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# IEEE 802.11 ah MODULE USER MANUAL

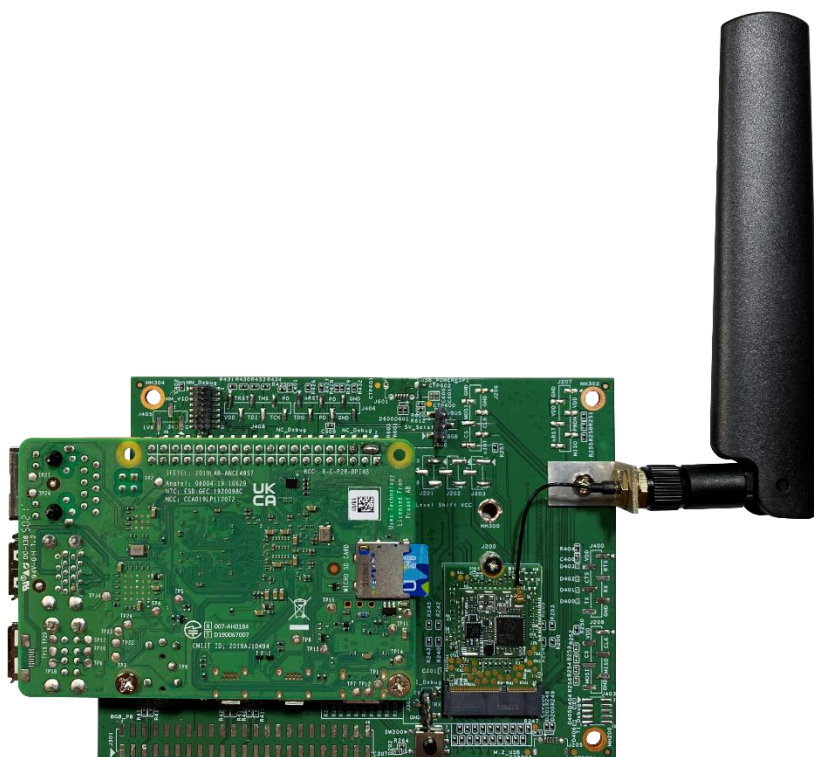
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Product : IEEE 802.11 ah Module

Model : WFAHLEXNIO4

FCC ID : S7Q-S04

IC : 31309-S04



Version 0.1

## Revision History

| Revision | Date       | Description                                 | Contributors | Approver |
|----------|------------|---------------------------------------------|--------------|----------|
| 0.1      | 2023/8/8   | 1 <sup>st</sup> release                     | Jerry Chuang | Bob      |
| 0.2      | 2023/10/16 | Update EVK picture and add hardware setting | Jerry Chuang | Bob      |
|          |            |                                             |              |          |
|          |            |                                             |              |          |
|          |            |                                             |              |          |
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## 1. Overview

The TM WFAHLEXNI04 IEEE 802.11 ah Wi-Fi HaLow Evaluation Kit is designed for testing the capabilities of the Wi-Fi HaLow transceiver through a familiar Linux user experience. With the EVK, users can test the functionality of the WFAHLEXNI04 in a variety of contexts, including raw throughput measurement with the iperf tool, or simple pinging between two separate EVKs to determine maximum usable range.

## 2. EVK Specification

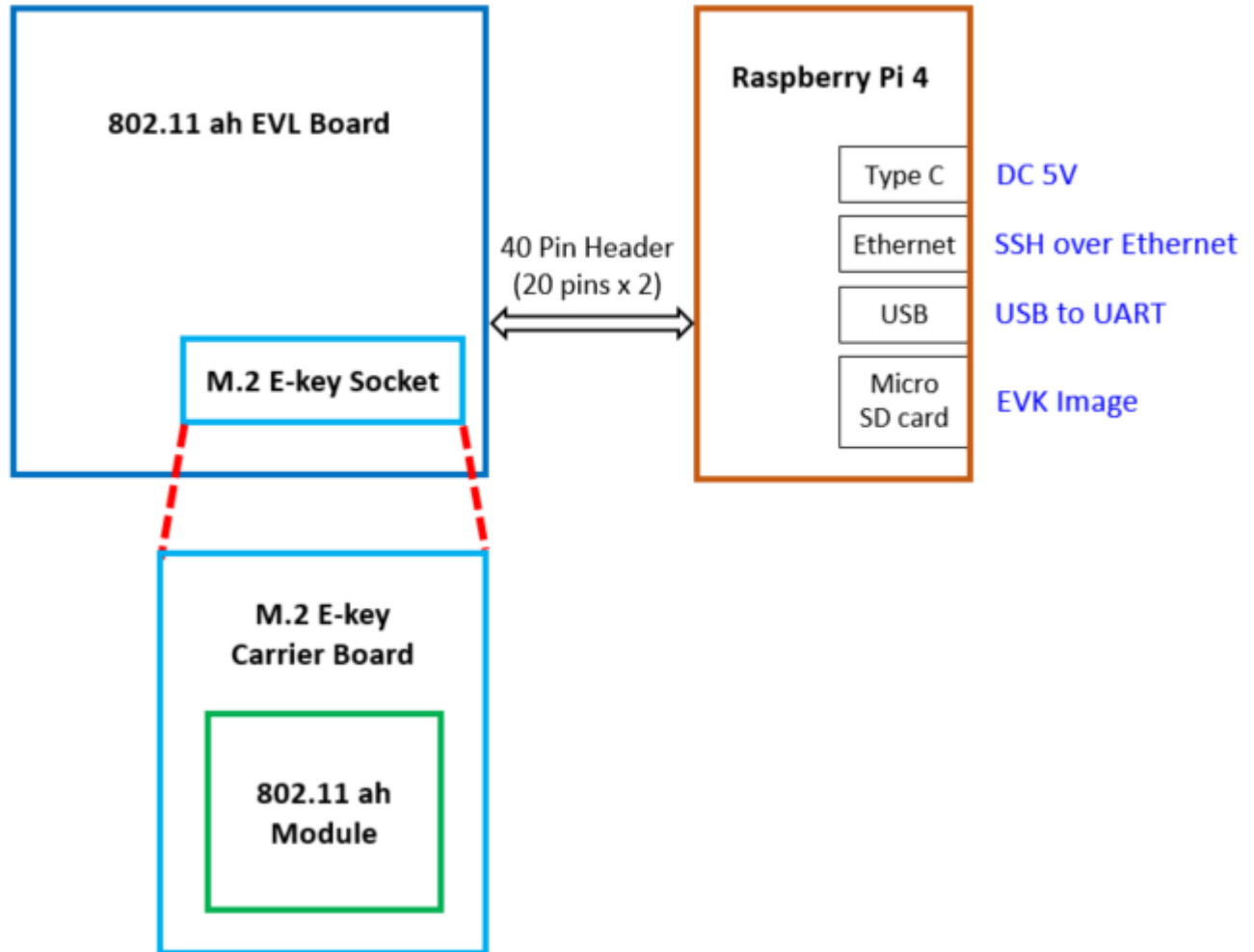
|                       |                                                                                                                     |
|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| PCBA                  | WFAHLEXNI04 evaluation board + Raspberry Pi 4                                                                       |
| Connectivity          | <ul style="list-style-type: none"> <li>▪ Gigabit Ethernet x1</li> <li>▪ USB 3.0 x2</li> <li>▪ USB 2.0 x2</li> </ul> |
| Storage               | Micro SD card slot                                                                                                  |
| Power supply          | External adaptor DC 5V 3.0A                                                                                         |
| Storage Temperature   | -20 to 65°C                                                                                                         |
| Operating Temperature | 0 to 45°C                                                                                                           |
| Product Size          | (L)130 x (W)88 x (H)19 mm                                                                                           |



### 3. EVK Content

| Item                 | Description                                                                                                                                                             |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PCBA                 | <ol style="list-style-type: none"> <li>1. WFAHLEXNI04 evaluation board with M.2 E key for the module on the carrier board</li> <li>2. Raspberry Pi 4 model B</li> </ol> |
| Module card x1       | Support Wi-Fi HaLow                                                                                                                                                     |
| RF Cable x1          | SMA to IPEX MHF1 pigtail cable for conductive performance validation or connecting to external antenna                                                                  |
| Antenna x1           | External dipole antenna for OTA test                                                                                                                                    |
| 8GB micro SD card x1 | For EVK image                                                                                                                                                           |
| DC adapter           | USB type-C adaptor, DC 5.1V 3.0A (PN : KSA-15E-051300HU)                                                                                                                |

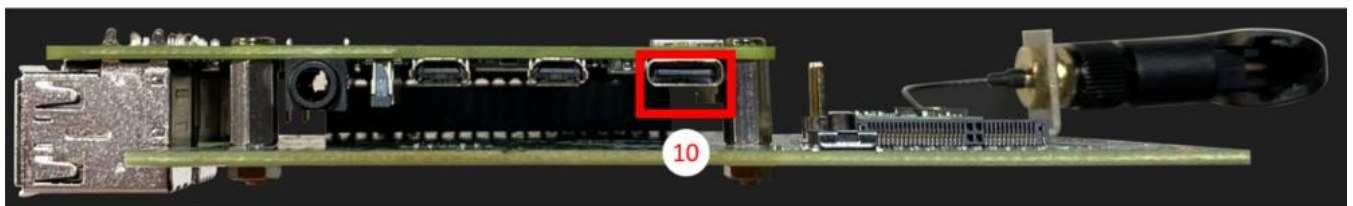
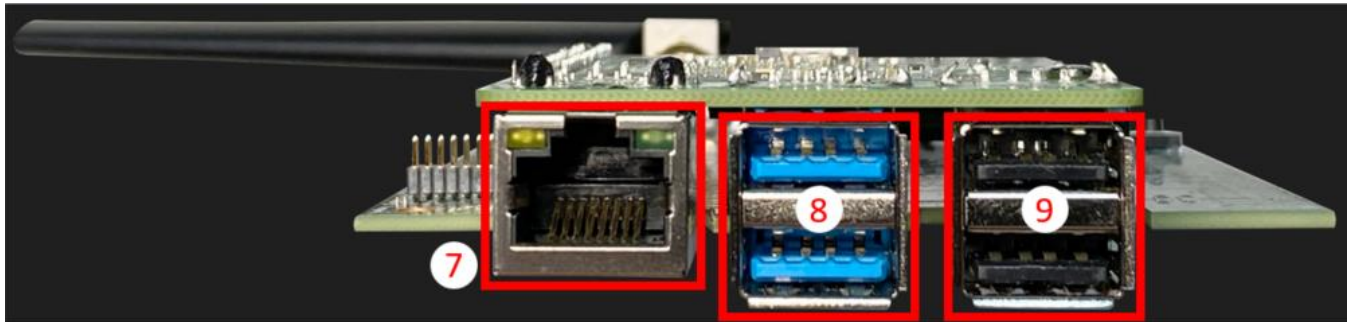
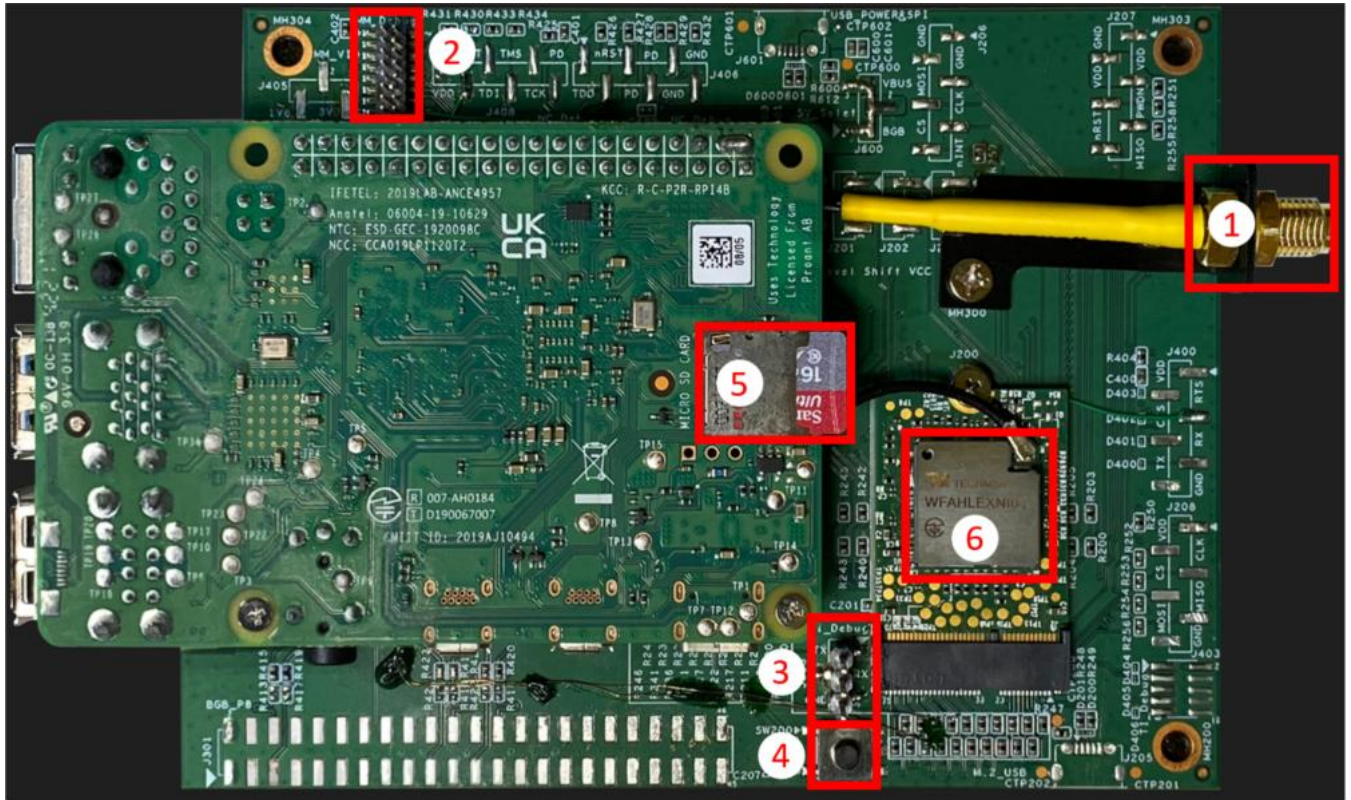
## 4. EVK Block Diagram



