General Description

ETM5200 is a Bluetooth Stereo module with fully-certified Bluetooth® Version 4.2 and 5.0 (BDR/EDR) for who wants to add Bluetooth® wireless audio and voice applications to products. This Bluetooth module provides a complete wireless solution with Bluetooth stack, integrated antenna, and worldwide radio certifications in a compact surface mount package, 29x15x1.7 mm(+/-10%). This stereo module built-in Li-Ion charger and contain a digital audio interface. It supports A2DP v1.3, AVRCP v1.6, HFP v1.7,HID v1.1, AVCTP v1.4, AVDTP v1.3,and SPP v1.2 profile. Note that the customer must connect their own external analog CODEC/DSP amplifier and MCU for audio output.

The ETM5200 module is a low power consumption, highly integrated Bluetooth system as an audio module. It integrates a high performance antenna, crystal and Bluetooth chip, which included RF transceiver, baseband processor, FLASH memory controller, multiple analog and digital peripherals, and a Bluetooth software stack including the audio, voice, and SPP profiles.

The cache based architecture enables full programmability with an SIP 8M FLASH memory device and can be used for both control and multimedia hybrid applications. The internal dual stereo ADC converts stereo analog input to digital signals that can be processed with a digital equalizer. Hardware realizations of the equalizer offload the MCU making the chip ideal for low power headset applications.

The module incorporates on-chip power management with linear and switch-mode buck regulators and also includes a 220 mA internal battery charge controller to further reduce external bill of material (BOM) costs.

Features

- Operation voltage from 2.8 V to 4.2 V
- 9 mA average current for A2DP
- 300 uA for 500 ms sniff current
- 0.8 uA deep sleep current
- Bluetooth Version 4.2 and 5.0 classic and low energy (backwards-compatible with Bluetooh 4.2)
- A2DP v1.3, AVRCP v1.6, HFP v1.7,HID v1.1, AVCTP v1.4, AVDTP v1.3,and SPP v1.2 profile
- True wireless stereo and two active link
- Two wires UART download interface
- 16 bits stereo ADC and DAC
- Stereo line in and dual microphone
- Five bands digital hardware equalizer
- SPI, UART, I2C, SDIO and USB
- I2S master and slave interface with MCLK output
- Interface for external PA and LNA
- Up to 220 mA battery charge controller

Applications

- Bluetooth stereo speaker with TWS
- Bluetooth Audio system linked with mobile phone
- Bluetooth Sound Bar
- Bluetooth stereo headset
- Bluetooth control and multimedia hybrid

Photo

1. Absolute Maximum Ratings

Parameter	Maximum Rating	Unit
VCC4BAT	-0.3 to 4.2	V
VCC5USB	4.75 to 5.75	V
VCCAUD	1.6 to 2.4	V
VCC3XTAL	2.8 to 3.8	V
Prx	10	dBm
Tstr	-40 to 150	℃

Notes:
1. Operation of this device in excess of any maximum rating as specified above may cause permanent damage to the device.
2. **Caution! ESD Sensitive Device.**

2. Specification Summary

Recommended Operating Conditions

Parameter	MIN	TYP	MAX	Unit	Test condition and description
VCC4BAT	2.8	3.6	4.2	V	Battery regulator supply voltage
VCC5USB	4.75	5	5.75	V	USB power supply voltage
VCCBT	1.6		2.4	V	BT transceiver supply voltage
VCCAUD	1.6		2.4	V	Audio supply voltage
VCC3XTAL	2.8		3.8	V	Crystal supply voltage
Topr	-20		80	℃	Operation temperature range

System LDO

Parameter	MIN	TYP	MAX	Unit	Test condition and description
VCC4BAT	2.8		4.2	V	Battery input voltage
VCC3SYS	2.8	3.2	3.8	V	LDO output voltage
Load Current			200	mA	Load current

USB LDO

Parameter	MIN	TYP	MAX	Unit	Test condition
VCC5USB	4.75	5	5.75	V	USB input voltage
VCC3SYS		3.3		V	LDO output voltage
Load Current			200	mA	Load current

BATTERY CHARGE

Parameter	MIN	TYP	MAX	Unit	Test condition
VCC5USB	4.75	5	5.75	V	Charger input voltage
I_trickle		10			Charger current at trickle mode as percent of fast change mode
I_fast	40		220	mA	Charge current at fast charge mode
V_end (need Calibrated)		4.2		V	VBAT voltage when charge end

