



Morse Micro

MM6108-MF08251

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

User Guide

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Product Overview

1.1. Introduction

Morse Micro provides a complete Wi-Fi HaLow connectivity solution. The MM6108-MF08251 is a fully integrated Wi-Fi HaLow® modules with long-range, low-power consumption and superior RF performance, featuring the MM6108 Wi-Fi HaLow SoC.

The MM6108-MF08251 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-MF08251: 1/2/4/8 MHz channel bandwidth
 - MM6104-MF08251: 1/2/4 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: 850-950 MHz
 - Max output power: 21 dBm
- 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





2. Pin Descriptions

The MM6108-MF08251 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

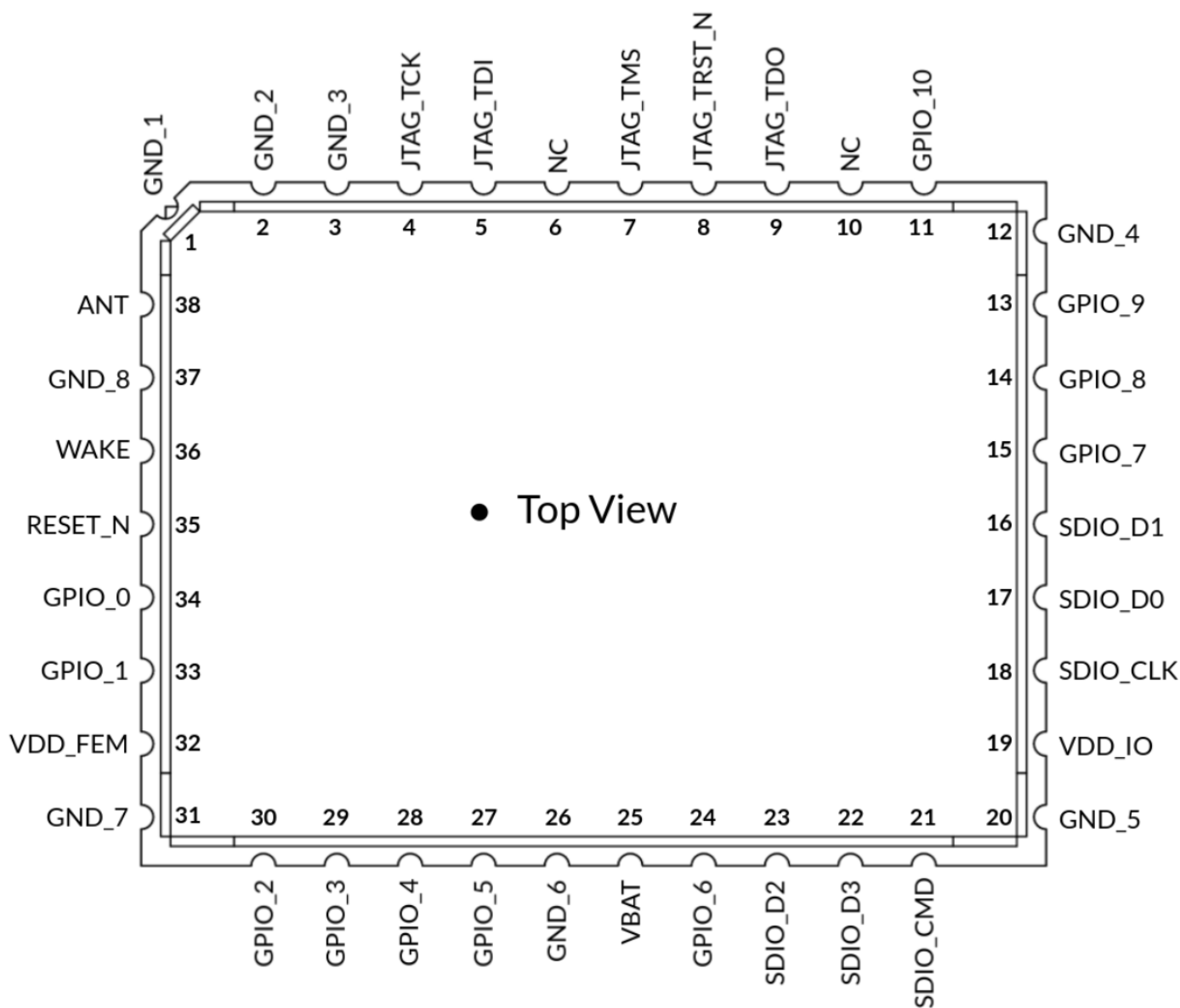




Table 2: Pin Description

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

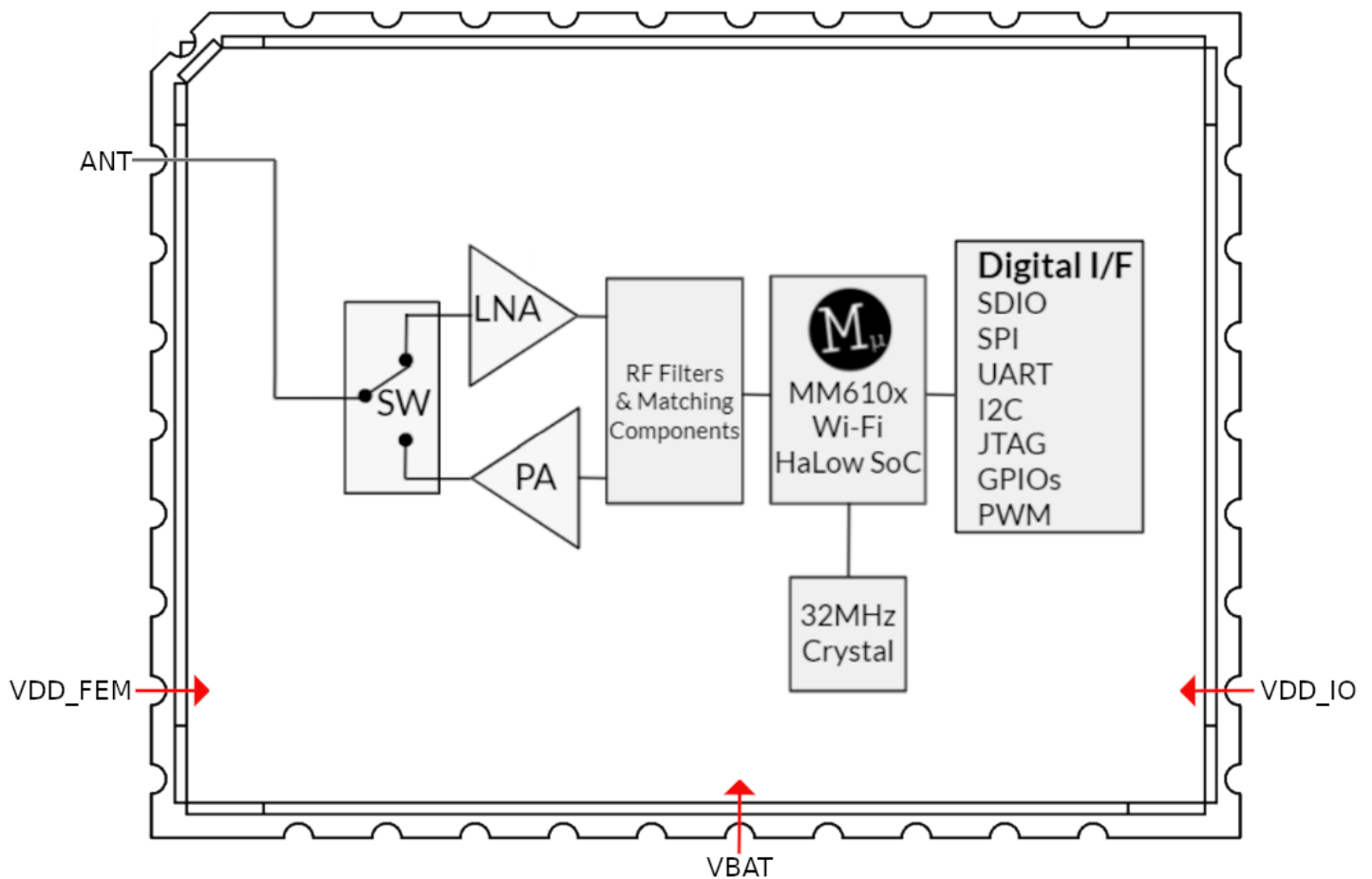


3. Functional Description

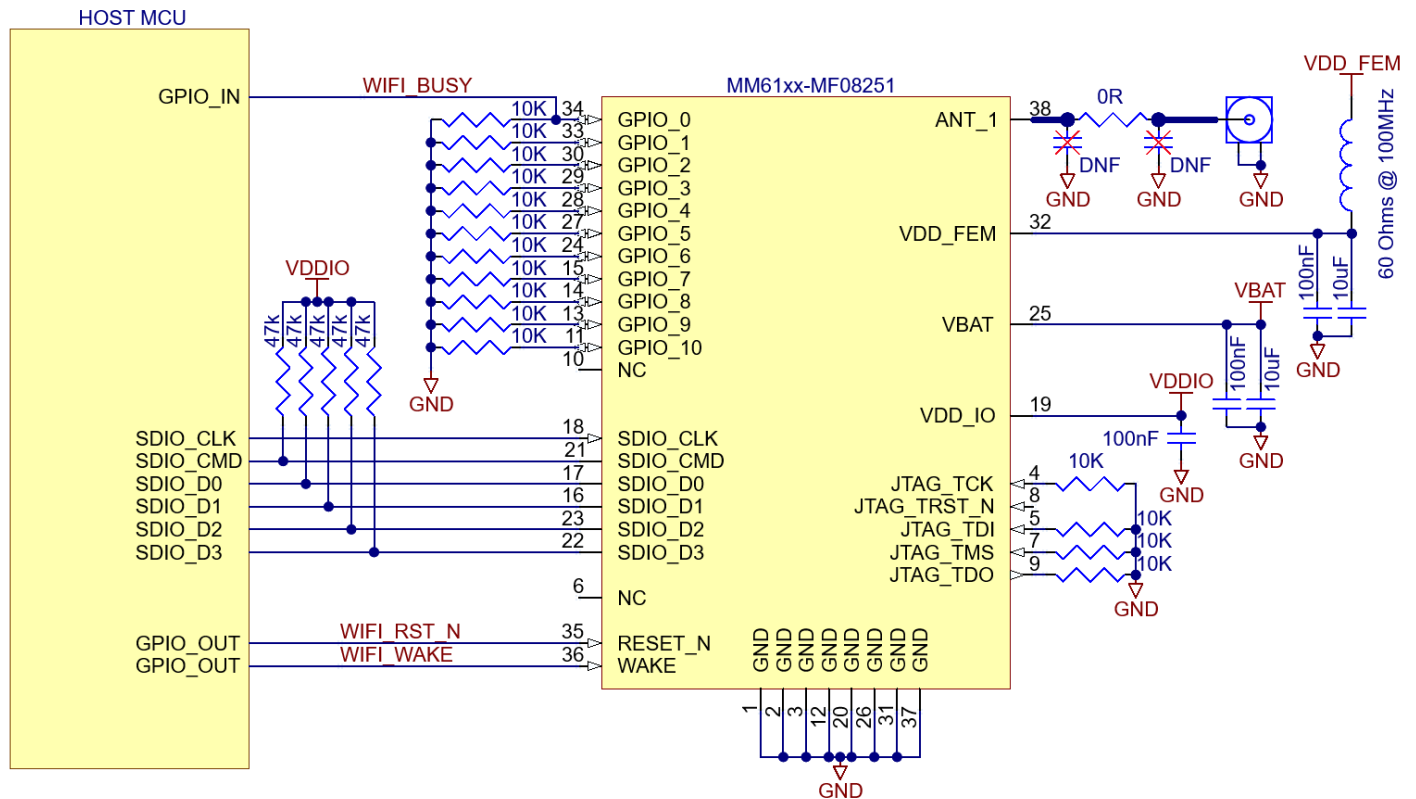
The following sections describe the functions of the MM6108-MF08251 device.

3.1. Block Diagram

Figure 1: Block Diagram

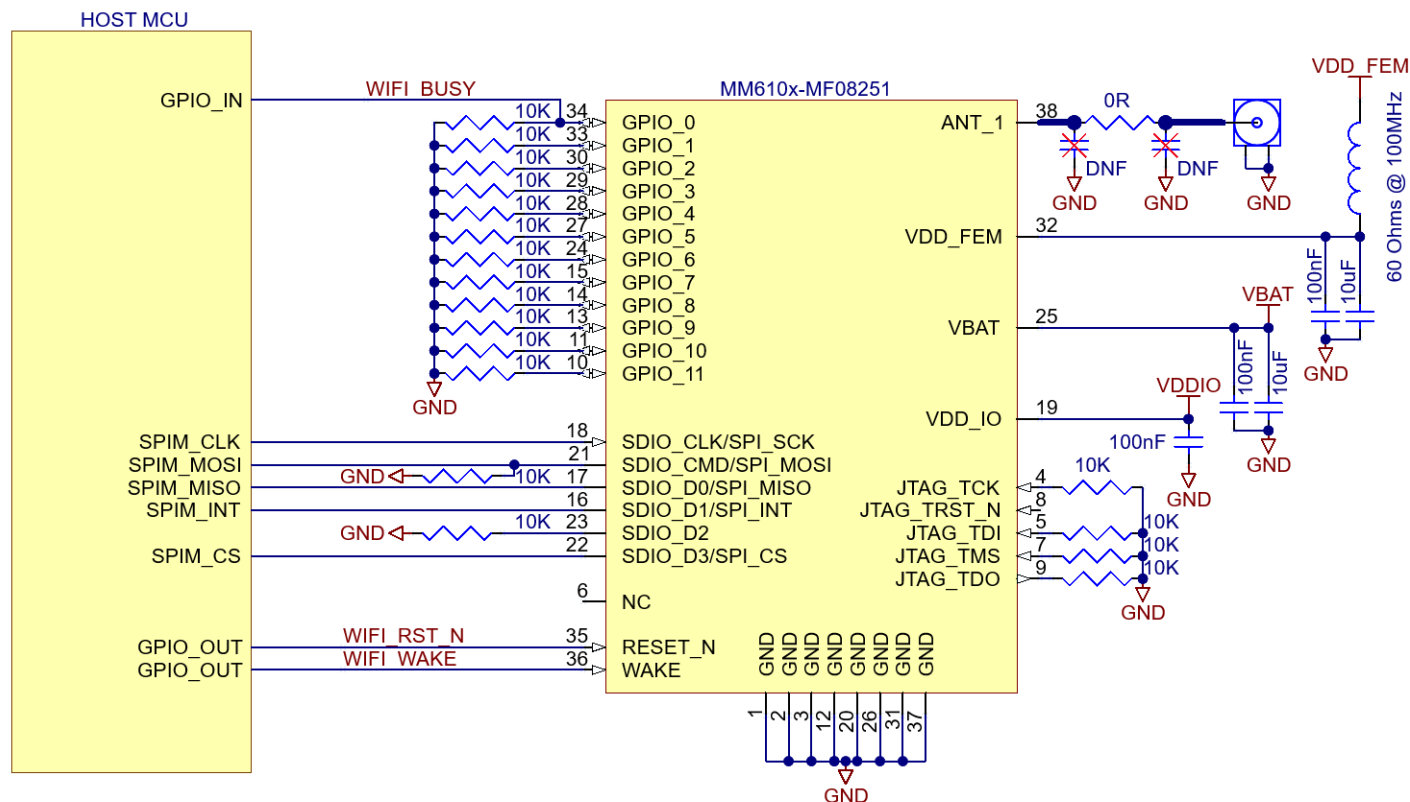


3.2. Recommended Usage Schematics



SDIO Configuration





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 1.8 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

