



MM6108-MF16858

Data Sheet

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



Table of Contents

Table of Contents	2
1 Product Overview	3
1.1 Introduction	4
1.2 Features	4
1.3 Applications	5
2 Pin Descriptions	6
3 Functional Description	9
3.1 Block diagram	10
3.2 Power supply requirements	10
3.3 SDIO host requirements	11
3.4 SPI host requirements	12
3.5 Digital interfaces	12
3.6 Sleep/Wake Sequencing	12
3.6.1 Host initiates wake sequence	13
3.6.2 MM6108-MF16858 initiates wake sequence with host interface disabled	13
3.6.3 MM6108-MF16858 initiates communication with host interface enabled	14
4 Electrical Characteristics	16
4.1 Absolute max ratings	16
4.2 Recommended operating conditions	16
5 Physical Dimensions	16
6 Recommended PCB Footprint	17
7 Certification	18
7.1 FCC	19
7.2 IC	22
8 Part Numbers and Ordering Information	23
9 Handling and Storage	24
10 Revision History	24

1 Product Overview

1.1 Introduction

Morse Micro provides a complete Wi-Fi HaLow connectivity solution. The MM6108-MF16858 is a fully integrated Wi-Fi HaLow® module featuring the MM6108 Wi-Fi HaLow SoC. It offers long-range, low-power consumption, and superior RF performance.

The MM6108-MF16858 module is designed in compliance with the IEEE 802.11ah standard. It supports data rates up to 32.5 Mbps and has programmable operation between 902 MHz and 928 MHz.

This module includes an ultra-long-reach PA, a high linearity LNA, a SAW filter, a T/R switch, and a 32 MHz crystal oscillator. It has been designed for a simplified Wi-Fi HaLow connection to an external host for applications where customers want to replace their prior RF technology with a Wi-Fi HaLow connection while using the latest WPA3 security protocol.

1.2 Features

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

- Channel bandwidth options of 1/2/4/8 MHz
- Single-stream max. data rate of 32.5 Mbps @ 8 MHz or 15 Mbps @ 4 MHz channel
- Radio supporting Sub-1 GHz frequency bands
 - Frequency range: 902-928 MHz
 - Max output power: 29 dBm
- 802.11ah OFDM PHY supporting WFA HaLow certification
 - BPSK & QPSK, 16-QAM & 64-QAM Modulation
 - Automatic frequency and gain control
 - Packet detect and channel equalization
 - Forward Error Correction (FEC) coding and 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 and Short Guard Intervals
- 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
 - Packet aggregation
 - Power-Saving Target Wake Time (TWT) support for long battery life
 - Restricted Access Window (RAW)
 - Automatic and manual MCS rate selection
- Support for various interface options
 - SDIO 2.0 compliant host/slave interface
 - 2 x UARTs
- Power Management Unit (PMU) for various modes of operation
 - Power-down (interrupt driven wake)
 - Hibernate mode (internal / external wake)
 - Active receive / transmit mode
 - Integrated DC-DC converter supporting a voltage supply 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

The MM6108-MF16858 is ideally suited 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 and sensors
- Building access control and 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 or
Vehicle-to-Infrastructure 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

2 Pin Descriptions

The MM6108-MF16858 module has 38 pins, which are described in this section. The following illustration shows the top view of the module pins.

