



Morse Micro
reaching farther™

2.4 GHz Range Extension Using HaLow

APPNOTE-33

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1 Scope

This application note provides a guide on configuring and verifying a 2.4 GHz range extension using Morse Micro HaLowLink 1 devices. By leveraging 802.11ah (Wi-Fi HaLow) links, the reach of a 2.4 GHz Wi-Fi network can be extended, ensuring connectivity in areas where traditional Wi-Fi signals degrade or become unreliable.

The following components are required:

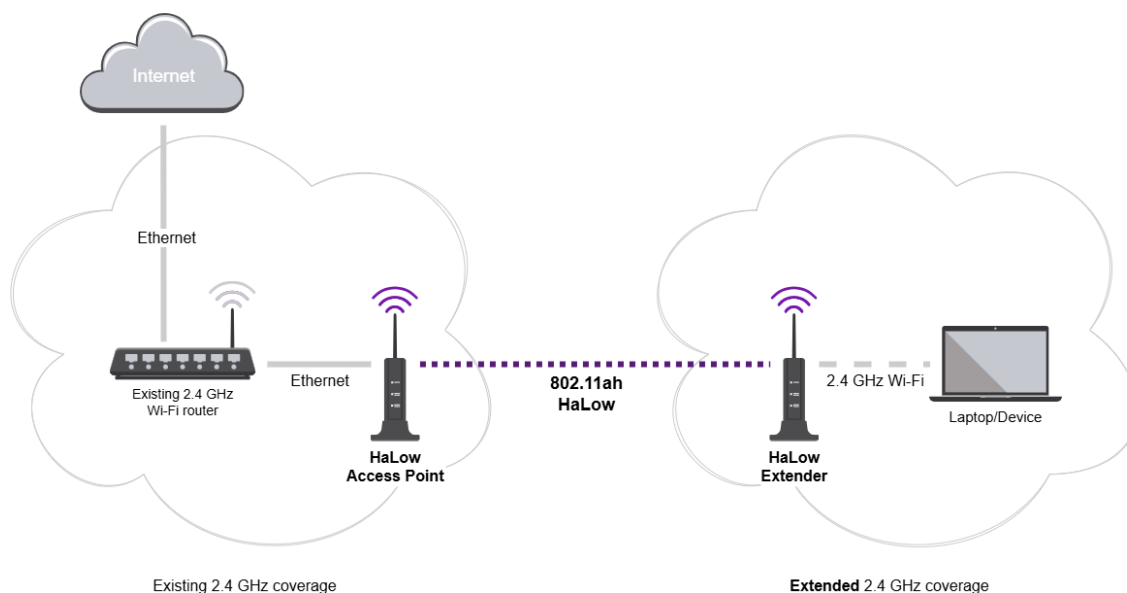
- 2 x [Morse Micro HaLowLink 1](#) devices with the latest software installed (this guide is based on version 2.7.4).
- 1 x Laptop with ping, traceroute, and iperf3 installed.
- 1 x Existing 2.4 GHz Wi-Fi router with LAN Ethernet connectivity available. This guide assumes that the credentials for this device are known and it is connected to the internet.
 - *Any additional 802.11ah HaLow WiFi compliant devices (such as Morse Micro EKH01 or EKH03) can be used, though this guide assumes HaLowLink 1 devices for simplicity.*

This application note covers:

- Configuring HaLowLink 1 devices to establish a long-range 802.11ah link.
- Validating that the connection is functioning correctly.
- Testing the reliability of the link under varying conditions.

2 Theory of Operation

The 2.4 GHz range extension configuration is a deployment strategy for Morse Micro products to extend Wi-Fi coverage beyond the reach of an existing 2.4 GHz Wi-Fi router. This configuration allows users to establish connectivity in areas with poor or no Wi-Fi signal by leveraging an 802.11ah (Wi-Fi HaLow) wireless backhaul, which has a significantly longer range than traditional 2.4 GHz Wi-Fi networks, whilst maintaining compatibility with standard 2.4 GHz Wi-Fi client devices.



It operates using a two-step approach:

- One device, the **HaLow Access Point (AP)**, is positioned near the existing 2.4 GHz Wi-Fi router and acts as a backhaul bridge.
 - *The uplink connection between the HaLow and the existing 2.4 GHz Wi-Fi router can operate over 2.4 GHz Wi-Fi, but this guide will refer to Ethernet as it is the more common method.*
- A second device, the **HaLow Extender**, is placed in the target coverage area (e.g., a dead zone) and paired with the HaLow AP via 802.11ah Wi-Fi. This Extender device then broadcasts a new 2.4 GHz Wi-Fi network for client devices which seamlessly routes all network traffic through to the internet, effectively extending the 2.4 GHz coverage of the existing infrastructure.

By default, the extended 2.4 GHz Wi-Fi network has a different SSID and credentials from the existing network. However, the user may configure these details to match on both sides for seamless roaming, depending on network requirements.

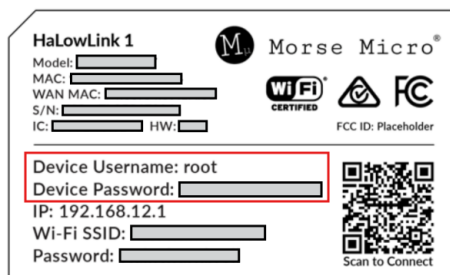
While this guide focuses on implementing this configuration using HaLowLink 1 devices as the most common use case, the strategy is applicable to any Morse Micro product that includes both an 802.11ah (Wi-Fi HaLow) and 802.11b/g/n (2.4 GHz) radio. Other evaluation kit products, such as the EKH03, can also be used to achieve the same functionality.