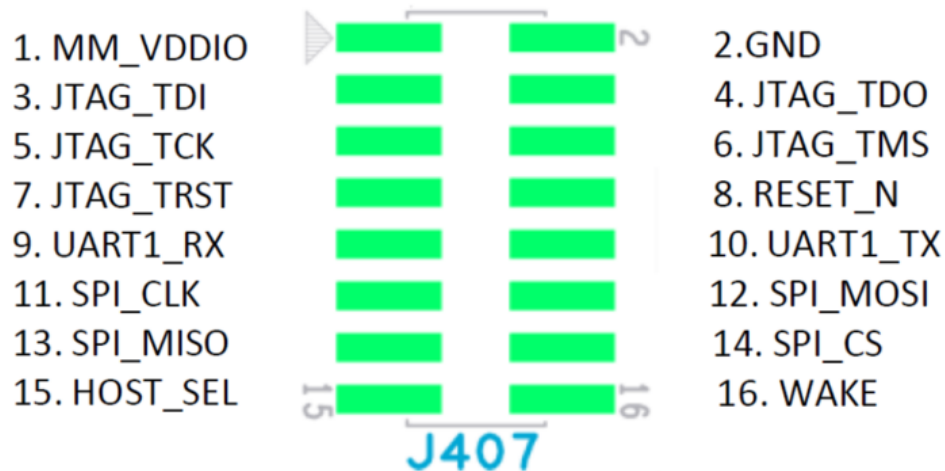
## 5. EVK Introduction

The EVK consists of 802.11 ah EVL board, 802.11 ah module, and Raspberry Pi 4. It supports external antenna for 802.11 ah, Ethernet port, USB port, Micro SD card slot, UART debug interface, Morse Micro module debug interface, and powered by external adaptor. Please refer to the following table and pin header define for more detail.

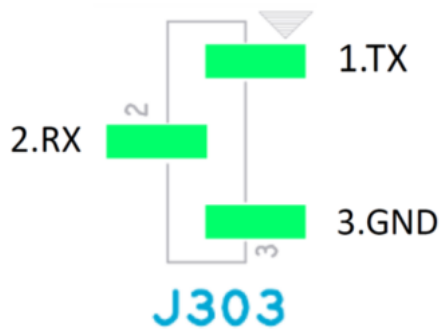
| Item | Description                           |
|------|---------------------------------------|
| 1    | SMA RF connector for external antenna |
| 2    | Morse Micro debug port (J407)         |
| 3    | UART debug port (J303)                |
| 4    | RESET button                          |
| 5    | Micro SD card slot                    |
| 6    | 802.11 ah module                      |
| 7    | Gigabit Ethernet                      |
| 8    | USB 3.0 port                          |
| 9    | USB 2.0 port                          |
| 10   | USB-C connector for 5V DC adaptor     |



Morse Micro module debug port pin header define:



UART debug port pin header define:

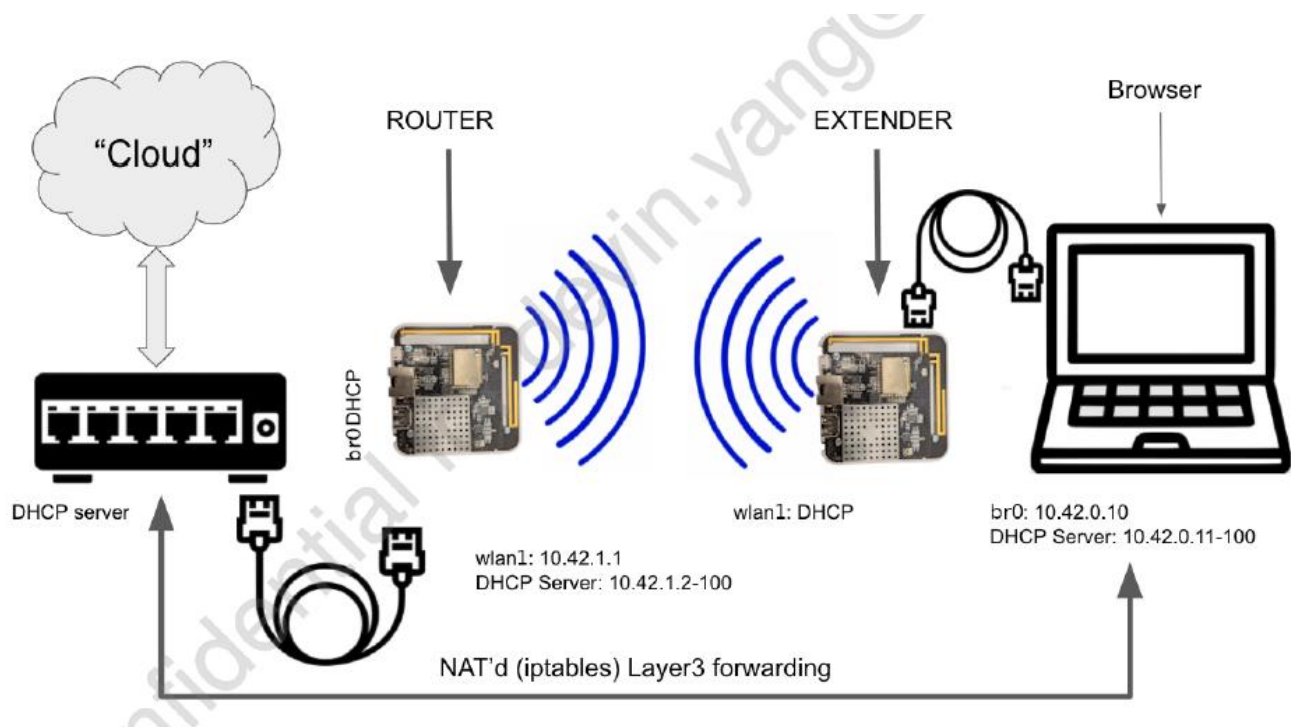


## 6. IPERF Traffic Setup

(pre configured devices)

For a first boot startup process with newly flashed EKH03s, please proceed to section 7.

The following reflects the configuration of a ROUTER/EXTENDER pair with one device configured as an AP/ROUTER and the other as a STA/EXTENDER. The combination of ROUTER and EXTENDER creates a Layer 3 forwarding network.



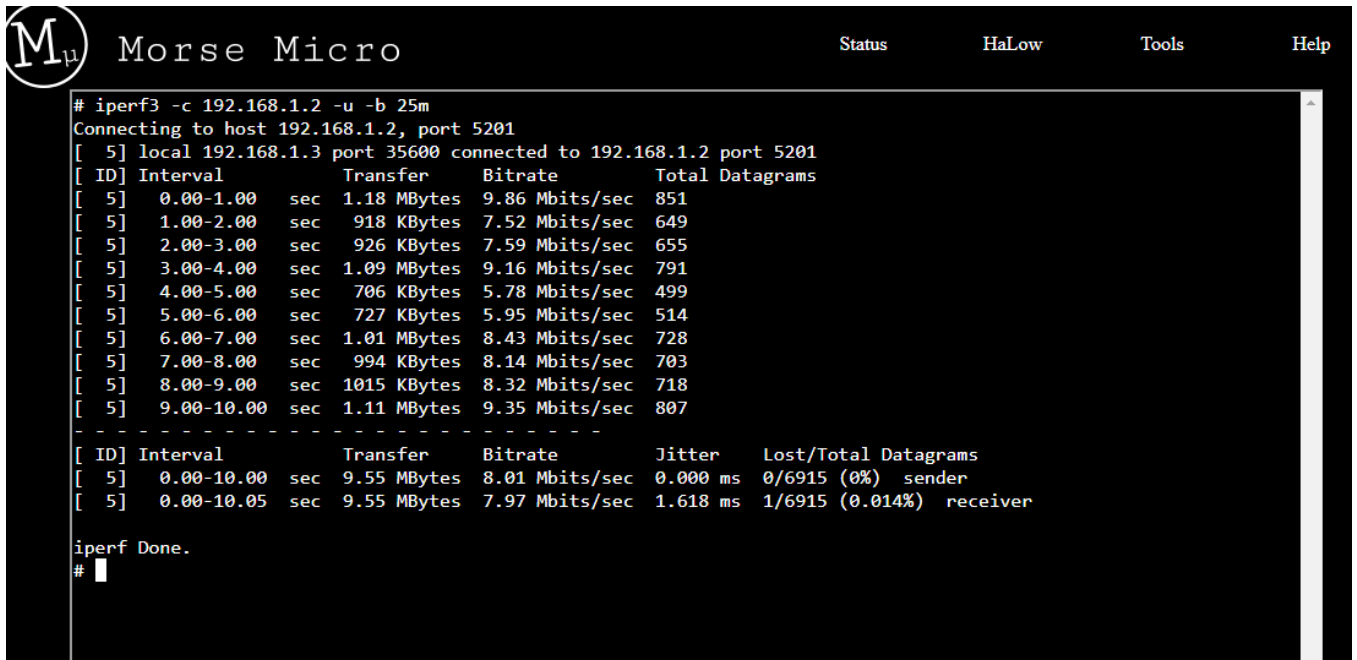
1. Connect the EKH03 to your computer via Ethernet (see section 1.1).
2. In a web browser, navigate to 10.42.0.2 for AP or 10.42.0.3 for STA.
  - a. Note, if router mode is enabled on the AP, the wired IP address will be DHCP assigned from the upstream router.
3. Navigate to the 'Shell' page under the Tools section in the navigation bar.