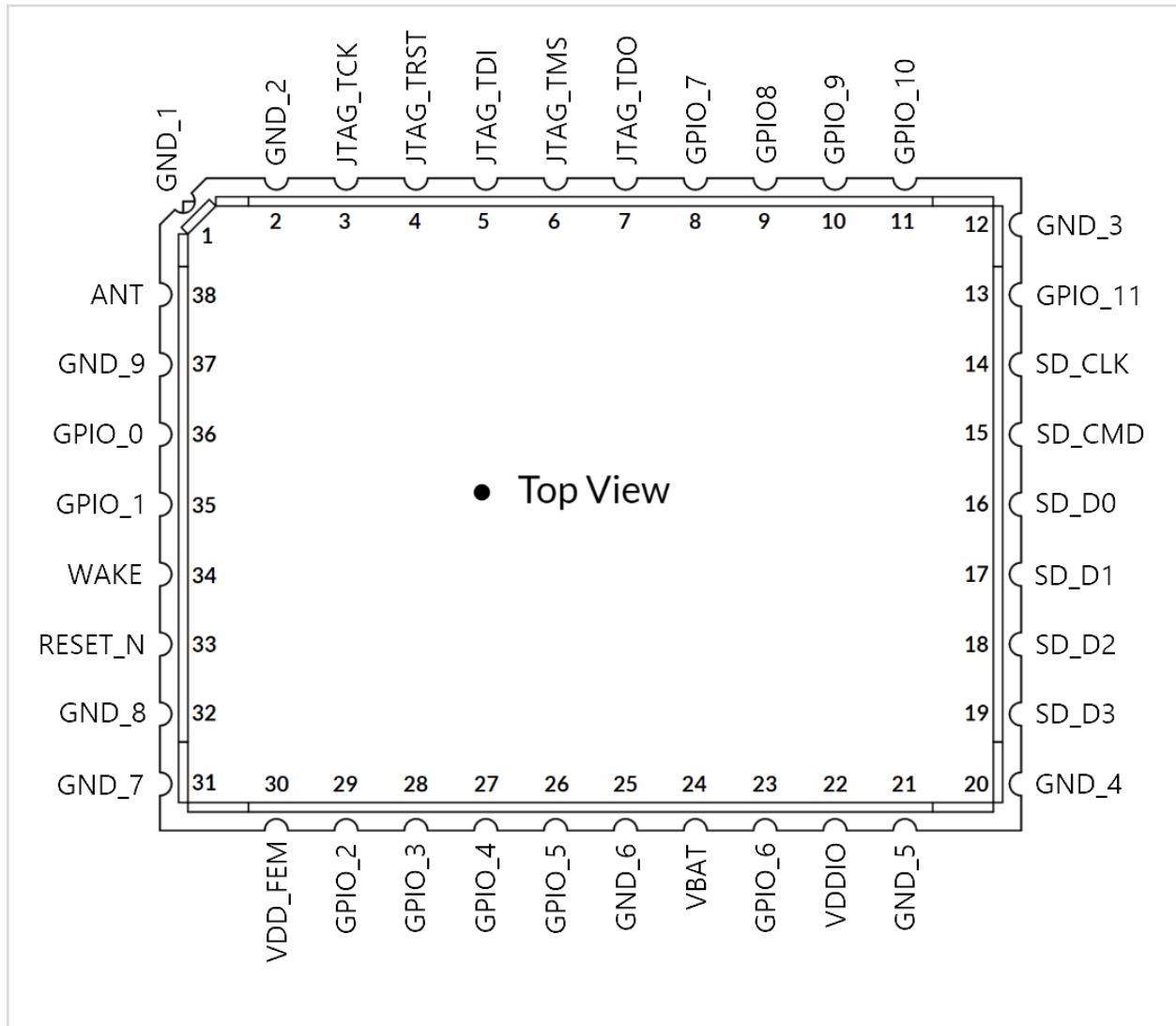


Figure 1: Pin diagram

Pin	Pin Name	Type	Description	Alternate
1	GND	Power	Ground	
2	GND	Power	Ground	
3	JTAG_TCK	I	JTAG Clock	
4	JTAG_TRST_N	I	JTAG Reset	
5	JTAG_TDI ^[1]	I	JTAG Data In	
6	JTAG_TMS ^[1]	I	JTAG Mode Select	
7	JTAG_TDO ^[1]	O	JTAG Data Out	
8	GPIO_7 ^[2]	I/O	General Purpose IO7	
9	GPIO_8 ^[2]	I/O	General Purpose IO8	
10	GPIO_9 ^[2]	I/O	General Purpose IO9	
11	GPIO_10 ^[2]	I/O	General Purpose IO10	
12	GND	Power	Ground	
13	GPIO_11 ^[2]	I/O	General Purpose IO11	
14	SDIO_CLK	I/O	SDIO Clock	
15	SDIO_CMD ^[3]	I/O	SDIO Command	SPI_MOSI
16	SDIO_D0 ^[3]	I/O	SDIO D0	
17	SDIO_D1 ^[3]	I/O	SDIO D1	
18	SDIO_D2 ^[3]	I/O	SDIO D2	
19	SDIO_D3 ^[3]	I/O	SDIO D3	SPI_CS
20	GND	Power	Ground	
21	GND	Power	Ground	
22	VDD_IO	I/O	3.3V VDD_IO Supply	
23	GPIO_6 ^[2]	I/O	General Purpose IO6	
24	VBAT	Power	3.3V VBAT Supply	
25	GND	Power	Ground	
26	GPIO_5 ^[2]	I/O	General Purpose IO5	
27	GPIO_4 ^[2]	I/O	General Purpose IO4	
28	GPIO_3 ^[2]	I/O	General Purpose IO3	
29	GPIO_2 ^[2]	I/O	General Purpose IO2	
30	VDD_FEM	Power	3.3V Frontend Module Supply	
31	GND	Power	Ground	
32	GND	Power	Ground	
33	RESET_N ^[4]	I	System Reset	
34	WAKE ^[4]	I	Wake	
35	GPIO_1 ^[2]	I/O	General Purpose IO1	
36	GPIO_0 ^[2]	I/O	General Purpose IO0	
37	GND	Power	Ground	
38	ANT	Analog	Antenna	

Pin	Pin Name	Type	Description	Alternate
-	GND	Ground	Exposed ground - 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 except SDIO_CLK should be pulled up with a 10k-100k resistor as per the the SDIO standard

[4] Supplied from VBAT domain. Other digital pins are driven by the VDDIO domain.

