MM6108-MF08651-US

IEEE 802.11ah Sub-1 GHz Wi-Fi HaLow Module

User Guide

Content

Product Overview

1.1.   Introduction

Morse Micro provides a complete Wi-Fi HaLow connectivity solution. The MM6108-MF08651-US is a fully integrated Wi-Fi HaLow® module with long-range, low-power consumption and superior RF performance, featuring the MM6108 Wi-Fi HaLow SoC.

The MM6108-MF08651-US module is designed in compliance with the IEEE 802.11ah standard, supporting data rates up to 32.5 Mbps with programmable operation between 850 MHz and 950 MHz.

This 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 security protocol.

Battery-operated applications are supported by a combination of features which are inherently supported by the module. The IEEE 802.11ah standard provides for extended sleep times for battery-operated Stations (STAs or client devices), with longer durations than other prior IEEE 802.11a/b/g/n/ac generations. It also allows longer extended maximum idle times for clients to conserve energy without being removed from the access point's (AP's) list of associated devices.

1.2. Features

Ultra-long-range, low-power Wi-Fi HaLow module for IoT Applications:

- Module Variants
  - MM6108-MF08651-US: 1/2/4/8 MHz channel bandwidth
- Single-stream max data rate of 32.5 Mbps @8MHz or 15 Mbps @4MHz channel.
- Radio supporting Sub-1 GHz frequency bands
  - Frequency Range: 902-928 MHz
  - Max output power: 21.5 dBm (Average power)
- 802.11ah OFDM PHY supporting WFA HaLow certification
  - BPSK & QPSK, 16-QAM & 64-QAM Modulation
  - Automatic frequency & gain control
  - Packet detect & channel equalization
  - Forward Error Correction (FEC) coding & decoding
  - Support for Modulation and Coding Scheme (MCS) rates MCS 0-7 and MCS 10
  - Support for 1 MHz and 2 MHz duplicate modes
  - Support for Traveling Pilots
- 802.11ah MAC supporting WFA HaLow certification
  - Support for STA and AP roles
  - Listen-Before-Talk (LBT) access with energy detect
  - 802.11 power save
  - 802.11 fragmentation and defragmentation
  - Power-Saving Target Wake Time (TWT) support for long battery life
  - Automatic and manual MCS rate selection
- Support for various interface options
  - SDIO 2.0 compliant host/slave interface
  - 2xUARTs
  - SPI Slave interface
  - I2C Master/Slave interface
  - 4-channel PWM
- Power Management Unit (PMU) for various modes of operation
  - Power-down (interrupt driven wake)
  - Hibernate mode (internal / external wake)
  - Target Wake Time mode
  - Active Receive / Transmit mode
  - Integrated DC-DC converter supports a wide supply voltages, from 3.0V to 3.6V
- Wide spectrum of Security features
  - AES encryption engine
  - Hardware support for SHA1 and SHA2 hash functions (SHA-256, SHA-384, SHA-512)
  - WPA3 including protected management frames (PMF)
  - Opportunistic Wireless Encryption (OWE)

1.3. Applications

For Internet of Things (IoT) and Machine-to-Machine (M2M) applications such as:

- Surveillance Cameras and Sensors
- Cloud Connectivity
- Low-power Sensor Networks
- Building Automation Systems (BAS)
- Asset Tracking and Management
- Machine Performance Monitors & Sensors
- Building Access Control & Security
- Drone Video and Navigation Communications
- Connected Toys and Games
- Rural Internet Access
- Agricultural and Farm Networks
- Utility Smart Meter and Intelligent Grid
- Proximity Sensors
- Industrial Automation Controls

- Smart Home Automation
- EV Car Chargers
- Appliances
- Construction Site Connectivity
- Smart Signs and Kiosks
- Retail Point-of-Sale Terminals
- Vehicle-to-Vehicle Communications
- IP Sensor Networks
- Biometric IDs and Keypads
- Warehouse Connectivity
- Intelligent Lighting Controls
- BT/ZigBee(™)/Z-Wave(™) to Wi-Fi HaLow Gateways
- Wi-Fi to Wi-Fi HaLow Bridges
- Wi-Fi HaLow Client Adapters/Dongles
- Smart City Networks

