



Morse Micro  
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# Morse Micro OpenWrt 2.8 Web UI User Guide

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# 1 Overview

Thank you for choosing to evaluate Morse Micro 802.11ah HaLow for use in your application. This guide will get you started using the kit and evaluating the 802.11ah technology. It is primarily intended for users of the web UI but will mention other configuration methods for reference.

The Morse Micro web UI provides a graphical interface for viewing and modifying device configurations, particularly the operating mode and HaLow radio parameters. The interface is available on EKH01 and EKH03 evaluation kits and is based on OpenWrt's standard LuCI interface.

Section [2](#) of this document provides a brief description on how to set up the hardware and outlines the basic scenarios that might be used for evaluation. Section [3](#) explains how to configure a system for the first time using the Morse Micro web UI. Sections [4](#), [5](#) and [6](#) describe how to test the performance of Wi-Fi HaLow using Wavemon, iPerf3 and the Range Testing GUI respectively. Section [8](#) outlines some of the available UI screens and tools, while Section [9](#) provides advanced configuration tips that are not usually required but may be useful in some situations. Section [10](#) explains the configuration architecture, including how UI configuration propagates through the system to effect changes. Section [11](#) provides some troubleshooting advice for common problems.

Throughout this document, references to 'AP' imply a Wi-Fi Access Point and references to 'STA' imply a Wi-Fi station.

## 2 Device Setup

A brief description of the hardware and browser set-up is included below for configuration via the web UI, along with a description of the standard test setup scenarios.

This guide applies to all variants of the evaluation kits described below, including those based on different Morse Micro HaLow chips such as the MM6108 and MM8108.

### 2.1 EKH01



- **microSD card** - this contains the device firmware.
- **Status LEDs** - the red LED indicates power, and the green LED indicates HaLow network activity.
- **USB Type-C** - USB-C port for supplying power to the EKH01. The kit includes an AC adapter that converts mains power to 5V for the EKH01 via the USB-C connector.
- **Micro HDMI** - Micro HDMI display outputs for EKH01, only used for debugging.
- **Headphone Jack** - not typically used.

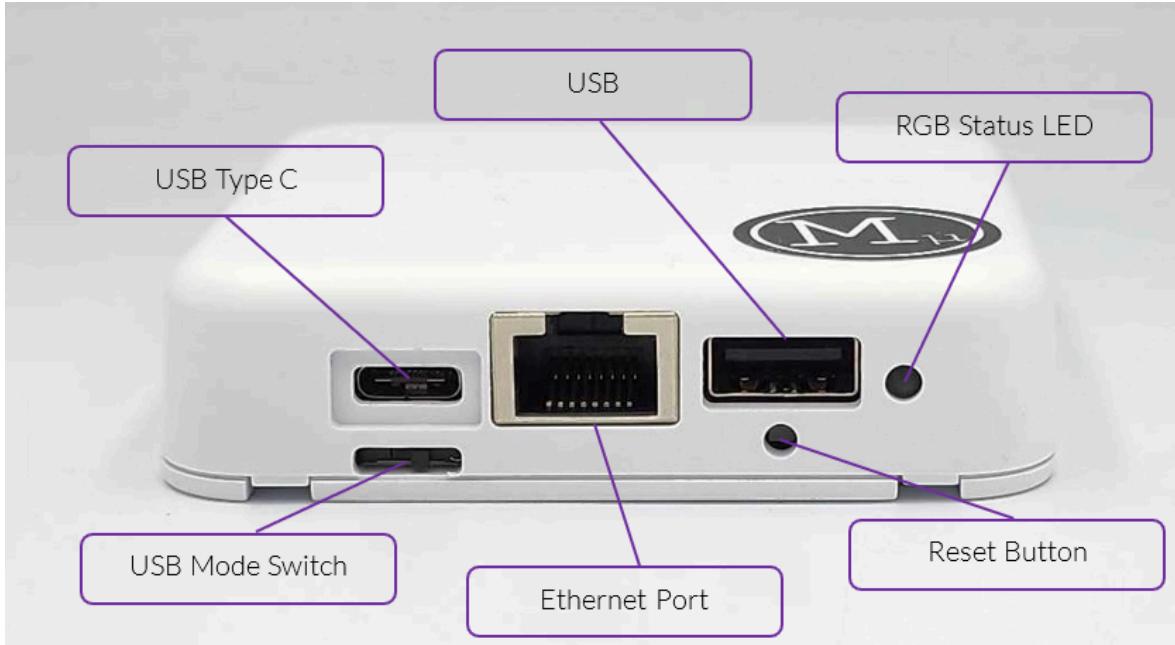


- **USB Ports** - USB-A ports for connecting peripherals and USB to serial adapter. Any of these ports can be used for serial console access, but note the cable must be plugged in at boot time to be detected. The serial console operates at 115,200 bps 8N1 by default.
- **Ethernet** - Ethernet port for either a LAN connection (e.g. a laptop) or an upstream WAN connection (e.g. gateway router).
- **(Optional) Camera** - the device may include a camera depending on the kit version ordered.

## 2.1.1 Basic setup

1. Connect the antenna to the HaLow antenna connector on top of the unit.
2. Optional - connect an RJ45 Ethernet cable to the Ethernet port if required.
3. Optional - connect a USB-serial cable to any of the USB ports if required for debugging. This is not usually required.
4. Once power is supplied, it should take the device around 60 seconds to boot up and be operational.

## 2.2 EKH03



- **USB Type C** - powers the board and can function as an Ethernet-to-USB adapter if the USB mode switch is in the leftmost position.
- **USB** - can be used for connecting peripheral devices to the EKH03 and provides a UART interface which can be accessed via a 3.3V TTL serial USB cable. For advanced users, UART access is also available through header pins on the internal PCB.
- **RGB Status LED** - is a multi-color LED that is used to indicate the status of the device (see [Basic setup](#) for details).
- **USB Mode Switch** - selects whether to use the USB-C or Ethernet port for the LAN connection. The direction of the switch determines which port is selected (*left* - USB-C for Ethernet, *right* - Ethernet port for Ethernet).
- **Ethernet Port** - for either a LAN connection (e.g. a laptop) or an upstream WAN connection (e.g. gateway router).
- **Reset Button** - can be used to reset the device. Pressing and holding the button for 5 seconds (until flashing green) will reboot the device. Holding for more than 10 seconds (until flashing yellow) will trigger a full factory reset of the device, returning it to the default configuration. This button is also used for DPP push button connections. For more details, see sections [3.6](#) and [3.8](#).
- **2.4 GHz Wi-Fi** - provides an access point which is brought up on the EKH03 by default. It is also automatically bridged to the Ethernet interface.

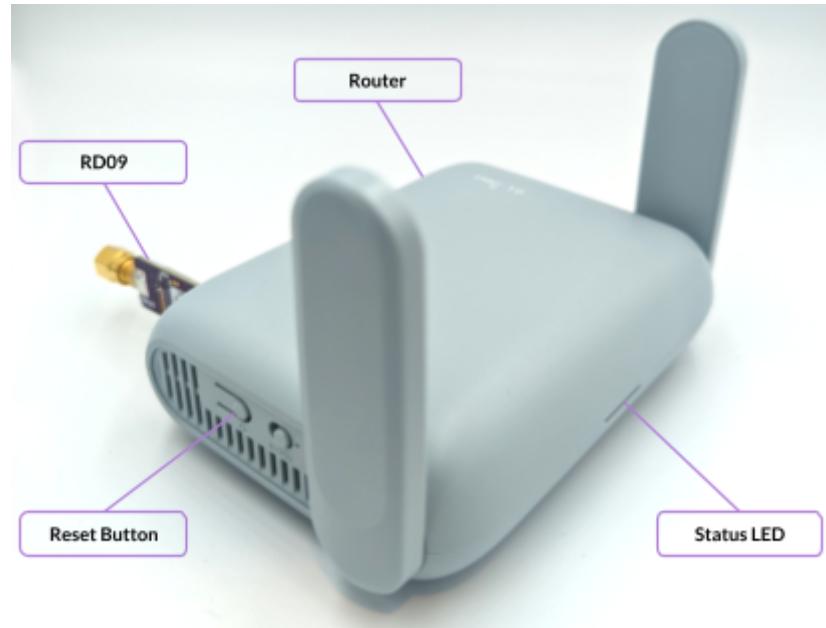
## 2.2.1 Basic setup



1. Connect the provided antenna to the HaLow Antenna Connector shown.
2. Plug the power adapter into the USB-C connector on the EKH03. The included USB-C to USB-A cable can also connect the EKH03 to a power source, such as a laptop or phone charger (via the USB-C connector).
3. Once the device is powered, the RGB LED will display the status of the device (see table).

Status	LED Color (behaviour)	Graphical Example
Booting stage 1 (bootloader)	Yellow (solid)	
Booting stage 2 (linux)	Green (flash 1.5 per sec)	
Fully booted	Green (solid)	
DPP running	Purple (flash 1 per sec)	
DPP failed (remains for 5 secs)	Purple (flash 5 per sec)	
Fully booted and HaLow connected	Purple (solid, flash activity)	
Error	Red (flash 10 per sec)	
Rebooting	Green (flash 1.5 per sec)	
Upgrading	Blue (flash 1.5 per sec)	
Factory resetting	Yellow (flash 5 per sec)	

## 2.3 EKH19



- **RD09** - a Wi-Fi HaLow USB dongle.
- **Router** - a host for the RD09.
- **Reset Button** - used to reset the device. Pressing and holding the button for 5 seconds (until rapidly flashing blue) will trigger a full factory reset.
- **Status LED** - a dual-color LED that is used to indicate the status of the device (see [Basic setup](#) for details).



- **USB Type C** - USB-C port for supplying power to the EKH19. The kit includes an AC adapter that converts mains power to 5V for the EKH19 via the USB-C connector.
- **Ethernet Ports** - Despite the markings, either port can be [configured](#) as either a LAN connection (e.g. a laptop) or an upstream WAN connection (e.g. gateway router).
- **2.4 & 5 GHz Wi-Fi** - provide access points which are brought up on the EKH19 by default. They are all automatically bridged together, including the ethernet interfaces.



- **Firmware LED** - A green LED indicating that the RD09 has loaded correctly.
- **Association LED** - A green LED which will light up only if the HaLow network has been configured as a station and has successfully associated with an Access Point.
- **Traffic LED** - A red LED which will blink to indicate HaLow network traffic.

### 2.3.1 Basic setup

1. Plug the provided RD09 Wi-Fi HaLow USB dongle into the router's USB Type-A port.
2. Connect the antenna to the HaLow antenna connector on the RD09.
3. Optional - connect an RJ45 Ethernet cable to the LAN Ethernet port if required.
4. Once power is supplied, the status LED will begin flashing blue. Once the router has fully booted it will become solid blue. This process normally takes about 40 seconds.

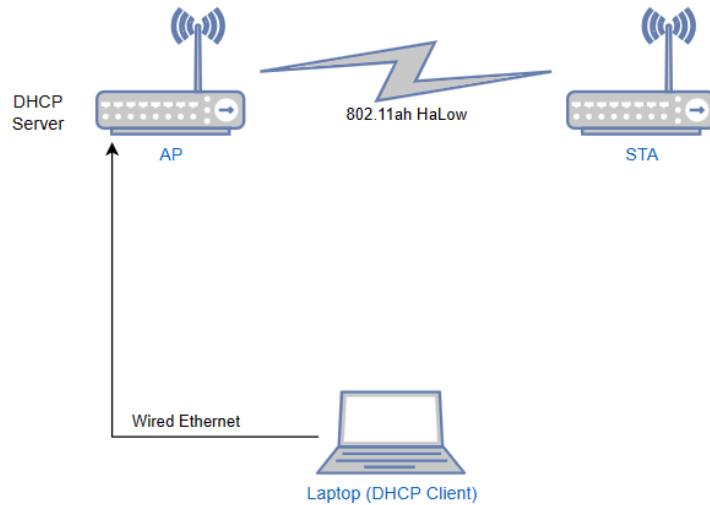
## 2.4 Browser support

The web UI has been tested and verified to work with up to date releases of the following browsers:

- Google Chrome
- Firefox
- Microsoft Edge
- Apple Safari

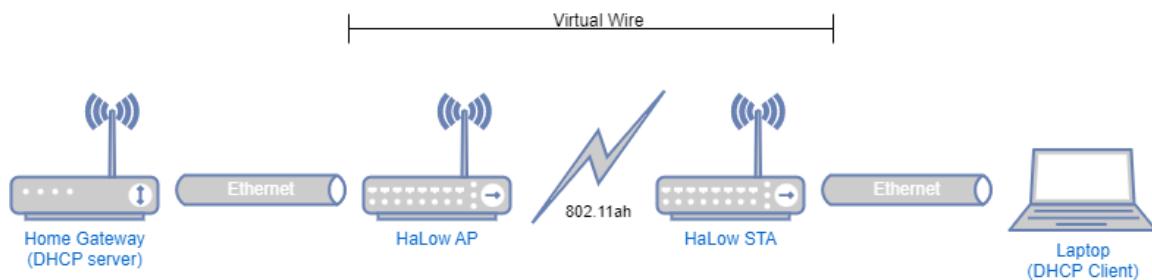
## 2.5 Standard setup scenarios

### 2.5.1 Standalone Access Point with client devices



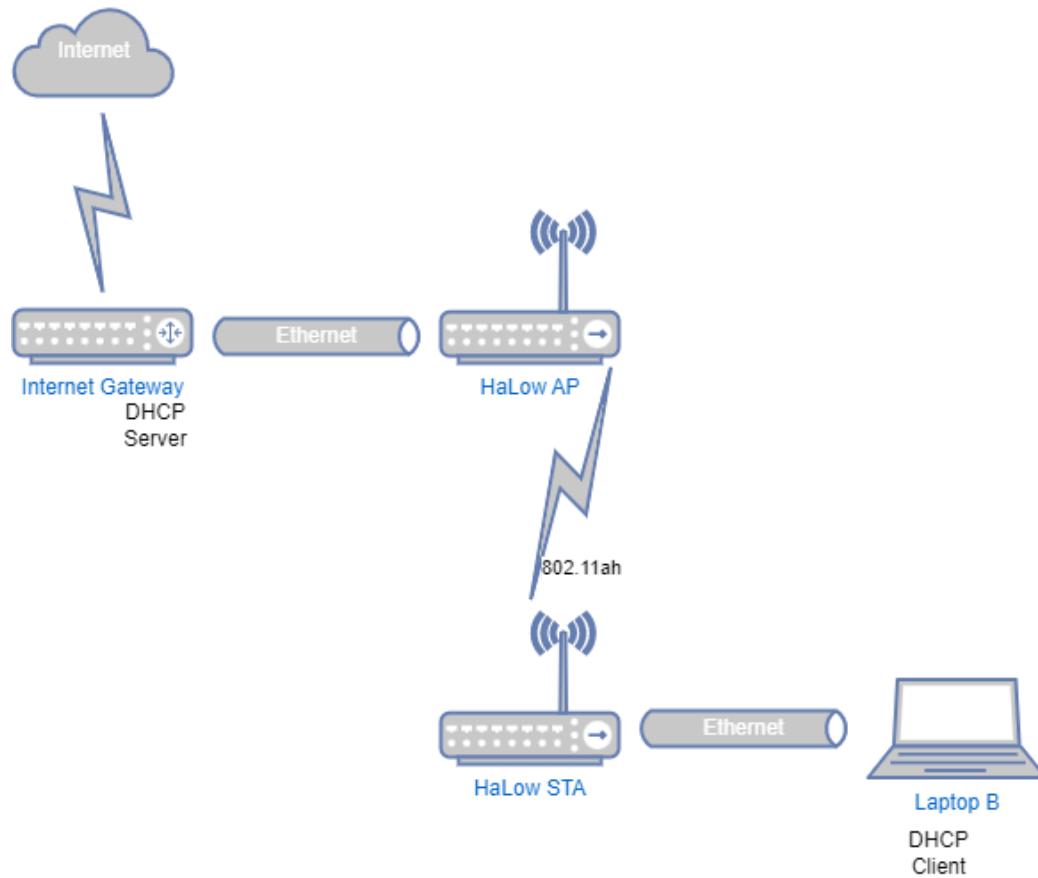
This configuration is typically used for standalone testing of a HaLow connection. It is useful in closed network scenarios where connected devices do not require access to external networks. The key here is that the traffic will only go between the AP and STA and is completely isolated from any external networks. If you're unsure which setup to use, start with this one.

### 2.5.2 Using HaLow as a ‘virtual wire’ (Layer 2 bridge)



In this configuration HaLow is transparent to the rest of the devices in the network. The HaLow link is used as a means of providing a ‘virtual’ Ethernet connection between two points where it may not be practical to run a physical cable. This scenario is useful as a simple way to test HaLow with real-world traffic by introducing it into an existing network without having to adjust the configuration of the non-HaLow devices.

### 2.5.3 Non-standalone Access Point with routing



This scenario is a more complicated version of the one above, where rather than using bridging to simplify the setup, each device is a router with its own DHCP server and local network. This allows for a more complex network configuration, but is more difficult to set up. It is also robust in that if the HaLow links goes down, the station will still have an IP address and the web UI will be reachable.

This scenario is useful for evaluating the HaLow device's ability to handle traffic flows at Layer 3, but places more load on the CPU. Unless you have a specific reason to use this approach, bridging is a simpler alternative.

## 2.6 Default Web UI IP Addresses

The following table lists the default IP addresses used to access the Web UI interface of Morse Micro evaluation kits. This Web UI is the primary graphical interface provided by the Morse OpenWrt system, and is referenced throughout this guide for configuration and management.

When connecting to a device over Ethernet, your device may need to be manually configured with a compatible IPv4 address on the same subnet (e.g., 10.42.0.x or 192.168.8.x). Refer to your device's network settings to set a static IP if the connection fails to load the interface.

Evaluation Kit	Ethernet Interface IP	HaLow Interface IP
EKH01	10.42.0.1	192.168.12.1
EKH03	10.42.0.1	192.168.12.1
EKH19	192.168.8.1	192.168.12.1

# 3 Configuration of Operating Modes

Evaluation kits are dispatched in a default configuration, and this guide assumes the devices will be used starting in that state. If the kits have been used previously you may need to reset them to their default state before following the steps below. See Section [3.6](#) for instructions on how to reset devices to the default configuration.

Since the 2.3.x release of OpenWrt a configuration wizard has been included in the UI to aid with quick setup of devices. This guide now focuses on using the configuration wizard, but it is also possible to use the standard configuration pages in the UI to set up the device.

