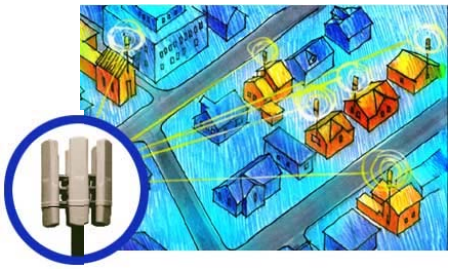
Cascade Networks Cyclone® System Release 8 User Guide, Issue 2



November 2007

Release 8.2 Features

Cyclone OFDM

Sections:

Planning Guide

Installation and Configuration Guide

Operations Guide

Reference Information

Notices

See the following information:

- important regulatory and legal notices in Section 36 on Page 493.
- personal safety guidelines in Section 15 on Page 169.

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GUIDE TO THIS USER GUIDE

1 NEW IN THIS ISSUE

1.1 NEW PRODUCTS AND FEATURES DESCRIBED IN ISSUE 2

Issue 2 adds the following products and features

- Release 8.2 features, including US and Canada DFS (Dynamic Frequency Selection) support for 5.4 GHz modules
- Cyclone OFDM in the 5.4 GHz band

1.2 NEW DESCRIPTIONS AND REVISIONS IN ISSUE 2

This section is a placeholder where other new descriptions, as wells as clarifications and corrections, will be listed in future issues.

1.3 CYCLONE Wi4 PORTFOLIO

The CYCLONE Wi4™ portfolio of wireless broadband solutions provides a range of flexible, mix-and-match options including

- wi4 Fixed
  - Cyclone unlicensed point-to-multipoint solutions
  - Point-to-point solutions, including
    - PTP 100 series Cyclone backhauls
    - PTP 400 and PTP 600 series bridges
  - Expedience licensed point-to-multipoint solutions
- wi4 Indoor
  - Broadband over Powerline (BPL) solutions
  - Enterprise Wireless LAN (WLAN) solutions
- wi4 Mesh, including the CYCLONE MESH series of products
- wi4 WiMAX, including infrastructure, CPE and devices, services, and IP core

1.4 PRODUCTS COVERED BY THIS USER GUIDE

Products covered by this user guide include

- Cyclone Access Points (APs), Subscriber Modules (SMs), and Backhauls (BHs) in the following frequency bands:
  - 900 MHz
  - 2.4 GHz
  - 5.1 GHz
  - 5.2 GHz
  - 5.4 GHz
  - 5.7 GHz
- Cyclone OFDM APs and SMs in the 5.4 GHz band
- Cluster Management Module micro (CMMmicro)
- Surge Suppressor
- Cyclone 900 MHz Indoor SMs

1.5 PRODUCTS NOT COVERED BY THIS USER GUIDE

Cyclone products with their own user guides include

- Cluster Management Module 4 (CMM4)
- Cyclone LENS

All the non-Cyclone wi4 products and solutions are covered by their own user guides and documentation.

1.6 SOFTWARE COMPATIBILITY DESCRIBED IN THIS USER GUIDE

The following sections of this document provide details and caveats about the compatibility of Cyclone products:

- Designations for Hardware on Page 372
- CMMmicro Software and Hardware Compatibility on Page 373
- MIB File Set Compatibility on Page 373

2 USING THIS USER GUIDE

This document should be used with Cyclone features through Software Release 8.2, Cyclone OFDM, and CMMmicro Release 2.2.1. The audience for this document includes system operators, network administrators, and equipment installers.

2.1 FINDING THE INFORMATION YOU NEED

2.1.1 Becoming Familiar with This User Guide

This is a guide to the guide. A high-level overview of the guide and some examples of where to look provide insight into how information is arranged and labeled.

The Table of Contents provides not only a sequential index of topics but also a visual glance at the organization of topics in this guide. A few minutes spent with the Table of Contents in either the paper or the electronic version of this guide can save much more time in finding information now and in the future. The List of Procedures may be especially useful in the paper version of this guide, particularly where you mark those procedures that you wish to frequently see.

In contrast, the List of Figures and List of Tables are most useful for automated searches on key words in the electronic version of this guide. If a match is present, the match is the first instance that the search finds.

Quick Reference

The Cyclone User Guide comprises six sections, as described in Table 1.

Table 1: Cyclone User Guide organization scheme

Section	Purpose
Guide to This User Guide (this section)	Identifies • products covered by this user guide. • products covered by their own separate user guides. • how this user guide is organized. • where to find module web pages and parameter descriptions. • what the various typefaces and admonitions indicate. • how to contact Cyclone.
Overview of Cyclone Networks	Provides • references to RF and networking theory. • a list of sections to see if you are building only a backhaul network. • overviews and comparisons of Cyclone products and how they communicate. • descriptions of data handling and synchronization. • a review of Cyclone optional features. • resources for developing familiarity and proficiencies with Cyclone networks.
Planning Guide	Provides essential information for • evaluating an area for a Cyclone network. • specifying the IP addresses and frequency band ranges to use for each type of link.
Installation and Configuration Guide	Provides systematic approaches for • avoiding hazards from RF and natural causes. • testing, storing, and deploying Cyclone equipment.
Operations Guide	Provides guidance for • expanding network coverage. • improving the security of Cyclone wireless links. • distributing bandwidth resources. • monitoring and changing variables through SNMP.
Reference Information	Provides supplemental information such as • authorizations, approvals, and notices. • a bibliography of adjunctive information sources. • a history of changes in Cyclone documentation.
Glossary	Defines terms and concepts that are used in this user guide.

Examples

A list of common tasks and references to information that supports each task is provided in Table 2.

Table 2: Examples of where to find information in this user guide

If you want to know…	then see…	because…
what the Spectrum Analyzer in SM and BHS feature does	Avoiding Self Interference on Page 152	this topic is important to RF planning.
	Monitoring the RF Environment on Page 369	this topic is also important to managing the network.
what types of slots compose the Cyclone frame	Understanding Bandwidth Management on Page 81	this information is helpful for understanding Cyclone networks.
how to calculate whether an object will interfere with a signal	Noting Possible Obstructions in the Fresnel Zone on Page 132	this topic is important to RF planning.
how long a cable you can use from the GPS antenna to the CMM	Cables on Page 35	cables are accessory components.
	Procedure 20 on Page 338 *or* Procedure 24 on Page 346	the advisory applies to mounting GPS antennas *and* CMMs.
how to react to a WatchDog Event Log message	Messages that Flag Abnormal Events on Page 419 *and* Messages that Flag Normal Events on Page 419	together, these two sections document all significant Event Log messages.
what beam angle the passive reflector dish produces	Specifications and Limitations on Page 70, then downward to a table for a Cyclone Part Number that includes “RF.”	the beam angle is a specification.
how to aim the passive reflector dish	Installing a Reflector Dish on Page 356	aiming is associated with Backhaul Module installation.
how to set Differentiated Services values so that traffic with original ToS byte formatting continues to be prioritized as it was before DSCP fields.	High-priority Bandwidth on Page 86	DSCP fields specify the level of priority that the device is requesting for the packet.

2.1.2 Searching This User Guide

To search this document and the software release notes of supported releases, look in the Table of Contents for the topic and in the Adobe Reader® search capability for keywords that apply.[1] These searches are most effective when you begin the search from the cover page because the first matches may be in titles of sections, figures, tables, or procedures.

2.1.3 Finding Parameter and Field Definitions for Module Web Pages

Because this user guide is sequentially arranged to support tasks, and various tasks require different settings and readings, parameter and field definitions are scattered according to the tasks that they support. The locations of these are provided in Table 3.

Table 3: Locations of screen captures and associated documentation

[1] Reader is a registered trademark of Adobe Systems, Incorporated.

2.2 INTERPRETING TYPEFACE AND OTHER CONVENTIONS

This document employs distinctive fonts to indicate the type of information, as described in Table 4.

Table 4: Font types

Font	Type of Information
variable width bold	Selectable option in a graphical user interface or settable parameter in the web-based interface to a Cyclone component.
`constant width regular`	Literal system response in a command-line interface.
`constant width italic`	Variable system response in a command-line interface.
`constant width bold`	Literal user input in a command-line interface.
`constant width bold italic`	Variable user input in a command-line interface.

This document employs specific imperative terminology as follows:

- *Type* means press the following characters.
- *Enter* means type the following characters and then press Enter.

This document also employs a set of consistently used admonitions. Each of these types of admonitions has a general purpose that underlies the specific information in the box. These purposes are indicated in Table 5.

Table 5: Admonition types

Admonition Label	General Message
	***NOTE:*** informative content that may • defy common or cursory logic. • describe a peculiarity of the Cyclone implementation. • add a conditional caveat. • provide a reference. • explain the reason for a preceding statement or provide prerequisite background for what immediately follows.
	***RECOMMENDATION:*** suggestion for an easier, quicker, or safer action or practice.

Admonition Label	General Message
	***IMPORTANT!*** informative content that may • identify an indication that you should watch for. • advise that your action can disturb something that you may not want disturbed. • reiterate something that you presumably know but should always remember.
	***CAUTION!*** a notice that the risk of harm to equipment or service exists.
	***WARNING!*** a notice that the risk of harm to person exists.

2.3 GETTING ADDITIONAL HELP

Help is available for problems with supported products and features. Obtaining Technical Support on Page 481 provides the sequence of actions that you should take if these problems arise.

2.4 SENDING FEEDBACK

We welcome your feedback on Cyclone system documentation. This includes feedback on the structure, content, accuracy, or completeness of our documents, and any other comments you have. Send your comments to technical-documentation@Cyclonewireless.com.

OVERVIEW OF CYCLONE NETWORKS

3 ADVANCING FROM RESEARCH TO IMPLEMENTATION

Before you begin to research a possible Cyclone implementation, you should have both

- basic knowledge of RF theory. See
  - Understanding RF Fundamentals on Page 117.
  - Engineering Your RF Communications on Page 129.
- network experience. See
  - Cyclone Link Characteristics on Page 81.
  - Understanding IP Fundamentals on Page 117.
  - Engineering Your IP Communications on Page 155.

4 REALIZING A WIRELESS BACKHAUL NETWORK

Cyclone backhaul modules (BHs) can connect Cyclone access point clusters to the point of presence or be the backbone of a Metro WiFi mesh network. In other applications, the backhaul modules can be used to provide connectivity for

- cell sites, in lieu of leased T1/E1 telecommunications lines.
- buildings in corporate or institutional campuses.
- remote sites, including temporary sites set up for relief efforts.

These BHs are available in 10- or 20-Mbps modulation rates from the factory. The rate is distinguished as BH10 or BH20 in the Software Version field of the General Status tab (in the Home page) of the module GUI.

For these and any other backhaul networks, Table 6 provides a quick reference to information that you would need to establish and maintain the Cyclone wireless backhaul network.

Table 6: Essential user guide elements for new backhaul network implementation

Element	Title	Page
Section 1.5	Products Not Covered by This User Guide	34
Section 5.1.8	Cyclone Backhaul Module	52
Section 5.1.11	Cluster Management Module-2 (Part 1008CK-2)	53
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Section 19.10	Installing a BH Timing Master	358
Section 19.11	Installing a BH Timing Slave	360

5 EXPLORING THE SCOPE OF SOLUTIONS

Cyclone wireless broadband applications include:

- local area network (LAN) extensions
- Internet subscriber service
- high-bandwidth point-to-point connections
- multicast video (for instruction or training, for example)
- private branch exchange (PBX) extensions
- point-to-multipoint data backhaul
- redundant network backup
- video surveillance
- voice over IP (VoIP)
- TDM over Ethernet (for legacy voice and data)

5.1 COMPONENTS

Cyclone networks use some or all of the following components. For the components that provide a graphical user interface (GUI), access to the GUI is through a web browser. In Release 8 and later, cascading style sheets (CSS) configure the GUI. Thus an operator is able to customize the GUI by editing these style sheets.

5.1.1 Cyclone Access Point Module and Cyclone OFDM Access Point Module

The Cyclone Access Point (AP) module provides broadband connectivity in a 60° sector. The Cyclone OFDM AP provides broadband connectivity in a 90° sector. Either supports up to 200 subscribers and 4,096 MAC addresses, which may be directly-connected PCs, IP appliances, gateways, Subscriber Modules (SMs), and the AP, except that *no limit* applies behind subscriber network address translation (NAT) gateways. The AP is configurable through a web interface. A Cyclone AP can only communicate with a Canopy SM, *not also* an Advantage SM or a Cyclone Lite SM. A Cyclone OFDM AP can only communicate with a Cyclone OFDM SM.

5.1.2 Advantage Access Point Module

The Cyclone Advantage AP distributes services as broadly as the Cyclone AP. However, the Advantage AP provides greater throughput and less latency. Each tab in the GUI for Cyclone Advantage modules displays the distinctive branding shown in Figure 1.

Figure 1: Cyclone Advantage Platform GUI logo

The Advantage AP communicates with all Canopy SMs in its frequency band range: Canopy SMs, Advantage SMs, and Cyclone Lite SMs.

5.1.3 Cyclone Access Point Cluster and Cyclone OFDM Access Point Cluster

An AP cluster covers as much as 360°.

The Cyclone FSK AP cluster consists of two to six APs that provide broadband connectivity to 1,200 or fewer subscribers. Each AP transmits and receives in a 60° sector.

The Cyclone OFDM AP cluster consists of two to four APs that provide broadband connectivity to 800 or fewer subscribers. Each AP transmits and receives in a 90° sector.

The variety of available APs, Advantage APs, and OFDM APs in frequency band range, power adjustability, and antenna configuration is shown under Acquiring a Cyclone Demonstration Kit, beginning on Page 117.

An AP cluster is pictured in Figure 2.

An OFDM AP, showing the antenna in front and the radio attached to it, is pictured in Figure 3.

Figure 2: Pole-mounted AP cluster

Figure 3: OFDM AP - Antenna and Radio

5.1.4 Canopy Subscriber Module

The Subscriber Module (SM) is a customer premises equipment (CPE) device that provides broadband services through communication with an AP. The SM is configurable through a web interface.

The variety of available SMs, Advantage SMs, and OFDM SMs in frequency band range, power adjustability, and antenna configuration is shown under Acquiring a Cyclone Demonstration Kit, beginning on Page 117.

Figure 4: Structure-mounted SM

A Canopy SM can communicate with either a Cyclone AP or an Advantage AP. A Cyclone OFDM SM can communicate with only a Cyclone OFDM AP.

An SM mounted directly to a structure is pictured in Figure 4.

An OFDM SM is shown in Figure 5 in both front and side views.

Figure 5: OFDM SM, front and side views

5.1.5 Advantage Subscriber Module

The Cyclone Advantage SM provides the same configurability and services as the Canopy SM. However, in a link with an Advantage AP, the Advantage SM provides uncapped sustained 2X throughput. See 2X Operation on Page 90. An Advantage SM can only communicate with an Advantage AP.

5.1.6 Cyclone Lite Subscriber Module

Cyclone Lite SMs cost less and provide less throughput than regular Canopy SMs. They support the same radio frequencies, interference tolerance, and product reliability. They give operators the additional option to serve cost-sensitive customers who want standard services (web browsing, email, VoIP, and downloads), but do not require the higher throughput that is available with a regular Canopy SM. Cyclone Lite SMs support an aggregate(uplink plus downlink) throughput of 512 kbps. Through purchased floating licenses that Prizm manages, they are upgradeable to 1, 2, 4, or 7 Mbps aggregate throughput. A Cyclone Lite SM can communicate with only a Cyclone Advantage AP. A comparison of the Cyclone Lite SM to the Canopy SM and Advantage SM is provided in Table 25 on Page 100.

5.1.7 900-MHz AP and SM

Cyclone 900 MHz AP and SM modules operate at a 3.3 Mbps carrier rate (compared to 10 Mbps for other Cyclone frequency bands).

Figure 6: Examples of flat panel antennas with 900-MHz modules

These 900-MHz modules run the same software and provide the same parameters, network features, and connections as all other Cyclone APs and SMs. The physics of longer-wavelength 900 MHz, the power allowed by regulatory authorities, and the low required level of Cyclone Carrier-to-Interference (C/I) ratio combine to support

- line of sight (LOS) range of up to 40 miles (over 64 km)
- increased non-line of sight (NLOS) range, depending on RF considerations such as foliage, topography, and obstructions.

When collocated with a Canopy SM of another frequency band range, the 900-MHz AP may serve, without a tower or BH, as a *remote* AP (see Deploying a Remote AP on Page 148). 900-MHz AP/SM links are logical choices for extending radio networks where you wish to

- add subscriber-handling capacity to a tower that is either
  - fully used in the other frequency band ranges.
  - not available to any other frequency band range.
- reach sparsely populated areas.
- penetrate foliage.
- add a remote AP behind an SM that operates in another frequency band range.

5.1.8 Cyclone

5.1.9 Backhaul Module

A pair of Backhaul Modules (BHs) provide point-to-point connectivity as either

- a standalone link
- a link through a cluster management module to an AP cluster.

You must configure a BH as either a timing master (BHM) or timing slave (BHS). The BHM provides synchronization signal (sync) to the BHS.

A BH mounted to a passive reflector dish is pictured in Figure 7. Carrier applications for these modules include reaching remote AP clusters, interconnecting campus buildings or remote branch offices, extending private branch exchange (PBX) circuits, backhauling cell sites, and extending central office T1s/E1s.

Figure 7: Dish-mounted 10- or 20-Mbps BH

These BHs are supported by this user guide. See Realizing a Wireless Backhaul Network on Page 47.

5.1.10 Radio Adjustable Power Capabilities

Cyclone offers adjustable power radios in all frequency bands.See Adjusting Transmitter Output Power on Page 330 to ensure that your radios do not exceed the maximum permitted EIRP.

5.1.11 Cluster Management Module-2 (Part 1008CK-2)

The Cluster Management Module-2 (CMM2) provides power, GPS timing from an antenna that is included, and networking connections for an AP cluster. The CMM2 can also connect to a BH, in which case the CMM2 is the central point of connectivity for the entire site. The CMM2 can connect as many as eight collocated modules—APs, BHMs, BHSs—and an Ethernet feed.

The CMM2 requires two cables for each connected module:

- One provides Ethernet communications and power. This cable terminates in an RJ-45 connector.
- The other provides synchronization (sync), GPS status, and time and date in a serial interface. This cable terminates in an RJ-11 connector.

A CMM2 is pictured in Figure 8. A CMM2 as part of a mounted Cyclone system is pictured in Figure 9.

Figure 8: CMM2 enclosure

Figure 9: CMM2 pole-mounted

5.1.12 Cluster Management Module micro (Part 1070CK)

The Cluster Management Module micro (CMMmicro) provides power, GPS timing, and networking connections for an AP cluster. Unlike the CMM2, the CMMmicro is configurable through a web interface.

The CMMmicro contains an 8-port managed switch that supports Power over Ethernet (PoE) on each port and connects any combination of APs, BHMs, BHSs, or Ethernet feed. Cyclone PoE differs from 803.3af PoE, and the two should not be intermixed. The CMMmicro can auto-negotiate speed to match inputs that are either 100Base-TX or 10Base-T, and either full duplex or half duplex, where the connected device is set to auto-negotiate. Alternatively, these parameters are settable.

A CMMmicro requires only one cable, terminating in an RJ-45 connector, for each connected module to distribute

- Ethernet signaling.
- power to as many as 8 collocated modules—APs, BHMs, or BHSs. Through a browser interface to the managed switch, ports can be powered or not.
- sync to APs and BHMs. The CMMmicro receives 1-pulse per second timing information from Global Positioning System (GPS) satellites through an antenna (included) and passes the timing pulse embedded in the 24-V power to the connected modules.

GPS status information is available at the CMMmicro, however

- CMMmicro provides time and date information to BHMs and APs if both the CMMmicro is operating on CMMmicro Release 2.1 or later and the AP/BHM is operating on Cyclone System Release 4.2 or later.
See Time Tab of the AP on Page 191.
- CMMmicro *does not* provide time and date information to BHMs and APs if either the CMMmicro is operating on a release earlier than CMMmicro Release 2.1 or the AP/BHM is operating on a release earlier than Cyclone System Release 4.2.

5.1.13 GPS Antenna

The Last Mile Gear GPS antenna provides either

- timing pulses to the CMMmicro.
- timing pulses and positioning information to the CMM2.

The GPS antenna is pictured in Figure 10.

Figure 10: Last Mile Gear GPS antenna

5.1.14 Surge Suppressor (Part 600SS)

The 600SS Surge Suppressor provides a path to ground (Protective Earth ⏚) that reduces the risk to persons, buildings, and inside equipment from over-currents and over-voltages associated with lightning strikes. A 600SS is pictured in Figure 11.

Figure 11: 600SS surge suppressor

5.1.15 Accessory Components

In addition to the above modules, the following accessories are available.

Power Supplies

The various power supplies available for Cyclone modules are listed in Table 7.

Table 7: Power supply descriptions

For Use With	Part Number	Voltage (AC)	Cycles per Second (Hz)	Includes
CMMmicro	ACPS81WA	100 to 240	50 to 60	US IEC line cord
	ACPS81W-02A	100 to 240	50 to 60	no IEC line cord
Cyclone radio[2]	ACPS110-03A[1]	120	50 to 60	US plug
	ACPSSW-09A[3]	90 to 240	50 to 60	US, Euro, and UK adaptors
	ACPSSW-10A[3]	90 to 240	50 to 60	Argentina adaptor
	ACPSSW-11A[3]	90 to 240	50 to 60	Australia adaptor
	ACPSSW-12A[3]	90 to 240	50 to 60	China adaptor

For Use With	Part Number	Voltage (AC)	Cycles per Second (Hz)	Includes
NOTES: 1. Pictured in Figure 12. 2. Single transceiver. 3. Pictured in Figure 13.				

Figure 12: ACPS110-03A power supply

Figure 13: ACPSSW-09A power supply

Passive Reflector Dish Assembly

A 27RD Passive Reflector Dish on both ends of a BH link extends the distance range of the link and provides a narrower beam width, which can reduce both received and transmitted interference. A 27RD on an SM extends the distance range in some bands (notably 5.7-GHz and 2.4-GHz) and can reduce both received and transmitted interference in all bands. An SMMThe module support tube provides the proper offset focus angle. See Figure 14.

For 5.*x*-GHz radios, the reflector gain is 18dB

Figure 14: 27RD with mounted module

and the 3 dB beam width is 6° in both azimuth and elevation. For 2.4-GHz radios, the reflector gain is 11dB and the 3 dB beam width is 17° in both azimuth and elevation.

Module Support Brackets

The SMMB1 support bracket facilitates mounting the SM to various surfaces of a structure and has slots through which chimney straps can be inserted. An SMMB1 is pictured in Figure 15.

The SMMB2 is a heavy duty mounting bracket that comes with the 900-MHz integrated SM or AP, and with the 27D passive reflector. It is also available separately for use with 900-MHz connectorized SMs and APs, other connectorized modules, and OFDM SMs.

