground	Boolean
20	19	Current Sense/Pull-Down Resistor	Ch3	"1" = 250 Ohm to ground	Boolean
21 to 36	20 to 35	Reserved			
37	36	Digital Output Fault Retry	Ch4	"0" = Clear command on fault, "1" = Retry after fault	Boolean
38	37	Digital Output Fault Retry	Ch5	"0" = Clear command on fault, "1" = Retry after fault	Boolean
39	38	Digital Output Fault Retry	Ch6	"0" = Clear command on fault, "1" = Retry after fault	Boolean

I/O/Calibration Settings

The I/O calibration feature allows the cnReach I/O inputs to be calibrated to real-world values. As an example, you can use the calibration field to convert analog signals from a pressure gauge to Psi units. Or 1-5 VDC into degress Celsius using these settings.

Set the real-world or actual units in the Customer/Engineering fields and then enter the correlating voltage or current readings in the raw input fields.



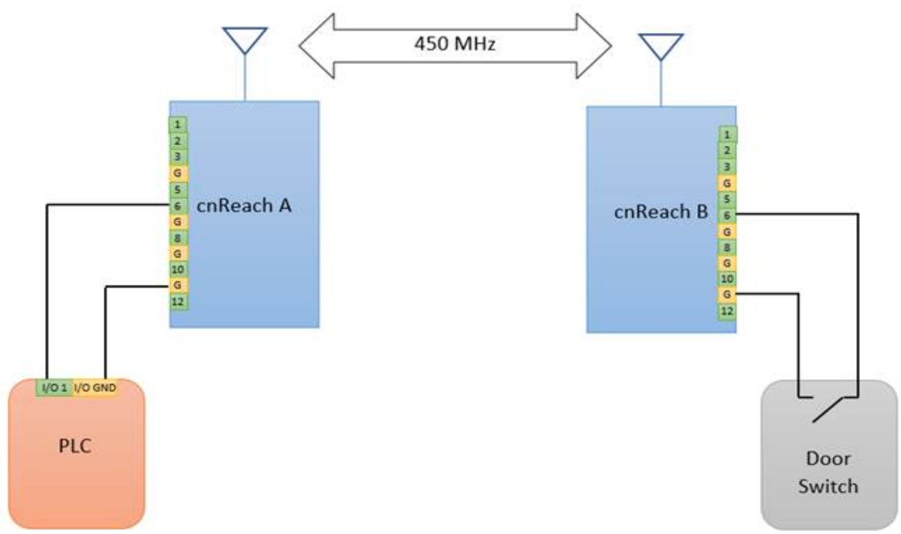
Wire-replacement Menu

The wire-replacement feature enables the operator to "pass" I/O input from one cnReach as I/O output to another cnReach. One I/O input can be passed to multiple cnReach IP addresses. The wire-replacement feature is implemented by hosting a Modbus-TCP master in the cnReach. This process will probe any cnReach's IO module (source) for status and trigger output on the destination cnReach unit. The "wire" can be configured on any cnReach unit (IO capable or non-IO capable radios or IO expanders). The source cnReach and destination cnReach should be IO capable.

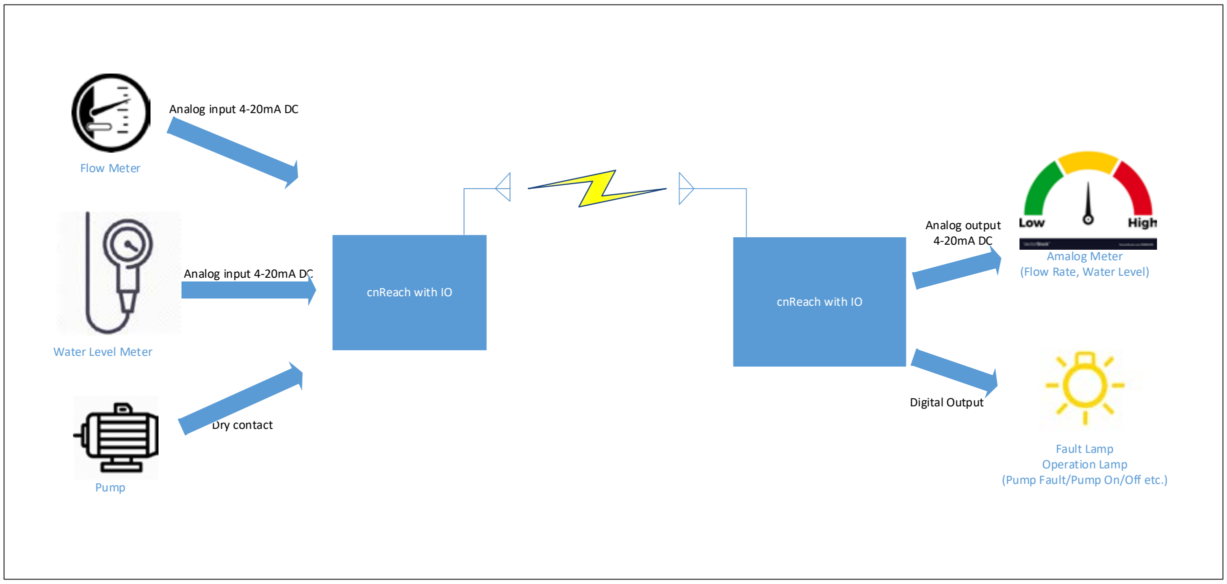
Wire-replacement is only supported on OS version 5.2.17 and above. **A wire-replacement software module needs to be uploaded and applied to the OS. This separate wire replacement software module should be downloaded from the support website and installed on the management/files pages just as an OS upgrade would be installed. After installation, the wire replacement menu and options will be visible in the GUI.**

The following are some example use cases for wire-replacement.

- Case #1 Read pin states on cnReach at Location A when state of pins on cnReach at location B changes (e.g. Door Switch opens/closes)



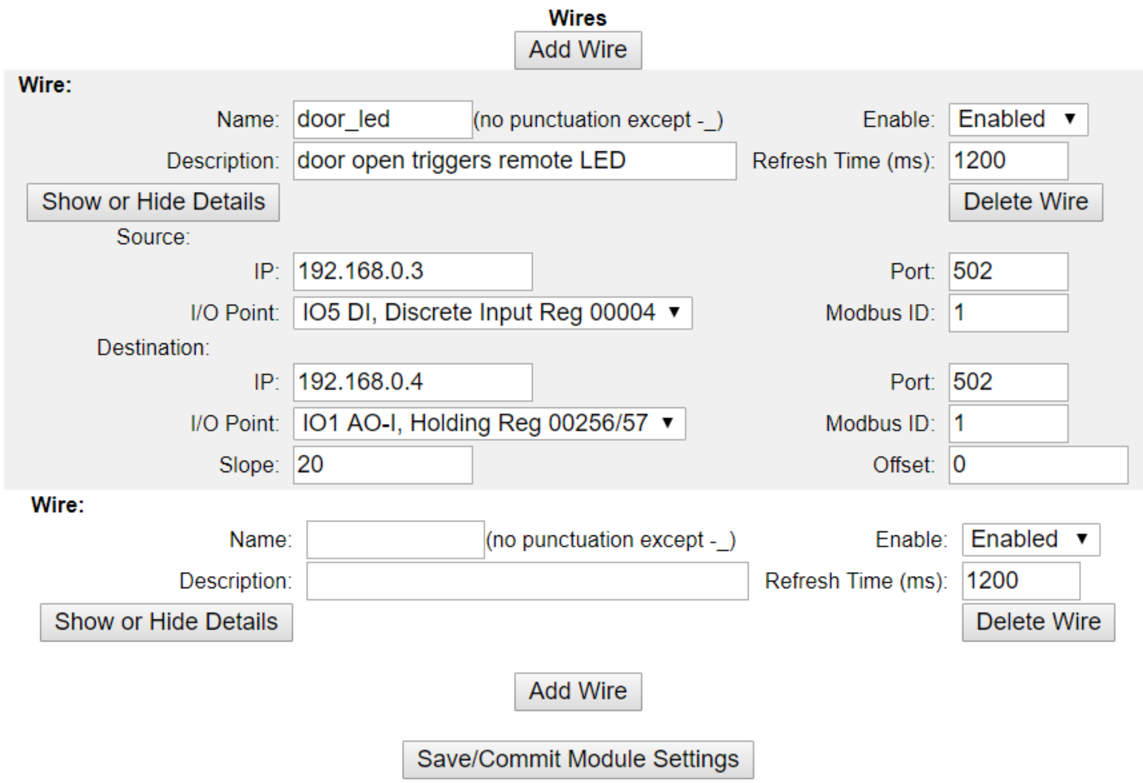
- Case #2 Water pumps deployment - Signals input on the intake pump side shall be output on the processing plant side in the same format and score



Step by Step for wire-replacement configuration

1. Go to the wire-replace page and click on "Add Wire"

2. Click on "Show Detail"



Enter all the configuration parameters and hit the "Save/Commit Module Settings" button.

The example above shows a wire replacement configuration that takes dry contact input from IO5 of 192.168.0.3 and generate analog output at 192.168.0.4 on IO1.

Meanings for each field in the wire-replacement configuration

Name: Name of the wire, you can enter any character strings except punctuations.

Enable/Disable: A wire can be enabled or disabled

Description: any description you want to provide about the wire

Refresh Time: how often the wire replacement module will try to poll the Modbus source, and write to the Modbus destination

Souce: Source IP address, TCP port number you want to poll from, also, which I/O pin and what I/O information you are polling for from the source unit.

Destination:Destination IP address, TCP TCP port number you want to poll from, also, which I/O pin and what I/O update you want to trigger based on the source input.

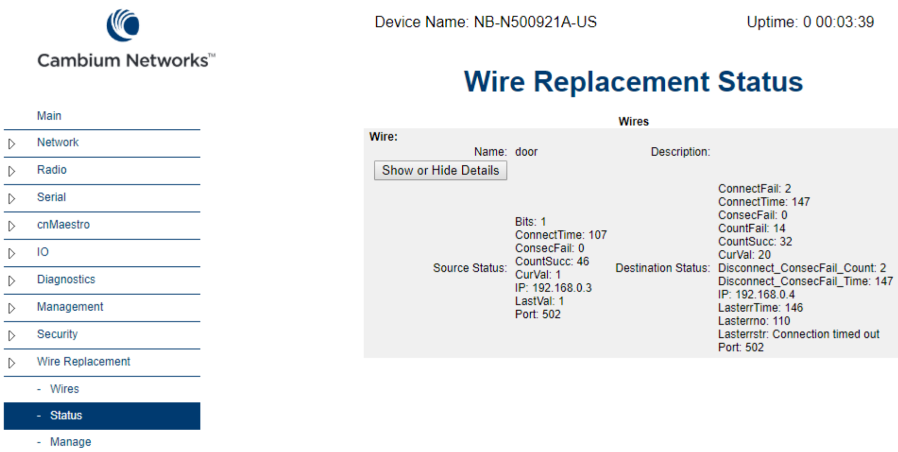
Slope and offset: Slope and offset allow you to scale various units to others,

Y (output) = slope * X (input) + offset.

For example, 1-5V input can't be written directly to a 4-20mA output, so offset would be zero but slope would be 0.004.

Wire Status

The user can click on the status menu to view the status of the wires.



PLC Menu

The PLC feature enables the operator to configure cnReach to “act” on a local I/O input event to trigger local I/O output. The input event handler is programmable using a BASIC-like language, strictly following BASIC syntax.

Any cnReach with IO capability can host a Local PLC module . The PLC module is a separate software module that must be downloaded from the support website and installed separately.

PLC is only supported on OS version 5.2.17 and above. **A PLC software module needs to be uploaded and applied to the OS. This separate PLC software module should be downloaded from the support website and installed on the management/files pages just as an OS upgrade would be installed. After installation, the PLC menu and options will be visible in the GUI.**

This PLC module executes the supplied BASIC language code approximately once every 100ms.

LOCAL PLC Supported Functions

int = fnCRGet(Reg) - Get coil register from Modbus registers.
int = fnDRGet(Reg) - Get discrete register from Modbus registers.
int = fnHRGet(Reg) - Get holding register from Modbus registers.
int = fnIRGet(Reg) - Get input register from Modbus registers.

int = fnHRGetFloat(Reg) - Get float from holding register and register+1, from Modbus registers.

fnCRSet(Reg,Val) - Set coil register in Modbus registers. Val is 0 or non-zero.
fnHRSet(Reg,Val) - Set holding register in Modbus registers. Val is 16 bits, unsigned.

fnHRSetFloat(Reg,Val) - Set float in holding register and register+1, in Modbus registers. Val is float/real.

fnGetSeconds() - Get float/real of uptime seconds.

LOCAL PLC Supported BASIC Language Key Words

Reserved Keywords:

REM, TRUE, FALSE, NIL, MOD, AND, OR, NOT, IS, LET, DIM, IF, THEN, ELSEIF, ELSE, ENDIF, FOR, IN, TO, STEP, NEXT, WHILE, WEND, DO, UNTIL, GOTO, GOSUB, RETURN, CALL, DEF, ENDDEF, ME, NEW, VAR, REFLECT, MEM, TYPE, END.

Standard Library:
ABS, SGN, SQR, FLOOR, CEIL, FIX, ROUND, SRND, RND, SIN, COS, TAN, ASIN, ACOS, ATAN, EXP, LOG, ASC, CHR, LEFT, LEN, MID, RIGHT, STR, VAL, PRINT.

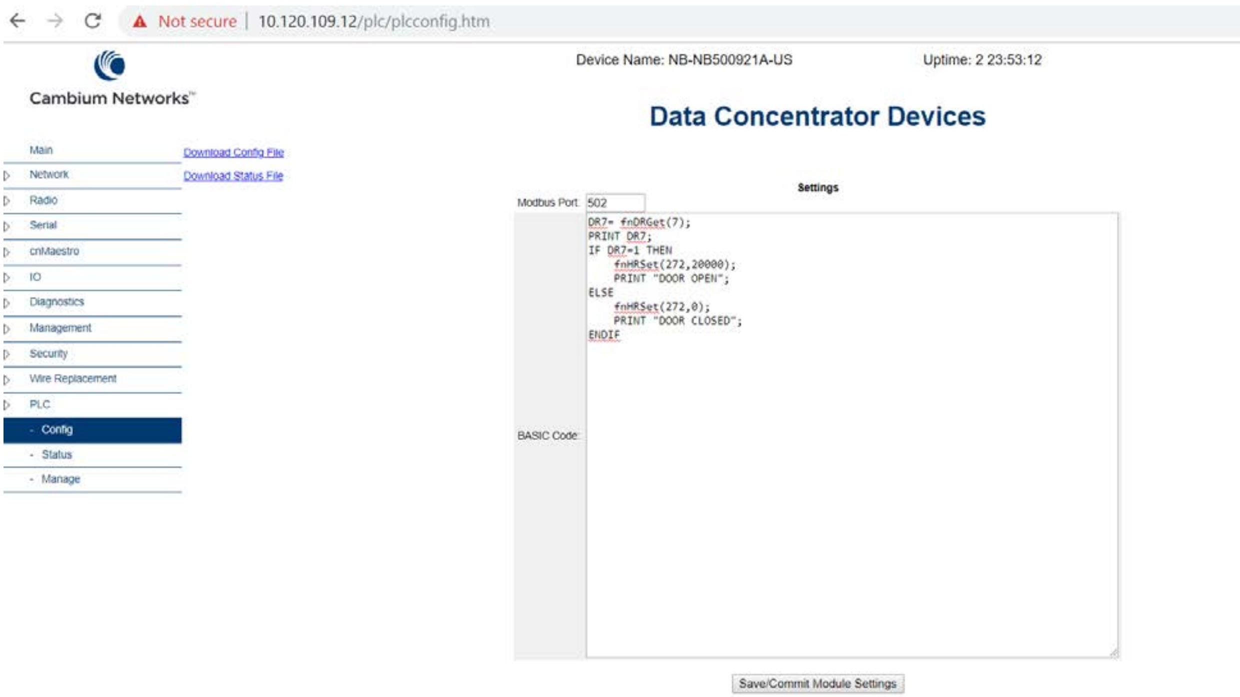
PRINT:

PRINT "string" - print string without trailing carriage return/line feed.
PRINT "string"; - print string with trailing carriage return/line feed.

PRINT Val1;Val2; - print Val1 and Val2 on individual lines.
PRINT "string"+CHR(10) - print string with trailing line feed.

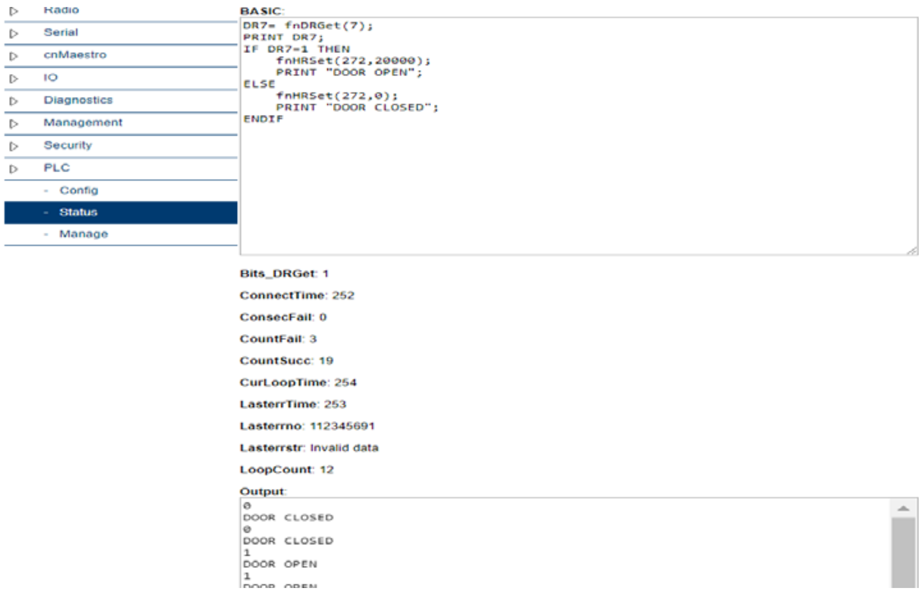
LOCAL PLC Configuration

To config/write PLC code, go to the PLC configuration GUI and write your code in the “BASIC Code” box, then hit the “Save/Commit Module Settings”.



LOCAL PLC Execution Status Monitoring

To monitor the PLC execution status, navigate to the PLC the status page.The output will be printed on the screen.



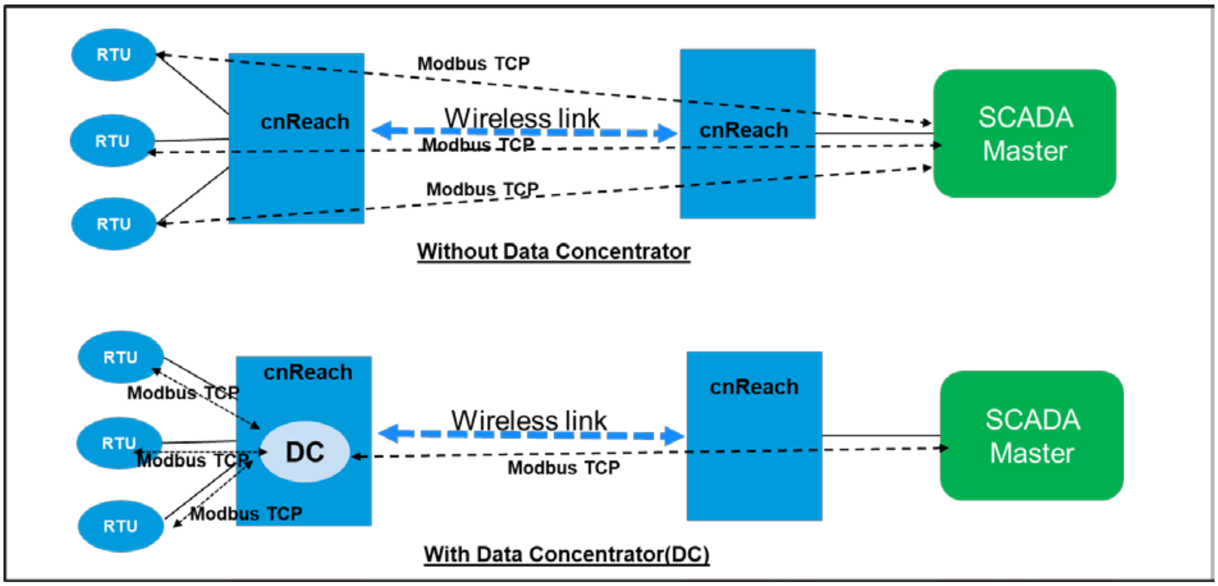
LOCAL PLC Manage Page

The PLC Manage Page allows the operator to do the following:

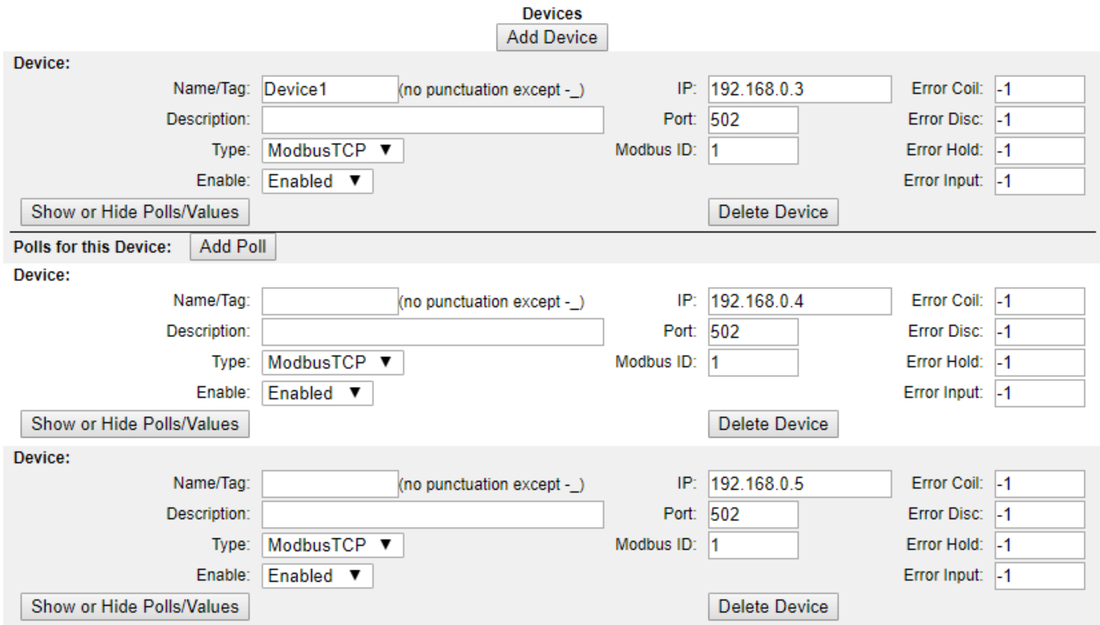
1. Upload PLC Config File
2. Remove PLC module and all settings

Data Concentrator Menu

The Data Concentrator module allows concentrating multiple Modbus devices into a single Modbus map, and allows those values to be accessed by either ModbusTCP or MQTT. This reduces the SCADA query frequency and cuts down the use of the network bandwidth. Instead of querying each RTU, the SCADA master can query the Data Concentrator in a single poll, and the DC returns parameters it received from multiple RTUs in a single response.

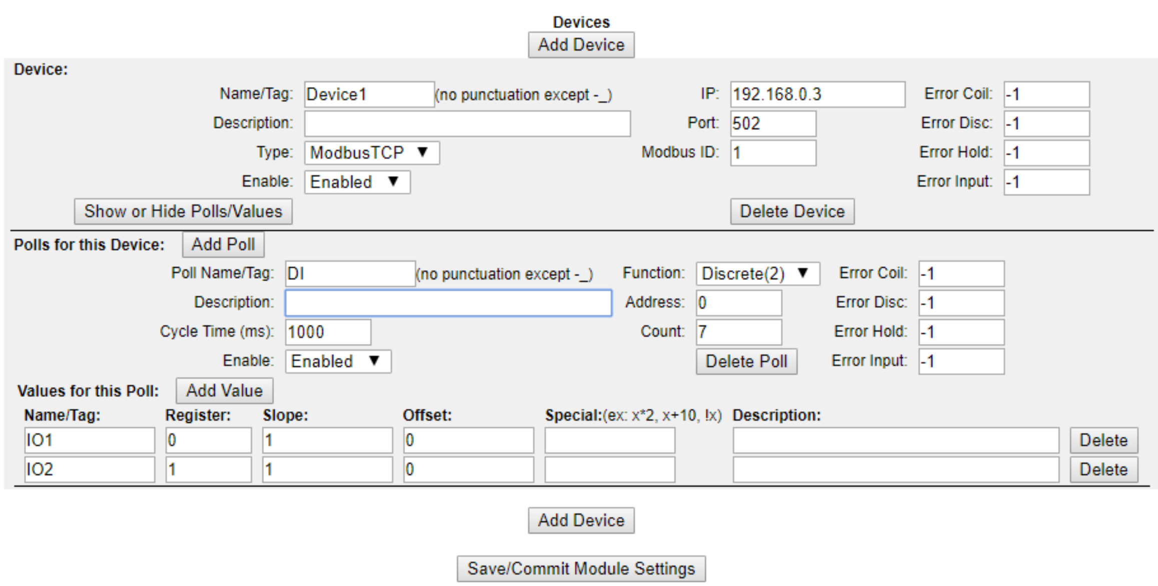


Data Concentrator is only supported on OS version 5.2.18c and above. A DC software module needs to be uploaded and applied to the OS. This separate DC software module should be downloaded from the support website and installed on the management/files pages just as an OS upgrade would be installed. After installation, the Data Concentrator menu and options will be visible in the GUI.



Each Device is set up with its connection parameters, and optional error indicators. Under each device a series of polls is defined, blocks of Modbus registers to fetch. Polls also have optional error indicators. Under each poll the particular values that are of interest are defined.One to many devices can be configured, each with their particular parameters. If you need ModbusRTU, configure the Data Concentrator to use the Modbus Bridge.

The error registers can be set to -1 to disable, or to any valid Modbus register (0-65534). If there's a conflict between error registers and output values, the error register will be written briefly, then the output value. Errors on any Poll under this device will set (1) the error registers, and only if all Polls are successful will the error registers be cleared (0).



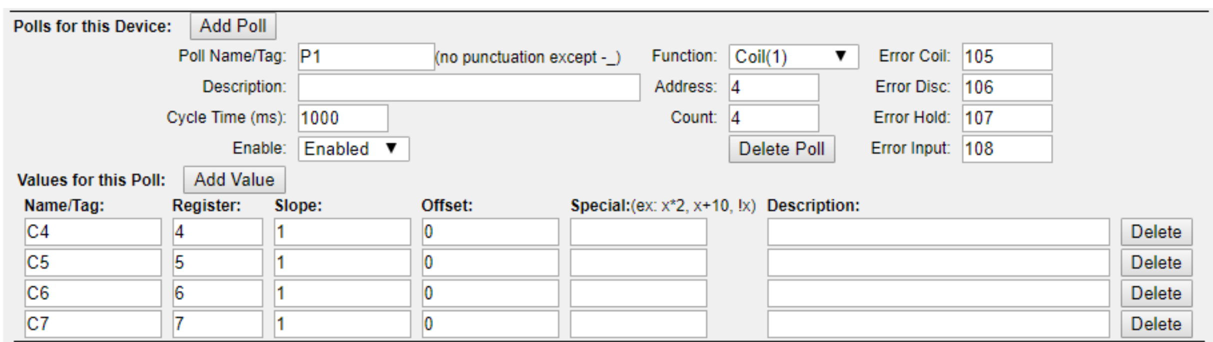
Each value has a number of transformations that can be applied: format, slope, offset, and special. The ormat field defines how to treat the incoming bytes from the Modbus response. Coils and Discretes do not have the format option, all incoming data is treated as a single bit by definition. After the incoming data is translated to the internal format (double), the slope and offset is applied (y=mx+b). Next step is applying the special transformation. This consists of any arbitrary math equation, of the form f(x), where x is the input value. Examples are "!x", to invert the incoming data, "123*x+456", a slope/offset calculation (though better handled by the defined slope/offset fields), etc.

Incoming data (bits or registers)	
Internal Value (IV, double)	= Convert bit or specified format
	= slope * IV + offset
	= f(x)
	= Final internal value

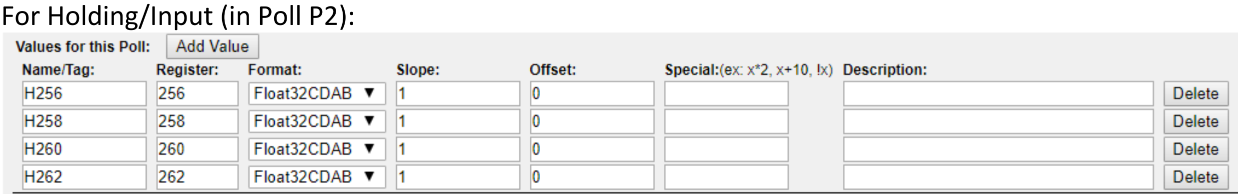
This internal value is then used in the output map, going through a format conversion for storage (and optionally slope/offset/special transformation). This internal value is also used for MQTT.

Poll and Value Setup

For Coils/Discretes:



For Holding/Input (in Poll P2):



The Function, Address, and Count fields define the Modbus poll. Each value in the poll must have a Register that is contained in the result of that poll.

The error registers can be set to -1 to disable, or to any valid Modbus register (0-65534). If there's a conflict between error registers and output values, the error register will be written briefly, then the output value. Errors on this Poll will set (1) the poll error registers and the parent device error registers, and if the Poll is successful the error registers be cleared (0).

Coils/Discretes do not have a format specification, Holding/Inputs do have a format specification. Formats of Bit, UInt16, Int16, Int32, UInt32, and Float32 are all available. For each of the 32bit values, all four combinations of word and byte order are available.

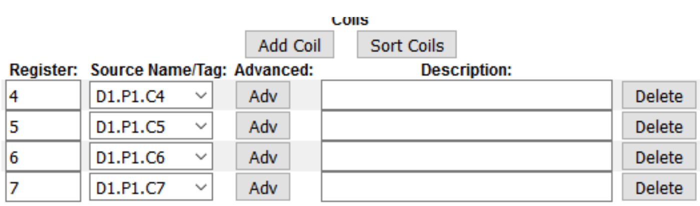
Slope and Offset are both treated as floats, and must be valid float values. The defaults are slope=1, offset=0, thus having no affect on the value.
Special is the arbitrary math function that can be applied to the value. If it is not used, ensure that it is empty, no spaces or other characters. To use it, put a function of the form y="f(x)", where the quoted part is entered into the box. Examples are "!x", to invert the incoming data, "123*x+456", a slope/offset calculation, etc. A slope/offset calculation is valid, but is not reversible if entered here, as opposed to the defined slope/offset are properly reversed on a write. The letter "x", lower case, is the input to the function. This supports addition (+), subtraction/negation (-), multiplication (*), division (/), exponentiation (^) and modulus (%) with the normal operator precedence, abs, acos, asin, atan, atan2, ceil, cos, cosh, exp, floor, ln, log, log10, pow, sin, sinh, sqrt, tan, tanh, fac, ncr, npr, with constants e and pi available. Constants can be integers, decimal numbers, or in scientific notation (e.g. 1e3 for 1000).

IMPORTANT: If this value will be written, ie a Modbus Master will write to the data concentrator output map, and the data concentrator will write through to the defined device/poll/register, then the special function must be reversible, or not used. "!x" is reversible (for bit like numbers), in that !1 = 0, and !0 = 1. Most other arbitrary math is not reversible.

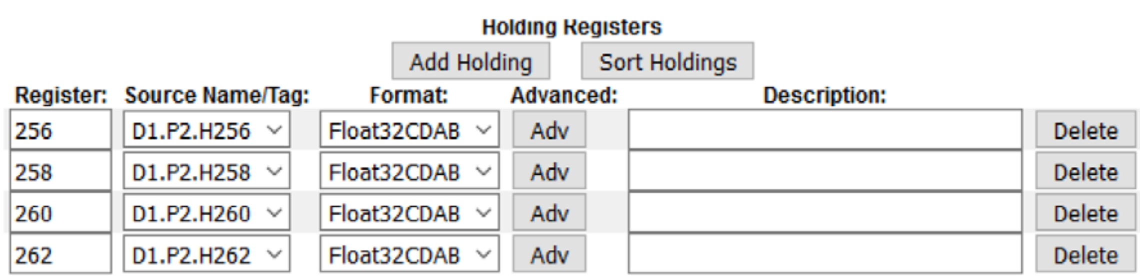
Output Value Setup

The output map defines a register, then a source which is a tag name comprised of the Device.Poll.Value. The advanced button hides another slope/offset/special set of data manipulations that can be used. This set of slope/offset/special is only applied to the Modbus output registers, not MQTT values.

Coil/Discrete:



Holding/Inputs:

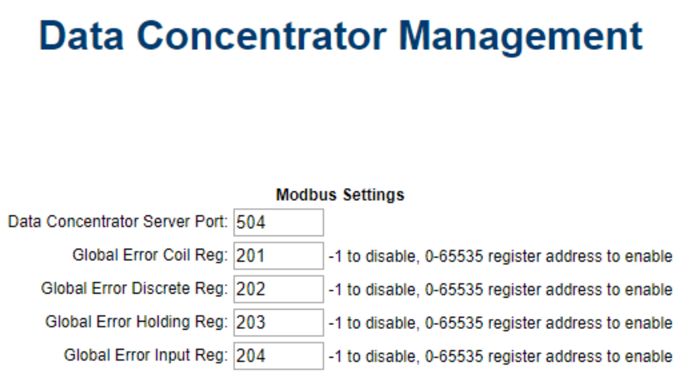


Note:

- All Modbus registers are in protocol address (0-65534), not PLC address (1..., 10,001..., 30,001..., 40,001...)
- Writing only supports (0x05) Write single coil, (0x06) Write single holding register, and (0x10) Write multiple holding registers.

Global Settings:

There is a global set of error registers, just like the Device and Poll, which indicate if any device or poll failed(1), or all have succeeded(0).
The data concentrator output port, Modbus slave, defaults to 504. Make sure it does not conflict with other ports defined on the system.
MQTT can be enabled or disabled, and its particular settings are configured here. A MQTT broker IP an port (default 1883) is specified, along with username and password, and the MQTT group name.
Global Settings is configured under the Manage Sub-menu.



MQTT

MQTT is included in the Data Concentrator package and it built on top of Data Concentrator.
MQTT uses the Sparkplug B specification, so the Group ID is typically a larger grouping, a facility, an area in a facility, a geographic area, etc. The Node Name is taken from the Device Name (also the host name) and appended with "_DataConcentrator". Device name, Poll name, and Value name form the rest of the tag to define each value.
Values are reported to MQTT on a change of more than 1% of its prior value.
If a Modbus input value is not modified, the MQTT format is derived from the input format. If a slope,= offset, or special modification is made to the value, then the MQTT double format is used.
No Modbus output map/values need to be defined for MQTT to work. MQTT uses only the input side, Devices, Polls, and Values to determine both the namespace and the data type. Both Modbus output and MQTT may be used simultaneously, or either by itself.

Bit	METRIC_DATA_TYPE_BOOLEAN
UInt16	METRIC_DATA_TYPE_UINT16
Int16	METRIC_DATA_TYPE_INT16
UInt32xxxx	METRIC_DATA_TYPE_UINT32
Int32xxxx	METRIC_DATA_TYPE_INT32
Float32xxxx	METRIC_DATA_TYPE_FLOAT
All manipulated values (slope/offset/special) are MQTT	
Double (Double)	METRIC_DATA_TYPE_DOUBLE

An example MQTT/Sparkplug B namespace, using the Device and Poll setup examples earlier, looks like:

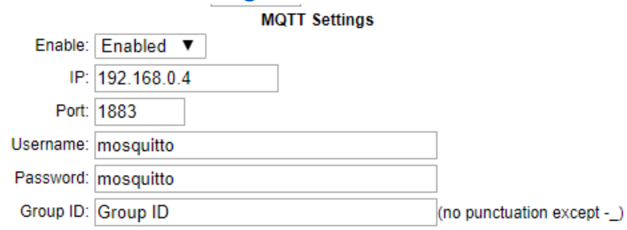
```
/spBv1.0 /<Group Name> /DDATA /<Device Name>_DataConcentrator        /D1      /P1      /C4
                                                                                      /C5
```

```
                /C6
                /C7
        /P2     /H256
                /H258
                /H260
                /H262
```

<Group Name> is specified on the Data Concentrator Management page, and <Device Name> is specified on the Home page, also the host name. The DDATA field is used for data as it changes in the Modbus inputs. Other values in that location will consist of NDATA, DBIRTH, DDEATH, NBIRTH, NDEATH, DCMD, and NCMD. For more details on any Sparkplug B topics, please see the specification at:

https://docs.chariot.io/display/CLD/Sparkplug+Specification

MQTT configuration is located under the Manage sub-menu



Diagnostics Menu

cnReach has many diagnostic tools available for fine tuning and troubleshooting the network. This chapter describes each of the tools in turn.