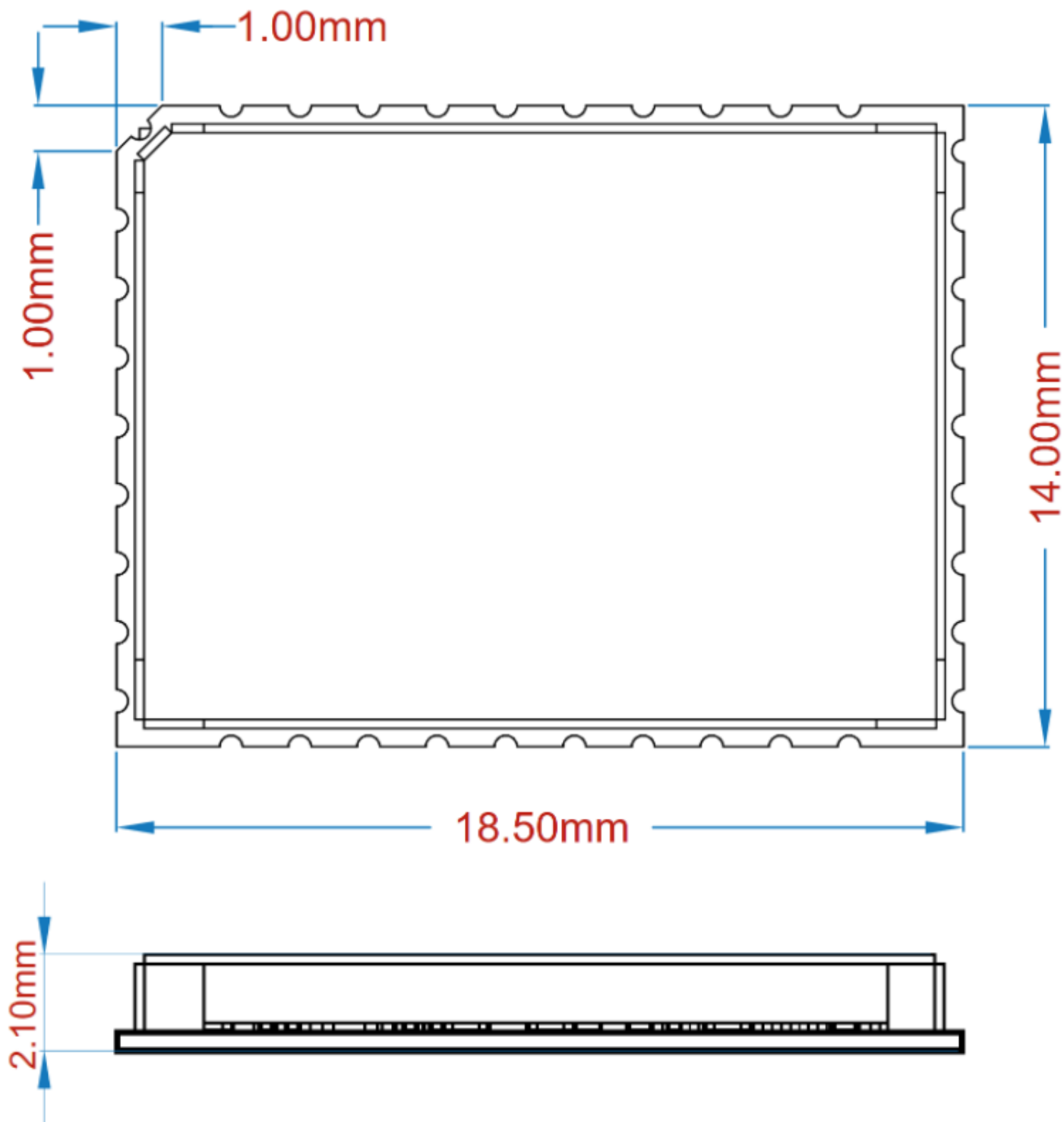
a. VDD_{IO} should not exceed VBAT

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



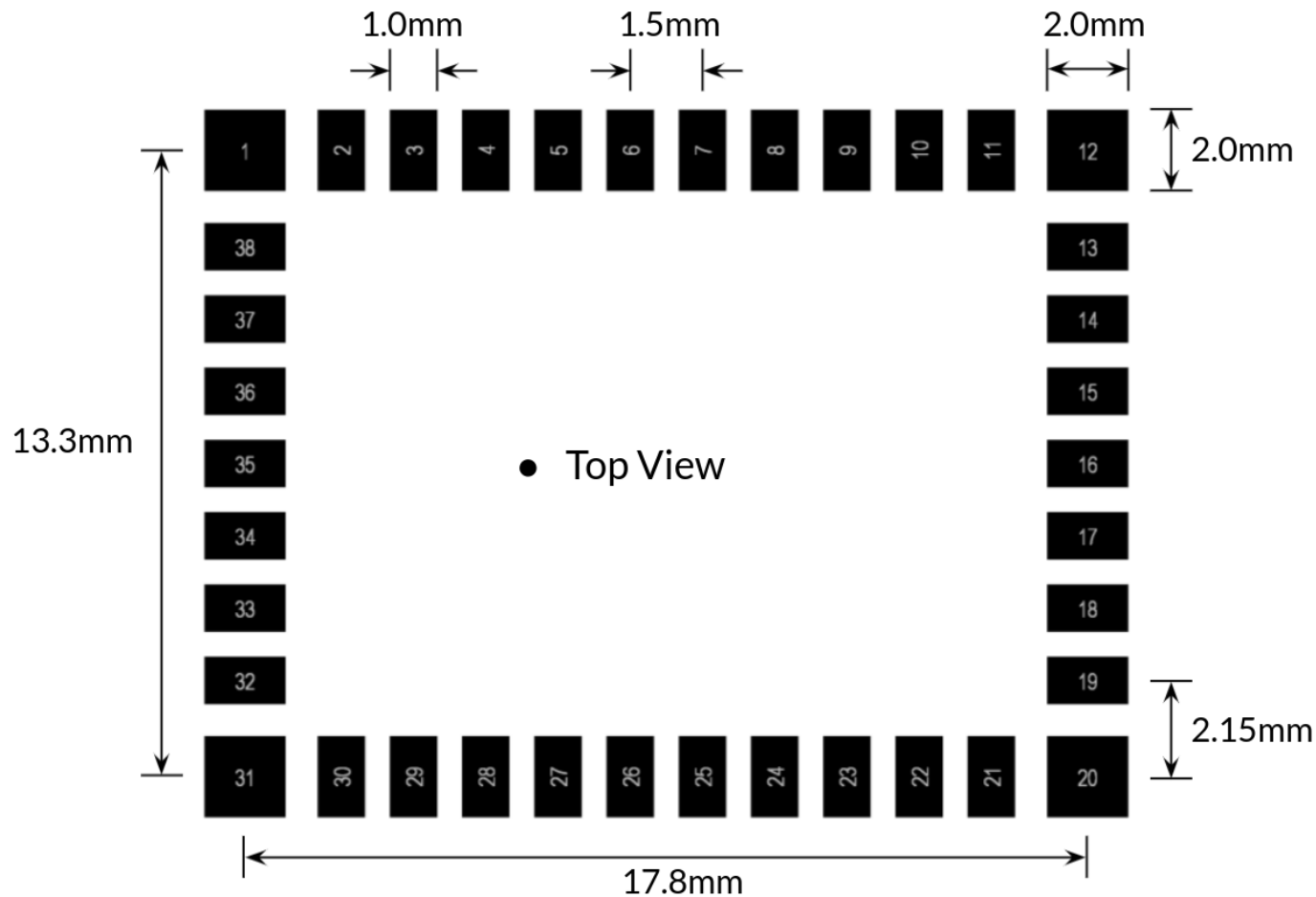


4.4. Physical Specification





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 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.

IMPORTANT NOTE:

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 & your body.

IMPORTANT NOTE:

This module is intended for OEM integrators. This module is only FCC authorized for the specific rule parts 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.

Additional testing and certification may be necessary when multiple modules are used.

USERS MANUAL OF THE END PRODUCT:

In the users manual of the end product, the end user has to be informed to keep at least 20cm separation with the antenna while this end product is installed and operated. The end user has to be informed that the FCC radio-frequency exposure guidelines for an uncontrolled environment can be satisfied.

The end user has to also be informed that any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment.

This device complies with Part 15 of 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.

LABEL OF THE END PRODUCT:

The final end product must be labeled in a visible area with the following:

"Contains TX FCC ID: 2A740-8A7DD6".

This device complies with Part 15 of 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.