Morse Micro

2. Pin Descriptions

The MM6108-MF08651-US module has 38-pins, which are described in this section.
The following illustration shows the top view of the module pin Diagram.
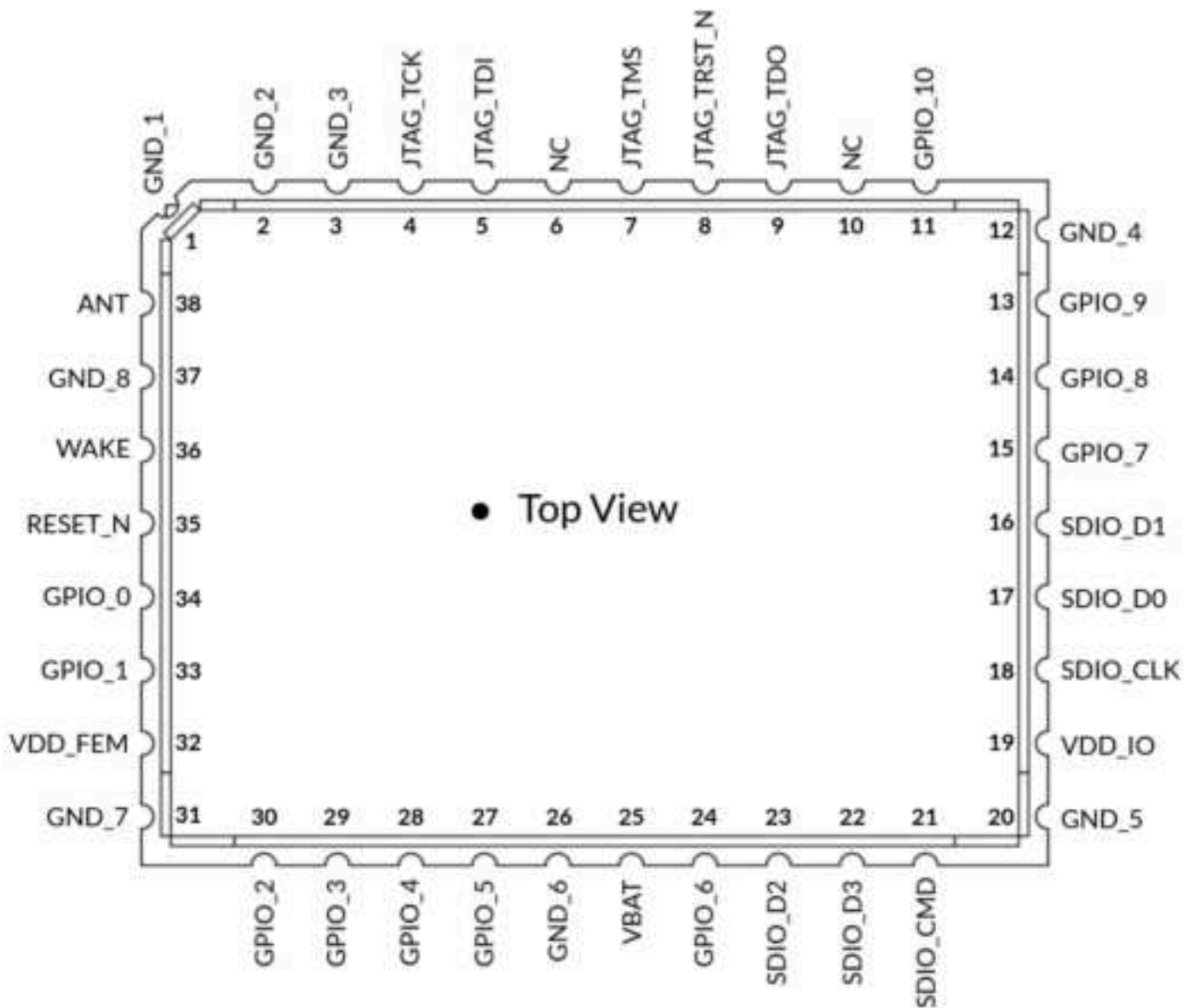
Figure 1: Pin Diagram

Table 2: Pin Description

Pin	Name	Type	Primary Function	Alternate & Other Function(s)
1	GND	Power	Ground	
2	GND	Power	Ground	
3	GND	Power	Ground	
4	JTAG_TCK[1]	I	JTAG Clock	
5	JTAG_TDI[1]	I	JTAG Data In	
6	NC	NC	Do Not Connect	
7	JTAG_TMS[1]	I	JTAG Mode Select	
8	JTAG_TRST	I	JTAG Reset	
9	JTAG_TDO[1]	O	JTAG Data Out	
10	NC	I/O	Do Not Connect	
11	GPIO10[2]	I/O	General Purpose IO10	
12	GND	Power	Ground	
13	GPIO9[2]	I/O	General Purpose IO9	
14	GPIO8[2]	I/O	General Purpose IO8	
15	GPIO7[2]	I/O	General Purpose IO7	UART1_TX
16	SDIO_D1[3]	I/O	SDIO D1	
17	SDIO_D0[3]	I/O	SDIO D0	
18	SDIO_CLK	I/O	SDIO Clock	
19	VDD_IO	Power	3.3V VDD_IO Supply	
20	GND	Power	Ground	
21	SDIO_CMD[3]	I/O	SDIO Command	
22	SDIO_D3[3]	I/O	SDIO D3	
23	SDIO_D2[3]	I/O	SDIO D2	
24	GPIO6[2]	I/O	General Purpose IO6	UART1_RX
25	VBAT	Power	3.3V VBAT Supply	
26	GND	Power	Ground	
27	GPIO5[2]	I/O	General Purpose IO5	I2C_SCL
28	GPIO4[2]	I/O	General Purpose IO4	I2C_SDA
29	GPIO3[2]	I/O	General Purpose IO3	UART0_TX, PWM1_3
30	GPIO2[2]	I/O	General Purpose IO2	UART0_RX, PWM1_2
31	GND	Power	Ground	
32	VDD_FEM	Power	3.3V Frontend Module Supply	
33	GPIO1[2]	I/O	General Purpose IO1	PWM1_1
34	GPIO0	I/O	WiFi BUSY	PWM1_0
35	RESET_N	I	System Reset	
36	WAKE	I	Wake	
37	GND	Power	Ground	
38	ANT	Analog	Antenna	
-	GND	Ground	Exposed ground pad - Connect to PCB GND	