Diagnostics/Neighbor List

The **Neighbor List** displays information about all the End Point Radios that are connected to an Access Point.

The End Point Neighbor List will only show the Access Point unless the **Bounce** setting is enabled in the Access Point; then the End Point list will display the Neighbor End Points.

Neighbor List

Radio	IP Address	MAC Address	Device id	Local RSSI	Local Noise	Local Age	Remote RSSI	Remote Noise	Remote TxPwr	Remote Age	Learned Age
1	192.168.0.4	70f1e501e449	4	-35	-121	14s	-36	-122	0	2m	7h
1	192.168.0.5	70f1e501e42a	5	-49	-123	8s	-53	-121	0	37s	7h

Refresh Clear

Radio shows which RF Module the Neighbor is connected to.

IP Address, **MAC Address** and **Device ID** can be used to identify the Neighbor Radios.

Local RSSI and **Local Noise** represents the local RSSI and Noise measured at the Access Point for each Neighbor.

Local Age is the age of the Local RSSI and Noise measurements, which will update periodically.

Remote RSSI, **Remote Noise** and **Remote Tx Power** are represented in dBm.

Remote Age is the age of the Remote RSSI and Noise measurements, which will update periodically.

Learned Age is the age at which the Neighbor was detected and populated into the list.

Diagnostics/RF Statistics

RF Diagnostics contains statistics about the radio's current RF Environment based on each channel/frequency in the modulations hop table.

RF Statistics

Radio 1

Radio Temp:	38 C	PA Temp:	39 C	Supply Voltage:	11875 mV	Radio Voltage:	7340 mV
Bytes Tx:	795674	Bytes Rx:	1214197				
Tx Rate:	0 kbps	Rx Rate:	0 kbps	Link Status:	Up		
Current Tx Percent:	49	Current Rx Percent:	82	LQM:	68.94	Disconnect Count:	0

Frequency	Max Noise	Min Noise	Avg Noise	Max Signal	Min Signal	Avg Signal	Fwd Power	Reverse Power	% Occupancy	PA Current
929100000	-200	0	0	-200	0	0	100	2	0	260
930100000	-114	-130	-121	-34	-74	-41	0	0	0	0

Radio / PA Temp shows the current temperature the radio / power amplifier in degrees C.

Supply Voltage is the DC supply voltage of the main power connector in mV.

Radio Voltage is the DC supply voltage received by the RF Module from the Ethernet board in mV. This value will differ between products.

Bytes Tx is the quantity of bytes transmitted by the radio.

Bytes Rx is the quantity of bytes received by the radio.

Tx Rate and **Rx Rate** are the instantaneous rates of how fast data is moving.

Cur Rx Percent is the current communications success rate.

The **Freq** column specifies the channel frequency. Refer to Hop Tables for channel frequencies per modulation.

When assessing Noise, look at “Average” as opposed to “Max”. ISM Noise levels vary depending on how many radio systems are in the vicinity and how their hopping pattern and timing parameters are configured. ISM is License Free which makes it a popular choice and although most systems use hopping technology to coexist in the same spectrum, noise can become an issue in high traffic areas with multiple overlaid systems.

Sampling the noise floor at various locations on a prospective network is something that Cambium Networks recommends as part of the link design process. The more the system designer knows about the RF environment, the better engineered the system can be.

Attention

Installing radio systems without sampling the noise floor can, in some cases, lead to unexpected performance. Cambium Networks recommends sampling the noise floor or at least making an allowance for a higher than expected noise floor in the link budget.

When assessing **Signal** look at the “Average” as opposed to “Max”. Consult the RSSI scale to ensure the signal isn’t too weak or too strong; see how to tune RSSI.

Fwd-Pwr is the output transmit power of the radio and should represent the transmit power setting Radio/RF Settings.

Reverse Pwr is the reflected power coming back into the radio from the transmission system and should be =<10% of **Fwd-Pwr**.

Attention

High Rev-Pwr indicates elevated VSWR, which usually means damaged coax, a faulty connector or water ingress (either in the coax or connector).

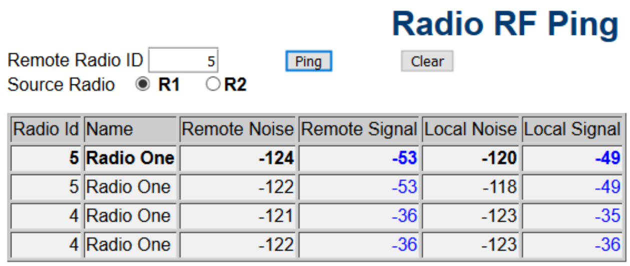
Coaxial connectors, coaxial cables, antennas and then the radio should be checked.

% Occupancy indicates the % of the time the radio went to transmit on the specified frequency and the noise measured was above the Diagnostic Threshold.

PA Current is the current being drawn by the Power Amplifier, in mA.

Diagnostics/RF Ping

The **RF Ping** Utility enables the direct testing of connectivity and signal quality between an Access Point and a remote End Point. The test can be initiated from either side of the link.



Radio RF Ping

Remote Radio ID 5 Ping Clear

Source Radio R1 R2

Radio Id	Name	Remote Noise	Remote Signal	Local Noise	Local Signal
5	**Radio One**	**-124**	**-53**	**-120**	**-49**
5	Radio One	-122	-53	-118	-49
4	Radio One	-121	-36	-123	-35
4	Radio One	-122	-36	-123	-36

Enter the **Device ID** for the radio on the opposing end of the link and press **Ping**.

> Note
>
> *When using this utility on a cnReach N500 radio, it is necessary to select which Source Radio (RF Module) to use for the test.*

Once the test is initiated the radio will attempt one "ping" at the RF protocol level. This is not the same pings as ICMP; they are strictly at the RF level.

Each successful ping will report signal and noise information for both the local and remote radios at opposing ends of the link.

The RF Ping Utility provides users with a diagnostic tool that can be used to:

- Verify that a remote End Point can be heard by the Access Point.
- Verify a specific End Point is connected to the Access Point and able to communicate.
- Obtain signal information at the Access Point for a specific link.

Clear can be used to remove previous test results from the page.

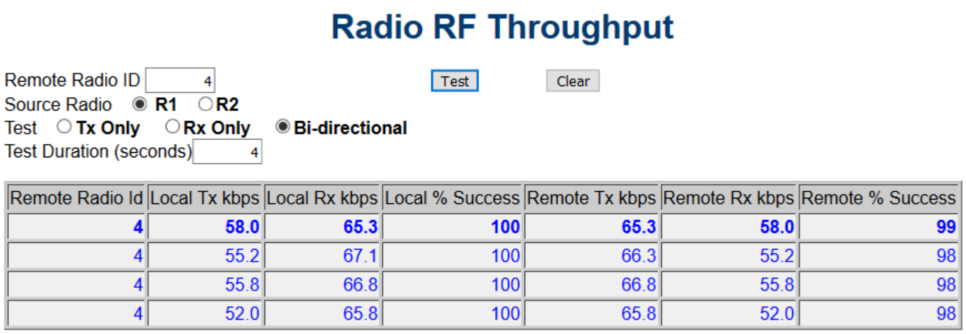
Radio ID is the ID of the opposing radio.

Name is the description given to the RF module of the opposing radio in Radio/Network Settings.

Signal and **Noise** levels are reported in dBm.

Diagnostics/RF Throughput

The **RF Throughput** utility enables the direct testing of link performance between an Access Point and a remote End Point. The test can be initiated from either side of the link.



Remote Radio Id	Local Tx kbps	Local Rx kbps	Local % Success	Remote Tx kbps	Remote Rx kbps	Remote % Success
4	**58.0**	**65.3**	**100**	**65.3**	**58.0**	**99**
4	55.2	67.1	100	66.3	55.2	98
4	55.8	66.8	100	66.8	55.8	98
4	52.0	65.8	100	65.8	52.0	98

Enter the **Device ID** for the radio on the opposing end of the link.

Set the test for:

- **Transmit Only**; i.e. from the local radio to the remote radio only.
- **Receive Only**; i.e. from the remote radio to the local radio only.
- **Bi-directional**; i.e. from local to remote and remote to local.

Enter a **Test Duration** in seconds and press the **Test** button.

> Note
> *When using this utility on a cnReach N500 radio, it is necessary to select which Source Radio (RF Module) to use for the test.*

Once initiated the link will be saturated with test packets at the RF protocol level. The link will be temporarily unavailable to normal Ethernet traffic during the test.

Each successful test will report Transmit and Receive throughput, in kbps, for both the local and remote radios at opposing ends of the link. Faster modulations and larger packet sizes produce more throughput.

> Note
> *RF throughput will be less than the RF Data Rate due to RF protocol overhead, but higher than TCP throughput due to TCP protocol overhead.*

Dropped Packets may indicate elevated noise levels at one or both sites. In a noisy environment, reducing the packet size (Max Payload Bytes) and using a faster modulation can help the Radio get on and off channels quicker, increasing effective throughput.

Clear can be used to remove previous test results from the page.

Diagnostics/Spectrum Analyzer

The spectrum analyzer feature is designed to assist in diagnosing channel interference issues and to understand the noise floor in a given area that can be detected by the radio and its antenna.

It can be a useful tool in diagnosing issues and understanding the impact noise may be having on link performance.   The spectrum analyzer provide 4 different data visualizations based on real-time measurements taken by the radio.

Attention

While the spectrum analyzer is active, the normal payload traffic and the link is DOWN. No traffic will pass until the spectrum analyzer is turned off again. This also implies that you can only run the spectrum analyzer on the AP side of a wireless link or when directly connected to an EP. In the case where a user accidentally runs the spectrum analyzer on an EP over a wireless link, the link will drop and communications will be lost to the end point. After a timeout period the EP will drop out of spectrum analyzer mode and return to the active payload connection.

Configuring the Spectrum Analyzer

There are several options for configuring the spectrum analyzer.

Remote Radio ID selects which radio is used to 'listen' on for the spectrum analyzer. Radio 1 or Radio 2. Radio 2 only for dual radio modules.

Lowest MHz selects the start of the range to be scanned.

Highest MHz selects the end of the range to be scanned.

Step KHz is the step size for each scan. Selecting a smaller value increases the resolution but also take longer for a complete sweep of the frequencies to be scanned.

Dwell Microsecs is the amount of time the spectrum analyzer sits on a a given frequency before continuing the scan. Typically should be left at default of 500 microsecs.

Average is a slider bar. When all the way left the real-time RSSI visualization displays the most recent value scanned in real-time. Moving the slider to the right causes the visualization to average over a number of readings. This tends to smooth the display and makes it easier to see signals impacts over time.

Decay Cycles is a slider bar. Moving to the right increases the number of cycles that will continue to be displayed in the real-time RSSI visualization when the **Show Decay** option is enabled.

Zoom is a slider that expands the real-time RSSI visualization around the center frequency. Note that clicking on a specific frequency in the real-time RSSI visualization also re-centers the display on that frequency.

Show Max Hold. When enabled, the real-time RSSI visualization in the upper right will display the maximum value.

Show Decay. When enabled, the real-time RSSI visualization will show recents results, 'decaying' over time. The Decay Cycles slider sets the number of historical scans to show as they fade away.

Reset Max Hold. Deletes the Max Hold settings and starts showing new max values from this moment forward if show max hold is enabled. If show max hold is disabled, this just clears the display.

Reset Occupancy. Restarts the analysis of the occupancy visualizations on the left.

Start. Starts the scan. Note that clicking start will cause any active link to drop and no payload traffic will

Stop. Stops the scan and returns the radio to normal payload carrying operation. Moving away from this screen in the GUI will also stop the scan after a timeout period.

Spectrum Analyzer Visualizations

The spectrum analyzer displays four different views or visualizations of the same real-time data that is being collected.

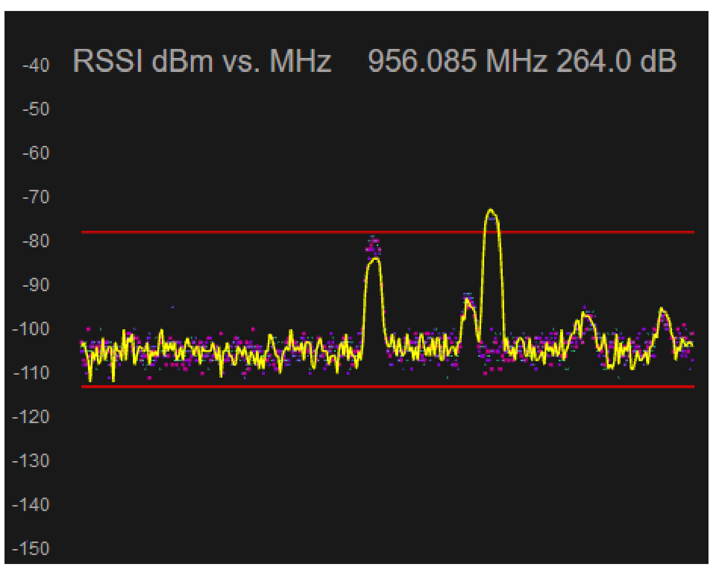
RSSI Real-time View

The display in the upper right shows a real-time view of the received signal strength for each frequency in the scanned range. There are several features to this display.

As you move the cursor over the graph, the text in the upper right changes to show the frequency and current measure value.

The red bars are used to narrow the dynamic range of the display. Clicking just above the lower red bar or just below the upper red bar sets the max and min values for the color coding of the other displays. To get the most distinction between high and low values you should set these bars close to the max and min displayed values. You'll see visually how this impacts the other displays.

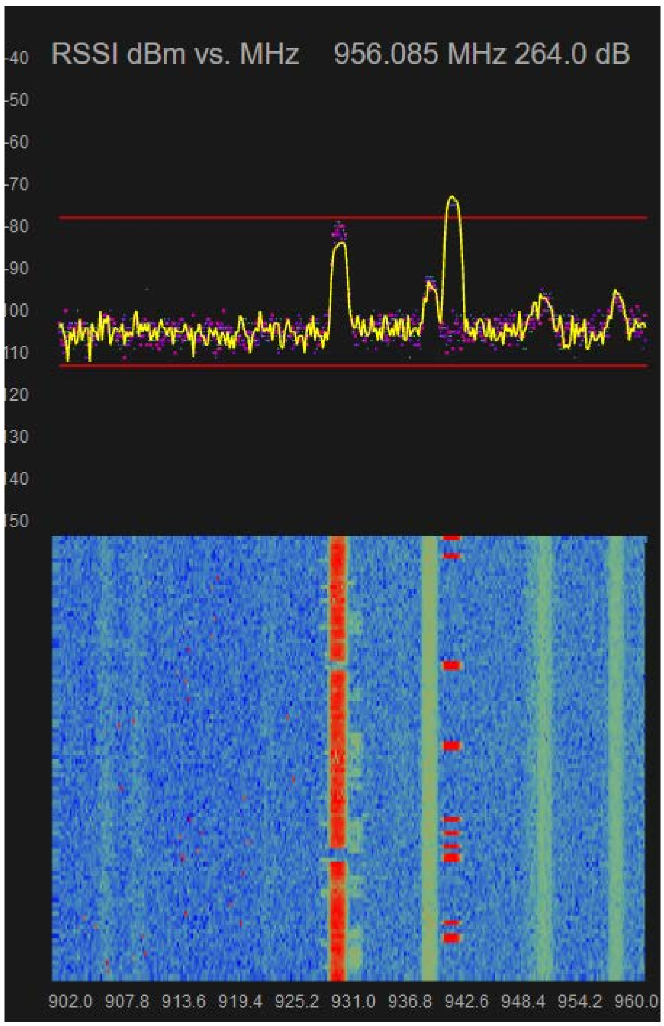
Also not that max hold and decay options can be used to show a historical view of max and also to 'fade' the older results. Finally, the average option can be used to smooth the curve.



Waterfall View

The waterfall view is in the lower right. This view shows the most recent result at the top and then a historical view descending towards the bottom of the screen. The x-axis is the same frequencies as shown in the RSSI view. The Y-axis is time with the most recent result at the top and approximately 5 minutes ago at the bottom (depending on the settings of range, dwell and step size). The color code shows higher signals as Red and lower signals as Blue.

This particular scan below shows 5 licensed band signals being seen by the analyzer. The frequency in all red is the highest continuous signal and the three yellow bars are lower levels. There is also an intermittent red signal that is showing a periodic presence. Possibly due to a SCADA system doing a periodic poll.



Power and Frequency Occupancy Visualizations

The Occupancy visualizations show the percentage of the time that the spectrum analzyer detects each power level and each frequency respectively. The x-axis is the same as the RSSI view.

The power occupancy in this case is showing most of the time the spectrum analyzer is seeing power between -101 and -105 dBm. This view is most useful in an ISM unlicensed band to get a general view of how much background noise is present.

The frequency occupancy is useful for both licensed and unlicensed bands and shows the percentage of time a particular frequency has a signal present. As expected, this graph is showing the licensed band frequencies with a signal present most of the time. For the unlicensed frequencies to the left of the graph the display shows a lower occupancy rate as these are more likely FHSS or frequency-hopping radios.

Diagnostics/Network Statistics

Network Statistics is split into two tables, both offering diagnostic information relating to Ethernet functionality; LAN and Wireless.

LAN

LAN

Interface	IP address	Rx Bytes	Rx Packets	Rx Errors	Rx Dropped	Tx Bytes	Tx Packets	Tx Errors	Tx Dropped
eth1		1,142,092	7,333	0	5	2,844,602	10,225	0	0
eth2		0	0	0	0	0	0	0	0
rad1		1,045,479	5,876	0	0	684,007	4,191	0	0
rad2		0	0	0	0	6,607	83	0	0
vlan1	192.168.0.3	535,919	3,720	0	148	1,793,361	4,569	0	0

Interface represents the interface; Ethernet 1, Ethernet 2, RF Module1, RF Module2 or any VLAN that might be configured.

Rx Bytes indicates the amount of data received on the Interface.

Rx Packets indicates the number of Layer 2 Ethernet Frames received on the Interface.

Rx Errors indicates the number of errors logged while receiving on the Interface. This would typically result from a cabling issue or a formatting issue such as a switch configured to send "jumbo-frames" that are too large for the radio to interpret.

Rx Dropped indicates the number of received packets dropped. Errors logged here would result from a "speed overrun" where the input queue becomes full and needs to drop incoming frames because there is no room in input buffers.

Tx Bytes represents the amount of data transmitted on the Interface.

Tx Packets represents the amount of packets transmitted on the Interface.

Tx Errors represents the number of errors logged when transmitting on the Interface. Errors logged here would result from a collision in situations where a hub was used instead of a switch and more than one device attempted to transmit simultaneously.

Tx Dropped indicates the number of transmitted packets dropped. For a RF Module this can indicate that the buffer is full.

Wireless

Wireless

Radio	Tx Bytes	Tx Frames	Rx Bytes	Rx Headers	Rx Frames	Rx Header CRC Errors	Rx Frags Out Of Order	Rx Frag Length Errors	Rx Frame CRC Errors	Rx Frame Age Errors	Rx Frames Out Of Order	Rx Frame Length Errors	Rx Frames Own Src MAC	Rx Frames Control	Total TCP Tx Bytes
1	767,827	4,191	1,620,750	17,652	15,513	0	0	0	0	0	0	0	0	9,637	0
2	8,228	82	0	0	0	0	0	0	0	0	0	0	0	0	0

Refresh

Radio represents the RF Module; 1 or 2 (cnReach N500).

Tx Bytes represents the amount of data transmitted by the RF Module.

Tx Frames represents the amount of Ethernet Frames transmitted by the RF Module.

Rx Bytes represents the amount of data received by the RF Module.

Rx Headers represents the number of RF Headers received by the RF Module. Headers are part of the cnReach N500 OTA protocol and are not part of the Ethernet Frame. Headers are used to encapsulate Ethernet frames over the air. Since Ethernet Frames can be broken up into fragments depending on the RF packet size, there can be more headers than actual Ethernet Frames.

Rx Frames indicates how many Ethernet Frames have been received by the RF Module.

Rx Header CRC Errors indicates the amount of CRC errors detected during receive.

Rx Frags Out of Order represents fragmented Ethernet Frames that arrived out of order.

Rx Frag Length Errors represents the fragmented Ethernet Frame being received with a different length and is usually the result of fragments being lost over the air.

Rx Frame CRC Errors indicates how many CRC errors have been detected receiving the Layer 2 Ethernet Frame.

Rx Frame Age Errors indicates errors with age of the Ethernet Frame being received, usually a result of excessive time taken for a missing fragment to arrive, where the radio will give up and drop the pieces of the Frame that have been received.

Rx Frames Out of Order indicates Layer 2 Ethernet Frames being received out of order.

Rx Frame Length Errors indicates the Ethernet Frame has been received with a different length and is usually caused by fragments being lost over the air. Since a frame can have multiple fragments this identifies how many Frames have encountered a problem.

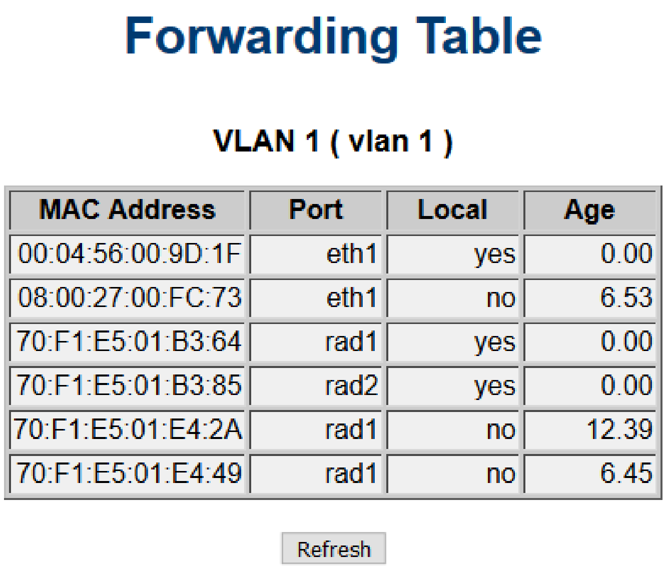
Rx Frames Own Src MAC directly relates to the “Bounce” setting and is the number of Frames transmitted by an End Point that have been bounced by the Access Point. The End Point needs to detect and drop these Frames to prevent Ethernet protocol issues.

Rx Frames Control is a count of control messages sent between the RF Module and the Ethernet board.

Diagnostics/Forwarding Table

The **Forwarding Table** is a dynamic table that maps device MAC addresses to ports/interfaces on the radio.

It is used to identify the forwarding port/interface that the input port/interface should forward an Ethernet frame



Forwarding Table

VLAN 1 (vlan 1)

MAC Address	Port	Local	Age
00:04:56:00:9D:1F	eth1	yes	0.00
08:00:27:00:FC:73	eth1	no	6.53
70:F1:E5:01:B3:64	rad1	yes	0.00
70:F1:E5:01:B3:85	rad2	yes	0.00
70:F1:E5:01:E4:2A	rad1	no	12.39
70:F1:E5:01:E4:49	rad1	no	6.45

Refresh

The Forwarding Table exists on the Data Link Layer of the OSI Model and contains the Ethernet packet as well as source and destination MAC addresses.

When the radio receives an Ethernet frame with a destination address in the Forwarding Table, it sends the frame out of the port/interface stored in the Forwarding Table.

The first time the radio sees the MAC address, it treats the frame as a broadcast and sends it out of all active ports/interfaces except for the interface where the frame was received.

Without a Forwarding Table, all Ethernet frames received by the radio would be sent out of all other ports (including RF Modules, which would eat up RF bandwidth).

The Forwarding Table allows the radio to send an Ethernet frame only out of the port/interface where the destination device is located.

Local designates whether the MAC address is contained within the radio.

Age designates how much time has passed since the MAC address was resolved.

Diagnostics/Route Table

The **Route Table** lists the Static Routes that have been configured in the radio.

Interface	Destination	Gateway	Flags
rad1	10.10.12.0	10.10.10.2	UG (0x0003)
rad1	192.168.4.0	10.10.10.2	UG (0x0003)
rad1	192.168.3.0	10.10.10.2	UG (0x0003)
rad1	10.10.10.0	0.0.0.0	U (0x0001)
rad1	10.10.11.0	10.10.10.2	UG (0x0003)
rad1	192.168.2.0	10.10.10.2	UG (0x0003)
eth1	192.168.1.0	0.0.0.0	U (0x0001)
vlan1	192.168.0.0	0.0.0.0	U (0x0001)
eth1	0.0.0.0	192.168.1.252	UG (0x0003)

Refresh

Interface is the outgoing port/interface the radio will use when forwarding a packet to destination subnet or next hop.

Destination is the subnet of the packet's final destination.

Gateway is the destination interface that the routed packet is sent to.

Flags define the status of the route;

- U signifies that the route is up.
- G signifies that the route is to a gateway; if this flag is missing then the route is to a directly connected destination and no gateway is required (0.0.0.0).

Diagnostics/ARP Table

Address Resolution Protocol (ARP) is a protocol used for resolving IPV4 addresses to a physical hardware address (MAC) that are recognized on the local network.

IPV4 addresses are Layer 3 (Network), whereas MAC addresses are Layer 2 (Data Link).

The **ARP Table** is used to maintain correlation between physical MAC addresses and their corresponding IPV4 addresses.

The table shows the resolved **IP Address**, status **Flags**, **HW Address** (MAC) and the **Device** it can be reached from.

In the case of a Bridged system, the **Device** will be the VLAN.

IP Address	Flags	HW Address	Device
192.168.0.2	complete (0x2)	70:f1:e5:01:67:ef	vlan1
192.168.0.254	complete (0x2)	34:17:eb:8e:ca:61	vlan1
192.168.0.1	complete (0x2)	70:f1:e5:01:3a:f2	vlan1
192.168.0.250	complete (0x2)	4c:5e:0c:65:65:dd	vlan1

Refresh

In the case of a Routed system, the **Device** will be the interface.

IP Address	Flags	HW Address	Device
192.168.0.250	complete (0x2)	4c:5e:0c:65:65:dd	vlan1
10.10.10.2	complete (0x2)	70:f1:e5:01:68:35	rad1
192.168.1.252	complete (0x2)	00:0f:9d:17:f3:42	eth1

Refresh

Flags indicate if the mac address has been learned (complete), or remains incomplete.

- 0x0 incomplete
- 0x2 complete

Diagnostics/Serial Statistics

Serial Statistics provides information on who is connected to the currently running Serial Service.

Description	IP Rx Bytes	Serial Tx Bytes	Serial Rx Bytes	IP Tx Bytes	Connected
Serial 1 TCP Terminal Server	145	145	68	68	192.168.1.252:60860

Refresh

IP Rx Bytes indicates how much TCP data has been successfully transmitted on the Ethernet side of the Serial Service.

Serial Tx Bytes indicates how much serial data has left the Serial port.

Serial Rx Bytes indicates the amount of data received on the Serial port.

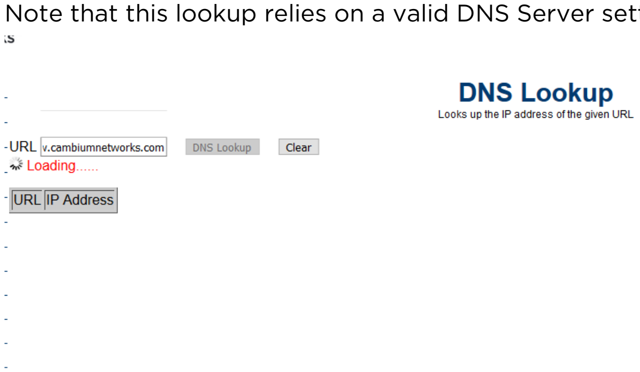
IP Tx Bytes indicates how much TCP data has been successfully transmitted on the Ethernet side of the Serial Service.

Connected represents the IP address and Port # of the remote device that's connected; on a flat network this could be the polling host. On a routed network this would be the upstream router interface.

Diagnostics/DNS Lookup

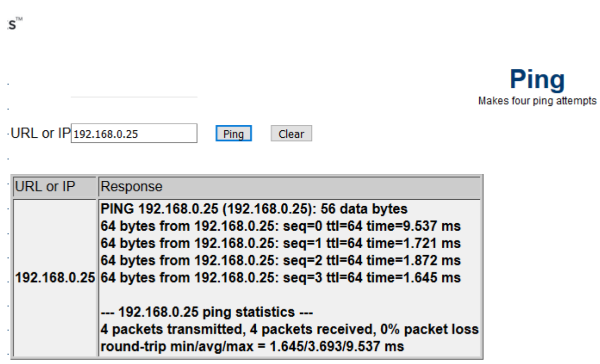
DNS Lookup can be used to test the DNS server setting on the radio. Entering a fully qualified domain name will return the IP address of the host.

Note that this lookup relies on a valid DNS Server setting in the Network/Interface Settings page.



Diagnostics/Ping

Ping generates an ICMP ping from the cnReach radio to the IP address or URL (if DNS server is configured in the Network/Interface Settings page.). cnReach generates 4 ICMP pings to the identified host and reports the roundtrip time in ms. This feature is useful to validate the the cnReach radio can 'see' the cnMaestro server or the IP-based SCADA master.



Diagnostics/Traceroute

Traceroute performs a traditional traceroute from the cnRadio to the host identified by the IP address or hostname (if DNS servers are configured and available). It can be useful in troubleshooting radio connectivity to specific servers such as cnMaestro or a SCADA master.

Traceroute

Attempts 20 hops along the route. If the trace fails, it will timeout within one minute. Please be patient.

URL 192.168.0.25 Traceroute Clear

URL	Response
192.168.0.25	**traceroute to 192.168.0.25 (192.168.0.25), 20 hops max, 38 byte packets** **1 192.168.0.25 (192.168.0.25) 1.151 ms 1.031 ms 0.933 ms**

Diagnostics/IO Status

Displays the current status of the integrated I/O.

IO Status

Channel	Voltage	Current	Calibrated	Digital
channel 0	0.000000	n/a	0.000000	off
channel 1	0.000000	n/a	0.000000	off
channel 2	0.000000	n/a	0.000000	off
channel 3	0.000000	n/a	0.000000	off
channel 4	n/a	n/a	n/a	off
channel 5	n/a	n/a	n/a	off
channel 6	n/a	n/a	n/a	off
channel 7	n/a	n/a	n/a	off

Refresh

Management Menu

Management features include firmware updates, password management, rebooting the system and general maintenance tasks on a cnReach radio.

Management / Logout

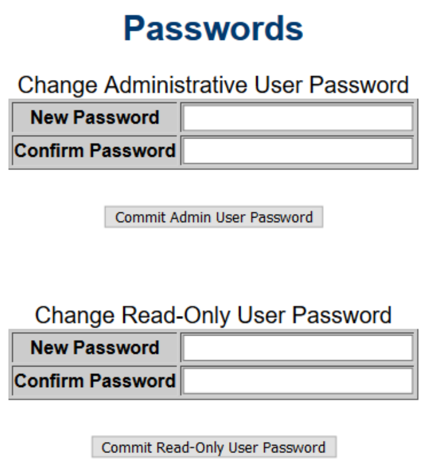
Clicking this menu option immediately logs the user out of the cnReach radio.

Management/Password

cnReach radios have both an administrative password and a read-only password. The password page allows the administrator to change these passwords. Note that cnMaestro also supports the ability to push new passwords as well.

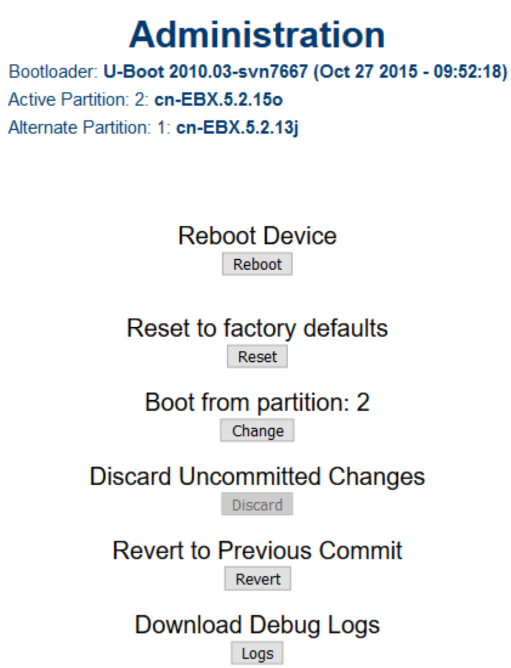
The default administrative username is: **admin** (which cannot be changed due to security).
The default administrative password is: **admin**

The default read-only username is: **ro** (which cannot be changed due to security).
The default read-only password is: **ro**



Management/Administration

This page provides for some additional device local management such as reboot, factory reset. It also allows for booting from the alternate partition



Reboot Device simply reboots the radio without changing any configuration parameters.
Reset to factory defaults returns the device to default settings.

Attention

Resetting to factory defaults modifies both the Network and Radio settings, making it possible to lose connectivity to the device via the RF Link and/or Ethernet Port.

Password changes are NOT reset to default.

The default **Network/Interfaces** configuration is Bridged Mode with a VLAN1 IP address of **192.168.0.3.**

Current boot partition allows the radio to boot from one of two boot partitions. This allows new firmware to be installed on one partition while keeping the previous version on the other. Note that the firmware update under management/files applies the new firmware to the inactive partition and then switches the active partion and reboots. To install firmware to both partitions, the upgrade should be applied twice.

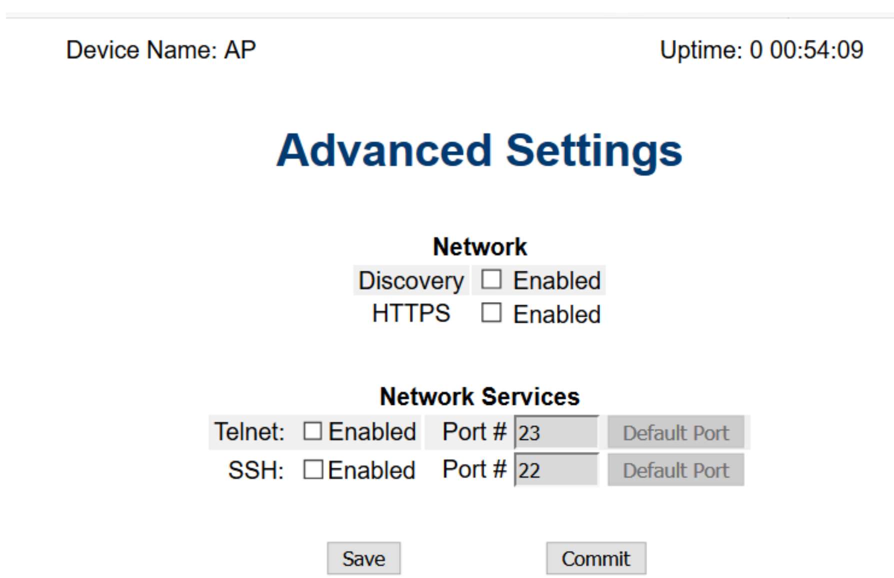
Download Debug Logs may be requested by Cambium support in order to get more detailed logs useful to the development engineering team. There isn't any useful information for the end user to collect with these logs**.**

Management/Advanced Settings

The advanced settings page includes the ability to enable/disable **https** web interface. By default the radio uses http.

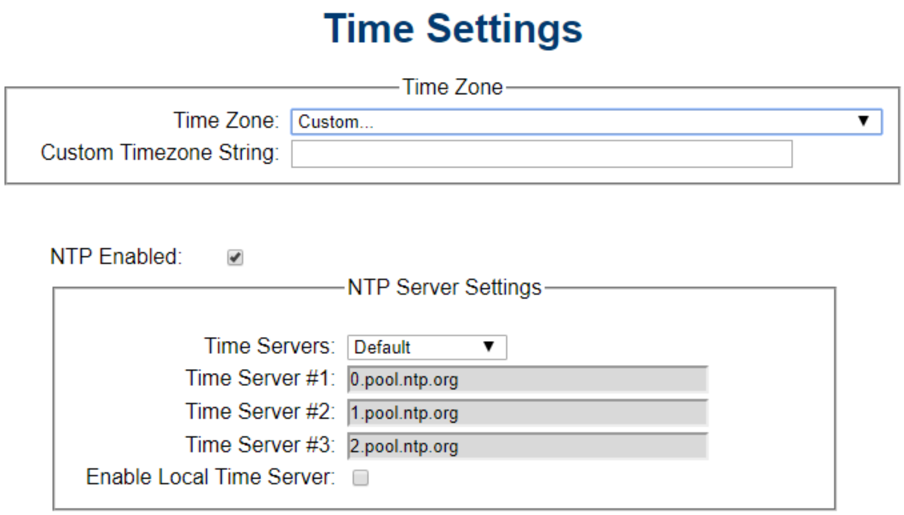
The **discovery** enabled button is for customer support use only.