7. Part Number and Ordering Information

7.1. Part Ordering Information

Part Number	Packing Type	Pins	Size (mm)	Description
MM6108-MF08251	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 MM610x-MF08251 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 ($\leq 30^{\circ}\text{C}$ and $< 60\% \text{ RH}$)
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-MF08251 UG100; September 1st, 2022

- Initial release



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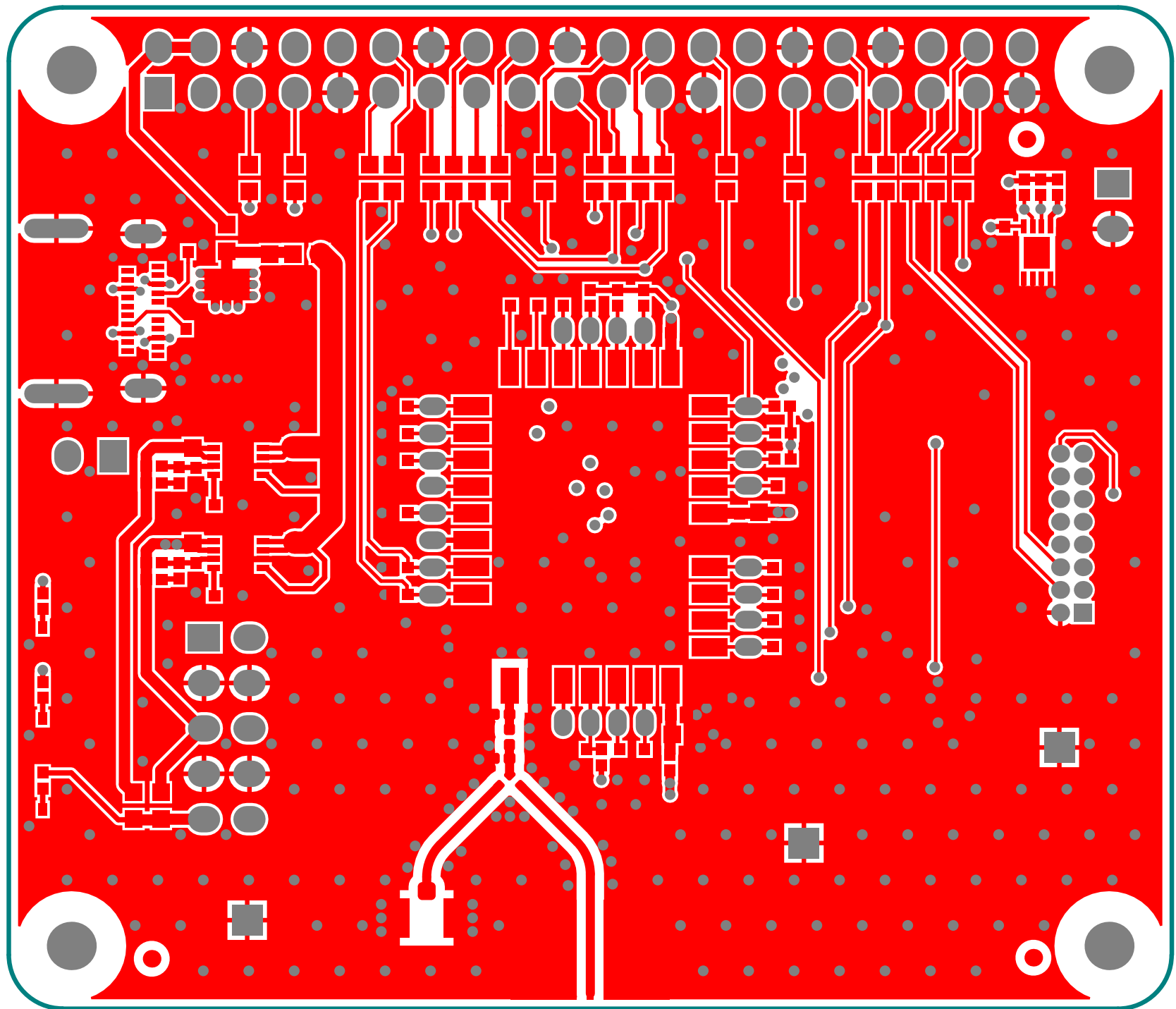
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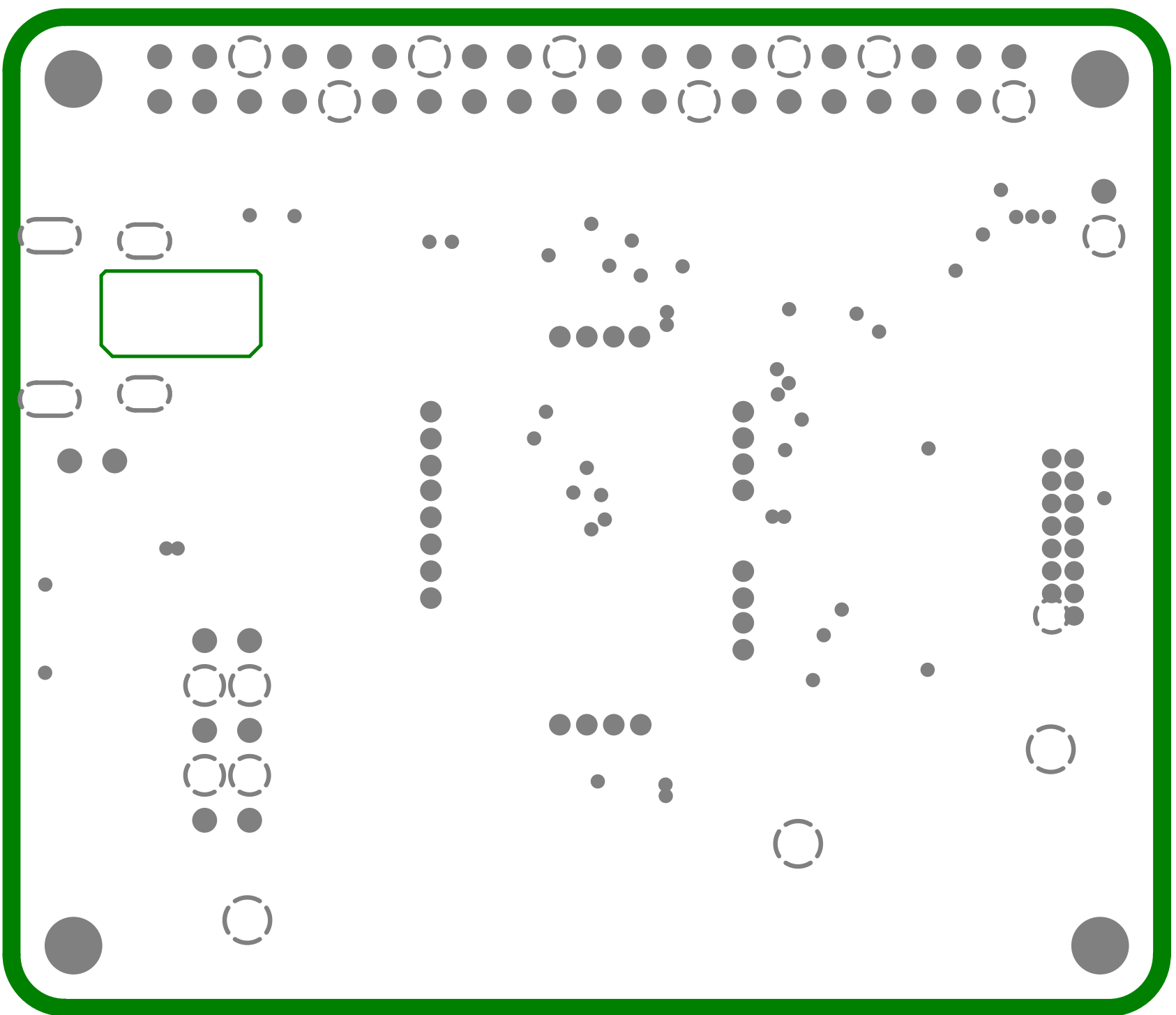
About Morse Micro