3 How to Configure

3.1 Configuring the HaLow Access Point

By default, HaLowLink 1 devices are configured as HaLow Access Points

1. Connect your laptop to the HaLowLink 1 device using a USB-C cable.
2. Connect an Ethernet cable from the port marked WAN on the HaLowLink 1 to the Ethernet port on the 2.4 GHz Wi-Fi router you wish to extend.
3. Wait until the Status LED is **solid green or aqua**.
4. Make sure the device is reset by holding down the **mode** button on the bottom of the device until the Status LED starts **flashing green**.
5. Wait until it's **solid green**.
6. Your laptop should detect the HaLowLink 1 as an Ethernet connection.
7. Access the web interface:
 - a. Open a browser and navigate to <http://192.168.12.1>.
 - b. Login with the username **root** and the password which is found on the sticker labeled "Device Password".



8. Click on the **Wizard** option in the side bar menu.
9. Select "HaLow Wi-Fi devices will get an IP on your existing router's network".

HaLow Mode ☒ Access Point ← Fastest mode if <4km range.
☐ 802.11s Mesh ← Use extra devices for more range.
☐ EasyMesh Controller ← Use extra devices for more range.

Network Mode ☒ HaLow Wi-Fi devices will get an IP on your existing router's network.
☐ HaLow Wi-Fi devices will get an IP on this device's local network.
☐ HaLow Wi-Fi devices will get an IP on this device's local network and use 2.4 GHz Wi-Fi for an uplink (not an Ethernet cable).

10. Click "Save & Apply" and wait for the changes to be applied.
11. Confirm that the Ethernet Uplink is marked as 'Connected' on the home page.

Once this configuration is complete you can disconnect the device from your laptop and power it on using the provided power adapter.

Note: By default, the HaLow Access Point also runs a 2.4 GHz Wi-Fi network, even if near your existing router. This can help with debugging but can be disabled to avoid interference.

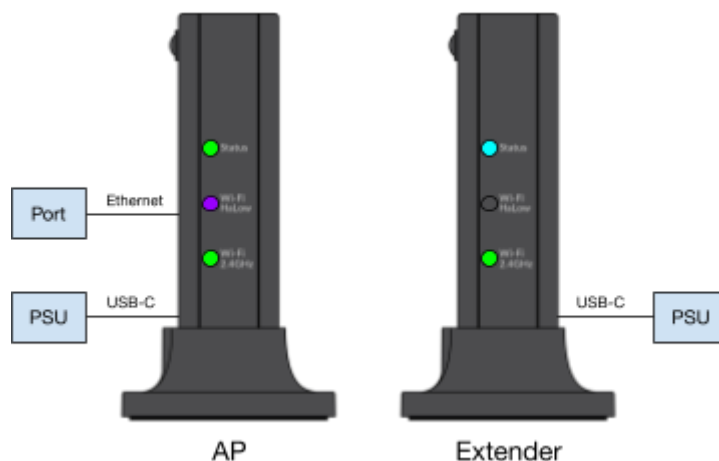
3.2 Configuring the HaLow Extender

This device will function as a HaLowLink 1 Extender. To change it into this mode:

1. Disconnect the Access Point device from your laptop if it's currently connected.
2. Connect your laptop to the other HaLowLink 1 using a USB-C cable.
3. Wait for the Status LED to turn **solid green**—this indicates the device is ready.
4. Activate Extender mode:
 - a. Press and hold the **mode** button (located at the bottom of the device).
 - b. The Status LED will first slowly flash green—continue holding the button.
 - c. Keep holding until the LED starts **rapidly flashing aqua**. If you release the button too early, wait for the LED to turn solid green and you will have to try again.
5. Wait for the LED to turn **solid aqua**—this confirms that the device is now in Extender Mode.
6. Disconnect the Extender from your laptop and power it on using the provided power adapter. The status LEDs should appear exactly as they were before.

3.3 Pairing Both Devices

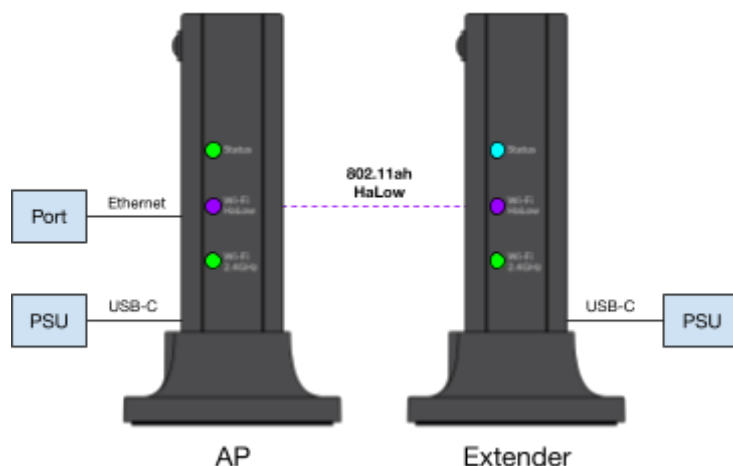
After completing steps 3.2 and 3.3, your devices should be connected this way:



You are now ready to establish the HaLow connection.

