

EMB1013 Bluetooth low energy module

Built-in MX1510 Bluetooth low energy microcontroller, 64 KB static memory, 512 KB flash memory

Bluetooth 5.1, security algorithms, high integration, rich peripherals

Version: 1.1

Date: 2023-09-11

No. : DS0200EN

Summary

- **Voltage input: 1.8 V ~ 3.6 V** Watchdog timer: IWDG and WWDG
- **Operating Temperature: -40 °C to + 85 °C**
- **Processor: MX1510**
 - Cortex-M0 kernel
 - Running at 64 MHz
- **Memory**
 - 64KB SRAM
 - 512KB XIP Flash
- **Bluetooth features**
 - Support for BLE 5.0/5.1, Bluetooth Mesh
 - Supports 125Kbps/500Kbps/1Mbps/2Mbps
 - Sensitivity: -96dBm@1mbps, 93dBm@2mbps, 105dBm@125kbps
 - Transmit Power: + 7dBm
 - Support for Single-Ended Antenna Output
- **Rich peripherals**
 - Up to 18 universal ios
 - 2-way I2C interface (with bus arbitration)
 - 2-way SPI interface
 - 3-way UART (supports ISO7816, Lin, Irda, etc.)
 - 2-way PDM interface, Digital Mic support,
 - 1-way I2S interface
 - 12-bit high-resolution SAR ADC, 5 channels
 - 6 timers, 14 PWM outputs, 4 complementary
 - RTC: supports high-precision hardware temperature compensation

● **Security and acceleration unit**

ECC (256)

AES (256/192/128)

T/DES (192/128/64)

True random number generation (TRNG)

Operation Accelerator (Calc)

● **Interface and size**

PCB antenna on board

3x7 pins, double rows of 1.4 mm spaced stamp holes,
1.8 mm spaced gold fingers

15.8 mm x 17.5 mm, gold finger size 2.8 mm x 12.8
mm

● **Rich set of software**

Support for the MXOS operating system

Support for XBT Bluetooth protocol stack, support for
broadcast, Scan, Peripheral and Central mode,
support for extended broadcast, Long-Range and
other 5.0 new features

Support for Bluetooth SIG Mesh

Support for MXCHIP MXMesh stack

Controller and Host modes are supported

Bluetooth AT firmware with Passthrough support

● **Order code**

Order code	Instructions
EMB1013-PZG7	PCB antenna on board

Notes on version updates

Date	Version	Update
2021-12-10	0.1	Initial version
2022-08-10	1.0	Adding a package diagram
2023-09-11	1.1	Updating electrical parameters

Copyright notice

All or any part of this manual shall not be used or reproduced without permission. This applies in particular to trademarks, model designations, part numbers and drawings.

Data in documentation below version 1.0 is for reference only and may still be adjusted and modified before final production.

1. Introduction to modules

MX1510 bluetooth microcontroller with Cortex-M0 ARM core at 64 MHz. It has the rich peripherals of a traditional microcontroller. Can be used as a host processor in a variety of embedded applications; also integrated with the latest Bluetooth communication technology, support broadcast, point-to-point, Mesh networking and other communications, it can upgrade the traditional embedded devices intelligently. It has a wide range of applications and has a very high cost-effective.