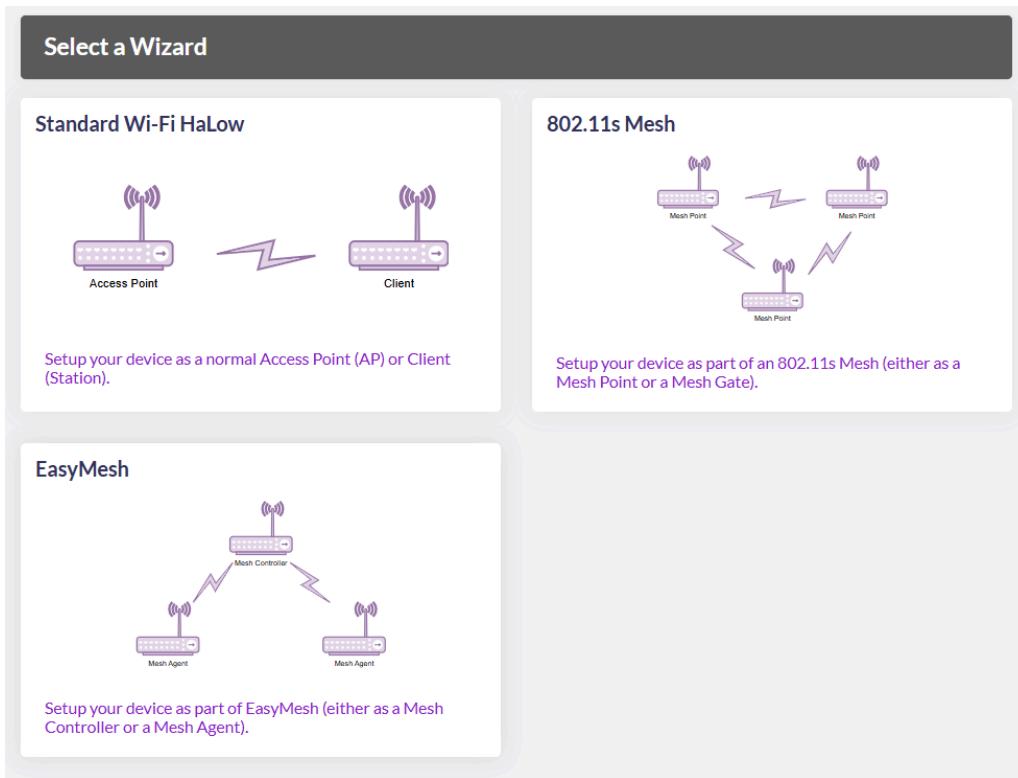
## 3.1 Initial Setup

The screenshot shows the initial setup wizard for the Morse Micro OpenWrt 2.8 User Guide. It consists of three main sections:

- Welcome!**: A message stating "This wizard will guide you through the initial setup of this device." and "You can exit now if you'd prefer to configure manually."
- HaLow Configuration**: A section where the user selects the **Country** as **US**. A note explains that the country determines the capabilities of the HaLow network and warns that changing it may cause loss of access.
- System Configuration**: A section where the user sets the **Hostname** to **ekh01-507e**, **Password**, and **Confirmation**. Notes indicate that the Hostname is used for device ID purposes and that setting a password protects both web and SSH access.

1. Connect your laptop to the Morse Micro HaLow device via an Ethernet cable.
2. Ensure that the Ethernet interface on the laptop is configured as a DHCP client (this is usually default, so often no change is required).
3. Open a web browser and navigate to the [default web UI IP address](#) in a browser.
4. Select the **Country** (for regulatory requirements) and optionally a unique **Hostname** for the device and a **Password** (which secures SSH and web access);
5. Click **Apply** in the bottom right.

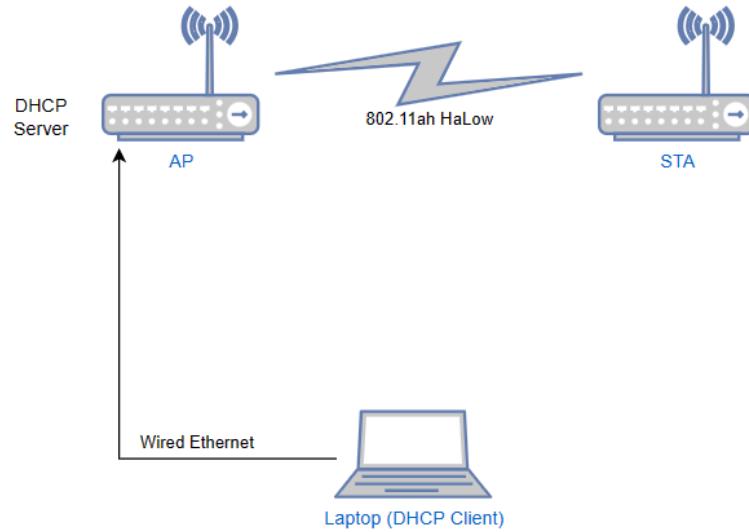
The next screen will present an option to configure the device either as a standalone AP/STA or as part of a mesh network using 802.11s mesh or EasyMesh. For first time users, the Standard Wi-Fi HaLow wizard is the best option to start with. Mesh configurations allow multiple APs to be linked in order to provide an even wider coverage area.



The following sections assume that the Standard Wi-Fi HaLow wizard has been selected.

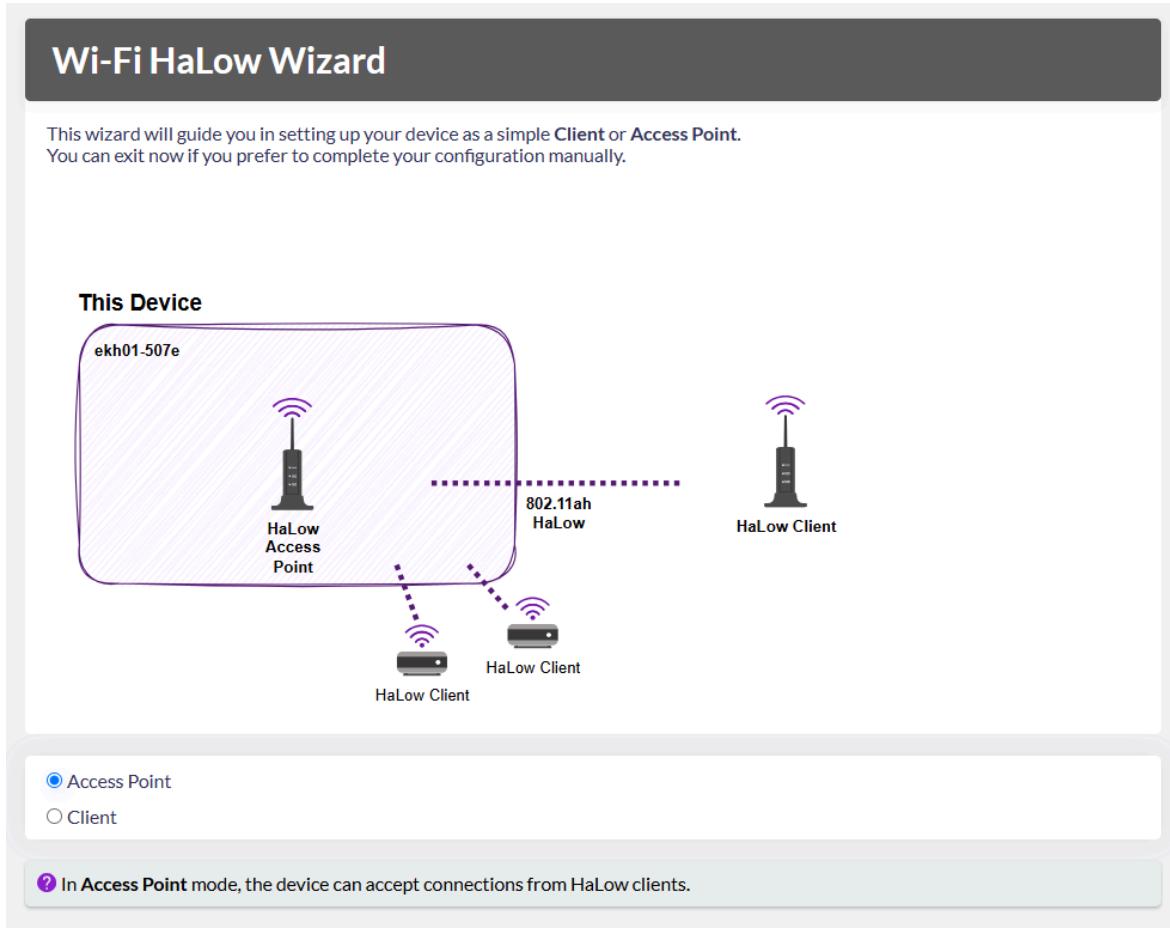
## 3.2 Standalone AP and STA

This section outlines how to configure the AP and STA per the scenario defined in [2.4.1](#).



### 3.2.1 Access Point configuration

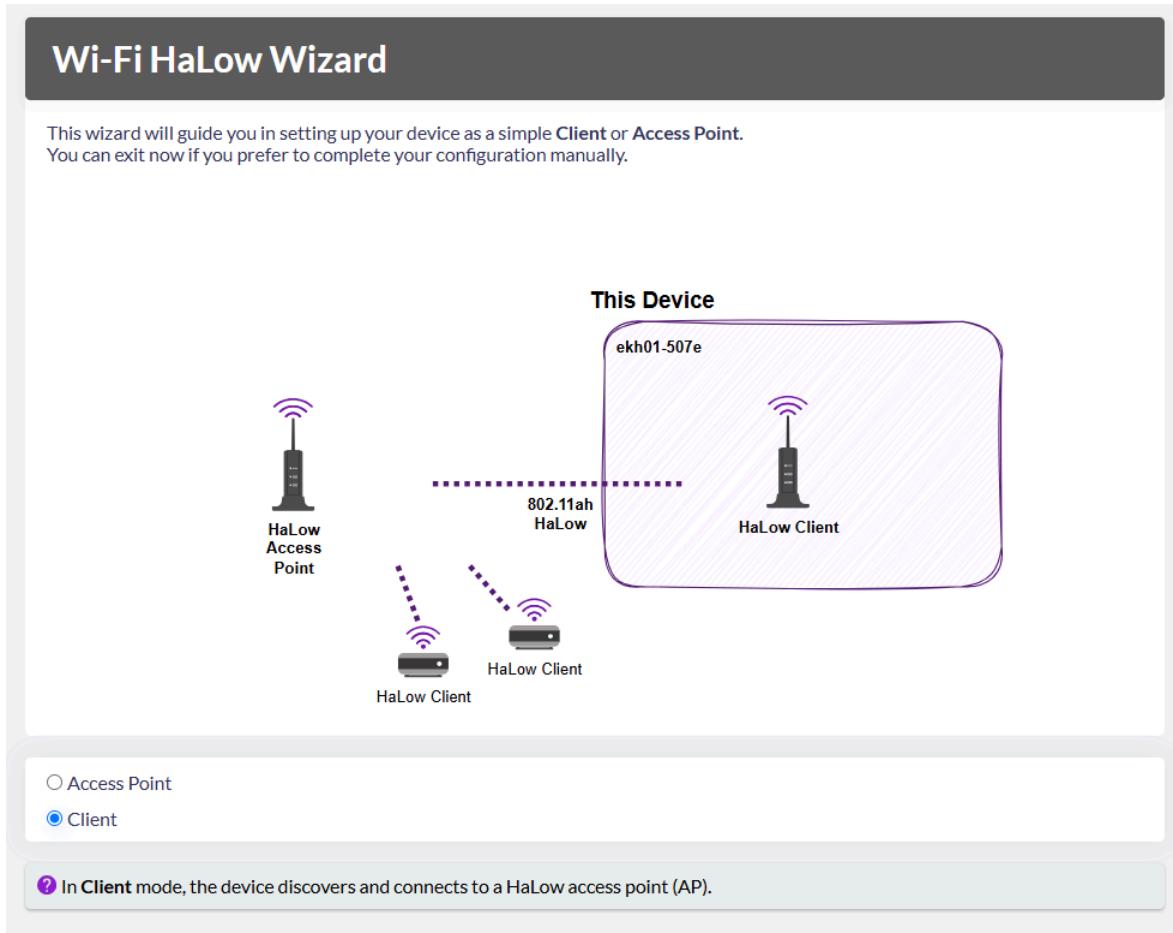
1. Follow the steps in [3.1](#) to connect to the device and set the region.
2. For **Mode** selection, choose 'Access Point':



3. Click the **Next** button at the bottom right to go to the next page.
4. On the following pages:
  - a. **Setup HaLow Network - AP** has a default SSID and passphrase which you can change if you wish. The Width and Channel options can be left as default. Then click **Next**.
  - b. Upstream **Network** should be set to 'None'. Click **Next**.
5. You can then **Apply** your configuration on the final page.

### 3.2.2 Station / Client configuration

1. Disconnect your laptop from the Ethernet interface of your AP (from Section [3.2.1](#) above) to prevent IP address conflicts with the client.
2. Follow the steps in Section [3.1](#) to connect to the device and set the region.
3. For the **Mode** selection, choose ‘Client’ and click **Next**.



4. On the **Connect to a HaLow Network** page, choose ‘Manual credentials’ and then **Scan** to find the SSID you entered for your AP. Enter the previously set passphrase and click **Next**.
5. For the **Traffic Mode**, select ‘Bridge’ and click **Next**.
6. If your device has 2.4 GHz capability, you will be presented with an **Enable Access Point** toggle which you can switch off if standard Wi-Fi access is not needed. Click **Next**.
7. Once you have saved the configuration by clicking **Apply**, you should disconnect your laptop from the Station and reconnect it to the AP. You can find the Station’s HaLow IP in the **DHCP Leases** card on the **Home** page of the AP web UI.

### 3.2.3 (Optional) Add upstream internet connectivity

In many situations it is helpful to have an upstream connection to the internet. The following instructions outline how to connect your AP to an upstream gateway which can provide internet access to the HaLow devices.

It assumed that the upstream gateway provides the following:

- a DHCP server to allocate an address to your AP.
- a DNS server, provided via a DHCP offer.
- a gateway address, assigned via a DHCP offer.

The steps are as follows:

1. Connect a laptop to your HaLow device as described in Section [3.1](#) and navigate to the admin interface.
2. If the wizard does not come up because you've already configured your device, go to **Wizards** in the side menu.
3. On the **Upstream Network** page, choose 'Ethernet', and set the **Traffic Mode** to 'Router'.
4. **Apply** the configuration on the final page.
5. Use an Ethernet cable to connect your AP to the existing network.
6. To access the device's admin interface again the [default web UI IP address](#) may be used over the HaLow link or the user will need to determine the address allocated the network's DHCP server. See section [3.6](#) for how to reset a device if access is lost.

### 3.2.4 (Optional) Add upstream internet connectivity via LTE

Using an LTE dongle for upstream internet connectivity is also supported (instead of via the Ethernet port). An LTE dongle will be automatically discovered and shown as another option available in the **Upstream Network** page. Follow the steps from Section [3.2.3](#), but choose 'Dongle' when selecting the upstream network to use (step 3).

Connectivity via the LTE dongle behaves the same as Ethernet.

#### Upstream Network

**This Device**

The diagram illustrates the internal structure of a HaLow device. It features a central purple-bordered box labeled "This Device". Inside, a "HaLow Access Point" is connected to a local network with the SSID "ekh01-ddeb". This access point is also connected to an "802.11ah HaLow" interface, which is further connected to a "HaLow Client".

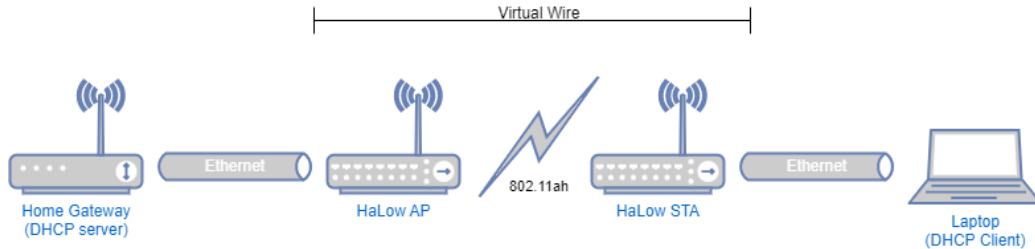
None  
 Dongle (eth1) - e.g. a USB LTE dongle or tethered phone  
 Ethernet (eth0)

**Note:** You are using this HaLow device as an access point, you should configure how it connects to the internet (or some other network). If you choose **None**, your device will have a static IP address and run a DHCP server on all interfaces, the HaLow and non-HaLow networks will be isolated from each other. If you choose an upstream network, your HaLow and non-HaLow networks will be connected.

**Note:** Only dongles that do not require a specific driver are supported (such as via CDC/RNDIS).

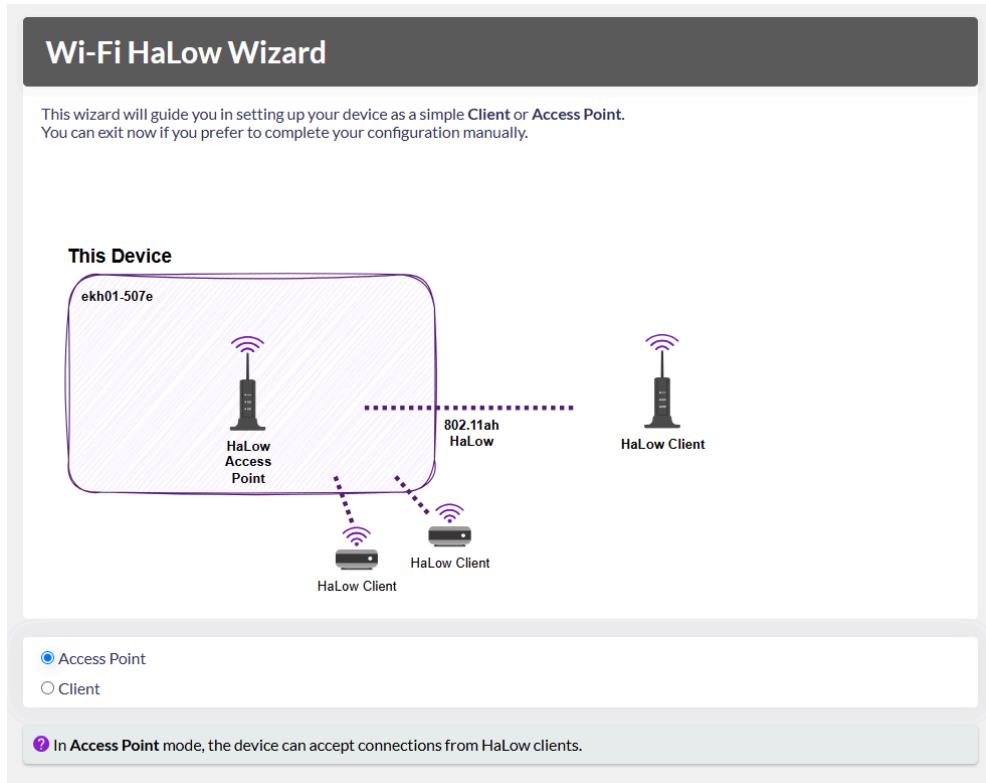
## 3.3 'Virtual Wire' - Layer 2 bridging

The following outlines how to configure the AP and STA per the scenario defined in [2.4.2](#).



### 3.3.1 Access Point configuration

1. Follow the steps in [3.1](#) to connect to the web UI and set the region.
2. For **Mode** selection, choose 'Access Point':



3. Click the **Next** button at the bottom right to go to the next page.
4. On the following pages:
  - a. **Setup HaLow Network - AP** has a default SSID and passphrase which you can change if you wish. The Width and Channel options can be left as default. Then click **Next**.

- b. **Upstream Network** should be ‘Ethernet’. Selecting Ethernet will show a new option for **Traffic Mode** which should set to ‘Bridge’. Click **Next**.
5. You can then **Apply** your configuration on the final page.