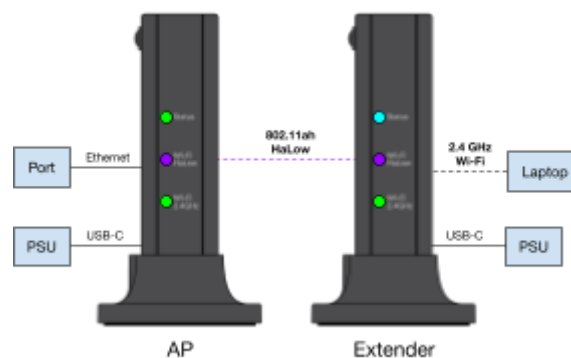
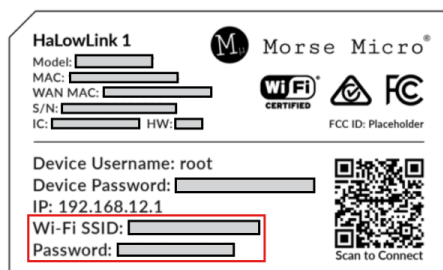
1. On the Access Point press and release the **mode** button on the underside of the device. The Wi-Fi HaLow LED should start **slowly flashing purple**.
2. On Extender press and release the **mode** button on the underside of the device. The Wi-Fi HaLow LED will start **slowly flashing purple**.
3. Wait until both devices have a **solid purple** HaLow LED. This indicates they are connected. This should usually happen within a minute.

If something went wrong during the pairing process, the Wi-Fi HaLow LED on the Extender will eventually stop flashing and turn off. In this case, make sure no-one else is trying to pair a HaLowLink 1 nearby (as for security reasons this will fail), wait 60 seconds, and try again. Once you have successfully paired your devices the Extender's Wi-Fi HaLow status LED should be **solid purple**:



3.4 Validating the connection

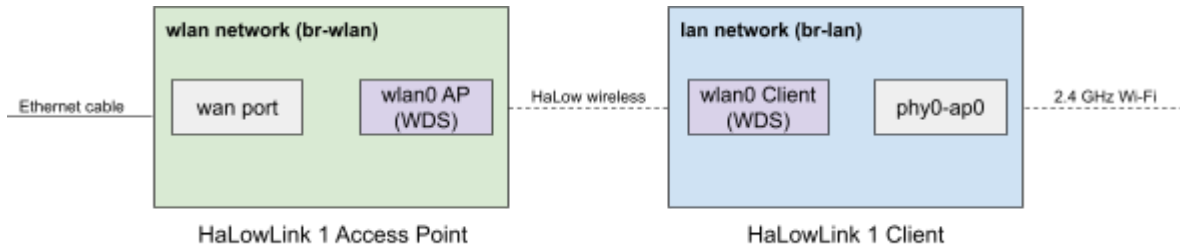
After pairing the AP and Extender, users can verify connectivity by connecting their laptop to the Extender's 2.4 GHz Wi-Fi and checking for internet access via the HaLow link. The default SSID and password are on the device sticker, and laptops should connect as usual.



Users may also want to check their speed via sites like <https://speed.cloudflare.com/>. Under optimal conditions with devices relatively close together the user can expect to achieve 18-22 Mbps.

4 How it Works

When configured this way, Linux bridges on the devices are used to connect the interfaces. On the Access Point side, the port labelled WAN is bridged with the HaLow Access Point (wlan0), and on the Extender side the HaLow Client (wlan0) is bridged with the 2.4 GHz AP (phy0-ap0). This means that any Layer 2 traffic is correctly passed across the HaLow link.



4.1 Technical details

If you ssh to a device (e.g. `ssh root@[deviceip]`) and use the password on your sticker), you can view this setup from the Linux command line using the **brctl show** command. On the AP side, it should show something like:

```
root@halowlink1-f4a1:~# brctl show
bridge name      bridge id                STP enabled  interfaces
br-wlan          7fff.9483c455f4a1        no           wlan0
                                                         wan
br-lan           7fff.9483c455f4a2        no           lan
                                                         phy0-ap0
                                                         usblan
```

Note that the name of the bridge here is **br-wlan**. This is because the name of the 'network' in OpenWrt is a higher level abstraction defined in the uci network file `/etc/config/network`:

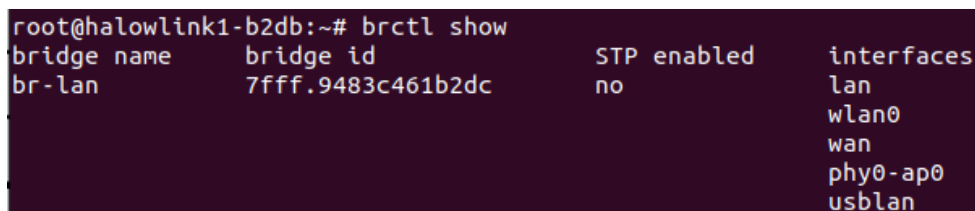
```
config interface 'wlan'
    option proto 'dhcp'
    option device 'br-wlan'
```

```
config device
    option name 'br-wlan'
    option type 'bridge'
    list ports 'wan'
```

Even though the wireless interface wlan0 is part of br-wlan, it is not specified here. Because wireless interfaces are dynamically constructed by hostapd or wpa_supplicant, OpenWrt specifies the **wlan network** on the wireless side in `/etc/config/wireless`:

```
config wifi-iface 'default_radio1'
    option mode 'ap'
    option wds '1'
    option device 'radio1'
    option network 'wlan'
    option ssid 'halowlink1-f4a1'
```

On the Client side, where instead everything is on the **lan network**, this looks like:



bridge name	bridge id	STP enabled	interfaces
br-lan	7fff.9483c461b2dc	no	lan wlan0 wan phy0-ap0 usblan

Excerpt from `/etc/config/network`:

```
config device
    option name 'br-lan'
    option type 'bridge'
    list ports 'usblan'
    list ports 'lan'
    list ports 'wan'

config interface 'lan'
    option device 'br-lan'
    option proto 'dhcp'
```

Excerpt from `/etc/config/wireless`:

```
config wifi-iface 'default_radio1'
    option mode 'sta'
    option wds '1'
    option device 'radio1'
    option network 'lan'
    option ssid 'halowlink1-f4a1'
```