[1] JTAG pins should be tied to GND via a 10k pull down resistor
[2] All unused GPIO should be tied to GND via a 10k pull down resistor
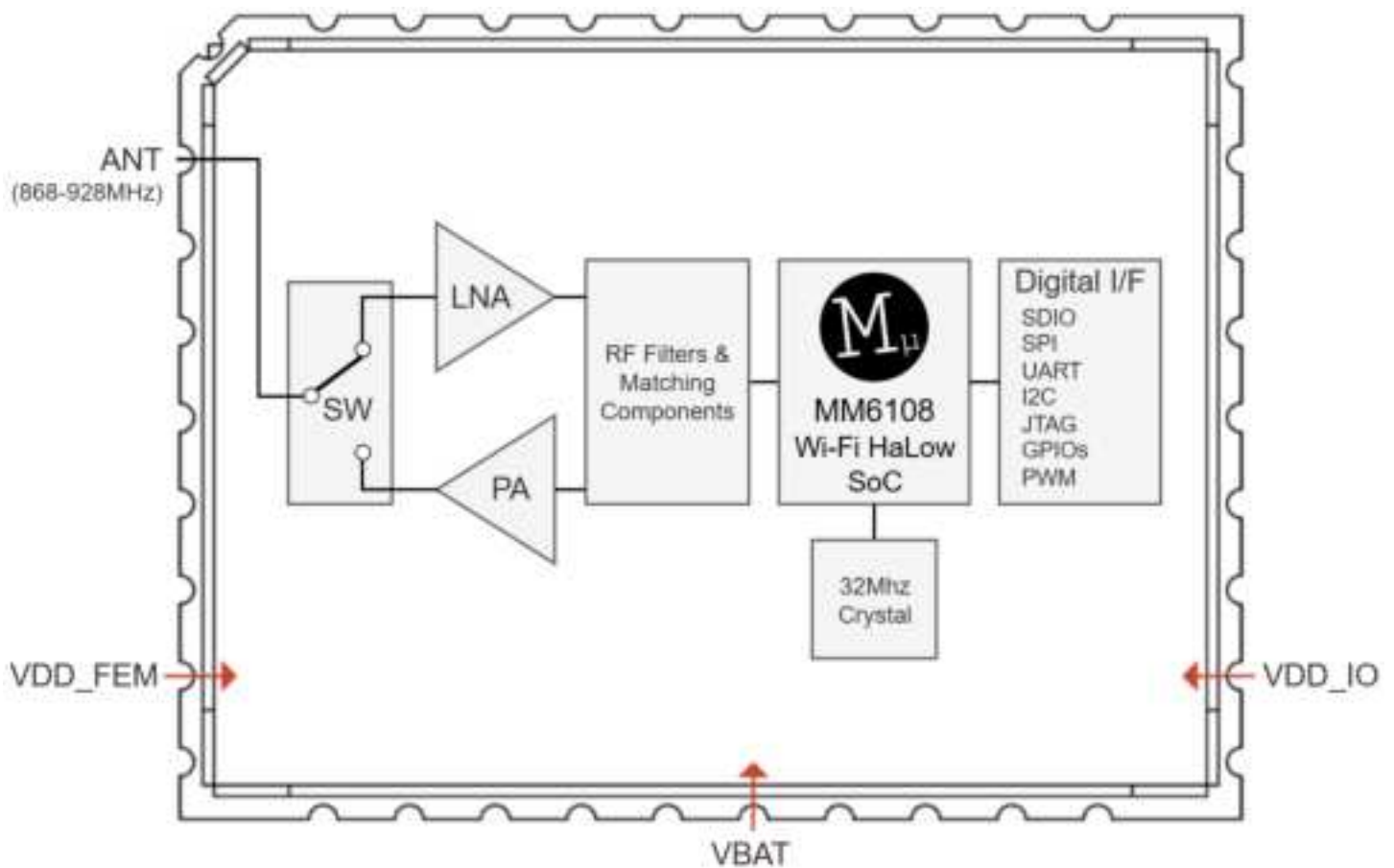[3] All SDIO bus pins should be pull up with a 10 … 100k resistor as per the the SDIO standard
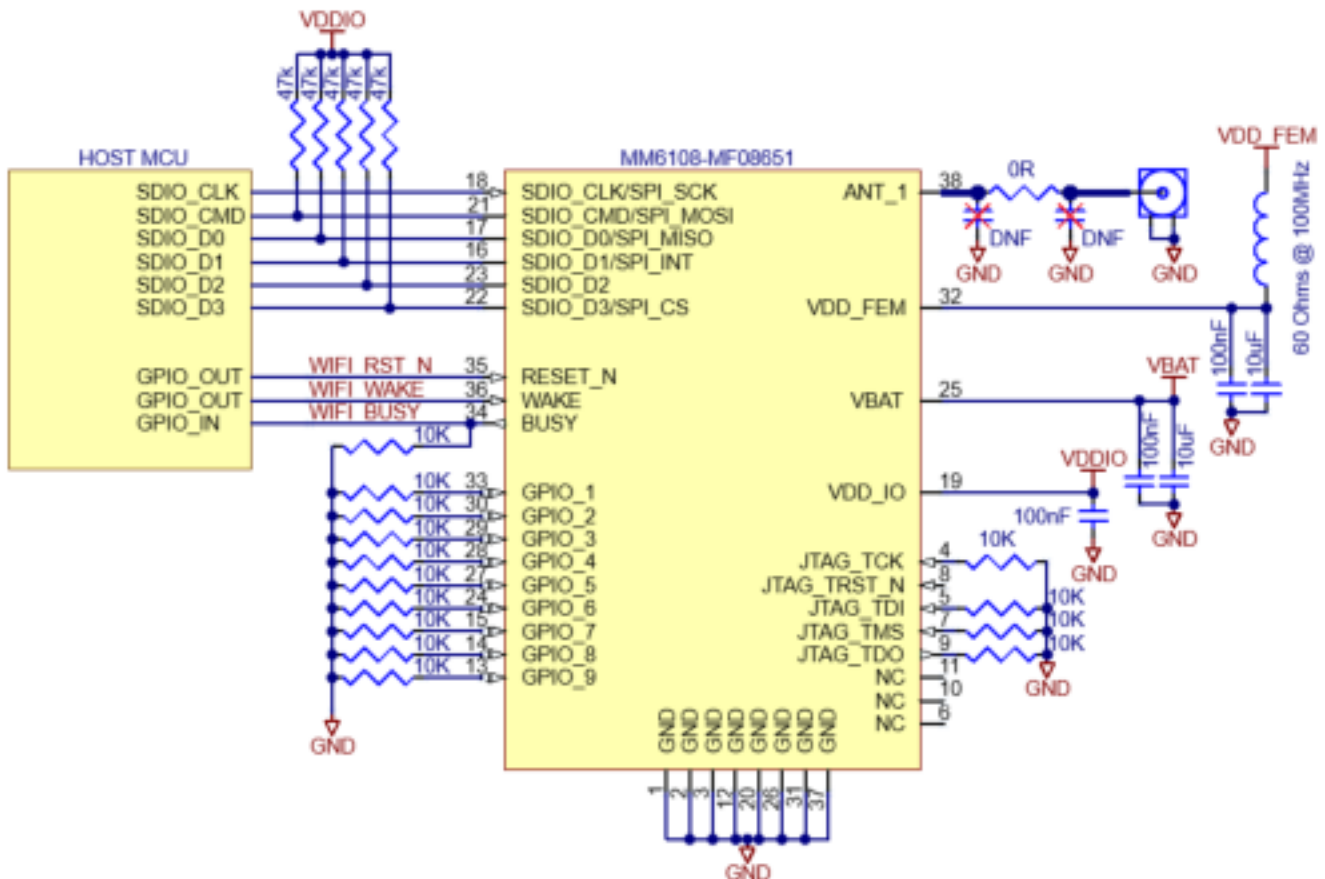
3. Functional Description