Analog LDO/BUCK

Parameter	MIN	TYP	MAX	Unit	Test condition
Analog LDO					
VDDANA	1.6	1.8	2.4	V	Analog output voltage
Load Current			150	mA	Load current
Analog Buck					
VDDANA	1.6	1.8	2.4	V	Analog buck output voltage
Load Current			150	mA	Load current
Switching Frequency	0.5	1	6	MHz	Buck modulation frequency

Digital LDO/BUCK

Parameter	MIN	TYP	MAX	Unit	Test condition
Digital LDO					
VDDDIG	1.0	1.2	1.34	V	Analog output voltage
Load Current			40	mA	Load current
Digital Buck					
VDDDIG	1.0	1.2	1.35	V	Analog buck output voltage
Load Current			40	mA	Load current
Switching Frequency	0.5	1	6	MHz	Buck modulation frequency

Typical Power Consumption

Parameter	MIN	TYP	MAX	Unit	Test condition
Shutdown		0.4	0.8	uA	Software sets device info shut down mode. Wake up from GPIO5
Standby		4	6	uA	Software sets device info standby mode. Wake up from GPIUO and RTC timer
Idle-sniff		300		uA	Idle state at Sniff mode
Active(A2DP)		9		mA	2DH5
Active(HFP)		9.5		mA	HV1

RF Characteristics

Parameter	MIN	TYP	MAX	Unit	Test condition
Operate frequency	2402		2480	MHz	2402-2480
RXSENS-1Mbps		-88		dBm	BER=0.001
RXSENS-2Mbps		-91		dBm	BER=0.0001
RXSENS-3Mbps		-83		dBm	BER=0.00001
Maximum received signal	0			dBm	BER=0.001
Maximum RF transmit power		8		dBm	
RF power control range	30			dB	

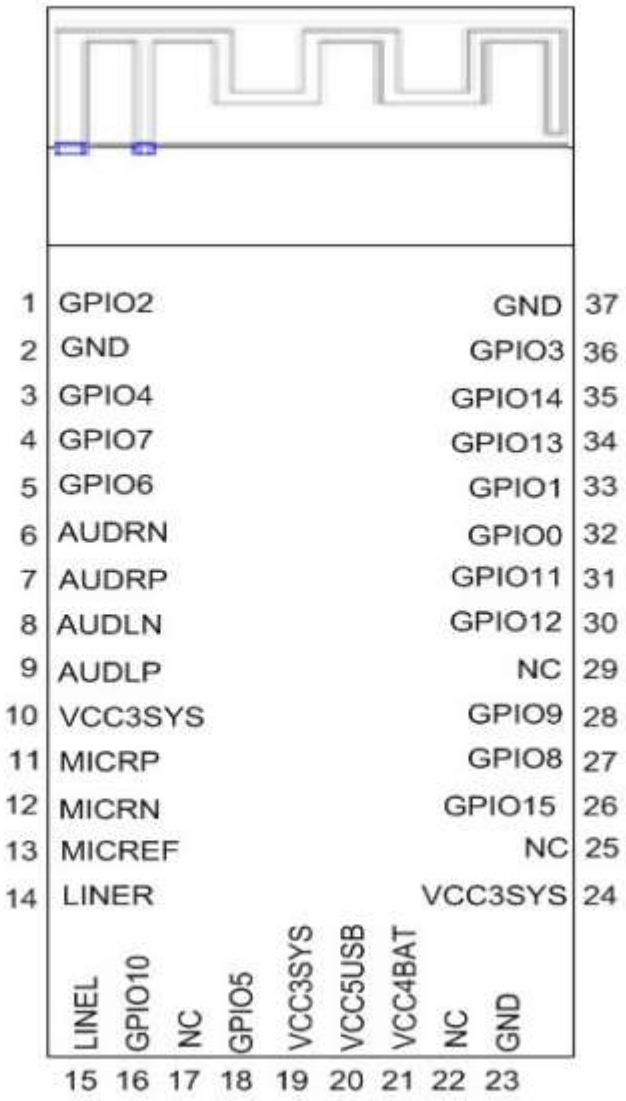
Audio Characteristics

Parameter	MIN	TYP	MAX	Unit	Test condition
DAC diff. output			1.1	Vrms	With 600 ohm loading
		-	-	Vrms	With 32 ohm loading
			0.9	vrms	With 16 ohm loading
DAC Diff. output THD		75		dB	With 1.1Vrms@600ohm loading 75 dB
		75		dB	With 0.8Vrms@16ohm loading
DAC output SNR		98		dB	1KHz sine wave
DAC sample rate	8		48	KHz	
ADC SNR		96		dB	1KHz sine wave
ADC sample rate	8		48	KHz	

3. Functional Pin Description

The ETM5200 is available in 37 Stamped pins Lane Grid Array package on 29x15mm Module.

