

Datasheet

EMB1016 BLE Module

Built-in ultra-low MX1510 MCU, 64KB SRAM, 512KB Flash
BT 5.1 core specification, Security Algorithm
ultra-high integration, rich peripherals

version: 1.0

Date: 2022-03-04

NO.: DS0194CN

Abstract



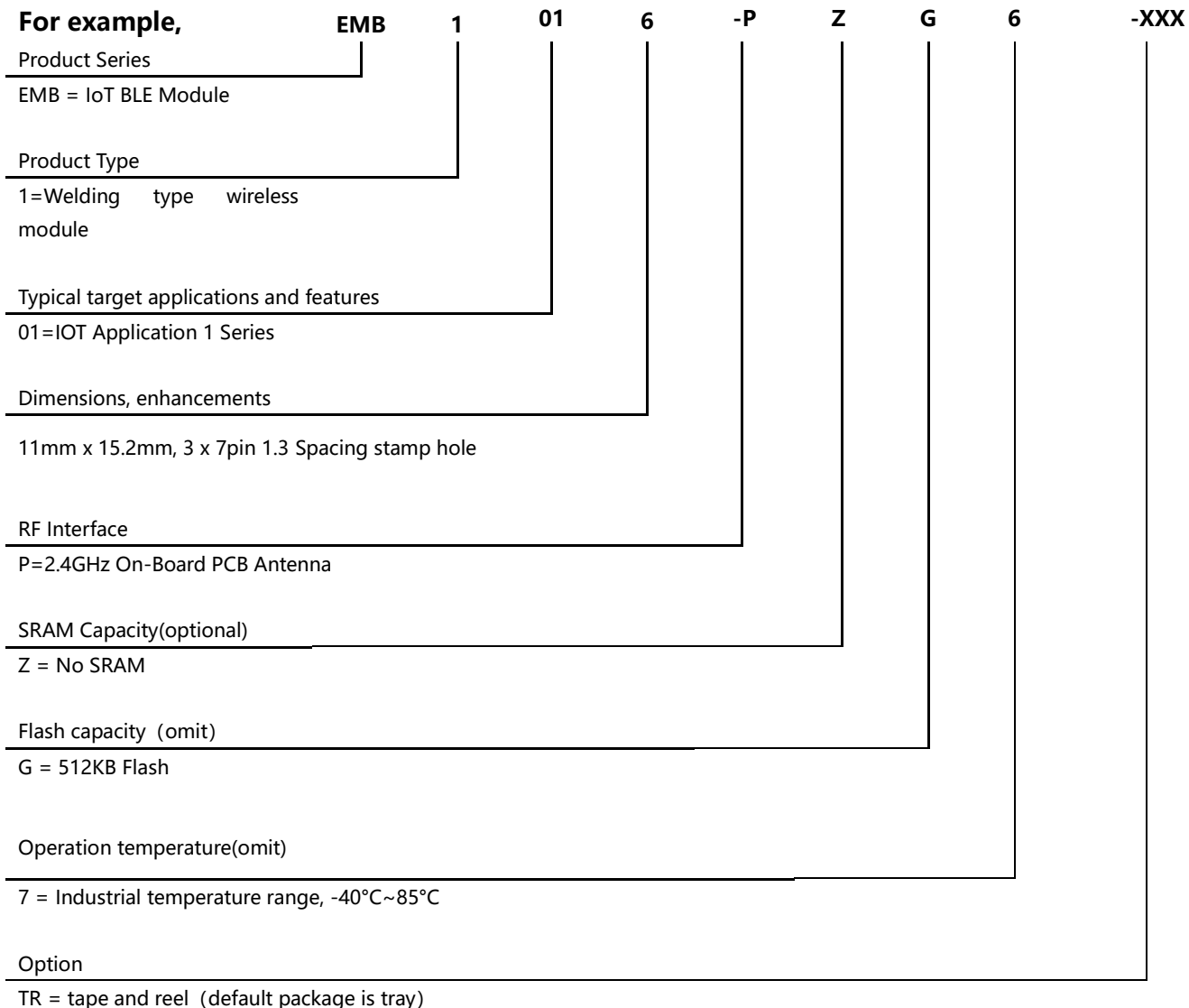
- **Input Voltage: 1.8V~3.6V**
- **Operating Temperature: -40°C to +85°C**
- **Processor: MX1510**
 - Main Frequency up to 20MHz
 - Cortex-M0 core
- **Memory**
 - 64KB SRAM
 - 512KB XIP Flash
- **Bluetooth**
 - Support BT 5.0/5.1 core specification, BLE Mesh
 - Support 125Kbps/500Kbps/1Mbps/2Mbps
 - RX Sensitivity: -96dBm @1Mbps, 94dBm@2Mbps, 105dBm@125kbps
 - TX power: +7dBm
 - Support Single-Ended Antenna Output
- **Rich Peripherals**
 - Support Up to 18 interface
 - 2 I2C interface(support bus arbitration)
 - 2 SPI interface
 - 3 UART (support ISO7816, LIN, IrDA)
 - 2 PDM interface, support Digital MIC,
 - 1 I2S interface
 - 12-bit high precision SAR ADC, 5 channels
 - 6 timers, 14 sets of PWM signal output, 4 sets of complementary support
 - RTC: supports high precision hardware temperature repair
 - Watchdog timers: IWDG and WWDG