The following sections describe the functions of the MM6108-MF08651-US device.

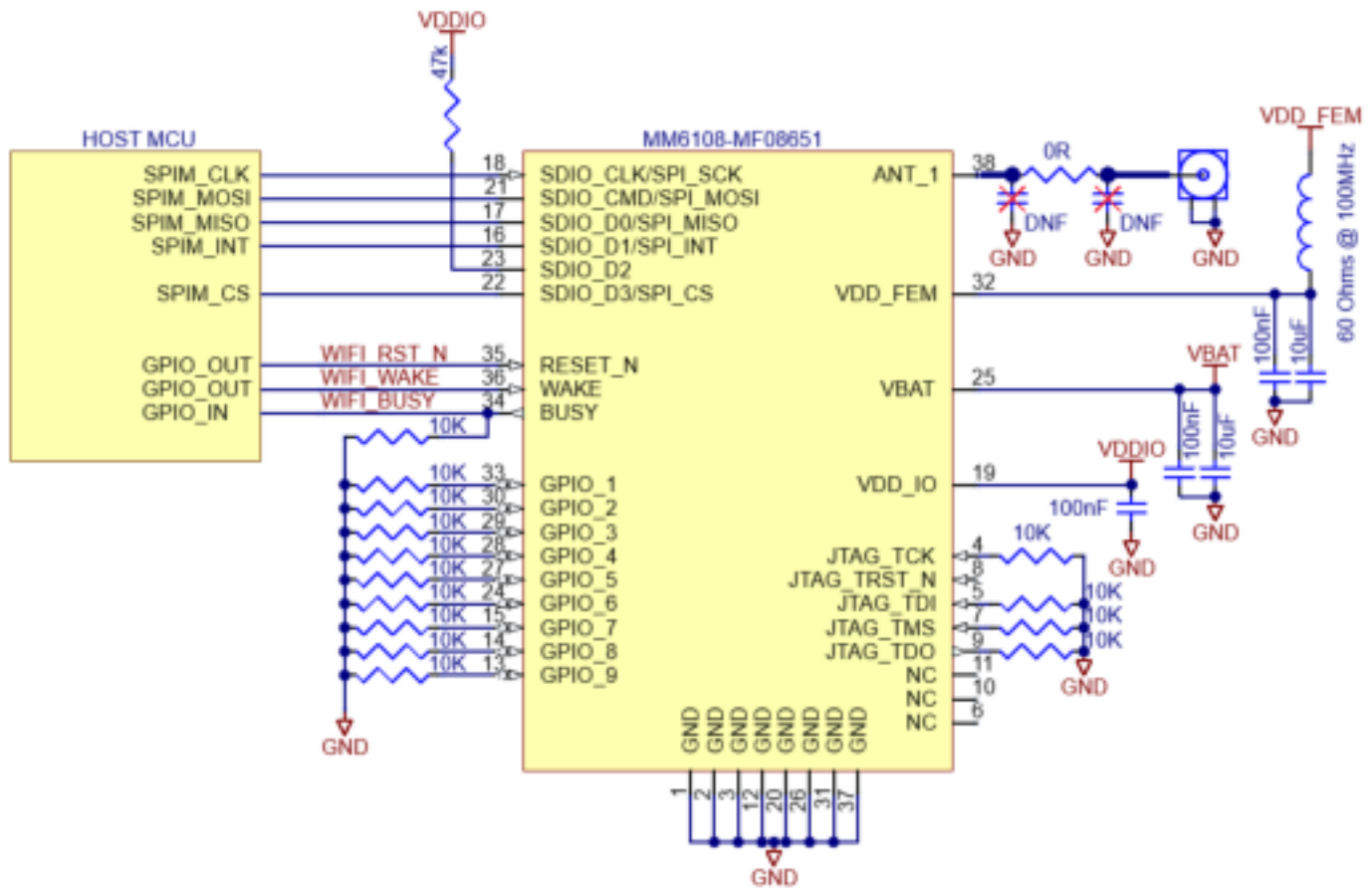## 3.1. Block Diagram

Figure 1: Block Diagram

3.2. Recommended Usage Schematics

SDIO Configuration

Morse Micro

SPI Configuration

3.3. General Layout Guidelines

In order to achieve optimal RF performance, the following steps should be followed:

1. Use a 50Ω impedance controlled trace from the antenna pin (38) and the antenna connection.
2. Use a solid ground plane under the RF trace and the module.
3. Ensure the ground fill is heavily stitched with vias round the RF traces.
4. Keep all power supply and digital signals away from the RF traces.
5. If an impedance matching circuit is needed, ensure that no RF stubs are created.
6. Keep the RF path short, smooth and near. Use large radius bends, never 90 degree bends.
7. Choose a pcb stackup so the RF trace width is close to the width of the matching component pads. This will minimize any impedance mismatch.
8. Do not use thermals on RF traces because of their high loss.

3.4. Power Management

Module power is derived from a 3.0 to 3.6V supply provided on pin VBAT. A 3.3V supply is provided on pin VDD_FEM to power the on-board ultra-long-range PA.