The BH1209 is a pole-mount bracket kit for Cyclone backhaul modules.

Figure 15: SMMB1 SM support bracket

Cables

Cyclone modules that are currently or recently sold can auto-sense whether the Ethernet cable is wired as straight-through or crossover. Some modules that were sold earlier cannot. The MAC address, visible on the module, distinguishes whether the module can. All CMMmicros can auto-sense the cable scheme.

Where a non auto-sensing module is deployed

- a straight-through cable must be used for connection to a network interface card (NIC).
- a crossover cable must be used for connection to a hub, switch, or router.

Cyclone-recommended Ethernet and sync cables can be ordered in lengths up to 328 ft (100 m) from Best-Tronics Manufacturing, Inc. at http://www.best-tronics.com/Last Mile Gear.htm. These cables are listed in Table 8 and Table 9.

Table 8: Recommended outdoor UTP Category 5E cables

Best-Tronics Part #	Description
BT-0562	RJ-45 TO RJ-45; straight-through Ethernet cable
BT-0562S	RJ-45 TO RJ-45; shielded straight-through Ethernet cable
BT-0565	RJ-45 TO RJ-45; crossover Ethernet cable
BT-0565S	RJ-45 TO RJ-45; shielded crossover Ethernet cable

BT-0563	RJ-11 TO RJ-11; sync cable
BT-0563S	RJ-11 TO RJ-11; shielded sync cable

NOTE:
Shielded cable is strongly recommended for all AP cluster and BH installations.

Table 9: Recommended indoor UTP Category 5E cables

Best-Tronics Part #	Description
BT-0596	RJ-45 TO RJ-45; straight-through Ethernet cable
BT-0595	RJ-45 TO RJ-45; crossover Ethernet cable

Approved Ethernet cables can also be ordered as bulk cable:

- CA-0287
- CA-0287S (shielded)

Cyclone-approved antenna cables can be ordered in lengths up to 100 ft (30.4 m), as listed in Table 10.

Table 10: Recommended antenna cables

Best-Tronics Part #	Description
BT-0564	N TO N GPS antenna cable for CMM2
BT-0716	BNC TO N GPS antenna cable for CMMmicro

Category 5 Cable Tester

For purchase within the U.S.A., the CTCAT5-01 Cable Tester is available.

Override Plug

An override plug (sometimes called a default plug) is available to provide access to a module whose password and/or IP address have been forgotten. This plug allows the AP, SM, or BH to be accessed using IP address 169.254.1.1 and no password. During the override session, you can assign any new IP address and set either or both user passwords (display-only and/or full access) as well as make other parameter changes.

This plug is available from Best-Tronics Manufacturing, Inc. at http://www.best-tronics.com/Last Mile Gear.htm as Part BT-0583 (RJ-11 Default Plug).

Alternatively if you wish, you can fabricate an override plug. For instructions, see Procedure 36 on Page 380 and the pinout in Figure 140 on Page 380.

Alignment Headset

The ACATHS-01 Alignment Headset facilitates the operation of precisely aiming an SM toward an AP (or a BHS toward a BHM). This device produces infinitely variable

- pitch, higher when the received signal is stronger.
- volume, louder when jitter is less.

Figure 16: ACATHS-01 alignment headset

An ACATHS-01 is pictured in Figure 16.

Pinouts for an alternative listening device are provided under Alignment Tone—Technical Details on Page 184.

Module Housing

The HSG-01 Cyclone Plastic Housing is available for replacement of a damaged housing on a module that is otherwise functional. The HSG-01 is pictured in Figure 17.

The HSG-01 and all module housings of this design provide clearances for cable ties on the Ethernet and sync cables.

> ***RECOMMENDATION:***
> Use 0.14" (40-lb tensile strength) cable ties to secure the Ethernet and sync cables to the cable guides on the module housing.

For the Ethernet cable tie, the Ethernet cable groove is molded lower at the top edge. For the sync cable tie, removal of a breakaway plug provides clearance for the sync cable, and removal of two breakaway side plates provides clearance for the sync cable tie.

Figure 17: HSG-01 Housing

5.2 FREQUENCY BAND RANGES

In the 2.4-, 5.2-, 5.1-, 5.4-, and 5.7-GHz frequency band ranges, Cyclone APs, SMs, and BHs are available. Additionally, in the 900-MHz frequency band range, Cyclone APs and SMs are available. National restrictions may apply. See Regulatory and Legal Notices on Page 493.

To avoid self-interference, a Cyclone network typically uses two or more of these ranges. For example, where properly arranged, all AP clusters and their respective SMs can use the 2.4-GHz range where the BH links use the 5.7-GHz range. In this scenario, subscriber links can span as far as 5 miles (8 km) with no reflector dishes, and the BH links can span as far as 35 miles (56 km) with reflector dishes on both ends.

Within this example network, wherever the 2.4-GHz module is susceptible to interference from other sources, AP clusters and their linked SMs may use the 5.2-GHz range to span as far as 2 miles (3.2 km) with no reflector dishes. The network in this example takes advantage of frequency band range-specific characteristics of Cyclone modules as follows:

- The 900-MHz modules cover a larger area, albeit with lower throughput, than modules of the other frequency bands. The 900-MHz modules can be used to
  - penetrate foliage
  - establish links that span greater distances
  - add subscribers
  - add overall throughput where modules of other frequency bands cannot be used (such as where interference would result or space on a tower is limited).
- The 2.4-GHz frequency band range supports AP/SM links of greater than 2-mile spans (with no reflectors).
- The 5.7-GHz frequency band range supports BH links that span as far as 35 miles.

5.3 CYCLONE PRODUCT COMPARISONS

5.3.1 Cyclone Product Applications

The product applications per frequency band range are is summarized in Table 11.

Table 11: Product applications per frequency band range

Product	Frequency Band Range						
	900 MHz	2.4 GHz	5.1 GHz	5.2 GHz	5.4 GHz	5.7 GHz	5.4 GHz OFDM
Access Point Module	•	•	•	•	•	•	•
Subscriber Module	•	•	•	•	•	•	•
Subscriber Module with Reflector[1]		•		•	•	•	
Backhaul Module		•	•	•	•	•	
Backhaul Module with Reflector[1]		•	•	•	•	•	

Product	Frequency Band Range						
	900 MHz	2.4 GHz	5.1 GHz	5.2 GHz	5.4 GHz	5.7 GHz	5.4 GHz OFDM
CMM2	•	•	•	•	•	•	
CMMmicro	•	•	•	•	•	•	•
Power supply	•	•	•	•	•	•	•
Surge suppressor	•	•	•	•	•	•	•

NOTES:

1. National or regional regulations may limit EIRP to the same as without a reflector, and therefore require Transmit Output Power to be reduced. In these cases
   - the reflector used with an SM reduces beamwidth to reduce interference, but *does not* increase the range of the link.
   - the reflector on both ends of a BH link reduces beamwidth to reduce interference and also increases the range of the link.

5.3.2 Link Performance and Encryption Comparisons

Encryption options are summarized in Table 12. Typical Line-of-Site (LOS) range and aggregate useful throughput for Cyclone PTMP links are summarized in Table 13. Typical Line-of-Site (LOS) range and aggregate useful throughput for Cyclone PTP links are summarized in Table 14.

Table 12: Products with encryption options available per frequency band, PTMP links

Frequency Band	Products available with the following encryption options	
	DES or none	AES or none
900 MHz	•	•
2.4 GHz @100 mW (ETSI)	•	•
2.4 GHz @ 1W	•	•
5.1 GHz	•	
5.2 GHz	•	•
5.4 GHz	•	•
5.7 GHz	•	•
5.4 GHz OFDM	•	

Table 13: Typical range and throughput per frequency band, PTMP links

Frequency Band		Advantage AP				Cyclone AP			
		Range		Aggregate Throughput Mbps	Round-trip Latency msec	Range		Aggregate Throughput[3] Mbps	Round-trip Latency msec
		no SM Reflector mi (km)	with SM Reflector mi (km)			no SM Reflector mi (km)	with SM Reflector mi (km)		
2.4 GHz ETSI		0.3 (0.5)	0.3 (0.5) [1]	14	6	0.6 (1)	0.6 (1) [1]	7	20
		0.6 (1)	0.6 (1) [1]	7	6				
2.4 GHz		2.5 (4)	7.5 (12)	14	6	5 (8)	15 (24)	7	20
		5 (8)	15 (24)	7	6				
5.1 GHz		1 (1.6)	na	14	6	2 (3.2)	na	7	20
		2 (3.2)	na	7	6				
5.2 GHz		1 (1.6)	na[2]	14	6	2 (3.2)	na[2]	7	20
		2 (3.2)	na[2]	7	6				
5.4 GHz		1 (1.6)	1 (1.6) [1]	14	6	2 (3.2)	2 (3.2)[1]	7	20
		2 (3.2)	2 (3.2) [1]	7	6				
5.7 GHz		1 (1.6)	5 (8)	14	6	2 (3.2)	10 (16)	7	20
		2 (3.2)	10 (16)	7	6				
900 MHz[4]		40 (64)	na	4	15				
5.4 GHz OFDM	1X					5 (8)		7	tbd
	2X					2.5 (4)		14	tbd
	3X					1.25 (2)		21	tbd

NOTES:

2. In Europe, 2.4-GHz ETSI and 5.4-GHz SMs can have a reflector added to focus the antenna pattern and reduce interference, but transmit output power must be reduced to maintain the same EIRP as without a reflector, so the throughput and range specs for PTMP links remain the same.
3. In the USA and Canada, the use of a reflector with a full power radio in the 5.2-GHz frequency band is not allowed.
4. These values assume a hardware series P9 AP running hardware scheduler. When running software scheduler on a series P7, P8, or P9 AP, aggregate throughput drops to 6.2 Mbps, and only 4 Mbps is available to any one SM. (Series P7 and P8 APs can only run software scheduler.)
5. All 900-MHz APs are Advantage APs.

GENERAL NOTES:

Range is affected by RF conditions, terrain, obstacles, buildings, and vegetation.

An Advantage AP in other than 900 MHz has an aggregate (sum of uplink plus downlink) throughput or capacity of 14 Mbps, if RF conditions, range, and SM hardware version permit.

An Advantage SM in other than 900 MHz has an aggregate sustained throughput of 14 Mbps if RF conditions and range permit.

A regular SM can burst to 14 Mbps if RF conditions and range permit, then run at 7 Mbps sustained throughput.

An OFDM SM has an aggregate throughput or capacity of XX Mbps, if RF conditions and range permit.d

Table 14: Typical range and throughput per frequency band, PTP links

Frequency Band	Modulation Rate (Mbps)	Throughput	
		No Reflectors	Both Reflectors
2.4 GHz @100 mW (ETSI)	10	7.5 Mbps to 2 km	7.5 Mbps to 16 km
	20	14 Mbps to 1 km	14 Mbps to 8 km
2.4 GHz @ 1W	10	7.5 Mbps to 5 mi (8 km)	7.5 Mbps to 35 mi (56 km)
	20	14 Mbps to 3 mi (5 km)	14 Mbps to 35 mi (56 km)
5.1 GHz	10	7.5 Mbps to 2 mi (3.2 km)	
	20	14 Mbps to 2 mi (3.2 km)	
5.2 GHz	10	7.5 Mbps to 2 mi (3.2 km)	
	20		
5.2 GHz ER	10		7.5 Mbps to 10 mi (16 km)
	20		14 Mbps to 5 mi (8 km)
5.4 GHz	10	7.5 Mbps to 2 mi (3.2 km)	7.5 Mbps to 10 mi (16 km)[1]
	20	14 Mbps to 1 mi (1.6 km)	14 Mbps to 5 mi (8 km)[1]
5.7 GHz	10	7.5 Mbps to 2 mi (3.2 km)	7.5 Mbps to 35 mi (56 km)
	20	14 Mbps to 1 mi (1.6 km)	14 Mbps to 35 mi (56 km)

NOTES:

1. These ranges are with power reduced to within 1 W (30 dBm) EIRP.
2. Use the Link Estimator tool to estimate throughput for a given link.

5.3.3 Cluster Management Product Comparison

Cyclone offers a choice between two products for cluster management: CMM2 and CMMmicro. Your choice should be based on the installation environment and your requirements. The similarities and differences between these two products are summarized in Table 15.

Table 15: Cluster management product similarities and differences

Characteristic	CMM2	CMMmicro
Approximate size	17” H x 13” W x 6.5” D (43 cm H x 33 cm W x 7 cm D)	12” H x 10” W x 3” D (30 cm H x 25 cm W x 8 cm D)
Approximate weight	25 lb (11.3 kg)	8 lb (3.5 kg)
Cabling	◦ one Ethernet/power cable per radio. ◦ one sync cable per radio.	one Ethernet/power/sync cable per radio.
Cyclone network interconnection	8 Ethernet ports	8 Ethernet ports

Characteristic	CMM2	CMMmicro
Data throughput	auto-negotiates to full or half duplex	auto-negotiates to full or half duplex
Ethernet operating speed standard	auto-negotiates to 10Base-T or 100Base-TX	auto-negotiates to 10Base-T or 100Base-TX
Additional Ethernet ports	one for data feed one for local access (notebook computer)	none
Power supply	integrated 24-V DC to power APs, BHs, and GPS receiver	external 24-V DC to power APs, BHs, and GPS receiver
SNMP management capability	none	provided
Sync (to prevent self-interference)	carried by the additional serial cable to each AP and BHM	embedded in power-over-Ethernet cable
Time & Date	carried by the additional serial cable to each AP and BHM	provided by NTP (Network Time Protocol). CMMmicro can be an NTP server.
Weatherized	enclosure and power supply	only the enclosure (not the power supply)
Web interface	none	web pages for status, configuration, GPS status, and other purposes
NOTE: Auto-negotiation of data throughput and Ethernet operating speed depend on the connected device being set to auto-negotiate as well.		

5.4 ANTENNAS FOR CONNECTION TO 900-MHz MODULES

Like the 2.4-, 5.2-, 5.4-, and 5.7-GHz module, the 900-MHz connectorized module has

- the same housing.
- a covered Ethernet port.
- a utility port for alignment headset, sync cable to CMM2, or override plug.

The 900-MHz AP or SM is available either

- as a connectorized unit with a 16-inch (approximately 40-cm) cable with a male N-type connector for connection to the antenna.
- with an integrated horizontally-polarized antenna in a different form factor.

5.4.1 Certified Connectorized Flat Panel Antennas

Last Mile Gear has certified four connectorized flat panel antenna options. Last Mile Gear resells one of these, whose attributes include

- gain—10 dBi
- dimensions—8.8 x 8.1 x 1.6 inches (22.4 x 20.6 x 4.06 cm)
- weight—1.2 lbs (0.54 kg)

- polarization—vertical or horizontal
- cable—12-inch (30.5 cm)
- connector—female N-type
- beamwidth—approximately 60° vertical and 60° horizontal at 3 dBm

Last Mile Gear has certified three other antennas, which are available through Cyclone resellers. The attributes of one of these other certified antennas include

- gain—10 dBi
- dimensions—12 x12 x 1 inches (30.5 x 30.5 x 2.5 cm)
- weight—3.3 lbs (1.5 kg)
- polarization—vertical or horizontal
- connector—female N-type
- beamwidth—approximately 60° vertical and 60° horizontal at 3 dBm

Examples of these antennas are pictured in Figure 6 on Page 52.

5.4.2 Third-party Certified Connectorized Flat Panel Antenna

A third party may certify additional antennas for use with the Cyclone connectorized 900-MHz module.

5.5 ADJUNCTIVE SOFTWARE PRODUCTS

The capabilities of available applications and tools are summarized for comparison in Table 16. In this table CNUT represents Cyclone Network Updater Tool, Release 1.1 or later, and BAM represents Bandwidth and Authentication Manager, Release 2.0 or later.

Table 16: Cyclone applications and tools

Capability	Application or Tool		
	Prizm	CNUT	BAM
authenticates SMs	●		●
controls **authentication** in APs	●	●	
manages **Committed Information Rate** (CIR)	●		●
has **dependency** on another application[3]		●	
automatically **discovers** elements	●	●	
exports network information with hierarchy	●	●	
supports user-defined **folder**-based operations	●	●	
senses **FPGA version** on an element	●	●	
upgrades **FPGA version** on an element		●	
enables/disables **hardware scheduling**		●	

Capability	Application or Tool		
	Prizm	CNUT	BAM
manages the **high-priority channel**	●		●
imports network information with hierarchy	●	●	
interface to a higher-level network management system (NMS)	●		
interface to an operations support system (OSS)	●		
manages **Maximum Information Rate** (MIR)	●		●
automatically works from **root** (highest) level		●	
element **selection** can be individual or multiple	●	●	●
element **selection** can be criteria based	●		
element **selection** can be user-defined branch	●	●	
senses **software release** on an element	●	●	
upgrades **software release** on an element		●	
manages **VLAN** parameters	●		●
provides access to element **web interface**	●		

5.6 BANDWIDTH AND AUTHENTICATION MANAGER

Cyclone Bandwidth and Authentication Manager (BAM) software allows you to use

- a primary server to distribute bandwidth resources per subscriber, require SMs to authenticate per AP, and deny service to unauthorized SMs.
- a secondary server to redundantly store identical SM bandwidth and authentication data and become governing if the primary server goes out of service.
- an optional tertiary server to do the same if both the primary and secondary servers go out of service.

In BAM Release 2.1, subscriber administration for an SM or batch of SMs is performed as follows:

- Insert the ESNs.
- Specify MIR and Security attributes.
- Specify CIR attributes.
- Specify whether BAM should send its stored CIR attributes.
- Specify VLAN attributes.
- Specify whether BAM should send its stored VLAN attributes.

- Specify VLAN IDs to associate with the SM(s).

This product is supported by the dedicated document *Cyclone Bandwidth and Authentication Manager Release 2.1 User Guide* and associated release notes.

The upgrade path from BAM Release 2.1 is Prizm Release 2.0. See *Last Mile Gear Cyclone Prizm User Guide*, Issue 3, and *Last Mile Gear Cyclone Prizm Release 2.0 Release Notes*.

5.7 Prizm

The product name PrizmEMS is changed to Prizm in Release 2.0 and later, to reflect that the product capabilities are expanded beyond those of the element management system (EMS). Throughout this user guide, the name change applies to text for Release 2.0 and for multiple releases that include 2.0. It does not apply to text that is for a previous release. Case by case, software elements such as the GUI in the client application and XML files on the server may retain the PrizmEMS syntax.

5.7.1 Network Definition and Element Discovery

Prizm allows the user to partition the entire Cyclone network into criteria-based subsets that can be independently managed. To assist in this task of defining networks, Prizm auto discovers Cyclone network elements that are in

- user-defined IP address ranges
- SM-to-AP relationships with APs in the user-defined range
- BHS-to-BHM relationships with BHMs in the user-defined range.
- PLV Modem-to-PLV Bridge relationships with PLV Bridges in the user-defined range.

For a Cyclone AP, SM, BHM, BHS, PLV Bridge, PLV Modem, or CMMmicro, Prizm

- auto discovers the element to the extent possible.
- includes the element in the network tree.
- shows general information.
- shows Cyclone information.
- supports Cyclone-specific operations.

For a generic element, Prizm

- auto discovers the element as only a generic network element.
- includes the element in the network tree.
- shows general information.
- shows events and alerts.
- charts port activity.

For passive elements (such as CMM2 or a non-manageable switch or hub), Prizm allows you to enter into the network tree a folder/group with name, asset/owner information, and descriptive information.

Supported element types include

Cyclone Access Point Module	Generic SNMP Device (16 Port)
Cyclone Backhaul Master Module	Generic SNMP Device (24 Port)
Cyclone Backhaul Slave Module	Generic SNMP Device (26 Port)
Cyclone PrizmEMS	High-Speed Backhaul Master Module 150/300 Mbps
Canopy Subscriber Module	High-Speed Backhaul Master Module 30/60 Mbps
Cluster Management Module micro	High-Speed Backhaul Slave Module 150/300 Mbps
Cluster Management Module-4	High-Speed Backhaul Slave Module 30/60 Mbps
Cluster Management Module-4 Switch	PLV Bridge Unit
Generic Group	PLV Modem Unit
Generic SNMP Device	Ultra Light Access Point
Generic SNMP Device (08 Port)	Ultra Light Outdoor Subscriber Unit

5.7.2 Monitoring and Fault Management

Prizm receives the traps that Cyclone elements send and generates an alert for each of these. Prizm also allows the user to establish sets of criteria that would generate other alerts and trigger email notifications. Optionally, the user can specify a trap template. In this case, Prizm receives traps for non-Cyclone elements in the network.

For any individual element that the user selects, Prizm offers text and graphed displays of element configuration parameters and performance statistics from an interval that the user specifies.

5.7.3 Element Management

Prizm allows the user to perform any of the following operations on any specified element or group of elements:

- Manage
  - large amounts of SNMP MIB data.
  - module passwords.
  - IP addresses.
  - other communications setup parameters.
  - site information: Site Name, Site Location, and Site Contact parameters.
- Reset the element.

5.7.4 BAM Subsystem in Prizm

Prizm Release 2.0 and later integrates Cyclone Bandwidth and Authentication Manager (BAM) functionality and supports simple migration of a pre-existing BAM data into the Prizm database. These releases also support the maintenance of authentication and bandwidth data on a RADIUS server, to the same extent that BAM Release 2.1 (the final release of BAM) did.

Either of the following modes is available for the Prizm server, subject to licensing:

- BAM-only functionality, which manages only
  - authentication, bandwidth service plans, and VLAN profiles of SMs.
  - authentication of Powerline LV modems.
- Full Prizm functionality, which manages attributes for all elements and authentication of SMs and Powerline LV modems.

One difference between a service plan (or VLAN profile) and a configuration template that has the identical set of attributes is that the former is a long-term association whereas the latter is a one-time push to the element. When a service plan or VLAN profile is modified, the change is automatically applied to all elements that have the association. Another difference is that a configuration template cannot overwrite any values that a service plan or VLAN profile has set in an element.

5.7.5 Northbound Interface

In Release 1.1 and later, Prizm provides three interfaces to higher-level systems:

- a Simple Network Management Protocol (SNMP) agent for integration with a network management system (NMS).
- a Simple Object Access Protocol (SOAP) XML-based application programming interface (API) for web services that supports integration with an operations support systems (OSS) such as a customer relationship management (CRM), billing, or provisioning system.
- console automation that allows such higher-level systems to launch and appropriately display the Prizm management console in GUI that is custom developed, using the *PrizmEMS™ Software Development Kit (SDK)*, which Cyclone provides for this purpose.

Together these interfaces constitute the Northbound Interface feature. Prizm server administrator tasks and GUI developer information are provided in the *PrizmEMS™ Software Development Kit (SDK)*. This SDK also describes the how to define new element types and customize the Details views.