4. Click the 'Spawn Shell' button to launch a shell.
5. Type 'iperf3 -s' and press enter to launch the iperf3 server.

```
MM_buildroot login: root
# iperf3 -s
-----
Server listening on 5201
-----
```

6. Remove the Ethernet cable from your PC.
7. Connect the EKH03 to your computer via Ethernet (see section 1.1).
8. In a web browser, navigate to 10.42.0.2 for AP or 10.42.0.3 for STA..
9. Navigate to the 'Shell' page under the 'Tools' section in the navigation bar.
10. Click the 'Spawn Shell' button to launch a shell.
11. Type 'iperf3 -c IP\_ADDR -u -b 25M' where IP\_ADDR is the IP address of the other side of the HaLow link and 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.



```
# iperf3 -c 192.168.1.2 -u -b 25m
Connecting to host 192.168.1.2, port 5201
[ 5] local 192.168.1.3 port 35600 connected to 192.168.1.2 port 5201
[ ID] Interval      Transfer    Bitrate    Total Datagrams
[ 5] 0.00-1.00 sec  1.18 MBytes 9.86 Mbits/sec 851
[ 5] 1.00-2.00 sec  918 KBytes 7.52 Mbits/sec 649
[ 5] 2.00-3.00 sec  926 KBytes 7.59 Mbits/sec 655
[ 5] 3.00-4.00 sec  1.09 MBytes 9.16 Mbits/sec 791
[ 5] 4.00-5.00 sec  706 KBytes 5.78 Mbits/sec 499
[ 5] 5.00-6.00 sec  727 KBytes 5.95 Mbits/sec 514
[ 5] 6.00-7.00 sec  1.01 MBytes 8.43 Mbits/sec 728
[ 5] 7.00-8.00 sec  994 KBytes 8.14 Mbits/sec 703
[ 5] 8.00-9.00 sec  1015 KBytes 8.32 Mbits/sec 718
[ 5] 9.00-10.00 sec 1.11 MBytes 9.35 Mbits/sec 807
-----
[ ID] Interval      Transfer    Bitrate    Jitter    Lost/Total Datagrams
[ 5] 0.00-10.00 sec  9.55 MBytes 8.01 Mbits/sec 0.000 ms 0/6915 (0%) sender
[ 5] 0.00-10.05 sec  9.55 MBytes 7.97 Mbits/sec 1.618 ms 1/6915 (0.014%) receiver

iperf Done.
#
```

## 7. Getting Started

When booting, the device will try to restore the state previously set by the GUI if there is one. If no previous state is available, the device's br0 will default to 10.42.0.3.

### 7.1 AP Setup

1. Connect the EKH03 to your computer via Ethernet (see section 1.1).
2. In a web browser, navigate to 10.42.0.3.
3. If you are prompted to initialize the HaLow Interface (see below screenshot), select a region from the dropdown(ex. AU) and click 'Submit' to start the interface and get redirected to the main status page.

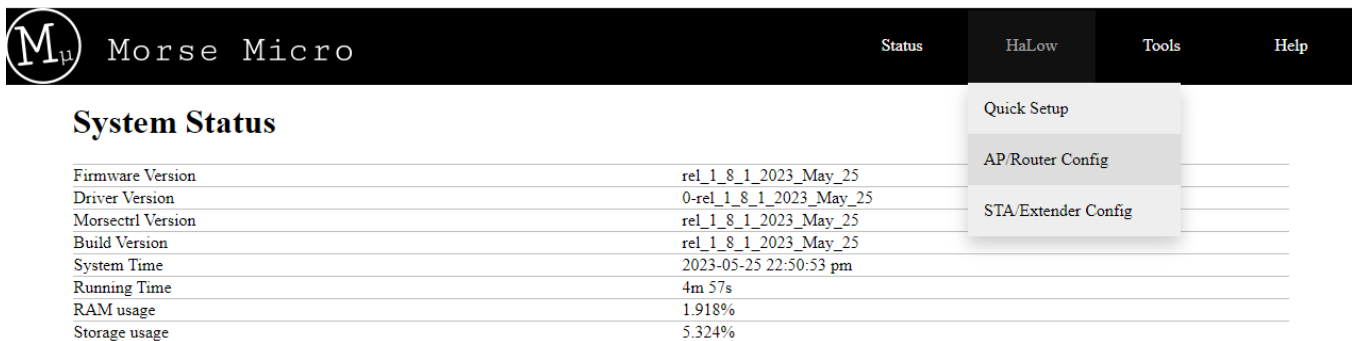


## Regions

No region selected for HaLow. Please select a region to use below.

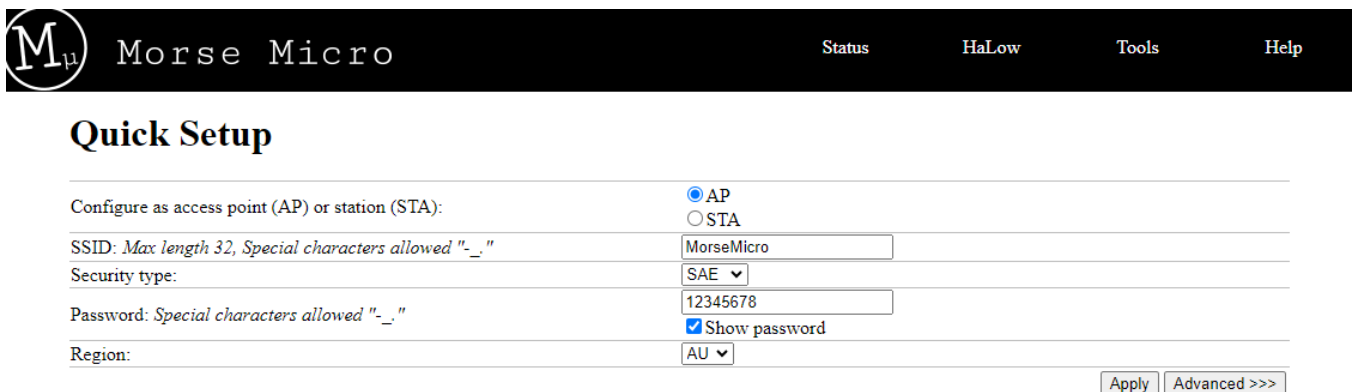
AU

- Navigate to the 'AP/Router Config' page under the HaLow section in the navigation bar.



| System Status     |                         |
|-------------------|-------------------------|
| Firmware Version  | rel_1_8_1_2023_May_25   |
| Driver Version    | 0-rel_1_8_1_2023_May_25 |
| Morsectrl Version | rel_1_8_1_2023_May_25   |
| Build Version     | rel_1_8_1_2023_May_25   |
| System Time       | 2023-05-25 22:50:53 pm  |
| Running Time      | 4m 57s                  |
| RAM usage         | 1.918%                  |
| Storage usage     | 5.324%                  |

- Configure the AP as desired. Click "Advanced" for detail setting. Note what the HaLow IP Address is, you will need it later to test the connection.



| Quick Setup                                                                               |                                                                  |
|-------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| Configure as access point (AP) or station (STA):                                          | <input checked="" type="radio"/> AP<br><input type="radio"/> STA |
| SSID: Max length 32, Special characters allowed "-_."                                     | MorseMicro                                                       |
| Security type:                                                                            | SAE                                                              |
| Password: Special characters allowed "-_."                                                | 12345678                                                         |
|                                                                                           | <input checked="" type="checkbox"/> Show password                |
| Region:                                                                                   | AU                                                               |
| <input type="button" value="Apply"/> <input type="button" value="Advanced &gt;&gt;&gt;"/> |                                                                  |

Warning: Quick setup for router expects an IP address through DHCP on its wired interface



Morse Micro

[Status](#)
[HaLow](#)
[Tools](#)
[Help](#)

## AP/Router Config

|                                                              |                                                                                            |
|--------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| SSID: <i>Max length 32, Special characters allowed "-_."</i> | <input type="text" value="MorseMicro"/>                                                    |
| Security type:                                               | SAE ▾                                                                                      |
| Password: <i>Special characters allowed "-_."</i>            | <input type="text" value="12345678"/><br><input checked="" type="checkbox"/> Show password |
| Enable protected management frames (PMF):                    | <input checked="" type="checkbox"/>                                                        |
| Region:                                                      | AU ▾                                                                                       |
| Operating bandwidth (in MHz):                                | 4 MHz ▾                                                                                    |
| Select channel:                                              | 48 (926 MHz) ▾                                                                             |
| Beacon Interval:                                             | <input type="text" value="100"/>                                                           |
| DTIM Period:                                                 | 1 ▾                                                                                        |
| Max Inactivity (1-65536):                                    | <input type="text" value="100"/>                                                           |
| Wired IP Address Method:                                     | <input type="radio"/> DHCP<br><input checked="" type="radio"/> Static                      |
| Wired IP Address:                                            | <input type="text" value="10.42.0.3"/>                                                     |
| Wired Netmask:                                               | <input type="text" value="255.255.255.0"/>                                                 |
| Wired Gateway:                                               | <input type="text" value="10.42.0.1"/>                                                     |
| Enable DHCP server on HaLow interface:                       | <input type="radio"/> Enabled<br><input checked="" type="radio"/> Disabled                 |
| HaLow IP Address:                                            | <input type="text" value="192.168.1.2"/>                                                   |
| HaLow Netmask:                                               | <input type="text" value="255.255.255.0"/>                                                 |
| HaLow Gateway:                                               | <input type="text" value="192.168.1.1"/>                                                   |
| Enable traffic forwarding:                                   | <input checked="" type="checkbox"/>                                                        |
| Bridge mode:                                                 | <input type="radio"/> Enabled<br><input checked="" type="radio"/> Disabled                 |

Morse Micro Configuration Interface

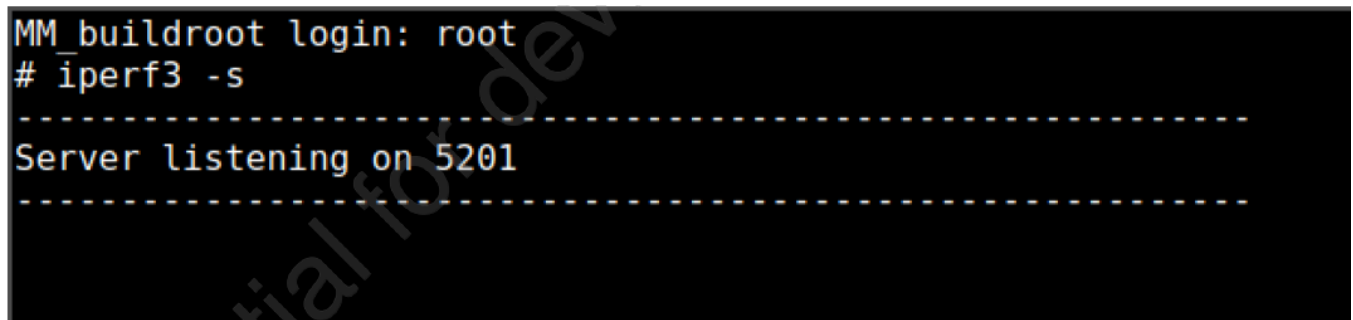
Current Mode: NONE

6. Click Apply to apply the configuration and bring up the router. Note, if a change is made to the wired IP Address, then please remember to navigate to the new address from the wired ethernet side.