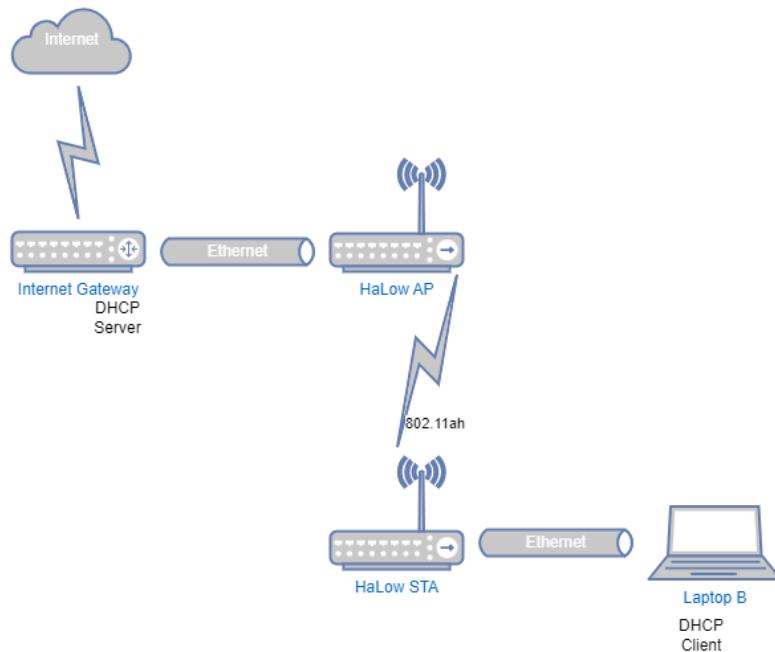
To access the device’s admin interface again, you will need to check the IP address allocated by your network’s DHCP server. See section [3.6](#) for how to reset your device if you lose access.

### 3.3.2 Station / Client configuration

Follow the instructions in [3.2.2](#). Once you’ve saved your configuration, however, your station’s IP address will be allocated by your network’s DHCP server and will be accessible on that network.

## 3.4 Non-standalone AP with routing

This section outlines how to configure the AP and STA per the scenario defined in [2.4.3](#).



### 3.4.1 Access Point configuration

Follow [3.2.1](#) and [3.2.3](#) to configure an Access Point with **Uplink** set to ‘Ethernet’ and **Device Mode** set to ‘Router’.

### 3.4.2 Station configuration

Follow the STA configuration for the scenario in [3.1](#), but for **Device Mode** choose ‘Extender’.

## 3.5 Setting a custom static IP

By default, devices configured as an AP are reached at a [static IP address](#) on the Ethernet or HaLow interfaces. If the two interfaces are bridged together, either they will operate in DHCP client mode or they will be assigned the [default HaLow interface IP address](#) depending on uplink configuration. Clients/Stations will use the static IP address for ethernet and DHCP client for HaLow if the interfaces are separate, and DHCP client mode if bridged.

If you would prefer to use a static IP instead of DHCP client mode or wish to change an existing static IP, go to the **Quick Config** option in the side menu. For more information, see section [8.2 Quick Config](#). Take care to avoid running multiple DHCP servers on a single network.

**Warning:** if you use DHCP on your HaLow AP, this will help it identify the IP/hostname of associated devices on the home page and allow you to access them via their hostname (e.g. <http://ekh01-9f62.lan>). If you switch your Clients to static IPs, make sure you note them down, otherwise it's easy to lose access.

## 3.6 Reset the device to default configuration

This section outlines how to get the device back to a default configuration in different situations. All firmware releases use SquashFS with an overlay which allows for full factory resets.

### 3.6.1 Access to web UI is available

In this scenario, you can login to the device and go to the ‘System > Backup/Flash Firmware’ page. Selecting ‘Reset to defaults’ will reset the device’s configuration and reboot.

### 3.6.2 SSH access is available

In this scenario, you can login to the device via ssh (`ssh root@<ipaddress>`) and run the following command at the prompt:

```
firstboot -y && reboot
```

### 3.6.3 No network access - EKH01

This scenario can occur when the IP address of the device has been changed, and it is not obvious what the address is. The quickest method here is to remove the SD card and write a new firmware image to it using a tool such as Balena Etcher.

### 3.6.4 No network access (Option 1) - EKH03

This scenario can occur when the IP address of the device has been changed, and the user is unable to identify it via the lease list on their DHCP server. Using a suitable object, press and hold the reset button, shown in Section [2.3](#) for more than 10 seconds to reset the device to factory defaults. It will first start flashing slowly green (for a normal reset) after 5 seconds, then after 10 seconds will quickly flash yellow. Release the button once it’s flashing yellow.

### 3.6.5 No network access (Option 2) - EKH03

This scenario requires using a serial console cable to access the device. Section [2.2](#) of this guide shows the location of the USB port on the EKH03 where a 3.3V TTL serial USB cable can be used to connect a computer to this port. Once connected, a suitable terminal emulator program will be needed to connect to it, such as PuTTY in Windows or picocom in Linux.

Once connected to the serial console, run the following command to reset the configuration:

```
firstboot -y && reboot
```

## 3.7 Using DPP QR code

Device provisioning protocol (DPP) provides a simple process to onboard stations into an existing wireless network. Station devices are provisioned by scanning a QR code with a “configurator” device already associated with the network.

### 3.7.1 On the AP

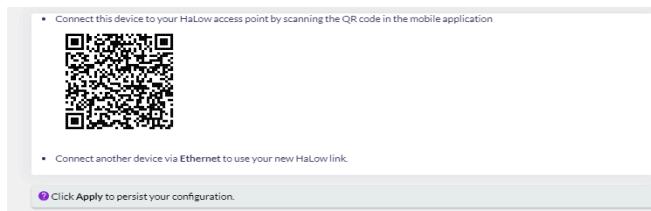
No explicit action is required to enable DPP in AP mode. Simply set your device to work as an AP with SAE security.

Note that if you are using 802.11s mesh, this does not by default include AP functionality, and the hostapd process will not be started. The hostapd process is required for DPP to function. It is possible to run 802.11s Mesh with an AP, this mode is known as a ‘Mesh Gate’ - see Section [3.9.2](#) for details.

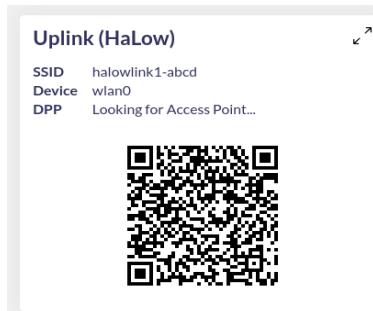
The credentials for the AP DPP configurator are set in `/etc/dppd/auth_secrets.txt`, you will be asked for these in the mobile app after selecting the AP to provision a device to. The default username is **morse** and the default password is **HaLow**.

### 3.7.2 On the STA

To enable DPP through the web UI, after setting your Device as a client via the wizard, set DPP in the page where it asks for credentials to connect to a HaLow network and proceed to the last page of the wizard where the QR code is shown.



Alternatively, you can also view the QR code from the **Home** page, on the HaLow **Uplink** card.



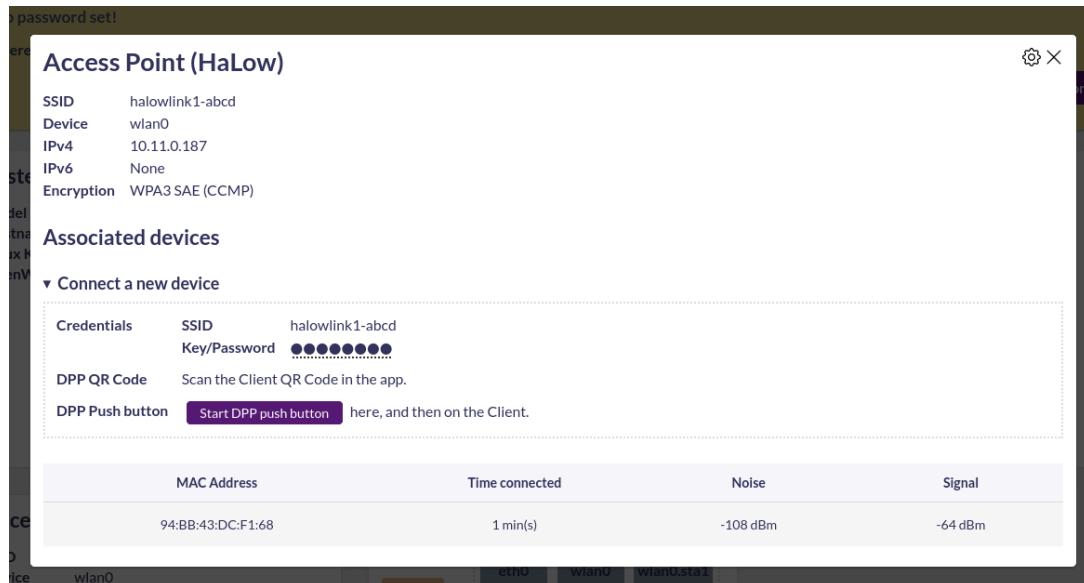
To start provisioning, use the Morse Micro DPP app on the phone to scan the QR code.

**Note:** The DPP QR code is not persistent on EKH01 devices and will change if updating the image without using the 'Keep settings and retain current configuration' option or if updating the image on the microSD card using a computer.

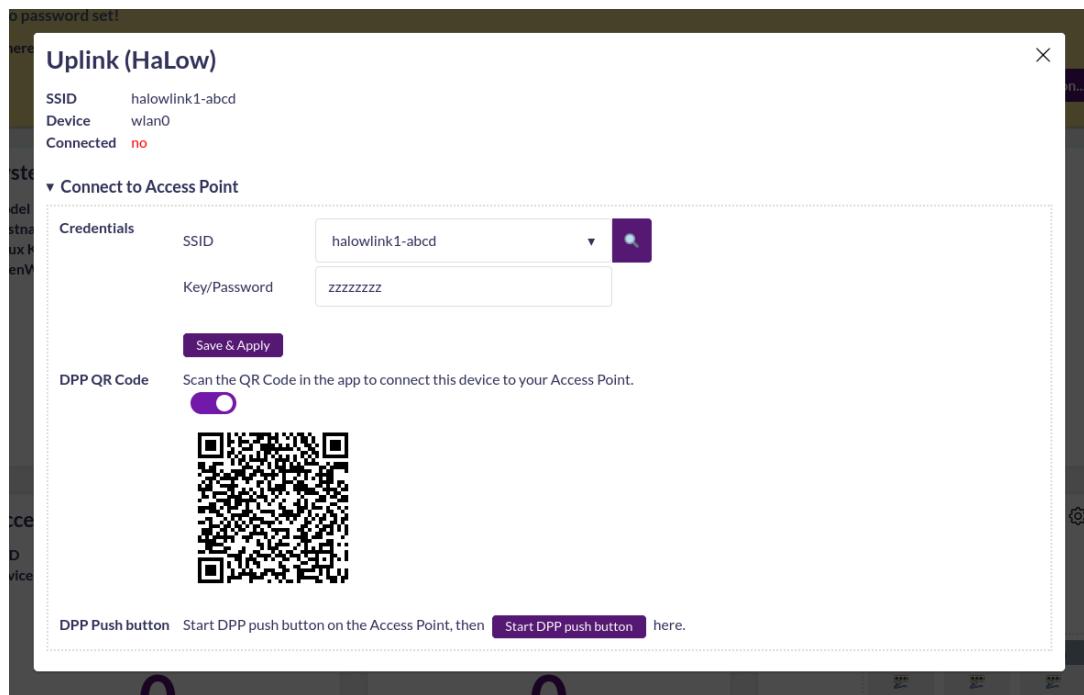
After a successful provision, SSID, key, and encryption will be set automatically.

## 3.8 Using DPP push button

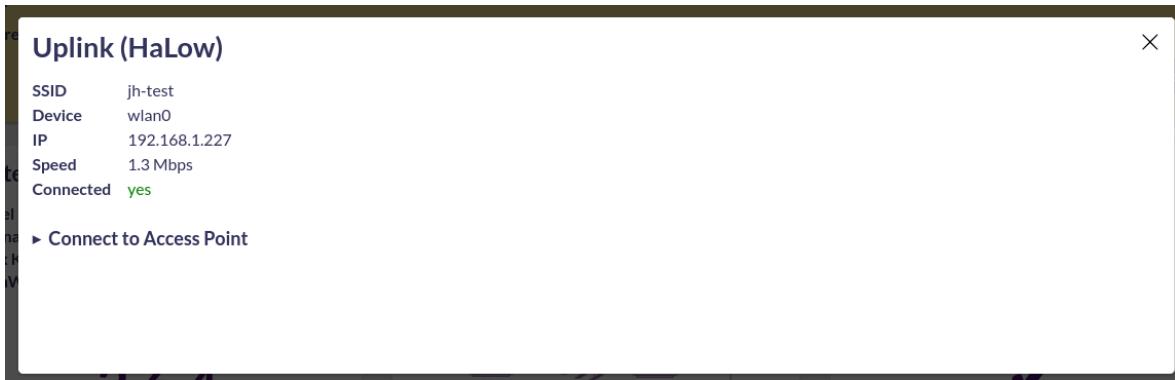
To utilize DPP (Device Provisioning Protocol) using the push button, simply set your device as an Access Point or Station and save the configurations. Then expand the **Access Point (HaLow)** card on the **Home** page of the Access Point and click on the 'Start DPP Push button'.



Simultaneously on the Station, expand the **Uplink (HaLow)** card on the **Home** page and click **Start DPP Push button**.



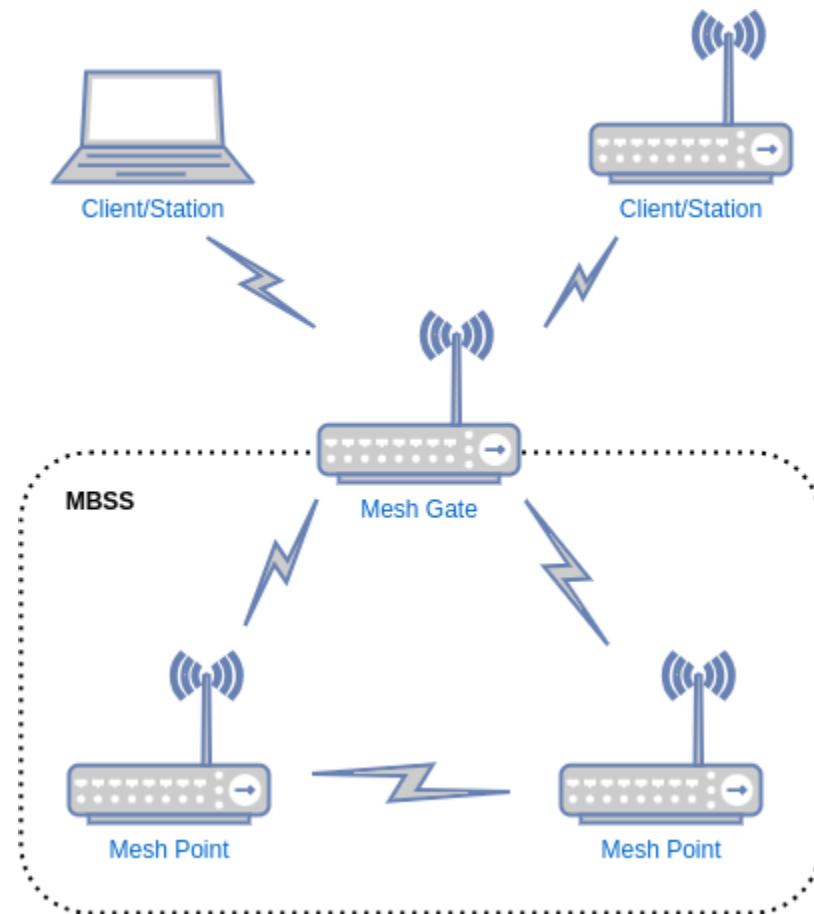
Upon successful completion of the DPP process the Station connection status will change to yes.



On the EKH03 the physical 'reset' button on the device can also be used for DPP. Pushing the button for less than 2 seconds will start the DPP push button process, if the device has been configured as an Access Point or Station. The RGB status LED will indicate that the DPP push button process is running, see the [EKH03 setup section](#) for details.

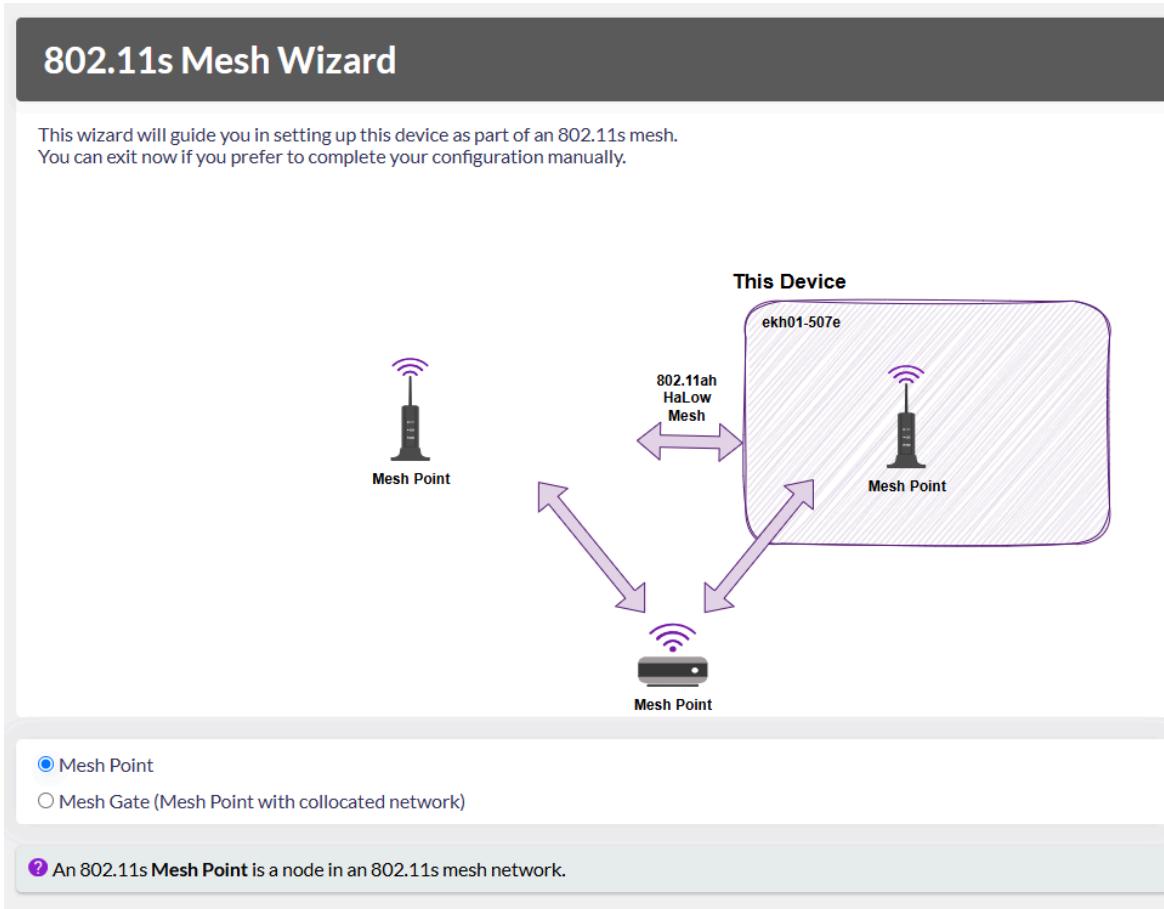
## 3.9 802.11s Mesh Configuration

802.11s mesh networks aim to increase coverage and range by establishing peer-to-peer links between the various neighbor mesh STAs in the mesh topology. Only mesh capable devices can join the mesh BSS (MBSS) or make use of the mesh functionality provided by the MBSS. Interaction with non-mesh capable devices is handled via mesh gateways (potentially co-located with a non-mesh AP).