Network services allow the network administrator to enable/disable access to the command-line via **telnet** and/or **ssh** as well as change the port number where these services will be located.



Time Setting

Time setting allows the operator to use NTP servers to provide day time to the radio.



RADIUS Settings

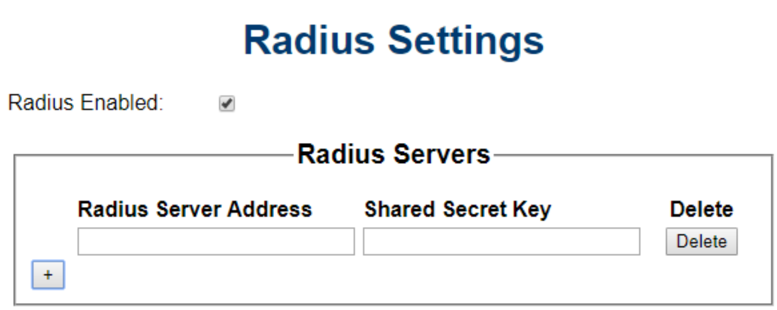
RADIUS (Remote Authentication Dial-In User Service) allows authentication of management account logins via a centralized RADIUS server.

To use RADIUS for management login authentication, the operator needs to enable RADIUS and also configure the IP address of the RADIUS server as well as shared secret. Multiple RADIUS servers can be supported. The operator will then provision the management accounts/credentials with the RADIUS servers.

Attention

Note that, unlike many other products, in case the radio cannot talk to the RADIUS server or RADIUS authentication failed, the radio will not authenticate the administrator locally using local account. Note that RADIUS only authenticate the operator when he/she tries to login using WEB GUI (http or https). CLS based login does not use RADIUS authentication.

Also, administrators should be aware that RADIUS authentication can be quite slow on a low-speed narrow-band connection due to the inherent size and # of packets needed for RADIUS authentication.



Management/Files

The Management/Files tab is used to upgrade OS and radio firmware. It can also be used to download a copy of the current configuration or to upload and apply configuration files. The amount of time it takes to apply software updates via this interface will vary from less than a minute to several minutes depending on the speed of the air interface or if you user is connected directly to the Ethernet port on the radio.

Software for the radio can downloaded from Cambium Networks support website: https://support.cambiumnetworks.com/files/n500/

Attention

Note that there are different radio firmware files depending on the band of the radio. The band is denoted in the filename (eg. 450 = 403-470MHz radios; 900 = 902-960 MHz radios.

Attention

Avoid interrupting power to the radio after clicking apply to prevent corruption of the radio's internal memory.

Task 1: Update OS software

The OS file consists of the cnReach application software and underlying operating system. To upgrade to a new version of firmware, first select upload. You will be presented with a standard file selection dialog box. Select the desired version. After the file is uploaded, the name of the file will appear in the box as shown in screenshot below.

Select Apply to install the new version replacing the previous version. You can also select delete if you'd like to remove this image from the device.

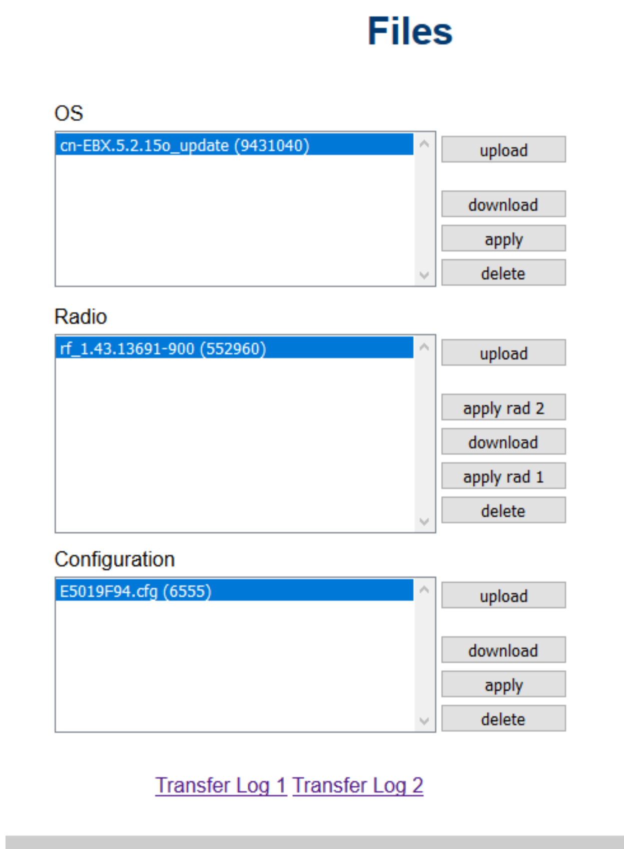
Task 2: Update Radio software

This process is similar to the OS update described above. Note that in dual-radio modules, there will be two Radio options. The apply button must be selected twice to apply the new image to each radio in turn (Rad1 and Rad2)

Task 3: Update Configuration file

The Configuration section of this page allows the user to collect the current configuration of the module (Download), send a new configuration to the module (Upload) or apply a configuration (Apply). Note that if the current configuration file is deleted or doesn't appear in the Configuration window, the current configuration file will be re-generated and re-populated the next time a configuration change is made and committed to the radio.

Note: the transfer log 1 and transfer log 2 links are not currently used.



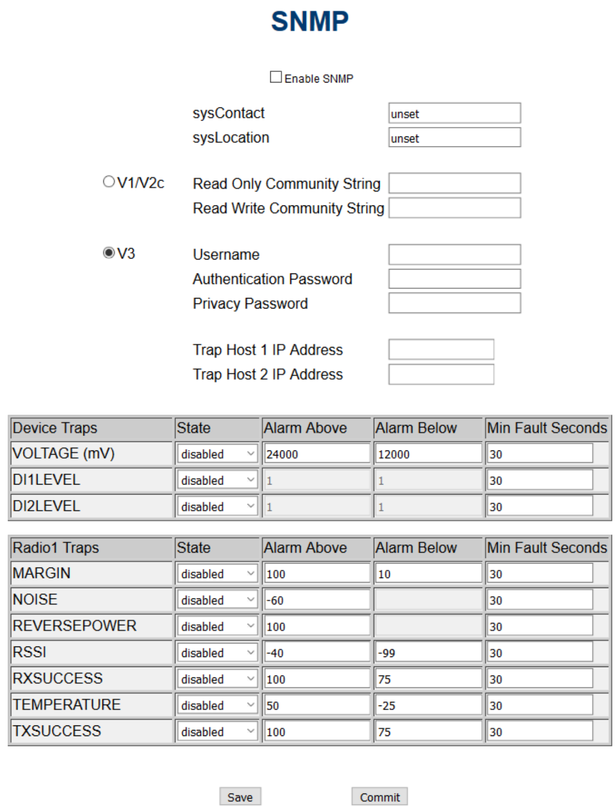
Management/SNMP

cnReach radios support SNMP V1/V2 and V3. **V1/V2** requires the use of the **Read Only Community String** unless the SNMP Manager is required to make changes to the radio, in which case the **Read Write Community String** is also required. Trap Host IP's are necessary if the radio is to send traps when alarm conditions are met.

V3 requires the use of a **Username**, **Authentication Password** and **Privacy Password**. Trap Host IP's are necessary if the radio is to send traps when alarm conditions are met.

An independent SNMP Manager is required to use this feature, such as OpenNMS, Solarwinds etc.

MIB files can be obtained by contacting: http://www.cambiumnetworks.com/support



Trigger can be set to “level” to enable SNMP for the desired traps.

Alarm Above sets the upper limit at which the radio will alarm and generate the trap notification once exceeded by the Min Fault Time.

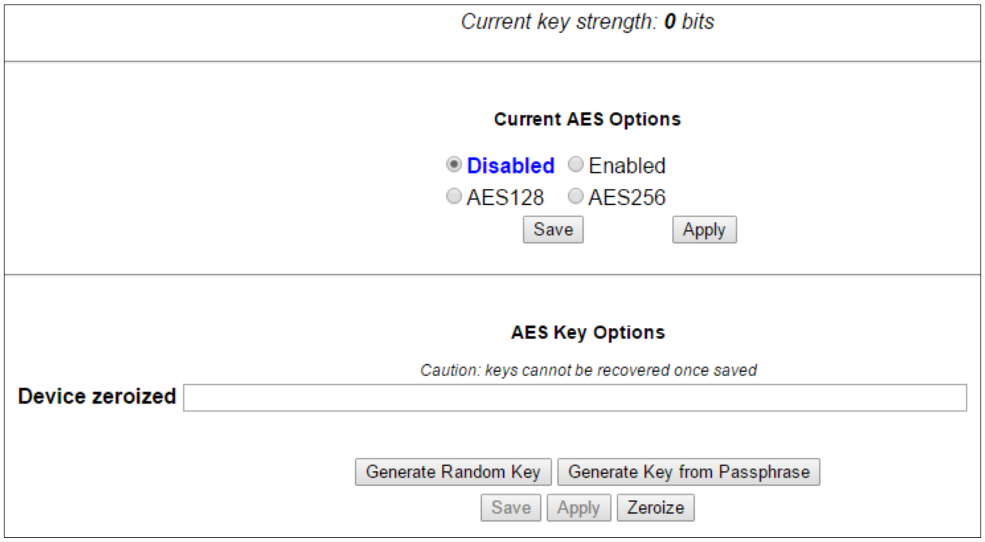
Alarm Below sets the lower level at which the radio will alarm and generate the trap notification once exceeded by the Min Fault Time.

Min Fault Time is the time, in seconds, that an alarm limit must be exceeded before generating a trap notification.

Security Menu

Security/AES

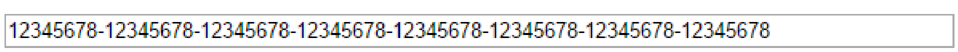
To enable AES Encryption, choose **AES128** or **AES256** and check **Enabled** on **ALL** radios in the network.



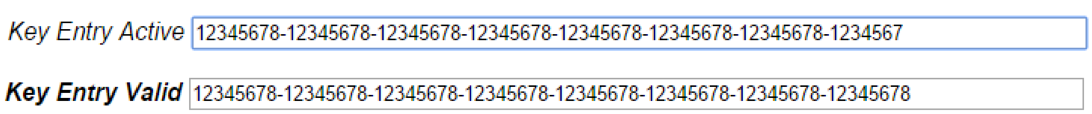
Entering a key is optional since the radios will communicate with a zeroized key.

AES128 - If desired, the key should be entered in hex (4bits per character) as a 32-character string. Dashes may be used to separate each 8-character sequence, but will be ignored.

AES256 - If desired, the key should be entered in hex (4bits per character) as a 64-character string. Dashes may be used to separate each 8-character sequence, but will be ignored.



If the key is valid, "Key Entry Active" will change to "**Key Entry Valid**"



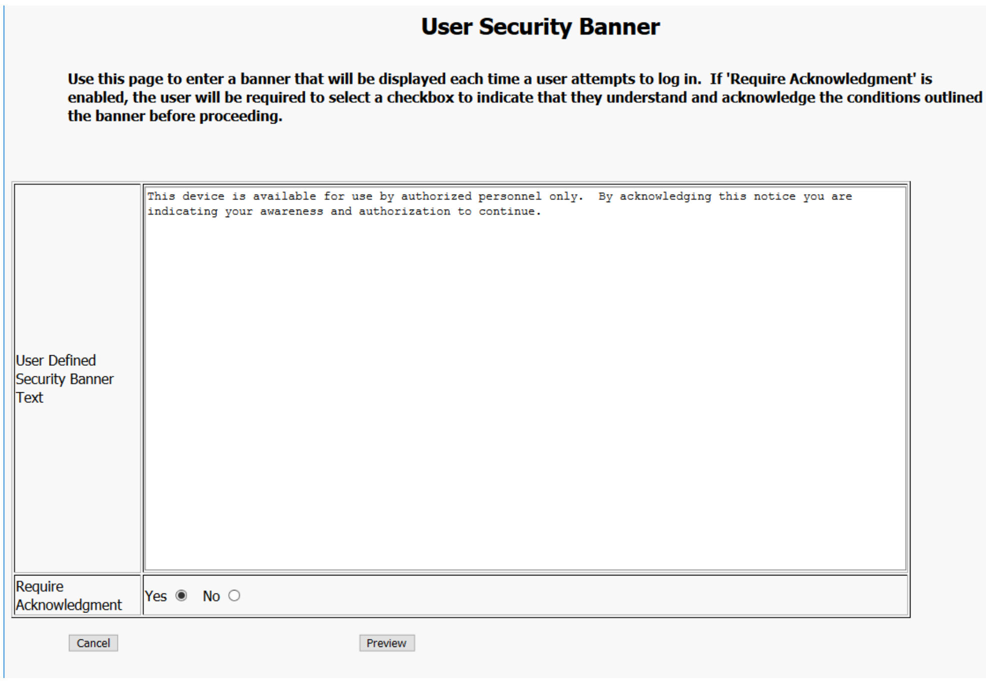
Generate Random Key will create a random key, which should be copied to a text file for use with to other radios.

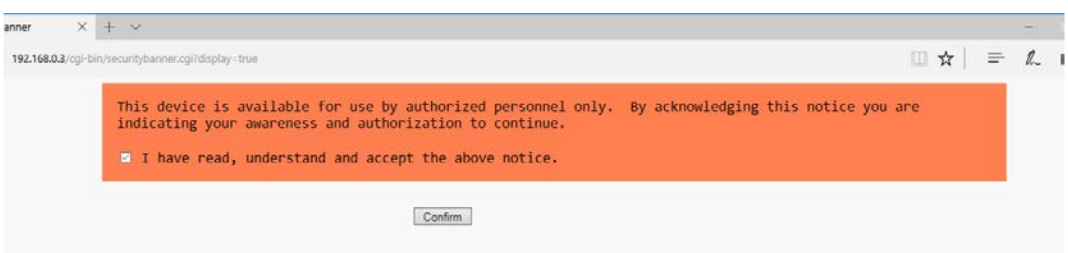
Generate Key from Passphrase will generate a key from a text string of choice, which makes it easier for the average human to remember.

Attention
The key must be the same on ALL radios in the network. If the key is mismatched, the radio LED's will appear to be linked but the radios will NOT pass Ethernet traffic.

Security/Banner

The banner page allows the administrator to set up a notification that appears each time a user attempts to access the cnReach radio.





Chapter 3: Technical Reference

This chapter provides complete details of the cnReach solution including:

- Radio/Air Interface Features
- Networking Features
- Reference tables including capacity, modulations, packet sizes, etc. per each supported radio band.
    - 900 MHz
    - 450 MHz
    - 700 MHz
    - 220 MHz
- Radio Hardware and Physical Interface Specifications

Radio/Air Interface Features

Network Role

The **Network Role** can be one of the following:

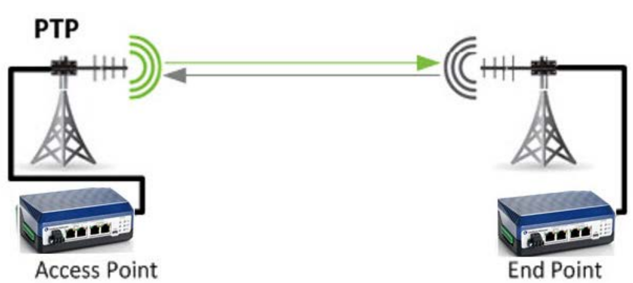
- **Access Point (AP)**; initiates contact/communication with End Point/Repeating End Point. The Access Point is the radio that is normally connected to the Enterprise or backhaul system where access to the radio system occurs. Downstream radios such as End Point's and Repeating End Points connect to the Access Point.

- **End Point (EP)**; waits for an Access Point radio to initiate communication. The End Point is the radio that is connected to the end devices in the field.

- **Repeating End Point (REP)**; waits for an Access Point radio to initiate communication.

Point to Point (PTP)

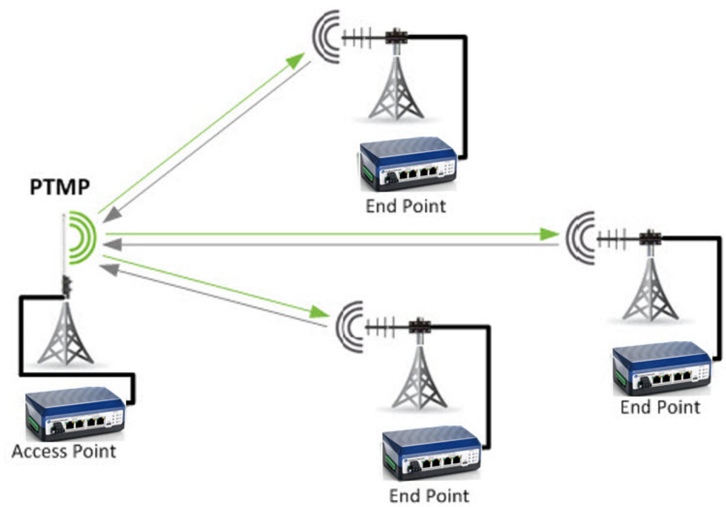
A **PTP** network consists of two radios; **Access Point (AP)** and **End Point (EP)** that can only communicate with each other. The Access Point sends a beacon message to the End Point, which then responds.



Data may be transferred in either direction. Data transfer speeds can be manipulated using the Max Payload Bytes and Dynamic Payload settings. When set to PTP with multiple End Point Transmit Rates selected, both radios will be fixed to the highest End Point Transmit Rate. The Access Point Transmit Rate will also be fixed to the same speed/modulation. Refer to the How to set up an ISM PTP Link section for configuration information.

Point to Multi-Point (PMP)

A Point to Multi-Point network consists of one Access Point and many End Points. The Access Point sends a beacon message to the End Points, which then respond.



Data may be transferred in either direction. Data transfer speeds can be manipulated using the Max Payload Bytes and Dynamic Payload settings. Refer to the How to set up a PTMP Network section for configuration information.

PMP Protocol Characteristics

- Any number of slaves or end points may attach to the master.
- The Master doesn't keep track of which slaves are present – any slave may attempt to communicate with master.
- The Master transmits data downstream in broadcast mode.
- The Master repeats each transmitted packet a configured number of times.
- Slaves or End Points respond with a request for attention if they have data to transmit.
- Master responds to an attention request with an attention grant, but data from master is still broadcast to all.
- If slave fails to get master's attention due to a collision, it employs a random back-off algorithm to decide when to request attention again.
- Once a slave has the master's attention, it may transmit data in response to each master packet; other slaves must not transmit.
- Master acknowledges receipt of slave transmission, along with continued broadcast data.
- Slave relinquishes master attention when done transmitting data, or after a configured limit.
- Master may revoke its attention from a slave if a configured number of consecutive receive errors occur, or if the slave does not relinquish attention after a configured limit.
- While a slave has the master's attention, the master acknowledges the slave's transmitted packets. If the slave fails to receive an "acknowledge" after a configured number of transmissions, it drops the packet and begins transmitting the next packet.

Additional Characteristics in PMP Ethernet Mode

- The Master and slave use the destination MAC address in a packet to distinguish Ethernet broadcast packets from Ethernet addressed packets.
- Slave determines which MAC addresses are currently behind it, up to a limit.
- Any slave may acknowledge a packet addressed to one of its known MAC addresses; master stops repeating the packet when it receives the acknowledgement.
- If no slave has master attention, an acknowledging slave transmits the acknowledge packet without requesting master attention.
- If one slave has master attention, other slaves may not acknowledge.

Transmit Power and RSSI

Transmit Power is set in milli-Watts. The range will vary depending on the radio band and region code. The recommendation is to not set the power level below 100mW.

mW can be converted to **dBm** using this [online calculator].

Attention

RF performance is often more problematic at higher RSSI levels. When the Transmit Power is set too high, the receiving radio RSSI may be too high and the overall noise floor in the area will increase.

Transmit Power should be tuned to provide enough SNR on the receiving radio.

Please refer to the RSSI and Sensitivity & Minimum SNR per Modulation sections.

When lab testing with the optional 0dBi “rubber duck” antenna, it is recommended to install 20dB coaxial attenuators and adjust the transit power to 100 mW.

RSSI

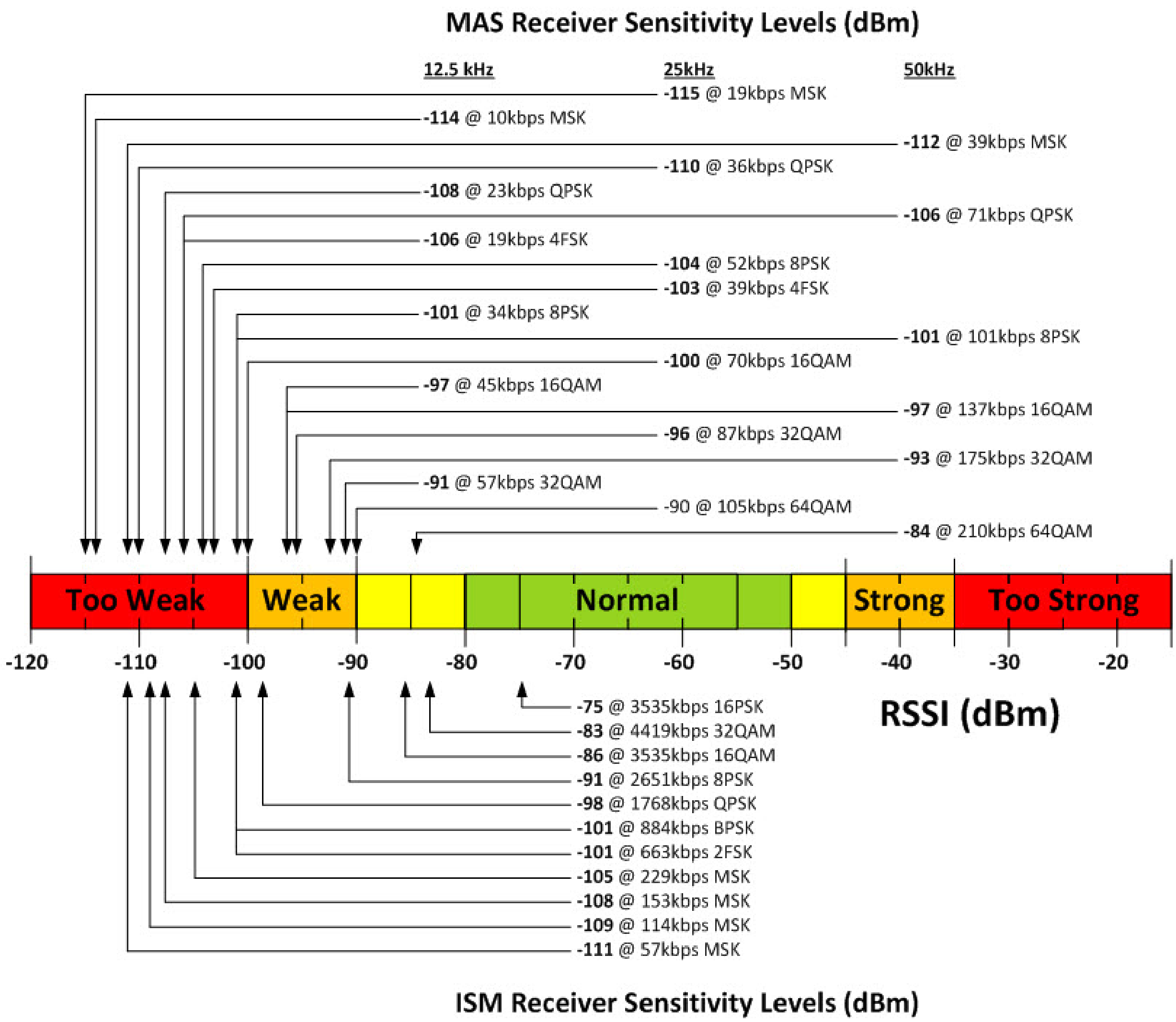
With the options of exceptional sensitivity and fast, complex modulations in one product it is important to consider the input signal level (RSSI) of the receiving radio to ensure that it’s not too low and not too high.

Slower less complex modulations have better sensitivity, require a smaller minimum SNR and will therefore operate at a lower RSSI offering greater effective range.

Faster more complex modulations have less sensitivity, require a larger minimum SNR and will therefore operate at a higher RSSI offering less effective range.

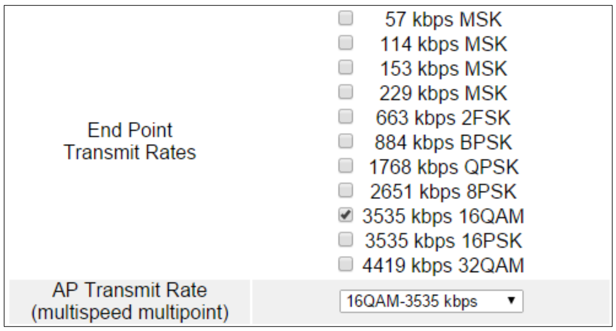
The RSSI scale below indicates the various receive signal levels in dBm and how they relate to the sensitivity levels of each modulation.

Strong signals are often more problematic than weaker signals and should be tuned if above -50 to -45dBm. LINKPlanner will help by indicating the expected RSSI level for a given path profile.


MAS Receiver Sensitivity Levels (dBm)
12.5 kHz
25kHz
50kHz
-115 @ 19kbps MSK
-114 @ 10kbps MSK
-112 @ 39kbps MSK
-110 @ 36kbps QPSK
-108 @ 23kbps QPSK
-106 @ 71kbps QPSK
-106 @ 19kbps 4FSK
-104 @ 52kbps 8PSK
-103 @ 39kbps 4FSK
-101 @ 34kbps 8PSK
-101 @ 101kbps 8PSK
-100 @ 70kbps 16QAM
-97 @ 45kbps 16QAM
-97 @ 137kbps 16QAM
-96 @ 87kbps 32QAM
-93 @ 175kbps 32QAM
-91 @ 57kbps 32QAM
-90 @ 105kbps 64QAM
-84 @ 210kbps 64QAM
Too Weak
Weak
Normal
Strong
Too Strong
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
RSSI (dBm)
-75 @ 3535kbps 16PSK
-83 @ 4419kbps 32QAM
-86 @ 3535kbps 16QAM
-91 @ 2651kbps 8PSK
-98 @ 1768kbps QPSK
-101 @ 884kbps BPSK
-101 @ 663kbps 2FSK
-105 @ 229kbps MSK
-108 @ 153kbps MSK
-109 @ 114kbps MSK
-111 @ 57kbps MSK
ISM Receiver Sensitivity Levels (dBm)

Transmit Rates

Transmit rates (or Modulations) are set in the GUI from a list available for that particular radio's available bandwidths and modulation rates. Adaptive modulation or Multi-Speed Multipoint can be used in PTP or PMP networks. In PMP networks the radio must be configured to support the minimum max payload size and for AP's the modulation must have enough link budget to reach the furthese EP. For PTP networks, MSMP works in both directions and there is no constraint on minimum max payload bytes.



Access Point Transmit Rates

In a PTP network the **Access Point Transmit Rate** works in the same way as the End Point Transmit Rates and will adjust speed based on signal quality.

In a PMP network the **ISM Access Point Transmit Rate** is **fixed to a single modulation**; the one limiting factor in a PMP network is that all remote End Point radios must be able to receive the Access Point, therefore the Access Point must transmit at a rate suitable for the furthest remote End Point to receive.

ISM Access Point Transmit Rate selection also depends on the amount of data that needs to be moved from the Access Point Radio to the End Point Radio(s) and end device(s). In SCADA applications where small poll requests are sent from Access Point to End Point, the Access Point Transmit Rate can be set to a slower modulation.

End Point Transmit Rates

ISM End Point Transmit Rates can be configured with Multi-Speed Multi-Point (MSMP).

Note

Cambium Networks recommends selecting a maximum for FOUR consecutive End Point Transmit Rates.

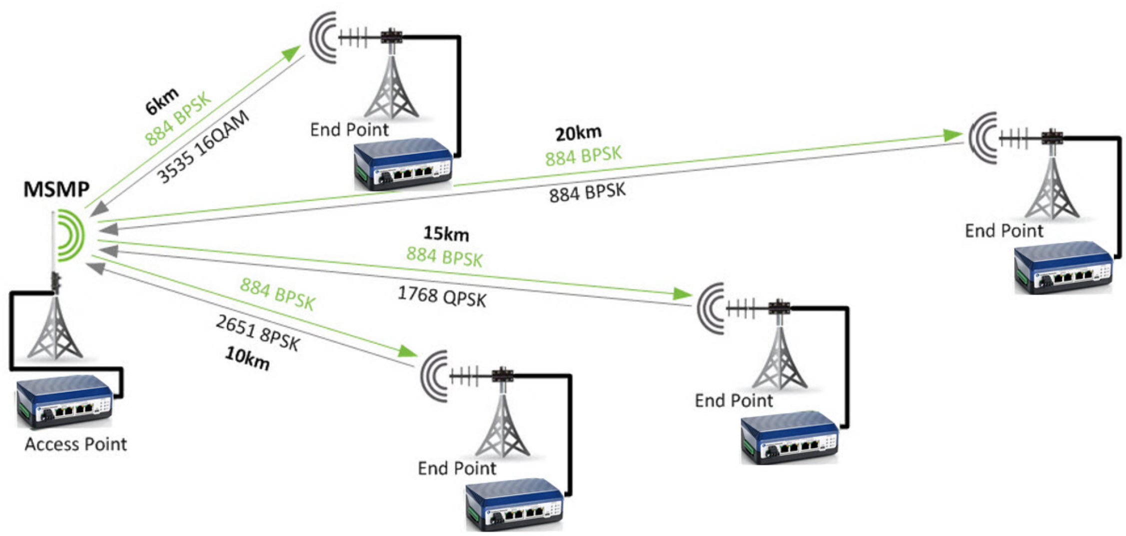
Refer to ISM Minimum Packet Sizes with Multi-Speed Multi-Point for minimum packet recommendations.

The radios will start transmitting data at the lowest speed and, if successful, will increase to the next selected speed. The radio dynamically changes the data rate based upon signal quality measurements. The advantage is to allow radios that have a good RF connection to maintain a high-speed link to the Access Point while radios on the same network that have a poor RF connection can maintain a link at a slower data rate without penalizing the "good link" radios. The available modulations range from the FHSS modes of 57 kbps – 229 kbps to the DTS modes of 663 kbps – 3535 kbps. The primary difference between the modes is the bandwidth of the signal and the required strength of signal received at the radio.

As a general rule, when the data rate increases, the sensitivity of the radio decreases and therefore the required signal strength at the receiving radio must increase to maintain the appropriate margin.

Adaptive Modulation

- The user may enable multiple bit rate/modulation modes, via the web GUI or the radio menu.
- The same set of modes must be enabled on all radios in the network.
- The master radio always transmits in one fixed mode (the master transmit mode), which can also be indicated via the GUI or radio menu. The master transmit mode is one of the enabled modes.
- Radios determine the slot period based on the maximum payload length for master and slave, at the highest-speed enabled mode.
- At lower speeds, maximum payload lengths are reduced from the maximum, to keep the slot time constant regardless of the mode.
- A slave transmits its request for master attention in the lowest-speed mode. Each packet's header contains a field indicating the mode in which the slave will transmit the next packet, after the current packet is acknowledged.
- Each slave independently determines the mode it transmits in, based on the acknowledge rate it observes over multiple master attention sessions.
- A slave transmits its request for master attention in the lowest-speed mode.
- If no slave has master attention, an acknowledging slave transmits the acknowledge packet in the lowest-speed mode.
- If one slave has master attention and wishes to acknowledge a master packet, it transmits the acknowledge packet in the mode established for the current attention session.



When configured as part of a cnReach N500 PMP network, End Point radios are not required to communicate at the same data transmit rate. This enables remote End Point radios that are closer to the Access Point or in a better RF environment to communicate at faster data-rates than remotes that are further away or in high-noise areas.

Since transmissions from the Access Point radio in a PTMP network must be received by all remotes irrespective of distance or RF conditions, the Access Point radio is limited to a single AP data transmit rate. Remote End Point radios must also be configured with the data transmit rate the Access Point will use to communicate.

Remote End Point radios in a PTMP network independently and dynamically select the optimal data rate. The list of data rates is selected by checking the corresponding check-boxes on the remote radio. Data rates which remote End Point radios may use to communicate must also be defined on the Access Point radio, therefore the configuration should match between the Access Point radio and each of the remote End Point radios.

Frequency Hopping (900 MHz ISM Only)

Frequency hopping is used with 900 MHz cnReach radios using the ISM unlicensed band. With frequency hopping, the radio never dwells very long on a given channel but instead 'hops' on a pattern defined in the configuration thereby avoiding interference. Note that for licensed channels

Note

Frequency hopping is ONLY used with 900 MHz Unlicensed/ISM bands. If the network is deployed in a licensed band, it stays on the same frequency. The hopping features described in this section are not relevant for licensed band operation.

Hop Channels

The occupied bandwidth of the RF signal is determined by the bit rate and modulation mode that is enabled. If multiple modes are enabled, the occupied bandwidth is that of the highest-bandwidth mode.

The number of available hop channels is the number of whole "occupied bandwidth" channels that will fit in the band allocated for hopping, avoiding any excluded band and FCC-mandated guard bands at the ISM band edges.

A hop channel is referred to by its center frequency, and occupies the band from (center frequency – occupied bandwidth/2) to (center frequency + occupied bandwidth/2). It may also be referred to by its channel number, where channel zero is the lowest frequency channel.

The radio displays the occupied bandwidth and number of available hop channels at the top of the RF and Hopping Menu.

Pseudorandom Hop Pattern

When the hop pattern parameter is 1, the radio uses a linear feedback shift register to build a table of N pseudorandom channel numbers between 0 and N-1, where N is the number of hop channels.

For example, if the number of hop channels is 20, the sequence of hop channel numbers in the table is:

19, 9, 4, 14, 16, 10, 18, 13, 6, 17, 8, 12, 15, 7, 3, 1, 0, 11, 5, 2.

Constant-Step Hop Pattern

When the hop pattern parameter is greater than 1, the radio builds a table of N channel numbers between 0 and N-1 that step by at least P channels for each hop, where N is the number of hop channels and P is the value given by the hop pattern parameter. The radio makes the necessary adjustments so the hop pattern doesn't repeat prematurely.

For example, if the number of hop channels is 20 and the hop pattern is 5, the sequence of hop channel numbers in the table is:

0, 5, 10, 15, 1, 6, 11, 16, 2, 7, 12, 17, 3, 8, 13, 18, 4, 9, 14, 19.

Hop Processing

For either type of hop pattern:

- Each channel number appears in the table exactly once.
- The starting point of the hop sequence within the table is given by the hop offset parameter, where zero indicates the first entry.
- The radio steps through the table, one step per hop, fetching the next channel number and converting it to the corresponding center frequency.
- When it reaches the end of the table, the hop sequence returns to the beginning of the table.
- If multi-master sync is enabled, at each sync pulse the hop pattern restarts at the table location indicated by the hop offset parameter.

Access Point Synchronization

It is common practice in large Ethernet SCADA communication systems to install multiple overlapping wireless networks to mitigate poor performance and prioritize traffic for different traffic types and mixed protocols.

Wireless Ethernet networks with many remote devices can experience low throughput and long latency. Dividing large wireless networks into many smaller networks can increase throughput and reduce latency; using PTP backhaul links for high throughput and PMP access links to interface various end devices. Different traffic types can cause low priority data to block high priority data. Separating networks for each application in a single area establishes guaranteed capacity for each traffic type.