7. Navigate to the 'Shell' page under the Tools section in the navigation bar.



8. Click the 'Spawn Shell' button to launch a shell.
9. Type 'root' and hit enter to log in
10. Type 'iperf3 -s' and hit enter to launch the iperf3 server.



## 7.2 STA Setup

1. Connect the EKH03 to your computer via Ethernet (see section 1.1).
2. Using a web browser, navigate to 10.42.0.3
3. If you are prompted to initialize the HaLow Interface (see below screenshot), select a region from the dropdown(ex. AU) and click 'Submit' to start the interface and get redirected to the main status page.

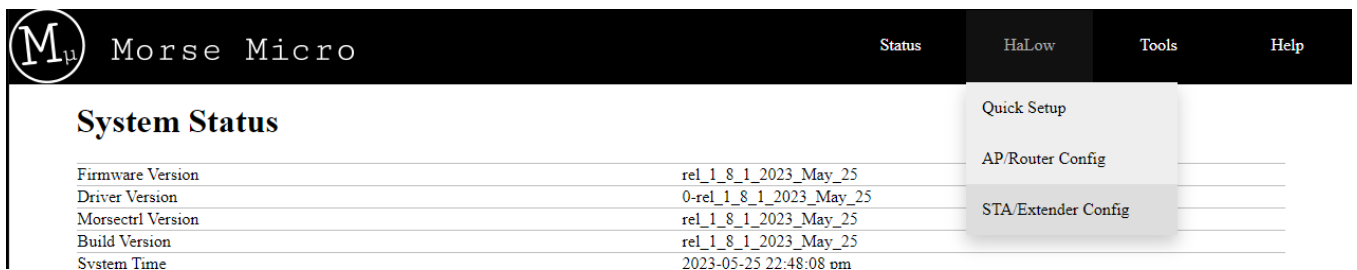


## Regions

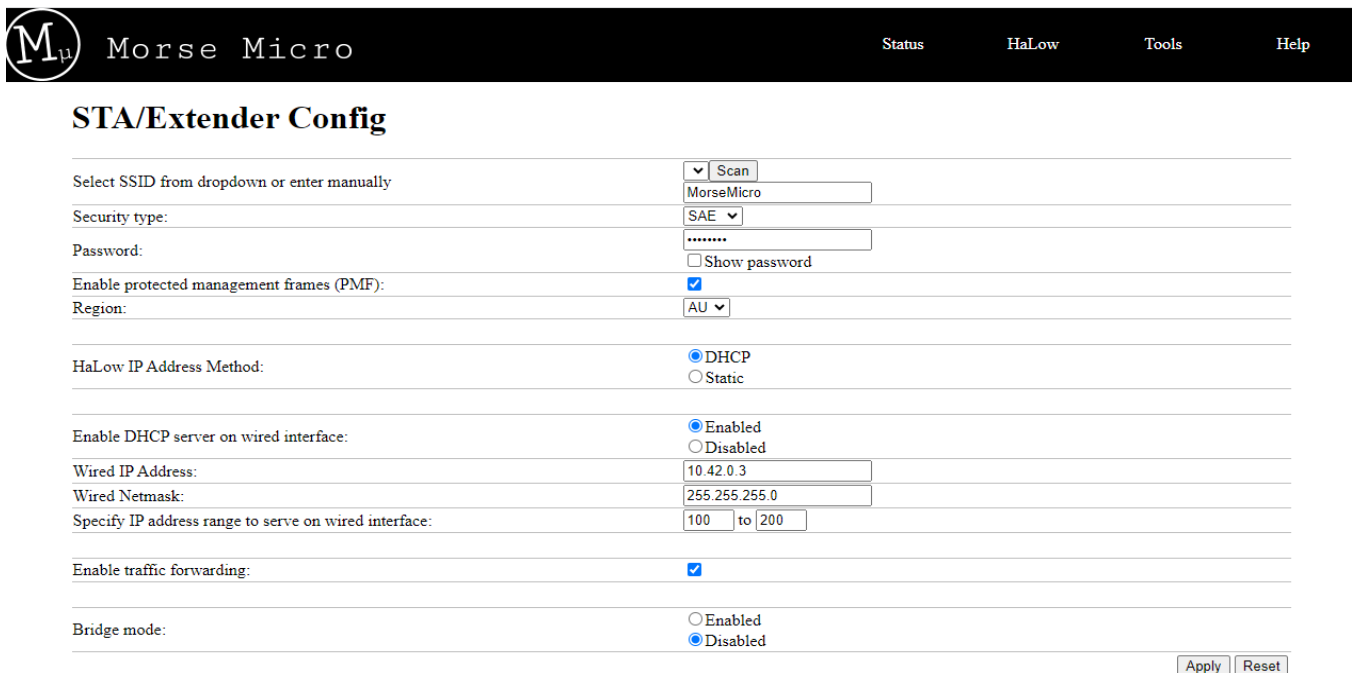
No region selected for HaLow. Please select a region to use below.

AU

- Navigate to the 'Extender Config' page under the HaLow section in the navigation bar.



- Setup the STA configuration as desired. The scan button can be used to populate the dropdown with available SSIDs.



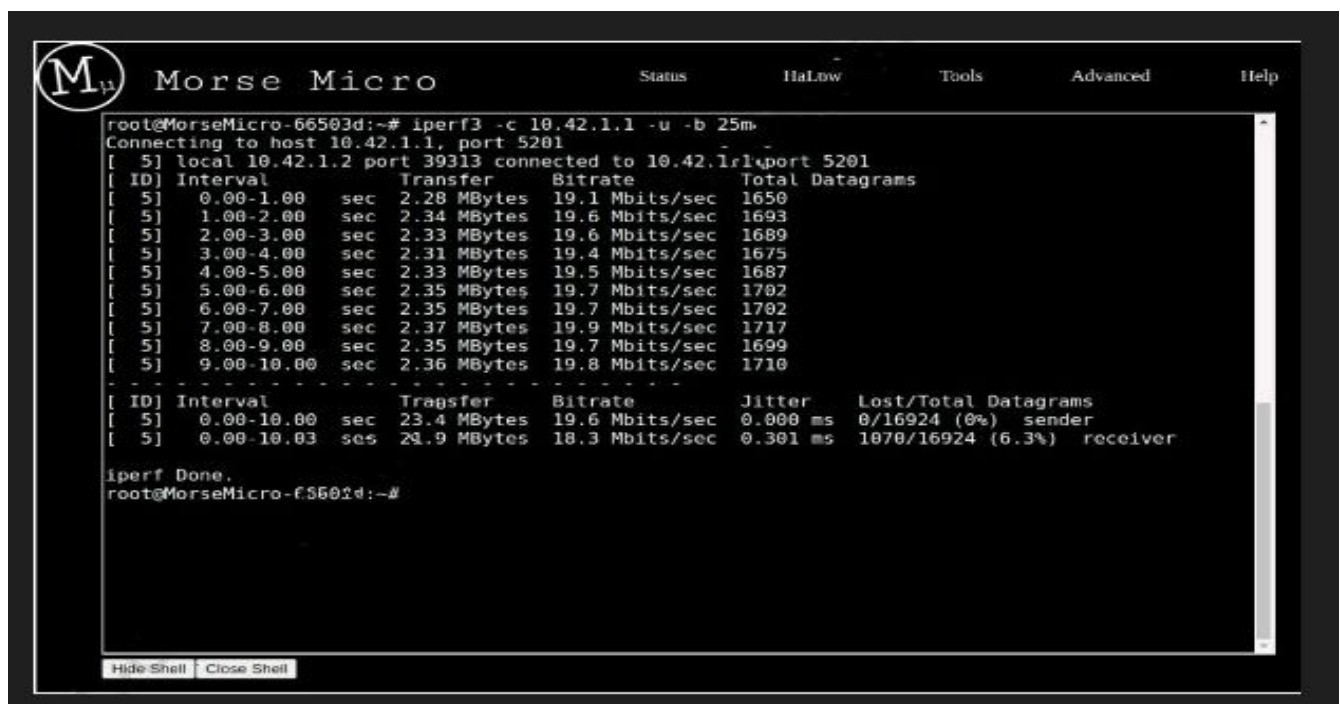
Click Apply to apply the configuration and bring up the STA/extender.

```
Connected to MorseMicro-3ef7c8
DHCP server started successfully
Traffic forwarding is enabled
Wired IP address: 10.42.0.3
HaLow IP address: 10.42.1.15
```

7. Navigate to the ‘Shell’ page under the Tools section in the navigation bar. Note, if a change is made to the wired IP Address, then please remember to navigate to the new address from the wired ethernet side.

8. Click the ‘Spawn Shell’ button to launch a shell.

9. Type ‘iperf3 -c IP\_ADDR -u -b 25M’ where IP\_ADDR is the IP address of the HaLow Router and press enter to launch the iperf3 client. The extender should connect as an iperf3 client to the server running on the router and show traffic running between them.



The screenshot shows the Morse Micro web interface with a terminal window open. The terminal displays the output of the iperf3 command, showing a successful connection and traffic flow between the router and the extender.

```
root@MorseMicro-66503d:~# iperf3 -c 10.42.1.1 -u -b 25M
Connecting to host 10.42.1.1, port 5201
[ 5] local 10.42.1.2 port 39313 connected to 10.42.1.1 port 5201
[ ID] Interval      Transfer    Bitrate      Total Datagrams
[ 5] 0.00-1.00 sec  2.28 MBytes 19.1 Mbits/sec 1650
[ 5] 1.00-2.00 sec  2.34 MBytes 19.6 Mbits/sec 1693
[ 5] 2.00-3.00 sec  2.33 MBytes 19.6 Mbits/sec 1689
[ 5] 3.00-4.00 sec  2.31 MBytes 19.4 Mbits/sec 1675
[ 5] 4.00-5.00 sec  2.33 MBytes 19.5 Mbits/sec 1687
[ 5] 5.00-6.00 sec  2.35 MBytes 19.7 Mbits/sec 1702
[ 5] 6.00-7.00 sec  2.35 MBytes 19.7 Mbits/sec 1702
[ 5] 7.00-8.00 sec  2.37 MBytes 19.9 Mbits/sec 1717
[ 5] 8.00-9.00 sec  2.35 MBytes 19.7 Mbits/sec 1699
[ 5] 9.00-10.00 sec 2.36 MBytes 19.8 Mbits/sec 1710
--
[ ID] Interval      Transfer    Bitrate      Jitter    Lost/Total Datagrams
[ 5] 0.00-10.00 sec 23.4 MBytes 19.6 Mbits/sec 0.000 ms  0/16924 (0%) sender
[ 5] 0.00-10.00 sec 23.9 MBytes 18.3 Mbits/sec 0.301 ms 1070/16924 (6.3%) receiver

iperf Done.
root@MorseMicro-66503d:~#
```

---

# IEEE 802.11AH MODULE DATASHEET

---

Product: IEEE 802.11ah module

Solution: Morse Micro MODULE

Model: WFAHLEXNI04

Version 0.4



### Revision History

| Revision | Date      | Description                      | Contributors | Approver |
|----------|-----------|----------------------------------|--------------|----------|
| 0.1      | 2023/8/29 | Preliminary version              | Jerry Chuang | Bob      |
| 0.3      | 2023/9/14 | Modify PCB Dimensions 2D drawing | Arthur Chen  | Bob      |
| 0.4      | 2023/9/14 | Modify ID rendering              | Tony Cahng   | Bob      |
|          |           |                                  |              |          |
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## 1. Product introduction

The WFAHLEXNI04 module includes ultra-long-reach PA, high linearity LNA, T/R switch, 32 MHz crystal oscillator and it has been designed for a simplified Wi-Fi HaLow connection to an external host for applications in which a customer wants to merely replace their prior RF technology with a Wi-Fi HaLow connection while leveraging the latest WPA3 personal security protocol.