### 3.9.1 Mesh STA / Mesh Point configuration

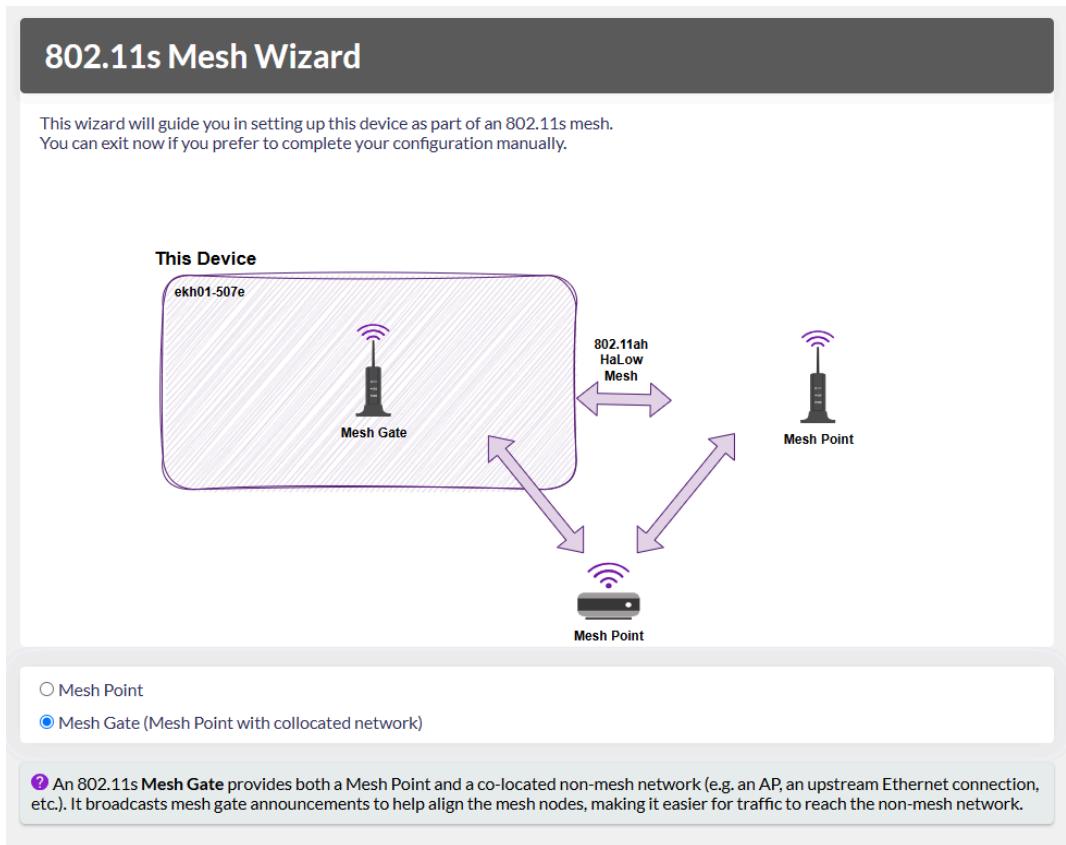
1. As a prerequisite, ensure that your device is configured with the appropriate region and a channel. Refer to steps in [3.1](#) to connect to the device and set the region.
2. Once you decide to configure your device as a Mesh Point, navigate to the **Wizards** config in the side menu and select **802.11s Mesh Wizard**.
3. As a first step, choose ‘Mesh Point’ as the mode and then click **Next**.



4. On the **Setup Mesh Network** set an appropriate Mesh ID, encryption and passphrase. Then click **Next**.
5. For the **Traffic Mode**, select ‘Bridge’ and click **Next**.
6. After saving the configuration (by clicking ‘Apply’), disconnect your laptop from the Mesh Point and connect it either to the Mesh Gate or another Mesh Point to integrate it into the Mesh Network and obtain an IP address for the device. To access the Mesh Point’s admin interface again, navigate to the **Home** page of the Mesh Gate’s admin interface and inspect the **DHCP Leases**.

### 3.9.2 Mesh Gate configuration

1. As a prerequisite, ensure that your device is configured with the appropriate region and a channel. Refer to steps in [3.1](#) to connect to the device and set the region.
2. Once you decide to configure your device as a Mesh Gate, navigate to the **Wizards** config in the side menu and select **802.11s Mesh Wizard**.
3. As a first step, choose ‘Mesh Gate’ as the mode and then click **Next**.



4. On the **Setup Mesh Network** page set an appropriate Mesh ID, encryption and passphrase. Then click **Next**.
5. On the following page, **Upstream Network** should be None. Click **Next**.
6. For a Mesh Gate, you have the option to set up an additional **HaLow Wi-Fi Access Point** interface (Co-located AP) alongside the Mesh interface to extend the HaLow network if needed. On the **HaLow Wi-Fi Access Point** page, if you enable the AP, then ensure to fill in the SSID, encryption and password for that interface. Please note, that this AP interface that is created is always bridged with the Mesh interface in the Mesh Gate mode. Then click **Next**.

## HaLow Wi-Fi Access Point

This Device

The diagram illustrates the internal structure of a HaLow Wi-Fi Access Point. It shows a central 'Mesh Gate' node connected to an 'Ethernet' port (IP: 10.42.0.1) and a 'Laptop/Device' (IP: 10.42.0.x). The Mesh Gate also serves as a 'DHCP Server' (IP: 192.168.12.1) with a 'SSID: Test\_HaLow\_AP'. Two 'HaLow Client' nodes are connected wirelessly to the Mesh Gate. The Mesh Gate is part of a '802.11ah Halow Mesh' with a 'Mesh ID: Test\_Mesh'. A 'Mesh Point' node is also connected to the mesh. The entire setup is labeled 'This Device'.

Enable HaLow Access Point

SSID

Passphrase  \*

?

Enable an Access Point (AP) to let non-mesh HaLow devices connect to the network. This interface will be bridged with the mesh interface.

7. You can then **Apply** your configuration on the final page.

### 3.9.3 (Optional) Add upstream internet connectivity in Mesh Gate mode

Typically a Mesh Gate is a device that provides access to one or more distribution systems via the wireless medium for the mesh basic service set (MBSS). In many situations it is helpful to have an upstream connection to the internet. The following instructions outline how to connect your Mesh Gate to an upstream internet gateway.

It is assumed that the upstream gateway provides the following:

- a DHCP server to allocate an address to your AP.
- a DNS server, provided via a DHCP offer.
- a gateway address, assigned via a DHCP offer.

The steps are as follows:

1. Connect a laptop to your HaLow device as described in Section 3.1 and navigate to the admin interface.
2. Go to the **Wizard** config in the side menu and select **802.11s Mesh Wizard**.
3. Repeat the steps 3 and 4 as in Section [3.9.2](#).
4. On the **Upstream Network** page, choose ‘Ethernet’, and set the **Traffic Mode** to ‘Router’.
5. Refer to step 6 in [3.9.2](#) and then proceed to **Apply** the configuration on the final page.
6. Use an Ethernet cable to connect your Mesh Gate to your existing network.
7. To access the device’s admin interface again, you can access the [default IP address](#) over the HaLow link or you will need to determine the address allocated by your network’s DHCP server. See section [3.6](#) for how to reset your device if you lose access.

### 3.9.4 Additional 802.11s Mesh settings

1. In addition to configuring the 802.11s Mesh settings through the wizard, you can access further options by navigating to the **Advanced Config > Network > Wireless** page. Click on **Edit** next to the Mesh Interface to access and adjust the advanced mesh settings available in this section.
2. If you decide to enable B.A.T.M.A.N for the Mesh Interface in Mesh Gate mode, remember to include the AP interface (if it exists) in the same network. You can achieve this by adding the same network name to the AP interface in **Network > Wireless > Edit (AP) > Interface Configuration > Network**.
3. To configure a static IP address on either the Ethernet or HaLow interface, set it in the **Quick Config** page, found in the side menu.

## 3.10 EasyMesh

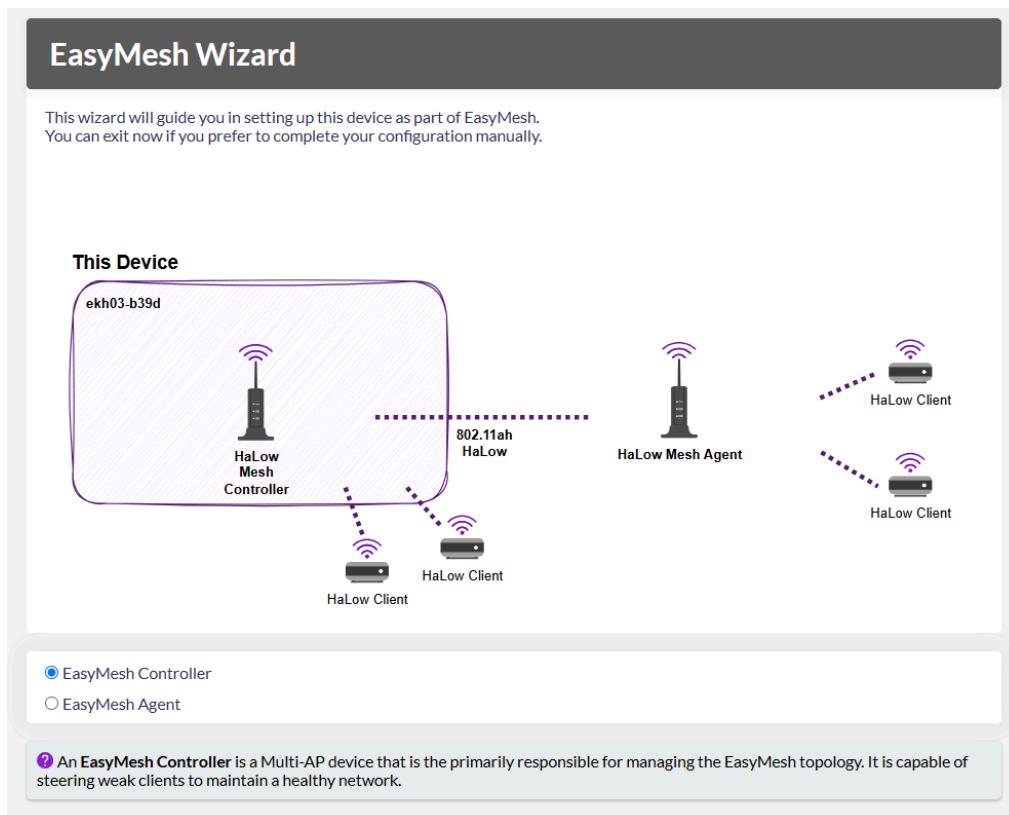
### 3.10.1 Theory of Operation

EasyMesh is a Wi-Fi branded, standards-based solution for meshing together access points to provide an extended coverage area (but with reduced bandwidth available to stations). EasyMesh forms a tree structure with a controller at the root that controls the mesh network, and agent APs that connect both upstream towards the controller and downstream towards stations. Stations are agnostic to mesh, and continue to connect to the closest AP as usual.

The current implementation supports up to 4 agents in addition to the controller, with at most 2 agents between the controller and a station.

### 3.10.2 EasyMesh Controller Configuration

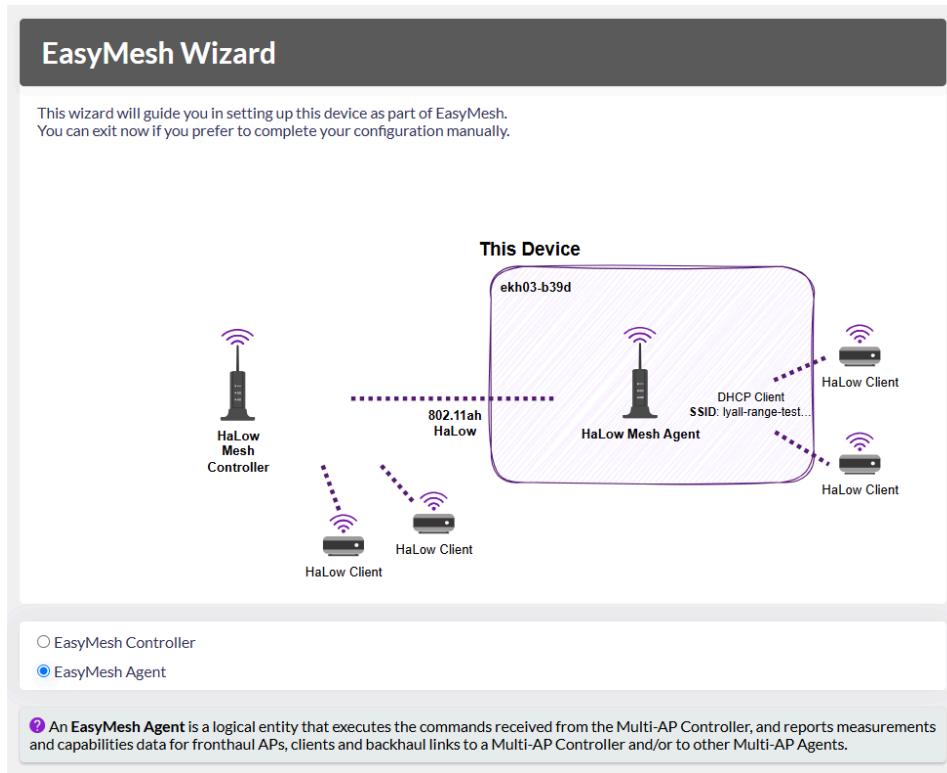
1. As a prerequisite, ensure that your device is configured with the appropriate region and a channel. Refer to steps in [3.1](#) to connect to the device and set the region.
2. Once you decide to configure your device as an EasyMesh Controller, navigate to the **Wizards** config in the side menu and select **EasyMesh Wizard**.
3. As a first step, choose ‘Easymesh Controller’ as the mode and then click **Next**.



4. On the **Setup EasyMesh Network** page set an appropriate SSID and passphrase. Encryption is defaulted to WPA3-SAE. Then click **Next**.
5. On the following page, **Upstream Network** should be 'None'. Click **Next**.
6. You can then **Apply** your configuration on the final page.
7. Proceed to Section [3.10.4](#) for pairing the device with other Agents.

### 3.10.3 EasyMesh Agent Configuration

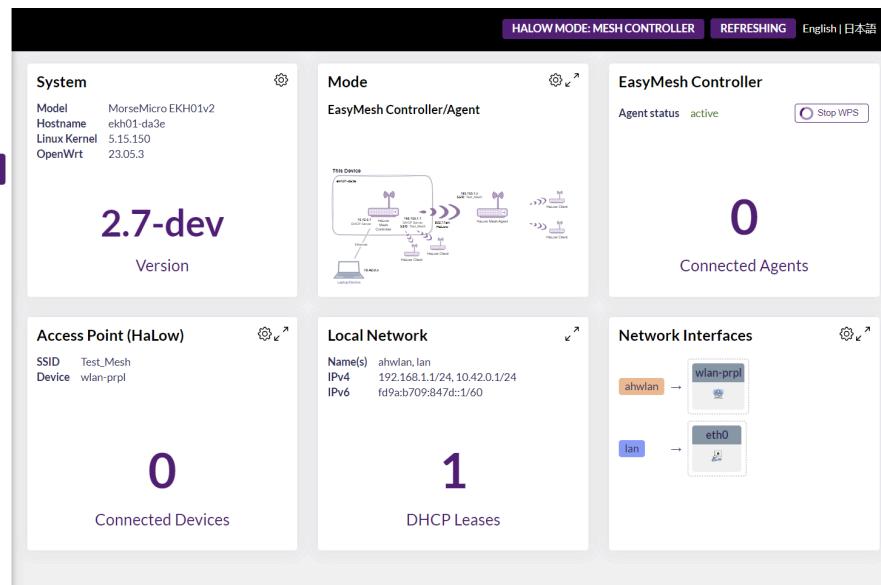
1. As a prerequisite, ensure that your device is configured with the appropriate region and a channel. Refer to steps in [3.1](#) to connect to the device and set the region.
2. Once you decide to configure your device as an EasyMesh Agent, navigate to the **Wizards** config in the side menu and select **EasyMesh Wizard**.
3. As a first step, choose 'EasyMesh Agent' as the mode and then click **Next**.



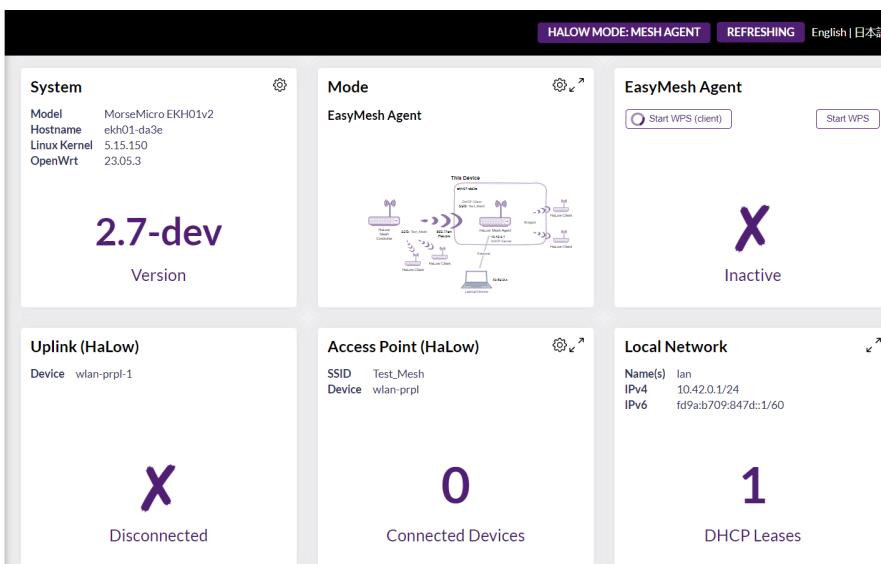
4. For the **Traffic Mode**, select 'None' and click **Next**.
5. Proceed to section [3.10.4](#) for pairing the device with EasyMesh Controller or other Agents.