4.2 Wireless Distribution System/4 address mode

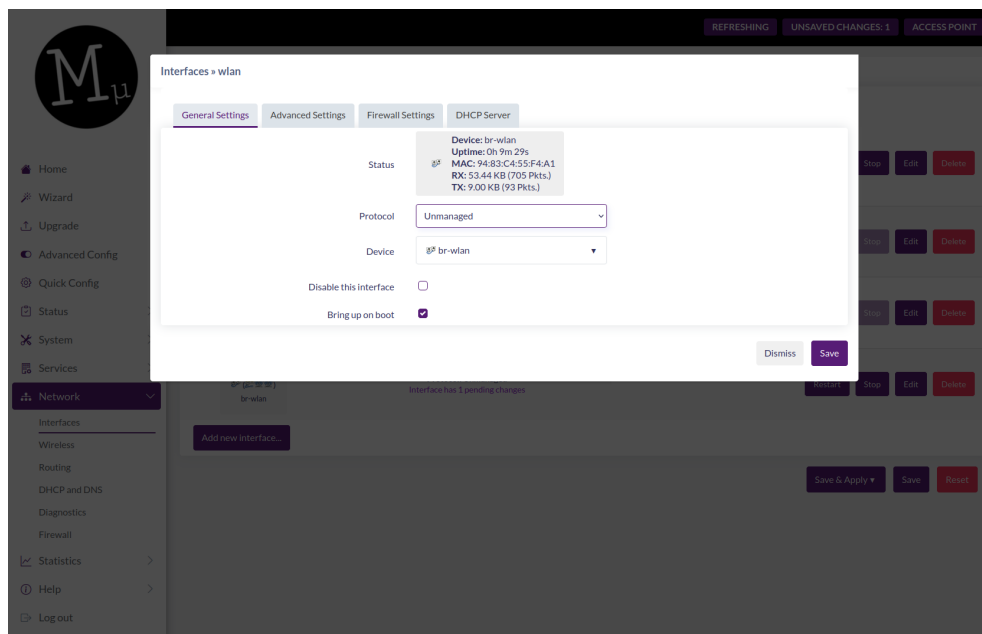
You may have noticed the **wds** option that was set in the above configuration. A normal wireless client would not be capable of attaching to a bridge, whether using HaLow or any other 802.11 wireless interface, as a normal wireless client does not use **4 address mode** (also known as **WDS**, “Wireless Distribution System”). Without four address mode, packets originating from or directed to the Client/Station side of a wireless link must share the MAC address of the wireless interface, whereas four address mode allows four distinct addresses: the TA (transmitter address - e.g. wlan0 AP), RA (receiver address - e.g. wlan0 Client), a DA (destination address) and SA (source address).

For this to work correctly, both AP and Client must be in **WDS** mode. In the setup in Section 3, this has been automatically selected for you. For more information about how to configure this manually, see Section 4.

4.3 DHCP client mode

The default configuration here leaves your HaLowLinks in DHCP client mode. This makes it easier to access their configuration interface or ssh to them, as if you have a DHCP server on your network they will get a DHCP lease. To discover their IP, refer to the DHCP lease table on your network.

However, if you wish them not to be accessible on your network at all, you should change the protocol to **unmanaged**. You can do this via the network interfaces page:



5 Manual Configuration

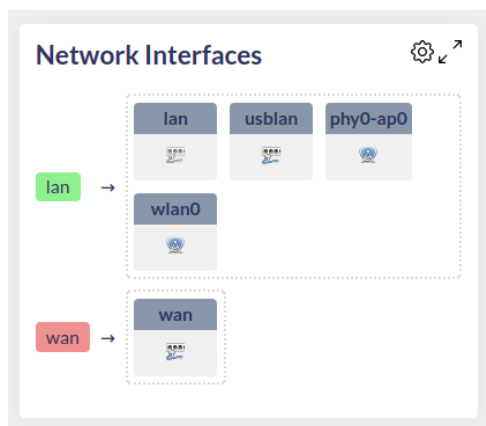
If you would like to better understand the configuration used for this range extension and identify which settings are critical, you can configure it manually via the following steps. This will also be helpful if you wish to make small modifications to an existing setup (as developed in Section 3).

5.1 Configuring the HaLow Access Point

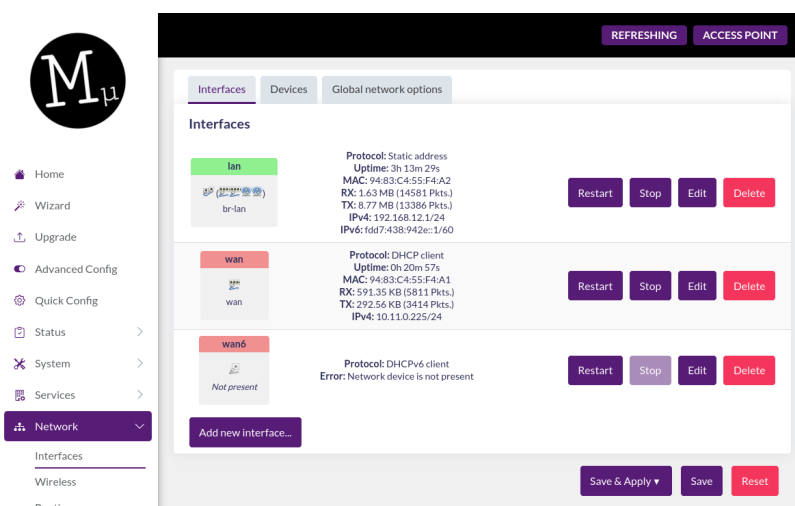
First, connect to the Access Point as in 3.1:

1. Connect your laptop via USB-C to the device.
2. Connect an Ethernet cable from the port marked WAN on the HaLow to the Ethernet port you wish to extend on the existing 2.4 GHz Wi-Fi router.
3. Wait until the Status LED is **solid green or aqua**.
4. Make sure the device is reset by holding down the **mode** button on the bottom of the device until the Status LED starts **flashing green**.
5. Wait until it's **solid green**.
6. Your laptop should detect the HaLowLink 1 as an Ethernet connection.
7. Go to <http://192.168.12.1>, and login with the username **root** and the “Device Password” printed on the sticker.
8. Confirm that the Ethernet Uplink is marked as ‘Connected’ on the Home page.