Top view



37-Pin GLA Module with Shielding can on 29x15mm diagram

Pin name and Description

Pin Num	Pin name	Description
1	GPIO2	GPIO2/SPI_CSN/ADC1/IrDA/Capture Time
2	GND	Ground Pin
3	GPIO4	GPIO4/SPI_MOSI//I2C_SCL
4	GPIO7	GPIO7/PWM1 / USBN
5	GPIO6	GPIO6/PWM0 / USBP
6	AUDRN	Differential Right Negative
7	AUDRP	Differential Right Positive
8	AUDLN	Differential Left Negative
9	AUDLP	Differential Left Positive
10	VCC3SYS	System LDO output
11	MICRP	Microphone mono differential analog positive input
12	MICRN	Microphone mono differential analog Negative input
13	MICREF	Microphone biasing voltage
14	LINER	Right channel single ended analog input
15	LINEL	Left channel single ended analog input
16	GPIO10	GPIO10/SD_DATA0/RX_EN/SPI2_MISO
17	NC	NC
18	GPIO5	GPIO5/SPI_MISO//I2C_SDA
19	VCC3SYS	System LDO output
20	VCC5USB	USB charge power input
21	VCC4BAT	Battery input
22	NC	NC
23	GND	Ground Pin
24	VCC3SYS	System LDO output
25	NC	NC
26	GPIO15	GPIO15/Soft shut down and wake up (active high)
27	GPIO8	GPIO8/SD_CLK//SPI2_SCK
28	GPIO9	GPIO9/SD_CMD/TX_EN/SPI2_MOSI
29	NC	NC
30	GPIO12	GPIO12/JTAG_TMS/PWM3/PCM_CLK/SD_CMD/SPI2_MOSI
31	GPIO11	GPIO11/JTAG_TCK/PWM2/ADC4/PCM_SYNC/SD_CLK//SPI2_SCK
32	GPIO0	GPIO0/TXD (Download port)
33	GPIO1	GPIO1/RXD (Download port)
34	GPIO13	GPIO13/JTAG_TDI/PWM4/ADC6/PCM_DIN/SD_DATA0/SPI2_MISO
35	GPIO14	GPIO14/JTAG_TDO/PWM5/ADC7/PCM_DOUT
36	GPIO3	GPIO3/SPI_SCK/ADC2/CLKOUT
37	GND	Ground Pin

4. Functional Description

Overview

The ETM5200 is a Bluetooth Module, which includes a single-chip Bluetooth SoC offering advanced audio processing and low power consumption by utilizing dedicated hardware blocks such as a five band equalizer and a hardware accelerator to increase performance and offload the MCU. It has Bluetooth version 4.2 and 5.0 EDR stack and application profiles and can be used for both control and multimedia hybrid applications.

The ETM5200 includes a rich set of analog and digital peripherals that allow users to add features such as a microphone input, stereo line-in inputs, SDIO memory card, and an FM radio to a Bluetooth application enhancing overall user experience.

Modes of Operation

The general operation of the ETM5200 is as follows. After system reset, the ETM5200 enters the low power standby mode waiting for external circuitry via the GPIO interface to wake the device up. Once the device is awake, it will establish a connection with other Bluetooth devices using the Inquire and Paging states. After a connection is made the device can be placed into Active or Sniff mode depending on the master Bluetooth device

Shutdown – In this mode all circuits are powered down except for the GPIO15interface to allow external circuitry to wake-up the device. Software can enter this mode by write special register and system can only be waked up by active level applied on GPIO15.

Standby – In this mode all circuits are powered down except the GPIO interface and a timer active to allow external circuitry and internal timer to wake-up the device. This is the default low power state of the chip while it is waiting to be used. There is no interaction with any Bluetooth devices in this state.

Active – During this mode, the ETM5200 and the other connected Bluetooth device are actively receiving and transmitting data on the channel. This data can be high fidelity audio, voice, or control commands depending on the application.

Sniff – In this mode, the device remains active but listens and communicates at a reduced rate. The device maintains connection with the master with its Active Member Address (AM_ADDR) and goes to sleep and wakes up at assigned Sniff Intervals to exchange packets with the master.

Test – The ETM5200 provides a test mode to test the internal RAM memory BIST and other blocks. The test mode is normally not used.