### 1.1 Application

- ◆ Low-power Sensor Networks
- ◆ Asset Tracking and Management
- ◆ Machine Performance Monitors & Sensors
- ◆ Building Access Control & Security
- ◆ Agricultural and Farm Networks
- ◆ Utility Smart Meter and Intelligent Grid
- ◆ Industrial Automation Controls
- ◆ Smart Home Automation
- ◆ Warehouse Connectivity
- ◆ Smart City Networks
- ◆ Wi-Fi HaLow Client Adapters/Dongles/Gateways

## 2. Feature

- ◆ Single-stream max data rate of 32.5 Mbps (MCS=7, 64-QAM, 8MHz channel, 4 uSec GI)
- ◆ Radio supporting worldwide Sub-1 GHz frequency bands
- ◆ Frequency Range: 860-930 MHz
- ◆ Channel width options of 1/2/4/8 MHz
- ◆ 802.11ah OFDM PHY supporting future WFA HaLow certification
- ◆ 802.11ah MAC supporting future WFA HaLow certification
- ◆ Support for STA and AP roles
- ◆ Power-Saving Target Wake Time (TWT) support for long battery life
- ◆ Automatic and manual MCS rate selection
- ◆ Power Management Unit (PMU) for various modes of operation
- ◆ Target Wake Time mode
- ◆ Wide spectrum of Security features
- ◆ AES encryption engine
- ◆ WPA3 including protected management frames (PMF)
- ◆ Support industrial temperature level
- ◆ Support Host Operating System Linux 4.19 above

### 3. Functional description

The following sections describe the functions of the module.

#### 4.2 SDIO host requirements

The host should support SDIO v2.0 with SDIO clock speeds of up to 50MHz. Slower clock speeds will impact the maximum achievable throughput. At a minimum, 2x GPIOs are required as a CMOS output to drive the RESET and WAKE signals. If power save is used, a third GPIO is needed, set as a CMOS input to receive the BUSY signal from the module. The SDIO data and command lines should be pulled up with 10k-100k resistors as per the SDIO 2.0 specification.

### 4.3 Power management

Module power is derived from a 3.0 to 3.6V supply provided on pins VBAT and VDD\_FEM. VBAT powers the internal circuitry of the MODULE and VDD\_FEM powers the on-board ultra-long-range power amplifier. VDDIO sets the IO voltage of the MODULE and should be connected to the same power supply as the host MCU. There are no strict power-up sequencing requirements, however the voltage on VDDIO must not exceed VBAT.

### 4.4 Digital interfaces

All unused digital IO pins must be pulled up or down to ensure they do not float. Failure to do so will result in a higher leakage current on the VDDIO supply.

## 4. Electrical Specification

### 5.1 Absolute Maximum Rating

|                                | Min. | Max. | Units |
|--------------------------------|------|------|-------|
| <b>Supply Voltages</b>         |      |      |       |
| VBAT (power supply for module) | -0.3 | 4.3  | V     |
| Voltage on digital I/O pin     | -0.3 | 4.3  | V     |
| Voltage on analog/RF pin       | -0.3 | 1.2  | V     |
| <b>Radio</b>                   |      |      |       |
| RF Input Power (CW)            | -    | 6    | dBm   |

### 5.2 Recommended Operating Conditions

| Parameter               | Min. | Nom. | Max.  | Units |
|-------------------------|------|------|-------|-------|
| VBAT / VBAT_AON         | 3.0  | 3.3  | 3.6   | V     |
| VDDIO (not exceed VBAT) | 1.8  | 3.3  | 3.6   | V     |
| Digital I/O voltage     | 0    | 3.3  | VDDIO | V     |
| Ambient Temperature     | -40  | 25   | 85    | °C    |

### 5.3 Power Consumption

#### 5.3.1 Transmit Power consumption

| Mode                                                                | Condition<br>TA=25°C, VBAT=VDDIO=3.3V, MCS7 | VBAT Current<br>Typ. | Units |
|---------------------------------------------------------------------|---------------------------------------------|----------------------|-------|
| Transmit Current(US, MCS0)<br>(20dBm output power, 100% duty cycle) | 1MHz channel                                | 218                  | mA    |
|                                                                     | 2MHz channel                                | 198                  | mA    |
|                                                                     | 4MHz channel                                | 179                  | mA    |
|                                                                     | 8MHz channel                                | 167                  | mA    |

#### 5.3.2 Receive Power consumption

| Mode                                                               | Condition<br>TA=25°C, VBAT=VDDIO=3.3V | VBAT Current<br>Typ. | Units |
|--------------------------------------------------------------------|---------------------------------------|----------------------|-------|
| Receive Current(US, MCS0)<br>(20dBm output power, 100% duty cycle) | 1MHz channel                          | 33                   | mA    |
|                                                                    | 2MHz channel                          | 35                   | mA    |
|                                                                    | 4MHz channel                          | 44                   | mA    |
|                                                                    | 8MHz channel                          | 56                   | mA    |

#### 5.3.3 Sleep Power consumption

| Mode         | Condition<br>TA=25°C, VBAT=VDDIO=3.3V         | VBAT Current<br>Typ. | Units |
|--------------|-----------------------------------------------|----------------------|-------|
| AP Mode      | Setup to AP mode                              | 183                  | mA    |
| Station Mode | Setup to Station mode                         | 174                  | mA    |
| Sleep Mode   | Power off, wait for external interrupt -DTIM3 | 0.34                 | mA    |

## 5.4 Interface Timing Characteristics

### 5.4.1 SDIO Timing Specifications

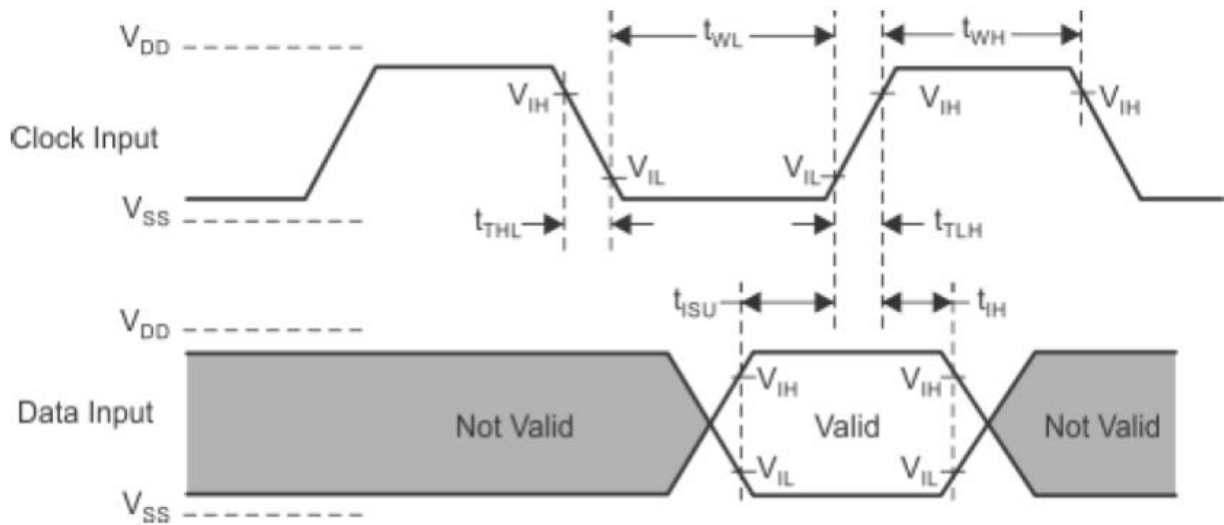


Figure5-1. SDIO Default Input Timing

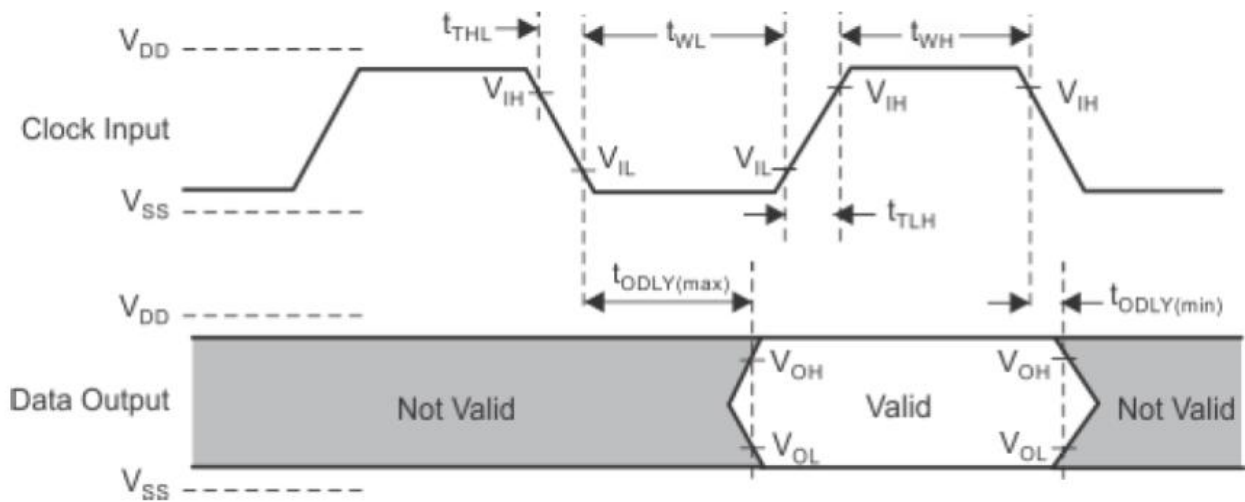


Figure5-2. SDIO Default Output Timing

Over recommended operating conditions. Parameters for maximum clock frequency

| Parameter                                     | Min   | Max   |
|-----------------------------------------------|-------|-------|
| Clock parameters                              |       |       |
| Clock frequency                               | 0     | 50MHz |
| Clock low time (t <sub>WL</sub> )             | 7ns   |       |
| Clock high time(t <sub>WH</sub> )             | 7ns   |       |
| Clock rise time (t <sub>LH</sub> )            |       | 3ns   |
| Clock fall time (t <sub>HL</sub> )            |       | 3ns   |
| Inputs on CMD, DAT lines to device from host  |       |       |
| Input setup time (t <sub>ISU</sub> )          | 6ns   |       |
| Input hold time (t <sub>IH</sub> )            | 2ns   |       |
| Outputs on CMD, DAT lines from device to host |       |       |
| Output delay (t <sub>ODLY(max)</sub> )        |       | 14ns  |
| Output hold time (t <sub>ODLY(min)</sub> )    | 2.5ns |       |
| Total system capacitance for each line        |       | 40pF  |