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

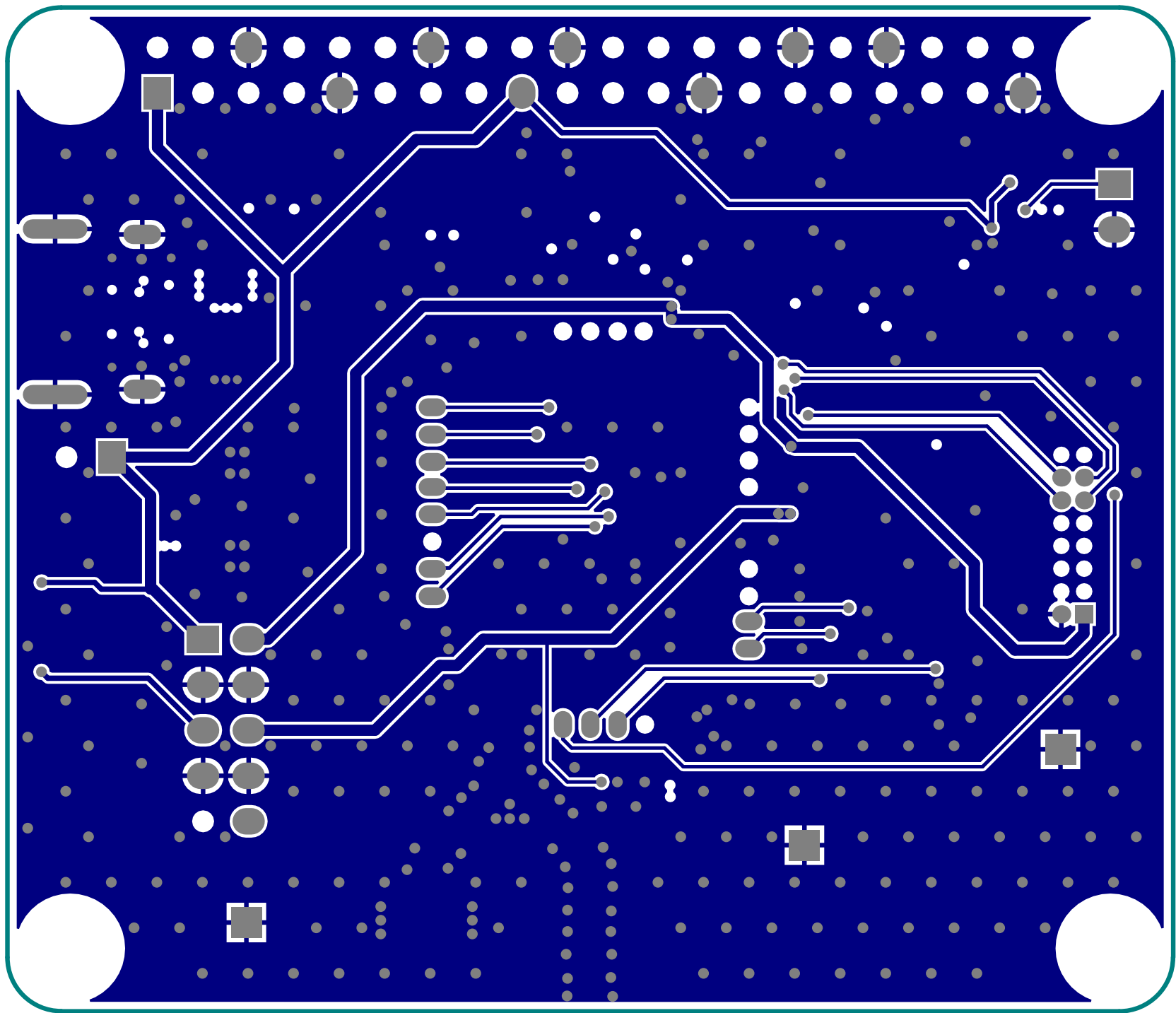




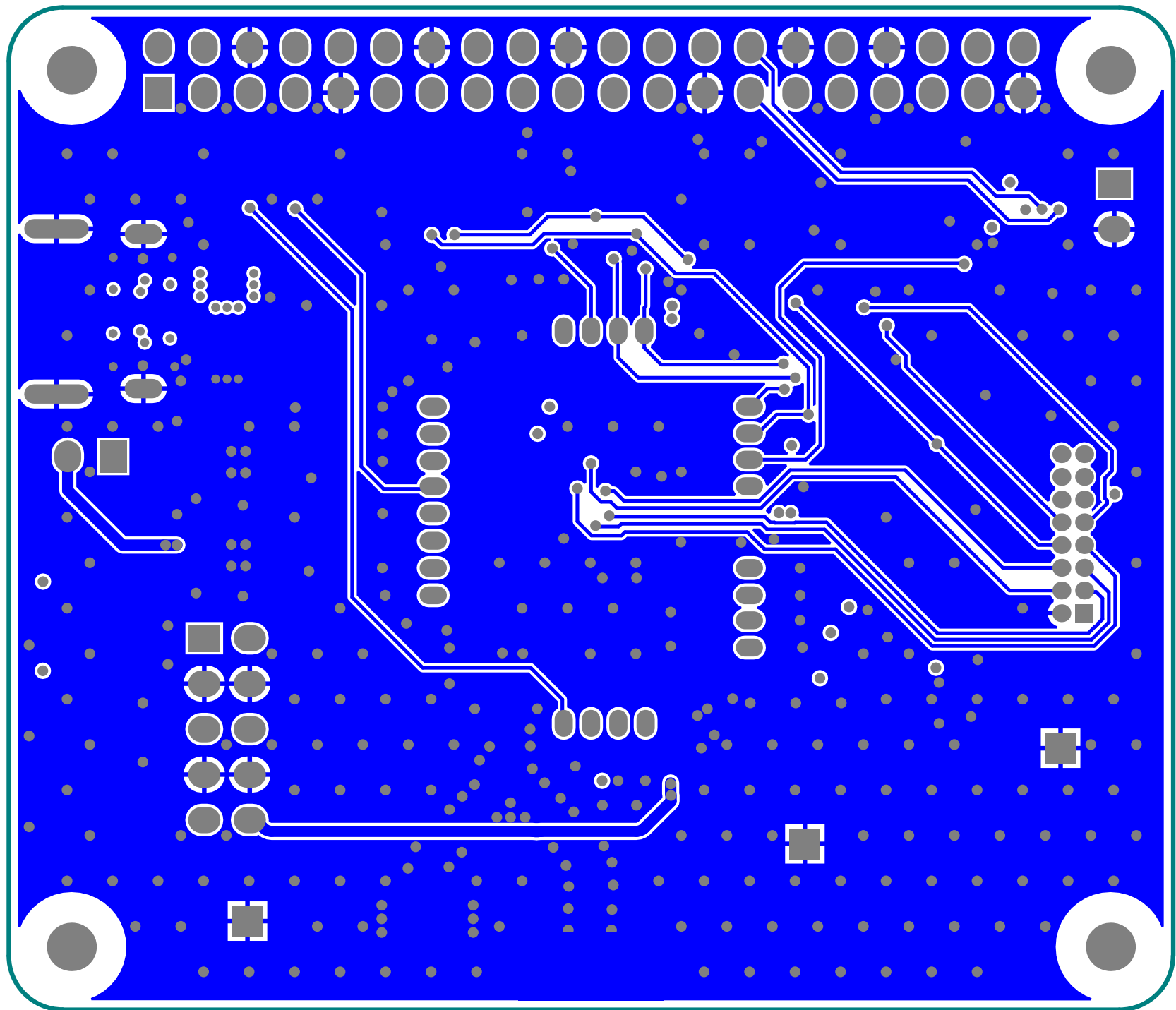
Top Layer



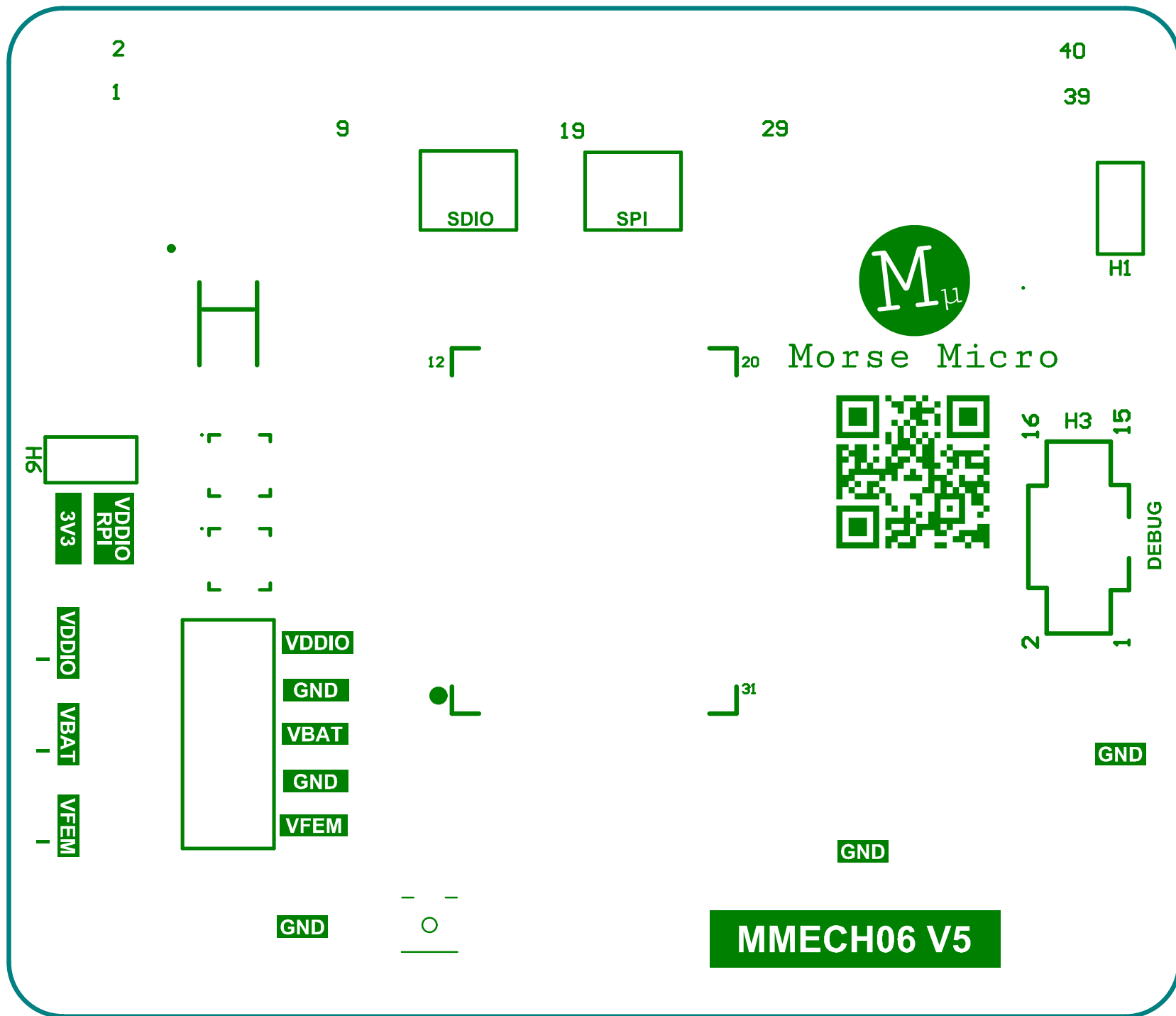
Ground Plane



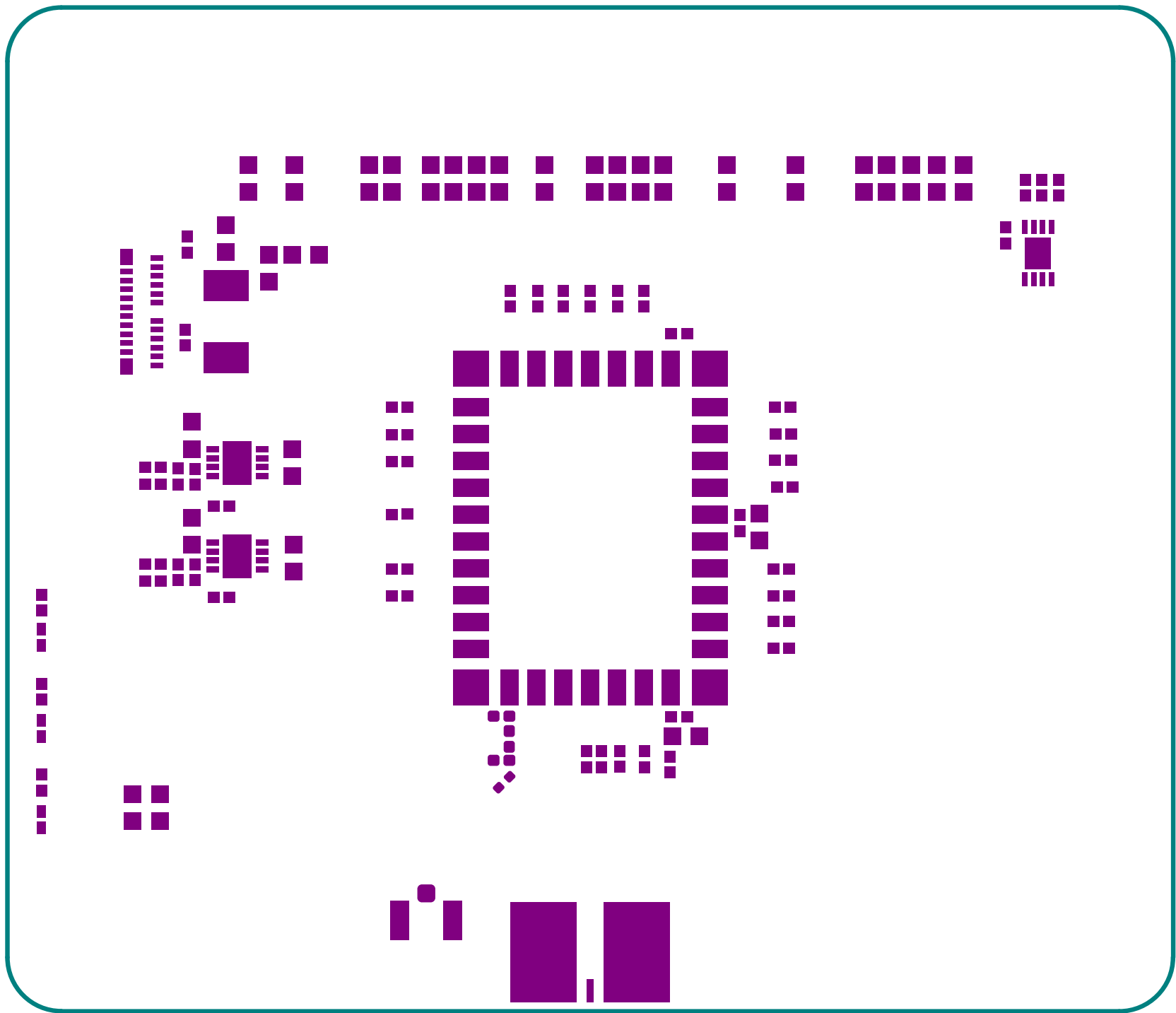
Mid Layer 1



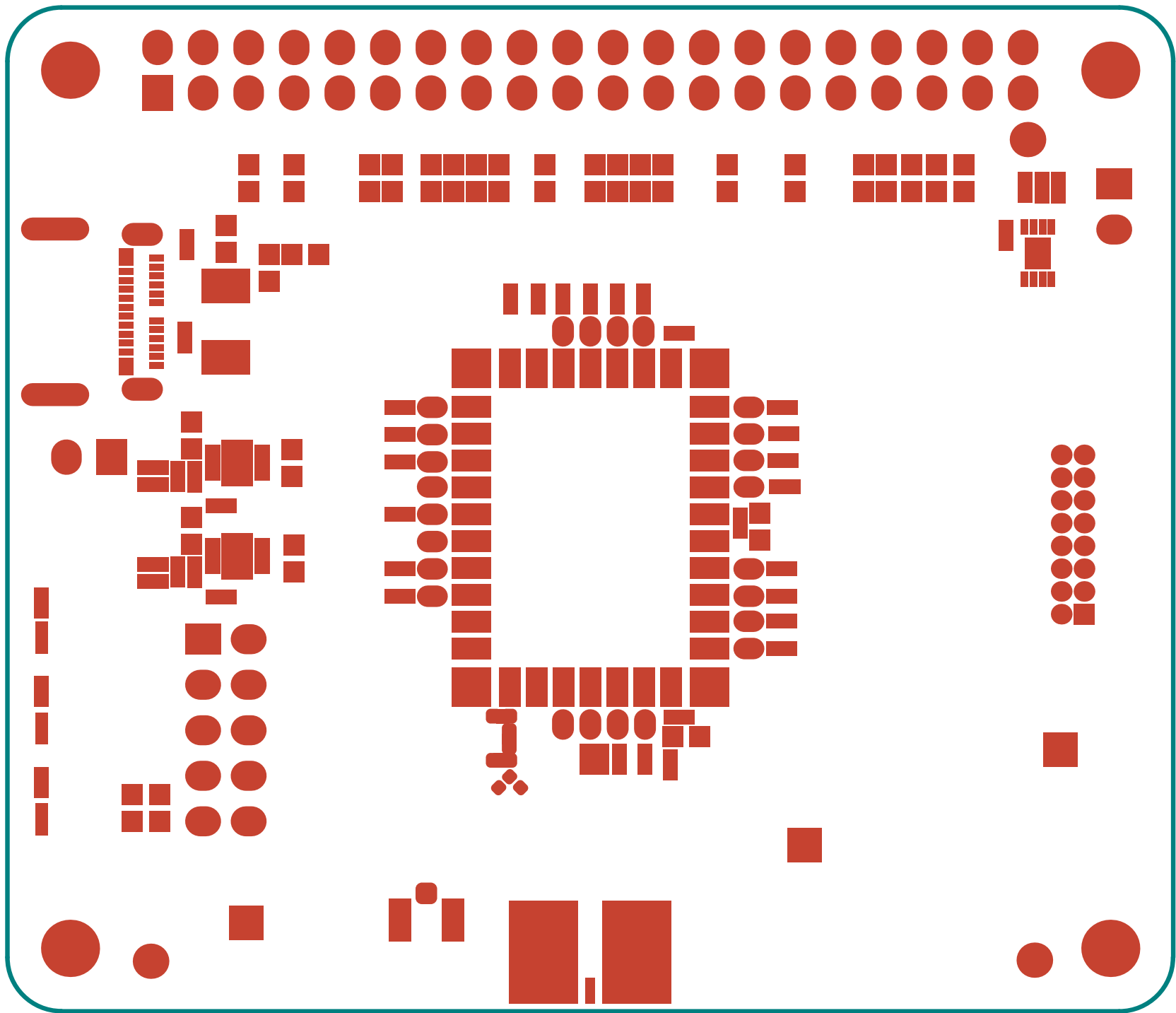
Bottom Layer



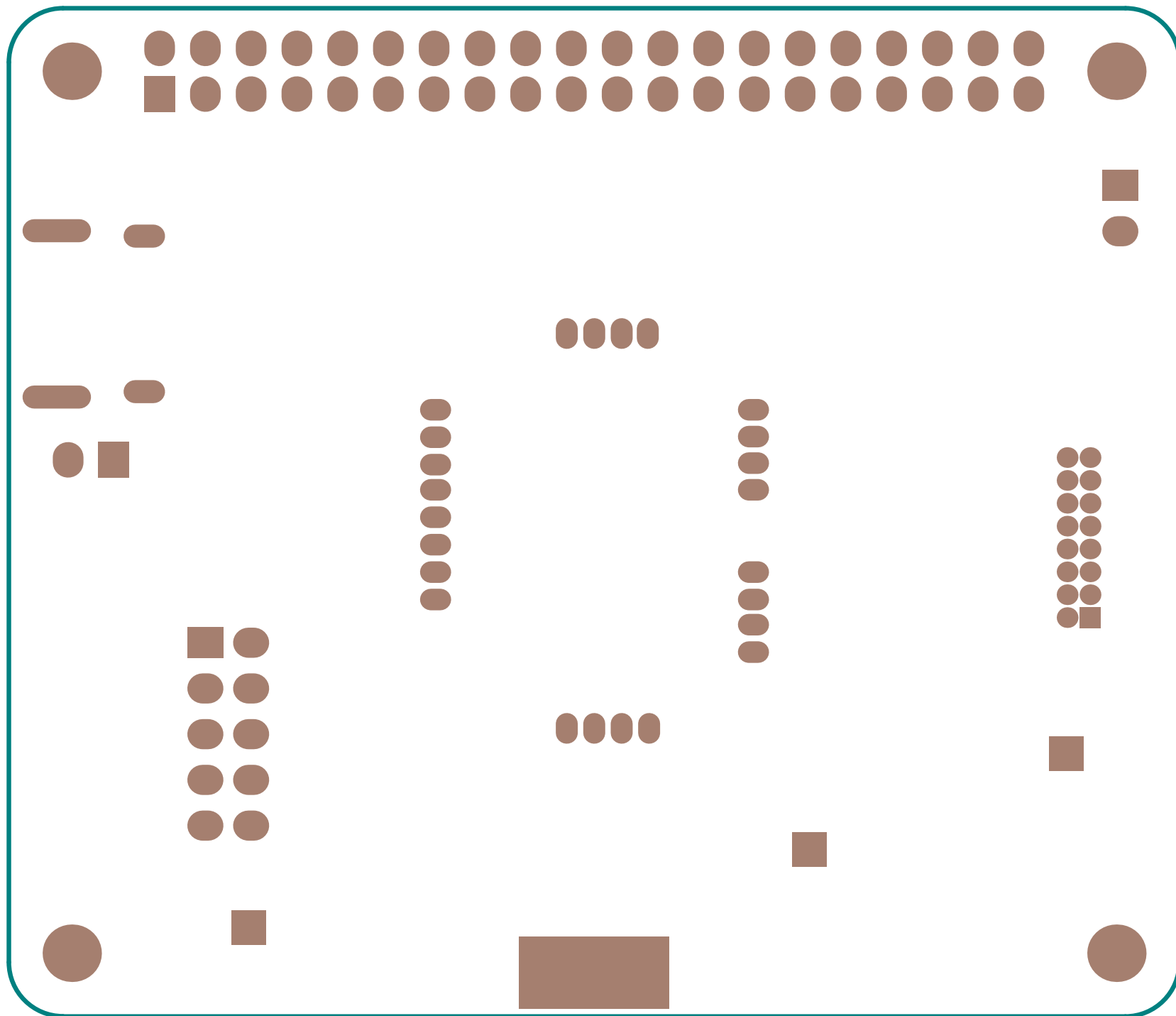
Top Overlay



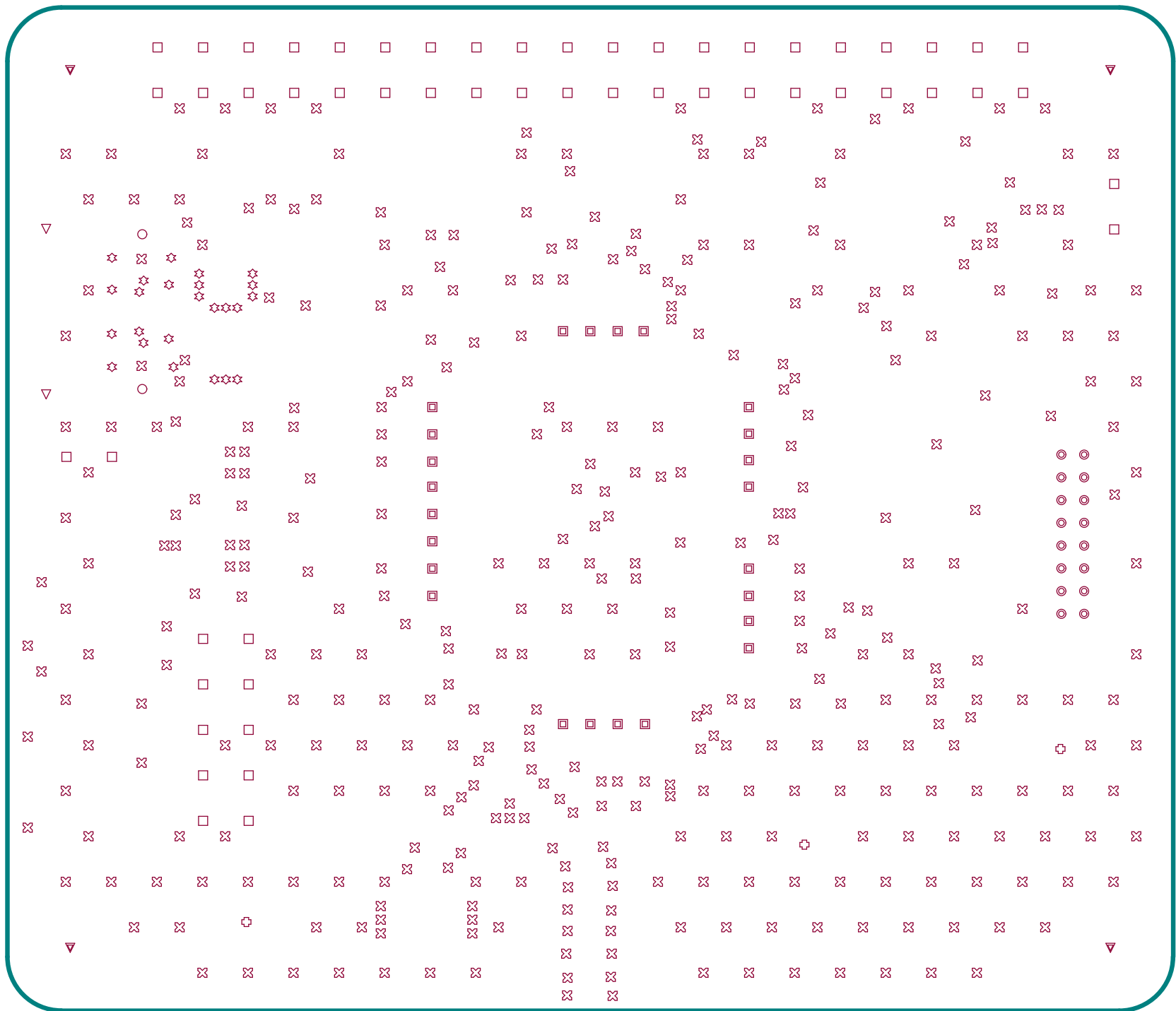
Top Paste



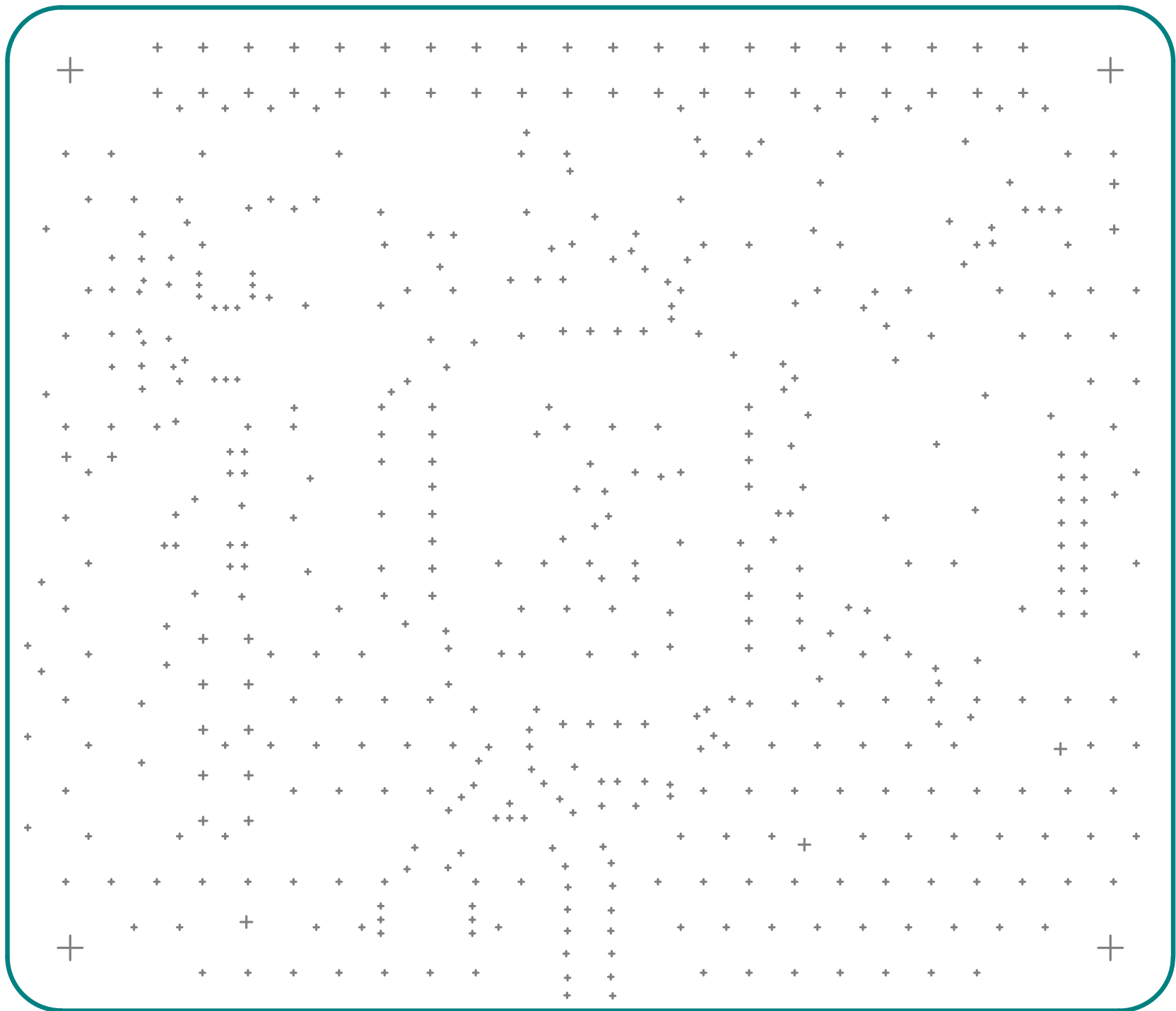
Top Solder



Bottom Solder



Drill Drawing



NOTES: UNLESS OTHERWISE SPECIFIED0

1. SPECIFICATIONS/TOLERANCES:

- A. FABRICATE PER IPC-6012, CLASS 2, USING PROVIDED DATA FILES XXXXXXXX.ZIP
- B. ALL SPECIFICATIONS USED SHALL BE PER THEIR LATEST REVISIONS.
- C. THE DIMENSIONS OF CIRCUIT FEATURES IN THE PROVIDED DATA MAY BE ADJUSTED ONLY TO COMPENSATE FOR PROCESS TOLERANCES; ADDING, REMOVING OR RELOCATING CIRCUIT FEATURES IS NOT ALLOWED
- D. REMOVE ALL BURRS AND BREAK SHARP EDGES, .381 [.015] MAX RADIUS.