RF Transceiver

The ETM5200 integrates a high-performance Bluetooth transceiver and frequency synthesizer. The transceiver is fully differential and incorporates an integrated on-chip balun which transforms the single ended RF signal from the antenna, into an internal differential balanced signal for the low noise amplifier (LNA). On the transmit side, the differential outputs of the power amplifier (PA) are combined and transformed to a single-ended output using the same on-chip balun thus enabling only one RF pin connection to the antenna for both transmit and receive operations. The device is able to output +8 dBm of transmit output power allowing users to develop a class 2 (+4 dBm) device with small printed circuit board (PCB) antenna. The frequency synthesizer is fully integrated and does not require any external components.

Bluetooth Baseband

The ETM5200 module has a SOC Bluetooth baseband chip implementing the Bluetooth version 4.2 and 5.0 Enhanced Data Rate (EDR) modem providing Basic Data Rate (BDR) 1 Mbps as well as the enhanced 2 Mbps, and 3 Mbps data rates.

Data Rate	Modulation	Bits/Symbol
BDR: 1 Mbps	GFSK	1
EDR: 2 Mbps	p/4 DQPSK	2
EDR: 3 Mbps	8 DPSK	3

The Bluetooth baseband utilizes a combination of both hardware blocks and firmware for the frequency hopping sequence generator, access code generation, detection, and correlation, encryption and decryption for security, forward error correction, 16-bit CRC, packet construction, and Bluetooth clocks and timers to optimize for power consumption and user programmability.

Audio Peripherals

The ETM5200 comes with a rich set of audio peripherals to enhance the Bluetooth listening experience. The chip includes a 5-band digital equalizer, 96 dB signal to- noise ratio (SNR) stereo analog-to-digital converter (ADC) and digital-to analog converter (DAC), microphone input amplifier and bias, line-in input, and stereo audio left and right (L/R) outputs.

5 – Band Digital Equalizer

A dedicated 5-band digital equalizer is implemented prior to digital-to-analog conversion to give users the option of customizing the frequency response of the audio output. The equalizer is implemented in hardware to reduce overall chip power consumption. The 5-band equalizer is easily configured using the ETM5200 software configuration tool kit. For more information, please refer to the ETM5200 Software Configuration Tool Users Guide.

Stereo ADC and DAC

The ETM5200 module contains high fidelity 96 dB SNR stereo ADCs with sample rates of 8 kHz, 16 kHz, 44.1 kHz, or 48 kHz. The chip also integrates high fidelity 96 dB SNR stereo DACs with sample rates of 8 kHz, 16 kHz, 44.1 kHz or 48 kHz.

Microphone Input Amplifier and Bias

ETM5200 module contains a fully differential analog microphone input amplifier and a low noise microphone bias generator. Expensive external components are not needed as the microphone amplifier and active bias circuitry are integrated into the chip allowing the microphone to be interfaced with only cheap passive resistors and capacitors. The microphone signal can be amplified with gain from -8 ~ 38dB with 0.5 dB step.

Line-in Input

ETM5200 module includes stereo line-in inputs which connect to the stereo left and right channel ADCs through a 0~6 dB amplifier with 2 dB step. The digitized line-in inputs can be further processed with the 5- band equalizer prior to digital-to-analog conversion.

Stereo Audio L/R Outputs

ETM5200 module provides high fidelity stereo audio L/R outputs capable of driving 16 W speakers with up to 30 pF of load capacitance.

MCU

The ETM5200 module includes a 32-bit internal RISC MCU, memory and a DMA bus controller to run the Bluetooth software stack and application while supporting efficient execution and data exchange with the internal SIP FLASH memory. The JTAG interface can be used for on-line debug and can also be configured as GPIO.

FLASH Access Interface

ETM5200 module internal RISC MCU operates with an external FLASH，which is used to store program code, external settings and configurations, and can also be used to store user data such as encryption key configuration and Bluetooth paring information.

TM Bluetooth Software Stack

The ETM5200 module comes with Bluetooth version 4.2 and 5.0 + EDR compliant software stack which run on the internal 32-bit RISC MCU. The SoC also runs the application program removing the need for an external host controller. An external host can be connected through the UART interface for debugging purposes but is not needed to run the application. TM Corporation provides a DEMO kit that customers can use to configure their applications. The interested reader is encouraged to contact their local TM Corporation representative for more information.

Crystal Oscillator

ETM5200 module contains an integrated crystal oscillator driver circuit to drive an external 26 MHz crystal. The 26 MHz crystal frequency provides the reference frequency to the frequency synthesizer and can also be selected as the reference clock to the internal MCU.

Power Management

The power management system on the ETM5200 module includes a battery charger, two buck regulators which can be configured as low–drop out (LDO) regulators and several internal LDO regulators to provide voltage and noise isolation to various parts of the chip.