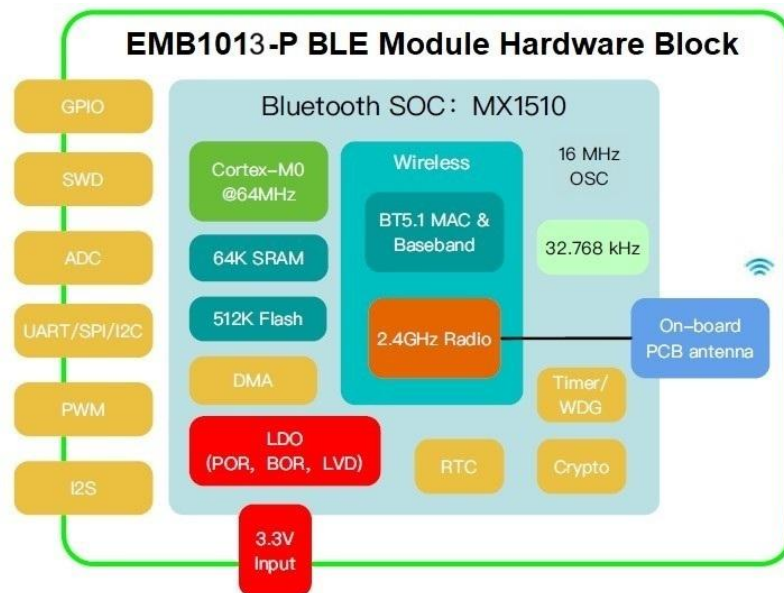
The EMB1013 series modules are based on MX1510 Bluetooth microcontrollers, which can use rich peripheral interfaces to achieve data acquisition and control, and communicate with other Bluetooth devices through the built-in Bluetooth subsystem, not only can it interact directly with the phone, but it can also connect data to the Internet of Things Cloud Service Platform through the Mesh network. This series of modules through a variety of different sizes, interface forms, antenna interface, used in a wide range of Internet of things products.

Shanghai Qingke provides MXOS software platform to support the development of EMB1013 series modules, providing an efficient development environment. MXOS includes XBT Bluetooth protocol stack, XMESH SDK, various Bluetooth sample programs and typical applications.

The following is the hardware block diagram of the EMB1013 module, including:

- Bluetooth microcontroller MX1510
- On-board antenna
- Power and communication interface

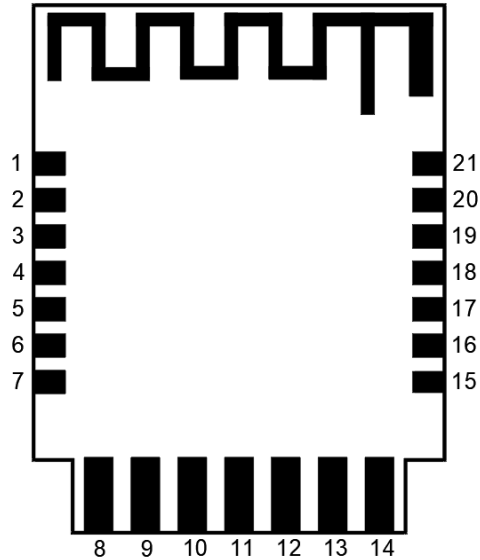
Fig. 1 hardware interface diagram



2. PIN definition

2.1. PIN distribution

Fig. 2 pin distribution (top view)



2.2. PIN definition

Table 1 pin definitions

Serial number	Name	Type	Description	Recommended settings (2)
1	PB12	I/o/Analog	GPIO/ADC	
2	PB13	I/o/Analog	GPIO/ADC	
3	PB14	I/O	GPIO/Boot (1)	Boot (1)
4	PB15	I/O	GPIO/Wakeup	STATUS
5	PA00	I/o/Analog	GPIO/ADC/Wakeup	
6	PB01	I/O	GPIO/UART1, debug serial port (1) , ISP Burn	Debug
7	PB00	I/O	GPIO/UART1, debug serial port (1) , ISP Burn	Debug
8	PA01	I/o/Analog	GPIO/ADC	
9	PA02	I/o/Analog	GPIO/ADC	
10	PA07	I/O	GPIO	
11	PA08	I/O	GPIO	
12	PA09	I/O	GPIO	
13	GND	Power		
14	VDD33	Power	3.3 V Power Input	
15	PB11	I/O	GPIO/Wakeup:	USER
16	PB10	I/O	GPIO	USER
17	PB05	I/O	GPIO/SWDIO	SWDIO

18	NRST	I	Reset signal, active at low level	Reset
19	PB06	I/O	GPIO/SWCLK	SWCLK
20	PB08	I/O	GPIO	
21	PB09	I/O	GPIO	

Special notes:

1. The hardware detects PB14 at boot time and decides whether to enter ISP mode. This is a hardwired feature, so it can not be modified. When using the SDK or firmware provided by MXCHIP, the firmware also detects the PB15 pin and decides whether to enter QC mode.