### 3.10.4 Pairing EasyMesh devices

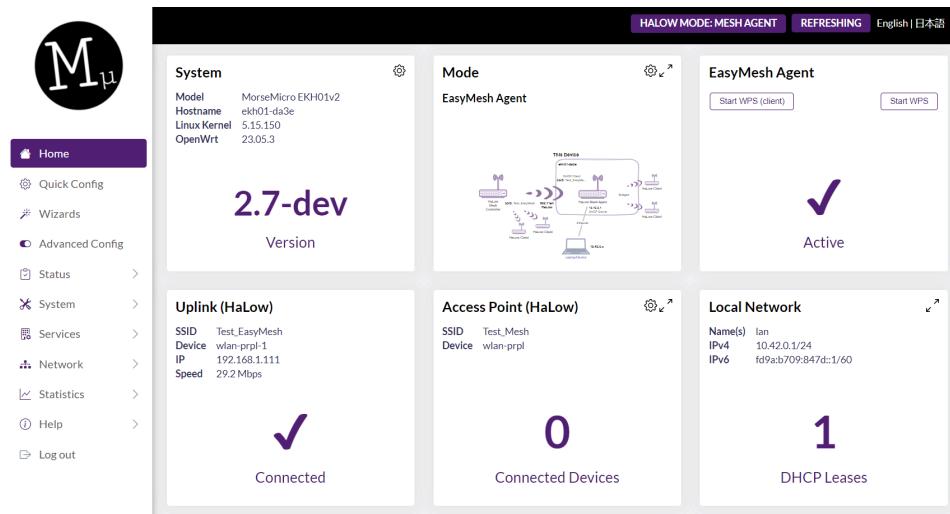
- As a prerequisite ensure that your device is configured either as an EasyMesh Controller or Agent following in the steps in sections [3.10.2](#) or [3.10.3](#) respectively.
- On the EasyMesh Controller, Navigate to the **Home** page in the UI, and once the Agent Status shows Active in the EasyMesh card, click on the **Start WPS** button.



- Simultaneously, on the EasyMesh Agent device, navigate to the **Home** page in the UI, and in the EasyMesh card, click on the **Start WPS (client)** button to pair itself with the Controller.

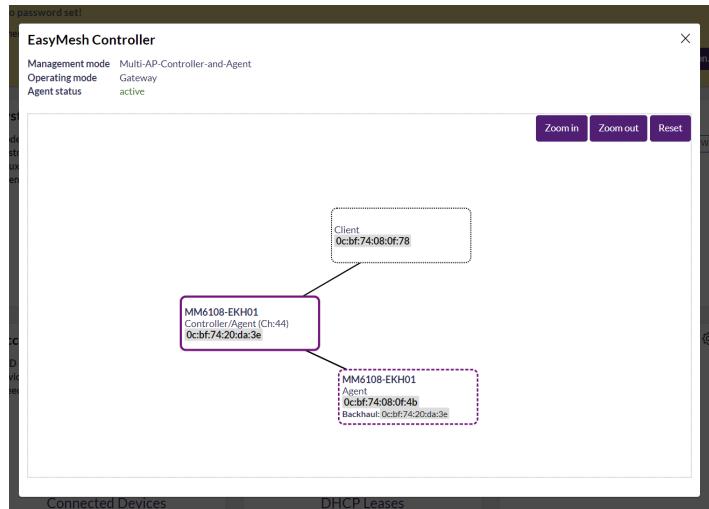


- Upon successful completion of WPS pairing the Home page will show the Agent Status as **Active**.



### 3.10.5 EasyMesh Status

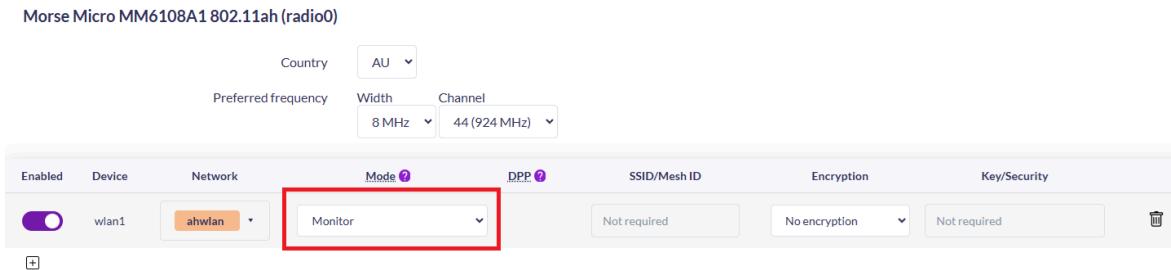
To confirm that EasyMesh has been enabled and is working, status information is available on the **Home** page of the **EasyMesh Controller**, which displays the number of **Connected Agents**. Clicking on **Connected Agents** in the EasyMesh card on the UI will open a topology diagram:



Logs are also available from **Advanced Config > Status > System Log** when EasyMesh is enabled. If these are not visible, you may need to logout of the frontend due to caching.

## 3.11 Monitor mode

It is possible to configure the HaLow interfaces to operate in monitor mode, which allows the device to capture all 802.11ah packets on the air within the specified channel and bandwidth. To enable monitor mode make the following changes on the **Quick Config** page:



Monitor mode can also be configured on the **Advanced Config > Network > Wireless** page by selecting the interface that you want to change to monitor mode and completing the popup dialog. This page provides additional options such as frequency, bandwidth, primary channel bandwidth and primary channel index. The additional options are not available in the **Quick Config** page, so if that extra control is needed then use the **Advanced Config** page.

After setting the interface into monitor mode, it is possible to start capturing packets using the **morse0** interface (**not the interface that is set to monitor mode**). Further changes to monitoring parameters can be made using **morse\_cli** command, for example:

```
morse_cli -i wlan0 channel -c 908000 -o 8 -p 2 -n 0
```

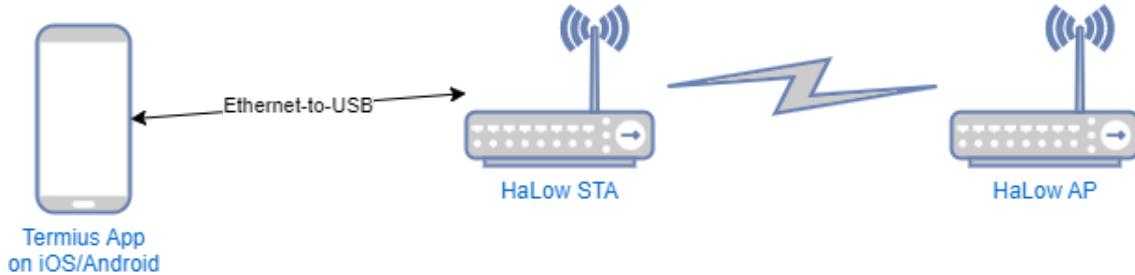
The full syntax for this command is as follows:

```
morse_cli -i wlan0 channel -c <channel_frequency> -o
<channel_bandwidth> -p <primary_bandwidth> -n
<primary_channel_index>
```

Please keep in mind that parameter changes are done via the monitor interface (wlan0, wlan1, ...) but the packet dump is done through **morse0** interface.

## 4 Wavemon and Ping Testing

Wavemon provides a powerful way to quickly test the performance and quality of a HaLow connection in the field. All that is required is a mobile phone, HaLow AP, HaLow STA (with a suitable power supply) and a USB-Ethernet cable to connect the mobile to one of the HaLow devices. The diagram below shows how to setup the equipment:



To run wavemon, the mobile device will need to be able to run an SSH session (e.g. using Termius for Android/iOS). Once an SSH session has been started run the command `pt` from the command line interface and a wavemon ping test will begin:

```
Interface
wlan0 IEEE 802.11ah , phy 1, reg: AU , SSID: MorseMicroMatt
Levels
link quality: 80% (56/70)
=====
signal level: -54 dBm (3.98 mW)
=====

Packet Counts
RX: 1k (173.19 KiB), drop: 19 (1.0%)
TX: 104 (15.63 KiB), retries: 92 (88.5%), failed: 1
Info
mode: Managed, connected to: 0C:Bf:74:67:B3:9D, time: 1:25m, inactive: 0.6s
freq: 924.0 MHz, channel: 44 (width: 8 MHz), bands: 1
station flags: WME MEP, preamble: short, slot: short
rx rate: 32.500 Mbit/s MCS 7 short GI
tx rate: 9.750 Mbit/s MCS 2 short GI
tx power: 21 dBm (125.89 mW), power save: off

64 bytes from 192.168.1.1: seq=55 ttl=64 time=3.735 ms
64 bytes from 192.168.1.1: seq=56 ttl=64 time=3.849 ms
64 bytes from 192.168.1.1: seq=57 ttl=64 time=8.573 ms
64 bytes from 192.168.1.1: seq=58 ttl=64 time=6.595 ms
64 bytes from 192.168.1.1: seq=59 ttl=64 time=3.873 ms
64 bytes from 192.168.1.1: seq=60 ttl=64 time=3.824 ms
64 bytes from 192.168.1.1: seq=61 ttl=64 time=8.369 ms
64 bytes from 192.168.1.1: seq=62 ttl=64 time=10.290 ms
64 bytes from 192.168.1.1: seq=63 ttl=64 time=7.408 ms
64 bytes from 192.168.1.1: seq=64 ttl=64 time=12.431 ms
64 bytes from 192.168.1.1: seq=65 ttl=64 time=5.538 ms
64 bytes from 192.168.1.1: seq=66 ttl=64 time=5.601 ms
64 bytes from 192.168.1.1: seq=67 ttl=64 time=3.712 ms
64 bytes from 192.168.1.1: seq=68 ttl=64 time=7.760 ms
64 bytes from 192.168.1.1: seq=69 ttl=64 time=3.821 ms
64 bytes from 192.168.1.1: seq=70 ttl=64 time=4.865 ms
64 bytes from 192.168.1.1: seq=71 ttl=64 time=12.008 ms
64 bytes from 192.168.1.1: seq=72 ttl=64 time=9.755 ms
64 bytes from 192.168.1.1: seq=73 ttl=64 time=3.731 ms
64 bytes from 192.168.1.1: seq=74 ttl=64 time=16.785 ms

[0] 0:ping*                                "MorseMicro-d0ddeb" 21:35 27-Apr-23
```

Note that `pt` will ping 192.168.12.1 by default, but an alternate address can be provided as an argument to the script, e.g. `pt 1.2.3.4`.

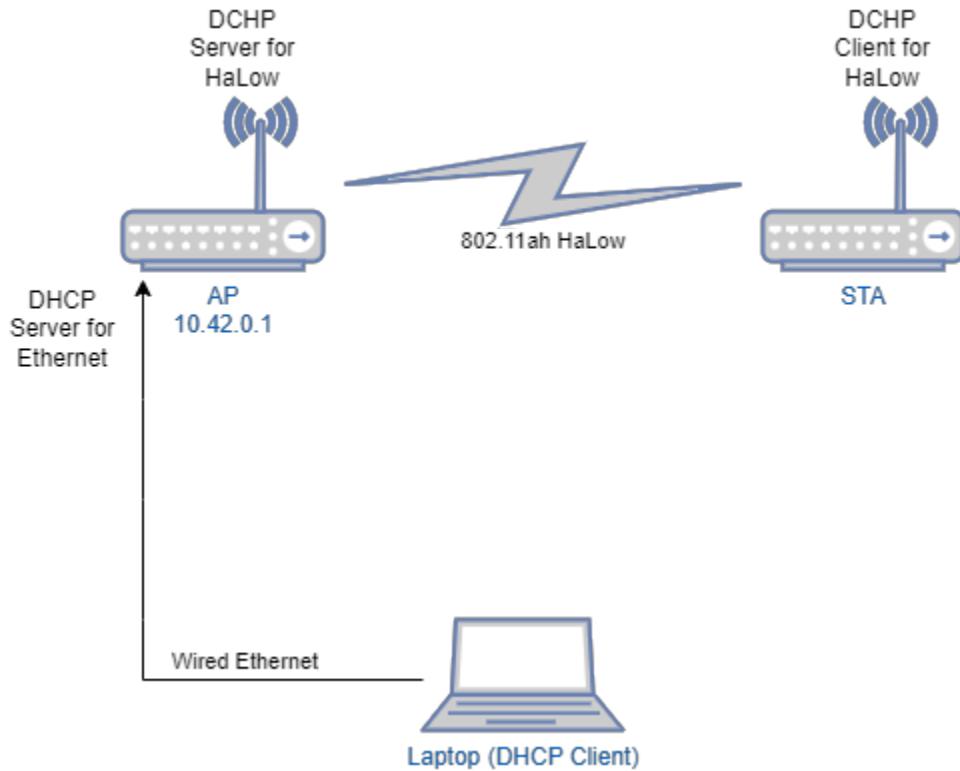
## 5 Setting up iPerf3 traffic testing

iPerf3 testing provides a tool for analysing the quality of HaLow connections by sending a stream of traffic and measuring the speed, throughput and latency.

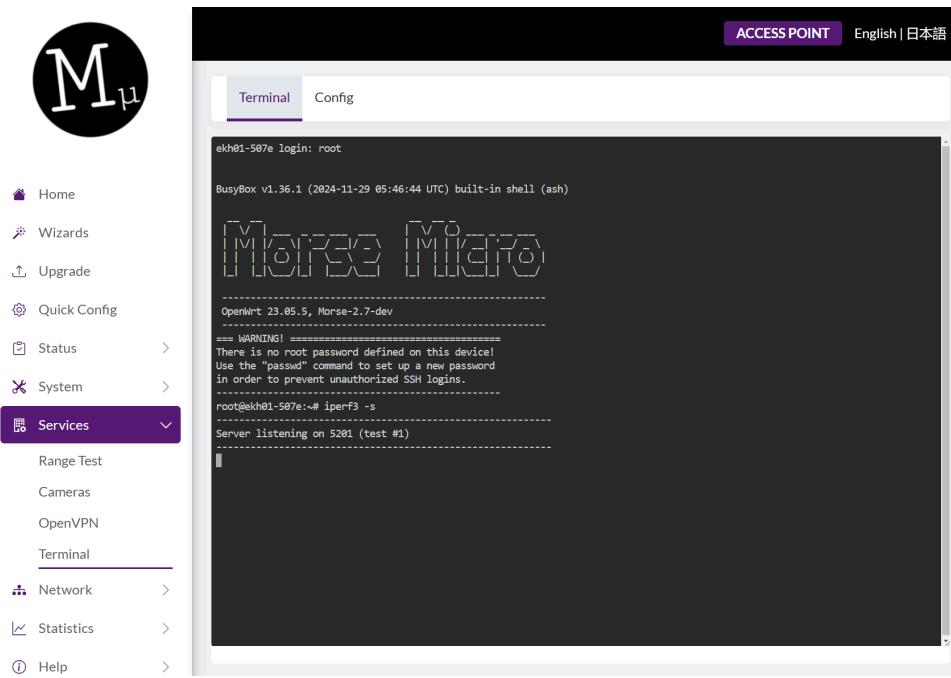
The following guide outlines how to run iPerf3 tests between two devices connected via HaLow. In the diagram below, there are two devices, an AP and a STA, which may be any of the available evaluation kits (EKH01, EKH03). The older iPerf2 (just called iPerf) also comes pre-installed on these evaluation kits and can be used instead of the newer iPerf3.

In this setup the AP will be the iPerf server and the STA will be the iPerf3 client, but these roles can be changed as needed.

## 5.1 AP configuration



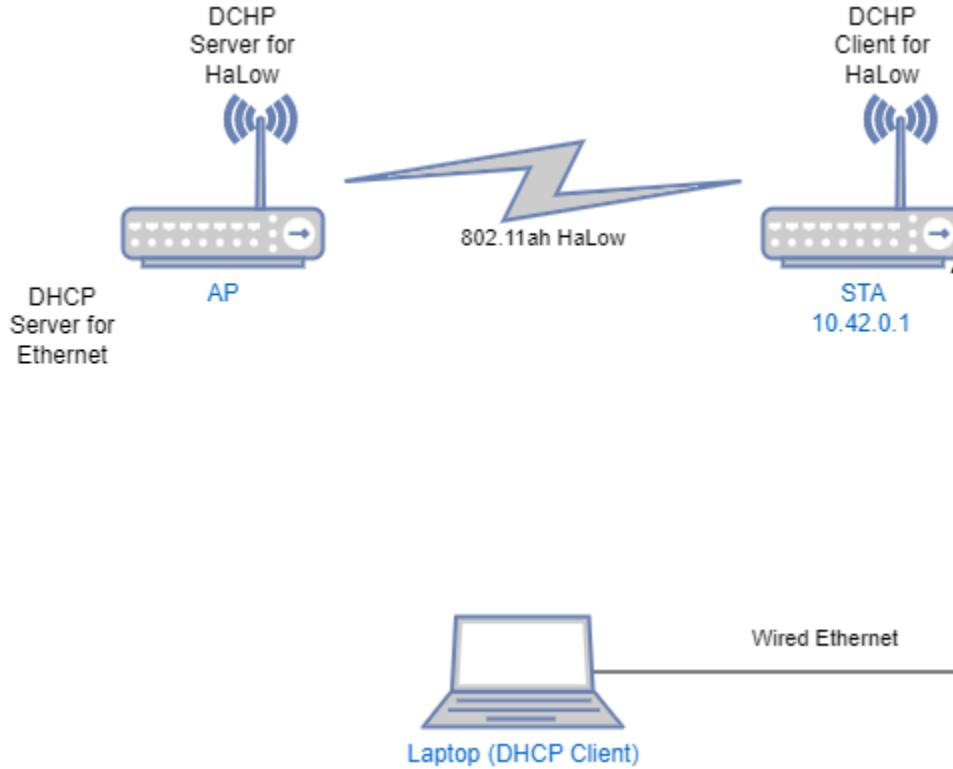
1. Setup a standalone AP as outlined in Section [3.2.1](#).
2. Navigate to the **Advanced Config > Services > Terminal** page in the side navigation bar.  
Note that the credentials will be the same as used to login to the web UI.
3. Type `iperf3 -s` and press enter to launch the iperf3 server.



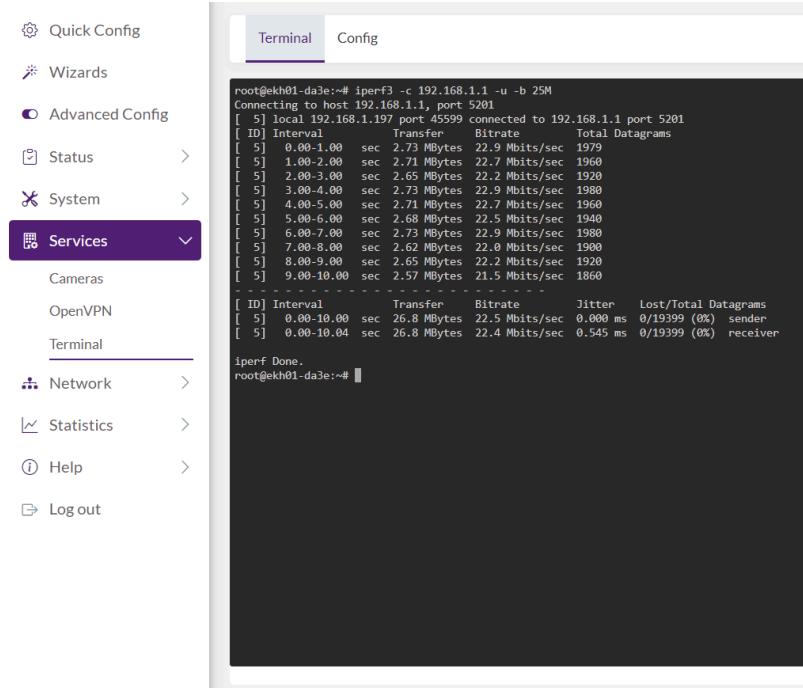
4. Remove the Ethernet cable from the device and begin setting up the iPerf3 client.

**Warning:** the server may eventually shut down when the ssh connection is timed out. You can run iperf3 inside **tmux** to avoid this (included in the image).