The ETM5200 module can be powered directly from a 2.8V to 4.2V external battery via theVCC4BAT pin or it can be powered from a 4.75V to 5.75V USB power supply via the VCC5USB pin. For battery powered applications, the ETM5200 will generate 3.2V to the VCC3SYS pin using the SYS LDO regulator for the other of the chip to run off of. When USB power is available, the ETM5200 will get its power from the USB power supply and will use the USB LDO regulator to generate 3.3V for the rest of the system to run from. If a low voltage battery is connected while the USB power supply is applied, the ETM5200 will automatically charge the battery using charge current control while providing power to the chip through the USB LDO regulator.

Please refer to the ETM5200 EVB Users Guide or application note for more details about choosing the proper bypass capacitors.

The two on-chip buck converters reduce the current consumption by about 50% and thus provide a significant improvement in overall chip power consumption. The ETM5200 can enter standby mode when there is no active connection. The standby mode can be awakened by any GPIO signal and by applying the USB power supply.

● GPIO and LED Driver

The ETM5200 has a total 16 GPIOs, which can be configured as shown below:

GPIO	Peripheral Mode
GPIO0	UART_TXD/I2C_SCL
GPIO1	UART_RXD/I2C_SDA
GPIO2	SPI_CSN/ADC1/IrDA/Capture Time
GPIO3	SPI_SCK/ADC2/CLKOUT
GPIO4	SPI_MOSI//I2C_SCL/Line in L
GPIO5	SPI_MISO//I2C_SDA/Line in R
GPIO6	PWM0 / USBP
GPIO7	PWM1 / USBN
GPIO8	SD_CLK//SPI2_SCK
GPIO9	SD_CMD/TX_EN/SPI2_MOSI
GPIO10	SD_DATA0/RX_EN/SPI2_MISO
GPIO11	JTAG_TCK/PWM2/ADC4/PCM_SYNC/SD_CLK//SPI2_SCK
GPIO12	JTAG_TMS/PWM3/PCM_CLK/SD_CMD/SPI2_MOSI
GPIO13	JTAG_TDI/PWM4/ADC6/PCM_DIN/SD_DATA0/SPI2_MISO
GPIO14	JTAG_TDO/PWM5/ADC7/PCM_DOUT
GPIO15	Shutdown IO (Shutdown mode, wake up by active high)

All GPIO pins can wake up the internal MCU from standby mode. In standby mode, any level change on the set GPIO will trigger the wake up procedure.

In shutdown mode, system can be only waked up by GPIO15 high level.

● Timer and Watch Dog Timer

There are two sets of timers. One set (fast) uses 1 MHz clock as the main clock, and another set (slow) uses divided 100 kHz clock as main clock. Each set has three 16-bit counters with 4-bit pre-divider.

The watch dog timer runs from the RC 100 kHz clock and has a maximum programmable period of up to 10.48 (2^16/100kHz * 16) seconds.

● PWM output

There are six PWM timers to provide six PWM output on GPIO. All the timers run with the same frequency, which can be either 26 MHz clock or low power clock.

The PWM timer has 16 bit resolution, with 1~16 pre scalar.

● I2C and UART Interface

There is an I2C interface or UART interface for debug or external MCU control of the ETM5200. They both share the same pins GPIO0 and GPIO1.

The I2C clock rate can be from 12 to 3072 divided frequency from 26 MHz clock.
The UART clock rate can be from 3.2 kHz to 6.5 MHz

● SPI Interface

The 4-wire SPI interface supports high speed data communication which can be used as an interface for an external memory or LCD controller.
The SPI clock rate is from 50.8 kHz to 6.5 MHz when acts as master, and can be 6.5 MHz maximum as slave.

● SDIO Card Interface and USB interface

ETM5200 includes a secure digital input output (SDIO) card interface. It supports either 1-bit mode, 2-bit mode or 4-bit mode. The initial clock rate is 203.125 kHz and can be up to 13 MHz.

The USB interface support both host and device mode, with full speed.

General Purpose SAR ADC

The general purpose SAR ADC has 10-bit resolution with a programmable sampling rate range from 5 kHz up to 50 kHz and is used to measure DC and low frequency voltages. The input voltage range for the ADC is from 0V 0V to 3V. The general purpose ADC has six channels as shown in below table.