All the module specific modes of operation and mode of entry are shown in Table 2 module mode of Operation Selection:

- ISP mode: through the UART connection module PB00(UART1) and PB01(UART1) , you can use the burn tool on-chip Flash programming. This mode is mainly used for production, at development time, you can directly through the SWD debug interface using the emulator to download firmware.
- QC mode: internal test program is executed and test data is output via PB11(USER) and PB10(USER) . Serial port parameters: 115200/8/n/1.
- Normal Mode: Normal execution of the application.

Table 2 module mode selection

Mode of operation	PB14	PB15
	Default state: 0	Default state: 1
ISP	1	x
X	0	1
QC	0	0

2. The processor can be configured to ATTACH GPIO to any digital peripheral. In the module SDK provided by qingke, the recommended settings are used by default.

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 Output Level Voltage			0.4	V
Source Current			60		mA
Sink Current			30		mA
VESD	Electrostatic discharge voltage		± 2000		V

3.2. Typical power consumption

Mode	Average	Max.	Unit
TX MODE@0dBm 1Mbps, CPU 64 MHz	15.8	31.9	mA
TX MODE@7dBm 1Mbps, CPU 64 MHz	27.3	35.2	mA
Rx Mode@1Mbps, CPU 64 MHz	16.2	22	mA
RF Idle@CPU 64 MHz	6.8	10	mA
Standby Mode	2		mA
Low Power Mode 2	1.1		mA
Low Power Mode 3	0.7		mA

3.3. RF parameters

Table 3 basic RF parameters

Item	Specification
Operating Frequency	2.400-2.4835 GHz
Channel BW	≤3 MHz
Antenna Interface	1T1R, Single stream
Bluetooth Standard	Bluetooth 5.1
Modulation Type	GFSK
Antenna type	One U. F. L connector for external antenna

Table 4 RF reception parameters

Symbol	Description	Min.	Typ.	Max.	Unit
Receiver operation					
PRXMAX	Maximum received signal strength at < 0.1%		-1.5		dBm
PRXSENS, 2m	Sensitivity (0.1% BER) at 2mbps		-96	-97	dBm
PRXSENS, 1m	Sensitivity (0.1% BER) at 1mbps		-99.7	-100.7	dBm
PRXSENS, 500K	Sensitivity (0.1% BER) at 500kbps		-98	-99	dBm
Prxsens, 250K	Sensitivity (0.1% BER) at 125kbps		-104	-105	dBm
PSENS IT 1mbps BLE	Receiver sensitivity: Ideal transmitter		-99	-100	dBm
PSENSDT 1mbps BLE	Receiver sensitivity: Dirty transmitter		-98.5	-99.5	dBm

Table 5 RF emission parameters

Symbol	Description	Min	Typ	Max	Unit
Low Power Pa.					
PRF	Maximum output power		7		dBm
PRFC	RF power control range		40		dB
PBW1	20dB bandwidth for modulated carrier		1000		KHz
FDR	Frequency Drift Error				KHz

4. Antenna information

An on-board PCB antenna was designed by EMB1013.