All other features of the Prizm product are supported by the dedicated document *Last Mile Gear Cyclone Prizm User Guide* and associated release notes.

5.8 LICENSE MANAGEMENT

Under the original licensing regime for Cyclone networks, licenses were permanently tied to the Media Access Control (MAC) address of the equipment that was licensed or that used the licensed feature. Thus, they were not transferable. Under server-based license management, for some functionalities, Cyclone offers licenses that

- float upon demand within the network.
- are tied to only the □osted (MAC address) of the license management server for which they were ordered.

In Release 4.2.3 and later, server-based license management adds flexibility and makes available licenses that previously would have been held by de-commissioned equipment. License management technology from Macrovision, based on a FLEXnet™ Publisher license management model, provides the platform for Cyclone server-based licensing. Cyclone capabilities that are authorized by licenses on this platform are *FLEXenabled* products.

In this platform, the license management server checks and then either assigns or declines to assign a license in real time. See the *Cyclone Networks License Manager User Guide*.

The total number of floating license keys that you need for any feature is the highest number that you will ever want to have simultaneously in use. The proper placement of these keys and the number and placement of fixed Cyclone licenses are listed in Table 17.

Table 17: Correct placement of license keys

In This Release	License Key	Must Be in Directory	If This Platform	On This Server Device
LM 1.0	License Manager Server	C:\Program Files\Last Mile Gear\Cyclone\FLEXnet\license_files	Windows	LM Server
		/usr/local/Cyclone/FLEXnet/license_files	Enterprise Linux	
BAM 2.0	BAM Server, AP Auth Server (APAS), Cap 2	C:\Program Files\Last Mile Gear\Cyclone\FLEXnet\license_files	Windows	LM Server[1]
		/usr/local/Cyclone/FLEXnet/license_files	Enterprise Linux	
		/usr/local/Cyclone/include	Enterprise Linux	BAM Server[2]
BAM 2.1	BAM Server, AP Auth Server (APAS), Cap 2	C:\Program Files\Last Mile Gear\Cyclone\FLEXnet\license_files	Windows	LM Server[1]
		/usr/local/Cyclone/FLEXnet/license_files	Enterprise Linux	
		/usr/local/Cyclone/FLEXnet/license_files	Enterprise Linux	BAM Server[2]
PrizmEMS 1.0	PrizmEMS Server, Element Pack	C:\Program Files\Last Mile Gear\Cyclone\FLEXnet\license_files	Windows	LM Server[3]
		/usr/local/Cyclone/FLEXnet/license_files	Enterprise Linux	
		C:\Program Files\Last Mile Gear\Cyclone\FLEXnet\license_files	Windows	PrizmEMS Server[4]
		/usr/local/Cyclone/Prizm/license_files	Enterprise Linux	
PrizmEMS 1.1	PrizmEMS Server, Element Pack	C:\Program Files\Last Mile Gear\Cyclone\FLEXnet\license_files	Windows	LM Server[3]
		/usr/local/Cyclone/FLEXnet/license_files	Enterprise Linux	

In This Release	License Key	Must Be in Directory	If This Platform	On This Server Device
Prizm 2.0 and 2.1 for full mgmt	PrizmEMS Server, Element Pack BAM Server, AP Auth Server (APAS), Cap 2 Cyclone Lite	C:\Program Files\Last Mile Gear\Cyclone\FLEXnet\license_files	Windows	LM server[5]
		/usr/local/Cyclone/FLEXnet/license_files	Enterprise Linux	
Prizm 2.0 and 2.1 for BAM-only or redundant BAM	BAM Server, AP Auth Server (APAS), Cap 2 Cyclone Lite	C:\Program Files\Last Mile Gear\Cyclone\FLEXnet\license_files	Windows	LM server[1]
		/usr/local/Cyclone/FLEXnet/license_files	Enterprise Linux	

NOTES:

1. One key required per each deployed BAM server.
2. Copied here so that BAM can find License Manager. No additional charge for using this copy.
3. One key required per each deployed PrizmEMS server.
4. Copied here so that PrizmEMS can find License Manager. No additional charge for using this copy.
5. One BAMServer key and one PrizmEMSServer key required per each full management Prizm server.

5.9 SPECIFICATIONS AND LIMITATIONS

5.9.1 Radios

Cyclone radio specifications are provided at http://Last Mile Gear.Cyclonewireless.com/products/specshome.php.

5.9.2 Cluster Management Products

Table 18: CMM2 specifications and limitations

Specification or Limitation	Cyclone System Range
Max length from Cluster Management Module to any radio	328 cable feet (100 meters)
Max length from Cluster Management Module to GPS antenna	100 cable feet (30.5 meters)
Dimensions	17.00" H x 12.88" W x 6.50" D (43.18 cm H x 32.72 cm W x 16.51 cm D)
Weight	25.0 lbs. (11.3 kg)
Operation Temperature	-40°F to +131°F (-40°C to +55°C)
Overall	Meets CE IP44 according to EN60529:2000
AC Input Voltage and Frequency	100 V – 240 V~, 0.7 A – 0.35 A, settable to either 230 V or 115 V nominal input. 50 Hz – 60 Hz Note: Applying 230 V to a unit that is set to 115 V may damage the unit.
AC Input Power	Nominal 66 watts, max 92 watts with 8 modules connected to the CMM at max cable length.
24-V DC Input Voltage	18 to 32 V DC, measured at CMM
24-V DC Input Power	Nominal 60 watts. Maximum 84 watts with 8 modules connected to the CMM at maximum cable length. 9A inrush upon start-up.
24-V DC Usage	If using a typical "24V +/-5%" power supply, ensure that CMM is within 400 cable feet (120 m) of the power supply. Use minimum 12 AWG (4 mm^2) copper wire.
12-V DC Input Voltage	11.5 to 32 VDC, measured at CMM
12-V DC Usage	If using a 12V power source (typically an automobile battery in a test or emergency situation), use 12 AWG (4 mm^2) wire between the power supply and the CMM, ensure that the CMM is within 10 cable feet (3 m) of the power supply, and ensure the modules are within 20 cable feet (6 m) of the CMM.
Ethernet, GPS Sync, and GPS Coax Cables	The use of cables that conform to the operational temperature of the product as well as being UV light protected is mandatory.

Table 19: CMMmicro specifications and limitations

Specification or Limitation	Cyclone System Range
Enclosure Size	Approximately 12” H x 10” W x 3” D (Approximately 30 cm H x 25 cm W x 7.5 cm D)
CMMmicro Weight (without DC power supply)	Approximately 8 lb (Approximately 3.5 k)
Max length from Cluster Management Module to any radio	328 cable feet (100 meters)
Max length from Cluster Management Module to GPS antenna	100 cable feet (30.5 meters)
Operating Temperature	-40°F to +131°F (-40°C to +55°C)
Provided DC Power Converter Input Voltage	100 – 240 V~
Provided DC Power Converter Input Frequency	50 – 60 Hz
CMMmicro Power Input Voltage	21.5 – 26.5 V DC
CMMmicro Power Current	3.36 A @ 24 V DC (3.75 – 3.0 A over voltage range)
Ethernet, GPS sync, and GPS coax cables	The use of cables that conform to the operational temperature of the product as well as having UV light protection is mandatory. Cables can be ordered from Best-Tronics Manufacturing, Inc. at http://www.best-tronics.com/Last Mile Gear.htm.

5.9.3 300SS and 600SS Surge Suppressors

Cyclone Surge Suppressor specifications are provided at http://Last Mile Gear.Cyclonewireless.com/products/specshome.php.

6 DIFFERENTIATING AMONG COMPONENTS

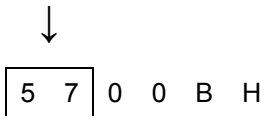
6.1 INTERPRETING MODEL (PART) NUMBER

The part number of a module typically represents

- the model number, which may indicate
  - radio frequency band range.
  - link distance range.
  - whether the module is Cyclone Advantage.
  - the factory-set encryption standard.
- the module type.
- whether the reflector dish is included.
- the antenna scheme of the module.
- whether adjustable power in the module is preset to low.
- the modulation capability.

Radio Frequency Band Range

The leading digits usually indicate the frequency band range in which the module can operate. For example, if the part number is 5700BH, then the frequency band range of the module is 5.7 GHz.

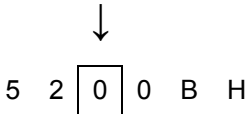


An exception to this general rule is that the leading digits in the part number of 5.1-GHz modules are 52. These modules are differentiated from 5.2-GHz modules by the leading four digits (5202 for 5.1 GHz, 5200 for 5.2 GHz).

You cannot change the frequency band range of the module.

Link Distance Range or Cyclone Advantage

The third digit in the part number may indicate whether the module is an extended range, Cyclone Advantage, or Cyclone model. 1 indicates extended range. For example, if the part number is 5210BH, then the module *is* an extended range module. If the part number is 5200BH, then the module is not an extended range model.

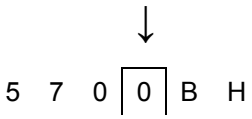


6 in the third position (5760SM, for example) indicates Cyclone Lite. 5 in the third position (5250AP, for example) indicates that the module is Cyclone Advantage. 0 in the third position (5200AP, for example) indicates that the module is Cyclone. However, part numbering for 900-MHz APs and SMs differs from this general rule. All APs and SMs in this frequency band range are Cyclone Advantage, but none of their part numbers use 5 in the third position.

You cannot change the link distance range of the module. However, you can license a Canopy SM to uncap its aggregate throughput (a capability of the Advantage SM).

Encryption Standard or Frequency Band Range

The fourth digit in the part number usually indicates the encryption standard that was preset at the factory. 1 indicates the Advanced Encryption Standard (AES). 0 indicates the Data Encryption Standard (DES) standard. For example, if the part number is 5201BH, then transmissions from the module are encrypted according to AES. If the part number is 5200BH, then transmissions from the module are encrypted according to DES.

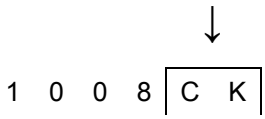


An exception to this general rule is that the fourth digit in the part number of 5.1-GHz modules is 2. These modules are differentiated from 5.2-GHz modules by the leading four digits (5202 for 5.1 GHz, 5200 for 5.2 GHz).

You cannot change the encryption basis (from DES to AES, for example), but you can enable or disable the encryption.

Module Type

The next two alpha characters indicate the module type. For example, CK indicates that the module is a Cluster Management Module.

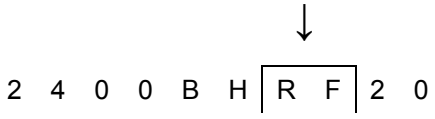


The module type cannot be changed.

Reflector Added

In specifications tables and price lists, the trailing characters RF or RF20 indicate that the associated information applies to the module being

- mounted to the 27RD Passive Reflector Dish, in the case of specifications.
- ordered with the 27RD Passive Reflector Dish, in the case of price lists.



However, this designation is not shown on either label of the module, and a module ordered with the dish can be deployed without the dish.

Antenna Scheme

In specifications tables and price lists, the trailing character C indicates that the module is connectorized for an external antenna.

An F in this position indicates that the module has an internal antenna with a band-pass filter (for example, 9000APF).

You cannot transform a module from connectorized to internal antenna or from internal antenna to connectorized, but you may have flexibility in what external antenna you deploy with it.

Adjustable Power Preset to High or Low

A trailing WL can indicate that the module had adjustable power that is preset to low.

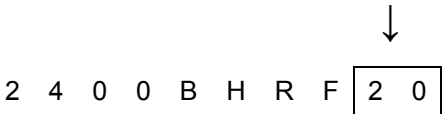
However, the 5700SMC and 5700APC are connectorized, but also have adjustable power preset to low. No special designation is made for adjustable power that is set to high (no trailing letters are used; for example, 5252AP).

You can reset power to higher in a module with adjustable power that is preset to low, but you are constrained by applicable regulations in your region and or nation.

Modulation Capability

A trailing 20 indicates that the module is capable of being set to either

- 20-Mbps modulation (aggregate throughput of 14 Mbps)
- 10-Mbps modulation (aggregate throughput of 7 Mbps).



The absence of a trailing 20 indicates that the module is capable of only 10-Mbps modulation.

6.2 SORTED MODEL NUMBERS

Model numbers of Cyclone modules are listed in Table 20. Not all models are available in all markets. Please check with your Cyclone distributor or reseller for availability.

Table 20: Cyclone model numbers

Range	Integrated Antenna				Connectorized for Antenna			
	Cyclone		Advantage		Cyclone		Advantage	
	DES	AES	DES	AES	DES	AES	DES	AES
5.7 GHz	5700AP 5700APHZ 5700SM 5760SM 5700SMMHZ 5700BH 5700BH20 5700BHRF 5700BHRF20	5701AP 5701SM 5701BH 5701BH20 5701BHRF 5701BHRF20	5750AP 5750APHZ 5750SM 5750SMHZ	5751AP 5751SM	5700APC 5700SMC 5700BHC 5700BHC20	5701APC 5701SMC 5701BHC 5701BHC20	5750APC 5750SMC	5751APC 5751SMC
5.4 GHz	5400AP 5400SM 5460SM 5400BH 5400BH20 5400BHRF 5400BHRF20	5401AP 5401SM 5401BH 5401BH20 5401BHRF 5401BHRF20	5450AP 5450SM	5451AP 5451SM	5400APC 5400SMC 5400BHC 5400BHC20	5401APC 5401SMC 5401BHC 5401BHC20	5450APC 5450SMC	5451APC 5451SMC
5.1 GHz	5202AP 5202SM 5202BH 5212BH20 5212BHRF20		5252AP 5252SM					
5.2 GHz	5200AP 5200APHZ 5200SM 5260SM 5200SMHZ 5200BH 5210BHRF 5210BHRF20	5201AP 5201SM 5201BH 5211BH20 5211BHRF 5211BHRF20	5250AP 5250APHZ 5250SM 5250SMHZ	5251AP 5251SM				

Range	Integrated Antenna				Connectorized for Antenna			
	Cyclone		Advantage		Cyclone		Advantage	
	DES	AES	DES	AES	DES	AES	DES	AES
2.4 GHz	2400AP 2400APWL 2400SM 2400SMWL 2460SM 2400SMLP 2400BH 2400BH20 2400BHRF 2400BHRF20 2400BHWL 2400BHWL20 2400BHWLRF 2400BHWLRF20	2401AP 2401APWL 2401SM 2401SMWL 2401BH 2401BH20 2401BHRF 2401BHRF20 2401BHWL 2401BHWL20 2401BHWLRF 2401BHWLRF20	2450AP 2450APWL 2450SM 2450SMWL	2451AP 2451APWL 2451SM 2451SMWL				
900 MHz			9000AP 9000APF 9000SM 9000SMF	9001AP 9001APF 9001SM 9001SMF			9000APC 9000SMC	9001APC 9001SMC
5.4 GHz OFDM	5440AP 5440APC 5440SM							

6.3 INTERPRETING ELECTRONIC SERIAL NUMBER (ESN)

Cyclone module labels contain a product serial number that could be significant in your dealings with Last Mile Gear or your supply chain. This is the electronic serial number (ESN), also known as the Media Access Control (MAC) address, of the module. This hexadecimal number identifies the module in

- communications between modules.
- the data that modules store about each other (for example, in the **Registered To** field).
- the data that the BAM software applies to manage authentication and bandwidth.
- Prizm auto discovery of SMs through the AP (or BHS through the BHM).
- software upgrades performed by the Cyclone Network Updater Tool (CNUT).
- information that CNUT passes to external tools.

6.4 FINDING THE MODEL (PART) NUMBER AND ESN

The labels and locations of Cyclone module model (part) numbers and ESNs are shown in Table 21.

Table 21: Labels and locations of model (part) numbers and ESNs

Numeric	Label and Location

String	Older Modules	Newer Modules
Model number	**PN** outside	**Model #** outside
ESN/MAC address	**S/N** inside	**ESN** outside

7 CYCLONE LINK CHARACTERISTICS

7.1 UNDERSTANDING BANDWIDTH MANAGEMENT

7.1.1 Downlink Frame Contents

The AP broadcasts downlink frames that contain control information, allocating slots in succeeding or future uplink frames to SMs that have requested service. The downlink frame also contains a beacon frame, control information, and data that specific SMs have requested. Each SM

- examines the downlink frame to distinguish whether data is addressed to that SM.
- retrieves data addressed to that SM.
- directs such data to the appropriate end user.

7.1.2 Uplink Frame Contents

Uplink frames contain control information from each SM that request service on succeeding uplink frames. SMs insert data into the uplink frames in an amount that the AP has established.

Optionally, you can configure the AP to change the source MAC address in every packet it receives from its SMs to the MAC address of the SM that bridged the packet, before forwarding the packet toward the public network. If you do, then

- not more than 10 IP devices at any time are valid to send data to the AP from behind the SM.
- the AP populates the Translation Table tab of its Statistics web page, displaying the MAC address and IP address of all the valid connected devices.
- each entry in the Translation Table is associated with the number of minutes that have elapsed since the last packet transfer between the connected device and the SM.
- if 10 are connected, and another attempts to connect
  - and no Translation Table entry is older than 255 minutes, the attempt is ignored.
  - and an entry is older than 255 minutes, the oldest entry is removed and the attempt is successful.
- the **Send Untranslated ARP** parameter in the General tab of the Configuration page can be
  - disabled, so that the AP will overwrite the MAC address in Address Resolution Protocol (ARP) packets before forwarding them.
  - enabled, so that the AP will forward ARP packets regardless of whether it has overwritten the MAC address.

This is the **Translation Bridging** feature, which you can enable in the General tab of the Configuration web page in the AP. When this feature is disabled, the setting of the **Send Untranslated ARP** parameter has no effect, because all packets are forwarded untranslated (with the source MAC address intact).

See Address Resolution Protocol on Page 162.

7.1.3 Default Frame Structures

With a 64-byte slot size, the default Cyclone frame in hardware scheduling consists of

- variable numbers of uplink and downlink data slots, subject to the following factors:
  - Maximum range decreases the number of available slots to 32.
  - Background bit error rate (BER) mode decreases the number of available data slots by one (and bandwidth by 200 kbps).
  - Every two control slots that are allocated decrease the number of available data slots by one.
- 0 to 10 control slots, subject to operator setting
- 0 to 9 downlink acknowledgement slots, dynamically assigned
- 0 to 9 uplink acknowledgement slots, dynamically assigned
- 1 uplink schedule slot
- 1 beacon slot, which identifies the
  - timing and distribution for the SMs
  - ratio of uplink to downlink allocation
  - ESN of the AP
  - color code
  - protocol (point-to-point or point-to-multipoint)
  - number of registered SMs
  - frame number
  - control slot information
- air delay, subject to the value of the **Max Range** parameter in the AP

Control Slots

The Radio tab of the Configuration web page in the AP displays the total of control slots (default 3, maximum 7 in the 900-MHz frequency band range[2] and 16 in all others). These control slots are contention slots. If too many SMs contend for these slots, then the number of control slots may be increased.

Frame Scheduling

When an SM boots, the following sequence occurs:

1. The SM finds this beacon slot from an AP.
2. The SM synchronizes with the AP.
3. If BAM is configured on the AP and the AP is licensed for authentication, then
   a. the AP sends a Registration Request message to Prizm for authentication.
   b. following a successful challenge, Prizm returns an Authentication Grant message to the AP.

[2] In the 900-MHz frequency band range, the frame size is 16,667 bits. In all others, the frame size is 25,000 bits. The smaller frame does not provide enough space to allocate more than 7 control slots.

c. the AP sends a Registration Grant to the SM.

If BAM *is not* configured on the AP or the AP is not licensed for authentication, then the AP simply returns the Registration Grant to the SM.

This Registration Grant includes the distance between the AP and SM. The SM uses the distance to distinguish when to transmit data in the uplink frame. The AP performs advance scheduling of up to 1024 frames that each SM will be permitted to use in the uplink frame.

7.1.4 Media Access Control and AP Capacity

Regardless of whether the maximum number of SMs (200) all request service at the same time, the reservation Media Access Control (MAC) system allows the AP to give a reservation slot to each SM that requests service.

Regardless of the distance between any SM and the AP, the reservation MAC system ensures that all SM data slots are free of contention. For this reason

- all SMs are equally able to compete for uplink and downlink bandwidth.
- the capacity of the AP is not degraded by distance from the SMs.

7.1.5 Cyclone Slot Usage

The frame illustrated in Figure 18 shows both packet fragments (yellow) and unused slot space (red) typical of uplink traffic. Packet sizes smaller than 64 bytes cause unused slot spaces.

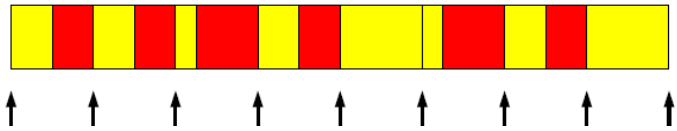


Figure 18: Uplink data slot usage

The following statistics apply to Cyclone frame slot usage:

- Slot capacity is 64 bytes.
- The optimum Ethernet packet size is 1518 bytes.
- The maximum downlink throughput for one AP to one SM is 1800 packets per second (pps).
- The maximum uplink throughput for one AP to one SM is 300 pps.
- The maximum backhaul throughput is 3000 pps.

7.1.6 Data Transfer Capacity

Cyclone modules use Time Division Duplex (TDD) on a common frequency to divide frames for uplink (orange) and downlink (green) usage, as shown in Figure 19.

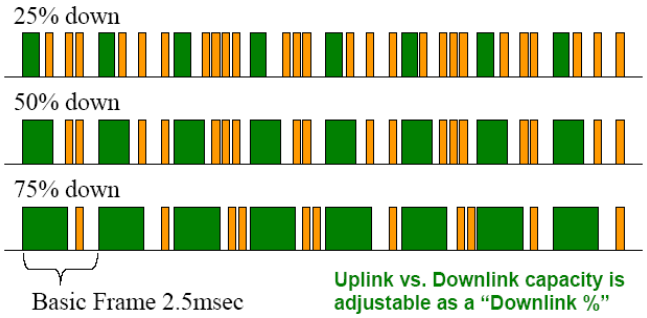


Figure 19: TDD dividing Cyclone frames

7.1.7 Maximum Information Rate (MIR) Parameters

Cyclone point-to-multipoint links use the following four MIR parameters for bandwidth management:

- **Sustained Uplink Data Rate** (kbps)
- **Uplink Burst Allocation** (kb)
- **Sustained Downlink Data Rate** (kbps)
- **Downlink Burst Allocation** (kb)

You can independently set each of these parameters per AP or per SM.

Token Bucket Algorithm

The Cyclone software uses a *token bucket* algorithm that

- stores credits (tokens) for the SM to spend on bandwidth for reception or transmission.
- drains tokens during reception or transmission.
- refills with tokens at the sustained rate set by the network operator.

