

# Airvine WaveTunnel™

Getting Started Guide

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## **Intended Audience**

This document is written for and intended for use by technical engineers with some background in Ethernet networking, Wi-Fi design, and 802.11 wireless engineering principles.

For additional information on Airvine and Airvine products, go to <u>https://airvine.com/</u>

# **Overview**

The purpose of this document is to provide guidance for the planning and implementation of an Airvine WaveTunnel<sup>™</sup> wireless distribution backbone. Primary markets include multi-dwelling, multi-family, hospitality, large public venues, warehousing and more. Providing a wireless backbone alternative to the traditional horizontal cabling infrastructure opens many opportunities that may have been delayed or not feasible due to cost, environmental or disruptive roadblocks.

Before the actual design of an mmWave backbone can start, there are several considerations that can dramatically impact the final design, deployment, and performance. These include:

- What type of vertical wired infrastructure will or can be used?
- What are the devices that will need to be deployed with the WaveTunnel<sup>™</sup> bridges?
- What is the expected network performance (SLA)?
- What network management topology will be used?

Answering these questions at the outset, planning carefully, and selecting Airvine Networks patented indoor mmWave technology will help tackle various deployment scenarios. This document discusses how to get started setting up and using the Airvine WaveTunnel<sup>™</sup> bridges and some best practices for planning and deploying a mmWave network.



# **Finding Airvine Resources**

General information and support for Airvine products can be found at:

https://airvine.com

#### https://airvine.com/support/

Support includes access to firmware downloads, documentation, warranty, product registration, and technical Q&A.

For Airvine Partners, once registered and have access to the Airvine Partner Portal, you will find many resources for marketing assets, sales tools and support resources including certification training and case escalations.

#### https://partner.airvine.com/wp-login.php

Username or Email Address		
 Password		
✓ Remember Me	====	====
 Log In	====	
 Register   Lost your password? ← Go to Airvine Partner Portal	====	
 888		



# **Pre-Testing Evaluation Gear**

**Received Equipment:** Please take a moment to send <u>support@airvine.com</u> a message that you have received the equipment and that it is in good condition.

Please do not attempt to use evaluation units if the box or contents appear damaged. Immediately send a description of the damage to <u>support@airvine.com</u> and replacement evaluation equipment will be sent.

#### The Box contains the following:

- WaveTunnel<sup>™</sup>
- Mounting Bracket
- Power Supply and Cord

#### Before connecting to an Ethernet switch

If connecting a WaveTunnel<sup>™</sup> to an Ethernet switch, connect to a non-PoE port or port that has the PoE disabled. Connecting a WaveTunnel<sup>™</sup> to an active PoE switch port may cause damage to a WaveTunnel<sup>™</sup>!

#### **Connecting to Power**

When connecting power to a WaveTunnel<sup>™</sup>, connect the DC plug from the power brick into the WaveTunnel<sup>™</sup> first. The circular connection is keyed for proper orientation. Once the DC plug is connected to the WaveTunnel<sup>™</sup>, plug the AC power cord from the power brick into an electrical outlet.

For model **2041DC**, the flat side of the power connector is up.



For model **2041SM**, the flat side of the power connector is down.





#### **Initial Setup**

In a staging environment, power on a WaveTunnel<sup>™</sup> bridge. This can be on a desktop or lab area. For ceiling mount, refer to the instruction shown in the WaveTunnel<sup>™</sup> Quick Setup Guide.

#### **LED Activity**

Once powered on, observe the LEDs on the WaveTunnel<sup>™</sup> unit.



LED	STATE	BEHAIVIOR
WaveTunnel 2 Downstream Radio	$\begin{array}{rr} \text{Off} & \rightarrow \\ \text{Blinking} & \rightarrow \\ \text{Solid} & \rightarrow \end{array}$	Radio disabled Radio enabled, searching to connect to an Upstream Radio Radio enabled, connected to an Upstream Radio
Status	$\begin{array}{rr} \text{Off} & \rightarrow \\ \text{Blinking} & \rightarrow \\ \text{Solid} & \rightarrow \end{array}$	System not functional, bootup sequence not started System booting up, being initialized System is operational
Alarm	$\begin{array}{c} \text{Off} \ \rightarrow \\ \text{Solid} \ \rightarrow \end{array}$	No Alarm, all alarms have been acknowledged by admin Indicates critical alarms are generated
WaveTunnel 1 Upstream Radio	$\begin{array}{c} \text{Off} \rightarrow \\ \text{Blinking} \rightarrow \\ \text{Solid} \rightarrow \end{array}$	Radio Disabled Radio Enabled, searching to connect to a Downstream Radio Radio Enabled, connected to a Downstream Radio
Power	$\begin{array}{c} \text{Off} \rightarrow \\ \text{Solid} \rightarrow \end{array}$	No power source detected Power source detected; unit has power