4.1. PCB antenna parameters and usage

4.1.1. PCB antenna parameters on board

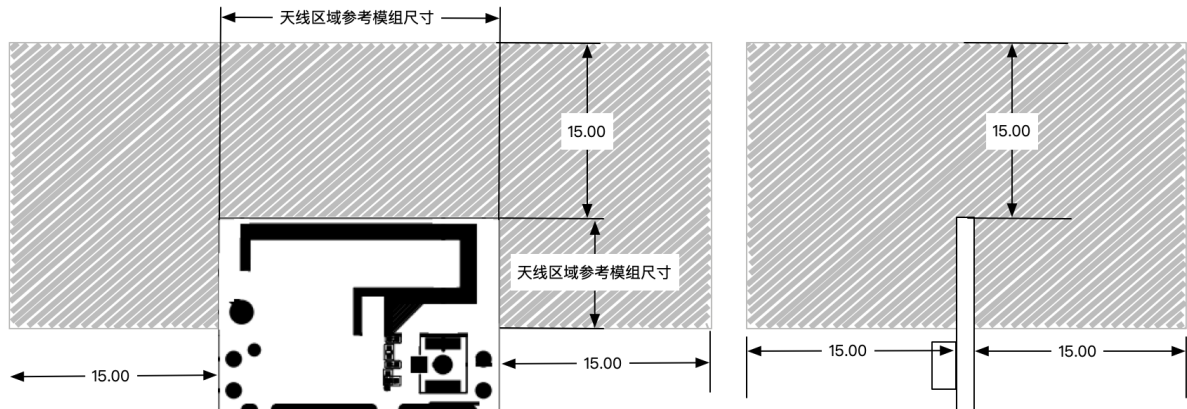
Table 6 parameters of PCB antenna

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

4.1.2. Key points in using PCB antenna

When using the PCB antenna on the module, make sure that the distance between the motherboard PCB and other metal devices, connectors, PCB vias, wiring, and copper cladding is at least 15 mm. The shaded areas should be kept away from metal components, sensors, sources of interference, and other materials that could interfere with the signal.

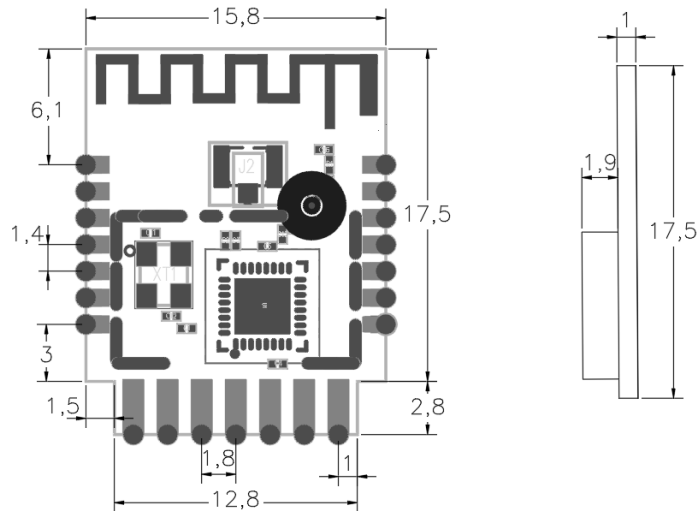
Fig. 3 schematic of minimum clearance area of PCB antenna (mm)



5. Final assembly size and PCB package

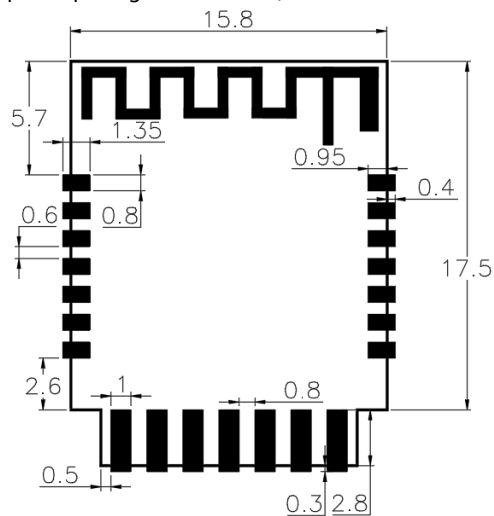
5.1. Dimension drawing of final assembly

Fig. 4 size diagram (in mm, error ± 0.1 , periphery $+ 0.2/-0.1$)



5.2. Recommended package diagram

Fig. 5 postage stamp hole package dimensions (in mm, tolerance ± 0.1 mm, peripheral $+ 0.2/-0.1$)



6. Production Guide

Qingke factory stamp mouth packaging module must be SMT machine placement, module humidity sensitive grade is MSL3, unpacking more than a fixed time before placement to bake the module.

- SMT chip needs instruments
 - (1) reflow mounter
 - (2) Aoi Detector
 - (3) 6-8mm nozzle
- Baking equipment:
 - (1) cabinet oven
 - (2) anti-static, high temperature tray
 - (3) anti-static and heat-resistant gloves

The storage conditions of the modules manufactured by Qingke are as follows:

- Moisture-proof bags must be stored at $< 30^{\circ}\text{C}$ and $< 85\% \text{ Rh}$.
- The sealed package contains a humidity indicator card.