By default, the HaLow Access Point is bridged with the local network (192.168.12.x) provided by default. You can see this in the Network Interfaces card on the Home page (if you hover over ‘wlan0’ it will provide more information about this link, and highlight the related cards):



For range extension, we instead want to bridge the Access Point with the uplink connection, which is on the **wan** port. However, the **wan** interface (which contains the **wan** port) is by default configured with a firewall which blocks traffic, as a standard internet router would be. We could amend these firewall rules, but a simpler option is to create an entirely new network interface. To do this, make sure Advanced Config is enabled in the menu, and go to Network -> Interfaces:



Now you can **Add new interface...**, typing in **wlan** and selecting **DHCP client**, leaving Device **unspecified**:

Add new interface...

Name

wlan

Protocol

DHCP client

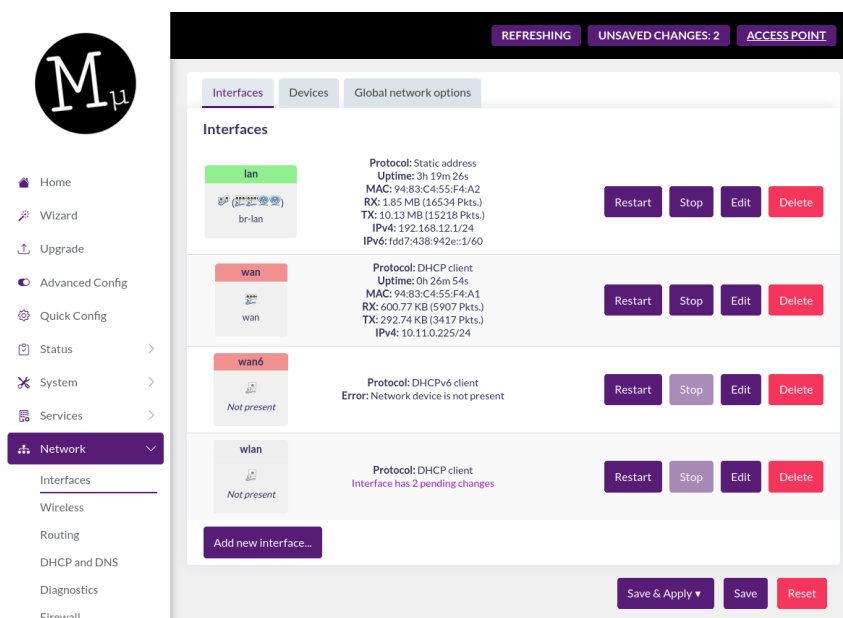
Device

unspecified

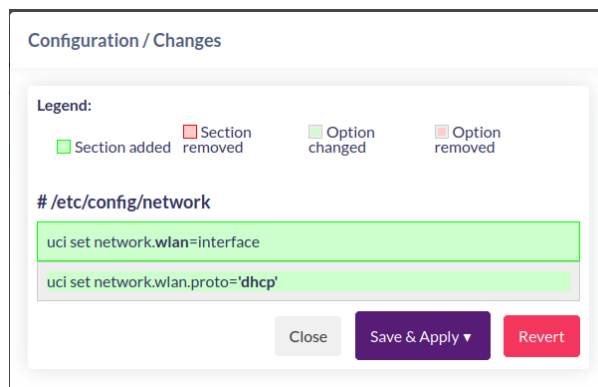
Cancel

Create interface

Once you've clicked **Create Interface**, dismiss the dialog that comes up. You should now see **UNSAVED CHANGES** at the top of the page.



At any point when configuring, you can click on **UNSAVED CHANGES** to view the commands that you would need to use via the CLI:



You do not need to **Save & Apply** this yet, although it won't hurt; the frontend allows you to accumulate a large changeset and apply it all at once.

Now go to the Quick Config page where we can see we have a new **wlan** interface (below **lan** and **wan**) which doesn't have any Wireless or Ethernet devices:

The screenshot shows the "Quick Configuration" page in the Morsemi UI. On the left is a sidebar with navigation links: Home, Wizard, Upgrade, Advanced Config, Quick Config (selected), Status, System, Services, Network, Statistics, Help, and Log out. The main content area has a header with "UNSAVED CHANGES: 2" and "ACCESS POINT". Below the header is a diagram titled "This Device" showing the network topology. It includes an "Existing router" connected to the "Internet", a "Laptop/Device" with IP 192.168.12.x, and a "HaLow Access Point" with IP 192.168.12.1. The Access Point is connected to a "HaLow Client" with IP 192.168.12.x via "2.4 GHz Wi-Fi". The Access Point also has an "Ethernet (usb|lan)" port connected to another "Laptop/Device" with IP 192.168.12.x. Below the diagram is a "Network Interfaces" table.