### **Ethernet port LEDs**



Green	Yellow	Behavior
Off	Off	No Ethernet Connection Detected
Off	On	Connected at 100 Mbps, No Traffic Passing
Off	On Blinking	Connected at 100 Mbps, Traffic Passing
On	Off	Connected at 1000 Mbps, No Traffic Passing
On Blinking	Off	Connected at 1000 Mbps, Traffic Passing



# **Reboot and Factory Reset**

A Reboot/Reset pinhole button is located next to the power connector.

- Depress for < 5 sec for a soft reboot.
- Depress for > 5 sec for a factory reset.

NOTE THAT AT FACTORY DEFAULTS, WHEN CONNECTING OVER A WIRED ETHERNET CONNECTION, THE IP ADDRESS OF THE WAVETUNNEL<sup>™</sup> GUI AND SSH IS: **192.168.0.253** 

THE IP ADDRESS FOR THE 2.4GHz WI-FI WIRELESS INTERFACE IS: **192.168.3.1** WI-FI SSID = "avb\_[WT MAC ADDRESS]" WI-FI PASSCODE = airvine!

DEFAULT LOGIN INFO: HTTP/SSH/MOBILE APP UN=admin PW= admin

As a best practice, reset the WaveTunnel<sup>™</sup> evaluation units to factory defaults and observe LED behavior during boot up.

The WaveTunnel<sup>™</sup> configuration wizard will prompt the user to configure a new password. It is strongly suggested that a password with at least 8 characters in length using special characters be used for security purposes.



# **Updating Firmware**

Typically, WaveTunnel<sup>™</sup> units will not have the latest code version when they ship from the warehouse. Important feature updates and fixes that will benefit the user experience may not be available. To update, download the latest version from the Airvine support site <u>https://airvine.com/support/</u> and refer to the "Airvine Tech Notes WaveTunnel<sup>™</sup> Firmware Updates" for additional instructions on updating the WaveTunnel<sup>™</sup> firmware.

Note other important links for Contact, Product Registration, Product RMA, and other available downloads.

SYSTE	M	Step1: Download/Upload The Firmware File
Ø	Operations ~	From: O HTTP O FTP O TFTP O Local File
	Troubleshooting	Choose a file avsImage-1.2.0.62
	Port Mirroring	Uploading the firmware file
	Firmware Update	Upload

From System > Firmware Update select the firmware file previously downloaded and Upload to the WaveTunnel<sup>™</sup>. The Local File method may be the easiest. Once the firmware has loaded, check the Write Image button, and let the system update and reboot.





# **Installation Notes**

Note that WaveTunnel<sup>™</sup> antenna allows for Beam Steering in the horizontal/azimuth axis providing a wide coverage of up to ±45<sup>°</sup> from center boresight.



### **Antenna Azimuth and Elevation**

Horizontal/Azimuth Axis:  $\pm 45^{\circ}$ Vertical/Elevation =  $\pm 9^{\circ}$ 

WaveTunnel<sup>™</sup> Bridges should be mounted at the same vertical height from the ceiling. Using the included mounting brackets will also ensure Fresnel zone clearance at up to 150 meters.