For each token, the SM can send toward the network in the uplink (or the AP can send toward the SM in the downlink) an equivalent number of kilobits. Two buckets determine the permitted throughput: one in the SM for uplink and one in the AP for downlink.

The applicable set of **Uplink Burst Allocation** and **Downlink Burst Allocation** parameters determine the *number* of tokens that can fill each bucket. When the SM transmits (or the AP transmits) a packet, the equivalent number of tokens is removed from the uplink (or downlink) bucket.

Except when full, the bucket is continuously being refilled with tokens at *rates* that the applicable set of **Sustained Uplink Data Rate** and **Sustained Downlink Data Rate** parameters specify. The bucket often drains at a rate that is much faster than the sustained data rate but can refill at only the sustained data rate. Thus, the effects of the allocation and rate parameters on packet delay are as follows:

- the burst allocation affects how many kilobits are processed before packet delay is imposed.
- the sustained data rate affects the packet delay that is imposed.

Which set of these MIR parameters are applicable depends on the interactions of other parameter values. These interactions are described under Setting the Configuration Source on Page 295. Also, where the **Configuration Source** parameter setting in the AP specifies that BAM values should be used, they are used only if Prizm is configured to send the values that it stores for the MIR parameters.

MIR Data Entry Checking

Uplink and downlink MIR is enforced as shown in Figure 20.

> ***NOTE:***
> In these figures, *entry* refers to the setting in the data rate parameter, not the burst allocation parameter.

$$\text{uplink cap enforced} = \frac{\text{uplink entry} \times \text{aggregate cap for the SM}}{\text{uplink entry} + \text{downlink entry}}$$

$$\text{downlink cap enforced} = \frac{\text{downlink entry} \times \text{aggregate cap for the SM}}{\text{uplink entry} + \text{downlink entry}}$$

Figure 20: Uplink and downlink rate caps adjusted to apply aggregate cap

For example, in the Canopy SM, if you set the **Sustained Uplink Data Rate** parameter to 2,000 kbps and the **Sustained Downlink Data Rate** parameter to 10,000 kbps, then the uplink and downlink MIR that will be enforced for the SM can be calculated as shown in Figure 21.

$$\text{uplink cap enforced} = \frac{2{,}000 \text{ kbps} \times 7{,}000 \text{ kbps}}{2{,}000 \text{ kbps} + 10{,}000 \text{ kbps}} = 1{,}167 \text{ kbps}$$

$$\text{downlink cap enforced} = \frac{10{,}000 \text{ kbps} \times 7{,}000 \text{ kbps}}{2{,}000 \text{ kbps} + 10{,}000 \text{ kbps}} = 5{,}833 \text{ kbps}$$

Figure 21: Uplink and downlink rate cap adjustment example

In this example case, the derived 1,167-kbps uplink and 5,833-kbps downlink MIR sum to the fixed 7,000-kbps aggregate cap of the Canopy SM.

7.1.8 Committed Information Rate

The Committed Information Rate (CIR) capability feature enables the service provider to guarantee to any subscriber that bandwidth will never decrease to below a specified minimum, unless CIR is oversubscribed. Bandwidth can be, and typically will be, higher than the minimum, but this guarantee helps the WISP to attract and retain subscribers.

In BAM Release 2.1 and in Prizm Release 2.0, CIR configuration is supported as follows:

- The GUI allows you to view and change CIR configuration parameters per SM.
- When an SM successfully registers and authenticates, if BAM or Prizm has CIR configuration data for the SM, then messages make the CIR configuration available to the SM, depending on the Configuration Source setting. (See Setting the Configuration Source on Page 295.)
- The operator can disable the CIR feature in the SM without deleting the CIR configuration data.

7.1.9 Bandwidth from the SM Perspective

In the Canopy SM, normal web browsing, e-mail, small file transfers, and short streaming video are rarely rate limited with practical bandwidth management (QoS) settings. When the SM processes large downloads such as software upgrades and long streaming video or a series of medium-size downloads, the bucket rapidly drains, the burst limit is reached, and some packets are delayed. The subscriber experience is more affected in cases where the traffic is more latency sensitive.

Example download times for various arbitrary tiers of service are shown in Table 55 on Page 388 and Table 56 on Page 389.

7.1.10 Interaction of Burst Allocation and Sustained Data Rate Settings

If the Burst Allocation is set to 1200 kb and the Sustained Data Rate is set to 128 kbps, a data burst of 1000 kb is transmitted at full speed because the Burst Allocation is set high enough. After the burst, the bucket experiences a significant refill at the Sustained Data Rate. This configuration uses the advantage of the settable Burst Allocation.

If both the Burst Allocation and the Sustained Data Rate are set to 128 kb, a burst is limited to the Burst Allocation value. This configuration does not take advantage of the settable Burst Allocation.

If the Burst Allocation is set to 128 kb and the Sustained Data Rate is set to 256 kbps, the actual rate will be the burst allocation (but in kbps). As above, this configuration does not take advantage of the settable Burst Allocation.

7.1.11 High-priority Bandwidth

To support low-latency traffic such as VoIP (Voice over IP) or video, the Cyclone system implements a high-priority channel. This channel does not affect the inherent latencies in the Cyclone system but allows high-priority traffic to be immediately served. The high-priority pipe separates low-latency traffic from traffic that is latency tolerant, such as standard web traffic and file downloads.

A Cyclone module prioritizes traffic by

- reading the Low Latency bit (Bit 3) in the IPv4 Type of Service (ToS) byte in a received packet.
- reading the 802.1p field of the 802.1Q header in a received packet, where VLAN is enabled on the module.
- comparing the 6-bit Differentiated Services Code Point (DSCP) field in the ToS byte of a received packet to a corresponding value in the DiffServe tab of the Configuration page of the module.

Low Latency Bit

Bit 3 is set by a device outside the Cyclone system. In the uplink frame, the SM monitors Bit 3. If this bit is set, then

- the SM prioritizes this traffic in its high-priority queue according to AP configuration settings for the high-priority channel.
- the system sends the packet on the high-priority channel and services this channel before any normal traffic.

802.1P Field

See Priority on VLANs (802.1p) on Page 166.

DSCP Field

Like Bit 3 of the original IPv4 ToS byte, the DSCP field (Bits 0 through 5) in the redefined ToS byte is set by a device outside the Cyclone system. A packets contains no flag that indicates whether the encoding is for the Low Latency bit or the DSCP field. For this reason, you must ensure that all elements in your trusted domain, including routers and endpoints, set and read the ToS byte with the same scheme.

Cyclone modules monitor ToS bytes with DSCP fields, but with the following differences:

- The 6-bit length of the field allows it to specify one of 64 service differentiations.
- These correlate to 64 individual (**CodePoint**) parameters in the DiffServe tab of the Configuration page.
- Per RFC 2474, 3 of these 64 are preset and cannot be changed. (See http://www.faqs.org/rfcs/rfc1902.html.)
- For any or all of the remaining 61 CodePoint parameters, you can specify a value of
  - 0 through 3 for low-priority handling.
  - 4 through 7 for high-priority handling.

RECOMMENDATION:
Ensure that your Differentiated Services domain boundary nodes mark any entering packet, as needed, so that it specifies the appropriate Code Point for that traffic and domain. This prevents theft of service level.

An example of the DiffServe tab in the Configuration page and parameter descriptions are provided under DiffServe Tab of the AP on Page 259. This tab and its rules are identical from module type to module type in Cyclone. However, any of the 61 configurable Code Points can be set to a different value from module to module, thus defining unique per-hop behavior for some traffic.

This tab in the AP and BHM sets the priorities for the various packets in the downstream (sent from the public network). This tab in the SM and BHS sets the priorities for the various packets in the upstream (sent to the public network).

Typically in the Cyclone network, some SMs attach to older devices that use the ToS byte as originally formatted, and others to newer devices that use the DSCP field. The *default* values in the DiffServe tab allow your modules to prioritize traffic from the older devices roughly the same as they traditionally have. However, these default values may result in more high-priority traffic as DSCP fields from the newer devices are read and handled. So, after making any changes in the DiffServe tab, carefully monitor the high-priority channel for high packet rates

- in SMs that you have identified as those to initially set and watch.
- across your Cyclone network when you have broadly implemented Code Point values, such as via SNMP.

The Cyclone frame structure is illustrated in Figure 22.

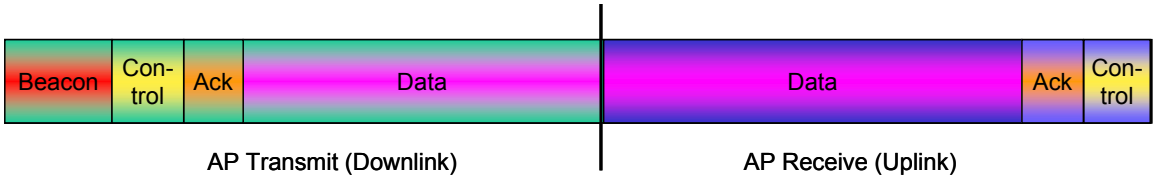


Figure 22: Cyclone frame structure

7.1.12 Hardware Scheduling

Cyclone Release 8 supports only hardware scheduling. Hardware scheduling always sends high-priority traffic first, even to the exclusion of other traffic.

> ***IMPORTANT!***
> The number of channels available to the AP is reduced by the number of SMs configured for the high-priority channel. With this feature enabled on all SMs, an AP can support 100 SMs (instead of 200).

Cyclone Release 8 requires APs, BHs, and AES SMs to be Series P9 or later hardware.[3] The characteristics of hardware scheduling in a Cyclone sector are summarized in Table 22.

[3] See Designations for Hardware in Radios on Page 164.

Table 22: Characteristics of hardware scheduling

Category	Factor	Treatment
Throughput	Aggregate throughput, less additional overhead	14 Mbps
	ACK slots in downlink used for data except when request for uplink is present	Yes
Latency	Number of frames required for the scheduling process	1
	Round-trip latency[1]	≈ 6 ms
	AP broadcast the download schedule	No
High-priority Channel	Allocation for *uplink* high-priority traffic on amount of high-priority traffic	Dynamic, based on amount of high-priority traffic
	Allocation for *downlink* high-priority traffic on amount of high-priority traffic	Dynamic, based on amount of high-priority traffic
	Order of transmission	1. CIR high-priority 2. CIR low-priority 3. Other high-priority 4. Other low-priority
Transmit Frame Spreading	Support for Transmit Frame Spreading feature	In Release 7.0 and later
CIR	Capability	In all releases
NOTES: 1. For 2.4- and 5.*n*-GHz modules.		

CAUTION!

Power requirements for modules that run hardware scheduling affect the recommended maximums for power cord length feeding the CMMmicro. See Table 50 on Page 347. However, the requirements *do not* affect the maximums for the CMM2.

Packets that have a priority of 4 to 7 in either the DSCP or a VLAN 802.1p tag are automatically sent on the high-priority channel, but only where the high-priority channel is enabled.

7.1.13 2X Operation

A General tab option in both Advantage SMs and hardware series P9 and greater Canopy SMs provides double the aggregate throughput for SMs that are nearer than half of the maximum typical range from the AP. The requirements of this feature are as follows:

- The AP must be an Advantage AP.
- The SM must be near the AP, roughly half the range of 1X.
- The SM must be of the P9 hardware series or later and enabled for hardware scheduling. See Designations for Hardware on Page 372.
- The **2X Rate** parameter in the SM must be set to enabled. This is the default setting.
- The amount of noise and multipath must be low enough to allow the receiver in the 6 dB less sensitive (2X) state to maintain a high carrier-to-interference (C/I) ratio.

The flexibility of this feature is as follows:

- At the time of registration, signaling is at the 1X rate. However, if the above requirements are all met, then the SM switches to 2X.
- Thereafter, whenever RF conditions are unfavorable for 2X operation, the SM switches to 1X. When favorable RF conditions allow, the SM switches back to 2X, if user data is present at that time.
- Similarly, whenever no user data is present, the SM switches to 1X. When user data flow resumes, the SM switches back to 2X, if RF conditions allow.
- Both links for the SM (uplink and downlink) are independent for this feature. (One can be operating at 2X operation while the other is operating at 1X.)
- Other SMs in the sector can be communicating with the AP at the other modulation rate.
- Although subscribers with Canopy SMs realize higher bursts, and subscribers with Advantage SMs realize both higher burst and higher sustained throughput, the network operator realizes higher sector throughput capacity in the AP.

The effect of 2X operation on aggregate throughput for the SM is indicated in Table 23.

Table 23: Effect of 2X operation on throughput for the SM

Type of SM		Typical Aggregate Rates[1]	
		Sustained[2]	Burst[2]
Advantage SM	900 MHz[3]	4 Mbps	4 Mbps
	Any other frequency band range	14 Mbps	14 Mbps
Regular SM (at least P9 Hardware Series)	Any frequency band range except 900 MHz	7 Mbps	14 Mbps

NOTES:

1. Subject to competition among all SMs in the sector.
2. Can be less if limited by the value of **Downlink Data** set in the Radio tab of the Configuration page in the AP.
3. All 900-MHz modules are Advantage.

Competition for Bandwidth

When multiple SMs vie for bandwidth, the AP divides its bandwidth among them, considering their effective CIR and MIR values. However, 2X operation uses bandwidth twice as efficiently as 1X, even where MIR values apply. This is because, in 2X operation, the modules transmit their data in 4-level frequency shift keying (FSK), not 2-level as they would in 1X operation. This moves twice the data per slot. Thus, for the sum of all bandwidth that 2X-eligible customers use, the bandwidth available to the remaining customers increases by half of that sum when these eligible customers are transmitting and receiving in 2X operation.

Engineering for 2X Operation

The following priorities should guide your implementation of 2X operation:

- In the near half of the distance range of the AP
  - identify the customers who use the most bandwidth.
  - enable their SMs first for 2X operation.
- When you have deployable Cyclone P7 and P8 SMs, *do not* deploy Cyclone Advantage SMs or Cyclone P9 SMs beyond half the distance range of the AP. At this distance, steady and reliable 2X operation typically is not achievable. Deploy the Cyclone P7 and P8 SMs here.
- Wherever practical, implement 25 MHz of channel separation for 2X operation.

Checking Link Efficiencies in 2X Operation

Unlike in 1X operation, efficiencies below 90% on the Link Capacity Test tab in the Tools web page of the SM may be acceptable for stable operation. An efficiency of 60% in 2X operation is equivalent to an efficiency of 120% in 1X. If you read efficiency between 60% and 90%, check the status of 2X operation (as described below) to confirm that the link is operating at 2X.

Since received signal strength typically varies over time, you should perform link tests at various times of day and on various days of the week. Efficiencies should consistently be 60% or greater for 2X operation. You may be able to achieve better efficiencies by re-aiming the SM, mounting it elsewhere, or adding a reflector dish.

Checking the Status of 2X Operation

The Session Status tab in the Home page of the AP provides operation status information about each *SM-to-AP* link. Under the MAC address of each SM, the data in this tab includes a line such as the following:

RATE : VC 19 Rate 2X/2X VC 255 Rate 2X/1X

Interpret this information is as follows:

- VC means virtual channel. If one VC is displayed, the high-priority channel is disabled. If two are displayed, the high-priority channel is enabled and is using the higher number VC (255 in the above example).
- 2X/2X indicates that the SM-to-AP link is in 2X operation.
- 2X/1X indicates that the SM is capable of 2X operation but the SM-to-AP link is in 1X operation. This can be for either of the following reasons:
  - The SM has not sent data on the channel yet.
  - The received signal does not support 2X operation.
- 1X/1X indicates that the SM is capable of only 1X operation. This can be for either of the following reasons:
  - The SM does not support 2X operation (SM is of the hardware series P7 or P8).
  - The **2X Rate** parameter is disabled in the General tab of the Configuration page in the SM or the AP.

CAUTION!

2X operation requires approximately 3 to 5% more power than 1X operation. This additional power affects the recommended maximum for power cord length feeding the CMMmicro. See Table 50 on Page 347. However, 2X operation *does not* affect the maximums for the CMM2.

Disabling 2X Operation

Disabling 2X operation for an SM can be helpful for alignment, troubleshooting, or preventing frequent automatic switches between 2X and 1X, where RF conditions are only marginally favorable to 2X. The ability to disable 2X for an SM is inherent since the 2X Operation feature was introduced.

Disabling 2X operation for a sector can be helpful for identifying a baseline for 1X-to-2X comparison, broader troubleshooting activities, or forcing all SMs to 1X rather than disabling 2X in each SM. Release 8 provides a **2X Rate** parameter in the General tab of the Configuration page in the AP:

- If you click **Disable**, then **Save Changes** and **Reboot**, 2X operation is disabled for the sector, regardless of the 2X Rate setting in each SM.
- If you later click **Enable**, then **Save Changes** and **Reboot**, 2X operation is enabled in the sector for SMs with 2X Rate enabled on their Configuration>General page. SMs with 2X Rate disabled on their Configuration>General page (or P7 or P8 SMs that don't support 2X Rate) will only operate at 1X.

7.1.14 3X Operation (Cyclone OFDM modules only)

Cyclone OFDM modules offer an additional modulation scheme that provides 3X operation in addition to 1X and 2X operation. In clear space, 3X operation is possible over half the range of 2X (which means it is possible over ¼ the range of 1X). However, in NLOS installations (typical for Cyclone OFDM), multipathing may be the predominant RF issue, not free-space attenuation, so the relationship between 1X, 2X, and 3X range may differ from clear space situations.

3X operation is configured on a Cyclone OFDM module's Configuration => General page using the Dynamic Rate Adapt pop-up under Mac Control Parameters.

7.2 UNDERSTANDING SYNCHRONIZATION

The system usesTime Division Duplexing (TDD) - one channel alternately transmits and receives - rather than using one channel for transmitting and a second channel for receiving. To accomplish TDD, the AP must provide sync to its SMs – it must keep them in sync. Furthermore, collocated APs must be synced together - an unsynchronized AP that transmits during the receive cycle of a collocated AP can prevent that second AP from being able to decode the signals from its SMs. In addition, across a geographical area, APs that can "hear" each other benefit from using a common sync to further reduce self-interference within the network.

7.2.1 GPS Synchronization

The Navigation Satellite Timing and Ranging (NAVSTAR) Global Positioning System (GPS) uses 24 satellites to relay information for precise derivation of position and time.

The Cyclone Cluster Management Module (CMM) contains a Last Mile Gear Oncore GPS Receiver. The CMM is a critical element in the operation of the Cyclone system. At one AP cluster site or throughout an entire wireless system, the CMM provides a GPS timing pulse to each module, synchronizing the network transmission cycles.

The Oncore GPS Receiver tracks eight or more satellites. The CMM uses the signal from at least four of these satellites to generate a one-second interval clock that has a rise time of 100 nsec. This clock directly synchronizes APs and BHMs which, in turn, synchronize the SMs and BHSs in the Cyclone network.

The Oncore GPS Receiver also provides

- the latitude and longitude of the GPS antenna (collocated with the CMM)
- the number of satellites that are being tracked
- the number of satellites that are available
- the date
- the time in Universal Coordinated Time (UCT)
- the altitude of the GPS antenna
- other information that can be used to diagnose network problems.

Alternative to GPS Sync

A Cyclone link can operate without *GPS* sync, but cannot operate without sync. The alternative to GPS sync is to configure the AP or BHM in the link to generate a sync pulse to pass to the SM or BHS, respectively. Depending on the RF environment in which the link operates, this latter alternative may or may not be plausible.

For example, in Figure 23, AP4

- is not synchronized with any of the other APs.
- is transmitting nearby the other APs while they are expecting to receive SM transmissions from a maximum distance.

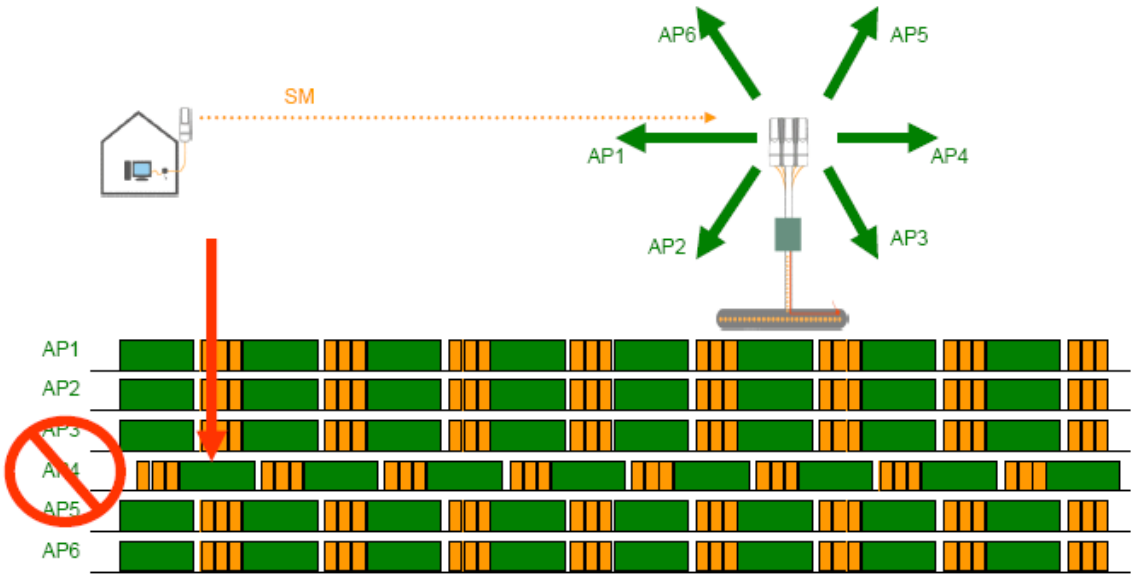


Figure 23: One unsynchronized AP in cluster

The result is self-interference. In this scenario, the self-interference can be avoided only by synchronizing the TDD transmit cycles of all APs that operate in the same frequency band.

An AP that is isolated by at least 5 miles (8 km) from any other Cyclone equipment, or a BHM in an isolated standalone BH link can generate and pass sync pulse without GPS timing and not risk that interference will result from the generated sync. In any other type of Cyclone link, sync should be derived from GPS timing.

NOTE:
The OFDM Series BHMs generate their own sync. For more information about these modules, see the user guides that support them. Titles are listed under Products Not Covered by This User Guide on Page 34.

Advantage of GPS Sync

Although the embedded timing generation capability of the Cyclone AP and BHM keeps a precise clock, no trigger exists to start the clock at the same moment in each AP of a cluster. So, the individual AP can synchronize communications between itself and registered SMs, but cannot synchronize itself with other Cyclone modules, except by GPS timing (shown in Figure 24).