## 5.5 Throughput

| Bandwidth= 8M & DTIM=1 |        | Throughput |
|------------------------|--------|------------|
| TCP                    | Send   | 14.9 Mbits |
|                        | Recive | 14.3 Mbits |
| UDP                    | Send   | 20.8 Mbits |
|                        | Recive | 20.1 Mbits |

### 5.6 General Radio Characteristics

|                       |                                                                                    |
|-----------------------|------------------------------------------------------------------------------------|
| Protocol              | IEEE 802.11 ah                                                                     |
| Interface             | SDIO                                                                               |
| Frequency Range       | 830MHz ~ 960 MHz                                                                   |
| Chennal Bandwidth     | 1/ 2/ 4/ 8 MHz                                                                     |
| MCS index             | MCS 0 ~ 7 /10                                                                      |
| Link Data Rate (Max.) | 1 MHz : 3333 kbps<br>2 MHz : 7222 kbps<br>4 MHz : 15000 kbps<br>8 MHz : 32500 kbps |

### 5.7 Transmitter Characteristics

|                |                  |                       |
|----------------|------------------|-----------------------|
| US             |                  |                       |
| Transmit Power | 1 MHz BW / MCS 0 | 20±2dBm @ EVM <-5dB;  |
|                | 1 MHz BW / MCS 7 | 17±2dBm @ EVM <-27dB; |
|                | 2 MHz BW / MCS 0 | 20±2dBm @ EVM <-5dB;  |
|                | 2 MHz BW / MCS 7 | 17±2dBm @ EVM <-27dB; |
|                | 4 MHz BW / MCS 0 | 20±2dBm @ EVM <-5dB;  |
|                | 4 MHz BW / MCS 7 | 17±2dBm @ EVM <-27dB; |
|                | 8 MHz BW / MCS 0 | 20±2dBm @ EVM <-5dB;  |
|                | 8 MHz BW / MCS 7 | 17±2dBm @ EVM <-27dB; |
| EU             |                  |                       |
| Transmit Power | 1 MHz BW / MCS 0 | 15±2dBm @ EVM <-5dB;  |
|                | 1 MHz BW / MCS 7 | 15±2dBm @ EVM <-27dB; |
| JP             |                  |                       |
| Transmit Power | 1 MHz BW / MCS 0 | 12±2dBm @ EVM <-5dB;  |

|                |                  |                       |
|----------------|------------------|-----------------------|
|                | 1 MHz BW / MCS 7 | 12±2dBm @ EVM <-27dB; |
| TW             |                  |                       |
| Transmit Power | 1 MHz BW / MCS 0 | 20±2dBm @ EVM <-5dB;  |
|                | 1 MHz BW / MCS 7 | 17±2dBm @ EVM <-27dB; |
|                | 2 MHz BW / MCS 0 | 20±2dBm @ EVM <-5dB;  |
|                | 2 MHz BW / MCS 7 | 17±2dBm @ EVM <-27dB; |
|                | 4 MHz BW / MCS 0 | 20±2dBm @ EVM <-5dB;  |
|                | 4 MHz BW / MCS 7 | 17±2dBm @ EVM <-27dB; |

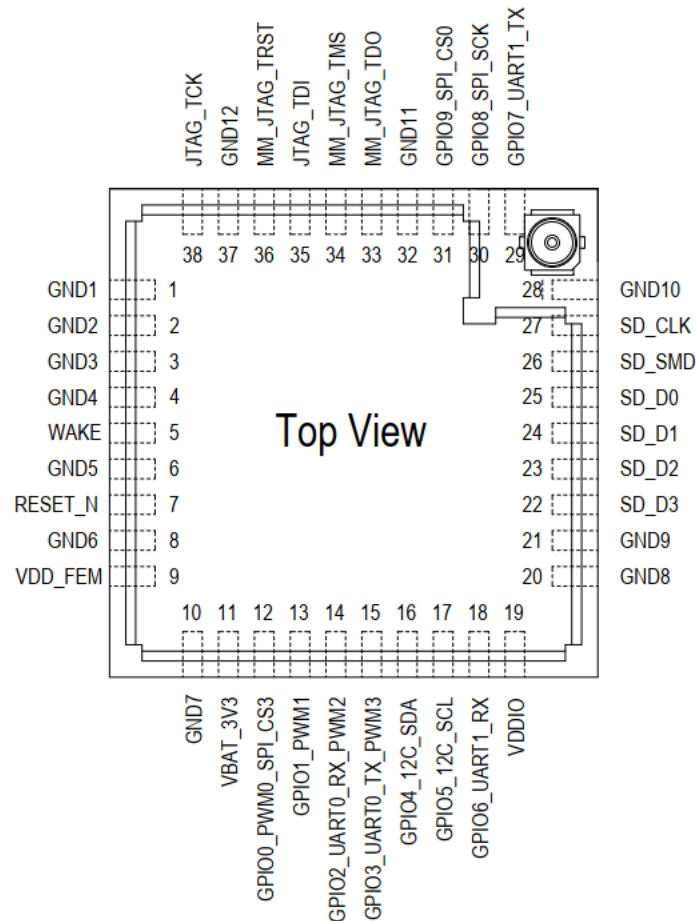
### 5.8 Receiver Characteristics

|                     |                  |             |
|---------------------|------------------|-------------|
| US                  |                  |             |
| Receive Sensitivity | 1 MHz BW / MCS 0 | < -105 dBm; |
|                     | 1 MHz BW / MCS 7 | < -86 dBm;  |
|                     | 2 MHz BW / MCS 0 | < -102 dBm; |
|                     | 2 MHz BW / MCS 7 | < -83 dBm;  |
|                     | 4 MHz BW / MCS 0 | < -99 dBm;  |
|                     | 4 MHz BW / MCS 7 | < -80 dBm;  |
|                     | 8 MHz BW / MCS 0 | < -95 dBm;  |
|                     | 8 MHz BW / MCS 7 | < -76 dBm;  |
| EU                  |                  |             |
| Receive Sensitivity | 1 MHz BW / MCS 0 | < -105 dBm; |
|                     | 1 MHz BW / MCS 7 | < -87 dBm;  |
| JP                  |                  |             |
| Receive Sensitivity | 1 MHz BW / MCS 0 | < -105dBm;  |
|                     | 1 MHz BW / MCS 7 | < -85dBm;   |
| TW                  |                  |             |
| Receive Sensitivity | 1 MHz BW / MCS 0 | < -105 dBm; |
|                     | 1 MHz BW / MCS 7 | < -86 dBm;  |

|  |                  |             |
|--|------------------|-------------|
|  | 2 MHz BW / MCS 0 | < -102 dBm; |
|  | 2 MHz BW / MCS 7 | < -83 dBm;  |
|  | 4 MHz BW / MCS 0 | < -99 dBm;  |
|  | 4 MHz BW / MCS 7 | < -80 dBm;  |

## 5. Pin Description

The module has 38 pins, which are described in this section. The following illustration shows the top view of the module pins.



| Pin No. | Name | Function | Description |
|---------|------|----------|-------------|
| 1       | GND  | POWER    | Ground      |
| 2       | GND  | POWER    | Ground      |
| 3       | GND  | POWER    | Ground      |
| 4       | GND  | POWER    | Ground      |

|    |          |       |                                       |
|----|----------|-------|---------------------------------------|
| 5  | WAKE     | I     | Wake (I/O 3.3V)                       |
| 6  | GND      | POWER | Ground                                |
| 7  | RESET_N  | I     | System Reset (I/O 3.3V)               |
| 8  | GND      | POWER | Ground                                |
| 9  | VDD_FEM  | POWER | Power 3.3V Frontend Module Supply     |
| 10 | GND      | POWER | Ground                                |
| 11 | VBAT     | POWER | 3.3V VBAT Supply                      |
| 12 | BUSY     | O     | Wi-Fi BUSY (I/O 3.3V)                 |
| 13 | GPIO_1   | I/O   | General Purpose IO1/PWM_1             |
| 14 | GPIO_2   | I/O   | General Purpose IO2/ UART0_RX, PWM1_2 |
| 15 | GPIO_3   | I/O   | General Purpose IO3/ UART0_TX, PWM1_3 |
| 16 | GPIO_4   | I/O   | General Purpose IO4/ I2C_SDA          |
| 17 | GPIO_5   | I/O   | General Purpose IO5/ I2C_SCL          |
| 18 | GPIO_6   | I/O   | General Purpose IO6/ UART1_RX         |
| 19 | VDD_IO   | POWER | 3.3V VDD_IO Supply                    |
| 20 | GND      | POWER | Ground                                |
| 21 | GND      | POWER | Ground                                |
| 22 | SDIO_D3  | I/O   | SDIO D3                               |
| 23 | SDIO_D2  | I/O   | SDIO D2                               |
| 24 | SDIO_D1  | I/O   | SDIO D1                               |
| 25 | SDIO_D1  | I/O   | SDIO D0                               |
| 26 | SDIO_CMD | I/O   | SDIO Command                          |
| 27 | SDIO_CLK | I/O   | SDIO Clock                            |

|    |             |       |                               |
|----|-------------|-------|-------------------------------|
| 28 | GND         | POWER | Ground                        |
| 29 | GPIO_7      | I/O   | General Purpose IO7/ UART1_TX |
| 30 | GPIO_8      | I/O   | General Purpose IO8           |
| 31 | GPIO_9      | I/O   | General Purpose IO9           |
| 32 | GND         | POWER | Ground                        |
| 33 | JTAG_TDO    | O     | JTAG Data Out                 |
| 34 | JTAG_TMS    | I     | JTAG Mode Select              |
| 35 | JTAG_TDI    | I     | JTAG Data In                  |
| 36 | JTAG_TRST_N | I     | JTAG Reset                    |
| 37 | GND         | POWER | Ground                        |
| 38 | JTAG_TCK    | I     | JTAG Clock                    |

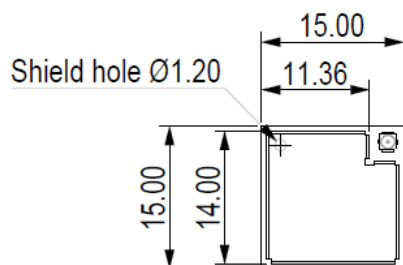
## 6. DESIGN RECOMMENDATIONS

### 8.1 Module Layout Recommendations

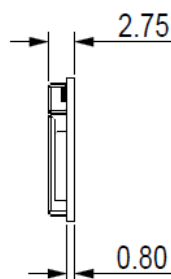
Follow these module layout recommendations:

- Supply and Interface
  - ✧ The power trace for VBAT must be at least 40-mil wide.
  - ✧ The 1.8-V trace must be at least 18-mil wide.
  - ✧ Make VBAT traces as wide as possible to ensure reduced inductance and trace resistance.
  - ✧ If possible, shield VBAT traces with ground above, below, and beside the traces.
  - ✧ SDIO signals traces (CLK, CMD, D0, D1, D2, and D3) must be routed in parallel to each other and as short as possible. **(Less than 12cm) Besides, every trace length must be the same as the others.** In addition, every trace length must be the same as the others. There should be enough space between traces – greater than 1.5 times the trace width or ground – to ensure signal quality, especially for the SDIO\_CLK trace. Remember to keep these traces away from the other digital or analog signal traces. TI recommends adding ground shielding around these buses.
- SDIO and digital clock signals are a source of noise. Keep the traces of these signals as short as possible. If possible, maintain a clearance around them