3 Functional Description

The following sections describe the functions of the MM6108-MF16858 module.

3.1 Block diagram

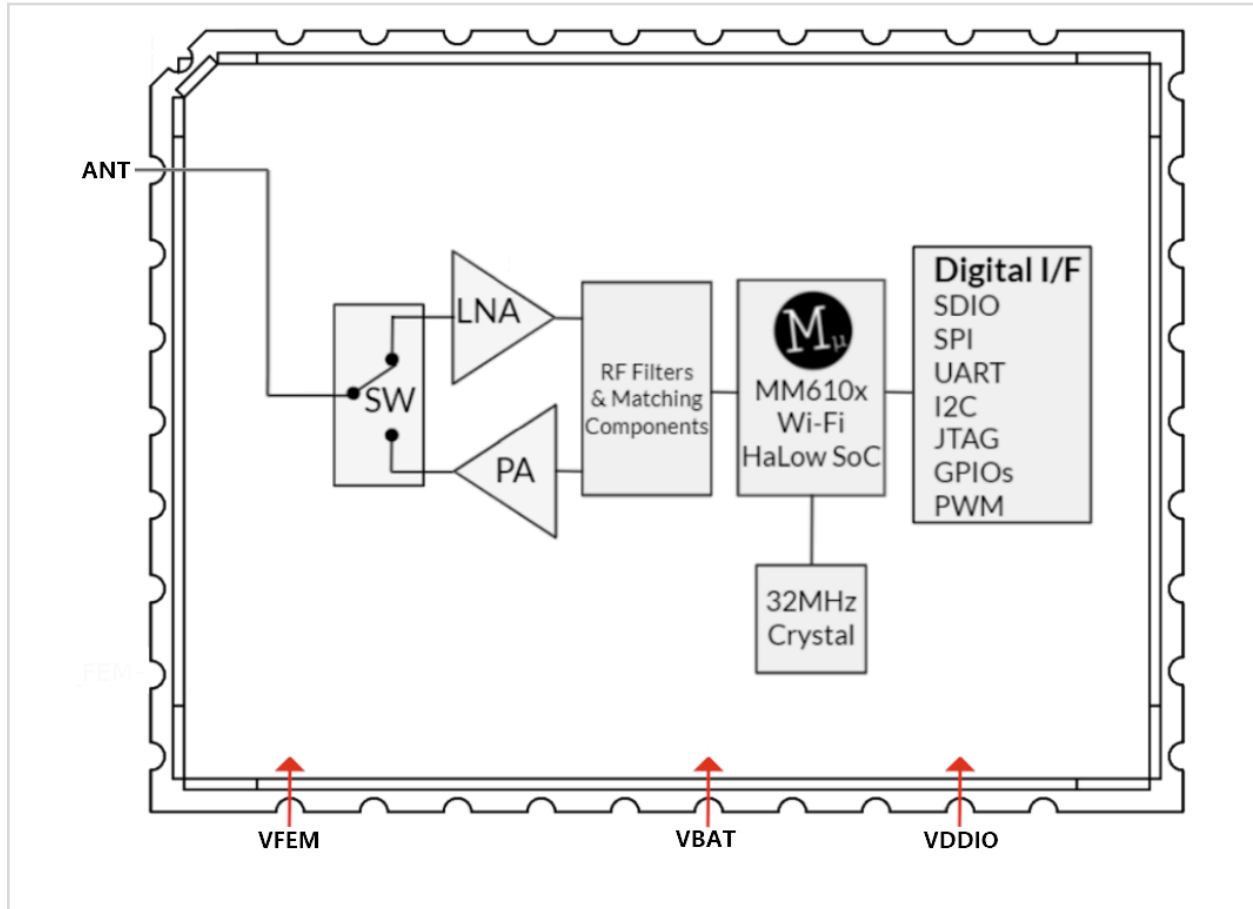


Figure 2: Functional Block Diagram

3.2 Power supply requirements

MM6108-MF16858 module power is derived from a 3.0 to 3.6 V supply on the VBAT pin and a 5.0 V supply on the VDD_FEM pin. VBAT powers the module's internal circuitry, while VDD_FEM powers the onboard ultra-long-range power amplifier.

VDDIO sets the IO voltage of the MM6108, which should be connected to the same power supply as the host MCU. The VDDIO voltage must be between 1.62V and 3.6V and must not exceed the voltage applied to VBAT.

3.3 SDIO host requirements

When selecting a CPU host to interface with the MM8108-MF16858 module via the SDIO interface, ensure the host supports SDIO 2.0 with SDIO clock speeds of up to 50 MHz. Slower clock speeds will impact the maximum achievable throughput.