Channel Number	Detected Voltage	Description
0	VCCBAT	Monitor battery voltage(0.65*VBAT)
1	GPIO2	GPIO2 voltage
2	GPIO3	GPIO3 voltage
3	VCC5USB	Monitor USB voltage(0.5*VUSB)
4	GPIO11	GPIO11 voltage
5	Temp-Sensor	Temp-Sensor Output voltage
6	GPIO13	GPIO13 voltage
7	GPIO14	GPIO14 voltage

IrDA interface

There is a hardware IrDA decoder interface to decode the signal. Also the interface has the capture timer capability to allow software decoding the input signal.

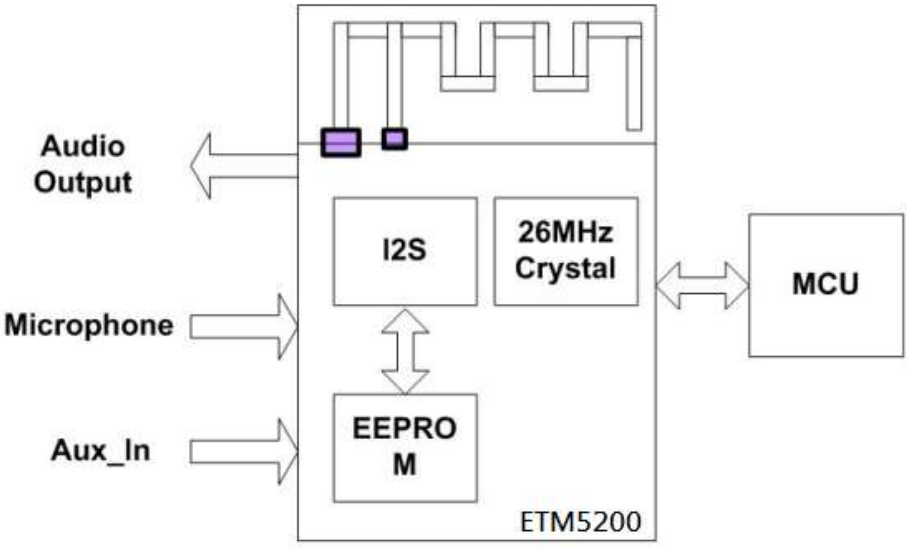
I2S interface

The I2S interface supports both master and slave mode, with sample rate from 7.35 kHz to 96 kHz. The master clock can be output from GPIO3.

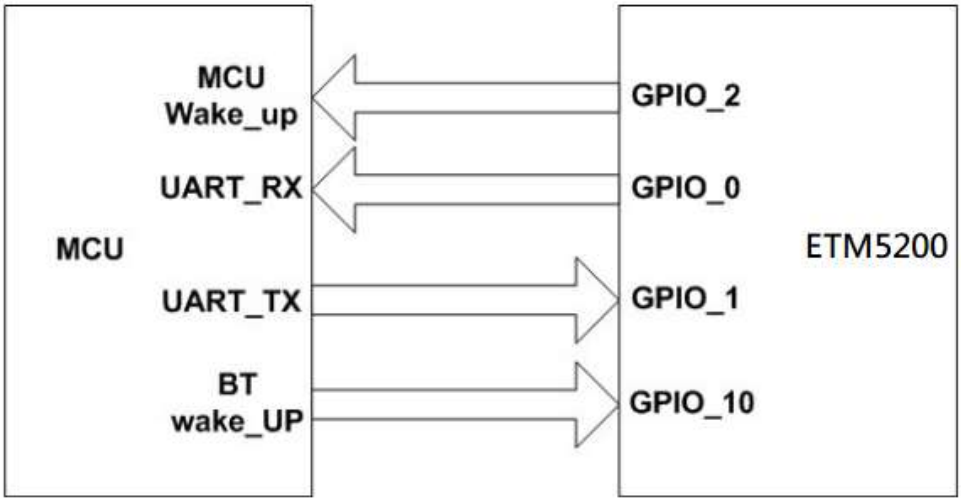
5. APPLICATION INFORMATION

ETM5200 Typical Application

The following depicts an example of ETM5200 module operates as an independent system or connected to an MCU.