- **Security and Arithmetic acceleration unit**
 - ECC Elliptic Curve encryption (256)
 - AES Advanced encryption (256/192/128)
 - T/DES Advanced Encryption (192/128/64)
 - True Random number generator (TRNG)
 - Computing Accelerator (CALC)
- **Interface and Dimension**
 - Onboard PCB Antenna
 - 3 x 7 pin, 1.3mm pitch, stamp hole
 - 11 mm x 15.2 mm
- **Rich supporting software**
 - Support MXOS
 - Support xBT Bluetooth stack, broadcast, scan, Peripheral and Central modes, extended broadcast, long-range and other 5.0 new features
 - Support Bluetooth Sig Mesh
 - Support the MXCHIP xMesh stack
 - Support Controller and Host modes
 - Bluetooth AT firmware, supporting transparent transmission

● **Ordering Code**

Ordering Code	Note
EMB1016-PZG6	PCB Antenna

Ordering Code



For a list of all relevant features (such as packaging, minimum order quantity, etc.) and other information, please contact the nearest MXCHIP sales point and agent.

Accessories

Order Code	Description
MXKIT-Base	Development board for all EMB1016 modules
MXKIT-Core-1016	The development board core board for the EMB1016, used with MXKIT-Base
FX-1016	EMB1016 production fixture with accompanying test board: MXKIT-Base, MXKIT-Core-1016

Version Update Instructions

Date	Version	Update Contents
2022-03-04	1.0	Initial Version

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1. Introduction

Based on MX1510 Bluetooth microcontroller, EMB1016 series modules can realize data acquisition and control with rich peripheral interfaces, and communicate with other Bluetooth devices through the built-in Bluetooth subsystem. They can not only interact directly with mobile phones, but also connect data to Internet of Things cloud service platform through Mesh network. This series of modules through a variety of different dimensions, interface forms, antenna interface, applied to a wide range of Internet of things products.

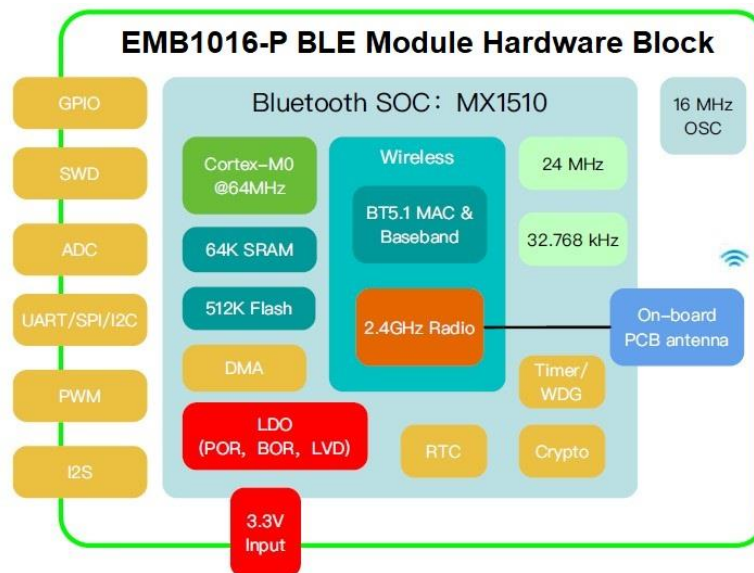
EMB1016 module is built with an ultra-high integration Bluetooth microcontroller, MX1510, which integrates 64KB bytes of SRAM, 512K bytes of Flash storage, and a Bluetooth controller that supports the Bluetooth 5.0 core specification. The processor supports multiple low power modes for Bluetooth beacon, tag, sensor, button and other applications. The module provides stamp hole interface for flexible installation. The module uses high temperature resistant components and white PCB ink, suitable for application in high temperature lighting scenarios.