Walls and other materials will attenuate a WaveTunnel<sup>™</sup> signal. Some typical attenuation numbers are listed below. Airvine includes a VineCalculator to assist with estimating WaveTunnel<sup>™</sup> signal strength in various scenarios. To use the VineCalculator, please visit <u>https://services.airvine.com/calculator/</u>



#### Please input the following parameters to calculate the Link Margin.

Link Distance 100	Distance (feet)		Channel 1 (Default)		
	Enter the link distance between two Wave Tunnels		Select the channel		el
Tx Antenna	a Angle (degree)		Rx Antenna Angle (	degree)	
Walls B	etween These Two WaveTunnel Devices	5			
Select	Wall Material	Thicknes	s(inch)	Sheets	Actions
	Drywall	1.25		1	ř
	Drywall-Semigloss	1.25		1	i
	Drywall-Flat Paint	1.25		1	i
	Ceiling Tile	1		1	i
	Plywood	1.25		1	i
	Glass	0.5		1	i
			Items per page:	10 - 1-6 of 6	

CALCULATE

🖹 RESET



### **Pre-Configuration**

#### **Collect the following hardware:**

- Mobile device running Android or iOS operating system.
  - Or computer installed with one of the following web browsers.
    - Google Chrome
    - Microsoft Edge
    - Safari
    - Firefox
- Ethernet cable if connecting via an Ethernet port.
- Serial console cable (Optional)
  - $\circ~$  2.0 USB A Male to Micro USB

If you are going to use the mobile App for configuration, download the **AirvineMobile** App to your mobile device.



Decide on how the WaveTunnel<sup>™</sup> units will be staged either in a chain or ring topology and the proper orientation of the units. A section on staging is included later in this document.



# WaveTunnel<sup>™</sup> Topology

This document will take you through the process of configuring a 4-node network ring as shown in the figure below. Once connected to your WaveTunnel<sup>™</sup>, enter the username and password to log in. Browser configuration, iOS, and Android configuration steps are outlined below.

The Root bridge is always configured first and the WaveTunnel<sup>™</sup> network is created. Once the network is created, additional Leaf bridges can be joined to the network.



#### **Browser Configuration**

To connect to the WaveTunnel over the wired Ethernet connection, enter the WaveTunnel<sup>™</sup> Ethernet IP address = **192.168.0.253** into the browser. *Note: The IP Address of the Laptop's Ethernet interface must first be configured to be on the same subnet (i.e. 255.255.255.0).* To connect to the WaveTunnel locally over a Wi-Fi connection, first configure the mobile device or Laptop to connect to the WaveTunnel's Wi-Fi radio. The factory default Wi-Fi SSID is "**avb\_[WT MAC ADDRESS]**" and Wi-Fi PASSCODE is "**airvine!**". After the device is connected to Wi-Fi, enter the WaveTunnel<sup>™</sup> Wi-Fi IP address = **192.168.0.253** into the browser. Note: The WaveTunnel uses DHCP to automatically assign the IP Address to the Laptop or Mobile device for its Wi-Fi connection to the WaveTunnel.

Leaf01

HTTP/SSH/MOBILE APP LOGIN DEFAULTS: UN=admin PW= admin



### **Root Bridge Configuration**

- To configure the initial Root bridge, login to the management interface of the WaveTunnel<sup>™</sup> and select "Create a new network" and give the network a name. In this example, "VineNet" is used. When subsequent nodes are added to the network, the option "Join the existing network" will be used.
- 2. Select "Next"

1 Network	2 Label	<b>3</b> IP	Password	5 Summary
eate a new network	or join the existing one work			
eate a new network Create a new net VineNet	or join the existing one work			
eate a new network Create a new net VineNet	or join the existing one work			
eate a new network Create a new net VineNet Join the existing Insertation node t	or join the existing one work network o the network			

- 3. Configure a Node Type and Node Label for this WaveTunnel™
- 4. Select "Next"

nput the Node informat	ion			
lode Type				
Root				
Node Type is an additio Iode Label	nal descriptor field that ca	n be associate and add	ditional name to a WaveTunn	el device)
Root				
lode Encryption O Al	S-128 💿 Disable			



5. Configure the IP management setting to either DHCP or Static

Initialization wizard

6. Select "Next"

1 Network	2 Label	<b>B</b> IP	4 Password	5 Summary
Update the managemen	t IP settings			
DHCP      Static     Managment IP				
192 168 0 100				
Subnet Mask				
255.255.255.0				
Gateway				

- 7. Create a new password.
- 8. Select "Next"

1 Network	2 Label	3 IP	4 Password	5 Summary
Change the administrator New Password	password			
password				
		PREVIOUS	IEXT	



9. Review the configuration.

10.Verify the configuration is correct, select "Submit".