The SDIO data and command lines should be pulled up with 10k-100k resistors per the SDIO 2.0 specification.

Most applications will benefit from the module's power-saving features. Two GPIOs, set as CMOS outputs, are required to drive the RESET and WAKE signals. A third GPIO, set as a CMOS input, is needed to receive the BUSY signal from the module.

In applications where the module must always be on, and the power-saving features can not be used, such as access points, the WAKE pin can be fixed to VBAT, reducing the need for GPIOs on the host processor to only one.

3.4 SPI host requirements

When selecting a CPU host to interface via SPI to the MM6108-MF16858 module, consider the following recommendations to achieve the best throughput:

- The host should support level-triggered interrupts.
- The host should support full-duplex SPI mode.
- The host should support DMA-backed transactions on the SPI bus.

Standard SPI can achieve up to 25 Mbps at 50 MHz, but this will be significantly reduced without DMA support. For example, an SPI interface with an 8-byte buffer per transaction might only achieve 2 Mbps throughput on the SPI bus.

Most applications will benefit from the module's power-saving features. Two GPIOs, set as CMOS outputs, are required to drive the RESET and WAKE signals. A third GPIO, set as a CMOS input, is needed to receive the BUSY signal from the module.

In applications where the module must always be on, and the power-saving features can not be used, such as access points, the WAKE pin can be fixed to VBAT, reducing the need for GPIOs on the host processor to only one.

3.5 Digital interfaces

All unused digital IO pins must be pulled up or down to prevent floating pins. Failure to do so will result in a higher leakage current on the VDDIO supply.

3.6 Sleep/Wake Sequencing

3.6.1 Host initiates wake sequence

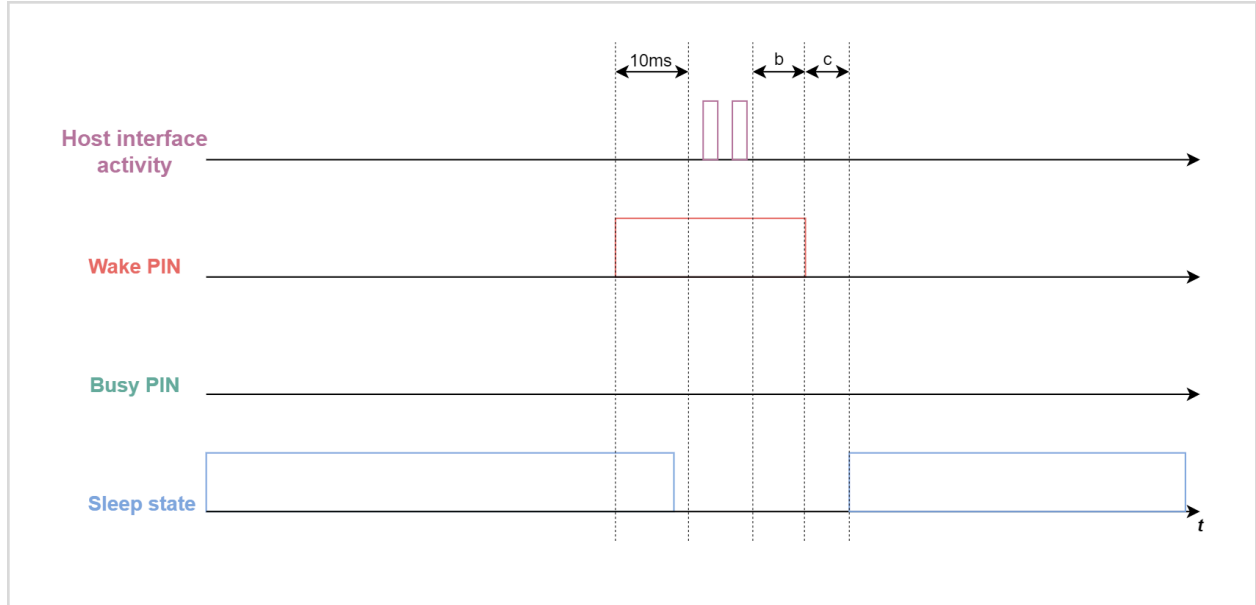


Figure 7: Host-initiated wake sequence diagram

1. The driver raises the wake pin and waits for a static period of 10 ms before initializing the shared communication bus and initiating host interface activity. On MM6108, this period is typically 10 ms.
2. After completing communication, the driver will wait a static period, b, before lowering the wake pin (assuming no further communication has occurred). Depending on the nature of the communication (802.11 data vs. commands), this period can range from 5 to 90ms.
3. After the wake pin has fallen, the MM6108 will wait for a period, c, before initiating hardware sleep. This dynamic period will differ depending on the power-saving protocol and other chip-specific factors.