Fig. 6 humidity card



Module split if the humidity card shows pink, you need to bake.

The baking parameters are as follows:

- Baking temperature: $120^{\circ}\text{C} \pm 5^{\circ}\text{C}$; baking time: 4 h;
- Alarm temperature was set at 130°C ;
- The SMT patch can be carried out after cooling $< 36^{\circ}\text{C}$ under natural condition
- Drying times: 1 time;
- If no welding occurs more than 12 hours after baking, bake again.

If the unpacking time is more than 3 months, it is prohibited to use SMT process to solder this batch of modules, because the PCB sink gold process, more than 3 months pad oxidation is serious, SMT patch is likely to lead to virtual solder, leakage solder, we will not be responsible for any problems caused by this

Before Smt Mount, please protect the module with ESD (electrostatic discharge, electrostatic discharge)

Please SMT according to the reflow curve, peak temperature 250 °C.

In order to ensure the qualified rate of reflow soldering, please sample 10% products for visual inspection and Aoi Test to ensure the rationality of Furnace Temperature Control, device adsorption mode and placement mode It is recommended to take 5-10 chips per hour for visual inspection and Aoi test for mass production.

Cautions

All operators must wear electrostatic gloves throughout the production process

Baking time should not exceed the baking time

No explosive, flammable or corrosive substances are allowed to be added during baking

When baking, the module should be placed in the oven with high temperature tray to keep air circulation between each module and avoid direct contact between the module and the inner wall of the oven

When baking, please close the door of the oven, ensure the oven closed, prevent temperature leakage, affect the baking effect;

Don't open the oven door when the oven is running. If it must be opened, shorten the opening time as much as possible

After baking, need to wait for the module natural cooling to < 36 °C, can wear electrostatic gloves out, so as not to burn;

When operating, prevent the bottom of the module from getting wet or dirty;

Qingke factory module temperature and humidity control level 3, storage and baking conditions according to IPC/JEDEC J-STD-020.

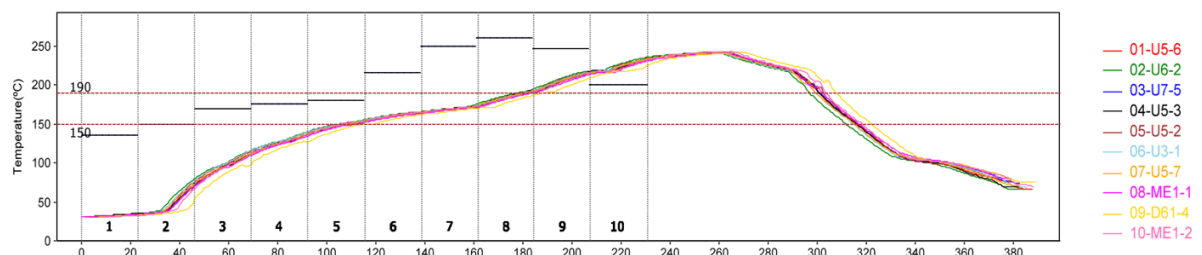
Secondary reflux temperature curve

Recommended solder paste type: SAC305, lead-free. No more than 2 reflows. The peak temperature does not exceed 245 °C. Here is a typical furnace temperature curve setting.

Table 7 typical furnace temperature settings

Setting of	Z1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z10
Upper	135	150	170	175	180	215	250	260	247	200
Lower	135	150	170	175	180	215	250	260	247	200

Fig. 7 typical secondary reflux temperature curve



30 °C-150 °C preheating temperature rise: 0-3 °C/S, typical value: 1.2 °C/s

150 °C-190 °C immersion time: 60-100 s, Typ. : 72 s

Peak Temperature: 245 °C, typical: 242 °C

Time above 220 °C: 50-90 seconds, typical: 70 seconds

217 °C cooling rate: -3—0 °C/S, typical value: -2.0 °C/s

6.1. Storage conditions

Fig. 8 schematic diagram of storage conditions

	CAUTION This bag contains MOISTURE-SENSITIVE DEVICES	LEVEL 3
If Blank, see adjacent bar code label		
1. Calculated shelf life in sealed bag: 12 months at <40°C and <90% relative humidity (RH)		
2. Peak package body temperature: <u>260</u> °C		
If Blank, see adjacent bar code label		
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		
If Blank, see adjacent bar code label		
≤30°C/60%RH, OR		
b) Stored at <10% RH		
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.		
5. If baking is required, devices may be baked for 48 hrs. at 125±5°C		
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		
Bag Seal Date: _____		
If Blank, see adjacent bar code label		
Note: Level and body temperature defined by IPC/JEDEC J-STD-020		