	(3) P (4) Password	5 Summary
Confirm the following settings are correct		
Node Type:	Root	
Network Id:	VineNet	
Node Label:	Root	
Node Encryption:	disable	
P type:	static	
P address:	192.168.0.100	
Subnet Mask:	255.255.255.0	
Gateway:	192.168.0.1	
Admin Password:	password	

### 11. Login to the newly configured Root bridge.

Root					
Enverseren hantes	Re Prese UZ54 ellen	ignories hires	g R. France Olix - 44 dan		
	Padate Store rates - PK		Tuber Service (B)		



#### Leaf Bridge Configuration

- 1. Make note of the upstream node MAC address that the Leaf node will be connecting to. In this case, the MAC address of the Root bridge.
  - a. To find the MAC address of the upstream bridge, see the label on the unit.
  - b. Or log into the WaveTunnel<sup>™</sup> bridge and go to Monitoring > Device > General and view the MAC Address.

a	Dashboard		
		Device general	
MON	ITORING		
_		Device Name	Root
	Device	Description	AirVine wave tunnel device
	General	Location MAC Address	a4:f9:e4:10:05:d0
	Ethernet	Serial number	47210093
		Model name	A1000
	Management WLAN	Country code	US
		Firmware version	0.4.1.1671736999
	Wave Tunnel	IP address	192.168.0.100
曲	Event	Up time	3 days, 19:53:21

 Log into the WaveTunnel<sup>™</sup> to be configured using a browser or the AirvineMobile App using UN= admin PW=admin for the browser. The Wi-Fi SSID WPA2 password for the Mobile App and 2.4GHz wireless interface is = airvine!





- 3. Select "Join the existing network" and use the drop-down menu to select the correct upstream node.
- 4. Click "Next"

	ice which has not be	en initialized.Please fo	blow the steps below to setu	p the wave tunnel device.
1 Network	2 Label	<b>B</b> IP	4 Password	5 Summary
Create a new network or join th	ne existing one			
O Create a new network				
<ul> <li>Join the existing network</li> <li>Inseration node to the network</li> </ul>	twork			
				~
Please select the network				
Please select the network				
Please select the network Please select the network avb_VineNet_a4:f9:e4:10:01:f0				
Please select the network Please select the network avb_VineNet_a4:f9:e4:10:01:f0 avb_VineNet_a4:f9:e4:10:00:f0				

Initialization wizard

This is a new wave tunnel device which has not been initialized.Please follow the steps below to setup the wave tunnel device.

a avicting and			
le existing one			
twork			
0			~
0	vork	vork	vork



- 5. Configure the Node Type and Node Label
- 6. Click "Next"

nput the Node informat	ion			
Node Type				
Leaf				
Node Type is an additio	nal descriptor field that ca	n be associate and addi	itional name to a WaveTunn	el device)
Vode Label				
1				
Lealut				
Lealui				

- 7. Configure the management IP settings.
- 8. Click "Next"

Initialization wizard
This is a new wave tunnel device which has not been initialized. Please follow the steps below to setup the wave tunnel device.
Network     2 Label     3 IP     4 Password     5 Summary
Update the management IP settings
DHCP      Static
PREVIOUS



9. Configure a new password with a minimum of 8 characters.

### 10.Click "Next"

Network	2 Label	<b>3</b> IP	Password	5 Summary
Change the administrator New Password	password			
password				
		PREVIOUS	IEXT	

11. Review configuration and select "Submit" if no changes are needed.

Note: After selecting "Submit", it typically takes up to 20 seconds to initialize the WaveTunnel.

1 Network 2 Labe	B B P Assword 5 Summary
Confirm the following settings are correct	
Node Type:	Leaf
Network Id:	VineNet
Node Label:	Leaf01
Node Encryption:	disable
IP type:	static
IP address:	192.168.0.101
Subnet Mask:	255.255.255.0
Gateway:	192.168.0.1
Admin Password:	password
	PREVIOUS



12.Log into WaveTunnel<sup>™</sup> with the new network credentials.