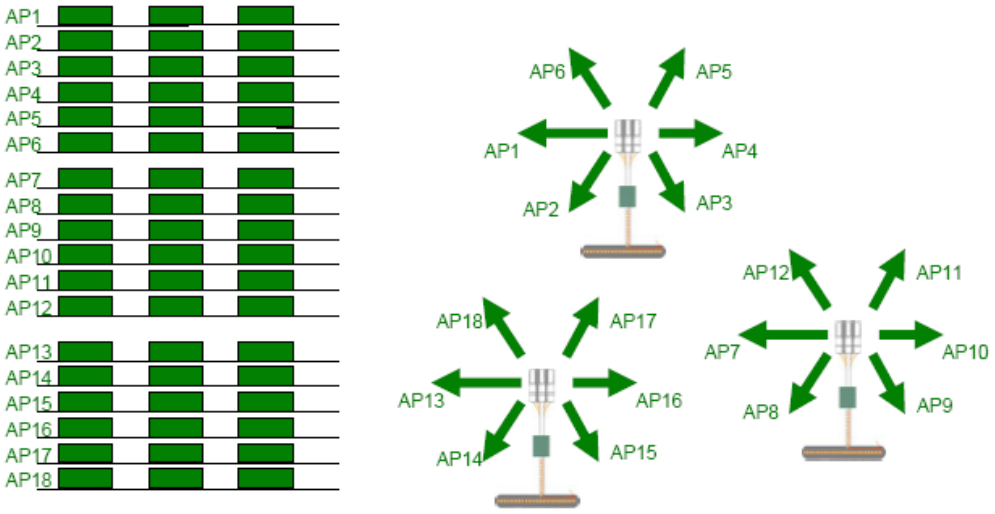


Figure 24: GPS timing throughout the Cyclone network (Cyclone FSK shown)

7.2.2 Passing Sync in a Single Hop

Network sync can be passed in a single hop in the following network designs:

- Design 1
  1. A CMM provides sync to a collocated AP.
  2. This AP sends the sync over the air to SMs.
- Design 2
  1. A CMM provides sync to a collocated BH timing master.
  2. This BH timing master sends the sync over the air to a BH timing slave.

7.2.3 Passing Sync in an Additional Hop

Network sync can be extended by one additional link in any of the following network designs:

> ***NOTE:***
> In each of these following designs, Link 2 *is not* on the same frequency band as Link 4. (For example, Link 2 may be a 5.2-GHz link while Link 4 is a 5.7- or 2.4-GHz link.)

- Design 3
  1. A CMM provides sync to a collocated AP.
  2. This AP sends the sync over the air to an SM.
  3. This SM delivers the sync to a collocated AP.
  4. This AP passes the sync in the additional link over the air to SMs.

This design is illustrated in Figure 25.

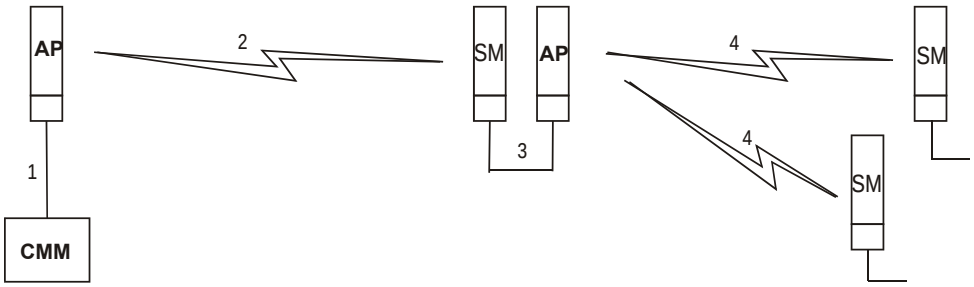


Figure 25: Additional link to extend network sync, Design 3

- Design 4
  1. A CMM provides sync to a collocated AP.
  2. This AP sends the sync over the air to an SM.
  3. This SM delivers the sync to a collocated BHM.
  4. This BHM passes the sync in the additional link over the air to a BHS.

This design is illustrated in Figure 26.

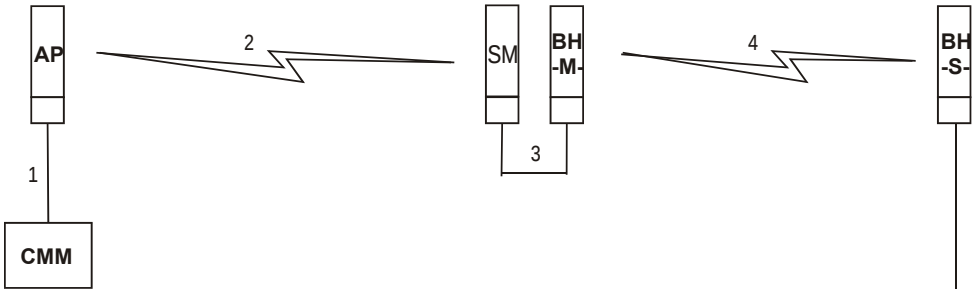


Figure 26: Additional link to extend network sync, Design 4

- Design 5
  1. A CMM provides sync to a collocated BHM or the BHM generates timing.
  2. This BHM sends the sync over the air to a BHS.
  3. This BHS delivers the sync to a collocated AP.
  4. This AP passes the sync in the additional link over the air to SMs.

This design is illustrated in Figure 27.

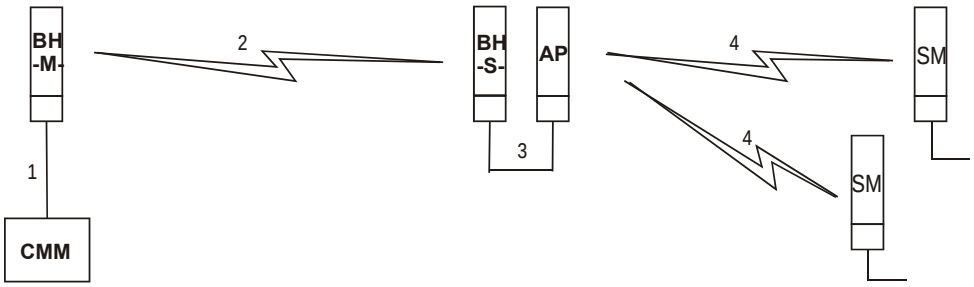


Figure 27: Additional link to extend network sync, Design 5

Wiring and configuration information for this sync extension is described under Wiring to Extend Network Sync on Page 374.

All Cyclone radios support the remote AP functionality. The BHS and the SM can reliably pass the sync pulse, and the BHM and AP can reliably receive it. The sync is passed in a cable that connects Pins 1 and 6 of the RJ-11 timing ports of the two modules. (The sync cable is described under Cables on Page 57.) When you connect modules in this way, you must also adjust configuration parameters to ensure that

- the AP is set to properly receive sync.
- the SM will not propagate sync to the AP if the SM itself ceases to receive sync.

8 MEETING LINK REQUIREMENTS

8.1 AP-SM LINKS

APs communicate with SMs using a point-to-multipoint protocol. An AP-SM link has lower throughput and higher latency than a backhaul link for two reasons:

- Many endpoints are involved.
- The bandwidth request and reservation process consumes bandwidth.

In the 900-MHz frequency band range, round-trip latency is typically

- 40 msec with software scheduling.
- 15 msec with hardware scheduling.

In all other Cyclone frequency band ranges, round-trip latency is typically

- 15 msec with software scheduling.
- 6 msec with hardware scheduling.

At range settings of greater than 40 miles (64 km) in the 900-MHz AP, more time elapses between transmit and receive cycles to compensate for greater air delay. In each frame, this reduces the number of data slots, which slightly reduces the aggregate throughput of the link. However, the throughput is as predictable as in other Cyclone point-to-multipoint links.

Throughput is a factor of the **Max Range** parameter in the AP and is effective for all SMs, regardless of their distance from the AP. Throughput includes all downlink data to all SMs and all uplink data from all SMs that link to the AP. For throughput with hardware scheduling, see Table 13 on Page 62.

End user perspective of throughput is based on both bandwidth in the sending direction and the return of TCP acknowledgement packets in the other. Where sufficient downlink bandwidth exists to support downlink traffic and overhead, transient traffic congestion in the uplink can cause some TCP acknowledgement packets to be dropped, and the end user to perceive a reduction in throughput. This can also occur with sufficient uplink bandwidth and dropping acknowledgment packets in the downlink.

However, a Cyclone network operator can optionally enable the **Prioritize TCP ACK** parameter in the AP and BHM, giving these packets priority over other packet types. This results in fewer of them being dropped.

The effects of changing network conditions on PTMP throughput are indicated in Table 24.

Table 24: Effects of network conditions on PTMP throughput

Changing Network Condition	Effect on AP Aggregate Throughput
Increasing the **Max Range** parameter setting[1] in the AP	somewhat decreased[2]
Increasing the number of SMs that register in the AP	no effect
Increase in downlink traffic	
Increase in uplink traffic	
Increasing the average bandwidth allotted to the SMs that register in the AP	no effect, even when the additional bandwidth is used.

NOTES:

1. For non 900-MHz APs, the AP accepts a **Max Range** value of up to 30 miles (48 km). See Max Range on Page 244.
2. To avoid a decrease of unnecessary proportion, set to not much further than the distance between the AP and the furthest SM that registers in the AP.

A comparison of SM products in link with a Cyclone Advantage AP is shown in Table 25.

Table 25: Comparison of SM products with Cyclone Advantage AP

Product	Maximum Sustained Aggregate Throughput to a Single SM	Burst	Cap on Committed Information Rate	Upgradability	VoIP Channels Supported
Cyclone Advantage SM	14 Mbps	14 Mb	none	none	multiple
Canopy SM	7 Mbps	14 Mb	none	to Advantage SM capabilities	multiple
Cyclone Lite SM as purchased	512 kbps	768 kb	100 kbps	to 1, 2, 4, or 7 Mbps	1
Cyclone Lite SM upgraded to 1 Mbps	1 Mbps	1.5 Mb	100 kbps	none	1
Cyclone Lite SM upgraded to 2 Mbps	2 Mbps	3 Mb	100 kbps	none	1
Cyclone Lite SM upgraded to 4 Mbps	4 Mbps	7 Mb	200 kbps	none	2
Cyclone Lite SM upgraded to 7 Mbps	7 Mbps	7 Mb	200 kbps	none	2

8.2 BH-BH LINKS

Cyclone BHs communicate with each other using a point-to-point protocol. This point-to-point protocol uses a 2.5-msec frame. A BH link has higher throughput and lower latency (typically 5 msec, 2.5 msec in each direction) for two reasons:

- Only two endpoints are involved.
- No bandwidth request and reservation process is involved.

For 10-Mbps BHs, the aggregate throughput on the channel is 7.5 Mbps. For 20-Mbps BHs, the aggregate throughput on the channel is 14 Mbps. If a BH is set to a downlink ratio of 50%, then the bandwidth in each direction is half of the total BH link bandwidth.

9 PREVIEWING NETWORK CONFIGURATIONS

The following are examples of network layouts. Customer experience case studies are also available.

9.1 VIEWING TYPICAL LAYOUTS

The following layouts are typical of Cyclone system implementations:

- Figure 28: Typical network layout with no BH
- Figure 29: Typical network layout with BH
- Figure 30: Typical multiple-BH network layout

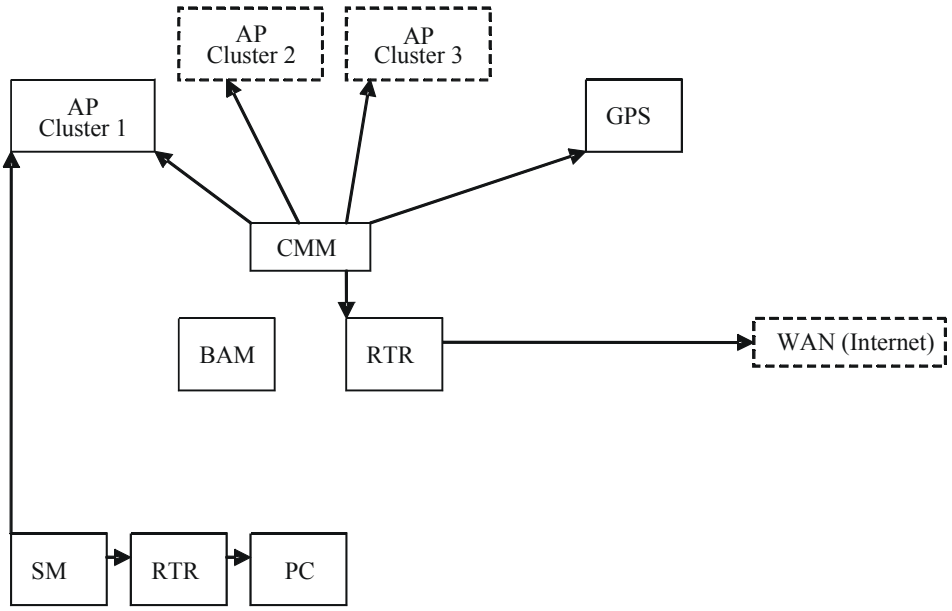


Figure 28: Typical network layout with no BH

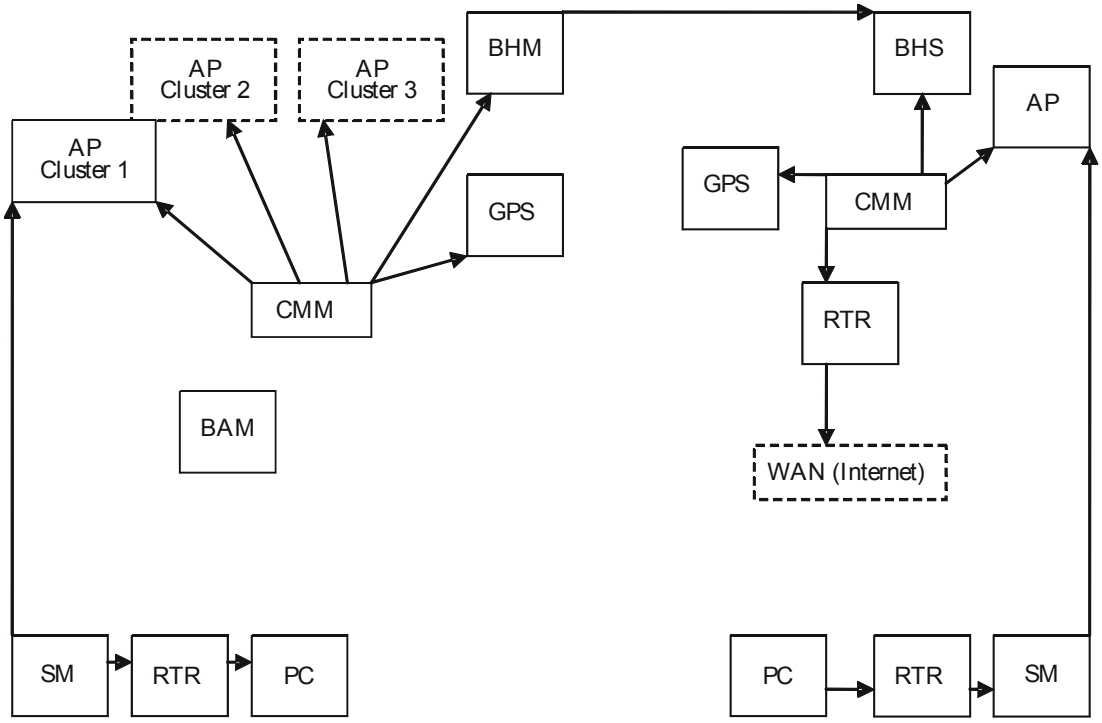


Figure 29: Typical network layout with BH

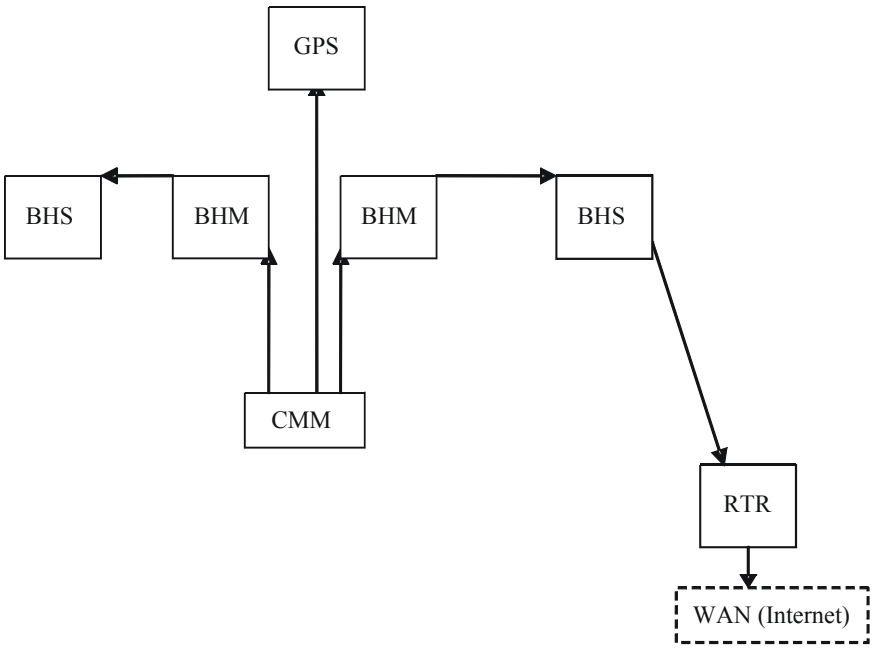


Figure 30: Typical multiple-BH network layout

9.2 VIEWING CASE STUDIES

Case studies of Cyclone implementations are available as “Feature Articles” for download from http://www.connectwithCyclone.com/index.cfm?Cyclone=menu.case.

10 ACCESSING FEATURES

Cyclone Release 8 networks support the features that are indicated in Table 26.

Table 26: Cyclone features

Regulatory Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
RoHS compliant (EU “green” mandate)	All modules	no	no
WEEE compliant	All modules	no	no
Complies with Human RF exposure limits (ETSI)	All radios	no	no
Radio Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Time Division Duplex	All radios	no	no
Scalable up to 6 sectors per cell.	AP SM	no	no
200 registered subscribers supported per AP	AP SM	no	no
Fixed /nomadic operation	All radios	no	no
20 ms or less round trip latency (OTA with Cyclone MAC, under normal conditions)	All radios	no	no
Transmit frame spreading for geographical area co-existence	AP BHM	Configuration/Radio	yes
Radio statistics (scheduler)	All radios	Statistics/Scheduler	yes
2X rate, enabled per link (requires Advantage AP or 20 Mbps BH)	SM BHS	Configuration/General	yes
2X rate, enabled per sector (requires Advantage AP or 20 Mbps BH)	AP BHM	Configuration/General	yes
Manual transmit power control - normal and low (-18 dB)	All radios	Configuration/Radio	yes
Manual transmit power control, 1 dB increments over 25 dB at the AP	AP BHM	Configuration/Radio	yes

RF Configuration Features	Module Type(s)	Controlled in GUI Page/Tab	SNMP Control
Configurable center-channel carrier frequency	AP BHM	Configuration/Radio	yes
255 configurable "color codes" to manage SM to AP (or (BHS to BHM) registration	All radios	Configuration/Radio	yes
16 configurable "sector IDs" for administrative convenience	AP BHM	Configuration/Radio	yes
Configurable range settings (determines air turn-around time)	AP	Configuration/Radio	yes
Configurable downlink data % (determines transmit/receive ratio)	AP BHM	Configuration/Radio	yes
Configurable number of reserved control slots (manages contention for uplink requests)	AP	Configuration/Radio	yes
Configurable frequency scan list at SM	SM BHS	Configuration/Radio	yes
Packet stats - RF interface	All radios	Statistics/Radio	yes
Timing Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Configurable AP/BHM sync source - Sync over Power over Ethernet, self-sync, or sync cable	AP BHM	Configuration/General	yes
"Remote AP" support, including timing pulse propagation through SM/BHS	SM BHS	Configuration/General	yes
Ethernet Interface Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Selectable link speeds - 10/100 Base T, half, full-duplex	All modules	Configuration/General	yes
Ethernet link auto-negotiation	All modules	Configuration/General	no
Accepts straight-through or crossover Ethernet cable wiring (Auto-MDX)	All modules	no	no
Wire line Interface: Ethernet cable with proprietary PoE	All modules	no	no
Disable SM Ethernet link	SM	Configuration/General	yes
Packet stats - Ethernet interface	All radios	Statistics/Ethernet	yes

IP Interface Features	Module Type(s)	Controlled in GUI Page/Tab	SNMP Control
Configurable LAN settings (IP address, mask, gateway)	All radios	Configuration/IP	yes
Module's management IP address assignable via DHCP	All radios	Configuration/IP	yes
Private LAN to support AP to SM (or BHM to BHS) communications	All radios	Configuration/IP	yes
Configurable SM mgmt accessibility (Local/Ethernet only, or Public/RF and Local/Ethernet)	SM	Configuration/IP	yes
Security Features (Authentication, Encryption, and Access Control)	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Configurable SM authentication using BAM/PrizmEMS	AP SM	Configuration/Security	yes
Configurable BH authentication, standalone	BHM BHS	Configuration/Security	no
DES encryption on standard product	All radios	no	yes
AES encryption on AES product	All radios	no	yes
Configurable whether SM/BHS displays AP/BHM beacon information	AP BHM	Configuration/Security	yes
Configurable web, telnet, and ftp session timeout	All radios	Configuration/Security	yes
Configurable access to radio management - up to 3 source IP addresses	All radios	Configuration/Security	yes
User/account names (up to 4) and passwords on modules	All radios	Account	yes
Permission levels control ability to add/delete users/passwords	All radios	Account	yes
Override plug to override lost IP address or user/password	All radios	no	no
Override plug configurable as a default plug - reset to factory defaults	AP SM BHM BHS	Configuration/Unit Settings	yes
Override switch to override lost IP address or user/password on CMM	CMMmicro	no	no

Monitoring Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
List of registered SMs/BHSs with full data, with hot links to SMs/BHSs	AP BHM	Configuration/General	multiple objects
Abbreviated list of SMs/BHSs, with hot links to SMs/BHSs	AP BHM	Configuration/General	multiple objects
Received power level indication	All radios	Configuration/General	yes
LEDs on modules to display states and activity	All modules	no	no
Received interference level indication (jitter)	All radios	Configuration/General	yes
Configurable web-page auto-refresh	All modules	Configuration/General	yes
SM registration failures	AP BHM	Statistics/Reg Failures	yes
Event log	All modules	Home/Event Log	no
Operator can use own logo on GUI pages	All modules	no	yes
Operator can use own style sheets for GUI	All modules	no	yes
Bridge Management Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Configurable bridge entry timeout	All radios	Configuration/General	yes
Bridging table statistics (up to 4096 entries)	All radios	Statistics/Bridging Table	yes
Disable bridging on BHs	BHM BHS	Configuration/General	yes
SM Isolation Features (preventing communication between SMs)	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
SM isolation at AP	AP	Configuration/General	yes
SM isolation at CMM	CMMmicro	Configuration/General	yes
SM Isolation Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Translation bridging (replace customer MAC with SM MAC address)	AP	Configuration/General	yes
With Translation bridging, choice of sending untranslated ARP	AP	Configuration/General	yes
Translation table statistics	All radios	Statistics/Translation Table	yes
Quick Start Feature	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
AP configuration quick-start wizard	AP BHM	Quick Start	