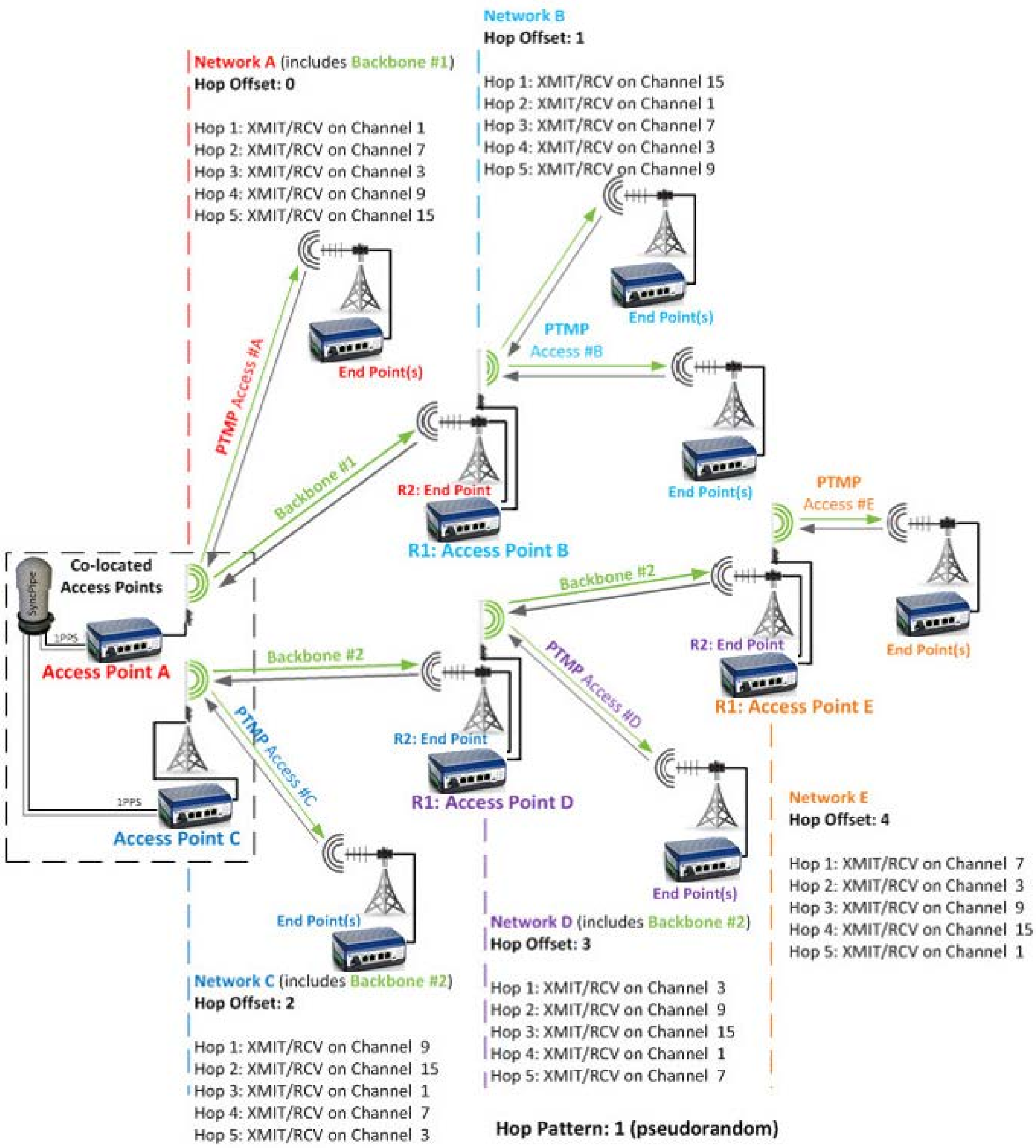
For example, SCADA polling, video surveillance and internet access can each have individual networks with the same or overlapping geographical coverage. Installing multiple radios at the same location or in the same geographical area must be done carefully to prevent interference.

cnReach radios have a technology to prevent problems related to multiple radios installed at the same location. With synchronization enabled, the radios in overlapping networks transmit and receive at the same time, but on different frequencies as shown in the following hop sequence.

For every hop in the sequence, each radio sub-network; 1x Access Point and connected End Points will transmit and receive on a unique frequency over the same time duration, therefore eliminating self-interference.

MMS is a timing feature that allows multiple Access Point radios in co-located networks and/or interconnected sub-networks to synchronize transmit and receive times to prevent self-interference.

Dividing the 902-928 MHz ISM band is not required since each Access Point in the network is timed to precisely and simultaneously transmit using different frequency channels. The respective End Points respond to their Access Points on the same channels before the entire system hops and the process continues.


Network B
Hop Offset: 1
Hop 1: XMIT/RCV on Channel 15
Hop 2: XMIT/RCV on Channel 1
Hop 3: XMIT/RCV on Channel 7
Hop 4: XMIT/RCV on Channel 3
Hop 5: XMIT/RCV on Channel 9
Network A (includes Backbone #1)
Hop Offset: 0
Hop 1: XMIT/RCV on Channel 1
Hop 2: XMIT/RCV on Channel 7
Hop 3: XMIT/RCV on Channel 3
Hop 4: XMIT/RCV on Channel 9
Hop 5: XMIT/RCV on Channel 15
End Point(s)
PTMP
Access #B
End Point(s)
PTMP Access #A
Backbone #1
R2: End Point
End Point(s)
PTMP
Access #E
R1: Access Point B
Co-located
Access Points
SyncPipe
1PPS
Access Point A
Backbone #2
Backbone #2
PTMP Access #D
R2: End Point
End Point(s)
R1: Access Point E
PTMP Access #C
R2: End Point
R1: Access Point D
1PPS
Access Point C
Network E
Hop Offset: 4
Hop 1: XMIT/RCV on Channel 7
Hop 2: XMIT/RCV on Channel 3
Hop 3: XMIT/RCV on Channel 9
Hop 4: XMIT/RCV on Channel 15
Hop 5: XMIT/RCV on Channel 1
End Point(s)
End Point(s)
Network D (includes Backbone #2)
Hop Offset: 3
Hop 1: XMIT/RCV on Channel 3
Hop 2: XMIT/RCV on Channel 9
Hop 3: XMIT/RCV on Channel 15
Hop 4: XMIT/RCV on Channel 1
Hop 5: XMIT/RCV on Channel 7
Network C (includes Backbone #2)
Hop Offset: 2
Hop 1: XMIT/RCV on Channel 9
Hop 2: XMIT/RCV on Channel 15
Hop 3: XMIT/RCV on Channel 1
Hop 4: XMIT/RCV on Channel 7
Hop 5: XMIT/RCV on Channel 3
Hop Pattern: 1 (pseudorandom)

Attention

MMS should be configured with FHSS modulations 57 MSK, 114 MSK, 153 MSK & 229 MSK OR DTS modulations 884 BPSK, 1768 QPSK, 2651 8PSK, 3535 16QAM and 3535 16PSK. It is not recommended to mix FHSS and DTS modulations.

Whether FHSS or DTS modulations are used, the following radio settings that affect transmission timing must be the SAME in ALL radios within ALL sub-networks in the system;

- Frequency Band and Excluded Frequencies
- Hop Pattern (1 is recommended for MMS)
- Access Point Transmit Rate
- End Point Transmit Rate(s)
- Max Payload Bytes
- Network Type; PTP or PMP
- Network Radius

MMS may operate in one of two modes;

- **Generate**; the system Access Point internally "generates" the 1Hz timing signal for all other radios in the network(s).

- **External**; a 1PPS "external" trigger signal from a GPS receiver is used to synchronize the 1Hz timing signal for all other radios in the network(s). See IO Connections for wiring info. The Cambium Networks uGPS is an option for providing the 1PPS sync signal.

Attention

MMS should be configured with FHSS modulatiOns 57 MSK, 114 MSK, 153 MSK & 229 MSK OR DTS modulations 884 BPSK, 1768 QPSK, 2651 8PSK, 3535 16QAM and 3535 16PSK. It is not recommended to mix FHSS and DTS modulations.

Whether FHSS or DTS modulations are used, the following radio settings that affect transmission timing must be the SAME in ALL radios within ALL sub-networks in the system;

- Frequency Band and Excluded Frequencies
- Hop Pattern (1 is recommended for MMS)
- Access Point Transmit Rate
- End Point Transmit Rate(s)
- Max Payload Bytes
- Network Type; PTP or PMP
- Network Radius

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- **Generate**; the system Access Point internally "generates" the 1Hz timing signal for all other radios in the network(s).

- **External**; a 1PPS "external" trigger signal from a GPS receiver is used to synchronize the 1Hz timing signal for all other radios in the network(s). See IO Connections for wiring info. The Cambium Networks uGPS is an option for providing the 1PPS sync signal.

Access Point Specific Settings

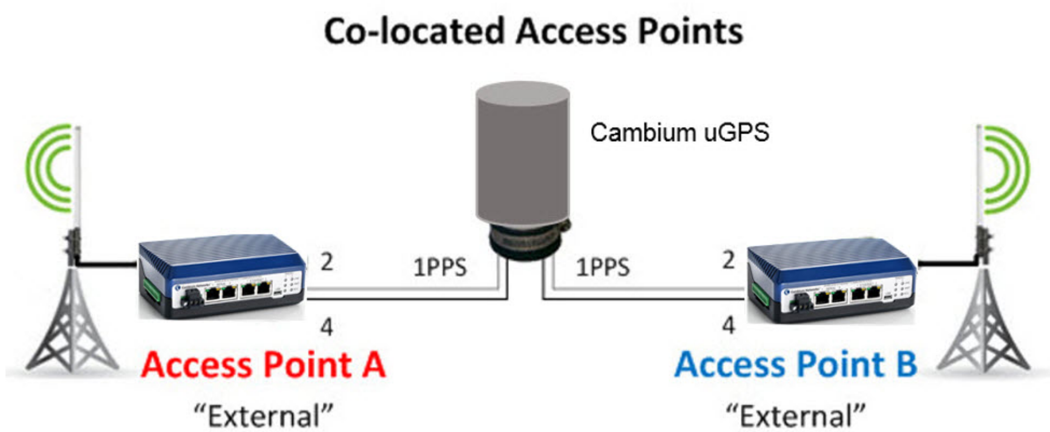
Generate

When the Access Point radio is set to Generate, it will internally generate a timing signal that can be used in two ways;

1. For timing downstream radios in any number of interconnected sub-networks.

2. For timing a co-located Access Point (and any number of interconnected sub-networks downstream of that Access Point).

–



Note

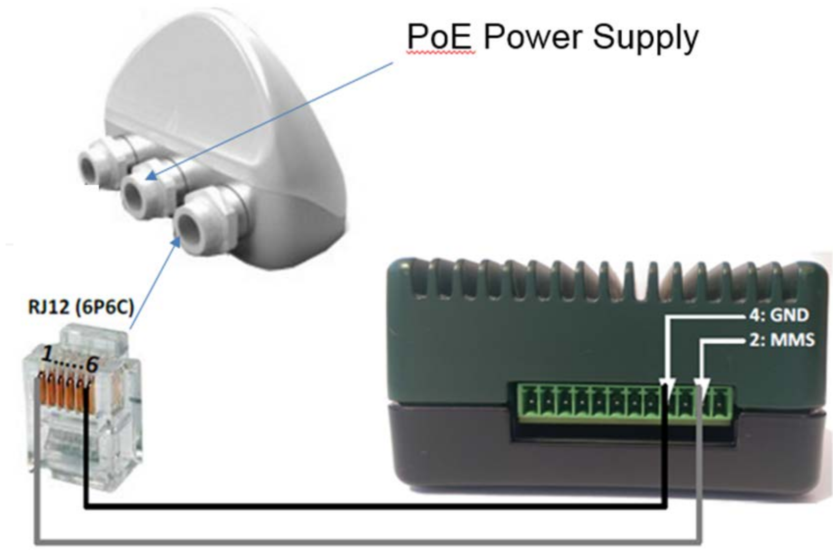
If co-locating Access Points connect Pin2 – Pin2 and Pin4 – Pin4 so that one Access Point will "generate" the timing signal and the other will receive it on the MMS Pins of the External IO connector.

External

Use of a 1PPS (one pulse-per-second) external trigger for MMS requires a GPS receiver capable of providing a 1PPS signal to the IO connector on the side of the radio.

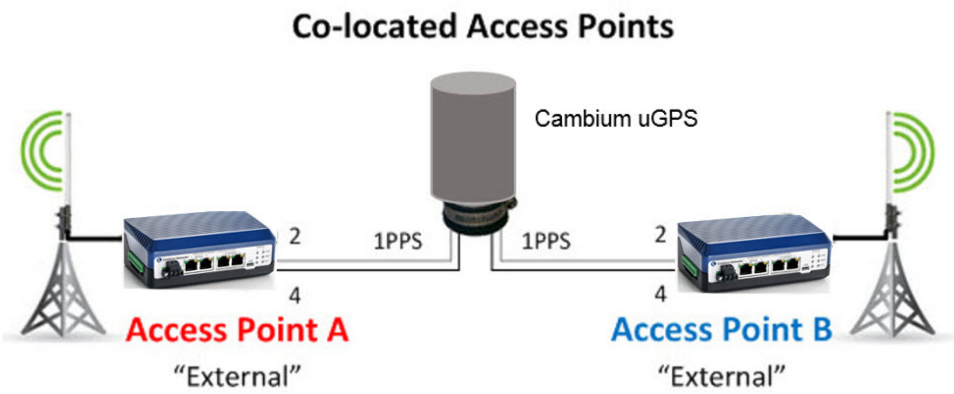
The Cambium Networks uGPS can be used for this purpose.

Either of the **RJ12 – Sync** ports can be used, with cable pinouts and wiring as follows;



RJ12 Pin #	Signal Pinout	Connect to MMS Pin #
1	1PPS GPS Sync	2
2 - 4	Not connected	-
6	Ground	4

With 2 x Sync Ports the SyncPipe can be used to precisely trigger two co-located Access Points.



Note
If using a GPS device with a single 1PPS port, it's possible to "daisy chain" the radios together Pin2 – Pin2 and Pin4 – Pin4 so that both radios are triggered simultaneously.

End Point Specific Settings

When using MMS the End Point radio should always be set to Generate, irrespective of the Access Point's MMS setting.

cnReach Dual Radio Specific Settings

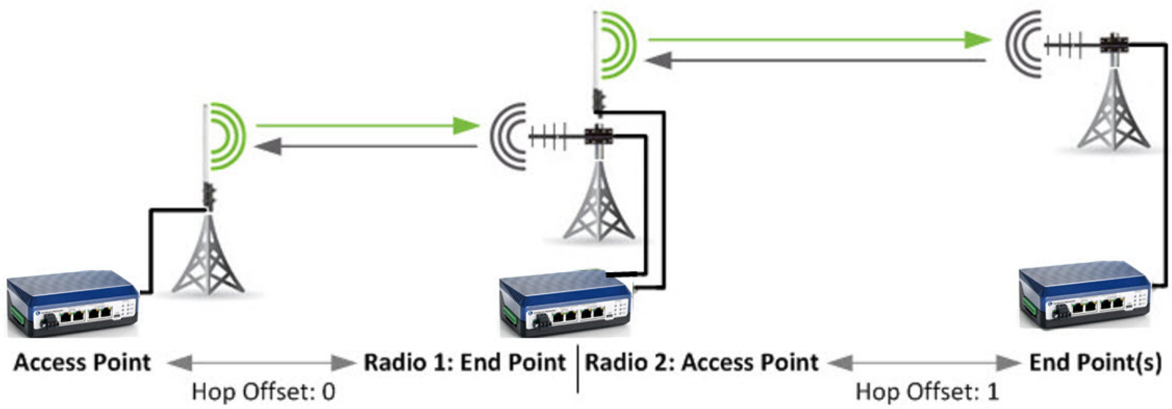
When using MMS with a cnReach N500 Dual Radio, the End Point radio that connects to an upstream Access Point should be set to **Generate** and the Access Point that has downstream End Points connected should be set to **External**; *the cnReach dual radio configurations have internal MMS circuitry between RF Modules that propagates the timing signal.*

MMS Hop Offset

MMS Hop Offset is a crucial setting for MMS to operate effectively; it is this parameter that permits the frequency/channel separation between the radios in the MMS Network.

The MMS Hop Offset should be set so that each of the sub-networks operate on a different channel in the hop table. For example, if there are 20 channels in the hop table (DTS: 884 BPSK upwards), setting the first radio to "0" and the second radio to "1" results in the radios transmitting on separate channels in the pseudorandom hop pattern.

The MMS Hop Offset should match between each Access Point and their connected End Points.



Max Payload Bytes

The Max Payload Bytes (or 'packet size') configuration is the key parameter to establish the size of the frame used in the air interface. The cnReach radio determines the duration of the uplink and downlink portions of the frame by combining the # of bytes in the max payload and the data rate of the maximum modulation. Essentially, the frame duration is the amount of time it takes the radio to send the maximum size payload at the maximum modulation.

Keep in mind that this setting is only used in multipoint networks. In PTP networks, the frame duration adjusts based on the modulation. In PMP networks, the frame must be fixed to enable communications to all of the end points.

With this in mind, there are several reasons to modify the max payload bytes:

- By choosing different max payload bytes from the AP and EP direction you can adjust how much time is spent in each direction. For example if most of the data is in the uplink direction you can make the EP payload bytes larger than the AP payload bytes.
- Selecting a larger value for payload bytes reduces the percentage of time allocated to the fixed overhead of each packet and in most cases increases overall capacity of the network. (the exception is when the network is predominately sending small packets)
- The smaller the payload bytes the lower the latency but also a lower capacity (see number 2).
- A larger max payload bytes will also take longer to transmit especially at low modulations. This can cause increased packet loss in a noisy environment as the noise floor can change in the middle of a packet transfer.
- You MUST set the Max payload bytes to AT LEAST the value in the tables below for Minimum Max Payload Bytes. The reason for this is that the radio must have enough duration in each direction to send 64 bytes.

Max Payload Bytes for Access Point and End Point range from 64 to 1600 Bytes with a default setting of 256.

> **Attention**
> Max Payload Bytes is one of the most frequently mis-configured parameters in a cnReach and setting an invalid value will cause the link to not pass traffic. Please review this section and make sure to reference the appropriate table for the band and channel size that you are deploying.
> Software release 5.2.16h and later incorporates some error-checking to reduce the occurrence of this mis-configuration.

The following tables are used to identify the minimum packet size that can be used. Note that there are different tables for each band and for each channel size. Please ensure that you are using the correct table. The tables are used as follows:

1. Find the fastest desired modulation at the top of the chart.
2. Find the slowest desired modulation on the left hand side of the chart.
3. The box where the column and the row meet is the smallest packet size that must be used for both Access Point and End Point Max Payload Bytes. Setting the max payload size SMALLER than this value will cause the link to NOT operate.

Examples of using the Minimum Max Payload Size Tables

Example 1: ISM

Fastest Modulation: 884Kbps (BPSK), Slowest Modulation 229Kbps (MSK).

Max Payload Bytes must be configured to 357 Bytes or larger.

Example 2: ISM

Modulations enabled: 2651 Kbps (8PSK), 884 Kbps (BPSK), 663 Kbps (2FSK).

Max Payload Bytes must be configured to 337 Bytes or larger.

Example 3: ISM

Fastest Modulation 2651 Kbps (8PSK), Slowest Modulation 153 Kbps (MSK).

This combination of modulation modes will not work.

900 MHz ISM – Minimum Packet Sizes with Multi-Speed Multi-Point

The following table charts the smallest “Max Payload Bytes” setting when using multiple ISM End Point Transmit Rates.

		Fastest Modulation											
			MSK				2FSK	BPSK	QPSK	8PSK	16QAM	16PSK	32QAM
		Kbps	57	114	153	229	663	884	1768	2651	3535	3535	4419
Slowest Modulation	MSK	57	64	165	229	358	111	1492					
		114		64	95	158	530	718	1459				
		153			64	112	396	539	1101				
		229				64	260	357	737	1118	1498	1498	
	2FSK	663					64	97	217	337	458	458	578
	BPSK	884						64	152	240	328	328	416
	QPSK	1768							64	108	152	152	196
	8PSK	2651								64	94	94	122
	16QAM	3535									64	64	86
	16PSK	3535									64	64	86
	32QAM	4419											64

900 MHz MAS Bands – Minimum Packet Sizes with Multi-Speed Multipoint

12.5 kHz Channels

			Maximum Modulation Mode					
			MSK	4FSK	QPSK	8PSK	16QAM	32QAM
		kbps	10	19	23	34	45	57
Minimum Modulation Mode	MSK	10	64	152	184	288	392	497
	4FSK	19		64	80	132	184	237
	QPSK	23			64	108	152	197
	8PSK	34				64	93	123
	16QAM	45					64	87
	32QAM	57						64

25 kHz Channels

			Maximum Modulation Mode					
			MSK	QPSK	8PSK	16QAM	32QAM	64QAM
		kbps	19	36	52	70	87	105
Minimum Modulation Mode	MSK	19	64	137	210	288	366	444
	QPSK	36		64	103	145	187	230
	8PSK	52			64	93	122	152
	16QAM	70				64	86	108
	32QAM	87					64	82
	64QAM	105						64

50 kHz Channels

			Maximum Modulation Mode					
			MSK	QPSK	8PSK	16QAM	32QAM	64QAM
		kbps	39	71	101	137	175	210
Minimum Moduatlion Mode	MSK	39	64	135	199	280	366	444
	QPSK	71		64	98	143	191	234
	8PSK	101			64	96	131	162
	16QAM	137				64	90	113
	32QAM	175					64	82
	64QAM	210						64

450 MHz FCC – Minimum Packet Sizes with Multi-Speed Multipoint

12.5 kHz Channels

			Maximum Modulation Mode				
			MSK	QPSK	8PSK	16QAM	32QAM
		Kbps	10	23	34	45	57
Minimum Modulation Mode	MSK	10	64	186	290	394	
	QPSK	23		64	110	154	198
	8PSK	34			64	95	124
	16QAM	45				64	87
	32QAM	57					64

25 kHz Channels

			Maximum Modulation Mode				
			MSK	QPSK	8PSK	16QAM	32QAM
		Kbps	18	29	44	59	76
Minimum Modulation Mode	MSK	18	64	118	189	258	
	QPSK	29		64	109	153	205
	8PSK	44			64	95	129
	16QAM	59				64	92
	32QAM	76					64

450 MHz ETSI – Minimum Packet Sizes with Multi-Speed Multipoint

12.5 kHz Channels

			Maximum Modulation Mode						
			BPSK	MSK	QPSK	8PSK	16QAM	32QAM	
		Kbps	9	10	17	26	35	44	
Minimum Modulation Mode	BPSK	9	64	77	153	241			
	MSK	10		64	133	211	288		
	QPSK	17			64	110		198	
	8PSK	26				64	95	124	
	16QAM	35					64	87	
	32QAM	44						64	

25 kHz Channels

			Maximum Modulation Mode						
			BPSK	MSK	QPSK	8PSK	16QAM	32QAM	
		Kbps	16	19	33	51	68	85	
Minimum Modulation Mode	BPSK	16	64	82	153	250			
	MSK	19		64	125	206	282		
	QPSK	33			64	114		206	
	8PSK	51				64	95	124	
	16QAM	68					64	87	
	32QAM	85						64	

700 MHz – Minimum Packet Sizes with Multi-Speed Multipoint

12.5 kHz Channels

			Maximum Modulation Mode				
			MSK	QPSK	8PSK	16QAM	32QAM
		Kbps	10	23	34	45	57
Minimum Modulation Mode	MSK	10	64	186	290	394	
	QPSK	23		64	110	154	198
	8PSK	34			64	95	124
	16QAM	45				64	87
	32QAM	57					64

25 kHz Channels

			Maximum Modulation Mode				
			MSK	QPSK	8PSK	16QAM	32QAM
		Kbps	19	36	52	70	87
Minimum Modulation Mode	MSK	19	64	139	211	289	
	QPSK	36		64	104	147	189
	8PSK	52			64	95	124
	16QAM	70				64	87
	32QAM	87					64

50 kHz Channels

			Maximum Modulation Mode				
			MSK	QPSK	8PSK	16QAM	32QAM
		Kbps	39	71	101	137	175
Minimum Modulation Mode	MSK	39	64	137	200	282	
	QPSK	71		64	100	145	192
	8PSK	101			64	98	132
	16QAM	137				64	91
	32QAM	175					64

100 kHz Channels

			Maximum Modulation Mode				
			MSK	QPSK	8PSK	16QAM	32QAM
		Kbps	76	160	240	320	400
Minimum Modulation Mode	MSK	76	64	163	255	348	
	QPSK	160		64	109	153	197
	8PSK	240			64	95	124
	16QAM	320				64	87
	32QAM	400					64

200 kHz Channels

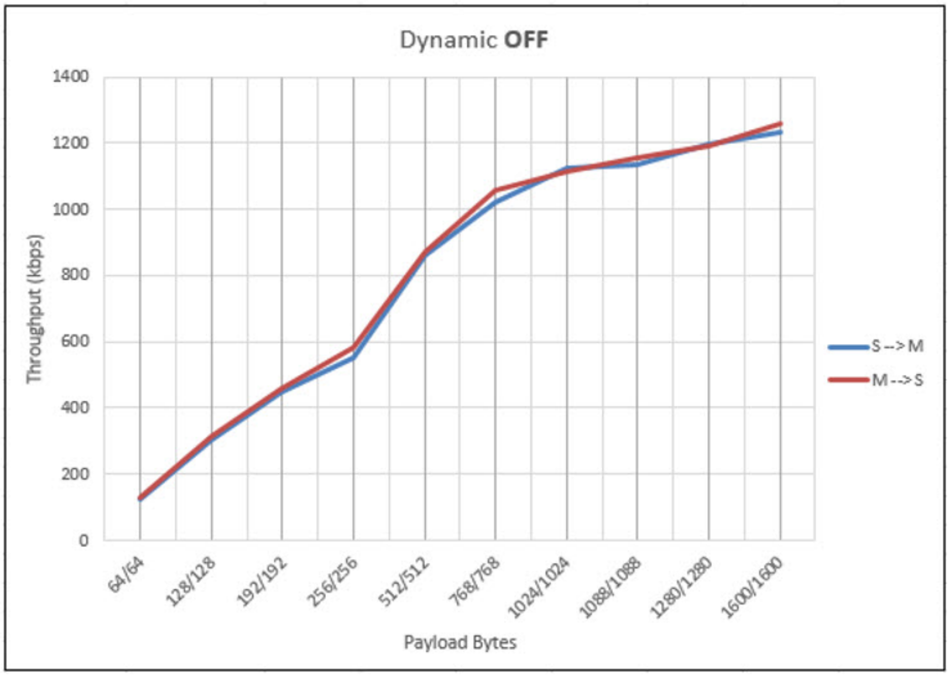
			Maximum Modulation Mode				
			MSK	QPSK	8PSK	16QAM	32QAM
		Kbps	153	320	480	640	800
Minimum Modulation Mode	MSK	153	64	163	255	348	
	QPSK	320		64	109	153	197
	8PSK	480			64	95	124
	16QAM	640				64	87
	32QAM	800					64

250 kHz Channels

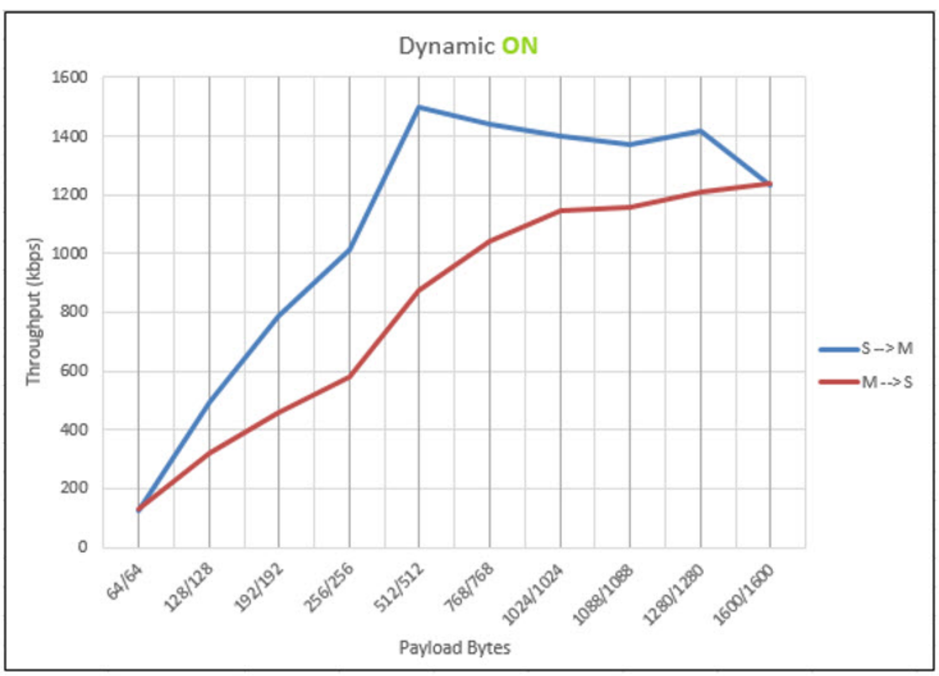
			Maximum Modulation Mode				
			MSK	QPSK	8PSK	16QAM	32QAM
		Kbps	194	403	605	806	1008
Minimum Modulation Mode	MSK	194	64	161	253	345	
	QPSK	403		64	109	153	197
	8PSK	605			64	95	124
	16QAM	806				64	87
	32QAM	1008					64

Dynamic Payload

Dynamic Payload is a feature that allocates the unused portion of the Access Point's timeslot to the End Point's timeslot to increase throughput from End Point → Access Point.



3535kbps 16QAM FBench throughput test results.



Networking Features

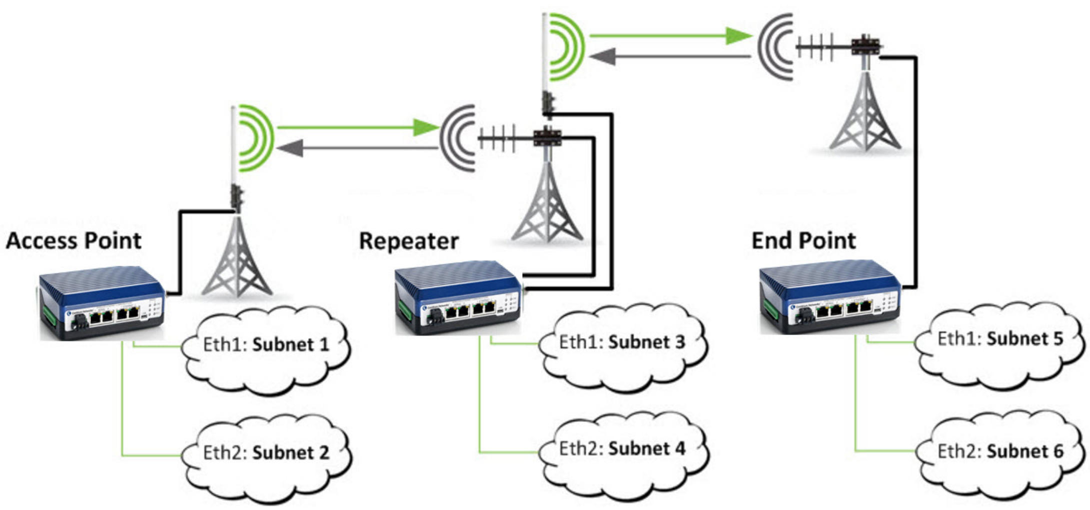
Routing

SCADA networks built with Ethernet bridges often exist within the same broadcast domain as the Enterprise network where the SCADA network terminates. With multiple PC's, printers and other network appliances from the Enterprise network also existing within the same broadcast domain, broadcast traffic from these network appliances can also traverse the SCADA system via the RF Links.

This unwanted broadcast traffic eats up RF Bandwidth, reducing the efficiency of the links. One way to reduce broadcast traffic is to add a router between the SCADA and Enterprise networks so that each system belongs to it's own broadcast domain.

This approach reduces the broadcast traffic from the Enterprise network but with the SCADA system being a flat network inside a single broadcast domain it remains likely that broadcast traffic from all connected devices could cause concern with a large deployment.

cnReach N500 Multi-Layer radios make it possible to build RF networks with data routed across multiple subnets, eliminating all unnecessary Ethernet traffic from the RF links.



Network/VLANs

CnReach radios function as 5-port enterprise Ethernet switches by implementing 802.1q VLANs and trunks. The five ports that participate in the Ethernet switching process are:

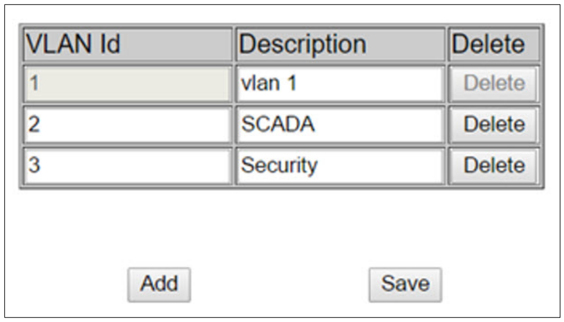
Port / Interface	Description
Ethernet 1	Physical Ethernet interface which can function as an access port, an 802.1q trunk, or both.
Ethernet 2	Physical Ethernet interface which can function as an access port, an 802.1q trunk, or both.
Radio 1	Wireless interface which functions as an 802.1q trunk.
Radio 2	Wireless interface which functions as an 802.1q trunk.
Management	Virtual Ethernet interface internal to the radio which functions as an access-port.

Native/Management VLAN

CnReach radios have an internal virtual Ethernet port to accept traffic destined for the radio's IP address when set up in a Bridge configuration. The VLAN specified here is the **Native** or **Management VLAN** that is associated with this internal virtual Ethernet port, which is **VLAN1** by default.

Additional VLANs

Additional VLANs can be given an ID between 2 and 4095 and a description to assist with identification.



– Click Add to create a new VLAN.

– Click Save to add the VLAN to the Radio configuration.

Note

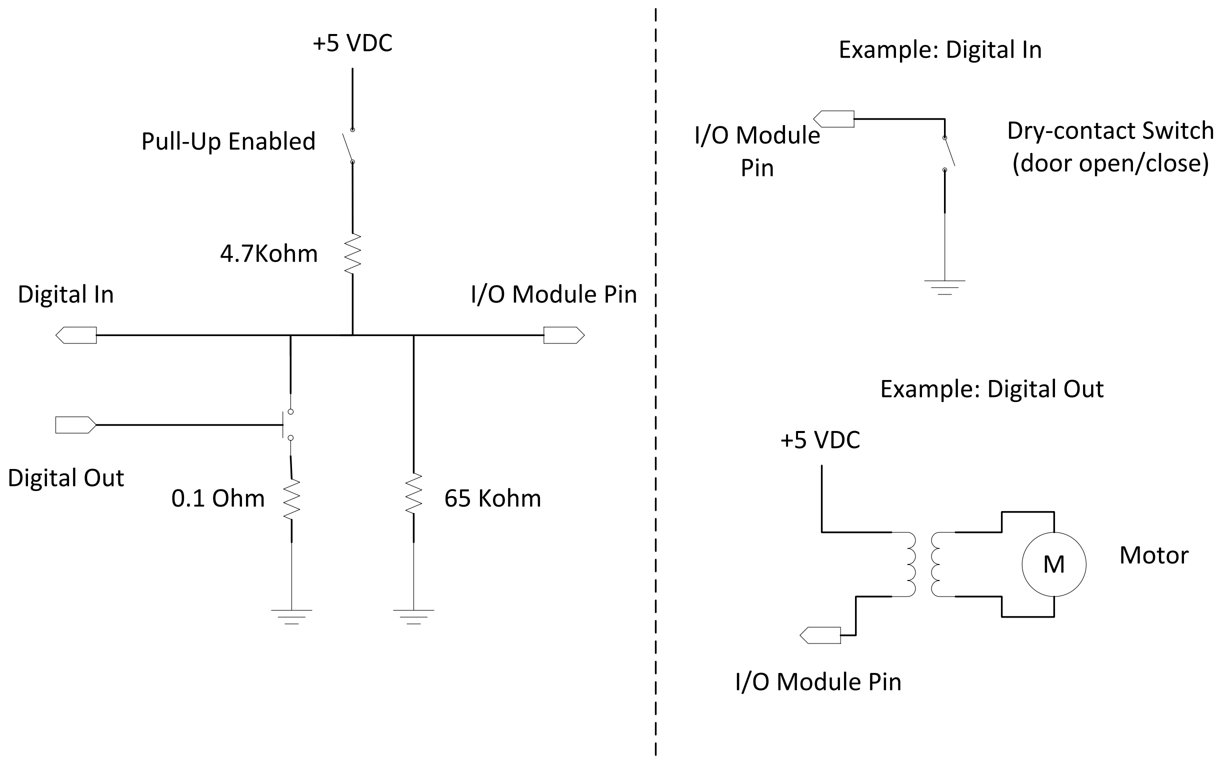
The maximum number of VLANs that can be created is 16.

IO Capability on cnReach Radios

For cnReach radios that have the optional IO capability there are 8 channels that can be configured for the capabilities in the table below. These pins can be read using MODBUS control software.