Login						
Sign Ir	to your account					
2	Username					
θ	Password		⊊5			
			Login			

13.For Leaf Nodes 3 and 4, perform the same <u>Leaf Bridge Configuration</u> steps as Leaf Node 2.





- 14.To close the loop on the WaveTunnel<sup>™</sup> network, log into the Root bridge and go to Configuration > Network > WaveTunnel<sup>™</sup> and Enable the Upstream Tunnel Connection if it is not already enabled.
- 15.Configure the Connection Name and select "Save".

0	Dachboard			
62	Uashboard		Wave Tunnel settings	Refresh
MON	ITORING			
			Network Id VineNet	
			Node Label	
Ø	Statistics		Root	
CONF	IGURATION			
٢			Cancel	
0	Network		Downstream Tunnel settings	
	Ethernet		Cospection	
	Wave Tunnel		Enabled      Disable	
	Management W	IAN	Charnel	
R			1 v Research the channel	
SYSTE				
5	Operations		⊘ Save ⊘ Cancal	
			Upstream Tunnel settings	
		(	Connection	
			Star	
			Special Connection Settings	
		Upstrea	am Tunnel settings	
		Connor	tion	
		Enal	abled Uisable	
		Connect	ction Name	
		VineN	Net Ring	
		Sav		



- 16.Just below this setting, under Special Connection Settings select Close Ring Network
- 17. Click "Close" and "Yes" to Confirm





18.Congratulations! Your WaveTunnel wireless network is configured and is ready to use.



#### 19.For assistance, contact <a href="mailto:support@airvine.com">support@airvine.com</a>





### iOS Mobile App Configuration

- Note the MAC Address of the WaveTunnel<sup>™</sup> that is to be configured. A label is located on top of the WaveTunnel<sup>™</sup> or under configuration > Monitoring > Device > General and view the MAC Address
- 2. If the WaveTunnel<sup>™</sup> is to be configured as a Leaf bridge, note the MAC address of the upstream Root or Leaf bridge to be connected to.
- 3. Open the AirvineMobile App and you should see the Wi-Fi Network SSID that you are connected to.
- 4. Click "Select Device Wi-Fi" and the list of Wi-Fi Services menu will appear.
- 5. Select the SSID that matches the MAC address of the WaveTunnel<sup>™</sup> to be configured.
- 6. Enter "airvine!" as the SSID WPA2 password and click "Join".





- 7. Go back to the AirvineMobile App
- 8. Click on "Connect"

<ul> <li>VineManager</li> <li>Settings</li> <li>Wi-Fi</li> </ul>	Edit	
Wi-Fi		WiFi: avb_a4:f9:e4:10:05:d0 Device IP: Get device IP from
avb_a4:f9:e4:10:05:d0	🔒 🤶 🚺	Device WiFi 💿 User Input 🔿

Select Device Network

=

- 9. For a new network, select "Create a new network" then click on "Next".
  - a. "Join the network" can be used to configure additional nodes onto an existing network.
- 10.Configure a Node Type and Device Label for the WaveTunnel<sup>™</sup>, click "Next".
- 11.Configure network settings for the WaveTunnel<sup>™</sup>, click "Next".

Network Segment     Create a new network or join the     existing one	<ul> <li>Device Settings</li> <li>Configure the Device Node Type, Label and Encryption</li> </ul>	Network Segment Create a new network or join the existing one
Wave Tunnel Network	Node Type Root	Node Label Use the auto-generated device label or Set its value
Create a new network 🔘	<sup>4/8</sup> Device Label Root	Set the Management IP
Join the network	4/8 Encryption	IP type
Insert a node after	Disable  AES-128	dhcp 💿 static 🔿
Network Id VineNet	BACK NEXT	BACK NEXT
7/8		
BACK NEXT		



- 12. Configure an Admin Password for the WaveTunnel<sup>™</sup>, click "Next".
- 13. Review Summary, click "Next".
- 14. The WaveTunnel<sup>™</sup> bridge will now initialize.
- 15. Note the new management SSID.
- 16.Click "Continue"





- 17. Click "Select Wi-Fi"
- 18. Click on the new management SSID, in this case avb\_VineNet\_Root
- 19. Go back to the VineManager App