MXCHIP provides MXOS software platform to support the development of EMB1016 series modules, providing an efficient development environment. MXOS includes xBT Bluetooth protocol stack, xMesh SDK, and various Bluetooth sample programs and typical applications.

The following is a hardware block diagram of the EMB1016 module. It mainly includes:

- Bluetooth MCU MX1510
- PCB Antenna
- Power supply and Communication interface

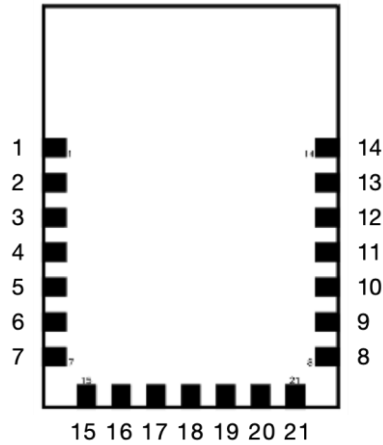
Figure 1 Hardware Block Diagram



2. Pin Definition

2.1. Pin Arrangement

Figure 2 Pin Arrangement



2.2. Pin Definition

Table 1 Module operating mode selection

No.	Name	Type	Despition	Setting ⁽²⁾
1	PB08	I/O	GPIO	PWM, Cold LED ⁽³⁾
2	PB09	I/O	GPIO	PWM, Warm LED ⁽³⁾
3	PB12	I/O/Analog	GPIO/ADC_CH0	
4	PB13	I/O/Analog	GPIO/ADC_CH1	
5	PB06	I/O	GPIO/SWCLK	SWCLK
6	PB05	I/O	GPIO/SWDIO	SWDIO
7	PB01	I/O	GPIO/UART1_RXD, debug serial port ⁽¹⁾ , ISP burn	DEBUG_UART_RX
8	PA00	I/O/Analog	GPIO/ADC_CH4/Wakeup	
9	PA01	I/O/Analog	GPIO/ADC_CH5	PWM, Red LED ⁽³⁾
10	NRST	I	Reset signal, active at low level	Reset
11	PA02	I/O/Analog	GPIO/ADC_CH6	PWM, Green LED ⁽³⁾
12	PA08	I/O	GPIO	PWM, Blue LED ⁽³⁾
13	PA13	I/O	GPIO	
14	PA14	I/O	GPIO	
15	PB00	I/O	GPIO/UART1_TXD, debug serial ⁽¹⁾ , ISP burn	DEBUG_UART_TX
16	PB11	I/O	GPIO/Wakeup:	USER_UART_TX
17	PB10	I/O	GPIO	USER_UART_RX
18	GND	Power		
19	VDD33	Power	3.3V Power Input	
20	PB14	I/O	GPIO/BOOT ⁽¹⁾	BOOT ⁽¹⁾
21	PB15	I/O	GPIO/Wakeup	STATUS ⁽¹⁾

Special notes:

1. At startup, the hardware detects PB14 to decide whether to enter ISP mode. This is a hardware-

solidified function, so it cannot be modified. When using the SDK or firmware provided by MXCHIP, the firmware will also detect the PB15 pin to determine whether to enter QC mode.

All specific working modes and entry modes of the module are shown in Table 2.