## 5.2 STA configuration



1. Setup a STA as outlined in Section [3.2.2](#), but select **None** for the Traffic Mode and NOT Bridge.
2. Navigate to the **Advanced Config > Services > Terminal** page in the side navigation bar. Note the credentials will be the same as used to login to the web UI.
3. Type `iperf3 -c 192.168.12.1 -u -b 25M` (or the relevant [default HaLow IP address](#)) press enter to launch the iPerf3 client. The STA will connect as an iPerf3 client to the server running on the AP to run traffic between them, testing the link.



## 5.3 Web user interface

You can also run iPerf in server and client mode via the web UI. This can be accessed from the top menu in UI by browsing to **Advanced Config > Network > Diagnostics**.

# 6 Range Testing



The Range Test application is designed as a simple way to analyse HaLow network performance by automating iPerf3 tests and collecting real-time statistics. It is a useful tool for quickly assessing signal strength, data throughput, and connection quality across different environments.

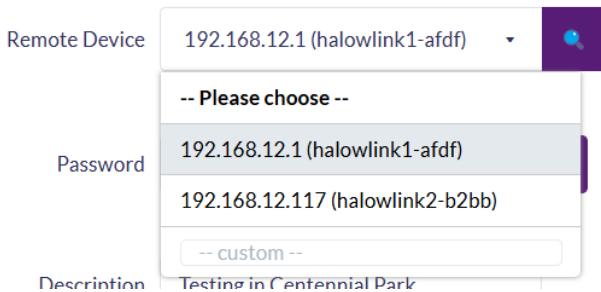
The screenshot shows the Morse Micro OpenWrt web interface with the following details:

- Header:** CLIENT English | 日本語
- Left Sidebar:** Home, Wizards, Upgrade, Quick Config, Status, System, Services (selected), Range Test, Cameras, OpenVPN, Terminal.
- Current Page:** Range Test
- Content Area:**
  - How to use:**
    - Associate this device with another remote device which you want to test against.
    - Choose that remote device from the dropdown list and select your desired test settings.
    - Click 'Start Test' to begin.
  - Test Configuration:**
    - Remote Device: 192.168.12.1 (halowlink1-afdf) (dropdown menu)
    - Password: \*\*\*\*\* (password field)
    - Description: Testing in Centennial Park (text input)
    - Local device coordinates: -33.89833698752066, 151.2357156 (text input)
    - Remote device coordinates: -33.895387173449, 151.236678340 (text input)
    - Range (m): 340 (text input)
  - Buttons:** Start Test, Test Complete (100%)

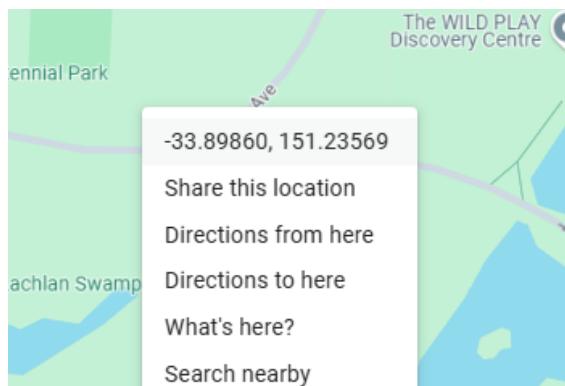
**Note:** before using this application ensure that all devices being tested are running the same version of Morse OpenWrt. This tool can run with different types of evaluation kit (i.e. between an EKH01 and an EKH19) but the software versions must be the same on each unit.

To use the range testing tool:

1. Connect the devices being tested on the same HaLow network of any type outlined in this guide ([Standalone AP and STA](#) configurations are generally the most reliable).
2. Set up the devices in the desired locations and select a 'local' device to connect a laptop to.
3. In a web browser navigate to the web UI of the device.
4. Navigate to **Services > Range Test**.
5. Click the Discover button to populate the 'Remote device' dropdown.
6. Select the HaLow IPv4 address of the desired remote test device. If it does not appear but is definitely connected to the same network as the current device, a user may enter any IPv4 address into the 'custom' field pictured below.



7. Fill in the 'Password' field if the remote device has one.
8. Optional - Provide user notes about the test for reference in the 'Description' field.
9. Optional - If you want to log the coordinates of the local and remote devices and have the range calculated automatically enter the coordinates into the local and remote device coordinates fields respectively. These values can be easily found by right clicking the relevant locations on Google Maps and then selecting the coordinates which will automatically place them in your clipboard (pictured below).



10. If you have entered valid coordinates as outlined in the steps above, the 'Range (m)' field should automatically populate, otherwise you must manually enter a value.

11. Optional - If you click the  icon in the top left corner of the **Test Configuration** subsection, you can modify the data directions and protocols which you would like to test.

12. Click **Start Test** and a progress bar will appear showing the status of the current test. This can be cancelled at any time by clicking the **Stop** button.

After the test completes, a row in the **Results Summary** subsection should appear, as pictured below. This result can be deleted by clicking the trash icon, or a JSON file containing all the raw data can be downloaded via the **Download** button, which is intended to help engineers with remote debugging. The **Download Results Summary (CSV)** button yields a CSV file of all the data represented in the results summary.

Results Summary												
Time	Remote Host	Description	Distance (m)	Location	Bandwidth (MHz)	Channel	UDP Send Throughput (Mbps)	UDP Receive Throughput (Mbps)	TCP Send Throughput (Mbps)	TCP Receive Throughput (Mbps)	Signal Strength (dBm)	Raw Data (JSON)
4/15/2025, 5:00:30 PM	192.168.12.1 (halowlink1-afdf)	Testing in Centennial Park	340	<a href="#">map view</a>	8	44 (924 MHz)	8.88	8.55	6.97	5.41	-88	<button>Download</button> 
<a href="#">Download Results Summary (CSV)</a>						<a href="#">Delete All</a>						

**Note:** test results are volatile to avoid overwhelming limited memory resources and will be deleted if power is removed or the device is rebooted.

# 7 Video Streaming

OpenWrt supports video streaming functionality where cameras attached to stations can stream video to an AP, viewable via the UI. This functionality includes automatic discovery of cameras on the HaLow network which are running compatible firmware (detailed below in station configuration). Any ONVIF-compliant cameras on the network which support H.264 streams will be detected automatically.

**Note:** When using the EKH03 as an AP, the web UI can display a maximum of two livestreams simultaneously due to CPU and memory requirements when proxying the streams.

## 7.1 Setting up

Follow Section [3](#) to configure your network and determine the IP address of your AP.

## 7.2 Accessing the Video Streams

In the web UI of the access point navigate to **Advanced Config > Services > Cameras**:

The screenshot shows the Morse Micro OpenWrt web interface. On the left, there's a sidebar with various configuration sections like Home, Quick Config, Wizards, Advanced Config, Status, System, and Services (which is currently selected). Under Services, 'Cameras' is also selected. The main content area has a header 'Cameras' and a 'HALOW MODE: AP' indicator. Below that is a table with columns: Hostname, Model, Firmware, Config, Streams, AWS KVS, and Live view (with a checkbox). One row is shown: 'ekh01-da3e' (Model EKH01v0, Firmware Morse-2.7-dev, Stream 1280x720@1000kbps), with 'AWS KVS - OFF' and a checked checkbox. Below the table is a 'Live view' section with a preview window showing a dark image and a 'Fullscreen' button. The top right of the interface has language and region selection buttons.

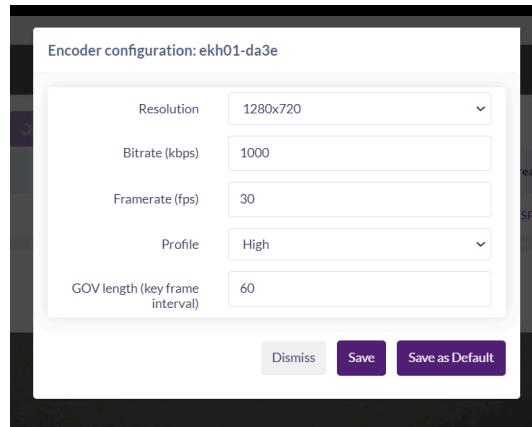
The AP will automatically discover all ONVIF cameras on the network. Note that it will only scan the selected network attached to the interface listed next to the **Discover** button. After scanning it will automatically start streaming from the discovered cameras.

The checkboxes under the 'Live view' column are used to select which video streams should be displayed.

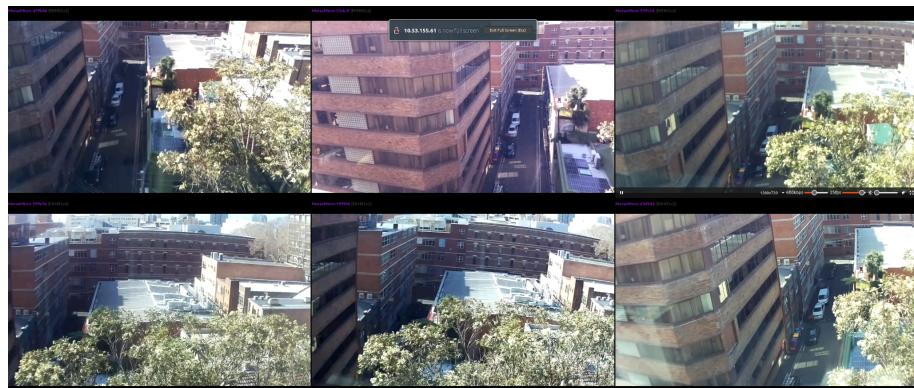
## 7.3 Configuration

The following options are available for configuring video streaming:

- **Discover** finds all cameras on the selected interface.
- **Reload All** reloads all the previously discovered camera streams.
- **Force Configs to Default** changes all camera configurations to the default configuration. Hovering over the button displays the default settings.
- **Config** opens a window to modify the camera's configuration.



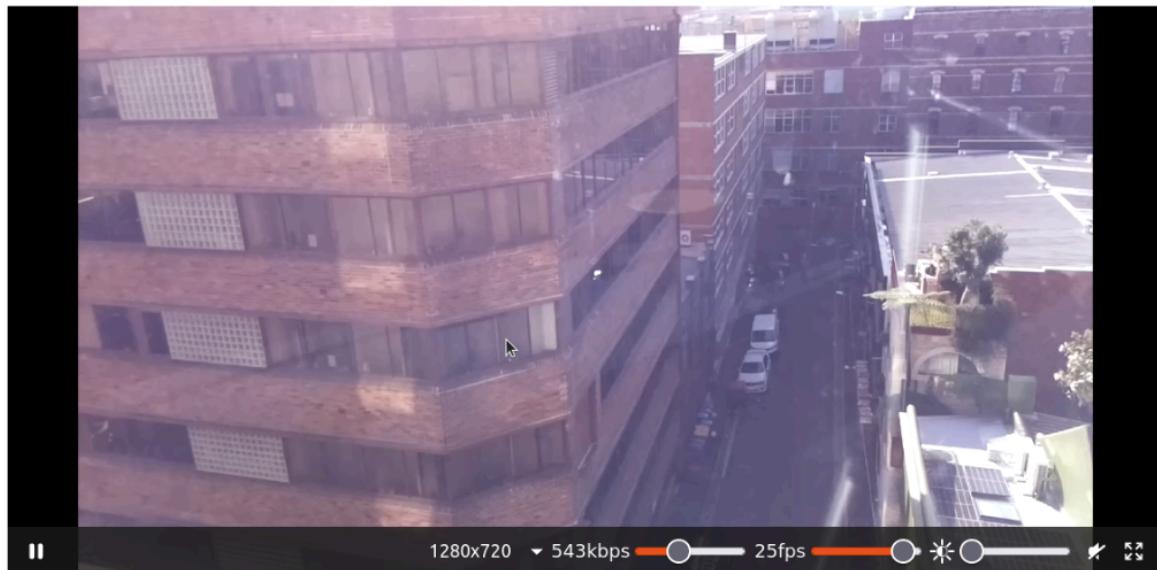
- **Resolution** of the camera
- **Bitrate** of the video stream
- **Framerate** of the video stream
- **Profile** for the H.264 compression
- **GOV length** sets number of frames between each key frame
- **Streams** selects the type of stream you want to view (opens in a new window).
- **Live View** selects whether to show a live stream on the current page (via WebRTC).
- **Fullscreen** shows a combined fullscreen view of all the currently enabled streams. To see a fullscreen view of an individual stream, hover over the stream to bring up the video controls.



### 7.3.1 Live View

Cameras can also be configured from the live view window, that includes the resolution, bitrate, framerate and brightness.

MorseMicro-01dc3f (EKH01v2)



# 8 Page Descriptions

This section describes some of the pages available in the web UI.

## 8.1 Home

The Home page provides a comprehensive view of the device's current status. It includes several key sections to help users understand the overall state of their device.

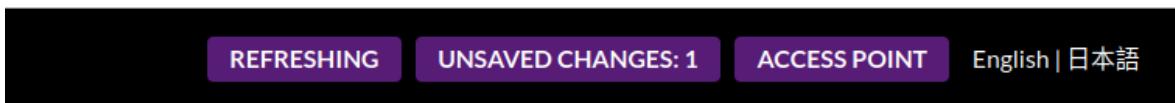
- **System** provides general details about the device, including the software version and model name. This section is essential for identifying the device and understanding its current firmware status.
- **Mode** displays the operational mode of the device and includes a configuration representation with a topology diagram. This visual aid helps users see how their device is configured and operating within the network.
- **HaLow Network Status** shows the current status of the HaLow network, including any connected clients if the device is functioning as an Access Point. This information is crucial for monitoring the HaLow network's health and connected devices.
- **Uplink Information** provides the status of the uplink connection, offering details about connectivity. This section ensures users are aware of their device's connection to the wider network or internet.
- **Local Network Info** gives detailed information about the local network, including DHCP lease information if the DHCP server is enabled. This section helps users manage their local network and understand IP address assignments within their network.
- **Network Interfaces Information** displays the groupings of network interfaces, showing how they are organized and connected. This information is important for managing and troubleshooting network interfaces.
- **EasyMesh Status** offers a topology view, showing the network's structure and connections between devices. It also lists the number of connected agents and provides options for WPS (Wi-Fi Protected Setup) pairing, making it easier to add new devices to the network.
- Additionally clicking on the  symbol in each of these cards will navigate to the corresponding advanced configuration page.

## 8.2 Quick Config

The **Quick Config** page gives you fine-grained control of the configuration files (the UCI format files in /etc/config), and is best used for making minor changes (e.g. setting a Static IP or an SSID/password). We recommend using the Wizard for larger changes, as it's easy to make your device inaccessible if you mis-configure the network interfaces. In particular, in most cases changing the mode of the wireless interface, such as changing from Access Point to Client, will not be useful without making other changes.

For more information about how your device is configured, refer to [10 UI Configuration Architecture](#).

Settings do not take effect until the **Save & Apply** button at the bottom of the page is clicked. If you click the **Save** button, changes will be staged, and can be applied later by clicking on the **UNSAVED CHANGES** indicator at the top of the screen:



The screenshot shows the Morse Micro OpenWrt 2.8 User Guide interface. At the top right, there are buttons for "ACCESS POINT", "English | 日本語", and a search bar. The main navigation menu on the left includes: Home, Wizards, Upgrade, Quick Config (selected), Status, System, Services, Network, Statistics, Help, and Log out.

The "Quick Configuration" section displays a network diagram titled "This Device". It shows a central device labeled "ekh01-507e" connected to a "Laptop/Device" via an "Ethernet" port. The "lan" interface is assigned IP "10.42.0.1" and is a "DHCP Server". The "wan" interface is assigned IP "10.42.0.x" and is a "DHCP Client". The "ahwlan" interface is assigned IP "192.168.12.1" and is a "DHCP Server" with SSID "lyall-range-test-network". A "HaLow Access Point" is connected to the "ahwlan" interface, and a "HaLow Client" is connected to it. Another "HaLow Client" is shown connected to the "lan" interface. The "Network Interfaces" section lists the interfaces with their settings:

Name	Forward	Wireless	Ethernet	DHCP Server	Protocol	IPv4 address
lan	None		eth0	On	Static IP	10.42.0.1
wan	None		None	Off	DHCP Client	
ahwlan	None	lyall-range-test-network	None	On	Static IP	192.168.12.1

The "Wireless" section for "Morse Micro MM6108A1 802.11ah (radio0)" shows the following configuration:

Enabled	Device	Network	Mode	DPP	SSID/Mesh ID	Encryption	Key/Security
On	wlan0	ahwlan	Access Point (WDS)	Off	lyall-range-test-network	WPA3-SAE	*****

At the bottom right of the wireless section are buttons for "Save & Apply", "Save", and "Reset".

## 8.2.1 Network Interfaces

This section allows you to make changes to the Network configuration. The following fields are available:

- **Name** displays the network name. The configurations for this network and the list of Ethernet and Wireless interfaces mapped to this network are displayed in the corresponding row.
- **Forward** enables traffic forwarding between the source and the selected network. Click 'Forward' for advanced firewall settings.
- **Ethernet** selects an Ethernet port and maps it to the specified network.
- **DHCP Server** enables the DHCP server for the network. Click 'DHCP Server' for advanced DHCP and DNS configurations.
- **Protocol** sets either 'Static IP' for manual IP address configuration or 'DHCP client' to retrieve an IP from a DHCP server if available. Using DHCP is generally preferred.
- Click the three dots at the end of the row to configure the following options:
- **Netmask** sets the netmask for the interface. This option is available only if the protocol is set to 'Static IP'.
- **Gateway** sets the IP address of the upstream gateway for default IP traffic routing. This option is available only if the protocol is set to 'Static IP'.
- Click on the  symbol, to navigate to the advanced Network Configuration page.

## 8.2.2 Wireless

This section allows you to modify the wireless settings. The available fields are:

- **Country** defines the regulatory region for your HaLow device. This setting applies restrictions on channel, bandwidth, power and duty cycle to ensure compliance with local regulations. Only supported regions will appear in the drop-down list. For more information, refer to the Channels Guide document.
- **Preferred Frequency Width** selects the operating bandwidth for the HaLow network. The dropdown menu is automatically populated based on the Country selection.
- **Channel** chooses the frequency channel for the HaLow network. The dropdown menu is automatically populated based on the selected Preferred Frequency Width.

The list of available wireless interfaces and their configurations are displayed in the corresponding row:

- **Enabled** indicates the status of the wireless interface. Toggle the slider to enable or disable the wireless interface.
- **Device** displays the name of the wireless interface.

- **Mode** selects the mode of operation for the wireless interface. Options include: Access Point (WDS), Access Point (no WDS), Client (WDS), Client (no WDS), Mesh Point, Ad-Hoc (IBSS), Monitor and None.
- **DPP** lets the device broadcast a DPP preference for connection establishment.
- **SSID/Mesh ID** configures the SSID for connection. The field initially shows the currently configured SSID. In Client mode, clicking the  icon will scan for visible HaLow networks and populate the dropdown with visible SSIDs. If the SSID is not visible, you can manually enter the name and press enter to set it. In Mesh Point mode, enter the Mesh ID here.
- **Encryption** selects the encryption method for data sent over the HaLow network. Available methods include OWE, SAE, Enterprise security (EAP), and None (Open security):
  - OWE (Opportunistic Wireless Encryption) - Ensures privacy between the station and access point without requiring a password or station authentication.
  - SAE (Simultaneous Authentication of Equals) - Uses pre-shared passwords for symmetric encryption, suitable for mesh networks.
  - EAP (Enterprise Security) - Requires RADIUS server configuration for the Access Point and TLS, TTLS, or PEAP authentication credentials for the Client.
- **Password** is visible when SAE is selected as the encryption method. It configures the password used to authenticate and set up encryption between the station and the access point.