Name	Forward	Wireless	Ethernet	DHCP Server	Protocol	IPv4 address
lan	wan	halowlink1: f4a1	usb lan lan	☒	Static IP	192.168.12.1
wan	None		wan	☐	DHCP Client	
wlan	Create Zone		None	☐	DHCP Client	

To set it up, we need to:

- click Create Zone to create a firewall zone (which will default to ACCEPT all)
- remove the **wan port** from the **wan** interface by unticking it
- add the **wan port** to the **wlan** interface by ticking it

It should now look like this:

Name	Forward	Wireless	Ethernet	DHCP Server	Protocol	IPv4 address
lan	wan	halowlink1-f4a1	usblan lan	☒	Static IP	192.168.12.1
wan	None		None	☐	DHCP CI	
wlan	None		wan	☐	DHCP CI	

Finally, go down to the 'Wireless', section, and change the network of your Morse Micro MM6108 device from **lan** to **wlan**:

Morse Micro MM6108A1 802.11ah (radio1)

Country: AU

Preferred frequency: 8 MHz, Channel: 44 (924 MHz)

Enabled	Device	Network	Mode	SSID/Mesh ID	Encryption	Key/Security
☒	wlan0	wlan	Access Point	halowlink1-f4a1	WPA3-SAE	*****

This change should be reflected in Wireless column of your Network Interfaces section:

Network Interfaces

Name	Forward	Wireless	Ethernet	DHCP Server	Protocol	IPv4 address	
lan	⇒ wan	halowlink1-f4a1	usblan lan	☒	Static IP	192.168.12.1	...
wan	⇒ None		None	☐	DHCP CI		...
wlan	⇒ None	halowlink1-f4a1	wan	☐	DHCP CI		...

If you now click **Save** only, you can again go to **UNSAVED CHANGES**:

Configuration / Changes

Legend:

Section added

Section removed

Option changed

Option removed

/etc/config/firewall

uci set firewall.wlan1=zone

uci set firewall.wlan1.name='wlan1'

uci add_list firewall.wlan1.network='wlan'

uci set firewall.wlan1.input='ACCEPT'

uci set firewall.wlan1.output='ACCEPT'

uci set firewall.wlan1.forward='ACCEPT'

/etc/config/network

uci set network.wlan=interface

uci set network.wlan.proto='dhcp'

uci del network.wan.device

uci add network device # =cfg080f15

uci set network.@device[-1].name='br-wlan'

uci set network.@device[-1].type='bridge'

uci add_list network.@device[-1].ports='wan'

uci set network.wlan.device='br-wlan'

/etc/config/wireless

uci set wireless.default_radio1.network='wlan'

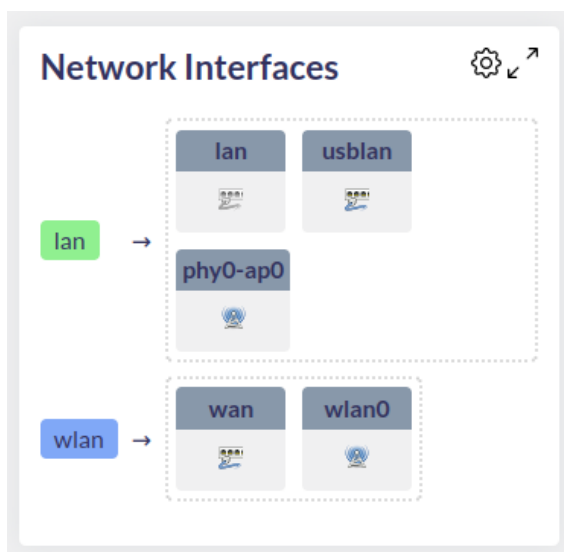
Close

Save & Apply

Revert

Click **Save & Apply** to make these take effect.

Return to the Home page to confirm that the **wan** port and the wlan0 HaLow interface are bridged:



You have now finished configuring your Access Point.

5.2 Configuring the HaLow Extender

First, reset the device and connect to it via Ethernet from your laptop:

1. Connect your laptop via USB-C to the device.
2. Wait until the Status LED is **solid green or aqua**.
3. Make sure the device is reset by holding down the **mode** button on the bottom of the device until the Status LED starts **flashing green**.
4. Wait until it's **solid green**.
5. Your laptop should detect the HaLowLink 1 as an Ethernet connection.
6. Go to <http://192.168.12.1>, and login with the username **root** and the "Device Password" printed on the sticker.

Navigate to the 'Quick Config' page. Under wireless you will see the Morse Micro device behaving as an Access Point (WDS) on the **lan** network.

The screenshot shows the "Wireless" configuration page for a Morse Micro MM6108A1 802.11ah (radio1) device. The page includes settings for Country (US), Preferred frequency, Width (8 MHz), and Channel (44 (924 MHz)). Below these are tabs for Enabled, Device, Network, Mode, SSID/Mesh ID, Encryption, and Key/Security. The "Network" tab is selected, showing the device is configured as an Access Point (WDS) on the "lan" network. The SSID/Mesh ID is "halowlink1-b09b", and the Encryption is set to WPA3-SAE. A key/security field is visible with a masked password and a reset icon.

At this point, change the mode to be Client (WDS) and search for the network of the corresponding HaLow Access Point which you would like to connect to. Once the network appears in the SSID/Mesh ID dropdown, you can select it and enter in the credentials from the sticker on that device, ensuring that you use WPA3-SAE encryption.

At this point the morse device is on the **lan** network, and we would like to remove its static IP. However, if we were to proceed with this change we would immediately lose access to the device, as the 192.168.12.1 IP would be removed.

The workaround to this is to move it to the **wan** network via the dropdown to test the client connection. The admin interface will temporarily remain accessible at <http://192.168.12.1> on the **lan** network.