Bandwidth Management Features	Module Type(s)	Controlled in GUI Page/Tab	SNMP Control
AP Maximum Information Rate (MIR) default settings	AP	Configuration/QoS	yes
Per SM Maximum Information Rate (MIR)	SM	Configuration/QoS	yes
Per SM Committed Information Rate (CIR) for high and low channels	SM	Configuration/QoS	yes
"Configuration Source" for MIR/CIR/HP/VLAN can be either SM or BAM/Prizm	AP	Configuration/General	yes
CIR for low priority channel on BH	BHS	Configuration/QoS	yes
Configurable priority for TCP Acks, to optimize bandwidth use	AP BHM	Configuration/General	yes
Bandwidth Management Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Configurable High Priority channel with configurable DiffServ mappings on AP, SM (2 classes of service)	AP SM	Configuration/DiffServe	yes
Permanent BH High Priority Channel with configurable DiffServ mappings on BH (2 classes of service)	BHM BHS	Configuration/DiffServe	yes
Virtual channel (high/low priority) statistics	All radios	Statistics/Data VC	yes
Network Address Translation (NAT) Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
NAT	SM	Configuration/NAT	yes
NAT DMZ	SM	Configuration/NAT	yes
NAT DHCP server on LAN with up to 254 IP addresses in pool	SM	Configuration/NAT	yes
NAT DHCP client on WAN (obtains NAT address from a DHCP server)	SM	Configuration/NAT	yes
NAT port mapping	SM	Configuration/NAT	yes
VPN "pass through" for L2TP over IPSec (but not PPTP)		no	no
NAT statistics	SM	Statistics/NAT Stats	yes
NAT DHCP statistics	SM	Statistics/NAT DHCP Statistics	yes
NAT table	SM	Logs/NAT Table	no
Filtering Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Protocol filtering based on protocol	SM	Configuration/Protocol Filtering	yes
Operator-defined port filtering (3 ports)	SM	Configuration/Protocol Filtering	yes
Packet filter statistics	All radios	Statistics/Filter	yes

VLAN Management Features	Module Type(s)	Controlled in GUI Page/Tab	SNMP Control
Configurable VLAN	AP SM CMMmicro	Configuration/VLAN	yes
Highly configurable VLAN (802.1Q)	AP SM	Configuration/VLAN	yes
Use of VLAN priorities (802.1p) with high priority channel	AP SM	no	yes
Port-based VLAN switching on CMM	CMMmicro	Configuration	yes
VLAN statistics	AP SM	Statistics/VLAN	yes
Dynamic Frequency Selection (DFS) Feature	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
DFS v1.2.3	All radios	no	yes
Time Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Time and Date from CMM via Network Time Protocol (NTP) server	AP BHM	Configuration/Time	yes
Time and Date manually settable	AP BHM	Configuration/Time	yes
CMM provides NTP server	CMMmicro	no	no
Spectrum Analyzer Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Spectrum analyzer	SM BHS	Tools/Spectrum Analyzer	no
Ability to switch an AP to an SM (or BHS to BHM)	AP BHM	Configuration/General	yes
Aim/Link Quality Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Alignment tone for using during aiming/alignment	SM BHS	no	no
Aiming support page when not using alignment tone	SM BHS	Tools/Alignment	multiple objects
LED for alignment	SM BHS	no	no
Configure SM power-up state - aiming or operational	SM BHS	Configuration/General	yes
Link capacity test, with configurable packet length	All radios	Tools/Link Capacity Test	yes
Display of SM configuration information at AP	AP BHM	Home/Session Status	yes
Display/evaluation of AP beacon data from all receivable APs	SM BHS	Tools/AP Evaluation	yes
Over-the-air radio Bit Error Rate (BER) indicator	All radios	Tools/BER Results	yes

Frame Tool Feature	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Frame calculator for supporting collocation	All radios	Tools/Frame Calculator	no
Personal Digital Assistant (PDA) Interface Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
GUI automatically sized/styled for PDA when displayed on a PDA	All radios	all	no
Spectrum analyzer display for PDA	All radios	PDA/Spectrum Results (PDA)	no
Specific pages for PDA display	All radios	PDA	no
SNMP Interface Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Support of SNMP v2	All modules	no	no
Cyclone Enterprise MIB	All modules	no	no
Configurable SNMP community string	All radios	Configuration/SNMP	yes
Configurable SNMP accessing subnet	All radios	Configuration/SNMP	yes
10 configurable SNMP trap addresses	All radios	Configuration/SNMP	yes
Configurable traps (sync and session)	All radios	Configuration/SNMP	yes
Configurable SNMP permissions (read, read/write)	All radios	Configuration/SNMP	yes
Configurable site information, including site name	All modules	Configuration/SNMP	yes
Upgrade Process Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
Upgrading using CNUT and SM Auto-update for SMs	All modules	no	no
Configurable update address to support distributed software upgrades	AP	Configuration/General	yes
AP Cluster Management Features	**Module Type(s)**	**Controlled in GUI Page/Tab**	**SNMP Control**
CMM port power control	CMMmicro	Configuration	yes
CMM port reset	CMMmicro	Configuration	yes
CMM: Sufficient ports for at least 4 AP, 2 BH, plus management	CMMmicro	no	no
CMM: Sufficient power for at least 4 AP plus 2 BH	CMMmicro	no	no
Powered from 90-264 VAC, 50/60 Hz; 55 V DC power output	AP BH	no	no

Physical Features	Module Type(s)	Controlled in GUI Page/Tab	SNMP Control
MTBF > 45 years (~400 000 hours)	All modules	no	no
neg 40 C to + 55 C (Ambient) operation	All modules	no	no
Temperature indication	All radios	Home/General	no
Non-condensing (Indoor/outdoor), weather protected form factor/packaging	All modules	no	no
Element Management System (Prizm) Features			
Current Prizm to manage all elements of the system (including Mot Backhaul)			
Up to 1000 APs, plus 100 devices/AP); minimal storage / minimal polling			
Redundant configuration for additional storage/reporting capability			
Commercial Off the Shelf (COTS) Platform and OS support (e.g. Intel, Linux, Windows)			
COTS Database support (e.g. MySQL, PostgreSQL, MS SQL Server, etc..); Oracle optional			

10.1 ACTIVATING FEATURES

A Cyclone feature is active if the software that allows the feature to be turned on or off (enabled or disabled) is present.

10.1.1 Fixed License Keys

Some features are activated by loading a fixed license key into the radio. Such a key arrives from Last Mile Gear as a *filename*`.url` file. When you double-click on this file, your browser opens and the location bar is populated by a lengthy string. This URL string begins with `http://`*<ModuleIPAddress>*`/`. If you need to load a key into a module whose IP address has changed since Last Mile Gear issued the key, perform the following steps.

Procedure 1: Modifying a fixed license key for a module IP address

1. Right-click on the license key filename.
2. Select **Properties**.
3. Select the **Web Document** tab.
4. At **URL**, substitute the current IP address for the original IP address in the URL.
5. Click **OK**.
6. Double-click on the license key filename.
   RESULT: The key loads into the module.

7. Open the Configuration web page of the module.
8. Review parameter settings and enable the feature if you wish to do so at this time (see next section).

end of procedure

10.2 ENABLING FEATURES

A Cyclone feature is enabled (functioning) if the feature is both active and enabled. For example, Transmit Frame Spreading is active (*can be* enabled) in any AP or BHM that operates on Release 8. However, Transmit Frame Spreading functions only if the **Enable** selection for the **Transmit Frame Spreading** parameter is checked in the Radio tab of the Configuration web page in the module.

11 ACQUIRING PROFICIENCIES

Designing and operating a Cyclone network requires fundamental knowledge of radio frequency transmission and reception, Internet Protocol addressing schemes, experimentation with Cyclone equipment, and for most operators participation in some forms of Cyclone training.

11.1 UNDERSTANDING RF FUNDAMENTALS

Cyclone training and user interfaces presume an understanding of RF fundamentals. Excellent written sources for these fundamentals are available. One such source is *Deploying License-Free Wireless Wide-Area Networks* by Jack Unger (ISBN 1-58705-069-2), published by Cisco Press.

11.2 UNDERSTANDING IP FUNDAMENTALS

Cyclone training and user interfaces also presume an understanding of Internet Protocol (IP) fundamentals. Excellent written sources for these fundamentals are available. One such source is *Sams Teach Yourself TCP/IP in 24 Hours* by Joe Casad (ISBN 0-672-32085-1), published by Sams Publishing.

NOTE:
The default IP address of each Cyclone component is 169.254.1.1.

11.3 ACQUIRING A CYCLONE DEMONSTRATION KIT

Cyclone Demonstration Kits are available through your Cyclone representative.

11.3.1 900-MHz with Integrated Antenna and Band-pass Filter Demonstration Kit

Each 900-MHz with integrated antenna and band-pass filter Demonstration Kit contains

- 2 9000SM SMs
- 1 9000APF AP
- 1 300SS Surge Suppressor
- 3 ACPSSW-02 90- to 230-V AC 50- to 60-Hz Power Supplies
- 3 CBL-0562 Straight-through Category 5 Cables
- 1 UGTK-0002 Trial Kit Quick Start Guide
- 1 CPT001-CD02EN Sales Overview on CD
- 1 CPT002-CD03EN Technical Overview on CD
- 1 CPT003-CD03EN Cyclone User Guides on CD

Part numbers for Demonstration Kits are provided in Table 27.

11.3.2 900-MHz with Connectorized Antenna Demonstration Kit

Each 900-MHz with connectorized (external) antenna Demonstration Kit contains

- 2 9000SMC SMs
- 1 9000APC AP
- 3 AN900 60° 9-dBi Antennas
- 1 300SS Surge Suppressor
- 1 SMMB2 Universal Heavy Duty Mounting Bracket
- 3 ACPSSW-02 90- to 230-V AC 50- to 60-Hz Power Supplies
- 3 CBL-0562 Straight-through Category 5 Cables
- 1 UGTK-0002 Trial Kit Quick Start Guide
- 1 CPT001-CD02EN Sales Overview on CD
- 1 CPT002-CD03EN Technical Overview on CD
- 1 CPT003-CD03EN Cyclone User Guides on CD

Part numbers for Demonstration Kits are provided in Table 27.

11.3.3 2.4-GHz with Adjustable Power Set to Low Demonstration Kit

Each 2.4-GHz with adjustable power set to low Demonstration Kit contains

- 1 2400SMWL SM
- 1 2450SMWL Advantage SM
- 1 2450APWL Advantage AP
- 1 300SS Surge Suppressor
- 1 SMMB1 Universal Mounting Bracket
- 3 ACPSSW-02 90- to 230-V AC 50- to 60-Hz Power Supplies
- 3 CBL-0562 Straight-through Category 5 Cables
- 1 UGTK-0002 Trial Kit Quick Start Guide
- 1 CPT001-CD02EN Sales Overview on CD
- 1 CPT002-CD03EN Technical Overview on CD
- 1 CPT003-CD03EN Cyclone User Guides on CD

Part numbers for Demonstration Kits are provided in Table 27.

11.3.4 2.4-GHz with Adjustable Power Set to High Demonstration Kit

Each 2.4-GHz with adjustable power set to high Demonstration Kit contains

- 1 2400SM SM
- 1 2450SM Advantage SM
- 1 2450AP Advantage AP
- 1 300SS Surge Suppressor
- 1 SMMB1 Universal Mounting Bracket
- 3 ACPSSW-02 90- to 230-V AC 50- to 60-Hz Power Supplies
- 3 CBL-0562 Straight-through Category 5 Cables
- 1 UGTK-0002 Trial Kit Quick Start Guide

- 1 CPT001-CD02EN Sales Overview on CD
- 1 CPT002-CD03EN Technical Overview on CD
- 1 CPT003-CD03EN Cyclone User Guides on CD

Part numbers for Demonstration Kits are provided in Table 27.

11.3.5 5.1-GHz Demonstration Kit

Each 5.1-GHz Demonstration Kit contains

- 1 5202SM SM
- 1 5252SM Advantage SM
- 1 5252AP Advantage AP
- 1 300SS Surge Suppressor
- 1 SMMB1 Universal Mounting Bracket
- 3 ACPSSW-02 90- to 230-V AC 50- to 60-Hz Power Supplies
- 3 CBL-0562 Straight-through Category 5 Cables
- 1 UGTK-0002 Trial Kit Quick Start Guide
- 1 CPT001-CD02EN Sales Overview on CD
- 1 CPT002-CD03EN Technical Overview on CD
- 1 CPT003-CD03EN Cyclone User Guides on CD

Part numbers for Demonstration Kits are provided in Table 27.

11.3.6 5.2-GHz Demonstration Kit

Each 5.2-GHz Demonstration Kit contains

- 1 5200SM SM
- 1 5250SM Advantage SM
- 1 5250AP Advantage AP
- 1 300SS Surge Suppressor
- 1 SMMB1 Universal Mounting Bracket
- 3 ACPSSW-02 90- to 230-V AC 50- to 60-Hz Power Supplies
- 3 CBL-0562 Straight-through Category 5 Cables
- 1 UGTK-0002 Trial Kit Quick Start Guide
- 1 CPT001-CD02EN Sales Overview on CD
- 1 CPT002-CD03EN Technical Overview on CD
- 1 CPT003-CD03EN Cyclone User Guides on CD

Part numbers for Demonstration Kits are provided in Table 27.

11.3.7 5.4-GHz Demonstration Kit

Each 5.4-GHz Demonstration Kit contains

- 1 5400SM SM
- 1 5450SM Advantage SM
- 1 5450AP Advantage AP

- 1 300SS Surge Suppressor
- 1 SMMB1 Universal Mounting Bracket
- 3 ACPSSW-02 90- to 230-V AC 50- to 60-Hz Power Supplies
- 3 CBL-0562 Straight-through Category 5 Cables
- 1 UGTK-0002 Trial Kit Quick Start Guide
- 1 CPT001-CD02EN Sales Overview on CD
- 1 CPT002-CD03EN Technical Overview on CD
- 1 CPT003-CD03EN Cyclone User Guides on CD

Part numbers for Demonstration Kits are provided in Table 27.

11.3.8 5.7-GHz with Integrated Antenna Demonstration Kit

Each 5.7-GHz with integrated antenna Demonstration Kit contains

- 1 5700SM SM
- 1 5750SM Advantage SM
- 1 5750AP Advantage AP
- 1 300SS Surge Suppressor
- 1 SMMB1 Universal Mounting Bracket
- 3 ACPSSW-02 90- to 230-V AC 50- to 60-Hz Power Supplies
- 3 CBL-0562 Straight-through Category 5 Cables
- 1 UGTK-0002 Trial Kit Quick Start Guide
- 1 CPT001-CD02EN Sales Overview on CD
- 1 CPT002-CD03EN Technical Overview on CD
- 1 CPT003-CD03EN Cyclone User Guides on CD

Part numbers for Demonstration Kits are provided in Table 27.

11.3.9 5.7-GHz with Connectorized Antenna and Adjustable Power Set to Low

Each 5.7-GHz with connectorized antenna and adjustable power set to low Demonstration Kit contains

- 1 5700SMC SM
- 1 5750SMC Advantage SM
- 1 5750APC Advantage AP
- 1 300SS Surge Suppressor
- 1 SMMB2 Universal Heavy Duty Mounting Bracket
- 3 ACPSSW-02 90- to 230-V AC 50- to 60-Hz Power Supplies
- 3 CBL-0562 Straight-through Category 5 Cables
- 1 UGTK-0002 Trial Kit Quick Start Guide
- 1 CPT001-CD02EN Sales Overview on CD
- 1 CPT002-CD03EN Technical Overview on CD
- 1 CPT003-CD03EN Cyclone User Guides on CD

Part numbers for Demonstration Kits are provided in Table 27.

11.3.10 Demonstration Kit Part Numbers

The part numbers for ordering Cyclone demonstration kits are provided in Table 27.

Table 27: Demonstration Kit part numbers

Frequency Band Range	Part Number
900 MHz integrated antenna with band-pass filter	TK10290
900 MHz connectorized antenna	TK10290C
2.4 GHz adjustable power set to low	TK10250
2.4 GHz adjustable power set to high	TK10251
5.1 GHz	TK10253
5.2 GHz	TK10252
5.4 GHz	TK10254
5.7 GHz	TK10257
5.7 GHz connectorized adjustable power set to low	TK10257C

11.4 ACQUIRING A CYCLONE STARTER KIT

Cyclone Starter Kits are also available through your Cyclone representative.

11.4.1 900-MHz with Integrated Antenna and Band-pass Filter Starter Kit

Each 900-MHz with integrated antenna and band-pass filters Starter Kit contains

- 20 9000SM SMs
- 3 9000APF Advantage APs
- 1 1070CK CMMmicro
- 21 300SS Surge Suppressors
- 1 UGSK-0003 Quick Start Guide
- 1 CPT003-CD03EN Cyclone User Guides on CD

Power supplies and SM mounting brackets *are not* included in this kit. Part numbers for Starter Kits are provided in Table 28.

11.4.2 900-MHz with Connectorized Antenna Starter Kit

Each 900-MHz with connectorized (external) antenna Starter Kit contains

- 20 9000SMC SMs
- 3 9000APC Advantage APs
- 23 AN900 60° 9-dBi Antennas
- 1 1070CK CMMmicro
- 21 300SS Surge Suppressors
- 20 SMMB2 Universal Heavy Duty Mounting Brackets
- 1 UGSK-0003 Quick Start Guide
- 1 CPT003-CD03EN Cyclone User Guides on CD

Power supplies *are not* included in this kit. Part numbers for Starter Kits are provided in Table 28.

11.4.3 2.4-GHz with Adjustable Power Set to Low Starter Kit

Each 2.4-GHz with adjustable power set to low Starter Kit contains

- 30 2400SMWL SMs
- 6 2450APWL Advantage APs
- 1 1070CK CMMmicro
- 31 300SS Surge Suppressors
- 30 SMMB1 Universal Mounting Brackets
- 1 UGSK-0003 Quick Start Guide
- 1 CPT003-CD03EN Cyclone User Guides on CD

Power supplies *are not* included in this kit. Part numbers for Starter Kits are provided in Table 28.

11.4.4 2.4-GHz with Adjustable Power Set to High Starter Kit

Each 2.4-GHz adjustable power set to high Starter Kit contains

- 30 2400SM SMs
- 6 2450AP Advantage APs
- 1 1070CK CMMmicro
- 31 300SS Surge Suppressors
- 30 SMMB1 Universal Mounting Brackets
- 1 UGSK-0003 Quick Start Guide
- 1 CPT003-CD03EN Cyclone User Guides on CD

Power supplies *are not* included in this kit. Part numbers for Starter Kits are provided in Table 28.

11.4.5 5.1-GHz Starter Kit

Each 5.1-GHz adjustable power set to high Starter Kit contains

- 30 5202SM SMs
- 6 5252AP Advantage APs
- 1 1070CK CMMmicro
- 31 300SS Surge Suppressors
- 30 SMMB1 Universal Mounting Brackets
- 1 UGSK-0003 Quick Start Guide
- 1 CPT003-CD03EN Cyclone User Guides on CD

Power supplies *are not* included in this kit. Part numbers for Starter Kits are provided in Table 28.

11.4.6 5.2-GHz Starter Kit

Each 5.2-GHz Starter Kit contains

- 30 5200SM SMs
- 6 5250AP Advantage APs
- 1 1070CK CMMmicro
- 31 300SS Surge Suppressors
- 30 SMMB1 Universal Mounting Brackets
- 1 UGSK-0003 Quick Start Guide
- 1 CPT003-CD03EN Cyclone User Guides on CD

Power supplies *are not* included in this kit. Part numbers for Starter Kits are provided in Table 28.

11.4.7 5.4-GHz Starter Kit

Each 5.4-GHz Starter Kit contains

- 30 5400SM SMs
- 6 5450AP Advantage APs
- 1 1070CK CMMmicro
- 31 300SS Surge Suppressors
- 30 SMMB1 Universal Mounting Brackets
- 1 UGSK-0003 Quick Start Guide
- 1 CPT003-CD02EN Cyclone System User Guide on CD

Power supplies *are not* included in this kit. Part numbers for Starter Kits are provided in Table 28.

11.4.8 5.7-GHz with Integrated Antenna Starter Kit

Each 5.7-GHz with integrated antenna Starter Kit contains

- 30 5700SM SMs
- 6 5750AP Advantage APs
- 1 1070CK CMMmicro
- 31 300SS Surge Suppressors
- 30 SMMB1 Universal Mounting Brackets
- 1 UGSK-0003 Quick Start Guide
- 1 CPT003-CD03EN Cyclone User Guides on CD

Power supplies *are not* included in this kit. Part numbers for Starter Kits are provided in Table 28.

11.4.9 5.7-GHz with Connectorized Antenna and Adjustable Power Set to Low

Each 5.7-GHz with connectorized antenna and adjustable power set to low Starter Kit contains

- 30 5700SMC SMs
- 6 5750APC Advantage APs
- 1 1070CK CMMmicro
- 31 300SS Surge Suppressors
- 30 SMMB1 Universal Mounting Brackets
- 1 UGSK-0003 Quick Start Guide
- 1 CPT003-CD03EN Cyclone User Guides on CD

Power supplies *are not* included in this kit. Part numbers for Starter Kits are provided in Table 28.

11.4.10 Starter Kit Part Numbers

The part numbers for ordering Cyclone Starter kits are provided in Table 28.

Table 28: Starter Kit part numbers

Frequency Band Range	Part Number
900 MHz integrated antenna with band-pass filter	TK10190
900 MHz connectorized	TK10190C
2.4 GHz adjustable power set to low	TK10150
2.4 GHz adjustable power set to high	TK10151
5.1 GHz	TK10153
5.2 GHz	TK10152
5.4 GHz	TK10154

Frequency Band Range	Part Number
5.7 GHz	TK10157
5.7 GHz connectorized adjustable power set to low	TK10157C

11.5 EVALUATING CYCLONE TRAINING OPTIONS

Cyclone and its distributors make technical training available to customers. For information on this training, either

- send email inquiries to training@Cyclonewireless.com.
- visit http://www.Last Mile Gear.com/Cyclone. Under Contact Us, select **Request Product Info**, select **Product Info**, then under Support, select **Training**.

11.6 ATTENDING ON-LINE KNOWLEDGE SESSIONS

Irregularly but often, Cyclone presents a knowledge session over the Internet about a new product offering. Some of these knowledge sessions provide the opportunity for participants to interact in real time with the leader of the session.