$\equiv$ Select Device Network	<ul> <li>✓ VineManager</li> </ul>		✓ VineManager	sus 🔳
	Settings Wi-Fi	Edit	Settings Wi-Fi	Edit
			Wi-Fi	
	Wi-Fi		✓ avb VineNet Root	≜ হ (i)
	🗸 StayFrostyWi-Fi	🔒 🗢 🚺		Ŭ
			MY NETWORKS	
	OTHER NETWORKS			
	AirVine_mgmt_a4:f9:e4	<sup>1</sup> 🔒 🗢 🚺		
WiFi: N/A	:10.01:11	-		
Device IP:	ARRIS-F0B9	🔒 🗢 🧻		
Device WiFi () User Input	ARRIS-F0B9-5G	🔒 🗢 🚺		
	avb_a4:f9:e4:10:00:f0	🔒 🗢 i		
Select WiFi Connect	avb_a4:f9:e4:10:02:c0	🔒 🗢 i		
	avb_VineNet_Root	) 🔒 🤝 🚺		

- 20. Click "Connect"
- 21. Enter the configured username and password and select "Log In".
- 22. Congratulations!
- 23. For Leaf node configuration and connecting the ring, see <u>Leaf Bridge</u> <u>Configuration</u>.





### **Android Configuration Mobile App**

- 1. Note the MAC Address of the WaveTunnel<sup>™</sup> bridge that is to be configured.
- 2. If the WaveTunnel<sup>™</sup> is to be configured as a Leaf bridge, note the MAC address of the upstream Root or Leaf bridge to be connected to.
- 3. Open the AirvineMobile App and you should see the Wi-Fi Network SSID that you are connected to.
- 4. Click "Select Wi-Fi" and the list of Wi-Fi Services menu will appear.
- 5. Select the Wi-Fi Network SSID that matches the MAC address of the WaveTunnel<sup>™</sup> to be configured.



6. Enter the Wi-Fi SSID WPA2 password "airvine!" and select "Connect".

avb_a4:f9:e4:10:05:d0
Password
airvine!
Show password
Advanced options 🗸
Cancel



- 7. The Android device will obtain an IP Address from the WaveTunnel.
- 8. If the "Tap for options" & "no internet access" notifications pop up, click on "Yes".



9. Go back to the AirvineMobile App





BACK NEXT

10.For a new network, select "Create a new network", click "Next".

- a. "Join the network" can be used to configure additional nodes onto an existing network.
- 11.Configure the name for the WaveTunnel<sup>™</sup>, click "Next".
- 12.Configure network settings for the WaveTunnel<sup>™</sup>, click "Next".

N Cr ex	etwork Segment reate a new network or join the kisting one	0	Device Settings Configure the Device Node Type, Label and Encryption		Network Segment Create a new network or join the existing one
	Wave Tunnel Network		Node Type Root		Node Label Use the auto-generated device label or Set its value
	Create a new network		Device Label Root	0	IP Settings Set the Management IP
	Insert a node after		4/8 Encryption Disable • AES-128		IP type dhcp 💿 static 🔿
	Network Id		BACK NEXT		BACK NEXT
	7/8				



- 13.Configure an Admin Password for the WaveTunnel<sup>™</sup>, click "Next".
- 14. Review Summary, click "Next".
- 15.The WaveTunnel<sup>™</sup> bridge will now initialize.
- 16.Note the new management Wi-Fi SSID.
- 17.Click "Continue"





18.Click "Select Wi-Fi"

19.Click on the new management Wi-Fi SSID, in this case avb\_VineNet\_Root 20.Go back to the AirvineMobile App

■ Select Device Network	<ul> <li>VineManager</li> <li>Settings Wi-Fi</li> </ul>	Edit	VineManager	SUS Edit
			Wi-Fi	
	Wi-Fi		✓ avb_VineNet_Root	🔒 🗢 і
	✓ StayFrostyWi-Fi	🔒 🗢 🚺		
			MY NETWORKS	
	OTHER NETWORKS			
WiFi: N/A	AirVine_mgmt_a4:f9: :10:01:f1	ie4 🔒 🗢 i		
Device IP:	ARRIS-F0B9	ê 🗢 i		
Device WiFi 🧿 User Input 🔘	ARRIS-F0B9-5G	â 🗢 (ì)		
	avb_a4:f9:e4:10:00:f	0 🔒 🗢 🚺		
Select WiFi Connect	avb_a4:f9:e4:10:02:c	0 🔒 🗢 🚺		
	avb_VineNet_Root	) 🕯 🗢 🚺		

- 21.Click Connect
- 22. Enter the configured username and password, click "Log In".
- 23.Congratulations!
- 24. For Leaf node configuration and connecting the ring, see Leaf Bridge

Configuration.