3.6.2 MM6108-MF16858 initiates wake sequence with host interface disabled

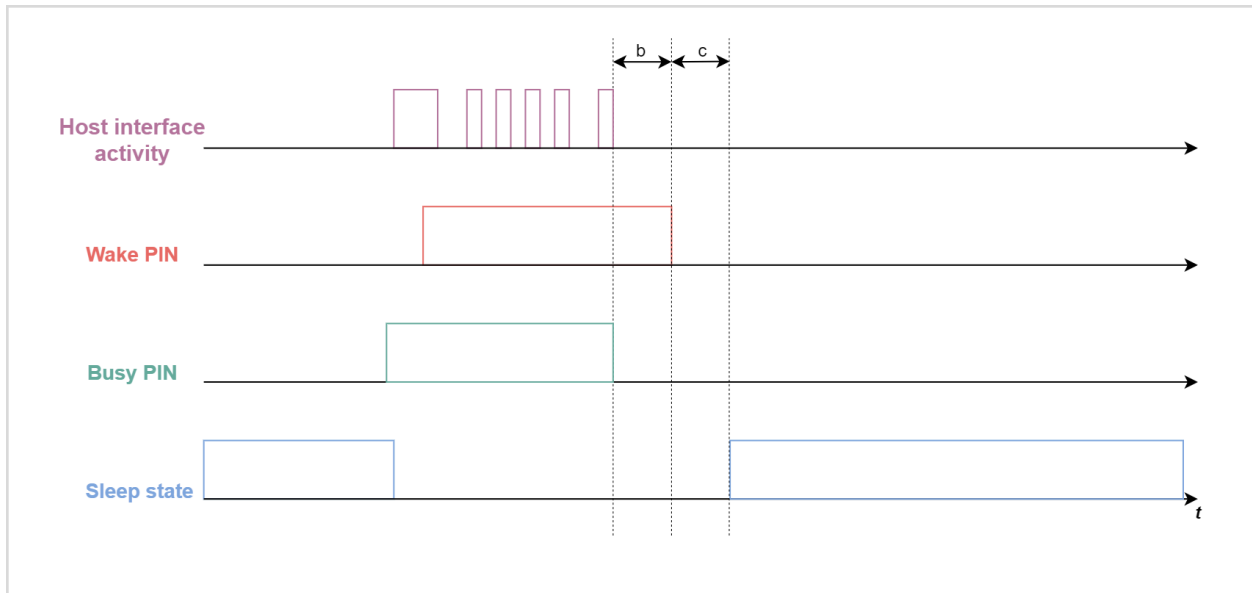


Figure 8: Module-initiated wake sequence with host interface disabled diagram

1. The MM6108 wakes from sleep and realizes it needs to pass traffic or an event to the host. It begins by asserting the busy pin.
2. The busy pin will fire an interrupt on the host, after which the host will immediately:
 - a. Raise the Wake PIN.
 - b. Wait a static period, 10ms
 - c. Initializes / enables the shared host interface.
3. After asserting the busy pin, the MM6108 will initiate host interface communication immediately. It does not wait until the host 'enables' the shared host interface. This is okay, as the bus transaction will be waiting for the host, and an interrupt should fire as soon as the host enables bus interrupts.
4. The busy pin will drop immediately once the MM6108 no longer needs to converse with the host. The host will wait a static period, b, before dropping the wake pin.
5. After the wake pin has fallen, the MM6108 will wait for a period, c, before initiating hardware sleep.