VDDIO sets the IO voltage of the MM6108 and should be connected to the same power supply as the host MCU.

3.5. 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.

Please refer to the MM6108 chip datasheets for a description of the supported peripheral interfaces.

4.   Electrical Characteristics

4.1.   Absolute Max ratings

Stress beyond absolute maximum ratings may cause permanent damage to the module. Functional operation is guaranteed for recommended operation conditions only. Operation of the device outside of recommended conditions may result in reduced lifetime and/or reliability problems even if the absolute maximum ratings are not exceeded.

Parameter	Min	Max	Unit
VBAT voltage	-0.3	4.3	V
VDD_FEM voltage	-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
Storage Temperature	-40	125	°C
RF Input Power (CW)	-	6	dBm

4.2.   Immunity

Parameter			Min	Max	Unit
Electrostatic discharge (ESD) performance	Human body model (HBM), per ANSI / ESDA / JEDEC JS001	All pins	TBD	TBD	V
	Charged device model (CDM), per JESD22-C101	All pins	TBD	TBD	V

4.3.   Recommended Operating Conditions

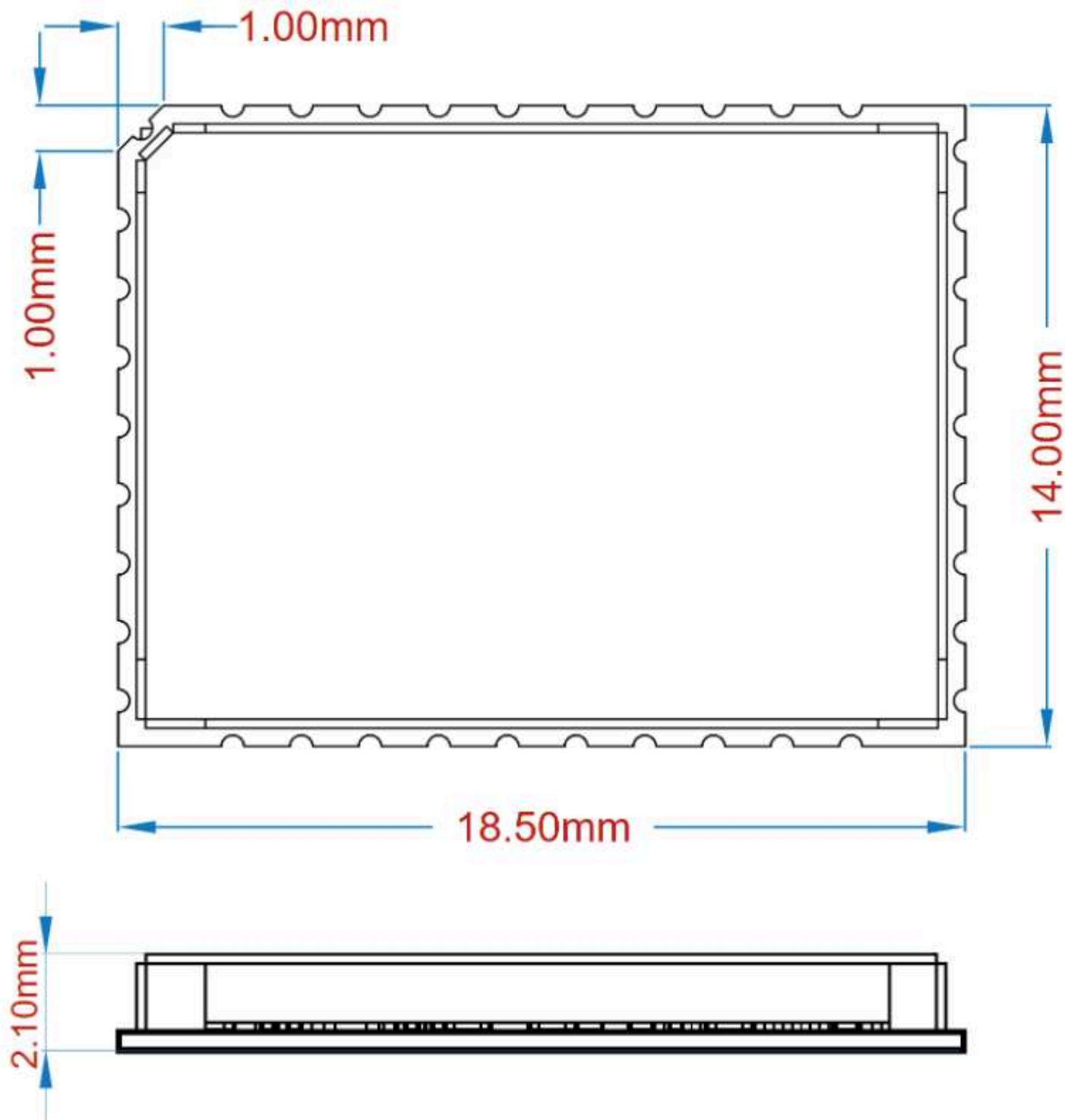| Parameter	Min	Typ	Max	Unit
Ambient Temperature	-40	27	85	°C
VBAT	3.0	3.3	3.6	V
VDD_FEM	3.0	3.3	3.6	V
VDD_{IO}[a]	1.8	3.3	3.6	V
Digital I/O voltage	0	3.3	VDD_{IO}	V