Click on the  icon to navigate to the advanced **Wireless Configuration** page and click **Edit** on the network's corresponding row to modify the following configurations in the **Interface Configuration** subsection:

- **802.11w Management Frame Protection** (Wireless Security) provides additional protection for management frames used for tasks such as authentication, de-authentication, association, disassociation, beacons, and probes. By default, this feature is set to 'required,' meaning management frames are encrypted, and forged frames can be rejected.
- **DTIM Interval** (Advanced Settings) specifies the DTIM (Delivery Traffic Indication Message) period to use, defined as the number of consecutive beacon intervals between DTIM transmissions.
- **Station inactivity limit** (Advanced Settings) sets the maximum number of seconds a wireless client (station) can remain inactive before the AP considers it disconnected or inactive.
- **Beacon Interval** (Advanced Settings) defines how often beacons are broadcast, measured in time units where 1 TU is equal to 1.024 milliseconds.

## 8.3 Statistics > Morse

This page provides processor core statistics on the Morse chip. **Read** displays the current statistics of a given core, whilst **Reset** sets counters back to zero. The underlying information on this page is gathered via the `morse_cli` command, which is also available via the CLI.

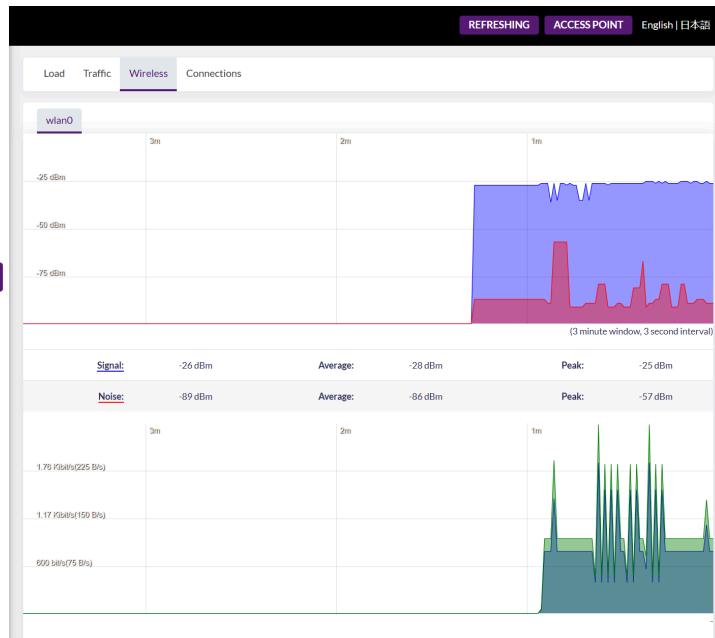
	Log	Action
Application Core Stats		<b>Read</b> <b>Reset</b>
MAC Core Stats		<b>Read</b> <b>Reset</b>
UPhy Core Stats		<b>Read</b> <b>Reset</b>

**MAC Statistics**

No A-MPDU candidate	: 4537
Commands expired in MAC req	: 0
Commands expired in MAC resp	: 0
DCE STIF fired	: 1460744
DCE LTF fired	: 319881
DCE PIFS detect fired	: 56388019
DCE aborted	: 8928755
DCE granted	: 876463
DCE medium busy before TX	: 851
DCE PIFS blocked before TX	: 0
Beacon lost	: 0
Beacon changed	: 0
Beacon RSSI changed	: 0
ADID change	: 0
TIM contains AID but STA awake	: 0
TIM group address	: 0
TIM nothing	: 0
TIM populated	: 0

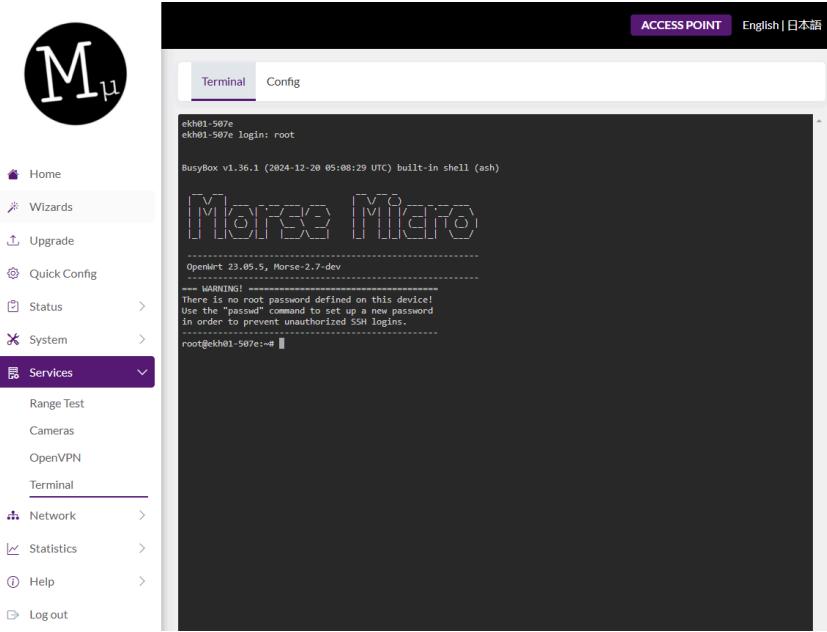
## 8.4 Status > Realtime Graphs > Wireless

This page displays live HaLow statistics graphs, showing the last 3 minutes of data, updated at a 3 second interval. The graphs are signal strength, data rates, and MCS respectively.



## 8.5 Services > Terminal

This page allows the user to spawn a usable shell in the web browser.



## 8.6 Services > OpenVPN

This tool is included from vanilla OpenWrt and provides an easy-to-use interface for configuring and managing OpenVPN client connections (see [documentation](#)).

## 8.7 System > Backup / Flash Firmware

The **Perform reset** button allows you to factory reset the device.

**Reset Defaults**

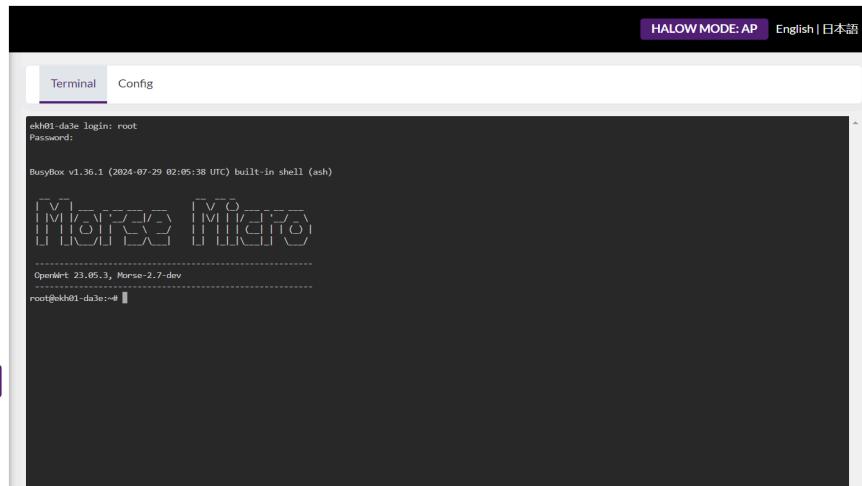
To reset the firmware to its initial state, click "Perform reset" (only possible with squashfs images).

## 8.8 Help > Regulatory Information

This page provides regulatory details for the selected country, including permissible 802.11ah HaLow parameters like channel frequency, transmission power, and duty cycle limits. It also indicates which channels are supported on your device, helping ensure compliance with local wireless regulations when planning deployments.

# 9 Additional Configuration Parameters

Some advanced configurations are useful to control HaLow behavior (particularly during certifications) and are documented here. Some may only be available via the CLI. If unsure, it is best not to modify default values unless advised by a Morse Micro engineer to do so.



For advanced users this CLI is also available via SSH and serial with the same credentials.

## 9.1 Disable AMPDU

### 9.1.1 Via UI

AMPDU can be configured in the advanced settings under the **Advanced Config > Network > Wireless** menu. Click **Edit** next to the HaLow network that is to be configured:

Navigate to the **Advanced Settings** tab under **Device Configuration** and untick 'AMPDU':

## 9.1.2 Via CLI

AMPDU can be disabled by entering `morse_cli -i wlan0 ampdu disable` into the CLI.

**Note:** Configurations made via the CLI are not persistent across reboots. To ensure your settings are saved permanently, please configure them through the UI.

## 9.2 Fragmentation Threshold

### 9.2.1 Via UI

In the same configuration section as described above for AMPDU, there is an option for configuring the fragmentation threshold. To disable this feature enter 'off' into the field, otherwise enter the number of bytes beyond which fragmentation should occur.

### 9.2.2 Via CLI

The fragmentation threshold can be set with the `iw` tool:

```
iw phy <phynname> set frag <fragmentation threshold|off>
```

Where the `<phynname>` is provided by the `iw list | grep Wiphy` command which might return something like:

```
Wiphy phy1
```

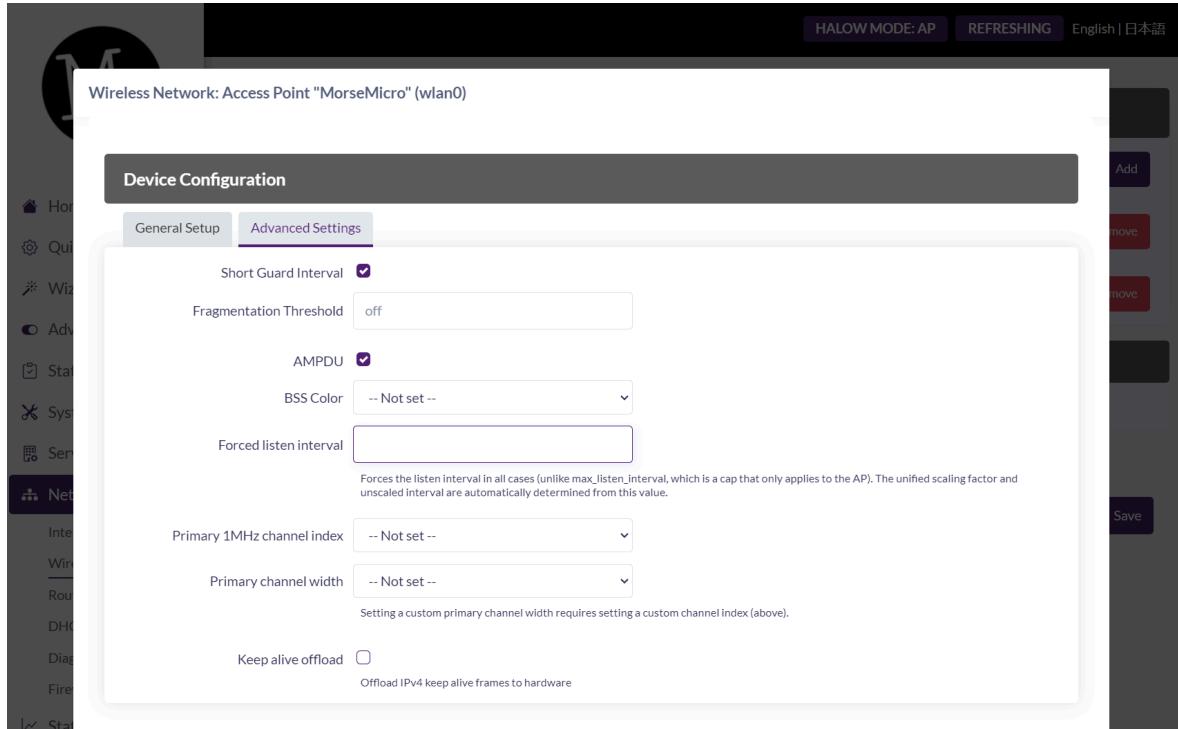
Where `phy1` is the `<phynname>`. The integer following `phy` enumerates every time the driver is (re)loaded.

**Note:** Configurations made via the CLI are not persistent across reboots. To ensure your settings are saved permanently, please configure them through the UI.

## 9.3 Unified Scaling Factor / Unscaled Interval

### 9.3.1 Via UI

Navigate to the **Advanced Config > Network > Wireless** page and then choose **Edit** beside the HaLow network. Use the ‘Forced listen interval’ input in the **Advanced Settings** tab of the **Device Configuration** section:



### 9.3.2 Via CLI

The USF and UI and must be set together, with the `morse_cli` tool using the command:

```
morse_cli -i wlan0 li <unscaled interval> <unified scaling factor>
```

Where `<unscaled interval>` multiplied by `<unified scaling factor>` must be less than or equal to the integer value 65536.

**Note:** Configurations made via the CLI are not persistent across reboots. To ensure your settings are saved permanently, please configure them through the UI.

## 9.4 DTIM Interval

### 9.4.1 Via UI

Beacon interval can be configured by navigating to the **Advanced Config > Network > Wireless** page and then choosing **Edit** beside the HaLow network. Set the 'DTIM Interval' input in **Advanced Settings** tab of the **Interface Configuration** section:

The screenshot shows two stacked configuration pages from the Morse Micro OpenWrt web interface.

**Device Configuration (Top):**

- General Setup:** Shows the status of the wireless network: "Wireless network is enabled" with a "Disable" button.
- Advanced Settings:** Shows the operating frequency as "8 MHz" and the channel as "44 (924 MHz)".
- Status:** Displays network statistics:
  - Mode: Master | SSID: lyall-range-test-network
  - BSSID: 0C:BF:74:09:50:7E
  - Encryption: WPA3 SAE (CCMP)
  - Channel: 44 (924.0 GHz)
  - Tx-Power: 21 dBm
  - Signal: -26 dBm | Noise: -88 dBm
  - Bitrate: 32.5 Mbit/s | Country: US

**Interface Configuration (Bottom):**

- General Setup:** Shows the "Isolate Clients" option with a checkbox and a note: "Prevents client-to-client communication".
- Advanced Settings:** Shows the "DTIM Interval" set to "2".
  - Delivery Traffic Indication Message Interval
- Power Save:** Shows the "Station inactivity limit" set to "300".
  - 802.11v: BSS Max Idle. Units: seconds.
- Centralised authentication control:** Shows the "GTK rekey period" set to "604800".
  - Dynamically adjusts the portion of stations which can send AuthReq messages
- GTK rekey period:** Shows the "Beacon Interval" set to "100".

At the bottom right of the configuration area are "Dismiss" and "Save" buttons.

## 9.5 Beacon Interval

### 9.5.1 Via UI

Beacon interval can be configured by navigating to the **Advanced Config > Network > Wireless** page and then choose 'Edit' beside the HaLow network. Use the 'Beacon Interval' in **Advanced Settings** tab of the **Interface Configuration** section:

The screenshot displays two configuration pages from the Morse Micro OpenWrt 2.8 User Guide.

**Device Configuration (Top Panel):**

- General Setup:** Status: Wireless network is enabled (button: Disable), Country Code: US, Operating frequency: Width 8 MHz, Channel 44 (924 MHz).
- Advanced Settings:** Mode: Master | SSID: iyall-range-test-network, BSSID: 0C:BF:74:09:50:7E, Encryption: WPA3 SAE (CCMP), Channel: 44 (924.0 GHz), Tx-Power: 21 dBm, Signal: -26 dBm | Noise: -88 dBm, Bitrate: 32.5 Mbit/s | Country: US.

**Interface Configuration (Bottom Panel):**

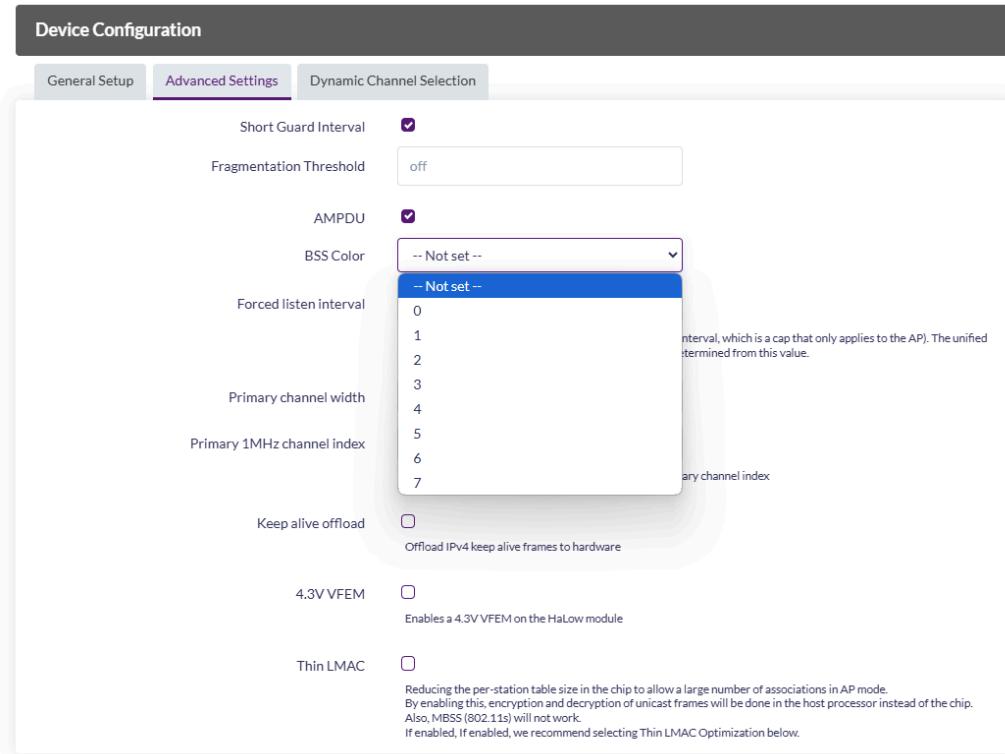
- General Setup:** Isolate Clients (checkbox: Prevents client-to-client communication), DTIM Interval: 2, Station inactivity limit: 300.
- Advanced Settings:** Centralised authentication control (checkbox: Dynamically adjusts the portion of stations which can send AuthReq messages), GTK rekey period: 604800, Beacon Interval: 100.

Buttons at the bottom right: Dismiss, Save.

## 9.6 BSS Color

### 9.6.1 Via UI

Navigate to the **Advanced Config > Network > Wireless** page and then choose ‘Edit’ beside the HaLow network. Use the ‘BSS Color’ list in **Advanced Settings** tab of the **Device Configuration** section:



### 9.6.2 Via CLI

BSS color can be configured using the following command:

```
morse_cli -i wlan0 bsscolor <value>
```

Where <value> is an integer from 0 to 7.

**Note:** Configurations made via the CLI are not persistent across reboots. To ensure your settings are saved permanently, please configure them through the UI.

## 9.7 Other HaLow settings

Other advanced settings are available within the text files found at `/etc/config/`. Generic options are defined in the OpenWrt documentation:

<https://openwrt.org/docs/guide-user/network/wifi/basic>.

## 9.8 morse\_cli

`morsectr1` is a command line utility that allows low-level access and control of the Morse radio chip. It is not intended to be included on consumer devices.

`morse_cli` contains a subset of `morsectr1` commands and is used by netifd to configure the radio (see Section 10). It is intended to be shipped on consumer devices.