The knowledge session

- provides a high-level understanding of the technology that the new product introduces.
- announces any subtleties and caveats.
- typically includes a demonstration of the product.
- is usually recorded for later viewing by those who could not attend in real time.

To participate in upcoming knowledge sessions, ask your Cyclone representative to ensure that you receive email notifications.

PLANNING GUIDE

12 ENGINEERING YOUR RF COMMUNICATIONS

Before diagramming network layouts, the wise course is to

- anticipate the correct amount of signal loss for your fade margin calculation (as defined below).
- recognize all permanent and transient RF signals in the environment.
- identify obstructions to line of sight reception.

12.1 ANTICIPATING RF SIGNAL LOSS

The C/I (Carrier-to-Interference) ratio defines the strength of the intended signal relative to the collective strength of all other signals. Cyclone modules typically do not require a C/I ratio greater than

- 3 dB or less at 10-Mbps modulation and −65 dBm for 1X operation. The C/I ratio that you achieve must be even greater as the received power approaches the nominal sensitivity (−85 dBm for 1X operation).
- 10 dB or less at 10-Mbps modulation and −65 dBm for 2X operation. The C/I ratio that you achieve must be even greater as the received power approaches the nominal sensitivity (−79 dBm for 2X operation).
- 10 dB or less at 20-Mbps modulation.

12.1.1 Understanding Attenuation

An RF signal in space is attenuated by atmospheric and other effects as a function of the distance from the initial transmission point. The further a reception point is placed from the transmission point, the weaker is the received RF signal.

12.1.2 Calculating Free Space Path Loss

The attenuation that distance imposes on a signal is the free space path loss. PathLossCalcPage.xls calculates free space path loss.

12.1.3 Calculating Rx Signal Level

The Rx sensitivity of each module is provided at http://Last Mile Gear.Cyclonewireless.com/prod_specs.php. The determinants in Rx signal level are illustrated in Figure 31.

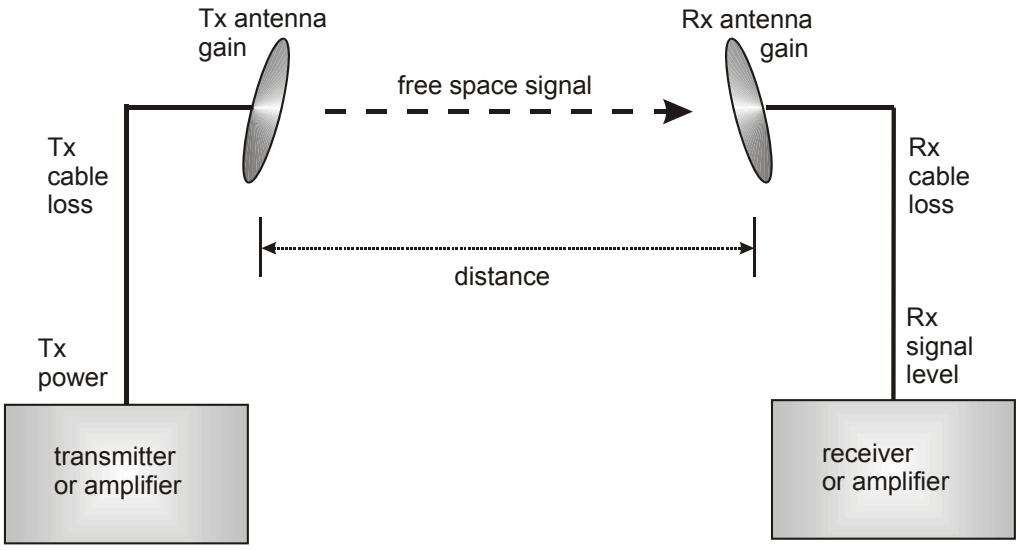


Figure 31: Determinants in Rx signal level

Rx signal level is calculated as follows:

`Rx signal level dB = Tx power – Tx cable loss + Tx antenna gain – free space path loss + Rx antenna gain – Rx cable loss`

> ***NOTE:***
> This Rx signal level calculation presumes that a clear line of sight is established between the transmitter and receiver and that no objects encroach in the Fresnel zone.

12.1.4 Calculating Fade Margin

Free space path loss is a major determinant in Rx (received) signal level. Rx signal level, in turn, is a major factor in the system operating margin (fade margin), which is calculated as follows:

`system operating margin (fade margin) dB =Rx signal level dB – Rx sensitivity dB`

Thus, fade margin is the difference between strength of the received signal and the strength that the receiver requires for maintaining a reliable link. A higher fade margin is characteristic of a more reliable link.

12.2 ANALYZING THE RF ENVIRONMENT

An essential element in RF network planning is the analysis of spectrum usage and the strength of the signals that occupy the spectrum you are planning to use. Regardless of how you measure and log or chart the results you find (through the Spectrum Analyzer in SM and BHS feature or by using a spectrum analyzer), you should do so

- at various times of day.
- on various days of the week.
- periodically into the future.

As new RF neighbors move in or consumer devices in your spectrum proliferate, this will keep you aware of the dynamic possibilities for interference with your network.

12.2.1 Mapping RF Neighbor Frequencies

Cyclone modules allow you to

- use an SM or BHS (or a BHM reset to a BHS), or an AP that is temporarily transformed into an SM, as a spectrum analyzer.
- view a graphical display that shows power level in RSSI and dBm at 5-MHz increments throughout the frequency band range, regardless of limited selections in the **Custom Radio Frequency Scan Selection List** parameter of the SM.
- select an AP channel that minimizes interference from other RF equipment.

The SM measures only the spectrum of its manufacture. So if, for example, you wish to analyze an area for both 2.4- and 5.7-GHz activity, take both a 2.4- and 5.7-GHz SM to the area. To enable this functionality, perform the following steps:

CAUTION!

The following procedure causes the SM to drop any active RF link. If a link is dropped when the spectrum analysis begins, the link can be re-established when either a 15-minute interval has elapsed or the spectrum analyzer feature is disabled.

Procedure 2: Analyzing the spectrum

1. Predetermine a power source and interface that will work for the SM or BHS in the area you want to analyze.
2. Take the SM or BHS, power source, and interface device to the area.
3. Access the Tools web page of the SM or BHS.
   RESULT: The Tools page opens to its Spectrum Analyzer tab. An example of this tab is shown in Figure 137.
4. Click **Enable**.
   RESULT: The feature is enabled.

5. Click **Enable** again.
   RESULT: The system measures RSSI and dBm for each frequency in the spectrum.
6. Travel to another location in the area.
7. Click **Enable** again.
   RESULT: The system provides a new measurement of RSSI and dBm for each frequency in the spectrum.
   NOTE: Spectrum analysis mode times out 15 minutes after the mode was invoked.
8. Repeat Steps 6 and 7 until the area has been adequately scanned and logged.

end of procedure

As with any other data that pertains to your business, a decision today to put the data into a retrievable database may grow in value to you over time.

RECOMMENDATION:
Wherever you find the measured noise level is greater than the sensitivity of the radio that you plan to deploy, use the noise level (rather than the link budget) for your link feasibility calculations.

12.2.2 Anticipating Reflection of Radio Waves

In the signal path, any object that is larger than the wavelength of the signal can reflect the signal. Such an object can even be the surface of the earth or of a river, bay, or lake. The wavelength of the signal is approximately

- 2 inches for 5.2- and 5.7-GHz signals.
- 5 inches for 2.4-GHz signals.
- 12 inches for 900-MHz signals.

A reflected signal can arrive at the antenna of the receiver later than the non-reflected signal arrives. These two or more signals cause the condition known as multipath. When multipath occurs, the reflected signal cancels part of the effect of the non-reflected signal so, overall, attenuation beyond that caused by link distance occurs. This is problematic at the margin of the link budget, where the standard operating margin (fade margin) may be compromised.

12.2.3 Noting Possible Obstructions in the Fresnel Zone

The Fresnel (pronounced *fre·NEL*) Zone is a theoretical three-dimensional area around the line of sight of an antenna transmission. Objects that penetrate this area can cause the received strength of the transmitted signal to fade. Out-of-phase reflections and absorption of the signal result in signal cancellation.

The foliage of trees and plants in the Fresnel Zone can cause signal loss. Seasonal density, moisture content of the foliage, and other factors such as wind may change the amount of loss. Plan to perform frequent and regular link tests if you must transmit though foliage.

12.2.4 Radar Signature Detection and Shutdown

With Release 8.1, Cyclone meets ETSI EN 301 893 v1.2.3 for Dynamic Frequency Selection (DFS). DFS is a requirement in certain countries of the EU for systems like Cyclone to detect interference from other systems, notably radar systems, and to avoid co-channel operation with these systems. All 5.4 GHz modules and all 5.7 GHz Connectorized modules running Release 8.1 have DFS. Other modules running Release 8.1 do not. With Release 8.1, Canopy SMs and BHSs as well as Cyclone APs and BHMs will detect radar systems.

When an AP or BHM enabled for DFS boots, it receives for 1 minute, watching for the radar signature, without transmitting. If no radar pulse is detected during this minute, the module then proceeds to normal beacon transmit mode. If it does detect radar, it waits for 30 minutes without transmitting, then watches the 1 minute, and will wait again if it detects radar. If while in operation, the AP or BHM detects the radar signature, it will cease transmitting for 30 minutes and then begin the 1 minute watch routine. Since an SM or BHS only transmits if it is receiving beacon from an AP or BHM, the SMs in the sector or BHS are also not transmitting when the AP or BHM is not transmitting.

When an SM or BHS with DFS boots, it scans to see if an AP or BHM is present (if it can detect a Cyclone beacon). If an AP or BHM is found, the SM or BHS receives on that frequency for 1 minute to see if the radar signature is present. For an SM, if no radar pulse is detected during this 1 minute, the SM proceeds through normal steps to register to an AP. For a BHS, if no radar pulse is detected during this 1 minute, it registers, and as part of registering and ranging watches for the radar signature for another 1 minute. If the SM or BH does detect radar, it locks out that frequency for 30 minutes and continues scanning other frequencies in its scan list.

Note, after an SM or BHS has seen a radar signature on a frequency and locked out that frequency, it may connect to a different AP or BHM, if color codes, transmitting frequencies, and scanned frequencies support that connection.

For all modules, the module displays its DFS state on its General Status page. You can read the DFS status of the radio in the General Status tab of the Home page as one of the following:

- `Normal Transmit`
- `Radar Detected Stop Transmitting for` *`n`* `minutes`, where n counts down from 30 to 1.
- `Checking Channel Availability Remaining time` *`n`* `seconds`, where n counts down from 60 to 1. This indicates that a 30-minute shutdown has expired and the one-minute re-scan that follows is in progress.

DFS can be enabled or disabled on a module's Radio page: Configuration > Radio > DFS.

Operators in countries with regulatory requirements for DFS must not disable the feature and must ensure it is enabled after a module is reset to factory defaults.

Operators in countries without regulatory requirements for DFS will most likely not want to use the feature, as it adds no value if not required, and adds an additional 1 minute to the connection process for APs, BHMs, and SMs, and 2 minutess for BHSs.

-

RECOMMENDATION:
Where regulations require that radar sensing and radio shutdown is enabled, you can most effectively share the spectrum with satellite services if you perform spectrum analysis and select channels that are distributed evenly across the frequency band range.

A connectorized 5.7-GHz module provides an **Antenna Gain** parameter. When you indicate the gain of your antenna in this field, the algorithm calculates the appropriate sensitivity to radar signals, and this reduces the occurrence of false positives (wherever the antenna gain is less than the maximum).

12.3 USING JITTER TO CHECK RECEIVED SIGNAL QUALITY (CYCLONE FSK ONLY)

The General Status tab in the Home page of the Canopy SM and BHS displays current values for **Jitter**, which is essentially a measure of interference. Interpret the jitter value as indicated in Table 29.

Table 29: Signal quality levels indicated by jitter

Signal Modulation	Correlation of Highest Seen Jitter to Signal Quality		
	High Quality	Questionable Quality	Poor Quality
1X operation (2-level FSK)	0 to 4	5 to 14	15
2X operation (4-level FSK)	0 to 9	10 to 14	15

In your lab, an SM whose jitter value is constant at 14 may have an incoming packet efficiency of 100%. However, a deployed SM whose jitter value is 14 is likely to have even higher jitter values as interfering signals fluctuate in strength over time. So, *do not* consider 14 to be acceptable. Avoiding a jitter value of 15 should be the highest priority in establishing a link. At 15, jitter causes fragments to be dropped and link efficiency to suffer.

Cyclone modules calculate jitter based on both interference and the modulation scheme. For this reason, values on the low end of the jitter range that are significantly higher in 2X operation can still be indications of a high quality signal. For example, where the amount of interference remains constant, an SM with a jitter value of 3 in 1X operation can display a jitter value of 7 when enabled for 2X operation.

However, on the high end of the jitter range, *do not* consider the higher values in 2X operation to be acceptable. This is because 2X operation is much more susceptible to problems from interference than is 1X. For example, where the amount of interference remains constant, an SM with a jitter value of 6 in 1X operation can display a jitter value of 14 when enabled for 2X operation. As indicated in Table 29, these values are unacceptable.

Cyclone OFDM uses a different modulation scheme and does not display a jitter value.

12.4 USING LINK EFFICIENCY TO CHECK RECEIVED SIGNAL QUALITY

A link test, available in the Link Capacity Test tab of the Tools web page in an AP or BH, provides a more reliable indication of received signal quality, particularly if you launch tests of varying duration. However, a link test interrupts traffic and consumes system capacity, so *do not* routinely launch link tests across your networks.

12.4.1 Comparing Efficiency in 1X Operation to Efficiency in 2X Operation

Efficiency of at least 98 to 100% indicates a high quality signal. Check the signal quality numerous times, at various times of day and on various days of the week (as you checked the RF environment a variety of times by spectrum analysis before placing radios in the area). Efficiency less than 90% in 1X operation or less than 60% in 2X operation indicates a link with problems that require action.

12.4.2 When to Switch from 2X to 1X Operation Based on 60% Link Efficiency

In the above latter case (60% in 2X operation), the link experiences worse latency (from packet resends) than it would in 1X operation, but still greater capacity, if the link remains stable at 60% Efficiency. Downlink Efficiency and Uplink Efficiency are measurements produced by running a link test from either the SM or the AP. Examples of what action should be taken based on Efficiency in 2X operation are provided in Table 30.

Table 30: Recommended courses of action based on Efficiency in 2X operation

Module Types	Further Investigation	Result	Recommended Action
Advantage AP with Advantage SM	Check the General Status tab of the Advantage SM.[1] See Checking the Status of 2X Operation on Page 92.	Uplink and downlink are both ≥60% Efficiency.[2]	Rerun link tests.
	Rerun link tests.	Uplink and downlink are both ≥60% Efficiency.	Optionally, re-aim SM, add a reflector, or otherwise mitigate interference. In any case, continue 2X operation up and down.

Module Types	Further Investigation	Result	Recommended Action
Advantage AP with Canopy SM	Check the General Status tab of the Canopy SM.[1] See Checking the Status of 2X Operation on Page 92.	Uplink and downlink are both ≥60% Efficiency.[2]	Rerun link tests.
	Rerun link tests.	Uplink and downlink are both ≥60% Efficiency.	Optionally, re-aim SM, add a reflector, or otherwise mitigate interference. In any case, continue 2X operation up and down.
		Results are inconsistent and range from 20% to 80% Efficiency.	Monitor the Session Status tab in the Advantage AP.
	Monitor the Session Status tab in the Advantage AP.	Link fluctuates between 2X and 1X operation.[3]	Optionally, re-aim SM, add a reflector, or otherwise mitigate interference. Then rerun link tests.
	Rerun link tests.	No substantial improvement with consistency is seen.	On the General tab of the SM, disable 2X operation. Then rerun link tests.
	Rerun link tests.	Uplink and downlink are both ≥90% Efficiency.	Continue 1X operation up and down.

NOTES:

1. Or check Session Status page of the Advantage AP, where a sum of greater than 7,000,000 bps for the up- and downlink indicates 2X operation up and down (for 2.4- or 5.x-GHz modules.
2. For throughput to the SM, this is equivalent to 120% Efficiency in 1X operation, with less capacity used at the AP.
3. This link is problematic.

12.5 CONSIDERING FREQUENCY BAND ALTERNATIVES

For 5.2-, 5.4-, and 5.7-GHz modules, 20-MHz wide channels are centered every 5 MHz. For 2.4-GHz modules, 20-MHz wide channels are centered every 2.5 MHz. For Cyclone OFDM, the operator can configure center channel frequencies of the 10 MHz channels with a granularity of 0.5 MHz.This allows the operator to customize the channel layout for interoperability where other Cyclone equipment is collocated.

Cross-band deployment of APs and BH is the recommended alternative (for example, a 5.2-GHz AP collocated with 5.7-GHz BH).

IMPORTANT!

In all cases, channel center separation between collocated Cyclone FSK modules should be at least 20 MHz for 1X operation and 25 MHz for 2X. For Cyclone OFDM, channel center separation between collocated modules should be at least XX MHz for 1X operation, XX for 2 X operation, and XX for 3X operation.

12.5.1 900-MHz Channels

900-MHz AP Available Channels

A 900-MHz AP can operate with its 8-MHz wide channel centered on any of the following frequencies:

(All Frequencies in MHz)

906	909	912	915	918	922
907	910	913	916	919	923
908	911	914	917	920	924

900-MHz AP Cluster Recommended Channels

Three non-overlapping channels are recommended for use in a 900-MHz AP cluster:

(All Frequencies in MHz)

906	915	924

This recommendation allows 9 MHz of separation between channel centers. You can use the Spectrum Analysis feature in an SM, or use a standalone spectrum analyzer, to evaluate the RF environment. In any case, ensure that the 8-MHz wide channels you select *do not* overlap.

12.5.2 2.4-GHz Channels

2.4-GHz BHM and AP Available Channels

A 2.4-GHz BHM or AP can operate with its 20-MHz wide channel centered on any of the following channels, which are separated by only 2.5-MHz increments.

(All Frequencies in GHz)

2.4150	2.4275	2.4400	2.4525
2.4175	2.4300	2.4425	2.4550
2.4200	2.4325	2.4450	2.4575
2.4225	2.4350	2.4475	
2.4250	2.4375	2.4500	

The center channels of *adjacent* 2.4-GHz APs should be separated by at least 20 MHz.

2.4-GHz AP Cluster Recommended Channels

Three non-overlapping channels are recommended for use in a 2.4-GHz AP cluster:

(All Frequencies in GHz)

2.4150	2.4350	2.4575

This recommendation allows 20 MHz of separation between one pair of channels and 22.5 MHz between the other pair. You can use the Spectrum Analysis feature in an SM or BHS, or use a standalone spectrum analyzer, to evaluate the RF environment. Where spectrum analysis identifies risk of interference for any of these channels, you can compromise this recommendation as follows:

- Select 2.4375 GHz for the middle channel
- Select 2.455 GHz for the top channel
- Select 2.4175 GHz for the bottom channel

In any case, ensure that your plan allows at least 20 MHz of separation between channels.

12.5.3 5.2-GHz Channels

Channel selections for the AP in the 5.2-GHz frequency band range depend on whether the AP is deployed in cluster.

5.2-GHz BH and Single AP Available Channels

A BH or a single 5.2-GHz AP can operate in the following channels, which are separated by 5-MHz increments.

(All Frequencies in GHz)

5.275	5.290	5.305	5.320
5.280	5.295	5.310	5.325
5.285	5.300	5.315	

The center channels of *adjacent* APs should be separated by at least 20 MHz. However, 25 MHz of separation is advised, especially for Advantage APs to take advantage of 2X operation.

5.2-GHz AP Cluster Recommended Channels

Three non-overlapping channels are recommended for use in a 5.2-GHz AP cluster:

(All Frequencies in GHz)

5.275	5.300	5.325

12.5.4 5.4-GHz Channels

Channel selections for the AP in the 5.4-GHz frequency band range depend on whether the AP is deployed in cluster.

5.4-GHz BH and Single AP Available

A BH or single 5.4-GHz AP can operate in the following channels, which are separated by 5-MHz.

(All Frequencies in GHz)

5495	5515	5535	5555	5575	5595	5615	5635	5655	5675	5695
5500	5520	5540	5560	5580	5600	5620	5640	5660	5680	5700
5505	5525	5545	5565	5585	5605	5625	5645	5665	5685	5705
5510	5530	5550	5570	5590	5610	5630	5650	5670	5690	

The channels of *adjacent* APs should be separated by at least 20 MHz, especially for Advantage APs to take advantage of 2X operation.

5.4-GHz AP Cluster Recommended Channels

The fully populated cluster requires only three channels, each reused by the module that is mounted 180° opposed. In this frequency band range, the possible sets of three non-overlapping channels are numerous. As many as 11 non-overlapping 20-MHz wide channels are available for 1X operation. Fewer 25-MHz wide channels are available for 2X operation, where this greater separation is recommended for interference avoidance.

5.4-GHz AP Cluster Limit Case

In the limit, the 11 channels could support all of the following, vertically stacked on the same mast:

- 3 full clusters, each cluster using 3 channels
- a set of 4 APs, the set using the 2 channels that no AP in any of the 3 full clusters is using

IMPORTANT!

Where regulations require you to have Dynamic Frequency Selection (DFS) enabled, analyze the spectrum, then spread your channel selections as evenly as possible throughout this frequency band range, appropriately sharing it with satellite services.

12.5.5 5.4-GHz OFDM Channels

Channel selections for the Cyclone OFDM AP in the 5.4-GHz frequency band range depend on whether the AP is deployed in cluster.

5.4-GHz BH and Single AP Available

OFDM modules are configured by the operator for channels, using the Configuration => Custom Frequencies page.

The channels of *adjacent* APs should be separated by at least XX MHz, especially for APs to take advantage of 3X operation.

5.4-GHz AP Cluster Recommended Channels

The fully populated cluster may be configured for two or four channels. If configured for two channels, each channel is reused by the module that is mounted 180° opposed.

The modules are pre-configured with channels which can be used as a starting point for selecting the two or four for use in a full 4 AP cluster.

12.5.6 5.7-GHz Channels

Channel selections for the AP in the 5.7-GHz frequency band range depend on whether the AP is deployed in cluster.

5.7-GHz BH and Single AP Available Channels

A BH or a single 5.7-GHz AP enabled for frequencies can operate in the following channels, which are separated by 5-MHz increments.

(All Frequencies in GHz)

5.735	5.765	5.795	5.825
5.740	5.770	5.800	5.830
5.745	5.775	5.805	5.835
5.750	5.780	5.810	5.840
5.755	5.785	5.815	
5.760	5.790	5.820	

The channels of *adjacent* APs should be separated by at least 20 MHz. However, 25 MHz of separation is advised, especially for Advantage APs to take advantage of 2X operation.