- E. PARENTHETICAL INFORMATION IS FOR REFERENCE ONLY.
- F. REPAIR OF PCB DEFECTS IS NOT PERMITTED.

2. DIELECTRIC MATERIAL:

- A. DIELECTRIC MATERIAL SHALL BE PER IPC-4101/99, /124, /126 OR /129 (RoHS COMPLIANT EPOXY-GLASS)
- B. MINIMUM DIELECTRIC THICKNESS SHALL BE .051 [.002] FOR REFERENCED STACK-UP DIMENSIONS OF.076 [.003] OR GREATER; IPC-6012 REQUIREMENTS SHALL OTHERWISE APPLY. SINGLE-PLY CONSTRUCTION IS ALLOWED.
- C. SEE LAYER STACK-UP FOR REQUIRED COPPER WEIGHTS AND THE FINISHED PCB THICKNESS. IF SPECIFIED, 1/3 OZ. STARTING FOIL MAY BE ACHIEVED BY 1/2 OZ. FOIL REDUCTION.
- D. FINISHED PCB THICKNESS SHALL BE MEASURED OVER LANDS AND/OR CONDUCTORS NOT COVERED BY SOLDER MASK. IF SPECIFIED, 1/3 OZ. STARTING FOIL MAY BE ACHIEVED BY 1/2 OZ. FOIL REDUCTION.

3. DRILLING:

- A. VIA DIAMETERS SHALL BE VERIFIED BEFORE PLATING; ALL OTHER HOLE DIAMETERS ARE FINISHED DIMENSIONS.
- B. LAYER-TO-LAYER MISREGISTRATION SHALL BE .127 [.005] MAXIMUM.

4. SOLDER MASK:

- A. APPLY LPI SOLDER MASK OVER BARE COPPER USING PROVIDED DATA.