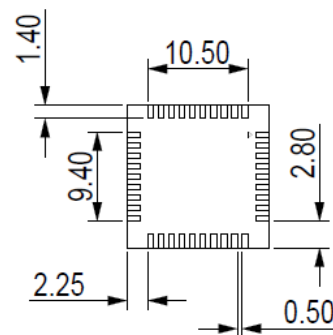
## 7. PCB Dimensions



Top View



Side View



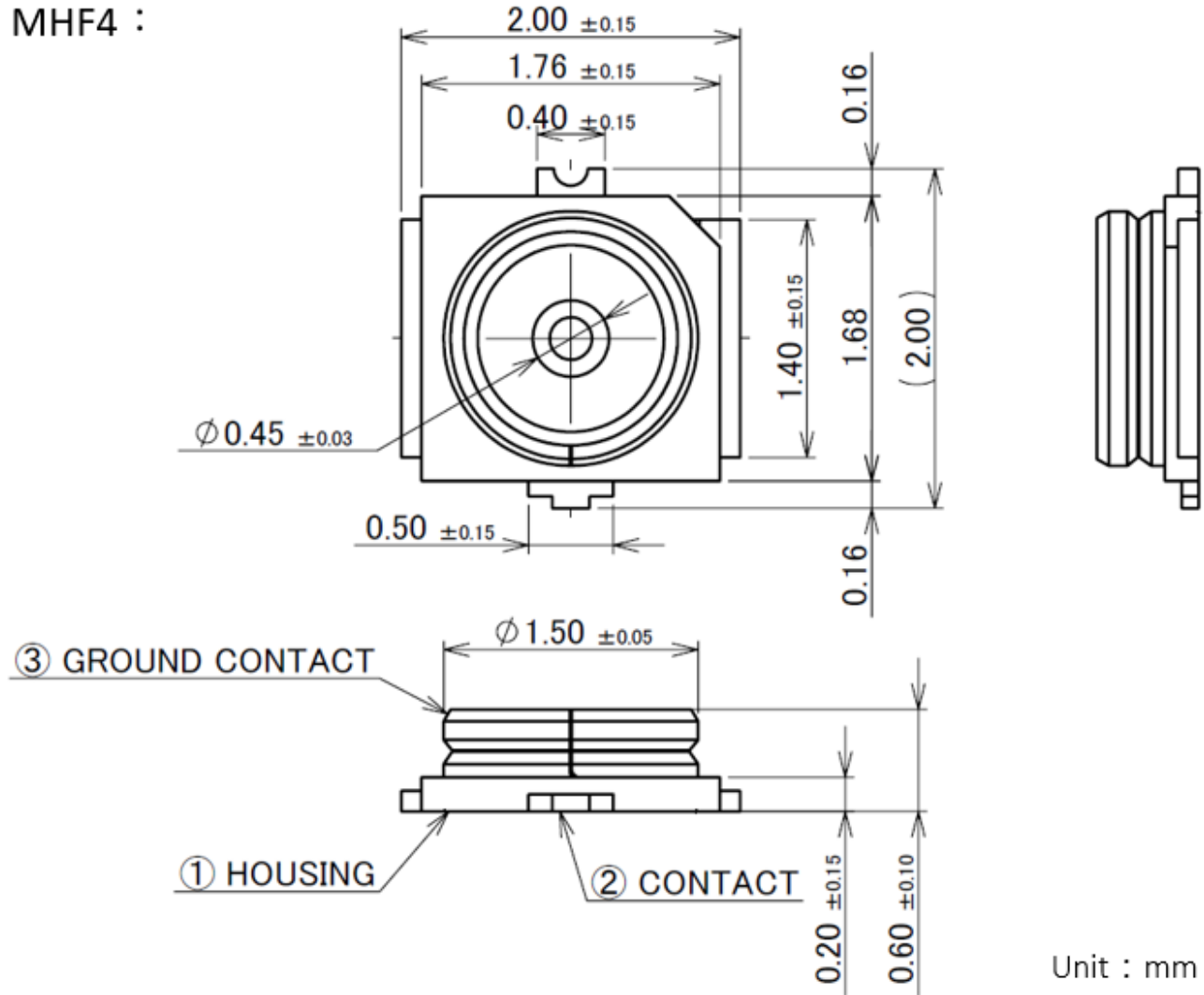
Bottom View

Unit : mm

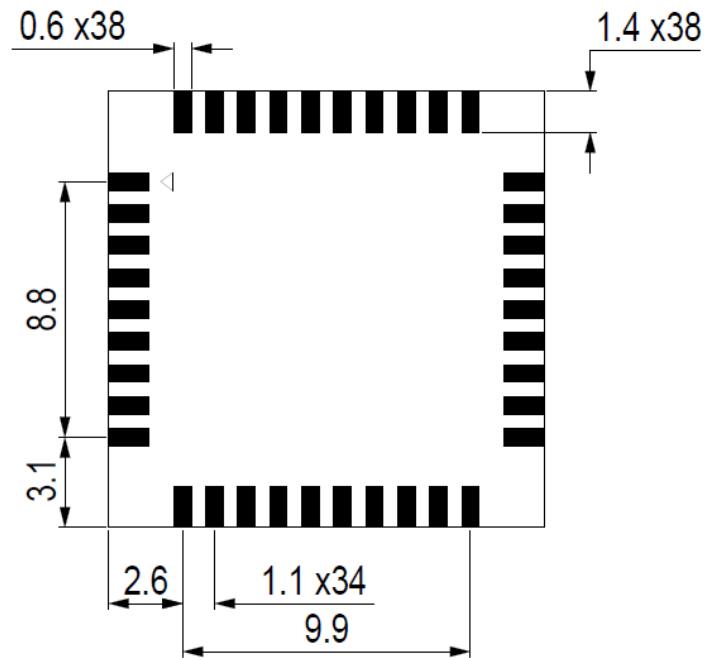
| PCB SIZE (mm) |          |
|---------------|----------|
| L             | 15.0±0.1 |
| W             | 15.5±0.1 |
| H             | 2.75±0.1 |

## 8. RF Connector Dimension

MHF4 :

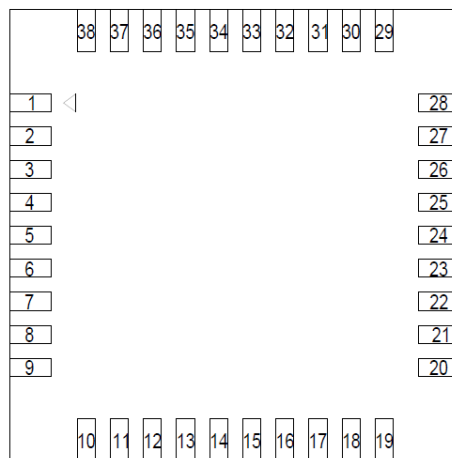


## 9. Land Pattern Drawing



Top View

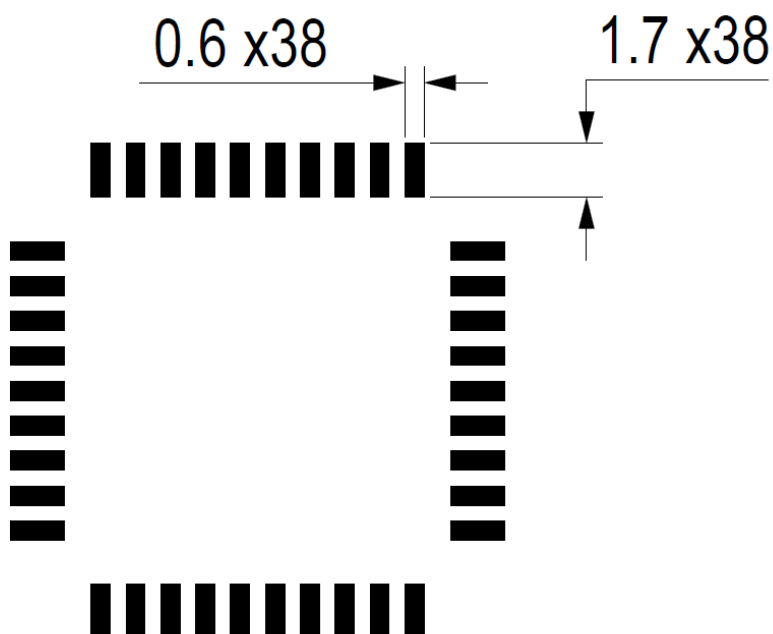
Unit : mm



Top View

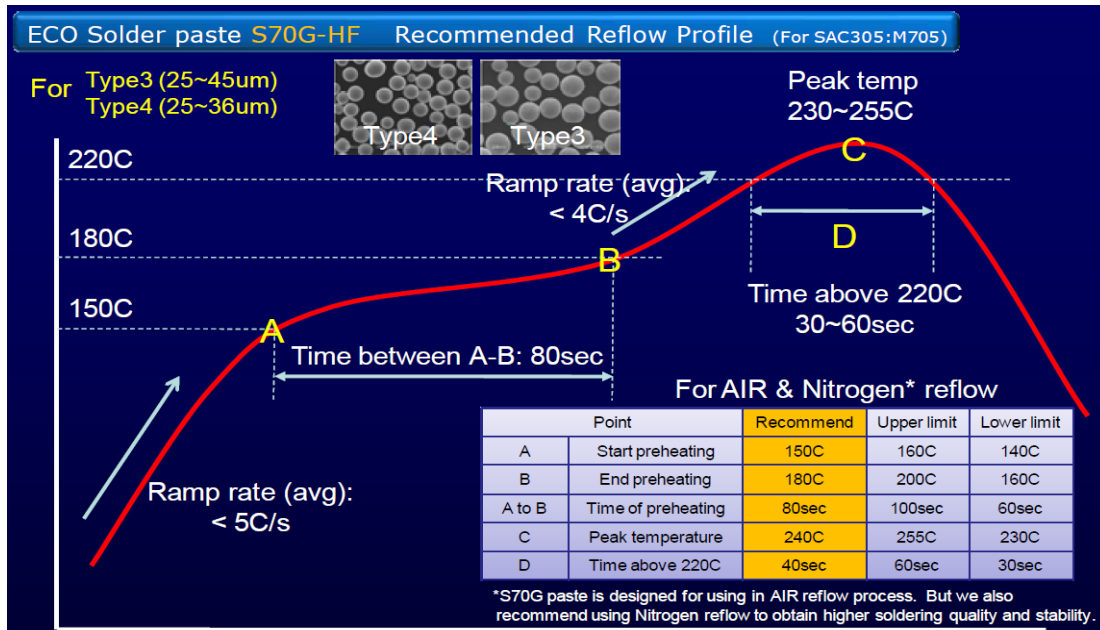
## 10. Stencil design Recommendations

The recommended aperture dimensions bellow is based on the stencil thickness 0.1mm. Please modify the aperture and thickness for real SMT situation.