### WaveTunnel<sup>™</sup> Orientation

The correct physical placement of the WaveTunnel<sup>™</sup> bridge is critical for link communication. Orientating the Downstream antenna of the Root node to the Upstream antenna for the Leaf node is shown in the diagram below.





Each WaveTunnel<sup>™</sup> unit contains two 60 GHz radios on either side of the WaveTunnel.

**Downstream Radio**: The 60 GHz Radio Located on the side furthest from the Airvine Logo is referred to as Downstream Radio. The WaveTunnel<sup>™</sup> 2 LED corresponds to the Downstream Radio.

**Upstream Radio**: The 60 GHz Radio Located on the side closest to the Airvine Logo is referred to as Upstream Radio. The WaveTunnel<sup>™</sup> 1 LED corresponds to the Upstream Radio.



The Downstream Radio is responsible for initiating the wireless connection to an Upstream Radio. Using Wi-Fi terminology, the Downstream Radio is analogous to an Access Point while the Upstream Radio is analogous to a Client. Configuring and/or obtaining status of the Downstream Radio and Upstream Radio is performed using the Web GUI, Mobile App, or CLI.



#### **Connecting WaveTunnel™ Units Together**

To wirelessly connect WaveTunnel<sup>™</sup> units together into a daisy chain or a ring topology, the physical orientation of the radio must be such that a Downstream Radio is always communicating an Upstream Radio.



Note: Having one of the WaveTunnel<sup>™</sup> units in an upside-down orientation (not common) IS INDEED valid so long as the Downstream-to-Upstream radio wireless connection rule is followed.



#### Invalid WaveTunnel<sup>™</sup> Connections

The following physical orientations Invalid Downstream-to-Downstream Radio Connections and Upstream-to-Upstream radio connections are **NOT** supported.



WaveTunnel Getting Started Guide



# **Evaluation: WaveTunnel™ Staging**

Staging for a WaveTunnel<sup>™</sup> evaluation can be as simple as placing two WaveTunnel<sup>™</sup> bridges on a tabletop, powering up, and configuring the units as a simple two node chain topology. For advanced staging and evaluation testing, the WaveTunnel<sup>™</sup> bridges can easily be placed on tripods.

**Note**: mark the WaveTunnel<sup>™</sup> bridges for correct orientation, this is especially useful if the WaveTunnel<sup>™</sup> nodes will be moved to multiple locations.



• Two WaveTunnel<sup>™</sup> node chain topology staged on a tabletop.

• Four WaveTunnel<sup>™</sup> node ring topology staged on a tabletop.





• WaveTunnel<sup>™</sup> node cluster configuration staged on portable tripods.







# **Evaluation: Network Configuration**

Shown below is a suggested network configuration for a two-node evaluation. If the WaveTunnel<sup>™</sup> bridges will be connected to a host network, modification of the static network setting may be required.



For monitoring link connectivity throughout the evaluation process, a continuous ping may be useful.

**Note**: for evaluation and testing in a corporate, education or other secured network setting, check with your IT staff about testing and disabling port security on the network port(s) connecting to the WaveTunnel<sup>™</sup> cluster. Also check on VLAN setting as needed. WaveTunnel<sup>™</sup> bridges will pass VLAN tagged traffic by default and are not configured to block any network traffic.