5.7-GHz AP Cluster Recommended Channels

Six non-overlapping channels are recommended for use in 5.7-GHz AP clusters:

(All Frequencies in GHz)

5.735	5.775	5.815
5.755	5.795	5.835

The fully populated cluster requires only three channels, each reused by the module that is mounted 180° offset. The six channels above are also used for backhaul point-to-point links.

As noted above, a 5.7-GHz AP can operate on a frequency as high as 5.840 GHz. Where engineering plans allow, this frequency can be used to provide an additional 5-MHz separation between AP and BH channels.

12.5.7 Channels Available for PTP 400 and PTP 600 radios

Channel selections for radios in the PTP400 and PTP 600 series are quoted in the user guides that are dedicated to those products. However, these units dynamically change channels when the signal substantially degrades. Since the available channels are in the 5.4- and 5.7-GHz frequency band ranges, carefully consider the potential effects of deploying these products into an environment where traffic in this range pre-exists.

12.5.8 Example Channel Plans for AP Clusters

Examples for assignment of frequency channels and sector IDs are provided in the following tables. Each frequency is reused on the sector that is at a 180° offset. The entry in the Symbol column of each table refers to the layout in Figure 32 on Page 143.

NOTE:
The operator specifies the sector ID for the module as described under Sector ID on Page 443.

Table 31: Example 900-MHz channel assignment by sector

Direction of Access Point Sector	Frequency	Sector ID	Symbol
North (0°)	906 MHz	0	A
Northeast (60°)	915 MHz	1	B
Southeast (120°)	924 MHz	2	C
South (180°)	906 MHz	3	A
Southwest (240°)	915 MHz	4	B
Northwest (300°)	924 MHz	5	C

Table 32: Example 2.4-GHz channel assignment by sector

Direction of Access Point Sector	Frequency	Sector ID	Symbol
North (0°)	2.4150 GHz	0	A
Northeast (60°)	2.4350 GHz	1	B
Southeast (120°)	2.4575 GHz	2	C
South (180°)	2.4150 GHz	3	A
Southwest (240°)	2.4350 GHz	4	B
Northwest (300°)	2.4575 GHz	5	C

Table 33: Example 5.2-GHz channel assignment by sector

Direction of Access Point Sector	Frequency	Sector ID	Symbol
North (0°)	5.275 GHz	0	A
Northeast (60°)	5.300 GHz	1	B
Southeast (120°)	5.325 GHz	2	C
South (180°)	5.275 GHz	3	A
Southwest (240°)	5.300 GHz	4	B
Northwest (300°)	5.325 GHz	5	C

Table 34: Example 5.4-GHz channel assignment by sector

Direction of Access Point Sector	Frequency	Sector ID	Symbol
North (0°)	5.580 GHz	0	A
Northeast (60°)	5.620 GHz	1	B
Southeast (120°)	5.660 GHz	2	C
South (180°)	5.580 GHz	3	A
Southwest (240°)	5.620 GHz	4	B
Northwest (300°)	5.660 GHz	5	C

Table 35: Example 5.7-GHz channel assignment by sector

Direction of Access Point Sector	Frequency	Sector ID	Symbol
North (0°)	5.735 GHz	0	A
Northeast (60°)	5.755 GHz	1	B
Southeast (120°)	5.775 GHz	2	C
South (180°)	5.735 GHz	3	A
Southwest (240°)	5.755 GHz	4	B
Northwest (300°)	5.775 GHz	5	C

12.5.9 Multiple Access Points Clusters

When deploying multiple AP clusters in a dense area, consider aligning the clusters as shown in Figure 32. However, this is only a recommendation. An installation may dictate a different pattern of channel assignments.

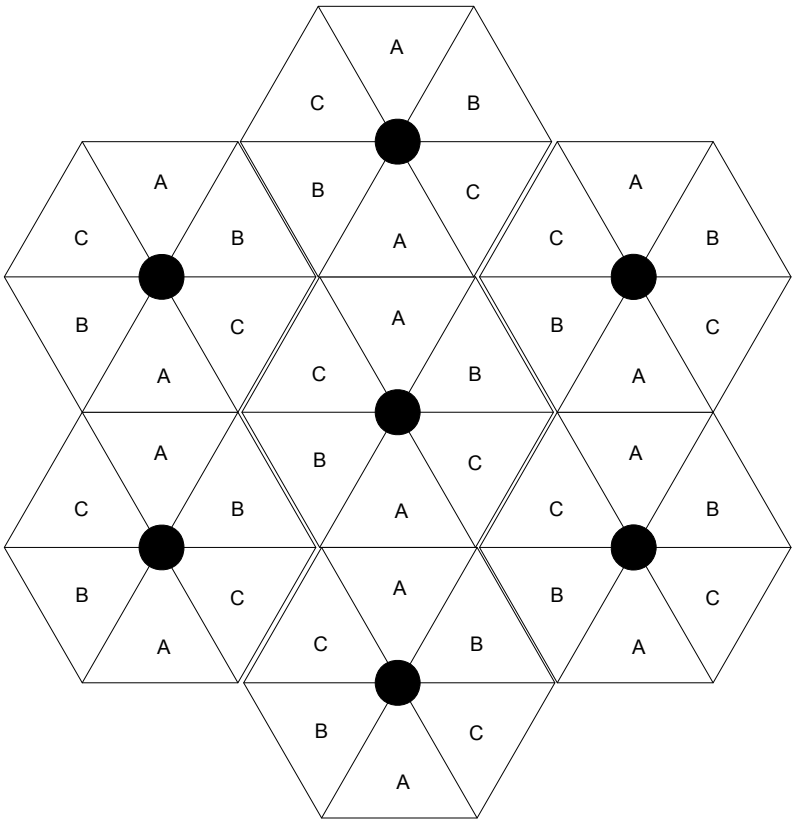


Figure 32: Example layout of 7 Access Point clusters

12.6 SELECTING SITES FOR NETWORK ELEMENTS

The Cyclone APs must be positioned

- with hardware that the wind and ambient vibrations cannot flex or move.
- where a tower or rooftop is available or can be erected.
- where a grounding system is available.
- with lightning arrestors to transport lightning strikes away from equipment.
- at a proper height:
  - higher than the tallest points of objects immediately around them (such as trees, buildings, and tower legs).
  - at least 2 feet (0.6 meters) below the tallest point on the tower, pole, or roof (for lightning protection).
- away from high-RF energy sites (such as AM or FM stations, high-powered antennas, and live AM radio towers).
- in line-of-sight paths
  - to the SMs and BH.
  - that will not be obstructed by trees as they grow or structures that are later built.

NOTE:
Visual line of sight does not guarantee radio line of sight.

12.6.1 Resources for Maps and Topographic Images

Mapping software is available from sources such as the following:

- http://www.microsoft.com/streets/default.asp
  - Microsoft Streets & Trips (with Pocket Streets)
- http://www.delorme.com/software.htm
  - DeLorme Street Atlas USA
  - DeLorme Street Atlas USA Plus
  - DeLorme Street Atlas Handheld

Topographic maps are available from sources such as the following:

- http://www.delorme.com/software.htm
  - DeLorme Topo USA
  - DeLorme 3-D TopoQuads
- http://www.usgstopomaps.com
  - Timely Discount Topos, Inc. authorized maps

Topographic maps with waypoints are available from sources such as the following:

- http://www.topografix.com
  - TopoGrafix EasyGPS
  - TopoGrafix Panterra
  - TopoGrafix ExpertGPS

Topographic images are available from sources such as the following:

- http://www.keyhole.com/body.php?h=products&t=keyholePro
  - keyhole PRO
- http://www.digitalglobe.com
  - various imagery

12.6.2 Surveying Sites

Factors to survey at potential sites include

- what pre-existing wireless equipment exists at the site. (Perform spectrum analysis.)
- whether available mounting positions exist near the lowest elevation that satisfies line of site, coverage, and other link criteria.
- whether you will always have the right to decide who climbs the tower to install and maintain your equipment, and whether that person or company can climb at any hour of any day.

- whether you will have collaborative rights and veto power to prevent interference to your equipment from wireless equipment that is installed at the site in the future.
- whether a pre-existing grounding system (path to Protective Earth ⏚) exists, and what is required to establish a path to it.
- who is permitted to run any indoor lengths of cable.

12.6.3 Assuring the Essentials

In the 2.4-, 5.2-, 5.4-, and 5.7-GHz frequency band ranges, an unobstructed line of sight (LOS) must exist and be maintainable between the radios that are involved in each link.

Line of Sight (LOS) Link

In these ranges, a line of sight link is both

- an unobstructed straight line from radio to radio.
- an unobstructed zone surrounding that straight line.

Fresnel Zone Clearance

An unobstructed line of sight is important, but is not the *only* determinant of adequate placement. Even where the path has a clear line of sight, obstructions such as terrain, vegetation, metal roofs, or cars may penetrate the Fresnel zone and cause signal loss. Figure 33 illustrates an ideal Fresnel zone.

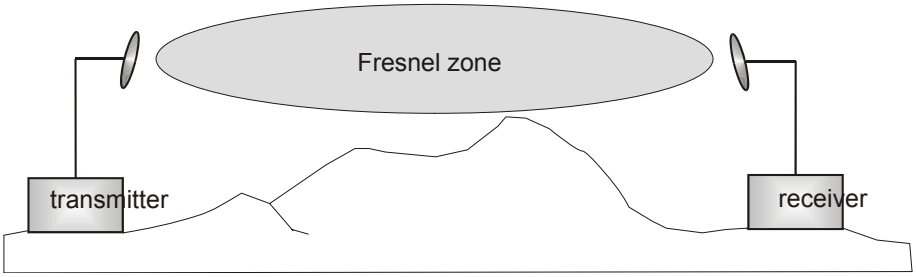


Figure 33: Fresnel zone

FresnelZoneCalcPage.xls calculates the Fresnel zone clearance that is required between the visual line of sight and the top of an obstruction that would protrude into the link path.

Non-Line of Sight (NLOS) Link

The Cyclone 900-MHz modules have a line of sight (LOS) range of 40 miles (more than 64 km) and greater non-line of sight (NLOS) range than Cyclone modules of other frequency bands. NLOS range depends on RF considerations such as foliage, topography, obstructions.

12.6.4 Finding the Expected Coverage Area

The transmitted beam in the vertical dimension covers more area beyond than in front of the beam center. BeamwidthRadiiCalcPage.xls calculates the radii of the beam coverage area.

12.6.5 Clearing the Radio Horizon

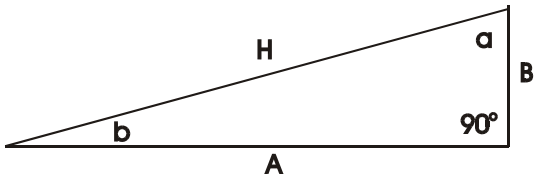
Because the surface of the earth is curved, higher module elevations are required for greater link distances. This effect can be critical to link connectivity in link spans that are greater than 8 miles (12 km). AntennaElevationCalcPage.xls calculates the minimum antenna elevation for these cases, presuming no landscape elevation difference from one end of the link to the other.

12.6.6 Calculating the Aim Angles

The appropriate angle of AP downward tilt is derived from both the distance between transmitter and receiver and the difference in their elevations. DowntiltCalcPage.xls calculates this angle.

The proper angle of tilt can be calculated as a factor of both the difference in elevation and the distance that the link spans. Even in this case, a plumb line and a protractor can be helpful to ensure the proper tilt. This tilt is typically minimal.

The number of degrees to offset (from vertical) the mounting hardware leg of the support tube is equal to the angle of elevation from the lower module to the higher module (<B in the example provided in Figure 34).



LEGEND

b	**Angle of elevation.**
B	**Vertical difference in elevation.**
A	**Horizontal distance between modules.**

Figure 34: Variables for calculating angle of elevation (and depression)

Calculating the Angle of Elevation

To use metric units to find the angle of elevation, use the following formula:

$$\tan b = \frac{B}{1000A}$$

where
B is expressed in meters
A is expressed in kilometers.

To use English standard units to find the angle of elevation, use the following formula:

$$\tan b = \frac{B}{5280A}$$

where
B is expressed in feet
A is expressed in miles.

The angle of depression from the higher module is identical to the angle of elevation from the lower module.

12.7 COLLOCATING CYCLONE MODULES

A BH and an AP or AP cluster on the same tower require a CMM. The CMM properly synchronizes the *transmit start* times of all Cyclone modules to prevent interference and desensing of the modules. At closer distances without sync from a CMM, the frame structures cause self interference.

Furthermore, a BH and an AP on the same tower require that the effects of their differing *receive start* times be mitigated by either

- 100 vertical feet (30 meters) or more and as much spectral separation as possible within the same frequency band range.
- the use of the frame calculator to tune the **Downlink Data** parameter in each, so that the receive start time in each is the same. See Using the Frame Calculator Tool (All) on Page 444.

Cyclone APs and a BHS can be collocated at the same site only if they operate in different frequency band ranges.

Where a single BH air link is insufficient to cover the distance from an AP cluster to your point of presence (POP), you can deploy two BHSs, connected to one another by Ethernet, on a tower that is between a BHM collocated with the AP cluster and another BHM collocated with the POP. This deployment is illustrated in Figure 35.

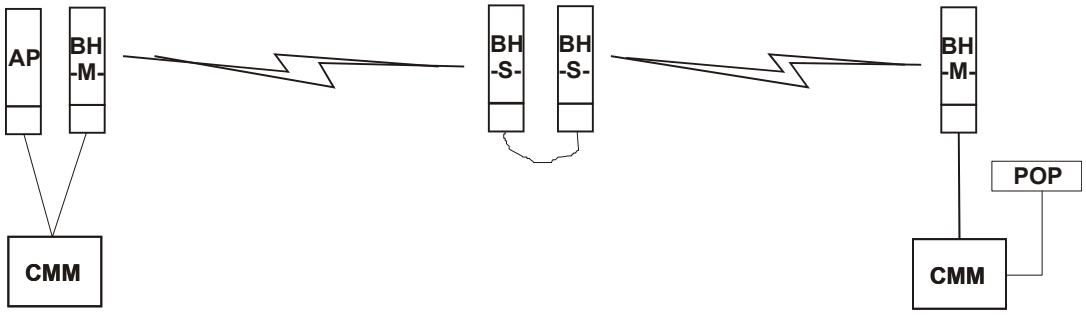


Figure 35: Double-hop backhaul links

However, the BHSs can be collocated at the same site *only if* one is on a different frequency band range from that of the other or one of the following conditions applies:

- They are vertically separated on a structure by at least 100 feet (30 m).
- They are vertically separated on a structure by less distance, but either
  - an RF shield isolates them from each other.
  - the uplink and downlink data parameters and control channels match (the **Downlink Data** parameter is set to **50%**).

The constraints for collocated modules in the same frequency band range are to avoid self-interference that would occur between them. Specifically, unless the uplink and downlink data percentages match, intervals exist when one is transmitting while the other is receiving, such that the receiving module cannot receive the signal from the far end.

The interference is less a problem during low throughput periods and intolerable during high. Typically, during low throughput periods, sufficient time exists for the far end to retransmit packets lost because of interference from the collocated module.

12.8 DEPLOYING A REMOTE AP

In cases where the subscriber population is widely distributed, or conditions such as geography restrict network deployment, you can add a Remote AP to

- provide high-throughput service to near LoS business subscribers.
- reach around obstructions or penetrate foliage with non-LoS throughput.
- reach new, especially widely distributed, residential subscribers with broadband service.
- pass sync to an additional RF hop.

In the remote AP configuration, a Cyclone AP is collocated with a Canopy SM. The remote AP distributes the signal over the last mile to SMs that are logically behind the collocated SM. A remote AP deployment is illustrated in Figure 36.

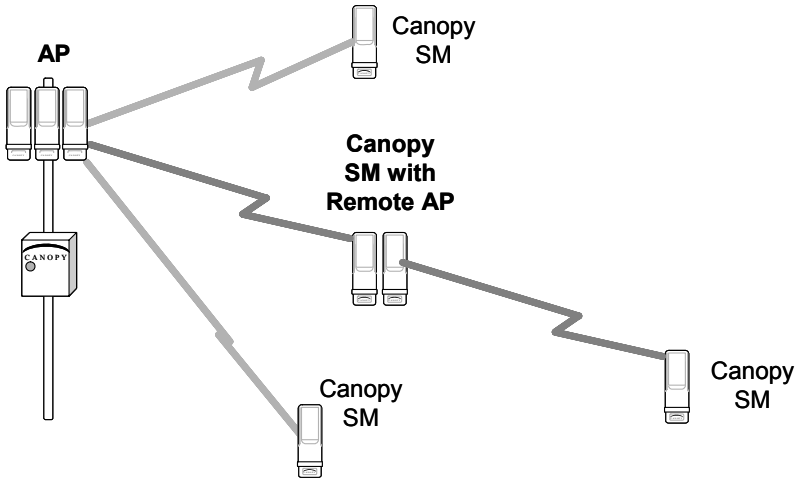


Figure 36: Remote AP deployment

The collocated SM receives data in one frequency band, and the remote AP must redistribute the data in a different frequency band. Base your selection of frequency band ranges on regulatory restrictions, environmental conditions, and throughput requirements.

IMPORTANT!

Each relay hop (additional daisy-chained remote AP) adds latency to the link as follows:

- approximately 6 msec where hardware scheduling is enabled.
- approximately 15 msec where software scheduling is enabled.

12.8.1 Remote AP Performance

The performance of a remote AP is identical to the AP performance in cluster. Throughputs, ranges, and patch antenna coverage are identical. Cyclone Advantage and Cyclone modules can be deployed in tandem in the same sector to meet customer bandwidth demands.

As with all equipment operating in the unlicensed spectrum, Last Mile Gear *strongly* recommends that you perform site surveys before you add network elements. These will indicate that spectrum is available in the area where you want to grow. Keep in mind that

- non-LoS ranges heavily depend on environmental conditions.
- in most regions, not all frequencies are available.
- your deployments must be consistent with local regulatory restrictions.

12.8.2 Example Use Case for RF Obstructions

A remote AP can be used to provide last-mile access to a community where RF obstructions prevent SMs from communicating with the higher-level AP in cluster. For example, you may be able to use 900 MHz for the last mile between a remote AP and the outlying SMs where these subscribers cannot form good links to a higher-level 2.4-GHz AP. In this case, the short range of the 900-MHz remote AP is sufficient, and the ability of the 900-MHz wavelength to be effective around foliage at short range solves the foliage penetration problem.

An example of this use case is shown in Figure 37.

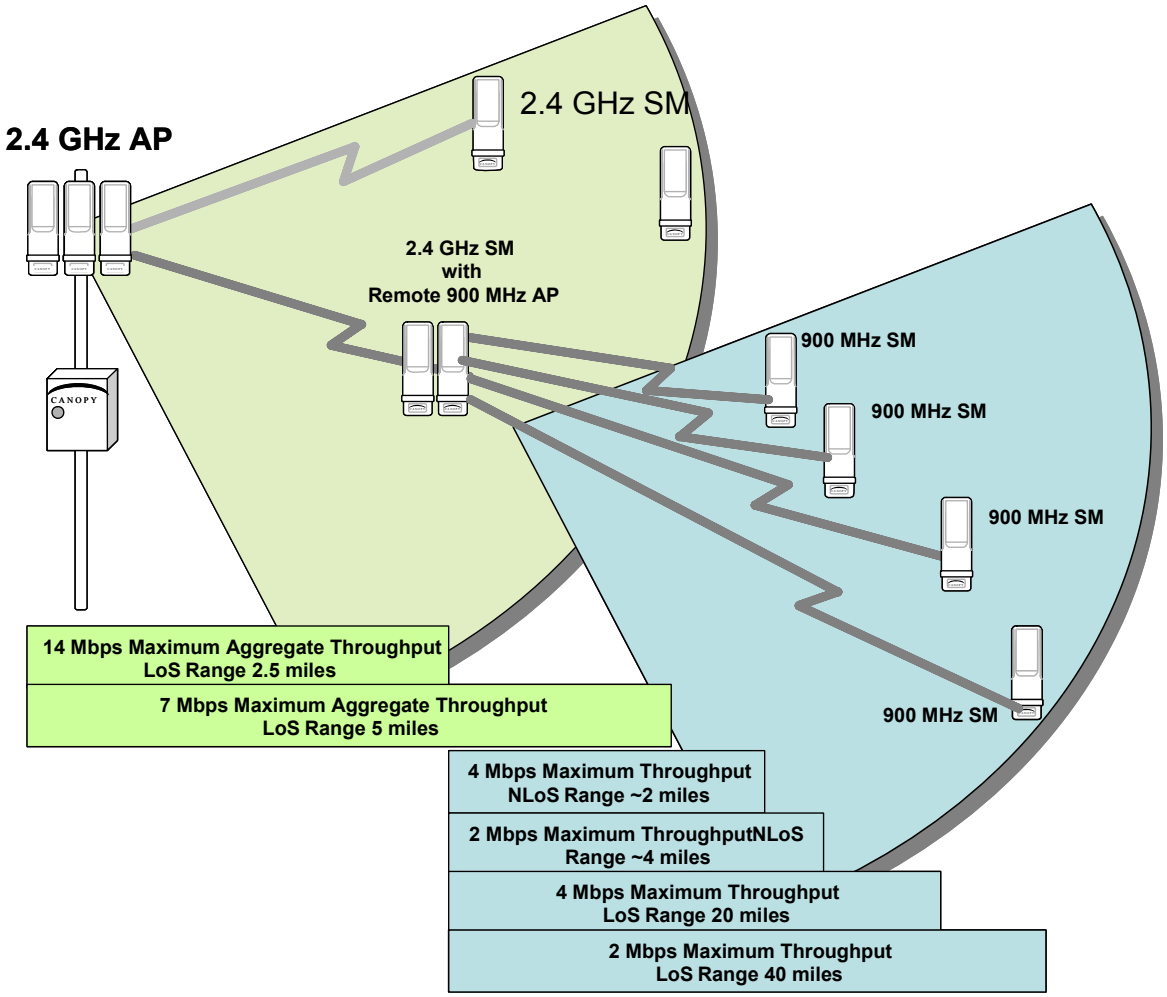


Figure 37: Example 900-MHz remote AP behind 2.4-GHz SM

The 2.4 GHz modules provide a sustained aggregate throughput of up to 14 Mbps to the sector. One of the SMs in the sector is wired to a 900-MHz remote AP, which provides NLoS sustained aggregate throughput[4] of

- 4 Mbps to 900-MHz SMs up to 2 miles away in the sector.
- 2 Mbps to 900-MHz SMs between 2 and 4 miles away in the sector.

12.8.3 Example Use Case for Passing Sync

All Cyclone radios support the remote AP functionality. The BHS and the SM can reliably pass the sync pulse, and the BHM and AP can reliably receive it. Examples of passing sync over cable are shown under Passing Sync in an Additional Hop on Page 95. The sync cable is described under Cables on Page 57.

[4] NLoS ranges depend on environmental conditions. Your results may vary from these.