Wireless

Morse Micro MM6108A1 802.11ah (radio1)

Country US

Preferred frequency Width Channel

8 MHz 44 (924 MHz)

Enabled	Device	Network	Mode ?	SSID/Mesh ID	Encryption	Key/Security
☒	wlan0	wan	Client (WDS)	halowlink1-afdf -42 dBm	WPA3-SAE	

+

Once the changes have been made to mimic the image above, you can now click **Save** only, you can again go to **UNSAVED CHANGES** at the top of the page to see something similar to this:

Configuration / Changes

Legend:

Section added

Section removed

Option changed

Option removed

/etc/config/network

uci add network device # =cfg070f15

uci set network.@device[-1].name='br-wan'

uci set network.@device[-1].type='bridge'

uci add_list network.@device[-1].ports='wan'

uci set network.wan.device='br-wan'

/etc/config/wireless

uci set wireless.default_radio1.network='wan'

uci set wireless.default_radio1.mode='sta'

uci set wireless.default_radio1.ssid='halowlink1-afdf'

uci set wireless.default_radio1.key='pulse67yield2cause'

Close

Save & Apply

Revert

Click **Save & Apply** to make these changes take effect.

After the changes have been applied and the page is reloaded, navigate to the 'Home' page. If you have entered the credentials correctly and the devices have associated you should be able to see the Uplink (HaLow) card indicating a connection with the newly assigned IP (which you should save somewhere accessible) like below:

Uplink (HaLow)

SSID

halowlink1-afdf

Device

wlan0

IP

192.168.12.247

Speed

32.5 Mbps

✓

Connected

18 | morsemicro.com

At this point, the HaLow connection has been made, but the range extension configuration is incomplete. In the final steps we will consolidate all the available devices onto the **lan** network and set it up to receive an IP from the HaLow Access Point.

Return to 'Quick Config' and modify the Morse Micro wireless device to use the **lan** network.

Wireless

Morse Micro MM6108A1 802.11ah (radio1)

Country: US

Preferred frequency: 8 MHz, Width: 44 (924 MHz), Channel: 44 (924 MHz)

Enabled	Device	Network	Mode	SSID/Mesh ID	Encryption	Key/Security
☒	wlan0	lan	Client (WDS)	halowlink1-afdf	WPA3-SAE	

The 'Network Interfaces' subsection should now show both your 2.4 GHz and HaLow networks colocated on the **lan** row under the 'Wireless' column.

Network Interfaces

Name	Forward	Wireless	Ethernet	DHCP Server	Protocol	IPv4 address
lan	wan	halowlink1-b09b, halowlink1-afdf	usblan lan	☒	Static IP	192.168.12.1
wan	None		wan	☐	DHCP Client	

Unset the DHCP Server slider and select DHCP Client under the protocol drop down to ensure that the Extender will correctly receive an IP from the AP. Then, using the 'Ethernet' dropdown options, remove the wan Ethernet device from the **wan** network to the **lan** one:

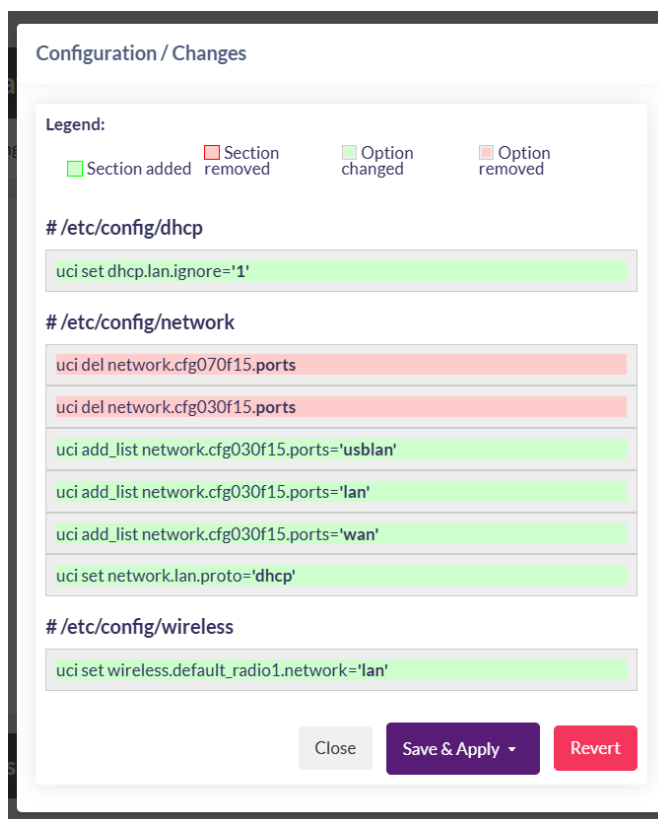
Network Interfaces

Name	Forward	Wireless	Ethernet	DHCP Server	Protocol	IPv4 address
lan	wan	halowlink1-b09b, halowlink1-afdf	usblan lan wan	☐	DHCP Client	
wan	None		usblan, lan, wan	☐	DHCP Client	

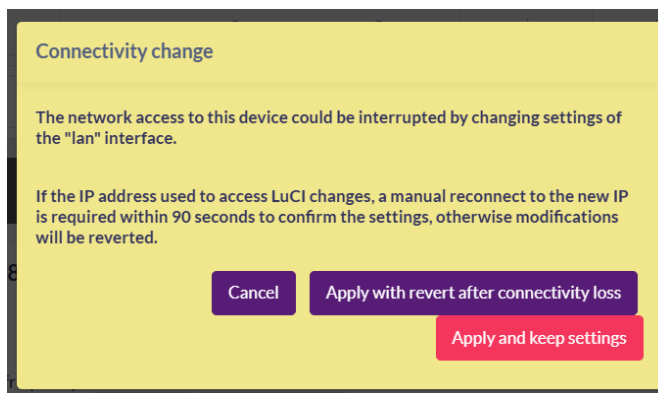
Network Interfaces

Name	Forward	Wireless	Ethernet	DHCP Server	Protocol	IPv4 address
lan	wan	halowlink1-b09b, halowlink1-afdf	usblan lan wan	☐	DHCP Client	
wan	None		None	☐	DHCP Client	

After clicking **Save** you should be able to see the following **UNSAVED CHANGES**:



From here click **Save & Apply** where you will be warned about losing your access to <http://192.168.12.1>. Select 'Apply and Keep Settings' to persist your changes.