C:\Users\chris>ping 192.168.0.100 -t
Pinging 192.168.0.100 with 32 bytes of data: Reply from 192.168.0.100: bytes=32 time=3ms TTL=64 Reply from 192.168.0.100: bytes=32 time=1ms TTL=64 Reply from 192.168.0.100: bytes=32 time<1ms TTL=64
C:\Users\chris>ping 192.168.0.101 -t
Pinging 192.168.0.101 with 32 bytes of data: Reply from 192.168.0.101: bytes=32 time=15ms TTL=64 Reply from 192.168.0.101: bytes=32 time=1ms TTL=64 Reply from 192.168.0.101: bytes=32 time=1ms TTL=64



### **Evaluation: Test Tools**

In addition to WaveTunnel<sup>™</sup> connectivity, users may want to optimize the link between WaveTunnel<sup>™</sup> bridges. There are several useful built-in tools that can assist with getting an optimized connection for the highest data throughput.

Dashboard Gauges are a quick way to see the status and link integrity of a WaveTunnel<sup>™</sup> connections. There are four gauges that are included in the dashboard.

**Rx Power:** Received Power after the Automatic Gain Control (AGC) at the Analog to Digital Converter (ADC) input. Best performance and tuning from -20 to -70 dBm. *Note:* While other performance gauges may show yellow or even orange readings, if the Rx Power gauge is in green, link performance should be good.

**Rx Power OTA (Over the Air):** Received Power after the Rx Antenna and before AGC. Optimum range is from -20 to -70dBm.

**SNR:** Signal to Noise ratio of the link connection. Optimum range is from 40 to 25dB.

**Packet Error Rate (PER):** Rate of error packets that are received and typically is less than 5%. Other conditions should be noted and addressed.





In addition to the dashboard gauges, take notice of the statistics at Monitoring > Device > WaveTunnel. The same stats displayed on the dashboard are listed here as well as several other performance tuning states.

Downstream Radio Status		
	10.50 10	
Rx Power	-12.50 dBm	
Rx Average Signal to	25.75 dB	
Noise Ratio		
Rx Power OTA	-37.50 dBm	
Rx Packet Error Rate (PER)	0.12 %	
Tx MCS	10	
Rx MCS	9	
Tx Beam Index	23	
Rx Beam Index	27	
Modem Temperature	55 °C	
Radio Temperature	59 °C	

**Tx and Rx MCS Rate** are the modulation and coding scheme index values. Higher MCS index offers a higher spectral efficiency that translates to a higher potential data rate at higher SNRs. The range of MSC is 1-10 with 7-10 MSC





# **Evaluation: Scenarios**

Provided below are some typical test scenarios for a WaveTunnel<sup>™</sup> evaluation. A predictive WaveTunnel<sup>™</sup> VineCalculator is provided on the Airvine website at <u>https://services.airvine.com/calculator/</u>

### **Open Air Connectivity**



Test: 1m clear line of sight	
Rx Power	-13dBm
SNR	25.25dB
Rx Power OTA	-38dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to Root	1.5Gbps

Test: 144m clear line of sight	
Rx Power	-50.50dBm
SNR	7.25dB
Rx Power OTA	-75.50dBm
PER	0.51
Tx MCS	8
Rx MCS	6
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to Root	1.2Gbps



### Single / Multiple Drywall



Test: One Interior Wall	
10' distance	
Rx Power	-27dBm
SNR	26.00dB
Rx Power OTA	-52dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to	1.5Gbps
Root	
Test: Two Interior Walls	
15' distance	
Rx Power	-30dBm
SNR	23.50dB
Rx Power OTA	-
	54.5dB
	m
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	32
Rx Beam index	32
Traffic sent from Leaf to	1.5Gbps
Root	



Test: Three Interior Walls 23' distance	
Rx Power	-39dBm
SNR	21.50dB
Rx Power OTA	-64.5dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	33
Rx Beam index	33
Traffic sent from Leaf to Root	1.5Gbps

### Wood Door



Test: Wood Door	
Rx Power	-31dBm
SNR	23.75dB
Rx Power OTA	-57dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to Root	1.4Gbps



#### **Glass Wall**

Test: Glass Wall	
Rx Power	-28dBm
SNR	25.00dB
Rx Power OTA	-53dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to Root	1.5Gbps





# **Samples Worksheets**

Test: \_\_\_\_\_\_ Test: \_\_\_\_\_

Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	
Traffic sent from Leaf to	
Root	
Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	
Traffic sent from Leaf to	

Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	
Traffic sent from Leaf to	
Root	