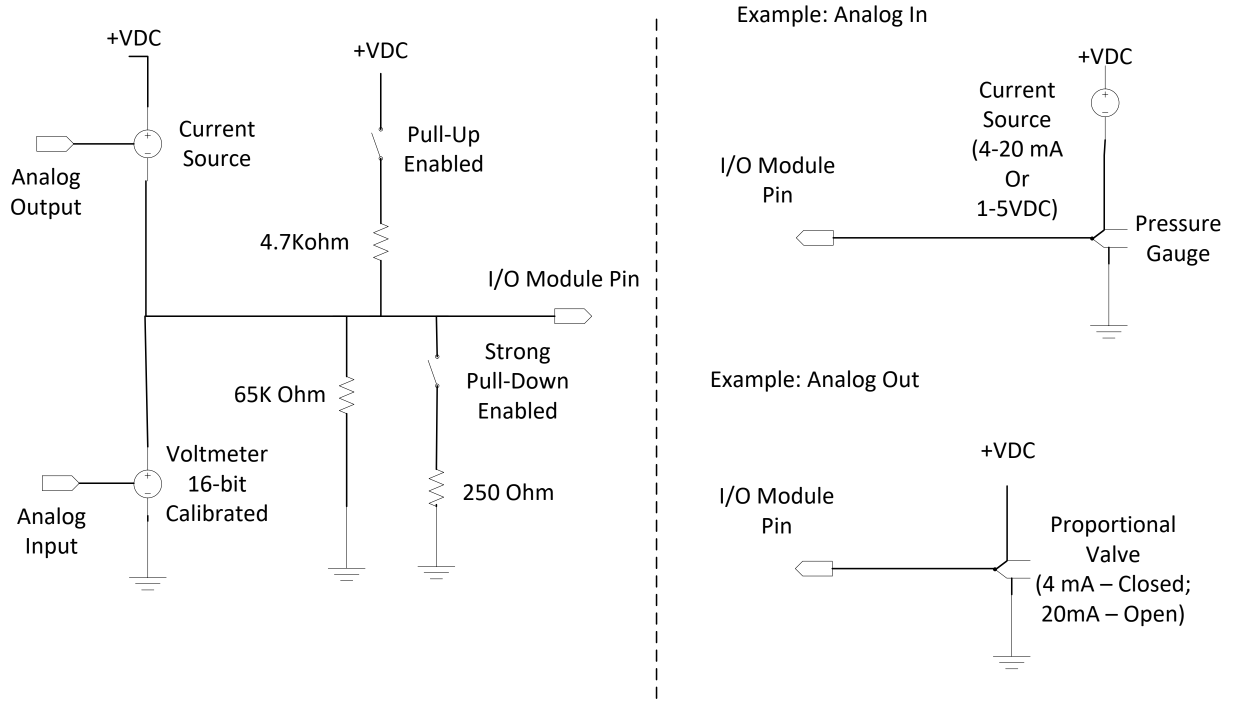
Digital I/O

- Sense switch closing/openings with Digital Inputs
- Drive motor contacts or actuators with Digital Outputs
- Count low-frequency or high-frequency occurrences with Digital Inputs
- Pull-up resistor used to keep DO either normally ‘low’ or normally ‘high’
- Digital In can sink maximum 2A



Analog I/O

- Measure pressures and levels with Analog inputs
- Drive variable valves or pump rates with Analog outputs
- Measurements use 16-bit A/D circuitry



Per-Pin Capabilties

PIN	1	2	3	4	5	6	7	8	9	10	11	12
Channel	CH0-A	CH1-A	CH2-A	GND	CH3-A	CH4-D	GND	CH5-D	GND	CH6-D	GND	CH7-D
Digital Output with 2Amp V+ switch to ground						Yes		Yes		Yes		Yes
Analog Output with 0 to 24 milliAmp Range	Yes	Yes	Yes		Yes							
Analog Input with true zero and 6 volt range	Yes	Yes	Yes		Yes							
Analog Input with true zero and 7.5 volt range						Yes		Yes		Yes		Yes
Analog input with 0 to 25 milliAmp range	Yes	Yes	Yes		Yes							
Digital Input	Yes	Yes	Yes		Yes	Yes		Yes		Yes		Yes
Digital Input with 200 Hz Counting						Yes		Yes		Yes		Yes
Digital Input with 10 kHz Counting						Yes						
Pullup Resistor						Yes		Yes		Yes		Yes
Weak Pulldown Resistor	Yes	Yes	Yes		Yes	Yes		Yes		Yes		Yes
Strong Pulldown Resistor	Yes	Yes	Yes		Yes							
MultiSync (without IO enabled)		Yes										
MultiSync (with IO enabled)						Yes						

The connector pinout for the 12-pin IO connector is listed here:

1. Channel 1
2. Channel 2
3. Channel 3
4. Ground
5. Channel 4

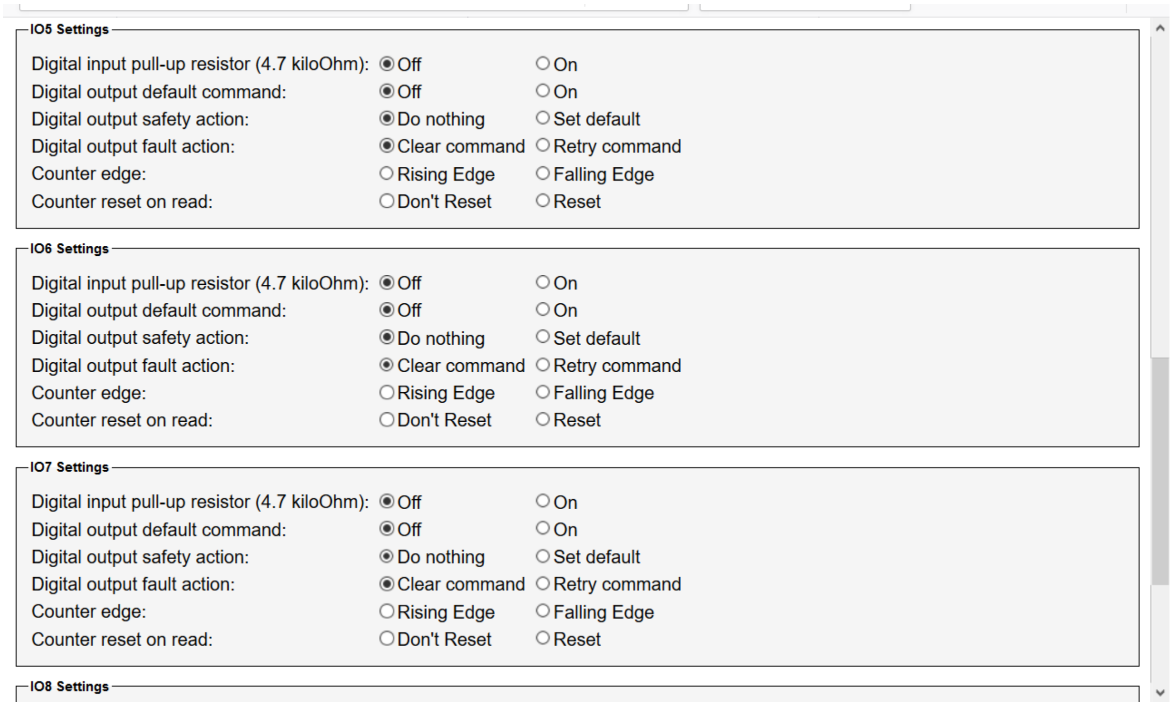
6. Channel 5
7. Ground
8. Channel 6
9. Ground
10. Channel 7
11. Ground
12. Channel 8

Digital Input

Digital input functions work by continually sensing voltage on the pin. A high-voltage on the pin returns "1" and a low voltage returns "0". Digital input sensing runs all the time. There is no user configuration needed to pull Digital Input status.

Digital inputs can be used to count pulse inputs. Unless identified as high-speed pulse counter, all digital inputs support 0.4 Hertz pulse counting. The minimum pulse width is 1.25 seconds. The minimum pulse width must be met at both the high and low levels. The user configures whether to count the rising or falling edge of the pulse.

- Digital input functions work by continually sensing voltage on the pin. A high voltage on the pin returns "1" and a low voltage returns "0". Digital input sensing runs all the time.
- There is no user configuration needed to pull Digital Input status.
- Digital inputs can be used to count pulse inputs. Unless identified as high speed pulse counter, all digital inputs support 0.4 Hertz pulse counting. The minimum pulse width is 1.25 seconds.
- The minimum pulse width must be met at both the high and low levels.
- The user configures whether to count the rising or falling edge of the pulse
- Pulldown resistance is 62 kilo Ohms to ground. The pulldown resistance comes from the channel's internal input impedance.
- Users can set a stronger pulldown resistor.
- A 250 Ohm pulldown resistor can be enabled by setting current mode on pins that support Analog Input current. In this case, the 250 Ohm current sense resistor is enabled and is used as the pulldown resistor.



Digital Input with Pull-Down Resistor

Pull-down resistance is 62 kOhms to ground. The pull-down resistance comes from the channel's internal input impedance. The pull-down resistor is always present and does not need configuration.

Users can set a stronger pull-down resistor. A 250 Ohm pull-down resistor can be enabled by setting current-mode on pins that support Analog Input current. In this case, the 250 Ohm current sense resistor is enabled and is used as the pull-down resistor.

Digital Input with Pull-Up Resistor

Pull-up resistors is 4.7 kiloOhms to 4.7 Volts. The pull-up resistor must be enabled by the user.

Digital Input with 200 Hertz Counting

Digital input channels with 200 Hertz counting can count up to 200 pulses per second. The minimum pulse width is 2.5 milliseconds.

Digital Input with 10 kiloHertz Counting

Digital input channels with 10 kiloHerts counting can count up to 10 thousand pulses per second. The minimum pulse width of the pulse is 50 microseconds.

Digital Output

The digital output is used to drive solenoids, latches, valves, pumps, lamps, etc. In the OFF/OPEN state digital outputs present a high impedance to the external equipment and prevent current from flowing. The high impedance when OFF/OPEN should not energize common equipment. In the ON/CLOSED state the digital output presents a low impedance to the external equipment and allows current to flow.

This energized the external equipment. In the event a dangerous condition is detected in the digital output, like too much current, the digital output will enter protection and disable the output. The user can choose whether the digital output should clear the ON/CLOSED command or to retry the command when safe to do so. Users should always follow good grounding practices and connect one ground wire for every digital output used.

- Used to drive solenoids, latches, valves, pumps, lamps, etc.
- In the OFF/OPEN state digital outputs present a high impedance to the external equipment and prevent current from flowing.
- The high impedance when OFF/OPEN should not energize common equipment. In the ON/CLOSED state the digital output presents a low impedance to the external equipment and allows current to flow.
- In the event a dangerous condition is detected in the digital output, (such as too much current), the digital output will enter protection and disable the output.
- The user can choose whether the digital output should clear the ON/CLOSED command or to retry the command when safe to do so.
- The digital output with 2 Amp switch to ground is implemented

Digital Output with 2 Amp V+ Switch to Ground

The digital output with 2 Amp switch to ground is implemented with a solid state NMOS transistor. The impedance when OFF/OPEN is roughly 62 kiloOhms to ground. The impedance when ON/CLOSED is roughly 50 milliOhms to ground. The current flowing through the equipment is measured and circuitry protection turns on above 2 Amps.

Analog Input

Analog input functions are used to measure voltage and current signals. The most common analog signals are 1 to 5 Volt and 4 to 20 milliAmp.

Analog Input with True Zero and 6 Volt Range

The maximum measurement error of analog inputs from 0 to 6 Volts is 0.5% across the entire operating temperature range.

Analog Input with True Zero and 7.5 Volt Range

The maximum measurement error of analog inputs from 0 to 7.5 Volts is 2.5% across the entire operating temperature range.

Analog Input with 0 to 25 milliAmp Range

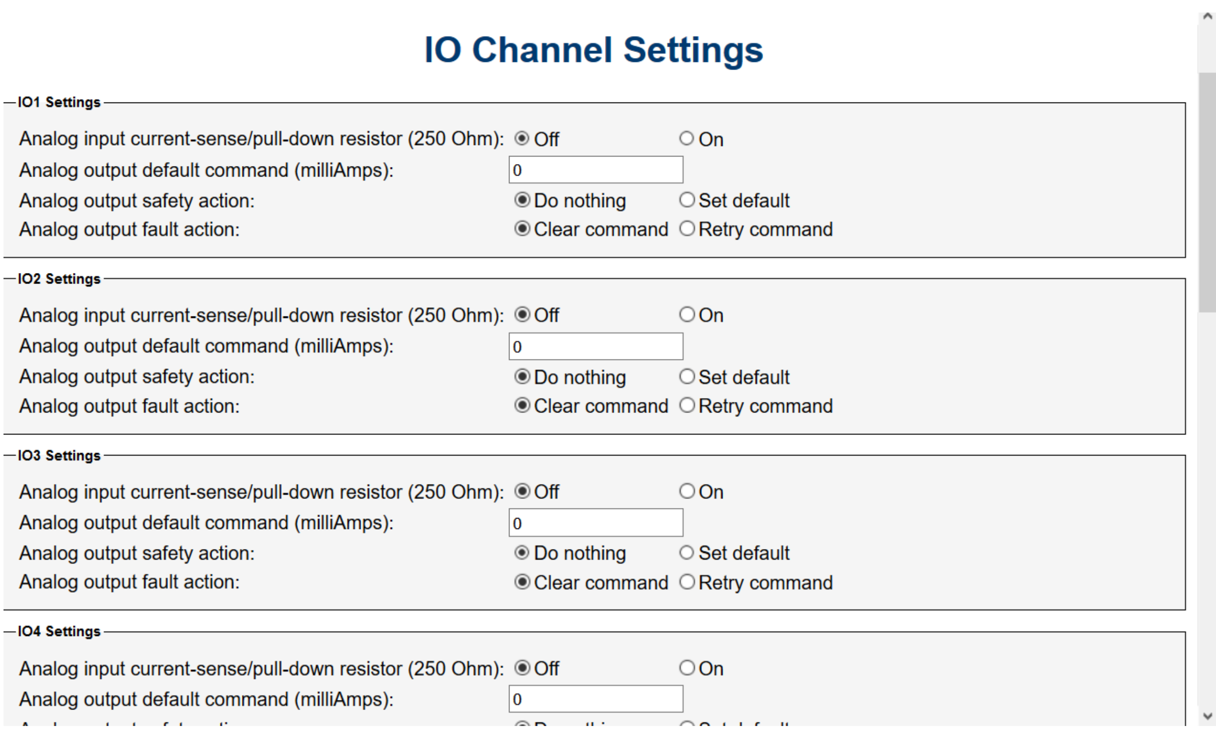
The maximum measurement error of analog inputs from 0 to 25 milliAmps is 0.5% across the entire operating temperature range.

Analog Output

Analog input functions are used to drive equipment to variable positions.

Analog Output with 0 to 24 milliAmp Range

The Analog Output can drive current from 0 to 24 milliAmps. The maximum output error is 0.5% across the entire operating temperature range.

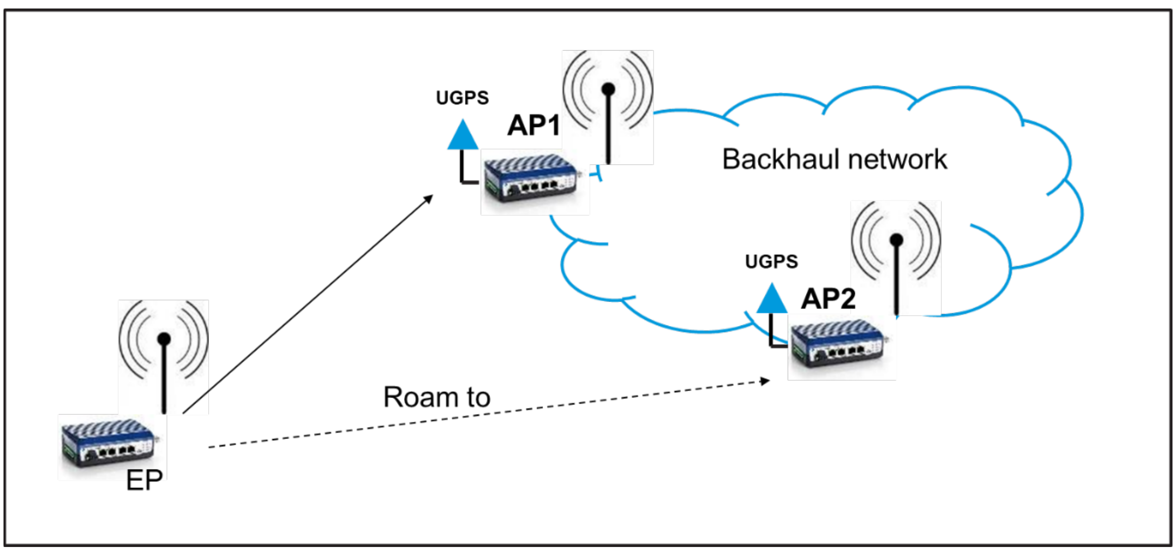


Roaming Feature (ISM only)

The roaming feature allows a mobile or fixed EP radio to seamlessly switch association between upstream radios as necessary to maintain the best possible link. It has been tested to support Mobility speed of up to 30 miles. Currently, roaming is only supported by ISM mode, with frequency hopping.

Roaming is implemented at the RF layer. Additional consideration must be taken at the Ethernet layer for traffic to be routed properly during handover. An Ethernet switch will maintain a FDB (forwarding database) which is populated from learning of traffic flow to keep track of which port to forward the Ethernet traffic. As an EP is roaming from one AP (e.g. AP1) to another AP (e.g. AP2), the switch is not aware of the situation and will continue to forward traffic targeting the EP via the original AP (e.g. AP1). If the network is converged with more than one AP, the payload devices behind the EP needs to initiate traffic to trigger the switch to re-learn/update the FDB.

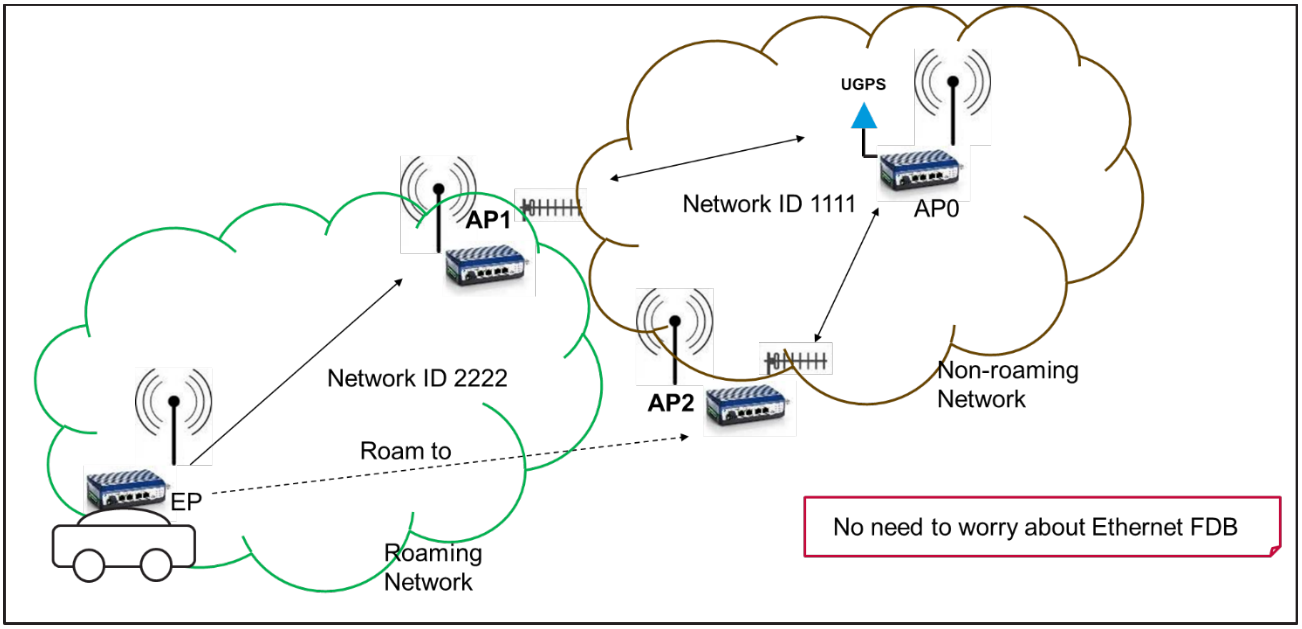
The following diagram showed a roaming scenario where the network is converged at two APs, so FDB update should be considered.



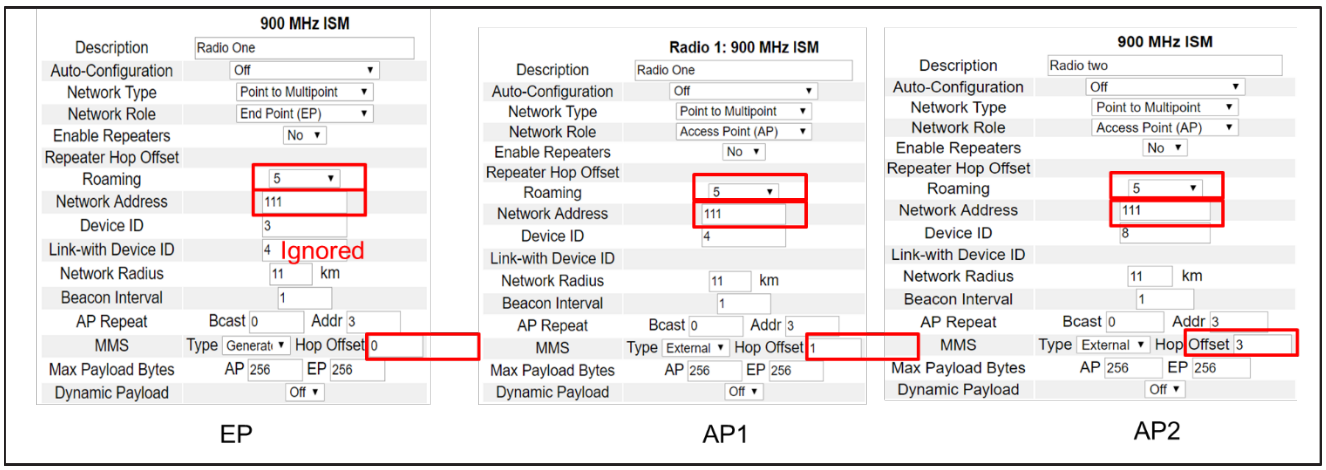
There are two other scenarios where FDB update will not be a concern.

1. Roaming with Back-to-back repeaters

   The following diagram showed a roaming EP with network converged to a single AP, back-to-back repeaters are distributed among the areas but all converged to a single AP. Notice that roaming is only turned on for network 2222, but not for network 1111.



Example of configurations following:



Pay attention to the following bullet points:

A. Make sure to use the same hop pattern and network address across the network

B. EP hop offset must be set to 0

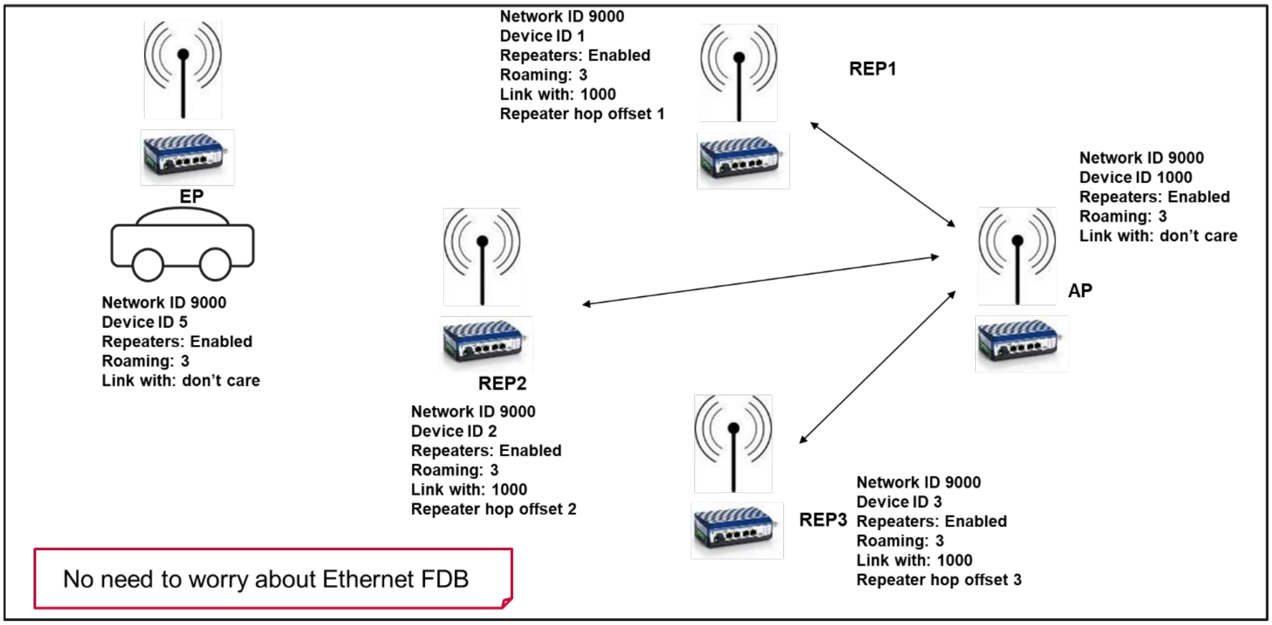
C. Each AP should have different hop offset

D. "Roaming" defines max number of APs that the EP can roam to

E. Follow sync rule – all frame duration/timing must be the same (transmit rate, payload bytes, Radius, dynamic off)

2. Roaming among REPs

The following diagram showed an EP romaing among the REPs.


Network ID 9000
Device ID 1
Repeaters: Enabled
Roaming: 3
Link with: 1000
Repeater hop offset 1
REP1
EP
Network ID 9000
Device ID 1000
Repeaters: Enabled
Roaming: 3
Link with: don't care
AP
Network ID 9000
Device ID 5
Repeaters: Enabled
Roaming: 3
Link with: don't care
REP2
Network ID 9000
Device ID 2
Repeaters: Enabled
Roaming: 3
Link with: 1000
Repeater hop offset 2
REP3
Network ID 9000
Device ID 3
Repeaters: Enabled
Roaming: 3
Link with: 1000
Repeater hop offset 3
No need to worry about Ethernet FDB

Management and Diagnostics Features

SNMP

Simple Network Management Protocol V1/V2 and V3 is standard in all cnReach N500 radios and can be used to monitor:

- **RF Module:** Margin, Noise, Reverse Power, RSSI, Rx Success, Temperature, Tx Success.
- **Device**: DI1 Level, DC Input Voltage.

SNMP requires the use of an SNMP Manager such as OpenNMS, Solarwinds etc. Radios can be polled and traps can be set. The current SNMP interface is read-only and therefore it is not used to configure the radios.

Radio Hardware and Interfaces

Interface Cabling

DC Power

Cambium Networks recommends using a power source capable of 8W peak / 4W sustained.

The 10 – 32 VDC Power Connector is a Phoenix Contact MSTB 2-Pin plug. The positive terminal is on the left and the negative terminal is on the right. cnReach N500 radios have reverse polarity protection to 32VDC.

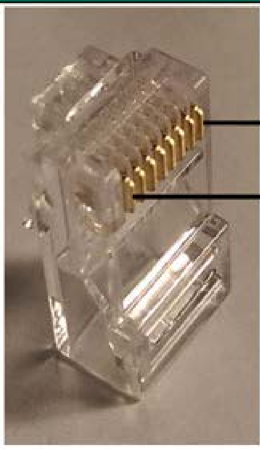
Figure 2: cnReach N500 DC Power

Caution

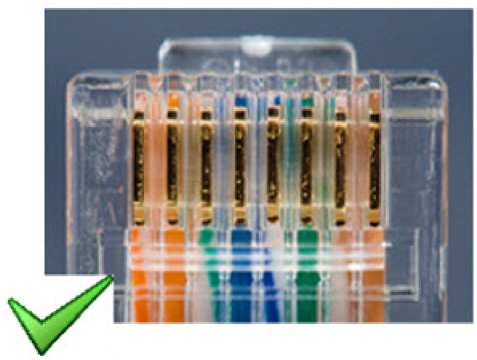
Use of 802.3af PoE/802.3at PoE+ is NOT supported.

TIA/EIA 568 Wiring Standard

The T568 standard defines the pin-out and wire pairing for the termination of RJ-45 connectors in two standard configurations; T568A and T568B.

8P8C RJ45 Plug	RJ45 Pin #	T568A Wire Color	T568A Pair #	T568B Wire Color	T568B Pair #
	1		3		2
	2		3		2
	3		2		3
	4		1		1
	5		1		1
	6		2		3
	7		4		4
	8		4		4

This manual assumes the use of the T568B wiring standard for serial RJ-45 connectors.



RJ-45 Serial Port Pin Assignments

All cnReach radios have the RJ-45 locking tab facing upwards, which means the pin numbering of the serial RJ-45 ports is reversed from right to left:

Connections Pinout for RS-232

cnReach uses the EIA/TIA-561 standard for RS-232 signals on the serial RJ-45 Port. With the serial port on the radio configured as RS-232, the following table applies:

Serial RJ-45 Pin #	RS-232 Signal Pinout EIA/TIA-561	T568B Wire Color	Connect to these lines on Serial End Device
1	Data Set Ready (DSR)	White/Orange	Data Terminal Ready (DTR)
2	Data Carrier Detect (DCD)	Orange	DSR/DTR line
3	Data Terminal Ready (DTR)	White/Green	Data Set Ready (DSR)
4	**Signal Ground* (GND)**	**Blue**	**Signal Ground* (GND)**
5	**Receive Data* (RXD)**	**White/Blue**	**Transmit Data* (TXD)**
6	**Transmit Data* (TXD)**	**Green**	**Receive Data* (RXD)**
7	Clear to Send (CTS)	White/Brown	Request To Send (RTS)
8	Request To Send (RTS)	Brown	Clear to Send (CTS)

Note
** **TXD, RXD** and **GND** are required as a bare minimum for interfacing most serial end devices to the Ethernet Bridge.*

Connections Pinout for 4-Wire RS-422/RS-485

When the serial port on the radio is configured to 4-wire RS-422 or RS-485, the following table applies:

Serial RJ-45 Pin #	RS 422/485 Signal Pinout	T568B Wire Color	Connect to these lines on Serial End Device
1		White/Orange	
2		Orange	
3		White/Green	
4	Signal Ground (GND)	Blue	Signal Ground (GND)
5	Receive + (A)	White/Blue	Transmit + (Y)
6	Transmit + (Y)	Green	Receive + (A)
7	Transmit – (Z)	White/Brown	Receive – (B)
8	Receive – (B)	Brown	Transmit – (Z)

Connections for 2-Wire RS-485

When the serial port on the radio is configured to 2-wire RS-485, the following table applies:

Serial RJ-45 Pin #	RS 422/485 Signal Pinout	T568B Wire Color	Connect to these lines on Serial End Device
1		White/Orange	
2		Orange	
3		White/Green	
4	Signal Ground (GND)	Blue	Signal Ground (GND)
5	Bus+ (short to Pin6)	White/Blue	Bus+
6	Bus+ (short to Pin5)	Green	
7	Bus- (short to Pin8)	White/Brown	Bus-
8	Bus- (short to Pin7)	Brown	

I/O Connections Pinout for Radios Sync

All cnReach radios include the following I/O pins. Additional I/O is available on the cnReach radios with I/O and the I/O expander. See the section on I/O for other pin definitions.

IO Pin #	Signal Pinout
1	DI-1 : *See SNMP Section for details*
2	Synchronization: *See Synchronization Section for details*
4	Ground

Status LEDs

cnReach radios have **LINK***, **XMIT*** and **RCV*** LEDs on the front for each of radio 1 and radio 2.

The **LINK** LED shows radio power and link state.

- A red LINK LED indicates that the radio has power but is **not** linked (a Point to Multipoint **Access Point** radio always shows a green LINK LED. All other radio configurations show a red LINK LED upon power up until the radio link is established).
- A green LINK LED indicates that the radio has power and is linked.
- When the link is established the LINK LED turns green.
- If the link is dropped, then the LINK LED returns to red.

The **XMIT** LED flashes red every time the radio transmits data.

The **RCV** LED flashes green when the radio is receiving and decoding an RF packet.

Because of the high speed of the embedded microprocessor and communications, all status LEDs can turn on and off very quickly. In some cases, the LEDs turn on and off so quickly that the LEDs appear to be on but dimly lit. This behaviour indicates that events are happening in very quick succession. A good example is the XMIT LED changing intensity from dim red to bright red to **off**. This indicates many small packets in quick succession (dim red), followed by many large packets with almost continuous transmissions (bright red), then no transmissions (**off**).


RADIO
1
2
LINK
XMIT
RCV


RADIO
1
2
LINK
XMIT
RCV

900 MHz Specific Performance Data

900 MHz ISM Throughput Measurements

Measured throughput in UDP. For each radio in the following performance data section throught is provided for a variety of frame sizes and modulations. And then also for the packet size. Some definitions:

Frame size: length of the payload frames in the user data

Packet size: configured packet (max payload size) in the radio GUI

Transmit rate: the selected modulation rate in the radio GUI. This refers to the RF signaling rate

Radio RF throughput: the capacity as displayed in the RF throughput diagnostics tool

Throughput shown in table: capacity as measured using UDP traffic by a JSDU handheld test set.

256 bytes packet size		Frame size [bytes]						
Transmit Rate [kbps]	Radio RF Throughput [kbps]	64	128	256	512	1024	1280	1518
4419	1414.1	397.8	645.0	1210.0	1296.2	1279.1	1272.4	1193.5
3535	1303.8	418.9	744.3	1044.7	1143.3	1168.3	1184.5	798.1
3535	1303.6	397.6	764.3	954.7	1145.2	1173.3	1181.1	1176.4
2651	1102.2	422.2	693.1	895.4	968.4	995.5	989.8	1004.4
2651	1145.8	518.2	781.5	978.3	1005.1	1026.0	1040.4	1045.4
2121	987.1	428.7	759.0	841.9	868.9	599.7	896.6	904.1
1768	921.3	429.3	709.2	787.2	810.8	834.6	840.7	608.2
1591	840.3	433.6	464.5	719.6	741.5	761.6	767.0	770.3
1061	655.7	441.8	498.8	555.6	572.9	590.3	594.5	598.7
884	581.1	397.3	447.8	497.5	513.6	529.3	534.3	536.2
663	462.5	317.2	356.9	396.9	410.3	422.7	426.3	428.9
530	384.4	263.5	297.1	330.2	341.7	350.0	200.1	200.1
229	180.3	124.0	139.7	156.1	162.0	99.9	163.8	170.0
153	123.6	85.2	96.3	106.0	109.4	99.9	102.4	97.2
114	94.4	62.5	70.0	40.0	81.9	81.9	81.9	72.9
57	47.6	33.6	20.5	41.4	41.0	32.8	41.0	24.3

1500 bytes packet size		Frame size [bytes]						
Transmit Rate [kbps]	Radio RF Throughput [kbps]	64	128	256	512	1024	1280	1518
4419	3238.7	458.5	865.9	1548.7	2482.3	3101.9	3117.6	3123.4
3535	2737.7	435.7	880.6	1551.2	2484.6	2628.3	2629.9	2636.8
2651	2142.2	470.5	868.0	1493.6	2009.3	2054.1	2072.3	2080.3
2121	1774.8	465.3	868.7	1586.5	1622.7	1714.0	1724.3	1729.7

900 MHz MAS Licensed Throughput Measurements

256 bytes packet size			Frame size [bytes]						
Transmit Rate [kbps]	Channel Size [kHz]	Radio RF Throughput [kbps]	64	128	256	512	1024	1280	1518
57	12.5	40.3	28.7	30.7	32.8	32.8	32.8	20.5	24.3
45		33.5	25.0	26.6	28.7	24.6	16.4	20.5	24.3
34		26.3	18.3	20.5	20.5	16.4	16.4	20.5	24.3
23		18.0	11.3	14.3	12.3	16.4	15.6	16.0	13.4
19		15.7	10.2	12.3	12.3	8.2	14.7	13.7	8.5
10		8.2	5.1	4.1	4.1	7.4	6.6	7.6	6.6
105	25	71.0	50.0	56.3	61.4	65.3	65.3	61.4	48.6
87		60.9	43.6	48.7	53.2	49.2	49.2	41.0	48.6
70		51.9	36.3	41.3	45.1	41.0	32.8	41.0	24.3
52		39.9	28.6	30.7	32.8	32.8	32.8	20.5	24.3
39		31.3	22.3	24.6	24.6	24.6	16.4	20.5	24.3
36		28.9	19.7	22.5	24.6	24.6	16.4	20.5	24.3
19		17.7	11.3	12.3	12.2	8.2	15.0	14.6	10.1
210	50	135.8	93.7	106.0	118.4	122.9	114.7	122.9	121.4
175		118.2	82.3	92.5	103.8	106.3	98.3	102.4	97.2
137		97.4	67.5	76.6	86.1	90.1	81.9	81.9	72.9
101		75.5	52.5	40.0	65.5	65.4	65.5	61.4	48.6
71		56.4	46.2	42.5	57.3	57.2	57.3	51.2	48.6
39		32.3	22.5	24.6	24.6	24.6	16.4	20.5	24.3
1500 bytes packet size			Frame size [bytes]						
57	12.5	53.2	33.6	43.0	45.1	49.2	49.2	41.0	48.6
45		no response	30.0	32.8	36.9	41.0	32.8	20.5	24.3
105	25.0	95.5	69.5	80.0	86.7	90.1	97.5	81.9	97.2
87		81.9	59.8	62.4	69.6	73.7	65.5	61.4	72.7
70		62.3	46.3	50.0	57.3	57.3	49.2	61.4	61.4
210	50.0	160.9	137.5	158.6	174.0	180.0	180.2	184.3	194.3
175		160.6	112.2	124.7	144.5	147.5	147.5	143.4	145.7
137		126.3	92.5	103.1	116.2	114.2	114.7	122.9	121.4

Tx Power and Sensitivity (900 MHz ISM)

Receive Sensitivities are stated with BER = 10E-4

ISM			
Modulation	Ch Size (kHz)	Sensitivity (dBm)	Max Tx (mW)
57 MSK [1]	77	**-111**	**1000**
114 MSK [1]	154	**-108**	**1000**
153 MSK [1]	207	**-107**	**1000**
229 MSK [1]	310	**-103**	**1000**
663 2FSK [1]	900	**-101**	**1000**
530 BPSK [1]	600	**-103**	**1000**
884 BPSK [1]	1200	**-101**	**1000**
1061 QPSK [1]	600	**-100**	**1000**
1768 QPSK [1]	1200	**-98**	**1000**
1591 8PSK	600	**-94**	**1000**
2651 8PSK [1]	1200	**-92**	**1000**
2121 16QAM[1]	600	**-89**	**1000**
3535 16QAM	1200	**-88**	**1000**
2651 32QAM	600	**-81**	**1000**
3535 16PSK	1200	**-84**	**1000**
4419 32QAM	1200	**-83**	**1000**
2651 16QAM	900	**-84**	**1000**

Tx Power and Sensitivity (900 MHz MAS)

Receive Sensitivities are stated with BER = 10E-4

MAS			
Modulation	Ch Size (kHz)	Sensitivity (dBm)	Max Tx (mW)
10 MSK	12.5	**-116**	**3000**
19 4FSK	12.5	**-104**	**3000**
23 QPSK	12.5	**-107**	**3000**
34 8PSK	12.5	**-102**	**3000**
45 16QAM	12.5	**-98**	**3000**
57 32QAM	12.5	**-95**	**3000**
19 MSK	25	**-114**	**3000**
39 4FSK	25	**-101**	**3000**
36 QPSK	25	**-109**	**3000**
52 8PSK	25	**-103**	**3000**
70 16QAM	25	**-99**	**3000**
87 32QAM	25	**-96**	**3000**
105 64QAM	25	**-89**	**3000**

Channel and Hop Tables (900 MHz ISM Band Only)

The number of ISM channels varies with modulation[1]. The following sections provide channel frequencies, spacing, bandwidth and minimum channel requirements for the available FHSS and DTS ISM modulations.