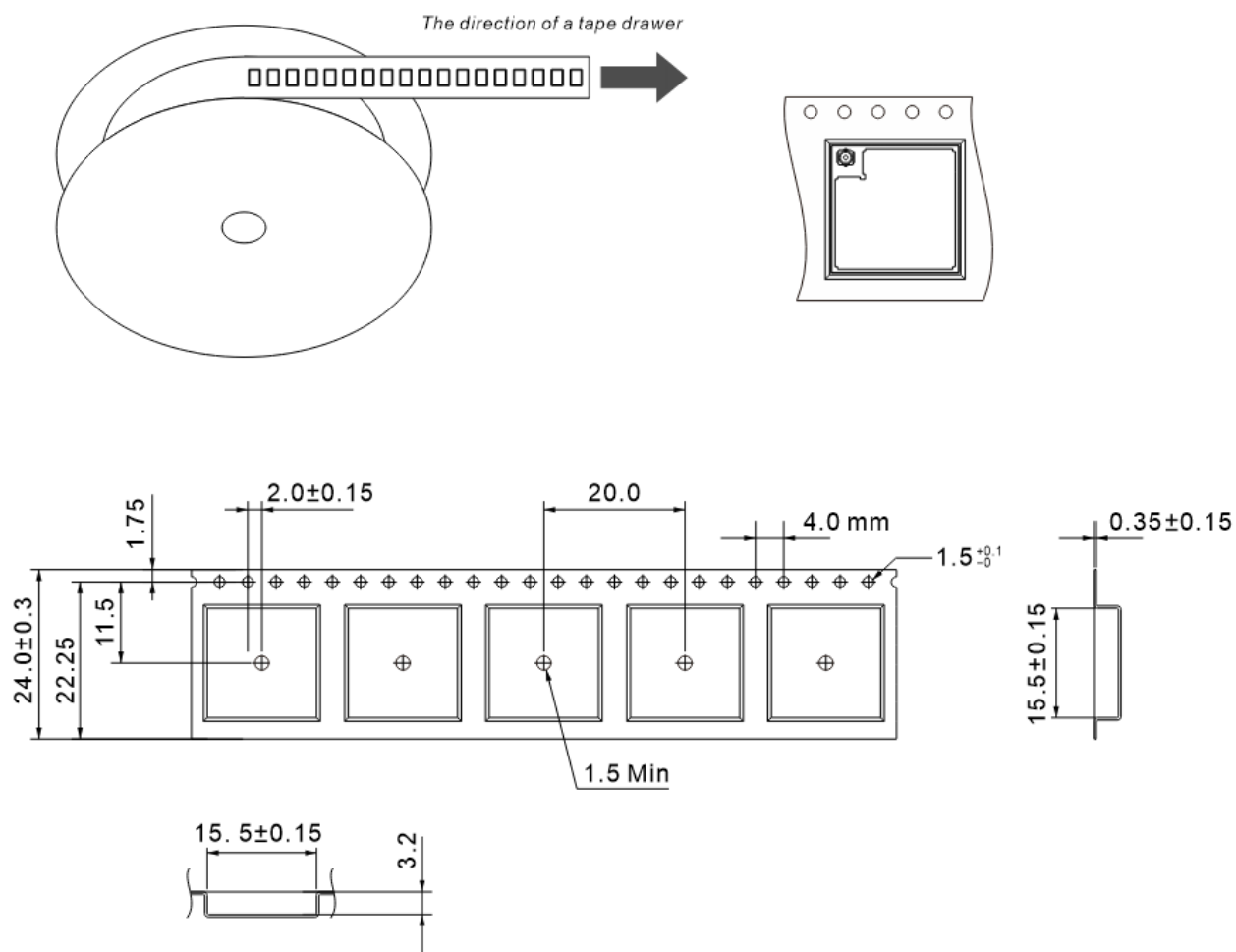
## 11. Reflow Thermal Profile Parameters

The following reflow profile is based on solder paste (Senju S70G-HF TYPE4) for reference only.



## 12. Packaging Information

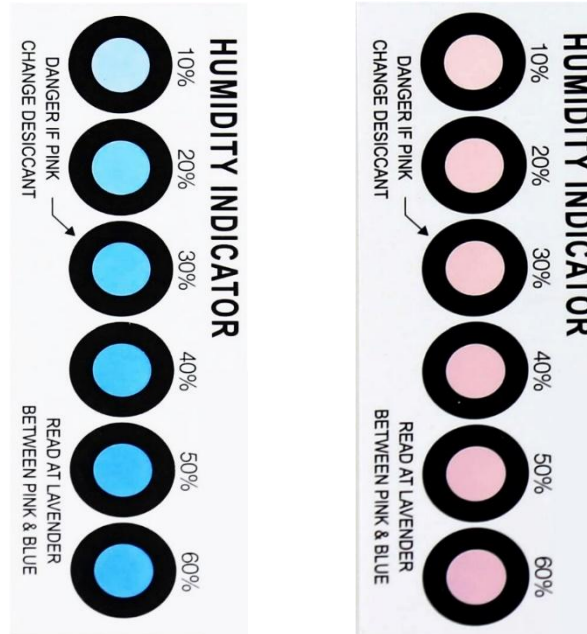
### Tape & Reel Packing



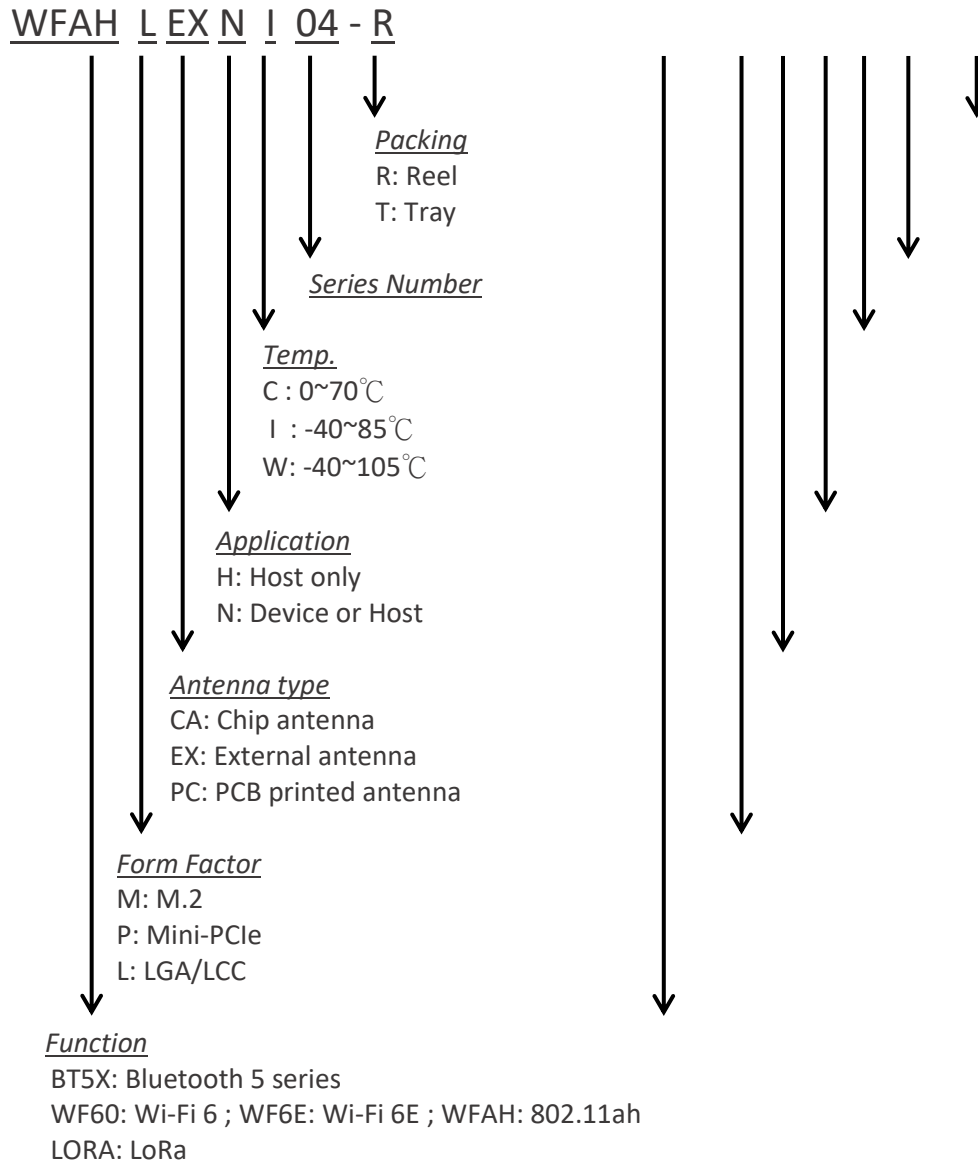
Reel packaging is 1000 pcs

### 13. Moisture Sensitive Level Information

The moisture sensitive level (MSL) of this module is rated as “3”. Before reflow soldering, please confirm the status of humidity indicator card and baking is required if humidity indicator card is not blue (>30%).



## 14. Part Number Definition



Order Code

| Model       | Reel          |
|-------------|---------------|
| WFAHLEXNI04 | WFAHLEXNI04-R |

## 15. Compliance

### Manufacturers Federal Communication Comm. Declaration of Conformity Statement

This equipment has been tested and found to comply with the limits for a **Class B** digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance **20cm** between the radiator & your body.

This module is certified pursuant to two Part 15 rules sections(**15.407, 15.247**).

The host product manufacturer must provide following statement in end-product manuals.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance **20cm** between the radiator & your body.

This module has been approved to operate with the antenna types **listed below**, with the maximum permissible gain indicated.

| Frequency Band | Antenna Type   | Model Number | Gain(dBi) |
|----------------|----------------|--------------|-----------|
| 902-928MHz     | Dipole Antenna | WFAHLEXNI04  | 0.8       |

#### Label of the end product:

The host product must be labeled in a visible area with the following " Contains FCC ID: **S7Q-S04** ".

The end product shall bear the following 15.19 statement: This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may

cause undesired operation.

Appropriate measurements (e.g. 15 B compliance) and if applicable additional equipment authorizations (e.g. SDoC) of the host product to be addressed by the integrator/manufacturer.

**Antenna Installation :**

To comply with FCC regulations, the antenna must be installed using a unique antenna connector to ensure compliance with FCC requirements.

**Industry Canada statement:**

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. L'appareil ne doit pas produire de brouillage;
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

**IC Radiation Exposure Statement:**

This equipment complies with IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance **20cm** between the radiator & your body.

*Cet équipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de **20cm** de distance entre la source de rayonnement et votre corps.*

OEM integrator is still responsible for testing their end product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

**Modular OEM Integrator Notice**

**End Product Labeling**

This transmitter module is authorized only for use in device where the antenna may be

installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: “Contains transmitter module IC: 31309-S04”.

*Contient le module d'émission IC: 31309-S04*

*The Host Model Number (HMN) must be indicated at any location on the exterior of the end product or product packaging or product literature which shall be available with the end product or online.*

IMPORTANT NOTE for OEM integrator:

This module is intended for OEM integrator.

The OEM integrator is still responsible for

1. ensuring that the end-user has no manual instructions to remove or install module
2. the ISED compliance requirement of the end product, which integrates this module.
3. Appropriate measurements and if applicable additional equipment authorizations of the host device to be addressed by the integrator/manufacturer.
4. The separate approval is required for all other operating configurations, including portable configurations and different antenna configurations

CAN ICES-3 (B)/NMB-3(B)

NCC 警語:

取得審驗證明之低功率射頻器材，非經核准，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。低功率射頻器材之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前述合法通信，指依電信管理法規定作業之無線電通信。低功率射頻器材須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。