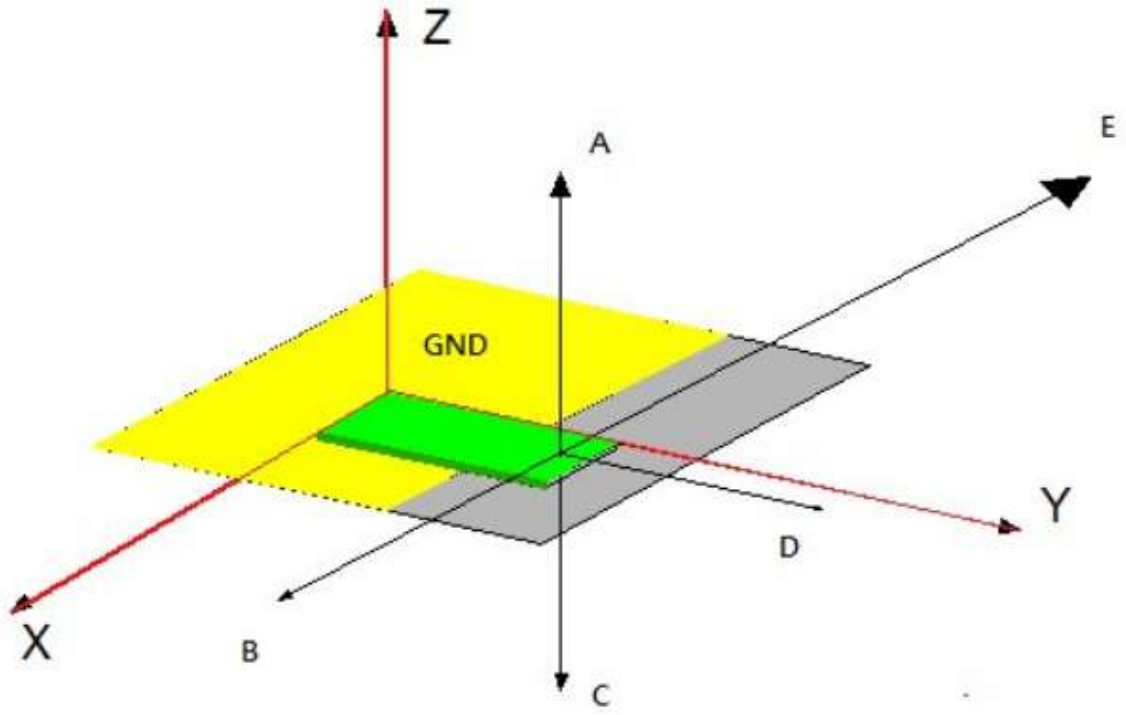


Interface between ETM5200 and MCU

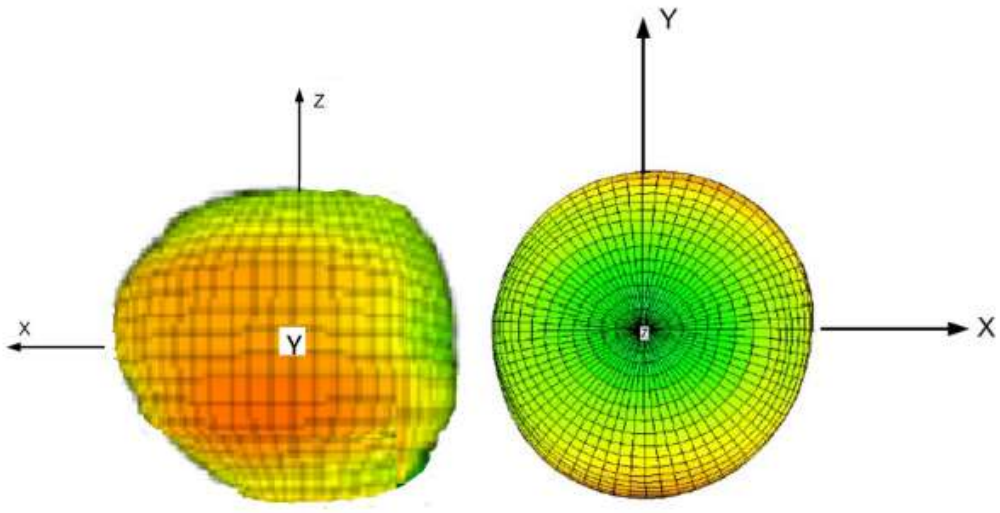


6. Antenna Radiation Pattern and placement

The stereo module contains a print circuit board antenna. The radiation pattern is shown as below.