You have now configured your HaLow Extender! It will remain accessible at the IP you recorded earlier when the HaLow Wi-Fi was on the **lan** network. You may now connect your client devices such as your laptop to the Extender's 2.4 GHz Wi-Fi network (ensuring that you have disconnected your Ethernet) and use the internet.

6 FAQ

Can I access the HaLowLink 1 admin interface once I'm in this mode?

You can access the admin interface on the AP by either:

- connecting to the LAN or USB port, and accessing 192.168.12.1 as before. This is because only the HaLow and WAN ports are bridged.
- connecting to the AP from your existing network by determining its IP from the DHCP lease table on your DHCP server.

You can access the admin interface on the Client by either:

- connecting to the Client from your existing network by determining its IP from the DHCP lease table on your DHCP server.
- connecting to the LAN or USB port, and setting your network connection to have a static IP of 10.22.121.110 and a netmask of 255.255.255.254. You can then access the admin interface at <http://10.22.121.111>

How do I disable the 2.4 GHz Wi-Fi network on my HaLow Access Point? It is interfering with my existing network.

HaLowLink 1s have a 2.4 Access Point enabled by default for ease of setup. If you do not want this, you should disable the 2.4 AP by going to the Quick Config page and clicking the slider in the 'Enabled' column so that it looks like this:

MediaTek MT7603E 802.11b/g/n (radio0)

Preferred frequency Mode Channel Width

N 1 (2412 MHz) 20 MHz

Enabled	Device	Network	Mode	SSID/Mesh ID	Encryption	Key/Security
☐	phy0-ap0	lan	Access Point	halowlink1-f4a1	WPA2-PSK	

How can I make my extender's 2.4 GHz network appear identical to my existing Wi-Fi?

As long as there is no significant signal overlap causing devices to compete for association, you can simply set the extender's 2.4 GHz network credentials to match via Quick Config.

MediaTek MT7603E 802.11b/g/n (radio0)

Preferred frequency Mode Channel Width

N 1 (2412 MHz) 20 MHz

Enabled	Device	Network	Mode	SSID/Mesh ID	Encryption	Key/Security
☒	phy0-ap0	lan	Access Point	my-existing-network-SSID	WPA2-PSK	my-existing-network-key

7 Revision History

Release Number	Release Date	Release Notes
1	11/04/2025	Initial release



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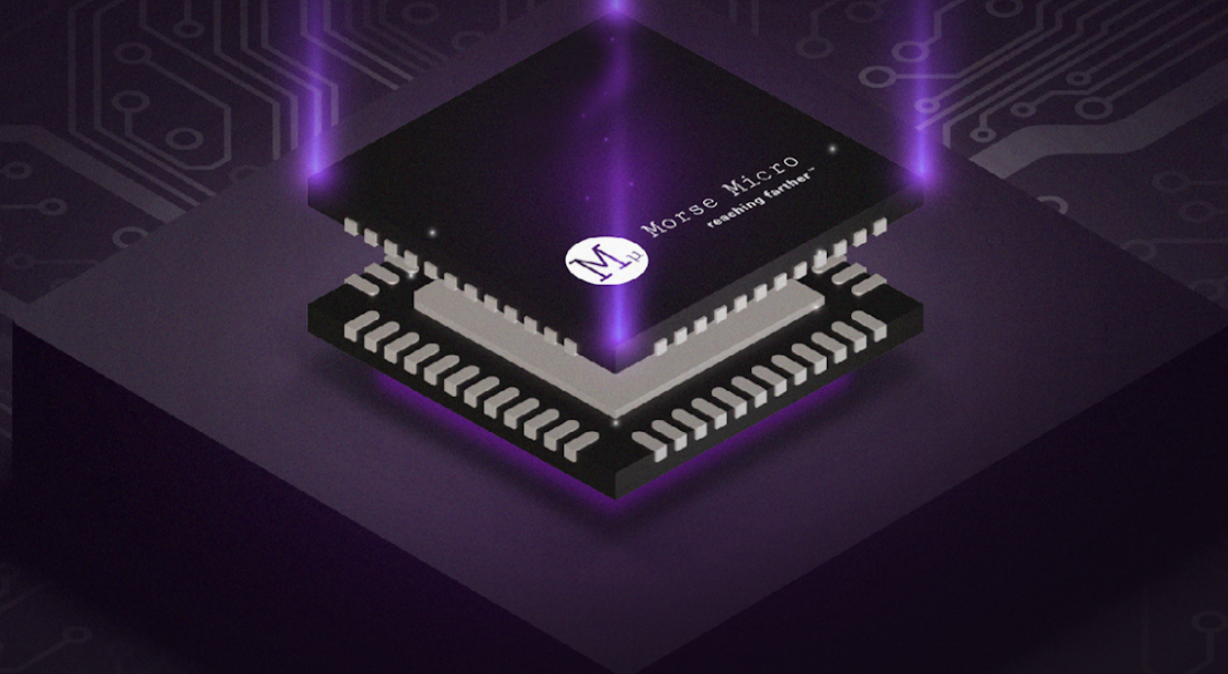
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About Morse Micro

Morse Micro is a leading Wi-Fi HaLow fabless semiconductor company based in Sydney, with global offices. As the world's premier Wi-Fi HaLow company, we pioneer next-gen IoT wireless connectivity solutions. Morse Micro is now sampling its Wi-Fi CERTIFIED HaLow MM6108 production silicon: the fastest, smallest, lowest power and longest-range Wi-Fi HaLow chip available in the market.



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