- ISP mode: UART connects the module's PB00 (UART1_TXD) and PB01 (UART1_RXD), allowing to program the on-chip Flash using a burn-in tool.
- This mode is mainly used for production. During development, firmware can be downloaded directly through the SWD debugging interface using an emulator.
- QC mode: Run an internal test program, which processes data via PB11 (USER_UART_TX) and PB10 (USER_UART_RX).
- Serial port parameters: 115200/8/n/1.
- Normal mode: The application executes automatically.

Table 2 Module operating mode selection

Operation Mode	PB14	PB15
	Default state: 0	Default state: 1
ISP	1	x
Normal	0	1
QC	0	0

2. The processor can be configured to attach GPIO to any digital peripheral. In the module SDK provided by MXCHIP, some IO port functions have been preset.
3. Default Settings in the PWM lighting example scenario.

3. Electrical Parameters

3.1. Electrical characteristics

Parameter	Description	Min.	Typ.	Max.	Unit
Operating Temperature		-40		85	°C
Supply Voltage	Regulator supply input	1.8	3.3	3.6	V
V _{IH}	High Level Input Voltage	0.9*VDD33		VDD33	V
V _{IL}	Low Level Input Voltage	0		0.1*VDD33	V
V _{OH}	High Level Output Voltage	VDD33-0.4		VDD33	V
V _{OL}	Low Level Output Voltage			0.4	V
Source Current			60		mA
Sink Current			30		mA
V _{ESD}	Electrostatic discharge voltage		±8000		V

3.2. Typical Parameters

Mode	Average	Max.	Unit
TX Mode @ 0dBm 1Mbps, CPU 64MHz	15.8	31.9	mA
TX Mode @ 7dBm 1Mbps, CPU 64MHz	27.3	35.2	mA
RX Mode @ 1Mbps, CPU 64MHz	16.2	22	mA
RF Idle @ CPU 64MHz	6.8	10	mA
Standby Mode	2		mA
Low Power Mode2	1.1		mA
Low Power Mode3	0.7		mA

3.3. RF parameter

Table 3 RF received parameter

Symbol	Description	Min.	Typ.	Max.	Unit
Receiver operation					
PRX _{MAX}	Maximum received signal strength at <0.1%		-1.5		dBm
PRX _{SENS,2M}	Sensitivity (0.1% BER) at 2 Mbps		-94	-97	dBm
PRX _{SENS,1M}	Sensitivity (0.1% BER) at 1 Mbps		-96	-100.7	dBm
PRX _{SENS,500k}	Sensitivity (0.1% BER) at 500 kbps		-98	-99	dBm
PRX _{SENS,250k}	Sensitivity (0.1% BER) at 125 kbps		-104	-105	dBm
P _{SENS IT} 1 Mbps BLE	Receiver sensitivity: Ideal transmitter		-99	-100	dBm
P _{SENS DT} 1 Mbps BLE	Receiver sensitivity: Dirty transmitter		-98.5	-99.5	dBm

Table 4 RF transmitted parameter

Symbol	Description	Min	Typ	Max	Unit
P_{RF_PA}	Maximum output power		8		dBm
P_{RFC_PA}	RF power control range		40		dB
P_{BW1_PA}	20 dB bandwidth for modulated carrier		1000		KHz
F_{DR}	Frequency Drift Error				KHz

4. Antenna Information

EMB1016 designs a PCB antenna.

4.1. PCB antenna parameters

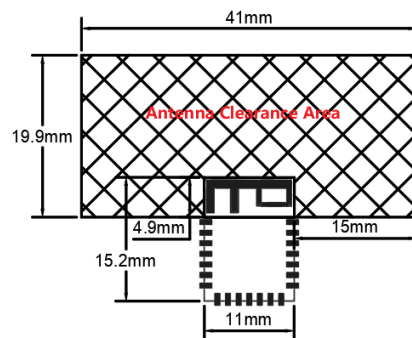
Table 5 On-board PCB parameter



Item	Min.	Typical	Max.	Unit
Frequency	2400		2500	MHz
Impedance		50		Ω
VSWR			2	
Gain	$\leq 2\text{dBi}$			
Efficiency	$> 54\%$ or $> -2.68\text{dB}$			

4.2. PCB Antenna Clearance

When using PCB antenna in BLE module, it is necessary to ensure that PCB and other metal devices are at least 15 mm away from the motherboard. The shaded areas in the figure below need to be far away from metal devices, sensors, interference sources and other materials that may cause signal interference.