The radio generates hop tables automatically based upon the modulation and frequency range in use.

The following is true for the complete 902-928 MHz ISM Band;

- 57 MSK — 171 channels with 76.45 kHz bandwidth 1.
- 114 MSK — 165 channels with 154.29 kHz bandwidth.
- 153 MSK — 123 channels with 207.11 kHz bandwidth.
- 229 MSK — 82 channels with 309.97 kHz bandwidth.
- 663 2FSK — 26 channels with 900 kHz bandwidth.
- 884 BPSK — 20 channels with 1.2 MHz bandwidth.
- 1768 QPSK — 20 channels with 1.2 MHz bandwidth.
- 2651 8PSK — 20 channels with 1.2 MHz bandwidth.
- 3535 16QAM 1 — 20 channels with 1.2 MHz bandwidth.
- 3535 16PSK 1 — 20 channels with 1.2 MHz bandwidth.
- 4419 32QAM 1 — 20 channels with 1.2 MHz bandwidth. provides

[1] 57 MSK uses the lower ISM band (902–915 MHz) even when **Band Stop** is set to **928** MHz.

Additionally, using the **Exclude MHz** settings to exclude 902 – 915 MHz has no effect and the Radio will continue to use the lower half of the ISM band.

To force the radio to use the upper ISM Band (915 – 928 MHz), set Band Start to 915 MHz and Band Stop to 928 MHz.

The radio will then use the upper half of the ISM Band maintaining 166 channels with 76.45 kHz channel bandwidth.

57 MSK (FHSS)

171 channels with 76.45 kHz channel spacing / bandwidth [1].

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	902.288225	44	905.575575	87	908.862925	130	912.150275
2	902.364675	45	905.652025	88	908.939375	131	912.226725
3	902.441125	46	905.728475	89	909.015825	132	912.303175
4	902.517575	47	905.804925	90	909.092275	133	912.379625
5	902.594025	48	905.881375	91	909.168725	134	912.456075
6	902.670475	49	905.957825	92	909.245175	135	912.532525
7	902.746925	50	906.034275	93	909.321625	136	912.608975
8	902.823375	51	906.110725	94	909.398075	137	912.685425
9	902.899825	52	906.187175	95	909.474525	138	912.761875

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
10	902.976275	53	906.263625	96	909.550975	139	912.838325
11	903.052725	54	906.340075	97	909.627425	140	912.914775
12	903.129175	55	906.416525	98	909.703875	141	912.991225
13	903.205625	56	906.492975	99	909.780325	142	913.067675
14	903.282075	57	906.569425	100	909.856775	143	913.144125
15	903.358525	58	906.645875	101	909.933225	144	913.220575
16	903.434975	59	906.722325	102	910.009675	145	913.297025
17	903.511425	60	906.798775	102	910.086125	146	913.373475
18	903.587875	61	906.875225	104	910.162575	147	913.449925
19	903.664325	62	906.951675	105	910.239025	148	913.526375
20	903.740775	63	907.028125	106	910.315475	149	913.602825
21	903.817225	64	907.104575	107	910.391925	150	913.679275
22	903.893675	65	907.181025	108	910.468375	151	913.755725
23	903.970125	66	907.257475	109	910.544825	152	913.832175
24	904.046575	67	907.333925	110	910.621275	153	913.908625
25	904.123025	68	907.410375	111	910.697725	154	913.985075
26	904.199475	69	907.486825	112	910.774175	155	914.061525
27	904.275925	70	907.563275	113	910.850625	156	914.137975
28	904.352375	71	907.639725	114	910.927075	157	914.214425
29	904.428825	72	907.716175	115	911.003525	158	914.290875
30	904.505275	73	907.792625	116	911.079975	159	914.367325
31	904.581725	74	907.869075	117	911.156425	160	914.443775
32	904.658175	75	907.945525	118	911.232875	161	914.520225
33	904.734625	76	908.021975	119	911.309325	162	914.596675
34	904.811075	77	908.098425	120	911.385775	163	914.673125
35	904.887525	78	908.174875	121	911.462225	164	914.749575
36	904.963975	79	908.251325	122	911.538675	165	914.826025
37	905.040425	80	908.327775	123	911.615125	166	914.902475
38	905.116875	81	908.404225	124	911.691575	167	914.978925
39	905.193325	82	908.480675	125	911.768025	168	915.055375
40	905.269775	83	908.557125	126	911.844475	169	915.131825
41	905.346225	84	908.633575	127	911.920925	170	915.208275
42	905.422675	85	908.710025	128	911.997375	171	915.284725
43	905.499125	86	908.786475	129	912.073825		

FHSS; FCC requires a minimum of 50 channels to be in use at any given time.

[1] *57 MSK uses the lower half of the ISM band (902 – 915 MHz) even when **Band Stop** is set to 928 MHz.*

Additionally, using the **Exclude MHz** settings to exclude 902 – 915 MHz has no effect and the radio will continue to use the lower half of the ISM Band – see next page.

Forcing 57 MSK to use Upper ISM Band (915 – 928 MHz)

To force the radio to use the upper half of the ISM Band, set **Band Start** to **915** MHz and leave **Band Stop** at **928** MHz. The radio will then use the upper half of the ISM Band maintaining **166 channels** with 76.45 kHz bandwidth;

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	915.038225	43	918.249125	85	921.460025	127	924.670925
2	915.114675	44	918.325575	86	921.536475	128	924.747375
3	915.191125	45	918.402025	87	921.612925	129	924.823825
4	915.267575	46	918.478475	88	921.689375	130	924.900275
5	915.344025	47	918.554925	89	921.765825	131	924.976725
6	915.420475	48	918.631375	90	921.842275	132	925.053175
7	915.496925	49	918.707825	91	921.918725	133	925.129625
8	915.573375	50	918.784275	92	921.995175	134	925.206075
9	915.649825	51	918.860725	93	922.071625	135	925.282525
10	915.726275	52	918.937175	94	922.148075	136	925.358975
11	915.802725	53	919.013625	95	922.224525	137	925.435425
12	915.879175	54	919.090075	96	922.300975	138	925.511875
13	915.955625	55	919.166525	97	922.377425	139	925.588325
14	916.032075	56	919.242975	98	922.453875	140	925.664775
15	916.108525	57	919.319425	99	922.530325	141	925.741225
16	916.184975	58	919.395875	100	922.606775	142	925.817675
17	916.261425	59	919.472325	101	922.683225	143	925.894125
18	916.337875	60	919.548775	102	922.759675	144	925.970575
19	916.414325	61	919.625225	102	922.836125	145	926.047025
20	916.490775	62	919.701675	104	922.912575	146	926.123475
21	916.567225	63	919.778125	105	922.989025	147	926.199925
22	916.643675	64	919.854575	106	923.065475	148	926.276375
23	916.720125	65	919.931025	107	923.141925	149	926.352825
24	916.796575	66	920.007475	108	923.218375	150	926.429275
25	916.873025	67	920.083925	109	923.294825	151	926.505725
26	916.949475	68	920.160375	110	923.371275	152	926.582175
27	917.025925	69	920.236825	111	923.447725	153	926.658625
28	917.102375	70	920.313275	112	923.524175	154	926.735075
29	917.178825	71	920.389725	113	923.600625	155	926.811525
30	917.255275	72	920.466175	114	923.677075	156	926.887975
31	917.331725	73	920.542625	115	923.753525	157	926.964425
32	917.408175	74	920.619075	116	923.829975	158	927.040875
33	917.484625	75	920.695525	117	923.906425	159	927.117325
34	917.561075	76	920.771975	118	923.982875	160	927.193775
35	917.637525	77	920.848425	119	924.059325	161	927.270225
36	917.713975	78	920.924875	120	924.135775	162	927.346675
37	917.790425	79	921.001325	121	924.212225	163	927.423125

38	917.866875	80	921.077775	122	924.288675	164	927.499575
39	917.943325	81	921.154225	123	924.365125	165	927.576025
4 0	918.019775	82	921.230675	124	924.441575	166	927.652475
41	918.096225	83	921.307125	125	924.518025		
42	918.172675	84	921.383575	126	924.594475		

FHSS; FCC requires a minimum of 50 channels to be in use at any given time.

114 MSK (FHSS)

165 channels with 154.29 kHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	902.327145	43	908.807325	84	915.133215	125	915.133215
2	902.481435	44	908.961615	85	915.287505	126	915.287505
3	902.635725	45	909.115905	86	915.441795	127	915.441795
4	902.790015	46	909.270195	87	915.596085	128	915.596085
5	902.944305	47	909.424485	88	915.750375	129	915.750375
6	903.098595	48	909.578775	89	915.904665	130	915.904665
7	903.252885	49	909.733065	90	916.058955	131	916.058955
8	903.407175	50	909.887355	91	916.213245	132	916.213245
9	903.561465	51	910.041645	92	916.367535	133	916.367535
10	903.715755	52	910.195935	93	916.521825	134	916.521825
11	903.870045	53	910.350225	94	916.676115	135	916.676115
12	904.024335	54	910.504515	95	916.830405	136	916.830405
13	904.178625	55	910.658805	96	916.984695	137	916.984695
14	904.332915	56	910.813095	97	917.138985	138	917.138985
15	904.487205	57	910.967385	98	917.293275	139	917.293275
16	904.641495	58	911.121675	99	917.447565	14 0	917.447565
17	904.795785	59	911.275965	10 0	917.601855	141	917.601855
18	904.950075	60	911.430255	101	917.756145	142	917.756145
19	905.104365	61	911.584545	102	917.910435	143	917.910435
20	905.258655	62	911.738835	102	918.064725	144	918.064725
21	905.412945	63	911.893125	104	918.219015	145	918.219015
22	905.567235	64	912.047415	105	918.373305	146	918.373305
23	905.721525	65	912.201705	106	918.527595	147	918.527595
24	905.875815	66	912.355995	107	918.681885	148	918.681885
25	906.030105	67	912.510285	108	918.836175	149	918.836175
26	906.184395	68	912.664575	109	918.990465	150	918.990465
27	906.338685	69	912.818865	110	919.144755	151	919.144755
28	906.492975	70	912.973155	111	919.299045	152	919.299045

29	906.647265	71	913.127445	112	919.453335	153	919.453335
30	906.801555	72	913.281735	113	919.607625	154	919.607625
31	906.955845	73	913.436025	114	919.761915	155	919.761915
32	907.110135	74	913.590315	115	919.916205	156	919.916205
33	907.264425	75	913.744605	116	920.070495	157	920.070495
34	907.418715	76	913.898895	117	920.224785	158	920.224785
35	907.573005	77	914.053185	118	920.379075	159	920.379075
36	907.727295	78	914.207475	119	920.533365	160	920.533365
37	907.881585	79	914.361765	120	920.687655	161	920.687655
38	908.035875	80	914.516055	121	920.841945	162	920.841945
39	908.190165	81	914.670345	122	920.996235	163	920.996235
40	908.344455	82	914.824635	123	921.150525	164	921.150525
41	908.498745	83	914.978925	124	921.304815	165	921.304815
42	908.653035						

FHSS; FCC requires a minimum of 50 channels to be in use at any given time.

153 MSK (FHSS)

123 channels with 207.11 kHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	902.353555	32	908.773965	63	915.194375	94	921.614785
2	902.560665	33	908.981075	64	915.401485	95	921.821895
3	902.767775	34	909.188185	65	915.608595	96	922.029005
4	902.974885	35	909.395295	66	915.815705	97	922.236115
5	903.181995	36	909.602405	67	916.022815	98	922.443225
6	903.389105	37	909.809515	68	916.229925	99	922.650335
7	903.596215	38	910.016625	69	916.437035	10 0	922.857445
8	903.803325	39	910.223735	70	916.644145	101	923.064555
9	904.010435	40	910.430845	71	916.851255	102	923.271665
10	904.217545	41	910.637955	72	917.058365	103	923.478775
11	904.424655	42	910.845065	73	917.265475	104	923.685885
12	904.631765	43	911.052175	74	917.472585	105	923.892995
13	904.838875	44	911.259285	75	917.679695	106	924.100105
14	905.045985	45	911.466395	76	917.886805	107	924.307215
15	905.253095	46	911.673505	77	918.093915	108	924.514325
16	905.460205	47	911.880615	78	918.301025	109	924.721435
17	905.667315	48	912.087725	79	918.508135	110	924.928545
18	905.874425	49	912.294835	80	918.715245	111	925.135655
19	906.081535	50	912.501945	81	918.922355	112	925.342765
20	906.288645	51	912.709055	82	919.129465	113	925.549875
21	906.495755	52	912.916165	83	919.336575	114	925.756985
22	906.702865	53	913.123275	84	919.543685	115	925.964095
23	906.909975	54	913.330385	85	919.750795	116	926.171205

24	907.117085	55	913.537495	86	919.957905	117	926.378315
25	907.324195	56	913.744605	87	920.165015	118	926.585425
26	907.531305	57	913.951715	88	920.372125	119	926.792535
27	907.738415	58	914.158825	89	920.579235	120	926.999645
28	907.945525	59	914.365935	90	920.786345	121	927.206755
29	908.152635	60	914.573045	91	920.993455	122	927.413865
30	908.359745	61	914.780155	92	921.200565	123	927.620975
31	908.566855	62	914.987265	93	921.407675		

FHSS; FCC requires a minimum of 50 channels to be in use at any given time.

229 MSK (FHSS)

82 channels with 309.97 kHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	902.404985	22	908.914355	43	915.423725	64	921.933095
2	902.714955	23	909.224325	44	915.733695	65	922.243065
3	903.024925	24	909.534295	45	916.043665	66	922.553035
4	903.334895	25	909.844265	46	916.353635	67	922.863005
5	903.644865	26	910.154235	47	916.663605	68	923.172975
6	903.954835	27	910.464205	48	916.973575	69	923.482945
7	904.264805	28	910.774175	49	917.283545	70	923.792915
8	904.574775	29	911.084145	50	917.593515	71	924.102885
9	904.884745	30	911.394115	51	917.903485	72	924.412855
10	905.194715	31	911.704085	52	918.213455	73	924.722825
11	905.504685	32	912.014055	53	918.523425	74	925.032795
12	905.814655	33	912.324025	54	918.833395	75	925.342765
13	906.124625	34	912.633995	55	919.143365	76	925.652735
14	906.434595	35	912.943965	56	919.453335	77	925.962705
15	906.744565	26	913.253935	57	919.763305	78	926.272675
16	907.054535	37	913.563905	58	920.073275	79	926.582645
17	907.364505	38	913.873875	59	920.383245	80	926.892615
18	907.674475	39	914.183845	60	920.693215	81	927.202585
19	907.984445	40	914.493815	61	921.003185	82	927.512555
20	908.294415	41	914.803785	62	921.313155		
21	908.604385	42	915.113755	63	921.623125		

FHSS; FCC requires a minimum of 50 channels to be in use at any given time.

663 2FSK (DTS)

26 channels with 900 kHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	903.350000	8	909.650000	15	915.950000	22	922.250000

2	904.250000	9	910.550000	16	916.850000	23	923.150000
3	905.150000	10	911.450000	17	917.750000	24	924.050000
4	906.050000	11	912.350000	18	918.650000	25	924.950000
5	906.950000	12	913.250000	19	919.550000	26	925.850000
6	907.850000	13	914.150000	20	920.450000		
7	908.750000	14	915.050000	21	921.350000		

DTS has no restrictions on the minimum number of channels.

884 BPSK (DTS)

20 channels with 1.2 MHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	903.500000	6	909.500000	11	915.500000	16	921.500000
2	904.700000	7	910.700000	12	916.700000	17	922.700000
3	905.900000	8	911.900000	13	917.900000	18	923.900000
4	907.100000	9	913.100000	14	919.100000	19	925.100000
5	908.300000	10	914.300000	15	920.300000	20	926.300000

DTS has no restrictions on the minimum number of channels.

1768 QPSK (DTS)

20 channels with 1.2 MHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	903.500000	6	909.500000	11	915.500000	16	921.500000
2	904.700000	7	910.700000	12	916.700000	17	922.700000
3	905.900000	8	911.900000	13	917.900000	18	923.900000
4	907.100000	9	913.100000	14	919.100000	19	925.100000
5	908.300000	10	914.300000	15	920.300000	20	926.300000

DTS has no restrictions on the minimum number of channels.

2651 8PSK (DTS)

20 channels with 1.2 MHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	903.500000	6	909.500000	11	915.500000	16	921.500000
2	904.700000	7	910.700000	12	916.700000	17	922.700000
3	905.900000	8	911.900000	13	917.900000	18	923.900000

4	907.100000	9	913.100000	14	919.100000	19	925.100000
5	908.300000	10	914.300000	15	920.300000	20	926.300000

DTS has no restrictions on the minimum number of channels.

3535 16QAM (DTS)

20 channels and 1.2 MHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	903.500000	6	909.500000	11	915.500000	16	921.500000
2	904.700000	7	910.700000	12	916.700000	17	922.700000
3	905.900000	8	911.900000	13	917.900000	18	923.900000
4	907.100000	9	913.100000	14	919.100000	19	925.100000
5	908.300000	10	914.300000	15	920.300000	20	926.300000

DTS has no restrictions on the minimum number of channels.

3535 16PSK (DTS)

20 channels with 1.2 MHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	903.500000	6	909.500000	11	915.500000	16	921.500000
2	904.700000	7	910.700000	12	916.700000	17	922.700000
3	905.900000	8	911.900000	13	917.900000	18	923.900000
4	907.100000	9	913.100000	14	919.100000	19	925.100000
5	908.300000	10	914.300000	15	920.300000	20	926.300000

DTS has no restrictions on the minimum number of channels.

4419 32QAM (DTS)

20 channels and 1.2 MHz channel spacing / bandwidth.

Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)	Ch	Freq (MHz)
1	903.500000	6	909.500000	11	915.500000	16	921.500000
2	904.700000	7	910.700000	12	916.700000	17	922.700000
3	905.900000	8	911.900000	13	917.900000	18	923.900000
4	907.100000	9	913.100000	14	919.100000	19	925.100000
5	908.300000	10	914.300000	15	920.300000	20	926.300000

DTS has no restrictions on the minimum number of channels.

450 MHz Specific Performance Data

450 MHz Throughput Measurements

256 bytes packet size			Frame size [bytes]						
Transmit Rate [kbps]	Channel Size [kHz]	Radio RF Throughput [kbps]	64	128	256	512	1024	1280	1518
	12.5kHz								
76	25	54.3	38.0	40.0	45.1	49.2	49.2	41.0	48.2
59		4.2	30.0	34.7	36.9	32.8	32.8	41.0	24.3
44		36.7	24.0	26.6	28.7	24.6	32.3	20.5	24.3
29		23.7	16.7	18.4	20.5	16.4	16.4	20.5	21.9
18		15.3	10.2	10.2	12.3	8.2	14.3	12.3	7.3
	25 kHz								
57	12.5	41.8	28.0	31.9	32.8	32.8	32.8	20.5	24.3
45		33.6	24.0	26.6	28.7	24.6	16.4	20.5	24.3
34		25.9	18.6	20.5	20.5	16.4	16.4	20.5	24.3
23		20.1	12.3	14.3	16.2	16.4	16.4	16.7	14.2
10		8.0	4.1	4.1	4.1	7.4	6.8	7.2	7.3
1500 bytes packet size			Frame size [bytes]						
	12.5 kHz								
76	25	69.0	48.0	58.0	65.3	65.5	65.3	61.4	48.6
59		53.9	39.9	45.0	49.2	49.2	49.2	41.0	48.6
	25 kHz								
57	12.5	53.0	36.0	44.0	45.1	49.2	49.2	41.0	48.6
45		43.1	27.9	36.0	36.9	41.0	32.8	20.5	24.3

450 MHz Tx Power and Sensitivity

Receive Sensitivities are stated with BER = 10E-4

Regulatory		Capacity (kbps)	Modulation	Ch Size (kHz)	Sensitivity (dBm)	Max Tx (mW)
ETSI						
ETSI		9	BPSK	12.5	-114	2000
		10	MSK	12.5	-118	2000
		17	QPSK	12.5	-110	2000
		26	8PSK	12.5	-105	2000
		35	16QAM	12.5	-101	2000
		44	32QAM	12.5	-98	2000
		52	64QAM	12.5	-95	2000
		16	BPSK	25	-111	2000
		19	MSK	25	-113	2000
		33	QPSK	25	-109	2000
		51	8PSK	25	-104	2000
		68	16QAM	25	-100	2000
		85	32QAM	25	-97	2000
FCC	FCC					
FCC		10	MSK	12.5	-114	8000
		23	QPSK	12.5	-103	8000
		34	8PSK	12.5	-97	8000
		45	16QAM	12.5	-94	8000
		57	32QAM	12.5	-90	8000
		19	MSK	25	-113	8000
		29	QPSK	25	-112	8000
		44	8PSK	25	-107	8000
		59	16QAM	25	-104	8000
		76	32QAM	25	-92	8000

700 MHz Specific Performance Data

700 MHz Throughput Measurements

256 bytes packet size			Frame size [bytes]						
Transmit Rate [kbps]	Channel Size [kHz]	Radio RF Throughput [kbps]	64	128	256	512	1024	1280	1518
	250 KHz								
1008	250	516.7	354.1	398.7	443.6	458.2	472.4	476.2	478.4
806		454.0	309.8	349.0	388.3	400.8	413.9	416.7	419.7
605		373.5	256.4	288.8	321.5	332.2	343.6	345.8	340.0
403		276.9	190.7	214.9	239.0	247.7	252.9	245.8	242.9
194		150.6	103.1	117.8	131.1	136.4	131.1	142.7	144.0
	200 KHz								
800	200	462.8	300.8	338.4	376.1	387.8	400.9	404.1	405.9
640		376.8	250.0	293.5	326.9	337.4	348.8	348.2	349.7
480		310.6	213.6	240.7	267.8	277.0	286.1	286.7	291.6
320		227.8	157.3	176.8	196.6	200.0	212.0	204.8	216.5
152		121.1	80.0	94.9	105.9	106.5	114.7	102.4	97.2
	100 KHz								
400	100	251.0	173.3	195.1	217.5	225.2	229.4	225.3	218.2
320		213.9	147.8	165.0	185.0	191.9	196.6	202.1	194.3
240		170.6	118.1	133.2	148.7	154.4	147.5	161.8	145.7
160		122.2	85.0	95.9	107.1	106.5	114.7	102.4	97.2
76		63.2	43.7	50.0	53.2	57.3	49.2	41.0	48.6
	50 kHz								
175	50	118.3	82.3	93.0	103.6	106.5	98.3	102.4	97.2
137		97.6	67.5	75.0	85.9	89.9	81.9	81.9	72.9
101		75.9	52.5	59.8	65.5	65.5	65.5	61.4	48.6
71		56.9	40.0	45.0	49.2	49.2	49.2	41.0	48.6
39		32.8	23.6	24.6	28.7	24.6	16.4	20.5	24.3
	25 kHz								
87	25	61.1	43.7	48.7	53.2	49.2	49.2	41.0	48.6
70		51.5	36.3	41.4	45.1	41.0	32.8	41.0	48.2
52		40.7	27.5	32.6	32.8	32.8	32.8	20.5	24.3

36		29.2	20.0	22.5	24.6	24.6	16.4	20.5	24.3
19		15.8	10.2	12.3	12.3	8.2	15.2	14.6	10.1
	12.5 kHz								
57	12.5	40.6	28.0	32.4	32.8	32.8	32.8	20.5	24.3
45		33.7	23.9	26.0	28.7	24.6	16.4	20.5	24.3
34		26.1	18.6	22.5	20.5	24.3	16.4	20.5	24.3
23		19.1	12.3	12.3	12.3	16.4	16.4	17.0	14.6
10		8.9	5.1	6.1	4.1	6.7	6.8	7.2	7.3
1500 bytes packet size			**Frame size [bytes]**						
	250 KHz								
1008	250	859.8	421.1	697.8	774.7	818.2	835.9	839.5	850.6
806		706.1	501.8	585.1	642.2	672.4	690.4	694.7	699.5
	200 KHz								
800	200	699.6	501.7	580.8	628.6	662.9	680.1	686.1	690.1
640		572.0	410.6	474.5	446.0	537.4	558.4	562.7	564.2
	100 KHz								
400	100	362.0	260.8	299.3	329.0	345.5	353.6	348.2	361.9
320		290.9	210.9	242.1	266.7	275.0	287.0	286.7	291.5
	50 KHz								
175	50	160.9	116.9	133.8	147.3	147.5	147.5	162.1	145.7
137		126.3	92.5	105.2	111.1	122.9	114.7	122.9	121.4
	25 KHz								
87	25	81.9	32.4	65.0	73.5	73.4	65.6	81.6	72.9
70		64.3	45.2	53.6	57.3	57.3	65.3	61.4	48.6
	12.5 KHz								
57	12.5	52.2	27.4	42.5	41.0	49.2	49.2	41.0	48.6
45		40.6	24.0	32.0	36.9	41.0	32.8	20.5	24.3

700 MHz Tx Power and Receive Sensitivity

Receive Sensitivities are stated with BER = 10E-4

Capacity (kbps)	Modulation	Ch Size (kHz)	Sensitivity (dBm)	Max Tx (mW)
10	MSK	12.5	**-116**	**10000**
23	QPSK	12.5	**-112**	**10000**
34	8PSK	12.5	**-106**	**10000**
45	16QAM	12.5	**-102**	**10000**
57	32QAM	12.5	**-99**	**10000**
19	MSK	25	**-114**	**10000**
36	QPSK	25	**-109**	**10000**
52	8PSK	25	**-103**	**10000**
70	16QAM	25	**-100**	**10000**
87	32QAM	25	**-95**	**10000**
39	MSK	50	**-111**	**10000**
71	QPSK	50	**-105**	**10000**
101	8PSK	50	**-100**	**10000**
137	16QAM	50	**-96**	**10000**
175	32QAM	50	**-92**	**10000**
76	MSK	100	**-108**	**10000**
160	QPSK	100	**-103**	**10000**
240	8PSK	100	**-95**	**10000**
320	16QAM	100	**-93**	**10000**
400	32QAM	100	**-89**	**10000**
153	MSK	200	**-108**	**10000**
320	QPSK	200	**-101**	**10000**
480	8PSK	200	**-94**	**10000**
640	16QAM	200	**-91**	**10000**
800	32QAM	200	**-87**	**10000**
194	MSK	250	**-107**	**10000**
403	QPSK	250	**-101**	**10000**
605	8PSK	250	**-94**	**10000**
806	16QAM	250	**-91**	**10000**
1008	32QAM	250	**-86**	**10000**

220 MHz Specific Performance Data

220 MHz Throughput Measurements

256 bytes packet size			Frame size [bytes]						
Transmit Rate [kbps]	Channel Size [kHz]	Radio RF Throughput [kbps]	64	128	256	512	1024	1280	1518
1374	500	556.4	389.2	452.2	507.0	511.5	511.3	513.6	516.4
1145		564.3	385.1	435.3	479.2	495.1	509.5	518.2	520.4
916		496.0	339.6	382.5	425.6	439.3	452.2	456.2	460.0
687		412.2	283.0	318.3	354.6	366.1	378.1	381.3	383.1
458		308.1	211.9	238.6	265.9	274.9	284.9	287.3	288.1
229		175.9	121.3	136.8	152.0	128.0	163.6	163.8	145.7
1209	250	537.7	368.0	416.8	461.5	471.7	479.5	482.3	487.6
1008		517.6	354.5	399.0	443.7	457.4	471.8	447.7	475.6
806		451.9	310.1	349.0	388.5	401.2	413.8	417.4	419.9
605		374.0	256.4	288.8	321.7	332.1	343.0	346.3	320.1
403		277.4	128.0	215.0	239.0	247.9	256.7	245.8	242.5
194		150.9	104.0	118.0	131.7	136.8	131.1	142.7	121.4
960	200	481.1	331.1	373.6	416.8	428.8	440.2	383.7	446.4
800		438.1	300.3	338.1	376.4	388.5	401.2	404.3	406.8
640		379.5	258.0	288.0	326.7	337.3	348.9	351.8	352.1
480		310.6	213.5	240.4	267.8	276.4	286.6	290.0	295.6
320		227.7	155.5	176.7	197.2	204.4	211.9	204.8	216.9
153		121.7	83.7	94.0	106.0	106.5	114.7	102.4	97.2
480	100	284.6	194.7	220.2	244.6	251.9	260.3	264.0	266.4
400		251.7	173.5	194.8	217.1	224.8	229.4	225.3	218.6
320		213.8	147.3	159.3	185.1	192.1	196.4	184.3	194.3
240		170.7	117.7	133.0	148.0	154.7	147.5	143.4	145.7
160		122.2	84.0	95.5	104.0	106.5	114.7	102.4	97.2
76		63.8	44.0	50.0	53.2	57.3	49.2	41.0	48.6
180	50	123.9	86.0	97.1	107.7	106.5	114.7	102.4	97.2
146		101.1	70.0	79.5	88.0	90.1	81.9	81.9	96.4
144		104.0	72.0	81.5	91.4	90.1	98.3	81.9	97.2
117		84.7	59.5	66.0	75.0	73.7	65.5	61.4	72.9

105		79.4	56.7	62.0	70.0	65.5	65.5	61.4	72.9
88		66.3	46.0	52.0	36.9	57.3	49.2	61.4	48.6
72		57.5	40.0	45.8	49.2	49.2	49.2	41.0	48.6
59		47.1	32.0	36.5	41.0	41.0	32.8	41.0	24.3
43		36.3	26.0	28.7	32.5	32.8	32.8	20.5	24.3
36		29.9	22.0	22.5	24.6	24.6	16.4	20.5	24.3
76	25	54.1	38.0	40.0	22.0	49.2	49.2	41.0	48.6
59		44.0	30.0	34.9	36.9	32.8	32.8	41.0	24.3
44		34.5	24.0	25.9	28.7	24.6	16.4	20.5	24.3
29		26.5	16.7	18.3	20.5	16.4	16.4	20.5	21.9
18		15.1	10.2	10.2	12.3	8.2	13.6	14.0	13.8
47	15	33.1	24.0	24.5	28.7	24.6	16.4	20.5	24.3
37		28.4	16.5	20.5	24.5	24.6	16.4	20.5	24.3
28		22.0	11.3	16.4	16.4	16.4	16.4	19.8	20.2
19		15.1	9.2	10.2	12.3	8.2	13.4	14.3	13.8
9		7.5	4.1	4.1	4.1	6.1	6.6	6.8	6.6
45	12.5	32.7	16.4	24.6	28.6	24.6	16.3	20.5	24.3
36		27.1	18.7	20.5	20.5	16.4	16.4	20.5	24.3
26		20.0	14.3	16.4	16.4	16.4	16.4	18.7	19.1
17		16.2	9.2	10.2	8.2	8.2	12.6	12.9	12.9
10		11.9	4.1	4.1	4.1	7.4	7.4	6.8	7.3
1500 bytes packet size			Frame size [bytes]						
1374	500	852.7	340.8	552.3	623.5	705.7	769.1	779.6	765.3
1145		975.7	397.0	806.6	880.4	895.9	943.0	949.9	953.7
916		799.1	427.8	664.2	719.9	656.7	768.1	781.1	681.1
1209	250	747.9	345.2	512.6	603.4	641.3	664.6	686.4	682.0
1008		867.4	404.1	676.7	782.1	820.6	840.1	846.6	850.3
806		710.5	443.2	588.9	573.5	671.1	688.0	693.4	698.0
960	200	759.2	405.5	581.4	651.1	678.8	707.2	722.5	711.6
800		699.4	451.9	580.1	632.5	662.2	681.7	685.6	688.9
640		572.5	410.5	473.6	517.6	541.1	558.4	561.4	563.5
480	100	398.7	266.9	302.5	332.0	364.5	378.0	371.9	368.2
400		363.9	258.9	300.9	327.4	345.5	351.7	349.3	361.2
320		251.7	211.0	235.8	263.8	279.3	282.0	287.9	295.2
180	50	166.3	119.9	136.0	144.0	159.9	163.3	163.1	145.7
146		137.0	98.0	96.0	123.9	130.0	131.1	122.9	121.4

144		134.0	96.0	96.0	119.9	122.9	130.8	122.9	121.4
117		110.0	79.6	88.0	95.7	106.4	98.3	102.4	97.2
76	25	70.6	48.0	60.0	64.0	65.2	65.5	61.4	48.6
59		50.5	31.8	43.0	45.1	49.2	49.2	41.0	48.6
47	15	41.8	14.0	36.4	36.9	40.8	32.8	41.0	24.3
37			24.0	28.7	20.5	32.8	32.8	20.5	24.3
45	12.5	41.3	25.9	30.9	32.8	41.0	32.8	20.5	24.3
36			16.2	26.6	24.6	24.6	32.8	20.5	23.9

220 MHz Tx Power and Receive Sensitivity

Receive Sensitivities are stated with BER = 10E-4

FCC Part 90 217 - 220 MHz			
Modulation	**Ch Size (kHz)**	**Sensitivity (dBm)**	**Max Power**
10 MSK	12.5	-117	2000
17 QPSK	12.5	-112	5000
26 8PSK	12.5	-106	5000
36 16QAM	12.5	-103	5000
45 32QAM	12.5	-100	5000
18 MSK	25	-115	2000
29 QPSK	25	-111	5000
44 8PSK	25	-105	5000
59 16QAM	25	-101	5000
76 32QAM	25	-97	5000
43 MSK	50	-108	2000
72 QPSK	50	-108	5000
105 8PSK	50	-101	5000
144 16QAM	50	-98	5000
180 32QAM	50	-94	5000

FCC Part 90 220 - 222 MHz			
Modulation	**Ch Size (kHz)**	**Sensitivity (dBm)**	**Max Power**
9 MSK	15	-116	2000
19 QPSK	15	-104	5000
28 8PSK	15	-98	5000
37 16QAM	15	-95	5000
47 32QAM	15	-91	5000
36 MSK	50	-107	2000
59 QPSK	50	-104	5000
88 8PSK	50	-98	5000
117 16QAM	50	-92	5000
146 32QAM	50	-89	5000

FCC Part 80 217 - 218, 219 - 220 MHz			
Modulation	**Ch Size (kHz)**	**Sensitivity (dBm)**	**Max Power**
76 MSK	100	-106	2000
160 QPSK	100	-106	2000
240 8PSK	100	-95	2000
320 16QAM	100	-96	2000
400 32QAM	100	-91	2000
153 MSK	200	-109	2000
320 QPSK	200	-103	2000
480 8PSK	200	-93	2000
640 16QAM	200	-93	2000
800 32QAM	200	-88	2000
194 MSK	250	-107	2000

Chapter 4: Tasks and Best Practices

This section contains information on the following topics:

- Accessing the User Interface
- Configure communications between the Access Point and End Point
- Configure PTP, PMP networks

Additional sections include information on how to:

- Obtain IP Addresses
- Configure RF Settings
- Configure Network Settings
- Configure VIAN Settings

Obtaining an Unknown IP Address

The IP address of the radio can be changed by the user at any time. It is also possible to assign different IP addresses to each interface; Eth1, Eth2, Radio1, Radio2 when using layer 3 routing. If the IP address of the radio is unknown, the CLI can be used to either discover the IP or default the radio back to the factory default IP address and configuration.