a. VDD_{IO} should not exceed VBAT

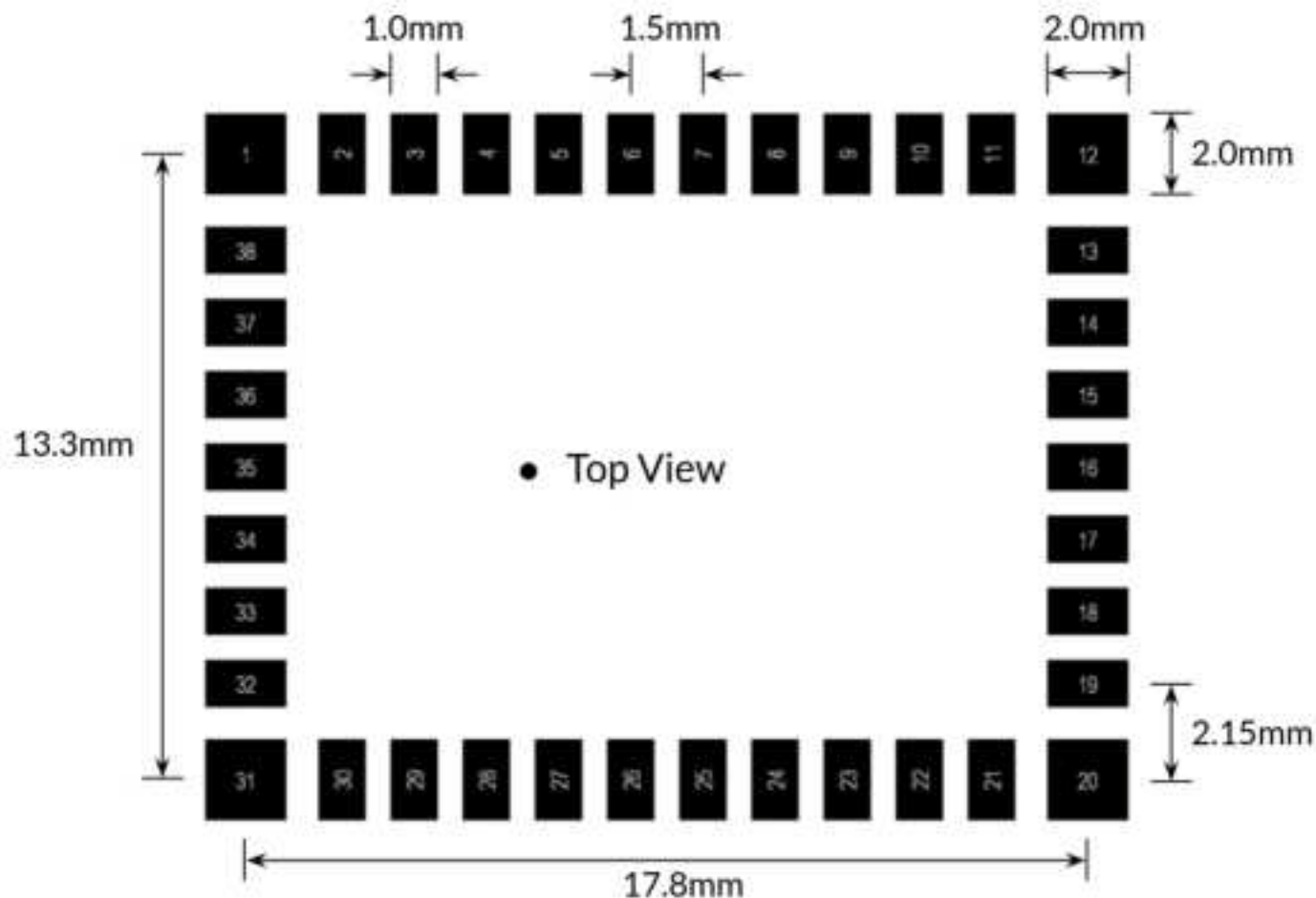Performance specifications are achieved under typical operating conditions, unless otherwise specified.