- B. SOLDER MASK SHALL BE PER IPC-SM-840, CLASS T, COLOR PURPLE.
- C. THE DIMENSIONS OF SOLDER MASK-DEFINED PADS ON PLANES AND/OR WIDE CONDUCTORS SHALL NOT BE MODIFIED.

5. SILKSCREEN/MARKING:

- A. SILKSCREEN PCB PER PROVIDED DATA USING PERMANENT, NON-CONDUCTIVE INK, COLOR WHITE.
- B. SUPPLIER ID AND TRACEABILITY INFORMATION SHALL NOT BE APPLIED ON ANY PART OF THE PCB
- C. INK SHALL NOT BE APPLIED TO ANY SOLDERABLE SURFACE. USING PROVIDED DATA.

6. ELECTRICAL TEST:

- A. DESIGN VERIFICATION SHALL BE DONE PRIOR TO PCB FABRICATION USING GERBER DATA AND AN IPC-D-356 NETLIST.
- B. ALL PCBS SHALL BE 100% ELECTRICALLY TESTED FOR OPENS AND SHORTS
- C. APPLY TEST STAMP IN NON-LEGEND AREA ON SECONDARY SIDE OF PCB.

7. FINAL FINISH:

- A. FINAL FINISH SHALL BE ELECTROLESS NICKEL/IMMERSION GOLD (ENIG) PER IPC-4552.

8. IMPEDANCE:

- A. IMPEDANCE TOLERANCE SHALL BE +/- 10%.
- B. SEE LAYER STACK-UP FOR IMPEDANCE REQUIREMENTS.

- 9. IF PANELIZATION SPECIFICATIONS ARE PROVIDED, THE PCBS SHALL BE DELIVERED IN PANEL FORM. HOWEVER, THESE SPECIFICATIONS MAY BE REPLACED BY SUPPLIER PREFERRED (SPECIFICATIONS AS APPROVED).



	Project: MMECH06	
	Company: Morse Micro	
	Drawn By: Chad O'Neill	
Date: 2/08/2022		Rev: 5

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:

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IMPORTANT NOTE:**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 minimum distance 20cm between the radiator & your body.

IMPORTANT NOTE:

This module is intended for OEM integrator. This module is only FCC authorized for the specific rule parts 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.

Additional testing and certification may be necessary when multiple modules are used.

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LABEL OF THE END PRODUCT:

The final end product must be labeled in a visible area with the following "Contains TX FCC ID: 2A74O-8A7DD6".

This device complies with Part 15 of 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.