Attention

Defaulting the radio via the CLI will also default the radio RF and radio network settings, which will bring down any active RF connections.

If your computer is on the same subnet as the default radio IP address and communications cannot be established, it's possible the IP address of the radio has changed. This is a common situation with previously used radios.

Note

It's good practice to apply some light colored electrical tape to the underside of the radio to track any IP address changes with a marker. You never know when you'll appreciate the time saved when needing to set up a radio in a rush!

Use the following equipment to obtain the IP address you need:

- Serial to USB cable
- Standard CAT5 Ethernet cable
- cnReach N500 DB-9 to RJ-45 adapter

Connect the Serial to USB cable to the computer and install the drivers per the manufacturer instructions (unless the Operating System recognizes the device).

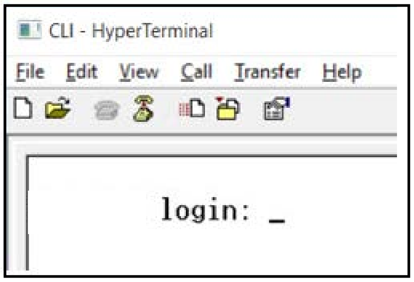
1. Note the COM Port number allocated to the device by the operating system.
2. Connect the RJ-45 to DB9 adapter to the DB9 Serial port on the Serial to USB cable.
3. Plug the CAT5 Ethernet cable into the RJ-45 to DB9 adapter.
4. **Look at the SERIAL ports on the Enclosed radio**. The SERIAL port that has the **blinking Orange LED** is the CLI port. Plug in the Cat5 Ethernet cable.

Attention

cnReach N500 radios use RJ-45 connectors for both Serial and Ethernet ports. This means it is possible to plug an Ethernet cable into a Serial port and vice versa.

1. Open a terminal emulator such as Teraterm, PuTTY or HyperTerminal and connect to the PC's **COM Port** at 115200 8N1.

2. Hit Enter. You will be prompted to log in. UserName: **admin**



1. Type show ifconfig. The default Interface configuration (bridge) lists an IP address for VLAN1 only.

```
> show ifconfig
eth0      Link encap:Ethernet  HWaddr 70:F1:E5:00:00:00
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:78331 errors:0 dropped:0 overruns:0 frame:0
          TX packets:54504 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:6290948 (5.9 MiB)  TX bytes:5780242 (5.5 MiB)

eth1      Link encap:Ethernet  HWaddr 70:F1:E5:01:5C:D1
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

eth1.1    Link encap:Ethernet  HWaddr 70:F1:E5:01:5C:D1
          UP BROADCAST PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

eth2      Link encap:Ethernet  HWaddr 70:F1:E5:01:5C:D1
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:78331 errors:0 dropped:0 overruns:0 frame:0
          TX packets:54504 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:4802659 (4.5 MiB)  TX bytes:5687626 (5.4 MiB)

eth2.1    Link encap:Ethernet  HWaddr 70:F1:E5:01:5C:D1
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:78309 errors:0 dropped:0 overruns:0 frame:0
          TX packets:54503 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:4801633 (4.5 MiB)  TX bytes:5687584 (5.4 MiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:179 errors:0 dropped:0 overruns:0 frame:0
          TX packets:179 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:1023108 (999.1 KiB)  TX bytes:1023108 (999.1 KiB)

rad1      Link encap:Ethernet  HWaddr 70:F1:E5:01:3A:F2
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:86289 errors:0 dropped:0 overruns:0 frame:0
          TX packets:110240 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:500
          RX bytes:7909518 (7.5 MiB)  TX bytes:8173919 (7.7 MiB)

rad1.1    Link encap:Ethernet  HWaddr 70:F1:E5:01:3A:F2
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:86289 errors:0 dropped:0 overruns:0 frame:0
          TX packets:110240 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:6701472 (6.3 MiB)  TX bytes:8173919 (7.7 MiB)

vlan1     Link encap:Ethernet  HWaddr 70:F1:E5:01:3A:F2
          inet addr:192.168.0.3  Bcast:192.168.0.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:116234 errors:0 dropped:0 overruns:0 frame:0
          TX packets:82339 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:8000170 (7.6 MiB)  TX bytes:6196725 (5.9 MiB)
```

1. If the radio configuration is **routed**, it is possible for each interface to have a unique IP address. This time, **show ifconfig** will return the IP address of each physical interface.

2. The User Interface can be accessed at either the Eth1/Eth2 interface IP via a direct connection to that interface.

Note

The Laptop/PC should be given a fixed IP address on the same subnet as the connected interface in order to establish Ethernet communications.

```
> show ifconfig
eth0      Link encap:Ethernet  HWaddr 70:F1:E5:00:00:00
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:79710 errors:0 dropped:0 overruns:0 frame:0
          TX packets:55566 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:6418040 (6.1 MiB)  TX bytes:5891577 (5.6 MiB)

eth1      Link encap:Ethernet  HWaddr 70:F1:E5:01:5C:D1
          inet addr:192.168.1.3  Bcast:192.168.1.255  Mask:255.255.255.0
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

eth2      Link encap:Ethernet  HWaddr 70:F1:E5:01:5C:D1
          inet addr:192.168.2.3  Bcast:192.168.2.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:79710 errors:0 dropped:62 overruns:0 frame:0
          TX packets:55566 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:4903550 (4.6 MiB)  TX bytes:5797191 (5.5 MiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:200 errors:0 dropped:0 overruns:0 frame:0
          TX packets:200 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:1145456 (1.0 MiB)  TX bytes:1145456 (1.0 MiB)

rad1      Link encap:Ethernet  HWaddr 70:F1:E5:01:3A:F2
          inet addr:10.10.10.1  Bcast:10.10.10.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:87269 errors:0 dropped:17 overruns:0 frame:0
          TX packets:111408 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:500
```

Optimizing Radio Settings

Modulation

- Lower modulations will have slower speeds, but offer better sensitivity. This equates to longer links with better ability to propagate through clutter.
- In the case of cnReach, lower modulations also have smaller channel bandwidths, which gives them higher noise immunity. This is because the narrow band has less chance of a bit becoming corrupted. One corrupted bit causes the whole packet to be thrown out unless FEC is enabled.
- Higher modulations will have faster speeds, but with lower sensitivities they will be restricted to shorter links.
- Higher modulations are more susceptible to noise as they have a larger bandwidth, although using small packet sizes allows them to get on and off channels a lot faster than slower modulations reducing the chance of noise affecting the signal in the time domain.

Payload Bytes

- cnReach N500 radio packet sizes can be set from 64 bytes to 1600 bytes.
- Smaller packet sizes will lead to lower throughput. This happens because each packet regardless of size has the same amount of overhead such as network address.
- Larger packet sizes will offer better throughput from less overall overhead.
- Larger packet sizes are more susceptible to noise. This happens due to the fact that they are modulated for a longer period of time which can result in corrupted bits.
- Dynamic allows the End Point to use as much as 512 bytes of an unused Access Point time slot. Dynamic does not work with multispeed or MMS. Ideal packet size settings are 512 and 512 when using dynamic.
- In PMP networks with multiple modulations selected ALWAYS confirm that the max payload size is greater than the min max payload size of the tables in chapter 3.

Transmit Power

- Never use 100 mW or greater with positive dB gain antennas in close proximity. This will cause dropped data, and can possibly damage the receiver.
- We recommend using 100 mW transmit power with a 20 dB attenuator for bench testing. When doing indoor tests use no more than 100mW, especially if there is no attenuation. If you have attenuation, tune the link to the proper receiver level mentioned below.
- RSSI levels should be between -40dBm to -80dBm depending on modulation.

Best Settings for Speed and Throughput

Speed and Throughput

32QAM or 16QAM with 1600 byte packet sizes (Only if power levels are tuned; QAM is very sensitive to high RSSI levels above -40dBm.). 8PSK with 1600 byte packet sizes.

Reliable Modulation with High Sensitivity and Speed

QPSK with 512 byte packet sizes.

Turn dynamic on to increase throughput.

High Sensitivity with High Noise Immunity

MSK with 256 byte packet sizes.

Creating a Simple Point-to-Point Link

Identical Radio Settings

These radio settings should be made identical between an Access Point and End Point:

Radio/RF Settings

- AP & EP Tx Freq
- Channel Size
- Transmit Rate

Radio/Network Settings

- Network Type: PTP
- Network Address
- Network Radius
- Max Payload Bytes: Access Point & End Point
- Dynamic: can be used unless Max Payload Bytes is 1600/1600

VLANS

Set both radios as follows:

VLAN Id	Description	Delete
1	vlan 1	Delete

Interface Settings

Access Point

Set the Access Point as follows:

Interface	Mode	Description	IP address	IP Mask	MAC Address	PVID	Allowed VLANs	VLAN port tagging	Bounce	Speed/Duplex	DHCP
eth1	bridged	port 1			70F1E5018D11	1	1	None		auto	
eth2	bridged	port 2			70F1E5018D11	1	1	None		auto	
rad1	bridged	radio 1			70F1E5019071	1	1	All	...		
vlan1	routed	vlan 1	192.168.0.1	255.255.255.0	70F1E5019071						

Default IP Gateway	none

End Point

Set the End Point as follows:

Interface	Mode	Description	IP address	IP Mask	MAC Address	PVID	Allowed VLANs	VLAN port tagging	Bounce	Speed/Duplex	DHCP
eth1	bridged	port 1			70F1E5018D11	1	1	None		auto	☐
eth2	bridged	port 2			70F1E5018D11	1	1	None		auto	☐
rad1	bridged	radio 1			70F1E5019071	1	1	All	...		☐
vlan1	routed	vlan 1	192.168.0.2	255.255.255.0	70F1E5019071						☐

Default IP Gateway	none

Static Routes

Both radios should have no static routes configured.

Network Id	Network Mask	Gateway IP	Delete

Radio

The Radio Menu is where you will configure the RF Module parameters, which define how the radios will communicate.

RF Settings

Set both radios as follows (frequencies, modulations and channel size will depend on link design.

AP Tx Freq	757.50000 MHz
EP Tx Freq	757.00000 MHz
Transmit Power	100 mW
Channel Size	250 kHz
Transmit Rates	☐ 194 kbps MSK 250 kHz ☑ 403 kbps QPSK 250 kHz ☑ 605 kbps 8PSK 250 kHz ☑ 806 kbps 16QAM 250 kHz ☑ 1008 kbps 32QAM 250 kHz
AP Transmit Rate (multispeed multipoint)	QPSK-403 kbps 250 k
Error Correction	◉ None ○ Low ○ High
Serial Number:	E5019774
Firmware Version:	1.40.10070

Attention

When lab/bench testing with the optional 0dBi test antenna, it is recommended to install 20dB coaxial attenuators and adjust the transmit power to 100 mW.

80dB of fixed attenuation is CRITICAL when CABLING radios together with test coax. This is to prevent permanent damage to the radio's front-end when exposed to extreme RSSI levels.

RSSI should be below -40dBm.

Cambium Networks tests the front-end for damage during the RMA process. Extreme RSSI resulting from improper use that causes subsequent damage is considered outside of warranty coverage.

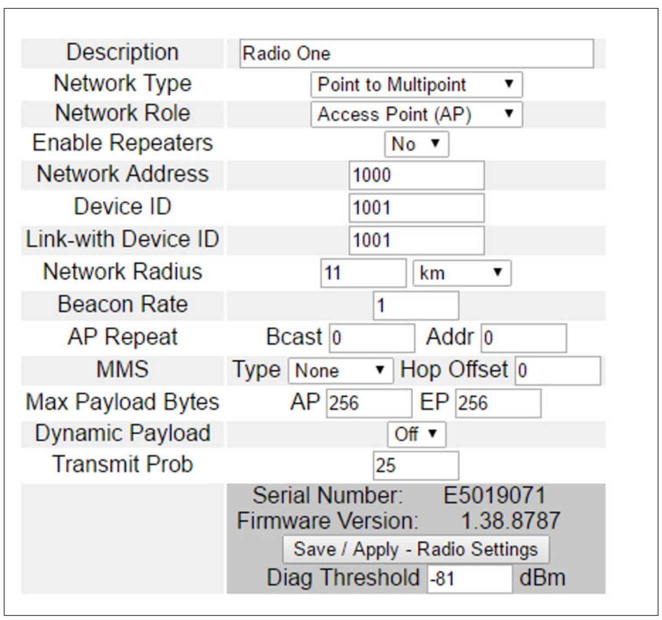
Using a paper clip instead of a proper antenna may damage the TNC connector, which may adversely impact performance when deployed.

Cambium Networks inspects the TNC connector during the RMA process. Improper use that causes subsequent damage is considered outside of warranty coverage.

Network Settings

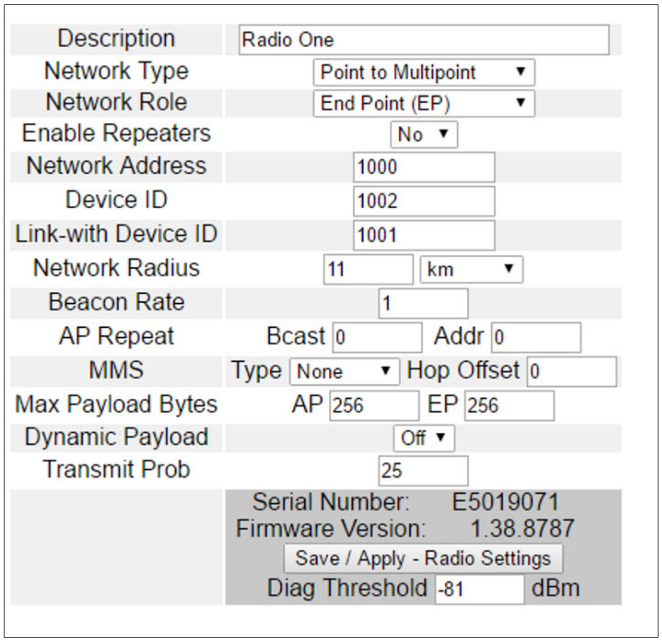
Access Point

Set the Access Point as follows:



End Point

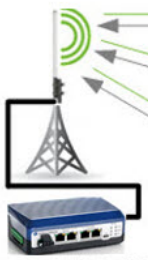
Set the End Point as follows:



Note: At this point, the radios will link up and pass data.

Setting up a Simple PMP Network

A PMP Network consists of 1 x Access Point radio and several End Point radios. The link table in the following diagram contains the settings required to set up the network.



PTMP Network	Access Point	End Point(s)
AP Tx Freq (MHz)	757.50000	757.50000
Ep Tx Freq (MHz)	787.50000	787.50000
Transmit Power	50mW	50mW
Channel Size	250kHz	250kHz
AP Transmit Rate	403 QPSK	403 QPSK
EP Transmit Rates	403 QPSK	403 QPSK
	605 8PSK	605 8PSK
	806 16QAM	806 16QAM
	1008 32QAM	1008 32QAM
Network Type	PTMP	PTMP
Network Role	Access Point	End Point
Enable Repeaters	No	No
Network Address	1000	1000
Device ID	1001	1002, 1003, 1004
Link with Device ID	N/A	1001
Network Radius (km)	11	11
Beacon Rate	1	N/A
AP Repeat (B'Cast)	0	N/A
AP Repeat (Addr)	0	N/A
MMS	None	None
Hop Offset	0	0
Max Payload Bytes	256/256	256/256
Dynamic	Off	Off
Transmit Prob	N/A	N/A

Identical Radio Settings

These radio settings should be made identical between an Access Point and End Point:

Radio/RF Settings

- AP & EP Tx Freq
- Channel Size
- Transmit Rate

Radio/Network Settings

- Network Type; PMP
- Network Address
- Network Radius
- Max Payload Bytes; Access Point & End Point
- Dynamic; can be used unless Max Payload Bytes is 1600/1600

Unique Radio Settings

These radio settings should be unique to each radio.

Radio/Network Settings

- Device ID
- Network Role: Access Point or End Point.
- Link with Device ID:
    - End Points, this should be the Access Point Device ID
    - Access Point, this is non-applicable and can be set to the Access Point Device ID

Notes for Bench Testing

Note

- Transmit power should be set so that RSSI levels are between -40dBm and -80dBm.
- For a bench test, this usually means setting the Transmit Power to 100 mW and adding 20dB of inline attenuation and test antennas with both radios set about 3ft apart.
- If a radio port is not being used, set it as EP with a network ID not currently in use. This will place that radio module in listen-only mode.
- Radios need to be separated by at least 10 feet to achieve good performance.
- Tx Power needs to be at least 100mw for QAM modulation to work.
- RSSI should be lower than -60dBm to avoid overheating.

Attention

When lab/bench testing with the optional 0dBi test antenna, it is recommended to install 20dB coaxial attenuators and adjust the transmit power to 100 mW.

80dB of fixed attenuation is CRITICAL when CABLING radios together with test coax. This is to prevent permanent damage to the radio's front-end when exposed to extreme RSSI levels.

RSSI should be below -40dBm.

Cambium Networks tests the front-end for damage during the RMA process. Extreme RSSI resulting from improper use that causes subsequent damage is considered outside of warranty coverage.

Using a paper clip instead of a proper antenna may damage the TNC connector, which may adversely impact performance when deployed.

Cambium Networks inspects the TNC connector during the RMA process. Improper use that causes subsequent damage is considered outside of warranty coverage.

Using the Status LEDs for Diagnostics

LINK/PWR - Access Point: green at all times. End Point: green indicates the link is up, red indicates the link is down. Intermittent flickering red indicates a mismatch in RF Transmission Settings between Access Point and End Point and the likelihood that traffic is not moving. Verify Access Point and End Point RF Transmission settings to ensure Frequency and MMS parameters match.

XMIT/TX - Lights up red when transmitting data; bright for large packets with almost continuous transmission; dim for small packets in quick succession; off for not transmitting at all.

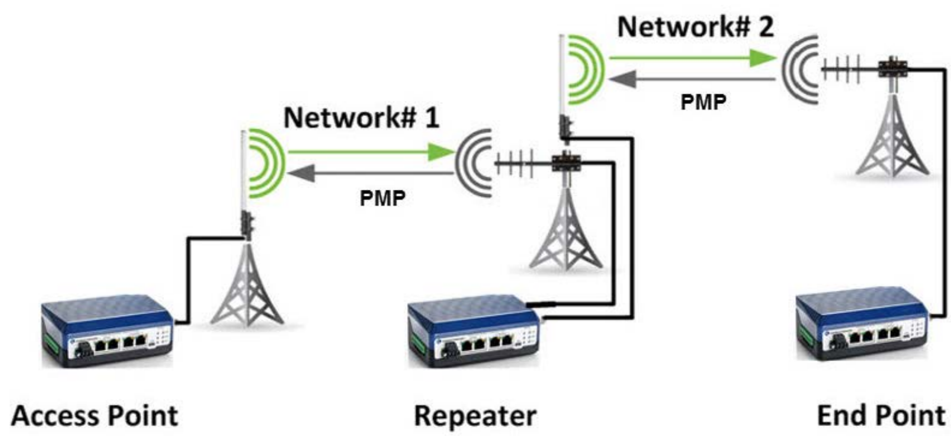
RCV/RX - Lights up green when receiving data; bright for large packets with almost continuous reception; dim for small packets in quick succession; off for not receiving at all.

If the RCV/RX LED is excessively flickering on a live network that's passing data, the link may be marginal; Check the Radio Diagnostics page for signal and noise levels.

Note
Increasing the Beacon Period on the Access Point slows down the RCV/RX LED blinking rate on the End Point when the link is idle; i.e. not passing traffic.

Setting up a Back-to-Back Repeater

The cnReach N500 dual radio modules provide a dual RF Module Repeater solution in a single enclosure.



All radios in the System can use the same **AP Tx** and **EP Tx** frequencies providing MMS is;

- Set to "Generate" on all radios except for Dual Radio Repeater Access Point.
- Set to "External" on the Repeater Access Point (Radio2: Access Point).

End Points can be connected to the Access Point or the cnReach N500 Dual Radio Repeater in two PMP Networks.

Each PMP Network should have its own Network ID and each RF Module should have a unique Device ID.

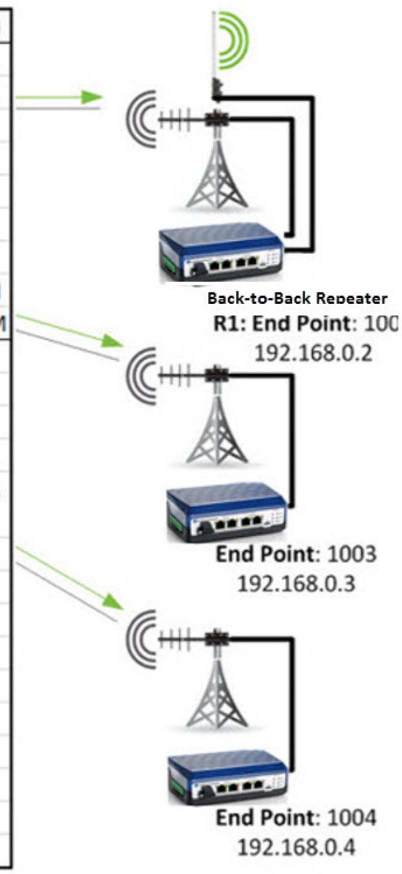
Note

The system limitation is for a single cnReach N500 700 MHz dual radio when only two licensed frequencies are used. Increasing the number of available frequencies allows more repeaters to be used within the system.

Configure PMP Network #1

The link table in the following diagram contains the settings required to set up a Point-to-MultiPoint network (Network #1).

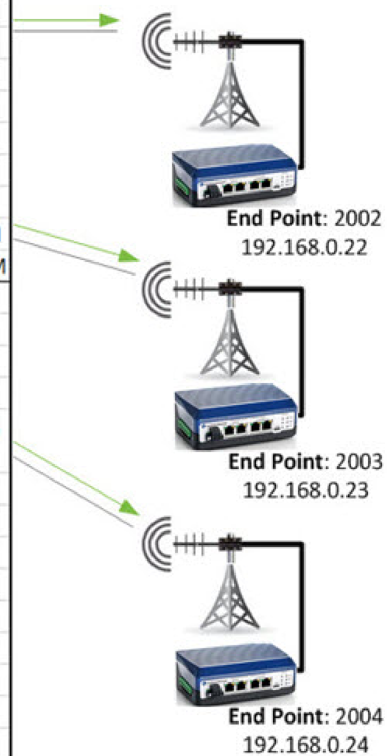
PMP Network #1	Access Point	End Point(s)
AP Tx Freq (MHz)	757.50000	757.50000
Ep Tx Freq (MHz)	787.50000	787.50000
Transmit Power	50mW	50mW
Channel Size	250kHz	250kHz
AP Transmit Rate	403 QPSK	403 QPSK
EP Transmit Rates	403 QPSK	403 QPSK
	605 8PSK	605 8PSK
	806 16QAM	806 16QAM
	1008 32QAM	1008 32QAM
Network Type	PTMP	PTMP
Network Role	Access Point	End Point
Enable Repeaters	No	No
Network Address	1000	1000
Device ID	1001	1002, 1003, 1004
Link with Device ID	N/A	1001
Network Radius (km)	11	11
Beacon Rate	1	N/A
AP Repeat (B'Cast)	0	N/A
AP Repeat (Addr)	0	N/A
MMS	Generate	Generate
Hop Offset	0	0
Max Payload Bytes	256/256	256/256
Dynamic	Off	Off
Transmit Prob	N/A	N/A



Configure PMP Network #2

The link table in the following diagram contains the settings required to set up a Point-to-MultiPoint network (Network #2).

PTMP Network #1	Access Point	End Point(s)
AP Tx Freq (MHz)	757.50000	757.50000
Ep Tx Freq (MHz)	787.50000	787.50000
Transmit Power	50mW	50mW
Channel Size	250kHz	250kHz
AP Transmit Rate	403 QPSK	403 QPSK
EP Transmit Rates	403 QPSK	403 QPSK
	605 8PSK	605 8PSK
	806 16QAM	806 16QAM
	1008 32QAM	1008 32QAM
Network Type	PTMP	PTMP
Network Role	Access Point	End Point
Enable Repeaters	No	No
Network Address	2000	2000
Device ID	2001	2002, 2003, 2004
Link with Device ID	N/A	2001
Network Radius (km)	11	11
Beacon Rate	1	N/A
AP Repeat (B'Cast)	0	N/A
AP Repeat (Addr)	3	N/A
MMS	External	Generate
Hop Offset	0	0
Max Payload Bytes	256/256	256/256
Dynamic	Off	Off
Transmit Prob	N/A	N/A



Setting Up Static Routes

Static Routing provides the capability to reduce Broadcast Traffic from on the RF links by creating multiple, smaller broadcast domains.

Static Routing requires each Ethernet and radio interface to be on a separate subnet;

Interface	Mode	Description	IP address	IP Mask	MAC Address	PVID	Allowed VLANs	VLAN port tagging	Bounce	Speed/Duplex	DHCP
eth1	routed	port 1	192.168.0.3	255.255.255.0	70F1E5019550					auto	☐
eth2	routed	port 2	192.168.11.3	255.255.255.0	70F1E5019550					auto	☐
rad1	routed	radio 1	10.10.10.1	255.255.255.0	70F1E5019774						☐
vlan1	routed	vlan 1	192.168.0.3	255.255.255.0	70F1E5019774						☐

Default IP Gateway	none

Note

Static Routing occurs at Layer 3 (of the OSI Model) and is completely independent of RF.

Attention

Cambium Networks recommends verifying systemwide RF configuration and link performance prior to configuring static routes.

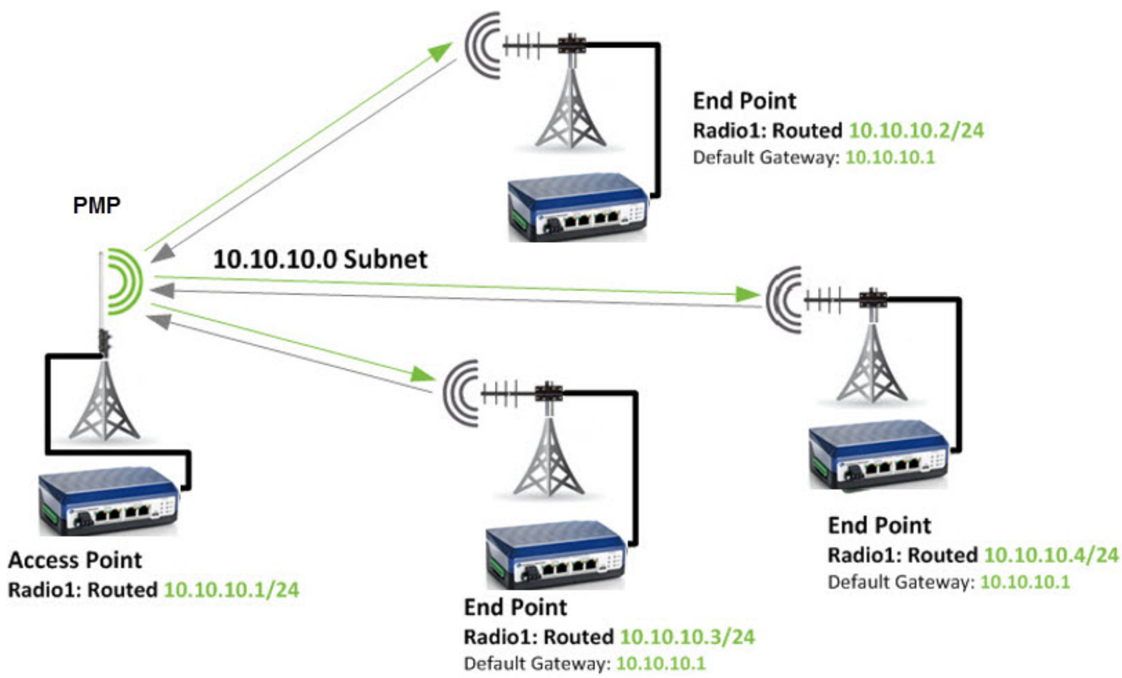
Radios that are required to communicate in a routed network must:

- Be connected in a PMP network or PTP Link.
- Be grouped in the same IP subnet; 10.10.10.0 (i.e. 10.10.10.1, 10.10.10.2 etc).

Radio Subnet

The radio subnet is the IP subnet containing all radios that are required to communicate at the Ethernet level. Radios must be able to communicate at the radio level before they will communicate at the Ethernet level.

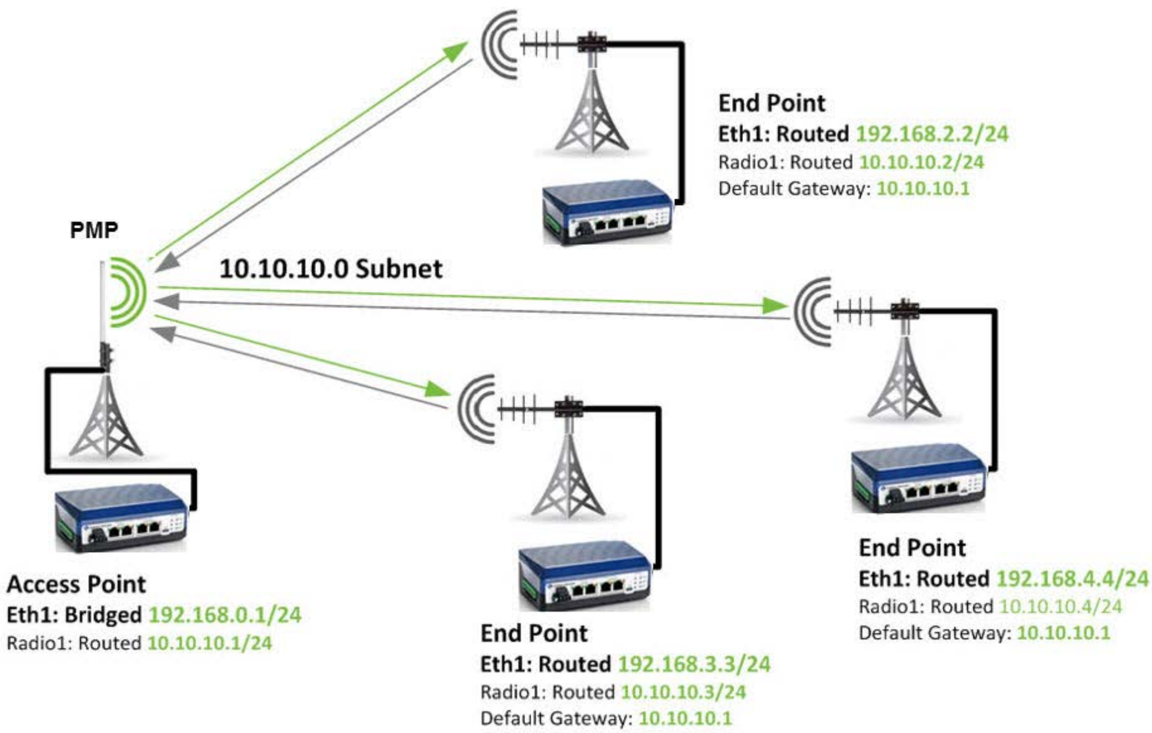
The default radio subnet is 10.10.10.0, so individual RF Modules can be assigned independent IP addresses on this subnet; i.e. 10.10.10.1, 10.10.10.2, 10.10.10.3 etc.



Ethernet Port Subnets

End Point Ethernet ports where communication is required should be placed on a unique subnet.

> **Note**
> Ethernet ports that do not require communication can be left as **Bridge**.



Gateways

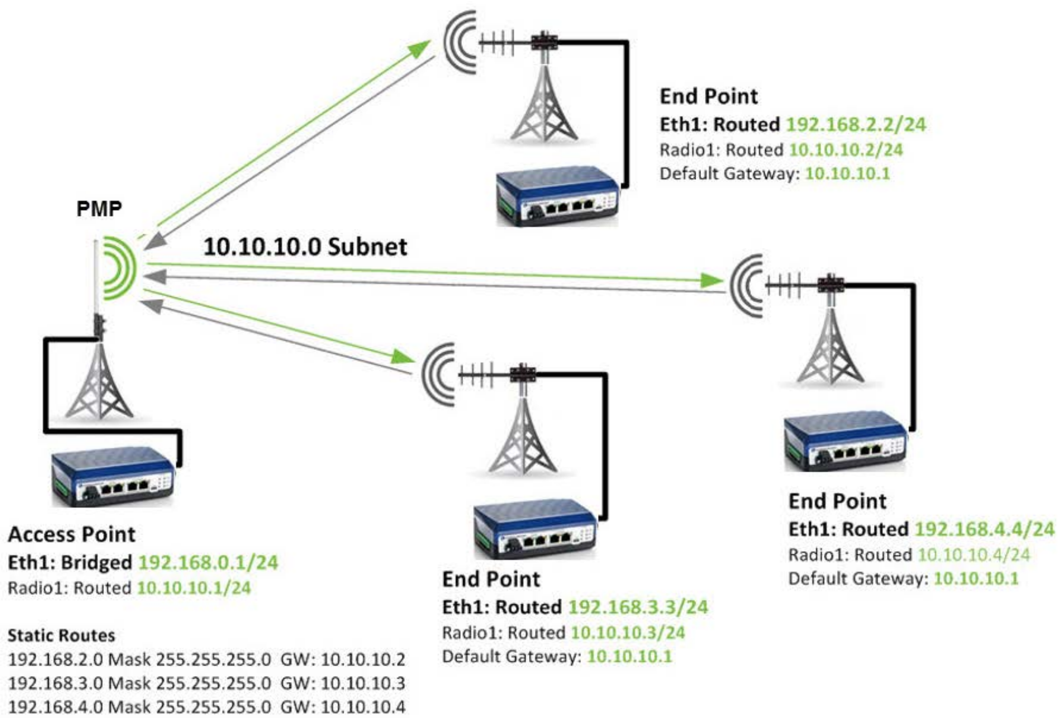
The **Default Gateway** is the IP address of the upstream interface.

- Devices connected to an Ethernet interface would use the IP address of that Interface as the Default Gateway.
- Radios in a PMP network would use the IP address of the **AP** Radio Module.

When configuring Static Routes, the **Gateway IP** is the IP address of the downstream interface where the routed data should be sent.

Adding Static Routes to the Radios

Static Routes should be added to the Access Point and any cnReach N500 Dual Radio Repeaters that may be present in the system.