Figure 3 Antenna minimum clearance area (unit: mm)

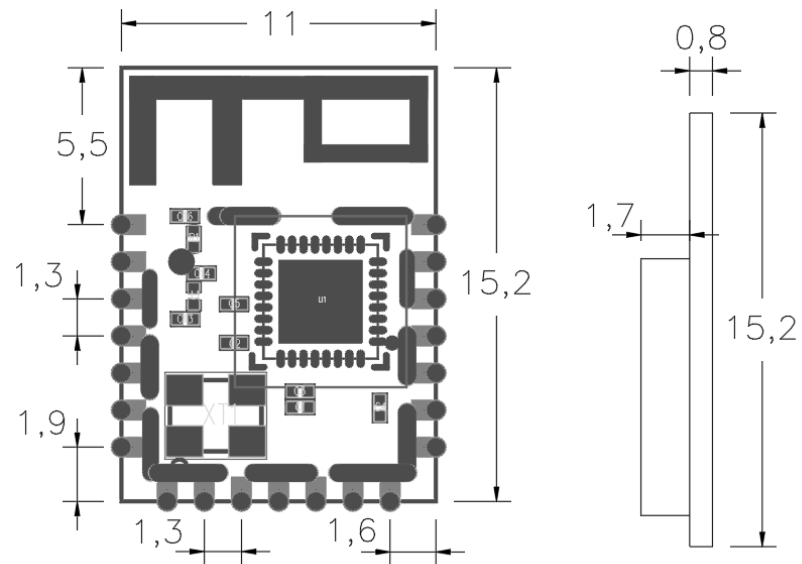


-  This area represents the antenna clearance area.
-  This area represents the projection area of the motherboard, No wiring and no ground wire.

5. Dimensions and Production Guidance

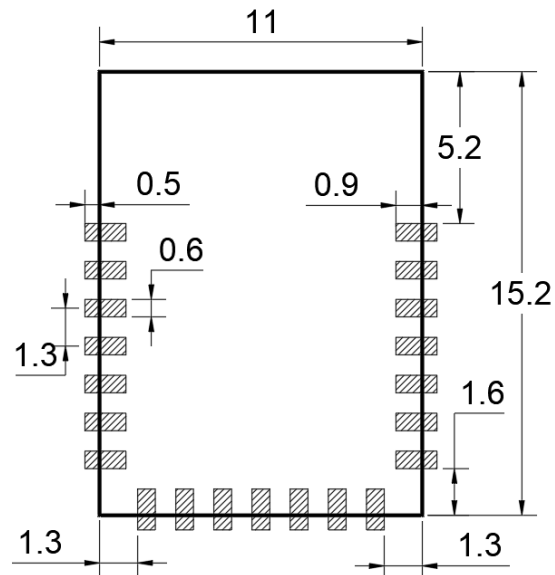
5.1. Assembly Dimension Diagram

Figure 4 Dimension diagram (unit: mm, tolerance: ± 0.1 , outside: $+0.2$)



5.2. Recommended package diagram

Figure 5 DIP packaging dimension diagram (unit: mm, tolerance: ± 0.1 , outside: $+0.2$)



6. Production Guidelines

MXCHIP stamp port packaging module must be SMT machine patches, module humidity sensitivity grade MSL3, after unpacking more than a fixed time patches to bake module.

- SMT patches require instruments
 - Reflow bonding machine
 - AOI detector
 - 6-8mm suction nozzle
- Baking requires equipment:
 - Cabinet oven
 - Anti-static, high temperature tray
 - Antistatic and heat resistant gloves

The storage conditions of MXCHIP module are as follows:

- Moisture-proof bags must be stored in an environment with temperature < 30 degree C and humidity < 85% RH.
- A humidity indicator card is installed in the sealed package.