3.6.3 MM6108-MF16858 initiates communication with host interface enabled

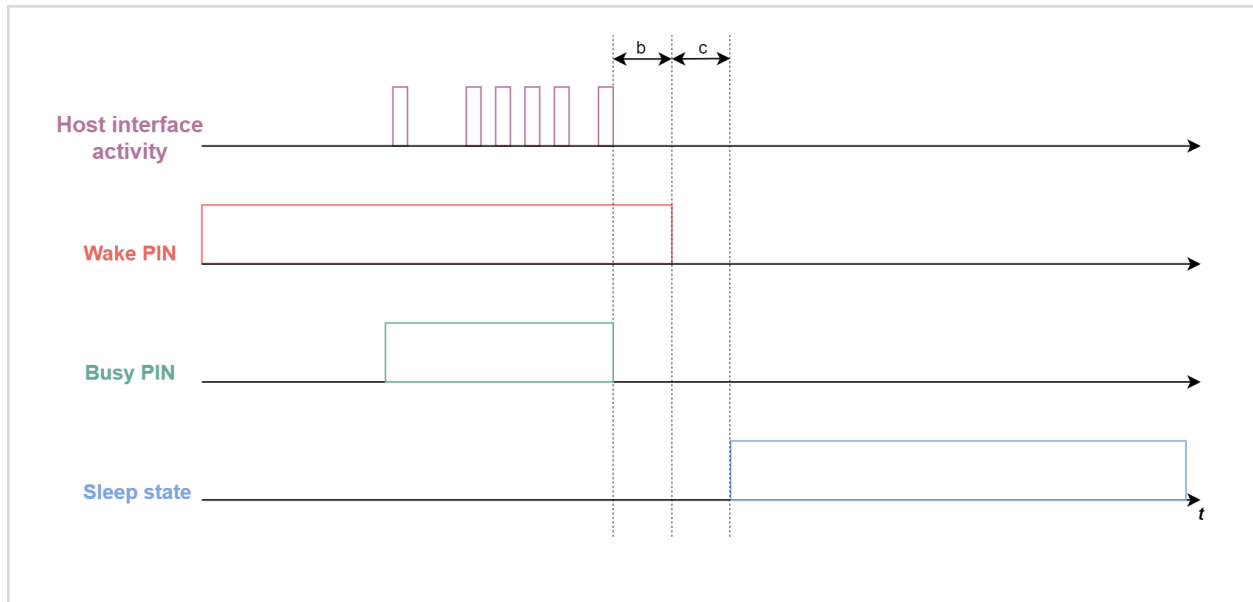


Figure 9: Module-initiated wake sequence with host interface enabled diagram

1. The MM6108 was previously woken by the host for communication.
2. Sometime after wake and host->MM6108 communication, the MM6108 realizes it needs to send data back to the host (MM6108->host). It will assert the busy pin.
3. The busy pin will fire an interrupt on the host, after which it will immediately:
 - a. Process the interrupt but take no further action, as the wake pin has already been asserted and the shared host interface is currently enabled/initialized.
4. After MM6108->host communication completion, hardware sleep will be initiated as described above.

4 Electrical Characteristics

4.1 Absolute max ratings

Stress beyond absolute maximum ratings may cause permanent damage to the MM6108-MF16858 module. Functional operation is only guaranteed for recommended operating conditions. Operation of the device outside the recommended conditions may result in a reduced lifetime and 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	5.5	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

Table 1: Absolute max ratings

4.2 Recommended operating conditions

Parameter	Min	Typ	Max	Unit
Ambient temperature	-40	25	85	°C
VBAT	3.0	3.3	3.6	V
VDD_FEM	4.7	5.0	5.3	V
VDDIO ^[1]	1.62	3.3	3.6	V
Digital I/O voltage	0	3.3	VDDIO	V
RESET / WAKE I/O Voltage	0	3.3	VBAT	V