7. Label information

Fig. 9 schematic diagram of labels



MXCHIP: Company logo

EMB1013-P: product model

FCC ID: model license ID

ZG7: Product Extension

W2145: production serial number

B0F89300A528: module MAC address

QR code: Module MAC address

Note: Due to the production batch and version and other reasons, the above labels are for reference only, please refer to the material.

8. FCC Information

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.

8.1 FCC Warning

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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

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

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.

8.2 Notice

1. The module is limited to OEM installation ONLY.
2. The OEM integrators is responsible for ensuring that the end-user has no manual instructions to remove or install module.
3. That module is limited to installation in mobile or fixed applications, according to Part 2.1091(b).
4. That separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093 and different antenna configurations.

9. Sales and technical support information

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

Office hours:

Monday to Friday: 9 a.m. to 12 p.m. ; 13 p.m. to 18 p.m.

Tel: + 86-21-52655026

Address: 9/F, Lane 5,2145 Jinshajiang Road, Putuo District, Shanghai

Postcode: 200333

Email: sales@mxchip.com

Requirement per KDB996369 D03

2.2 List of applicable FCC rules

List the FCC rules that are applicable to the modular transmitter. These are the rules that specifically establish the bands of operation, the power, spurious emissions, and operating fundamental frequencies. DO NOT list compliance to unintentional-radiator rules (Part 15 Subpart B) since that is not a condition of a module grant that is extended to a host manufacturer. See also Section 2.10 below concerning the need to notify host manufacturers that further testing is required.3Explanation: This module meets the requirements of FCC part 15C(15.247).

2.3 Summarize the specific operational use conditions

Describe use conditions that are applicable to the modular transmitter, including for example any limits on antennas, etc. For example, if point-to-point antennas are used that require reduction in power or compensation for cable loss, then this information must be in the instructions. If the use condition limitations extend to professional users, then instructions must state that this information also extends to the host manufacturer's instruction manual. In addition, certain information may also be needed, such as peak gain per frequency band and minimum gain, specifically for master devices in 5 GHz DFS bands.

Explanation: The EUT has a PCB Antenna, , and the antenna use a permanently attached Antenna which is not replaceable.

2.4 Limited module procedures

If a modular transmitter is approved as a "limited module", then the module manufacturer is responsible for approving the host environment that the limited module is used with. The manufacturer of a limited module must describe, both in the filing and in the installation instructions, the alternative means that the limited module manufacturer uses to verify that the host meets the necessary requirements to satisfy the module limiting conditions.

A limited module manufacturer has the flexibility to define its alternative method to address the conditions that limit the initial approval, such as: shielding, minimum signaling amplitude, buffered modulation/data inputs, or power supply regulation. The alternative method could include that the limited module manufacturer reviews detailed test data or host designs prior to giving the host manufacturer approval. This limited module procedure is also applicable for RF exposure evaluation when it is necessary to demonstrate compliance in a specific host. The module manufacturer must state how control of the product into which the modular transmitter will be installed will be maintained such that full compliance of the product is always ensured. For additional hosts other than the specific host originally granted with a limited module, a Class II permissive change is required on the module grant to register the additional host as a specific host also approved with the module.

Explanation: The module is not a limited module.

2.5 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 wave-length, 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;
- 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.

2.6 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 – 20 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 for 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-EMB1013

2.7 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 "omnidirectional 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 a 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 uses a permanently attached antenna, which is unique.

2.8 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-EMB1013

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

2.10 Additional testing, Part 15 Subpart B disclaimer

The modular transmitter is only FCC authorized for FCC Part 15 Subpart C 15.247 & 15.209 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.