Figure 6 Humidity Card



After the module is split, if the humidity card shows pink, it needs to be baked.

The baking parameters are as follows:

- The baking temperature is $120^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and the baking time is 4 hours.
- The alarm temperature is set to 130°C .
- SMT patches can be made after cooling < 36°C under natural conditions.
- Drying times: 1 time.
- If there is no welding after baking for more than 12 hours, please bake again.

If the disassembly time exceeds 3 months, SMT process is forbidden to weld this batch of modules, because PCB gold deposition process, over 3 months, pad oxidation is serious, SMT patch is likely to lead to virtual welding, leak welding, resulting in various problems, our company does not assume the corresponding responsibility.

Before SMT patch, ESD (Electrostatic Discharge, Electrostatic Release) protection should be applied to the module.

SMT patches should be made according to the reflow curve. The peak temperature is 250°C.

In order to ensure the qualified rate of reflow soldering, 10% of the first patches should be taken for visual inspection and AOI testing to ensure the rationality of furnace temperature control, device adsorption mode and placement mode, and 5-10 patches per hour are recommended for visual inspection and AOI testing in subsequent batch production.

6.1. Precautions

- Operators of each station must wear static gloves during the entire production process.
- Do not exceed the baking time when baking.
- It is strictly forbidden to add explosive, flammable, or corrosive substances during baking.
- When baking, the module uses a high temperature tray to be placed in the oven to keep the air circulation between each module while avoiding direct contact between the module and the inner wall of the oven.
- When baking, please close the oven door to ensure that the oven is closed to prevent temperature leakage and affect the baking effect.
- Try not to open the door when the oven is running. If it must be opened, try to shorten the time for opening the door.
- After baking, the module should be naturally cooled to <36°C before wearing the static gloves to avoid burns.
- When operating, strictly guard against water or dirt on the bottom of the module.

The temperature and humidity control level of MXCHIP factory module is Level3, and the storage and baking conditions are based on IPC/JEDEC J-STD-020.

6.2. Storage Condition

Figure 7 Storage Conditions Diagram

	CAUTION This bag contains MOISTURE-SENSITIVE DEVICES	LEVEL 3 <small>If Blank, see adjacent bar code label</small>
<p>1. Calculated shelf life in sealed bag: 12 months at <40°C and <90% relative humidity (RH)</p> <p>2. Peak package body temperature: <u>260</u> °C <small>If Blank, see adjacent bar code label</small></p> <p>3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must a) Mounted within: <u>168</u> hrs. of factory conditions <small>If Blank, see adjacent bar code label</small> ≤30°C/60%RH, OR b) Stored at <10% RH</p> <p>4. Devices require bake, before mounting, if: a) Humidity Indicator Card is > 10% when read at 23 ± 5°C b) 3a or 3b not met.</p> <p>5. If baking is required, devices may be baked for 48 hrs. at 125±5°C</p> <p>Note: If device containers cannot be subjected to high temperature or shorter bake times are desired, reference IPC/JEDEC J-STD-033 for bake procedure</p> <p>Bag Seal Date: _____ <small>If Blank, see adjacent bar code label</small></p> <p>Note: Level and body temperature defined by IPC/JEDEC J-STD-020</p>		

7. Label Information

Figure 8 Module Label Schematic Diagram



1. MXCHIP: Company Logo.
2. FCC ID: FCC Authorization ID
3. Product Module: EMB1016-P
4. ZG6: Product extended code
5. W2145: Production serial number
6. B0F89300A528: MAC address.
7. QR code: MAC Address.

Note: Due to production batches and versions, etc., the above label schematics are for reference only, please refer to the actual product.

8. FCC Declaration

8.1. Trace antenna designs

For a modular transmitter with trace antenna designs, see the guidance in Question 11 of KDB Publication 996369 D02 FAQ – Modules for Micro-Strip Antennas and traces. The integration information shall include for the TCB review the integration instructions for the following aspects: layout of trace design, parts list (BOM), antenna, connectors, and isolation requirements.