Table 3: Recommended operating conditions

[1] VDDIO should not exceed VBAT

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

5 Physical Dimensions

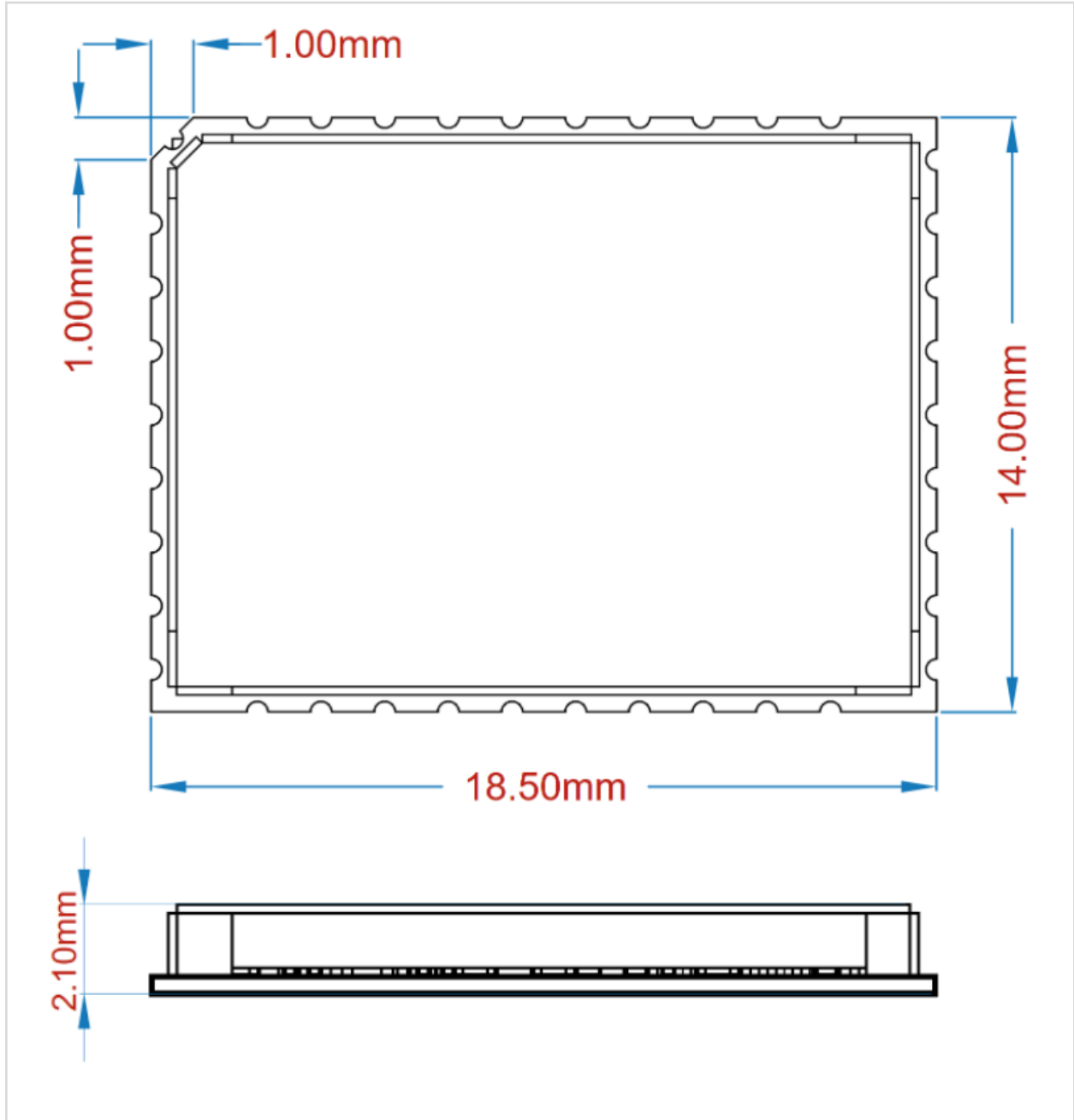


Figure 11: Package dimensions

6 Recommended PCB Footprint

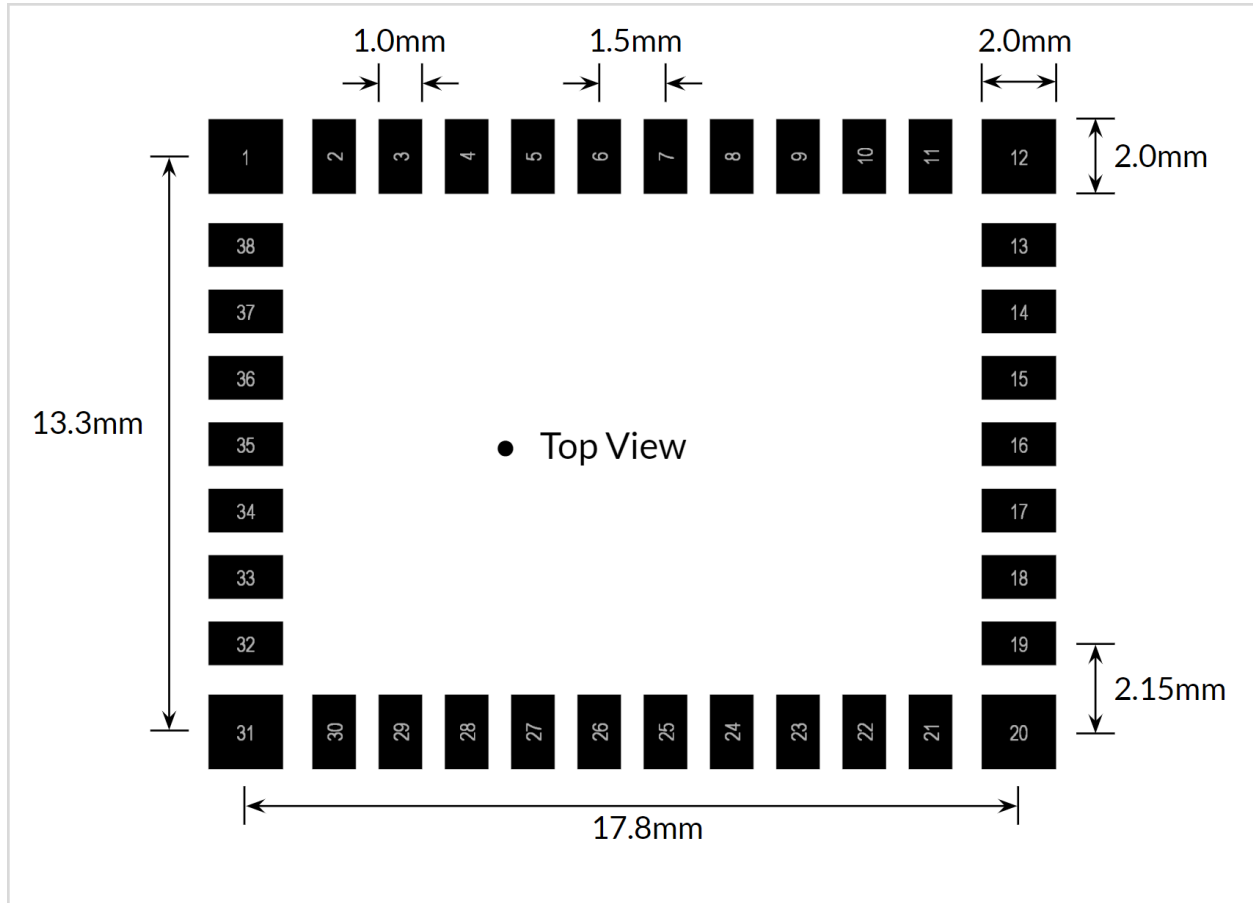


Figure 12: PCB Footprint diagram

7 Certification

7.1 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 user 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 operated in conjunction with any other antenna or transmitter except in accordance with multi-transmitter product procedures. Users 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-B075FC"