In the EKH01 and EKH03 both of these utilities are included. For more information about their available options, refer to their respective command help messages via `-h`.

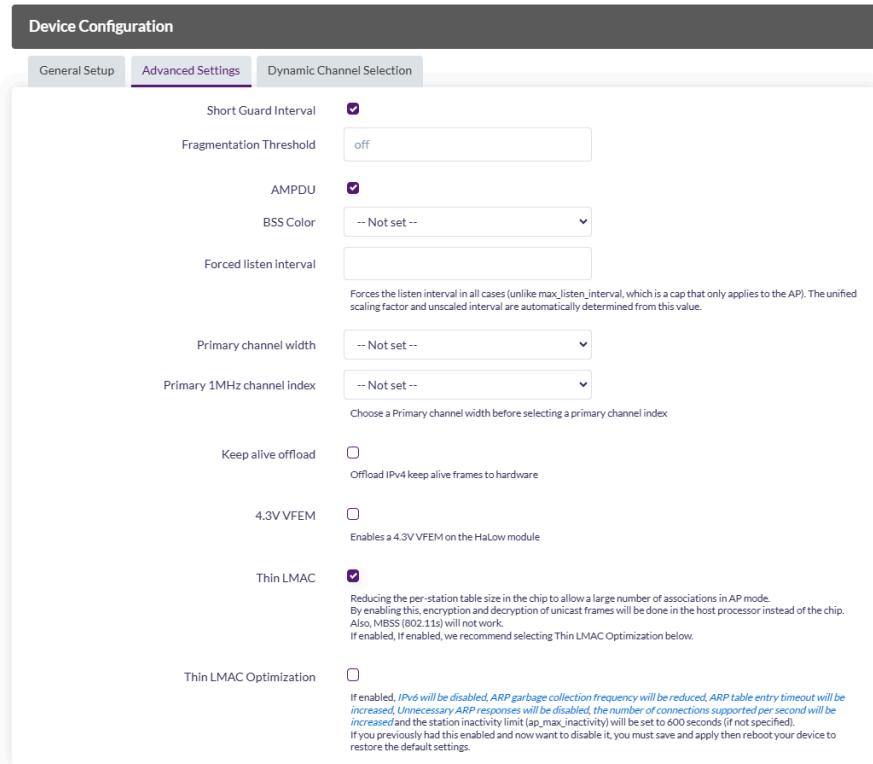
**Note:** Configurations made via the CLI are not persistent across reboots. To ensure your settings are saved permanently, please configure them through the UI.

## 9.9 Thin LMAC

Thin LMAC mode allows the firmware running in AP mode to support a large number of associations. This is achieved by reducing the per-station table memory from 88 bytes to 8 bytes inside the chip and moving them to the upper layers of the stack onto the host processor.

### 9.9.1 Via UI

To enable Thin LMAC through UI navigate to **Advanced Config > Network > Wireless** and choose 'Edit' beside the HaLow network. Select the 'Thin LMAC' option in **Advanced Settings** tab of the **Device Configuration** section:



### 9.9.2 Via CLI

Enable thin LMAC from command line with the following CLI commands:

```
uci set wireless.radio1.thin_lmac='1'  
uci commit  
reload_config
```

Disable thin LMAC by setting the above option back to 0 or deleting it from UCI.

## 9.9.1 Thin LMAC considerations

Since the goal of thin LMAC is to allow a large number of stations, there are some further suggested changes that may be helpful to reduce unnecessary traffic. These include:

- Disabling IPv6
- Reducing ARP garbage collection frequency
- Increasing ARP table entry timeout
- Disabling unnecessary ARP responses

It is also recommended to increase the number of connections supported per second as there might be a large number of simultaneous connections through the AP. In the UI, an 'Thin LMAC Optimization' option is provided to easily apply this set of recommended actions.

# 10 UI Configuration Architecture

This section outlines how changes to configuration in the UI are applied to the system.

From OpenWrt 2.0.2 onwards, the web UI configuration pages use the `LuCI.uci` API to configure a standard set of UCI configuration sections, which are stored in `/etc/config/`. Starting from OpenWrt 2.6, the Morse > HaLow Configuration page, previously based on a shim layer, has been replaced with a more resilient **Quick Config** page.

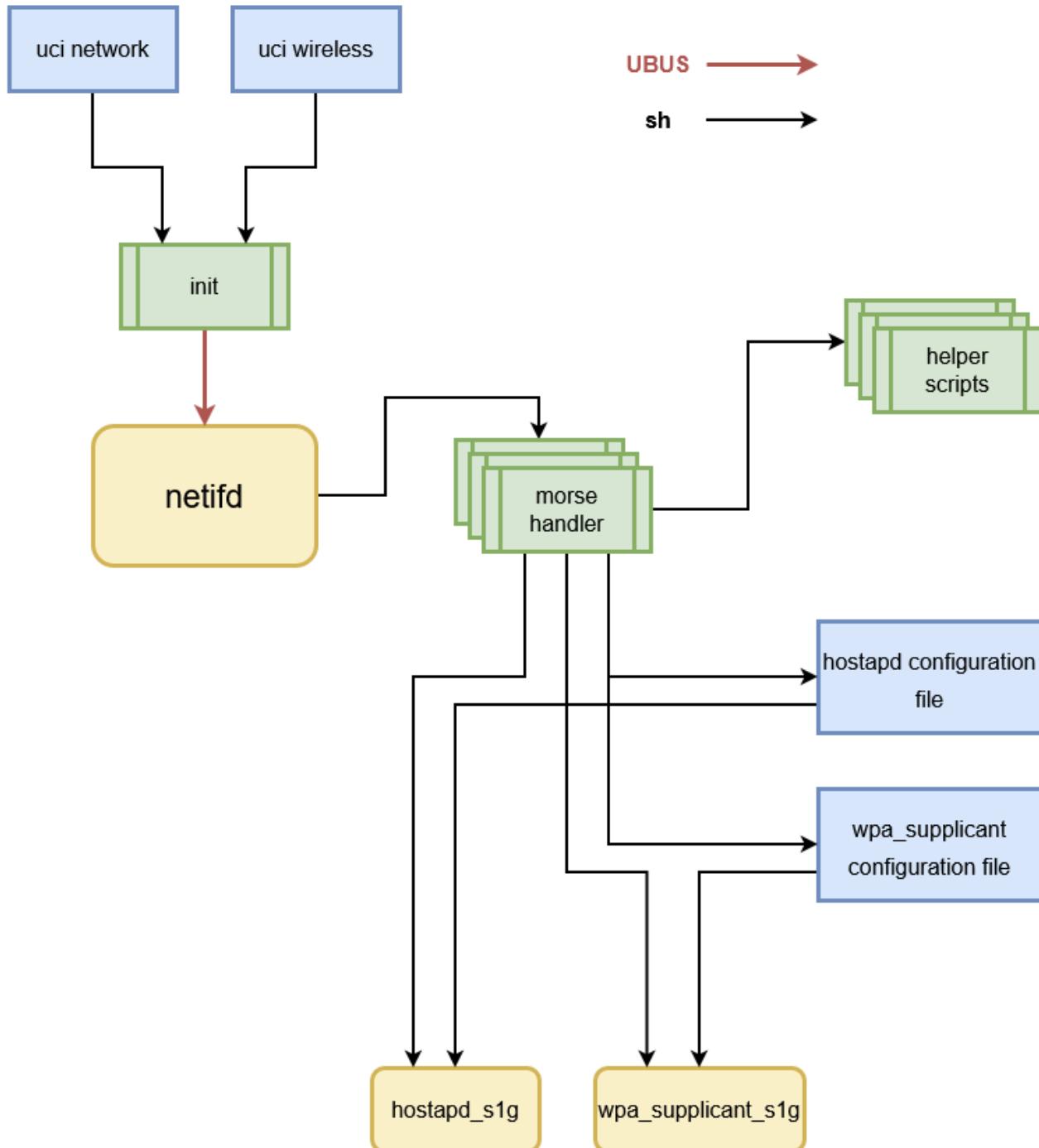
The **Quick Config** page addresses many of the pitfalls of the earlier HaLow Config page. Unlike the previous version it does not rely on hardcoded UCI sections, offering greater flexibility by directly getting or setting configurations in the underlying UCI configurations.

The network service daemon, netifd, examines changed UCI configurations upon reload and calls the necessary handler scripts to update the affected components. For a UCI `wireless.wifi-device`, netifd invokes wireless protocol handlers located in `/lib/netifd/wireless/*.sh`. For MorseMicro HaLow devices, the UCI configuration includes `type=morse`, triggering netifd to load `/lib/netifd/wireless/morse.sh`.

This protocol handler carries out the following:

- Parses sections with a Morse type of `wifi-device` in `/etc/config/wireless`
- Kills `hostapd_s1g` and `wpa_supplicant_s1g`
- Tears down the HaLow configured interfaces
- Rebuilds any morse module parameters - e.g. region information
- Reloads the morse driver module if parameters have changed
- Brings up the HaLow interface
- Creates appropriate `hostapd` or `wpa_supplicant` configuration files.
- Starts `hostapd_s1g` or `wpa_supplicant_s1g` as required.

The image below captures the execution flow of this process:



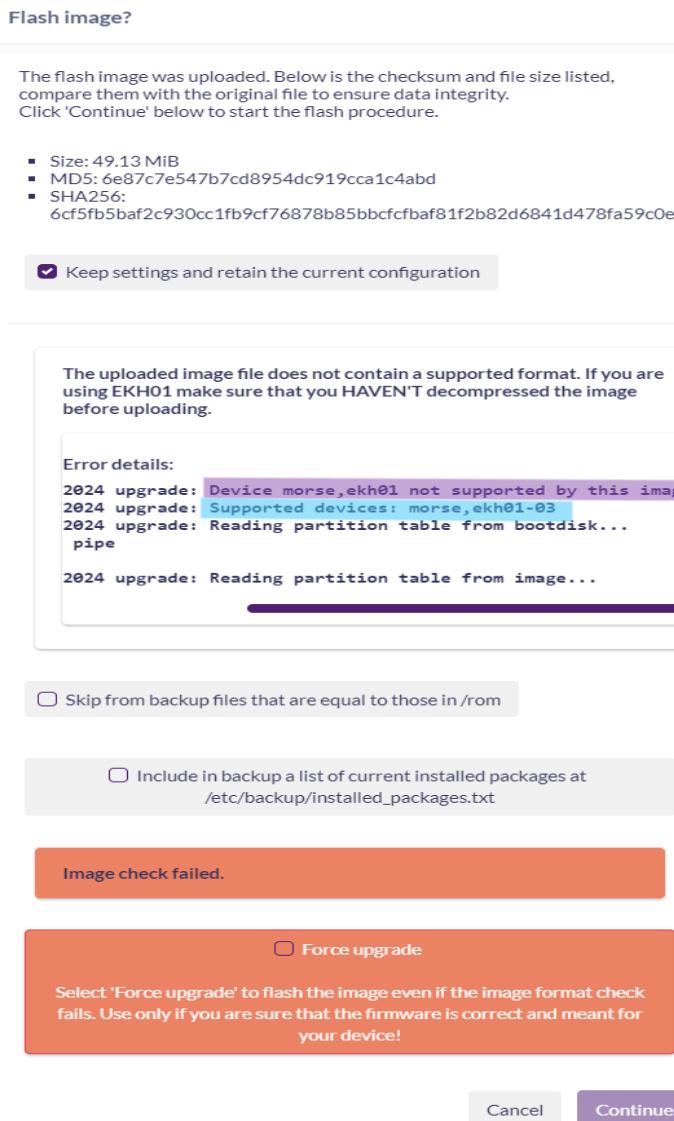
# 11 Troubleshooting

## 11.1 Updating firmware

Occasionally a platform name is updated, which can result in an error during upgrade e.g. "The uploaded image does not contain a supported format" (see below image). This is expected for the following upgrades:

- Updating an EKH01 from an image older than 2.3.3 to an image version 2.3.3 or higher.

Before proceeding, check that the 'Supported devices' line matches the device revision; the device revision is printed on the case, and on a sticker on the case.



**Note 1:** This line describes the image currently running on the device.

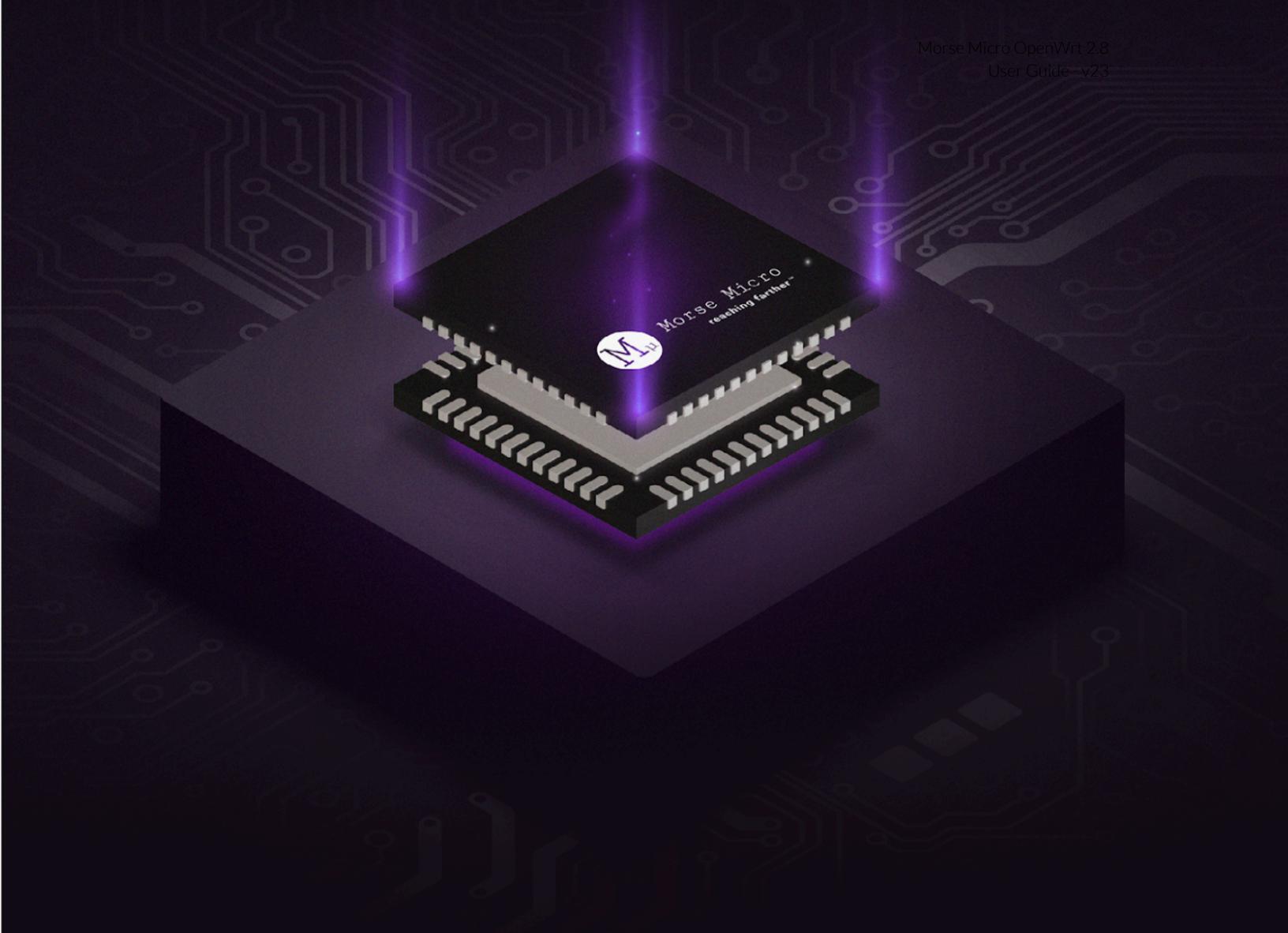
**Note 2:** This line describes the image you are trying to install. Match the device name you see here to the information printed on your device.

When you have verified the image matches the device, click 'Force Upgrade' and continue. The warning will not be shown again for future upgrades.

# 12 Revision History

Release Number	Release Date	Release Notes
01	12/01/2021	<ul style="list-style-type: none"><li>Initial release</li></ul>
02	12/02/2022	<ul style="list-style-type: none"><li>Update for firmware release 1.3</li></ul>
03	04/03/2022	<ul style="list-style-type: none"><li>IPERF Traffic Setup</li><li>Added Tools &gt; HaLow Firmware Upgrade</li></ul>
04	05/10/2022	<ul style="list-style-type: none"><li>Updated for the LuCI interface</li><li>Added in EKH01</li></ul>
05	10/10/2022	<ul style="list-style-type: none"><li>Improved formatting and reworded some sections for clarity.</li><li>Added UI Configuration architecture</li></ul>
06	20/10/2022	<ul style="list-style-type: none"><li>Added example of how to run wavemon for basic HaLow testing</li></ul>
07	18/10/2022	<ul style="list-style-type: none"><li>Add description of key setup scenarios, and refactored configuration to match these.</li><li>Removed references to custom configurations, and manual configuration except where not available in UI.</li><li>Other general improvements</li></ul>
08	22/11/2022	<ul style="list-style-type: none"><li>Updated device images</li></ul>
09	12/12/2022	<ul style="list-style-type: none"><li>Updated formatting and cover page image</li></ul>
10	6/01/2023	<ul style="list-style-type: none"><li>Updated for UCI configuration</li><li>Updated default IP address to 10.42.0.1</li></ul>
11	27/02/2023	<ul style="list-style-type: none"><li>Correct some typos</li></ul>
12	02/06/2023	<ul style="list-style-type: none"><li>Update for new HaLow configuration page</li><li>Update for new EasyMesh feature</li><li>Update for new Video UI feature</li><li>Update for adding internet connectivity</li></ul>
13	03/11/2023	<ul style="list-style-type: none"><li>General update and 1st release to Doc. Control</li></ul>
14	12/12/2023	<ul style="list-style-type: none"><li>Updated for 2.4.4 release</li></ul>
15	7/03/2024	<ul style="list-style-type: none"><li>Updated for 2.5.0 release</li></ul>

Release Number	Release Date	Release Notes
16	21/03/2024	<ul style="list-style-type: none"><li>• Updated for 2.5.2 release</li></ul>
17	28/03/2024	<ul style="list-style-type: none"><li>• Updated LED flash pattern for button presses (section 2.2.1)</li></ul>
18	02/08/2024	<ul style="list-style-type: none"><li>• Updated for 2.6 release</li></ul>
19	17/12/2024	<ul style="list-style-type: none"><li>• Updated for 2.7 release</li><li>• Updated EKH03 LED changes</li><li>• Added LTE features section</li></ul>
20	20/12/2024	<ul style="list-style-type: none"><li>• Updated for 2.7.1 release</li><li>• Added Range Testing section</li></ul>
21	14/01/2025	<ul style="list-style-type: none"><li>• Updated for 2.7.2 release</li><li>• Add monitor mode guide</li></ul>
22	14/04/2025	<ul style="list-style-type: none"><li>• Updated for 2.8.3 release</li><li>• Added in EKH19</li><li>• Add Default Web UI IP Addresses section</li></ul>
23	20/05/2025	<ul style="list-style-type: none"><li>• Updated for 2.8.5 release</li></ul>



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