Morse Micro

4.4. Physical Specification

5. Recommended PCB Footprint

6. Certification

6.1. FCC

Federal Communication Commission Interference 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 use is encouraged to try to correct the interference by one 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.

FCC Radiation Exposure Statement:

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

IMPORTANT NOTE:

This module has been tested and found to comply with the following requirements for Modular Approval.

● Part 15.247 - Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

RF exposure considerations

In the end product, the antenna(s) used with this transmitter must be installed to provide a separation distance of at least 20cm from all persons and must not be co-located or operation in conjunction with any other antenna or transmitter except in accordance with multi-transmitter product procedures. User and installers must be provided with antenna installation instructions and transmitter operating conditions for satisfying the RF exposure compliance.

Antennas

This radio transmitter has been approved by the FCC and ISED to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Antennes

Cet émetteur radio a été approuvé par la FCC et ISED pour fonctionner avec les types d'antennes répertoriés ci-dessous avec le gain maximal autorisé indiqué. Les types d'antennes non inclus dans cette liste, ayant un gain supérieur au gain maximum indiqué pour ce type, sont strictement interdits pour une utilisation avec cet appareil.

Radio	Antenna Type	Freq. (MHz)	Peak Antenna Gain (dBi)
802.11 ah	Dipole Antenna	902-928	1.00

Required End Product Labeling

Any device incorporating this module must include an external, visible, permanent marking or label which states: "Contains FCC ID: 2A74O-628C73"

Test Modes

This device uses various test mode programs for test set up which operate separate from production firmware. Host integrators should contact the grantee for assistance with test modes needed for module/host compliance test requirements.

Additional testing, Part 15 Subpart B disclaimer

The modular transmitter is only FCC authorized for the specific rule parts (i.e. FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification.

The final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

EMI Considerations

Note that a host manufacture is recommended to use KDB996369 D04 Module Integration Guide recommending as "best practice" RF design engineering testing and evaluation in case non-linear interactions generate additional non-compliant limits due to module placement to host components or properties.

For standalone mode, reference the guidance in KDB996369 D04 Module Integration Guide and for simultaneous mode; see KDB996369 D02 Module Q&A Question 12, which permits the host manufacturer to confirm compliance.

How to make changes

Only Grantees are permitted to make permissive changes, if the module will be used differently than granted conditions, please contact us to ensure modifications will not affect compliance.

Antenna Trace Design

The modular transmitter is configured for monostatic operation, which requires only a single RF I/O pin for full duplex communication. The output must be routed to the antenna via 50 ohm microstrip or stripline on the OEM PCB. No coupling capacitor is required given that the RF pin is AC-coupled internally.
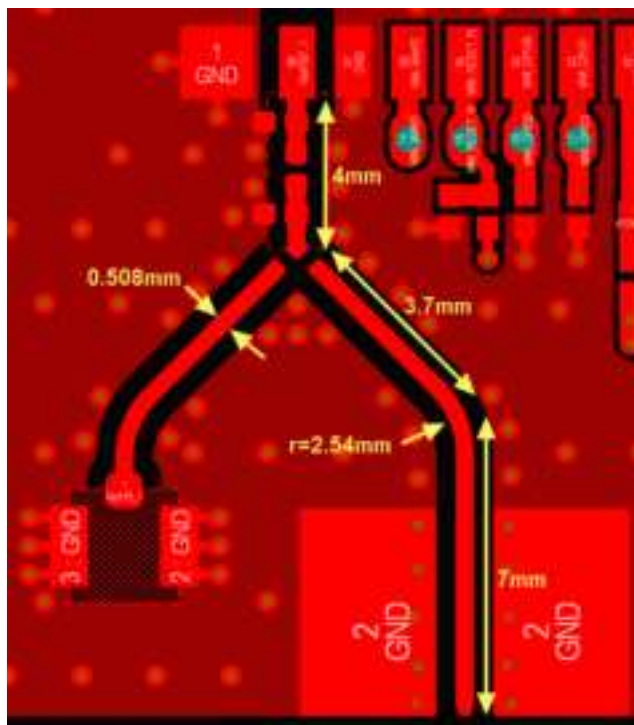
Length: 15mm
Width: 0.508mm
Thickness: 1.6mm
Type of trace: 1/2oz
Dielectric constant: 4.3
Antenna connector: RP-SMA

The trace from Pin No. 38 to antenna connector on the OEM PCB must be maintained identical as the above specification with RP-SMA connector. Only trace designs approved with an original grant or through permissive change can be used by an OEM, any changes are deemed as antenna type change and should be reviewed to ensure compliance with the FCC and ISED requirements.

Verification must be conducted and the results shall not exceed below ranges to ensure identical antenna design is applied to subsequent integration and end product production.

Impedance 50 ohm +/- 10%
Max power is 21.5dBm (Average power)
VSWR absolute max ≤ 10:1 (limit to avoid permanent damage)
VSWR recommended ≤ 1.92:1 (limit to fulfill all regulatory requirements)

Test procedure of verification
1. Set module device in support transmission mode.
2. Verify RF power through conducted measurement at balanced impedance of 50ohms, the KDB 971168 D01 Power Meas License Digital System shall be used as the supplemental test methodology to adjust the proper setting obtaining the measurement results.
3. Verify the Tx power in the datasheet, and compliance test reports.

6.2. IC

Industry Canada Statement
This device contains license-exempt transmitter(s) / receiver(s) that comply with Innovation, Science and Economic Development Canada's license-exempt RSS(s).