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 manufacturer 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.

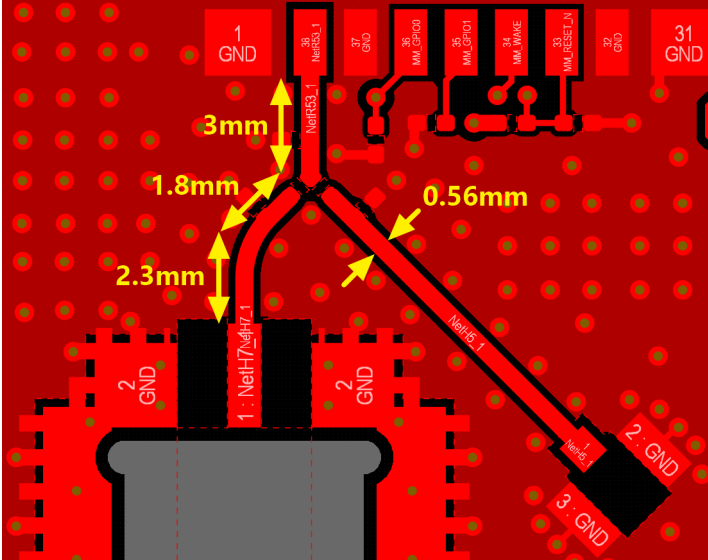
How to make changes:

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.

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: 7.1mm
Width: 0.56mm
Thickness: 1.6mm
Type of trace: 1/2oz
Dielectric constant: 4.3
Antenna connector: SMA

The antenna trace to the antenna connector on the OEM PCB must be maintained identical to the above specification with 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 ISSED 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%

Input power is 29dBm (Average power)

VSWR absolute max $\leq 10:1$ (limit to avoid permanent damage)

VSWR recommended $\leq 1.92:1$ (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 558074 D01 15.247 Meas Guidance 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

7.2 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 radioélectrique subi, même 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-B075FC"

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-B075FC"

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 operated in conjunction with any other antenna or transmitter except in accordance with multi-transmitter product procedures. Users and installers must be provided with antenna installation instructions and transmitter operating conditions for satisfying the RF exposure compliance.

8 Part Numbers and Ordering Information

Part Number	Packing Type	Pins	Size (mm)	Description
MM6108-MF16858	Tray	38	14.0 x 18.5 x 2.1	IEEE 802.11ah Sub-1 GHz High-Power Wi-Fi HaLow Module

Table 13: Part number and ordering information

9 Handling and Storage

The MM6108-MF16858 module is 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 ($\leq 30^{\circ}\text{C}$ and $< 60\% \text{ RH}$)
- OR
2. Continuously stored per IPC/JEDEC J-STD-033

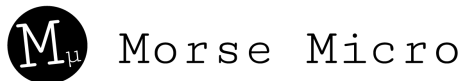
Modules exposed to moisture and environmental conditions exceeding packaging and storage conditions MUST be baked before mounting according to IPC/JEDEC J-STD-033.

Failure to meet packaging and storage conditions will result in irreparable damage to modules during solder reflow.

10 Revision History

Release Number	Release Date	Release Notes
DS100	TBA	Initial release

Morse Micro provides this information "as is" without warranties of any kind, express or implied. No guarantee is made as to the accuracy, completeness, or suitability of this information or Morse Micro's products for any specific purpose. Use of this information and products is at the user's sole risk. Morse Micro products are not designed or tested for use in mission-critical systems, and should not be used in such applications. Performance specifications are based on internal testing and are believed to be reliable; however, they are not guaranteed. It is the Buyer's responsibility to test and validate all product performance, compatibility, and compliance, both in isolation and within end applications. Morse Micro assumes no liability for the use or application of any product, circuit, or information described herein. No license or other rights, express or implied, are granted under Morse Micro's intellectual property. This document contains proprietary information of Morse Micro and is subject to change without notice.



Morse Micro Pty. Ltd. Corporate Headquarters

Level 8, 10-14 Waterloo Street, Surry Hills, NSW 2010, AUSTRALIA

Email: sales@morsemicro.com

Copyright © Morse Micro Pty. Ltd.