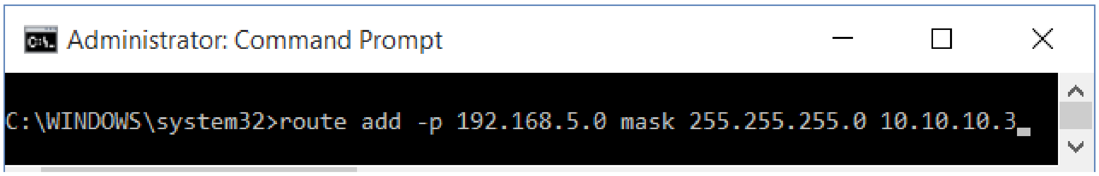
The following table shows the static routes and downstream gateways for the Access Point in the above diagram:

Network Id	Network Mask	Gateway IP	Delete
192.168.2.0	255.255.255.0	10.10.10.2	Delete
192.168.3.0	255.255.255.0	10.10.10.3	Delete
192.168.4.0	255.255.255.0	10.10.10.4	Delete

Adding Routes to a Host

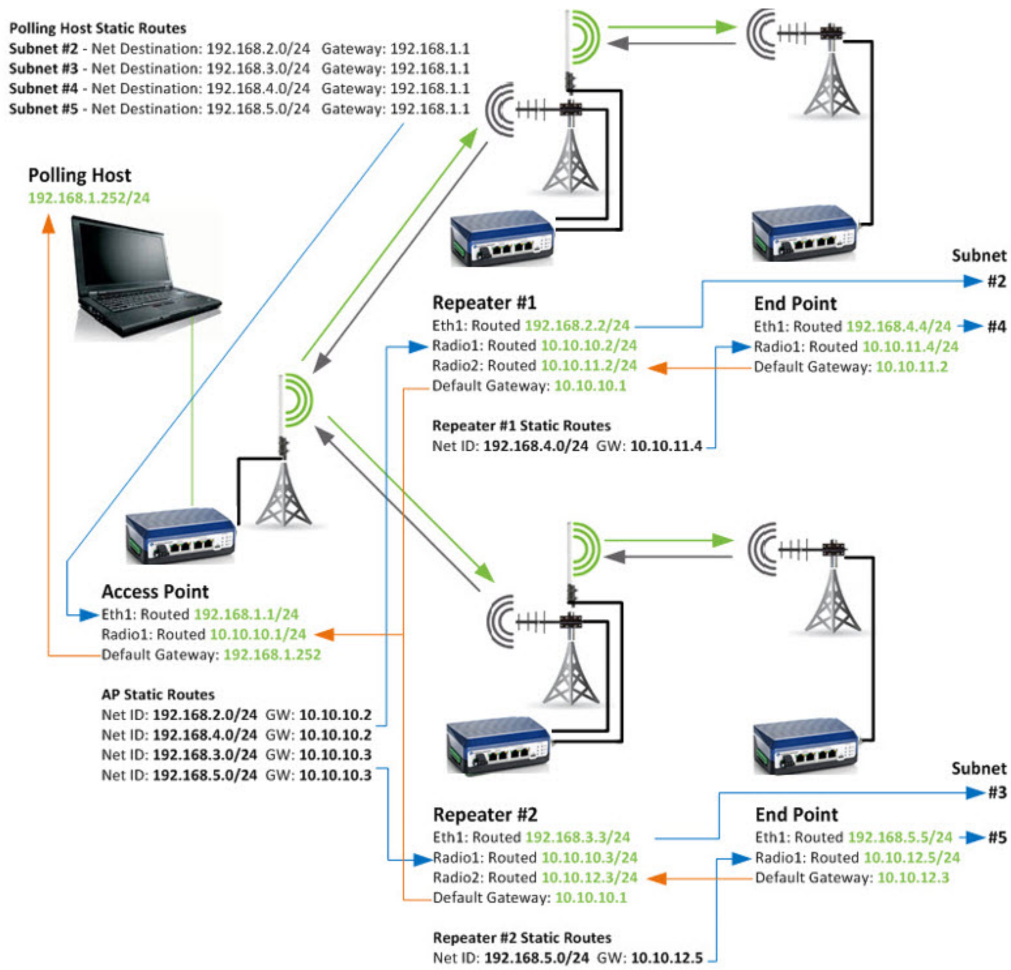
Static Routes should be configured in any host that is connected to the Access Point. This can be done from Command Prompt Window (open as Administrator) and entering each route in the following format:

route add –p <Subnet IP> mask 255.255.255.0 <Gateway IP>



Static Routing Example

The following is an example of deploying static routes in the Access Points.



The Static Routes in the above example would be configured as follows:

Polling Host

Administrator: Command Prompt

```
Network Destination        Netmask          Gateway       Interface  Metric
        192.168.2.0    255.255.255.0      192.168.1.1    192.168.1.252     21
        192.168.3.0    255.255.255.0      192.168.1.1    192.168.1.252     21
        192.168.4.0    255.255.255.0      192.168.1.1    192.168.1.252     21
        192.168.5.0    255.255.255.0      192.168.1.1    192.168.1.252     21
===========================================================================
```

Access Point

Network Id	Network Mask	Gateway IP	Delete
192.168.2.0	255.255.255.0	10.10.10.2	Delete
192.168.3.0	255.255.255.0	10.10.10.3	Delete
192.168.4.0	255.255.255.0	10.10.10.2	Delete
192.168.5.0	255.255.255.0	10.10.10.3	Delete

Repeater #1

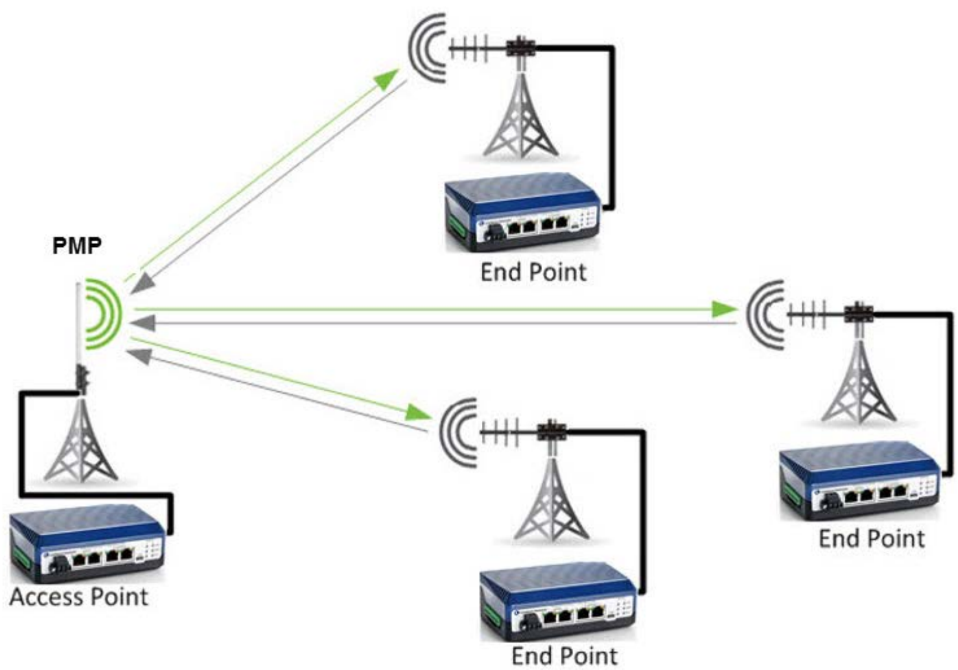
Network Id	Network Mask	Gateway IP	Delete
192.168.4.0	255.255.255.0	10.10.11.4	Delete

Repeater #2

Network Id	Network Mask	Gateway IP	Delete
192.168.5.0	255.255.255.0	10.10.12.5	Delete

Optimizing Receive Levels (RSSI)

As previously discussed in this guide, RF is more problematic at higher RSSI levels so tuning of the system by strategically reducing transmit power may be necessary. Links should be looked at individually; in a PMP Network the Transmit Power of each and every remote End Point can be tuned individually. The Access Point's Transmit Power should be tuned to the furthest or weakest link.



At the Access Point location, use the RF Ping Tool to test each link by entering the End Point ID of each remote and clicking Ping. Record the Remote and Local Signal and Noise levels.

Radio Id	Name	Remote Noise	Remote Signal	Local Noise	Local Signal
1002	**Radio One**	**-128**	**-66**	**-117**	**-67**
1002	Radio One	-125	-66	-118	-67
1002	Radio One	-128	-66	-116	-67
1002	Radio One	-125	-66	-122	-68

Note

If both the Access Point and End Point radios have the same transmit (Tx) power level, the gains in the system are the same and the link should be well balanced (i.e. have nearly symmetrical RSSI as in the above table).

Attention

Signal levels should meet the MINIMUM SNR for the modulation scheme you have selected.

Tune the Longest Link First

For the longest/weakest link, reduce the Transmit Power of the End Point until the RSSI at the Access Point is sufficiently reduced to meet the Minimum SNR for the modulation selected.

Note

Use the RF Ping tool to check the RSSI levels as this provides specific measurements at both ends of each link and not a combined average.

Set the Access Points Transmit Power level so that the End Point RSSI on the longest/weakest link meets the Minimum SNR for the modulation selected.

Work Your Way Back

For all other End Point radios reduce the Transmit Power until the RSSI at the Access Point is sufficiently reduced to meet the Minimum SNR for the modulation selected.

Note

Use the RF Ping tool to check the RSSI levels as this provides specific measurements at both ends of each link and not a combined average.

Once you have adjusted the Transmit Power on all the End Points you have completed the tuning process.

Converting dBm to mW to dBm

Transmit Power is adjusted in mW and RSSI is reported in dBm.
For every required 3dB reduction in RSSI, the Transmit Power should be divided by 2.
Alternatively,

- **dBm** can be converted to **mW** using this online calculator.
- **mW** can be converted to **dBm** using this online calculator.

Transmission Systems

Cambium Networks recommends the use of a DC Grounded Transmission System featuring;

– DC Grounded Antenna from a reputable manufacturer with desired frequency range, gain, beam pattern (coverage) and an input surge impedance of 50 ohms.

– DC Block Surge Suppressor; Polyphaser TSX-NFF or IS-B50LN-C2.

Losses within the Transmission System

The decibel is a logarithmic unit with the following net effects on signal loss;

- **1dB** loss = **21%** signal loss
- **2dB** loss = **37%** signal loss
- **3dB** loss = **50%** signal loss
- **6dB** loss = **75%** signal loss
- **10dB** loss = **90%** signal loss

When modelling the transmission system in your planning software, such as LINKPlanner, the insertion loss from the connectors & surge suppressor should be combined with the loss from any planned strain relief jumper cables in addition to the loss from the coaxial transmission line. LINKPlanner takes drop cable and jumper cables into account when using the Cambium antennas with installation kits.

The following Cable Loss Calculators can be used to calculate the **Cable Loss** for the main transmission line.

– Times Microwave Cable Loss Calculator

– Use the "Cable Run Attenuation" value, since the connector losses are included in the table below.

Belden/Andrew Cable Loss Calculator

Use the "Matched Loss" value with SWR left at 1:1.

Calculating Transmission System Loss

Refer to the table to obtain the **Connector & Jumper Loss** for the frequency you intend to use;

LINKPlanner also provides for cable loss by selecting cable type and cable drop length.

Connector & Jumper Losses						
Part	Description	Loss (dB)				
		200 MHz	300 MHz	400 MHz	900 MHz	2.4 GHz
1	TNC Connector (Male)	0.1	0.1	0.1	0.2	0.2
2	3ft/1m LMR240 Jumper	0.1	0.1	0.2	0.2	0.4
3	N-Type Connector (Male)	0.1	0.1	0.1	0.2	0.2
4	Surge Suppressor	<0.1	<0.1	<0.1	<0.1	<0.25
5	N-Type Connector (Male)	0.1	0.1	0.1	0.2	0.2
6	N-Type Connector (Male)	0.1	0.1	0.1	0.2	0.2
	Total Loss	**0.60**	**0.60**	**0.70**	**1.10**	**1.45**

1. Use an online calculator to calculate the coaxial Cable Loss for the length and type of coax you intend to use;

   Times Microwave Cable Loss Calculator

   Use the "Cable Run Attenuation" value, since the connector losses are included in the table below.

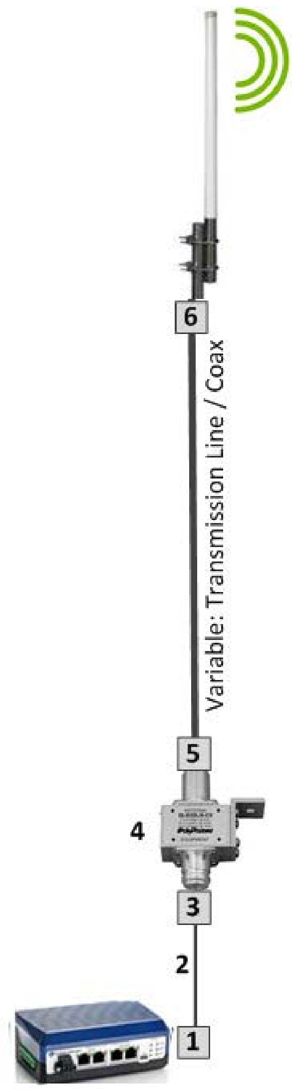
   Belden/Andrew Cable Loss Calculator

   Use the "Matched Loss" value with SWR left at 1:1.

2. Add the Connector & Jumper Loss from Step 1 to the Cable Loss from Step 2 to get the Transmission System Loss.

3. Enter the Transmission System Loss into LINKPlanner.

   –



Chapter 5: InstallationSafety

Warning

To prevent loss of life or physical injury, observe the following safety guidelines. In no event shall Cambium Networks be liable for any injury or damage caused during the installation of the cnReach equipment. Ensure that only qualified personnel install cnReach equipment.

Power lines

Exercise extreme care when working near power lines.

Working at heights

Exercise extreme care when working at heights.

Power Supplies

The cnReach radio modules can be powered with direct 10-32 VDC or with the Cambium supplied options of either an AC/DC power supply brick or DIN-Rail mount AC/DC power supply. Ensure that the power source is installed according to local standards to ensure safe operation.

Grounding and protective earth

Ensure that all equipment is properly grounded to protect against lightning. The optional antenna installation kits available from Cambium include surge suppression devices for the antenna ingress points into the cabinet.

It is the user's responsibility to install the equipment in accordance with national regulations.

In the USA follow the requirements of the National Electrical code NFPA 70-2005 and 780-2004 Installation of Lightning Protection Systems.

In Canada, follow Section 54 of the Canadian Electrical Code. These codes describe correct installation procedures for grounding the cabinet, mast, lead-in wire and discharge unit, size of grounding conductors and connection requirements for grounding electrodes.

Other regulations may apply in different countries and therefore it is recommended that installation be performed by a professional installer.

Powering down before servicing

Before servicing cnReach equipment, always switch off the power supply or remove the power plug from the radio thereby removing the power source.

Primary disconnect device

The power supply connection on the front of the cnReach module is the primary disconnect device. Most installations will also have an additional circuit breaker or isolation switch supplying power to the cabinet in which the cnReach module is mounted..

RF exposure near the antenna

Strong radio frequency (RF) fields will be present close to the antenna when the transmitter is on. Always turn off the power to the ODU before undertaking maintenance activities in front of the antenna.

Minimum separation distances

Ensure that personnel are not exposed to unsafe levels of RF energy. The units start to radiate RF energy as soon as they are powered up. Never work in front of the antenna when the radio module is powered. Install the modules so as to provide and maintain the minimum separation distances from all persons. For minimum separation distances, see Calculated distances on page 6-15.

Grounding and lightning protection requirements

Warning

Electro-magnetic discharge (lightning) damage is not covered under warranty. The recommendations in this guide, when followed correctly, give the user the best protection from the harmful effects of EMD. However 100% protection is neither implied nor possible.

Structures, equipment and people must be protected against power surges (typically caused by lightning) by conducting the surge current to ground via a separate preferential solid path. The actual degree of protection required depends on local conditions and applicable local regulations. To adequately protect a cnReach installation, both ground bonding and transient voltage surge suppression are required.

Full details of lightning protection methods and requirements can be found in the international standards IEC 61024-1 and IEC 61312-1, the U.S. National Electric Code ANSI/NFPA No. 70-1984 or section 54 of the Canadian Electric Code.

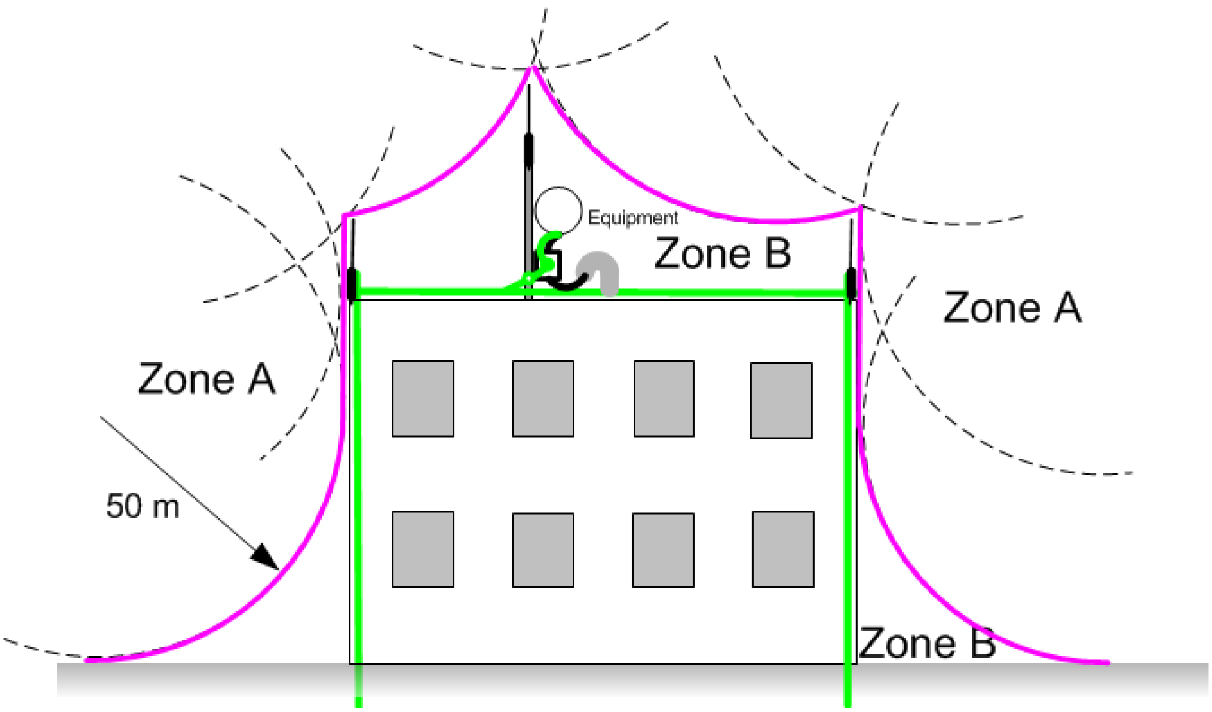
Note

International and national standards take precedence over the requirements in this guide.

Lightning protection zones

Use the rolling sphere method (see figure below) to determine where it is safe to mount equipment. An imaginary sphere, typically 50 meters in radius, is rolled over the structure. Where the sphere rests against the ground and a strike termination device (such as a finial or ground bar), all the space under the sphere is considered to be in the zone of protection (Zone B). Similarly, where the sphere rests on two finials, the space under the sphere is considered to be in the zone of protection.

Rolling sphere method to determine the lightning protection zones



Zone A: In this zone a direct lightning strike is possible. Do not mount equipment in this zone.

Zone B: In this zone, direct EMD (lightning) effects are still possible, but mounting in this zone significantly reduces the possibility of a direct strike. Mount equipment in this zone.

Warning

Never mount equipment in Zone A. Mounting in Zone A may put equipment, structures and life at risk.

Site grounding system

Confirm that the site has a correctly installed grounding system on a common ground ring with access points for grounding cnReach equipment.

If the outdoor equipment is to be installed on the roof of a high building, confirm that the following additional requirements are met:

- A grounding conductor is installed around the roof perimeter to form the main roof perimeter lightning protection ring.
- Air terminals are installed along the length of the main roof perimeter lightning protection ring, typically every 6.1m (20ft).
- The main roof perimeter lightning protection ring contains at least two down conductors connected to the grounding electrode system. The down conductors should be physically separated from one another, as far as practical.

Grounding cable installation methods

To provide effective protection against lightning induced surges, observe these requirements:

- Grounding conductor runs are as short, straight and smooth as possible, with bends and curves kept to a minimum.
- Grounding cables must not be installed with drip loops.
- All bends must have a minimum radius of 200 mm (8 in) and a minimum angle of 90°. A diagonal run is preferable to a bend, even though it does not follow the contour or run parallel to the supporting structure.
- All bends, curves and connections must be routed towards the grounding electrode system, ground rod, or ground bar.
- Grounding conductors must be securely fastened.
- Braided grounding conductors must not be used.
- Approved bonding techniques must be used for the connection of dissimilar metals.

Siting the uGPS and antennas

External antennas and GPS receivers are not designed to survive direct lightning strikes. For this reason they must be installed in Zone B as defined in Lightning protection zones covered in the previous section.

Thermal Safety

The ODU enclosure may be hot to the touch when in operation. The ODU must not be operated in ambient temperatures exceeding 40°C unless mounted in a Restricted Access Location.

Warning
Do not install the cnReach radio in a location where the ambient temperature could exceed 40°C unless this is a Restricted Access Location as defined by EN 60950-1.

Alerte
L'unité externe ne doit pas être installée dans un endroit où la température ambiante est supérieure à 40C à moins que l'accès soit limité au personnel autorisé.

Mounting the cnReach Module

The cnReach module can be placed on a horizontal surface or onto a DIN-Rail with option DIN-rail mount option. cnReach radios MUST be installed in weather-proof cabinet or indoors. cnReach modules are not meant for outdoor deployments.

	**Warning** Ensure that personnel are not exposed to unsafe levels of RF energy. The units start to radiate RF energy as soon as they are powered up. Respect the safety standards defined in Compliance with safety standards on page 6-13, in particular the minimum separation distances. Observe the following guidelines: Never work in front of the antenna when the cnReach module is powered. Always remove power from the cnReach module before connecting or disconnecting the drop cable the antenna.

Deployment Process

Successful network deployments are those that are installed predictably, perform well over time and recover from unexpected conditions quickly. Our experience troubleshooting networks taught us to plan, install and troubleshoot networks with the considerations listed below. Follow these steps to deploy a successful network.

Planning

- Understand customer's application and required network throughput. This is especially important when working with narrow-band channels on licensed spectrum. Take into account the polling cycles and the sizes of each poll especially when planning PMP networks.
- Test radios on the bench with desired equipment before first deployment. This is especially important when interfacing with serial or general-purpose IO equipment to confirm wiring diagrams, cables and cnReach module settings.
- Perform a path study for each link using Cambium Networks LINKPlanner.
- Plan radio settings to achieve desired network throughput with consideration of expected signal strength, RF noise and overlapping networks.
- Perform a Site Survey to sample in-band noise levels.
- Prepare equipment list that includes radios, radio accessories, cables, connectors, adapters, antennae, towers/poles, brackets, etc.

LINKPlanner

- The Cambium Networks LINKPlanner software and user guide may be downloaded from the support website: http://www.cambiumnetworks.com/linkplanner
- LINKPlanner imports path profiles and predicts data rates and reliability over the path. It allows the system designer to try different antenna heights and RF power settings. It outputs an installation report that defines the parameters to be used for configuration, alignment and operation. Use the installation report to compare predicted and actual link performance.

Site Survey

A site survey involves using a spectrum analyzer or alternative spectrum tool to check in-band noise levels at the site.

- Cambium Networks considers this an important step when deploying standard networks since the in-band noise levels can be factored into the network design.
- Other aspects of a site survey include sweeping any existing installed coaxial transmission line, jumpers, surge suppressors and antennas for Return Loss or VSWR.
- Identifying possible causes of interference with co-located systems.

Installation

- Use compass to align antennae to magnetic azimuth as recommended by the LINKPlanner installation report

- Fine-tune the alignment by monitoring the results of the RF Ping diagnostic tool in the GUI to optimize the displayed RSSi value. This value can be compared to the predicted value in LINKPlanner. Any deviations from the LINKPlanner prediction should be justified before completing the installation.
- Properly torque all mechanical connections.
- Apply appropriate weatherproofing material to all exposed RF and electrical connections.
- Measure noise floor with final hardware installed (i.e. antennae, cable) using radio or spectrum analyzer. The in-built spectrum analyzer can be used to scan the on-channel and neighboring channel noise levels.
- Compare actual received signal strength with expected signal strength from path study.
- Perform throughput and latency tests before leaving site using the built-in RF Throughput diagnostic tool and/or a throughput tool such as iperf.
- Confirm successful customer data test before leaving site.

Troubleshooting

- Obtain customer success/fail statistics on SCADA master polls.
- Capture radio settings (via screen shot and/or the active configuration file).
- Capture radio statistics (via screen shot or other).
- Capture LAN statistics (via screen shot or other).
- Capture terminal server statistics (via screen shot or other).
- Perform noise measurement with radio and/or spectrum analyzer.
- Obtain diagnostic slot capture from Access Point on problematic link.
- Sweep cable and antenna for loss with network analyzer (a.k.a site analyzer, cable and antenna tester).

Chapter 6: Legal/Regulatory Information

This chapter provides end user license agreements and regulatory notifications.

Caution Intentional or unintentional changes or modifications to the equipment must not be made unless under the express consent of the party responsible for compliance. Any such modifications could void the user's authority to operate the equipment and will void the manufacturer's warranty.

Attention Changements ou modifications Intentionnels ou non de l'équipement ne doivent pas être entrepris sans l'autorisation de l'organisme responsable de la déclaration de conformité. Ces modifications ou changements pourraient invalider le droit de l'utilisateur à utiliser cet appareil et annuleraient la garantie du fabricant.

The following topics are described in this chapter:

- Compliance with safety standards lists the safety specifications against which the cnReach N500 has been tested and certified. It also describes how to keep RF exposure within safe limits.
- Compliance with radio regulations describes how the cnReach N500 complies with the radio regulations that are in force in various countries, and contains notifications made to regulatory bodies for the cnReach N500.
- Cambium Networks end user license agreement contains the Cambium and third party license agreements for the cnReach N500 Series products.

Complying with rules for the country of operation

The cnReach product operates in a wide variety of frequency bands between 220 MHz and 960 MHz depending on the radio model and its configuration. These bands are made available for licensed or unlicensed operation according to the individual rules and regulations in force in each country.

Ensure that the equipment is operated in accordance with applicable regulations.

Obtain the necessary licenses or permits before using the equipment in licensed bands.

Some regional variants of cnReach are locked to a single country of operation (eg. Australian version of the 900 MHz cnReach).

In some regulatory bands, cnReach may be allowed as a secondary user of the band, where operation is subject to the condition that the product does not cause interference to primary users of the band. In this case, take care to avoid causing interference to primary users.

USA specific information

Attention

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference, and
- This device must accept any interference received, including interference that may cause undesired operation.

Canada specific information

Attention

This device complies with Innovation, Science and Economic Development Canada's licence-exempt RSSs. Operation is subject to the following two conditions:

(1) This device may not cause interference; and

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

Renseignements specifiques au Canada

Attention

Le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement Economique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

	(1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

EU specific information

	BE	BG	CZ	DK	DE	EE	IE	EL	ES
	FR	HR	IT	CY	LV	LT	LU	HU	MT
	NL	AT	PL	PT	RO	SI	SK	FI	SE
	UK								

EU Declaration of Conformity

Cambium Networks Ltd declares that cnReach, to which this declaration relates, conforms to the applicable essential requirements of the following Directive(s) of the Council of the European Communities:

2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC

2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive)

The declaration of conformity may be consulted at:

http://www.cambiumnetworks.com/support/compliance/

Application firmware

Download the latest cnReach firmware and install it before deploying the cnReach equipment. Instructions for installing firmware are provided in this document.

Specific expertise and training for professional installers

To ensure that the cnReach equipment is installed and configured in compliance with the requirements of ISEDC and the FCC, installers must have the radio engineering skills and training described in this section.

External antennas

When using a connectorized version of the product (as compared to the version with an integrated antenna), the conducted transmit power may need to be reduced to ensure the regulatory limit on transmitter EIRP is not exceeded. The installer must have an understanding of how to compute the effective antenna gain from the actual antenna gain and the feeder cable losses.

Antennas externes

Lorsque vous utilisez une version du produit sans antenne intégrée, il peut être nécessaire de réduire la puissance d'émission pour garantir que la limite réglementaire de puissance isotrope rayonnée équivalente (PIRE) n'est pas dépassée. L'installateur doit avoir une bonne compréhension de la façon de calculer le gain de l'antenne de gain de l'antenne réelle et les pertes dans les câbles de connections.

Ethernet networking skills

The installer must have the ability to configure IP addressing on a PC and to set up and control products using a web browser interface.

Lightning protection

To protect outdoor radio installations from the impact of lightning strikes, the installer must be familiar with the normal procedures for site selection, bonding and grounding..

Training

The installer needs to have basic competence in radio and IP network installation. The specific requirements applicable to the cnReach should be gained by reading this manual and by performing sample set ups at base workshop before live deployments.

Compliance with safety standards

This section lists the safety specifications against which the cnReach N500 has been tested and certified. It also describes how to keep RF exposure within safe limits.

Electrical safety compliance

The cnReach N500 hardware has been tested for compliance to the electrical safety specifications

Table 111: cnReach N500 safety compliance specifications

Region	Standard
USA	UL 60950-1, 2nd Edition; UL60950-22
Canada	CAN/CSA C22.2 No.60950-1-07, 2nd Edition; CAN/CSA C22.2 No.60950-22-07
EU	EN 60950-1:2006 + Amendment 12:2011, EN 60950-22
International	CB certified to IEC 60950-1: 2005 (modified); IEC 60950-22: 2005 (modified)

Human exposure to radio frequency energy

Relevant standards (USA and EC) applicable when working with RF equipment are:

- ANSI IEEE C95.1-1991, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
- Council recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC) and respective national regulations.
- *Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013* on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC
- US FCC limits for the general population. See the FCC web site at http://www.fcc.gov, and the policies, guidelines, and requirements in Part 1 of Title 47 of the Code of Federal Regulations.
- Health Canada limits for the general population. See the Health Canada web site at http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/99ehd-dhm237/limits-limites_e.html and Safety Code 6.
- EN 50383:2002 to 2010 Basic standard for the calculation and measurement of electromagnetic field strength and SAR related to human exposure from radio base stations and fixed terminal stations for wireless telecommunication systems (110 MHz - 40 GHz).
- BS EN 50385:2002 Product standard to demonstrate the compliances of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz – 40 GHz) – general public.
- ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines for the general public. See the ICNIRP web site at http://www.icnirp.de/ and Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields.

Power density exposure limit

Install the radios for the cnReach solutions so as to provide and maintain the minimum separation distances from all persons.

The applicable power density exposure limit for RF energy between 220 MHz and 960 MHz is **1.46 W/m^2 and 6.4 W/m^2 respectively.**

Calculation of power density

The following calculation is based on the ANSI IEEE C95.1-1991 method, as that provides a worst case analysis. Details of the assessment to EN50383:2002 can be provided, if required.

Peak power density in the far field of a radio frequency point source is calculated as follows:

$$S = \frac{PG}{4\pi d^2}$$

Where:

- S is the power density in W/m^2
- P is the average transmit power capability of the radio in W, equal to the configured maximum transmitter power as a linear number, multiplied by 0.8 to account for the worst case transmit/receive ratio
- G is the effective antenna gain, including cable losses, expressed as a linear number (not in dBi)
- d is the distance from the antenna

Rearranging terms to solve for distance yields:

$$d = \sqrt{\frac{PG}{4\pi S}}$$

Calculated distances

Error! Reference source not found.shows calculated minimum separation distances each frequency band and for the highest gain antenna of each type, assuming that the equipment is operating at the maximum transmit power for cnReach. At these and greater separation distances, the power density from the RF field is below generally accepted limits for the general population.

Calcul des distances pour la conformité aux limites de radiation radiofréquence

Le tableau ci-dessous indique les distances minimales de séparation calculées, les distances recommandées et les marges de sécurité qui en découlent pour chaque bande de fréquence et chaque antenne. À ces distance et des distance supérieures, la densité de puissance du champ de radiofréquence est inférieur aux limites généralement admises pour la population.

Minimum safe distances for cnReach at maximum transmitter power

Freq.	Antenna	P(W)	G	S (W/m2)	d (m)
		(*1)	(*2)		(*3)
220 MHz	10 dBi Yagi	4.0	8	1.5	1.32
220 MHz	4 dBi Omni	4.0	2	1.5	0.66
450 MHz	10 dBi Yagi	6.4	8	3.0	1.17
450 MHz	4 dBi Omni	6.4	2	3.0	0.58
757 MHz	10 dBi Yagi	8.0	8	5.0	1.00
757 MHz	4 dBi Omni	8.0	2	5.0	0.50
960 MHz	10 dBi Yagi	3.2	8	6.4	0.56
960 MHz	4 dBi Omni	3.2	1	6.4	0.20
915 MHz	10 dBi Yagi	0.8	8	6.4	0.28
915 MHz	4 dBi Omni	0.8	1	6.4	0.10

(*1) P: maximum average transmit power capability of the radio (Watt)
capacité de puissance d'émission moyenne maximale de la radio (Watt)

(*2) G: total transmit gain as a factor, converted from dB, including 0.9 dB cable loss for connectorised antennas
gain total d'émission, converti à partir de la valeur en dB prenant en compte une perte de 0.9 dB correspondant aux câbles de connexion nécessaire pour les antennes externs

(*3) d: minimum distance from the antenna (meters)
distance minimale de source ponctuelle (en mètres)

Note

Gain of antenna in dBi = 10*log(G).

The regulations require that the power used for the calculations is the maximum power in the transmit burst subject to allowance for source-based time-averaging.

Remarque

Gain de l'antenne en dBi = 10*log(G).

Les règlements exigent que la puissance utilisée pour les calculs soit la puissance maximale de la rafale de transmission soumis à une réduction pour prendre en compte le rapport cyclique pour les signaux modulés dans le temps.

Minimum separation distances for other transmitter powers, antenna gains and power densities

The minimum separation distances can be calculated for any transmit power or antenna gain using the formula provided above.

In many deployments, the antenna gains will be lower than the maximum listed and the duty cycles especially for end points will be significantly lower; in such cases, the minimum separation distances will be significantly reduced.

Compliance with radio regulations

This section describes how cnReach complies with the radio regulations that are in force in various countries.

Attention

Where necessary, the end user is responsible for obtaining any National licenses required to operate this product and these must be obtained before using the product in any particular country. Contact the appropriate national administrations for details of the conditions of use for the bands in question and any exceptions that might apply.

Attention

Changes or modifications not expressly approved by Cambium Networks could void the user's authority to operate the system.

Attention

For the connectorized version of the product and in order to reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the Effective Isotropically Radiated Power (EIRP) is not more than that permitted for successful communication.

Attention

Le cas échéant, l'utilisateur final est responsable de l'obtention des licences nationales nécessaires pour faire fonctionner ce produit. Celles-ci doivent être obtenus avant d'utiliser le produit dans un pays particulier. Contactez les administrations nationales concernées pour les détails des conditions d'utilisation des bandes en question, et toutes les exceptions qui pourraient s'appliquer

Attention

Les changements ou modifications non expressément approuvés par les réseaux de Cambium pourraient annuler l'autorité de l'utilisateur à faire fonctionner le système.

Attention

Pour la version du produit avec une antenne externe, et afin de réduire le risque d'interférence avec d'autres utilisateurs, le type d'antenne et son gain doivent être choisis afin que la puissance isotrope rayonnée équivalente (PIRE) ne soit pas supérieure au minimum nécessaire pour établir une liaison de la qualité requise.

Type approvals

The system has been tested against various local technical regulations and found to comply. Table 1 to Error! Reference source not found. list the radio specification type approvals that have been granted for cnReach products.

Table 1 Radio certifications (900 MHz)

Region	Regulatory approvals
USA	FCC 47 CFR Part 90
Canada	ISEDC RSS-111, Issue 5

Table 2 Radio certifications (450 MHz)

Region	Regulatory approvals
USA	FCC 47 CFR Part 15E
Canada	ISEDC RSS-111, Issue 5

Table 3 Radio certifications (220 MHz)

Region	Regulatory approvals
USA	FCC Part 90 and Part 80

Cambium Networks end user license agreement

Definitions

In this Agreement, the word "Software" refers to the set of instructions for computers, in executable form and in any media, (which may include diskette, CD-ROM, downloadable internet, hardware, or firmware) licensed to you. The word "Documentation" refers to electronic or printed manuals and accompanying instructional aids licensed to you. The word "Product" refers to Cambium Networks' fixed wireless broadband devices for which the Software and Documentation is licensed for use.

Acceptance of this agreement

In connection with Cambium Networks' delivery of certain proprietary software or products containing embedded or pre-loaded proprietary software, or both, Cambium Networks is willing to license this certain proprietary software and the accompanying documentation to you only on the condition that you accept all the terms in this End User License Agreement ("Agreement").

IF YOU DO NOT AGREE TO THE TERMS OF THIS AGREEMENT, DO NOT USE THE PRODUCT OR INSTALL THE SOFTWARE. INSTEAD, YOU MAY, FOR A FULL REFUND, RETURN THIS PRODUCT TO THE LOCATION WHERE YOU ACQUIRED IT OR PROVIDE WRITTEN VERIFICATION OF DELETION OF ALL COPIES OF THE SOFTWARE. ANY USE OF THE SOFTWARE, INCLUDING BUT NOT LIMITED TO USE ON THE PRODUCT, WILL CONSTITUTE YOUR ACCEPTANCE TO THE TERMS OF THIS AGREEMENT.

Grant of license

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