Operation is subject to the following two conditions:
1. This device may not cause interference, and
2. This device must accept any interference, including interference that may cause undesired operation of the device.

This device contains license-exempt transmitter(s) / receiver(s) that comply with Innovation, Science and Economic Development Canada's license-exempt RSS(s).

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, et
2. L'utilisateur de l'appareil doit accepter tout brouillage radioelectrique subi, meme si le brouillage est susceptible d'en compromettre le fonctionnement.

Caution: Exposure to Radio Frequency Radiation
1. To comply with the Canadian RF exposure compliance requirements, this device and its antenna must not be co-located or operating in conjunction with any other antenna or transmitter.
2. To comply with RSS 102 RF exposure compliance requirements, a separation distance of at least 20 cm must be maintained between the antenna of this device and all persons.

Attention: exposition au rayonnement radiofréquence
1. Pour se conformer aux exigences de conformité RF canadienne l'exposition, cet appareil et son antenne ne doivent pas être co-localisés ou fonctionnant en conjonction avec une autre antenne ou transmetteur.
2. Pour se conformer aux exigences de conformité CNR 102 RF exposition, une distance de séparation d'au moins 20 cm doit être maintenue entre l'antenne de cet appareil et toutes les personnes

Antennas
This radio transmitter has been approved by the ISED to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Antennes
Cet émetteur radio a été approuvé par la ISED pour fonctionner avec les types d'antennes répertoriés ci-dessous avec le gain maximal autorisé indiqué. Les types d'antennes non inclus dans cette liste, ayant un gain supérieur au gain maximum indiqué pour ce type, sont strictement interdits pour une utilisation avec cet appareil.

Radio	Antenna Type	Freq. (MHz)	Peak Antenna Gain (dBi)
802.11 ah	Dipole Antenna	902-928	1.00

Required End Product Labeling
Any device incorporating this module must include an external, visible, permanent marking or label which states: "Contains IC : 29791-628C73"

Obligation d'étiquetage du produit final:
Tout dispositif intégrant ce module doit comporter un externe, visible, marquage permanent ou une étiquette qui dit: "Contient IC : 29791-628C73"

RF exposure considerations

In the end product, the antenna(s) used with this transmitter must be installed to provide a separation distance of at least 20cm from all persons and must not be co-located or operation in conjunction with any other antenna or transmitter except in accordance with multi-transmitter product procedures. User and installers must be provided with antenna installation instructions and transmitter operating conditions for satisfying the RF exposure compliance.

7. Part Number and Ordering Information

7.1. Part Ordering Information

Part Number	Packing Type	Pins	Size (mm)	Description
MM6108-MF08651-US	Tray	38	14.0 x 18.5 x 2.1	IEEE 802.11ah Sub-1 GHz 1/2/4/8 MHz Wi-Fi HaLow Module

8. Handling and Storage

The MM6108-MF08651-US class of modules are a moisture sensitive device rated at Moisture Sensitive Level 3 (MSL3) per IPC/JEDEC J-STD-20.

After opening the moisture sealed storage bag, modules that will be subjected to reflow solder or other high temperature processes must be:

1. Mounted to a circuit board within 168 hours at factory conditions (≤30°C and <60% RH) OR
2. Continuously stored per IPC/JEDEC J-STD-033

Modules that have been exposed to moisture and environmental conditions exceeding packaging and storage conditions MUST be baked before mounting according to IPC/JEDEC J-STD-033. Failure to meet packaging and storage conditions will result in irreparable damage to modules during solder reflow.

9. Revision History

MM6108-MF08651-US UG100; 2nd November, 2023

- Initial release

Morse Micro Pty. Ltd. Corporate Headquarters
Level 8, 10-14 Waterloo Street, Surry Hills, NSW 2010,
AUSTRALIA

Morse Micro Inc. – USA
40 Waterworks Way
Irvine, CA 92618, UNITED STATES

Morse Micro – China
Floor 7, Room 08-210, Wework office 292 Yan'an Rd,
Shangcheng District, Hangzhou 310003

USA: +1.949.501.7080
Australia: +61.02.905.45922
China: +86.571.229.30277
Email: sales@morsemicro.com
www.morsemicro.com

Morse Micro makes no warranty, representation, or guarantee regarding the information contained herein or the suitability of its products and services for any particular purpose, nor does Morse Micro assume any liability whatsoever arising out of the application or use of any product or circuit. The products sold hereunder and any other products sold by Morse Micro have been subject to limited testing and should not be used in conjunction with mission-critical equipment or applications. Any performance specifications are believed to be reliable but are not verified, and Buyer must conduct and complete all performance and other testing of the products, alone and together with, or installed in, any end-products. Buyer shall not rely on any data and performance specifications or parameters provided by Morse Micro. It is the Buyer's responsibility to independently determine suitability of any products and to test and verify the same. The information provided by Morse Micro hereunder is provided "as is, where is" and with all faults, and the entire risk associated with such information is entirely with the Buyer. Morse Micro does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other IP rights, whether with regard to such information itself or anything described by such information. Information provided in this document is proprietary to Morse Micro, and Morse Micro reserves the right to make any changes to the information in this document or to any products and services at any time without notice.

About Morse Micro

Morse Micro is producing IEEE 802.11ah / Wi-Fi HaLow solutions for Internet of Things (IOT) - based on a newly certified Wi-Fi standard called HaLow. Morse Micro is a VC-backed Startup headquartered in Sydney, Australia. Learn more at www.morsemicro.com