- a) Information that includes permitted variances (e.g., trace boundary limits, thickness, length, width, shape(s), dielectric constant, and impedance as applicable for each type of antenna);
- b) Each design shall be considered a different type (e.g., antenna length in multiple(s) of frequency, the wavelength, and antenna shape (traces in phase) can affect antenna gain and must be considered);
- c) The parameters shall be provided in a manner permitting host manufacturers to design the printed circuit (PC) board layout;
- d) Appropriate parts by manufacturer and specifications;
- e) Test procedures for design verification; and
- f) Production test procedures for ensuring compliance.

The module grantee shall provide a notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify the module grantee that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the grantee, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.

Explanation: Yes, The module with trace antenna designs, and This manual has been shown the layout of trace design,, antenna, connectors, and isolation requirements.

8.2. RF exposure considerations

It is essential for module grantees to clearly and explicitly state the RF exposure conditions that permit a host product manufacturer to use the module. Two types of instructions are required for RF exposure information: (1) to the host product manufacturer, to define the application conditions (mobile, portable – xx cm from a person's body); and (2) additional text needed for the host product manufacturer to provide to end users in their end-product manuals. If RF exposure statements and use conditions are not provided, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID (new application).

Explanation: This module complies with FCC RF radiation exposure limits set forth for an uncontrolled environment, This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body." This module is designed to comply with the FCC statement, FCC ID is: P53-EMB1016.

8.3. Antennas

A list of antennas included in the application for certification must be provided in the instructions. For modular transmitters approved as limited modules, all applicable professional installer instructions must be included as part of the information to the host product manufacturer. The antenna list shall also identify the antenna types (monopole, PIFA, dipole, etc. (note that for example an “omni-directional antenna” is not considered to be a specific “antenna type”)).

For situations where the host product manufacturer is responsible for an external connector, for example with an RF pin and antenna trace design, the integration instructions shall inform the installer that unique antenna connector must be used on the Part 15 authorized transmitters used in the host product. The module manufacturers shall provide a list of acceptable unique connectors.

Explanation: The EUT has a PCB Antenna, and the antenna use a permanently attached antenna which is unique.

8.4. Label and compliance information

Grantees are responsible for the continued compliance of their modules to the FCC rules. This includes advising host product manufacturers that they need to provide a physical or e-label stating “Contains FCC ID” with their finished product. See [Guidelines for Labeling and User Information for RF Devices – KDB Publication 784748](#).

Explanation: The host system using this module, should have label in a visible area indicated the following texts: "Contains FCC ID: P53-EMB1016.

8.5. Information on test modes and additional testing requirements

Additional guidance for testing host products is given in KDB Publication 996369 D04 Module Integration Guide. Test modes should take into consideration different operational conditions for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product.

The grantee should provide information on how to configure test modes for host product evaluation for different operational conditions for a stand-alone modular transmitter in a host, versus with multiple, simultaneously transmitting modules or other transmitters in a host.

Grantees can increase the utility of their modular transmitters by providing special means, modes, or instructions that simulates or characterizes a connection by enabling a transmitter. This can greatly simplify a host manufacturer’s determination that a module as installed in a host complies with FCC requirements.

Explanation: Top band can increase the utility of our modular transmitters by providing instructions that simulates or characterizes a connection by enabling a transmitter.

8.6. Additional testing, Part 15 Subpart B disclaimer

The grantee should include a statement that 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. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuitry), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

Explanation: The module without unintentional-radiator digital circuitry, so the module does not require an evaluation by FCC Part 15 Subpart B. The host should be evaluated by the FCC Subpart B.

- The module is limited to OEM installation ONLY.
- The OEM integrator is responsible for ensuring that the end-user has no manual instructions to remove or install module.
- The module is limited to installation in mobile or fixed applications

Appendix: Sales and Technical support Information

If you need to consult or purchase this product, please call Shanghai MXCHIP Information Technology Co., Ltd. during office hours.

Office hours: Monday to Friday morning: 9:00-12:00, afternoon: 13:00-18:00

Contact Tel: +86-21-52655026

Address: 9th Floor, Lane 5, 2145 Jinshajiang Road, Putuo District, Shanghai

Zip code: 200333

Email: sales@mxchip.com