The antenna's A,B,C,D,E must keep out from the GND 15mm min, are shown in the above

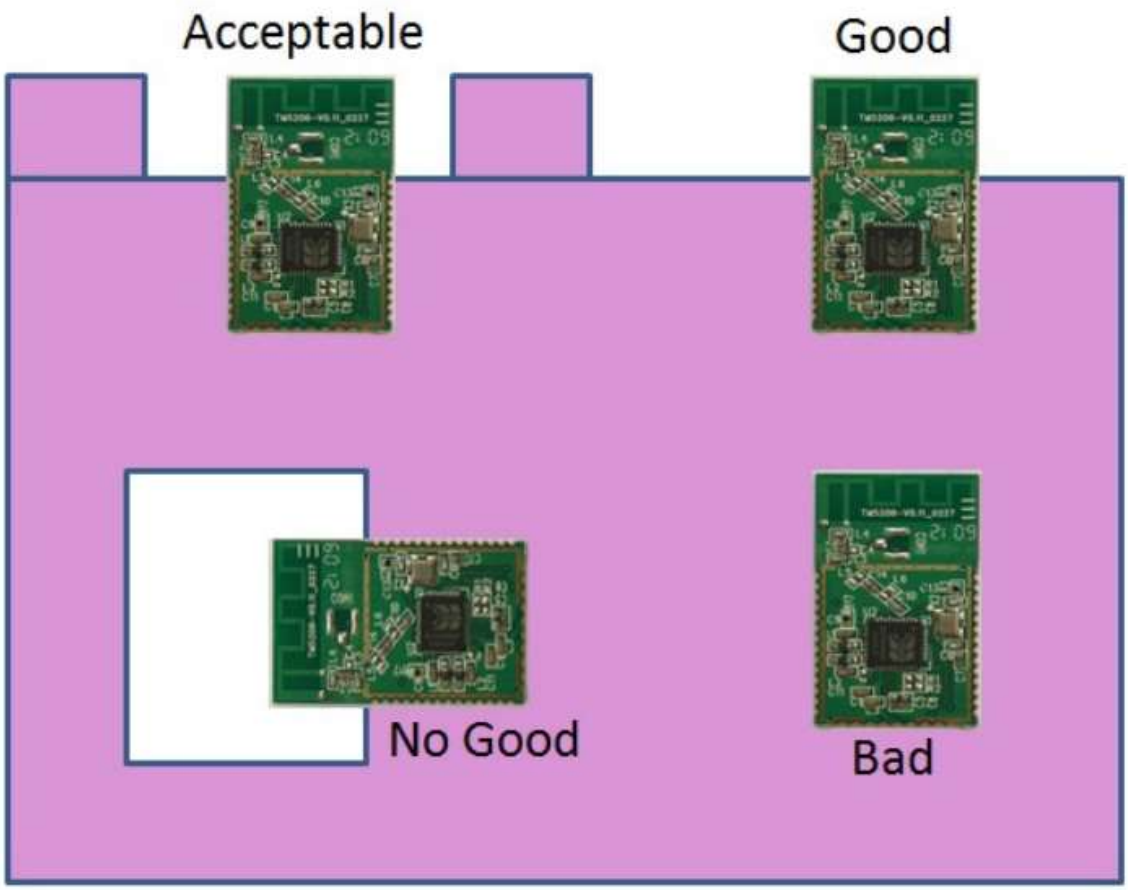


The radiation pattern at Z-X axis

The radiation pattern at X-Y axis

7. Module Placement example

On the main PCB, the area under the antenna should not contain any top inner layer or bottom copper.

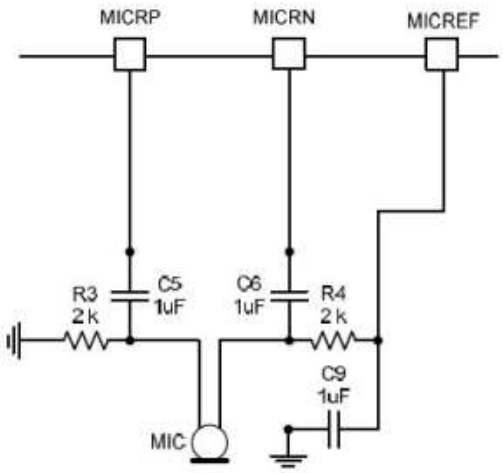


Notice:

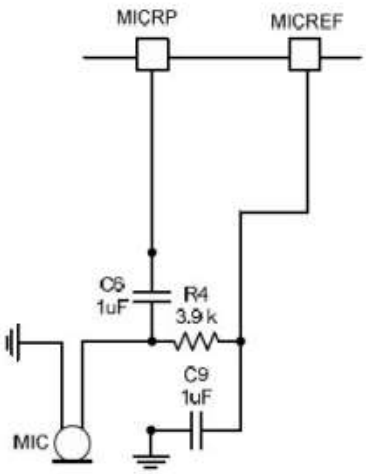
1. For the best range performance, keep all external metal away from the antenna at least 15 mm.
2. A ground plane will ensure the best radio performance (best range, lowest noise).

8. Evaluation Board and Application Circuit

The microphone signal can be amplified with gain from -8 ~ 38dB with 0.5 dB step.

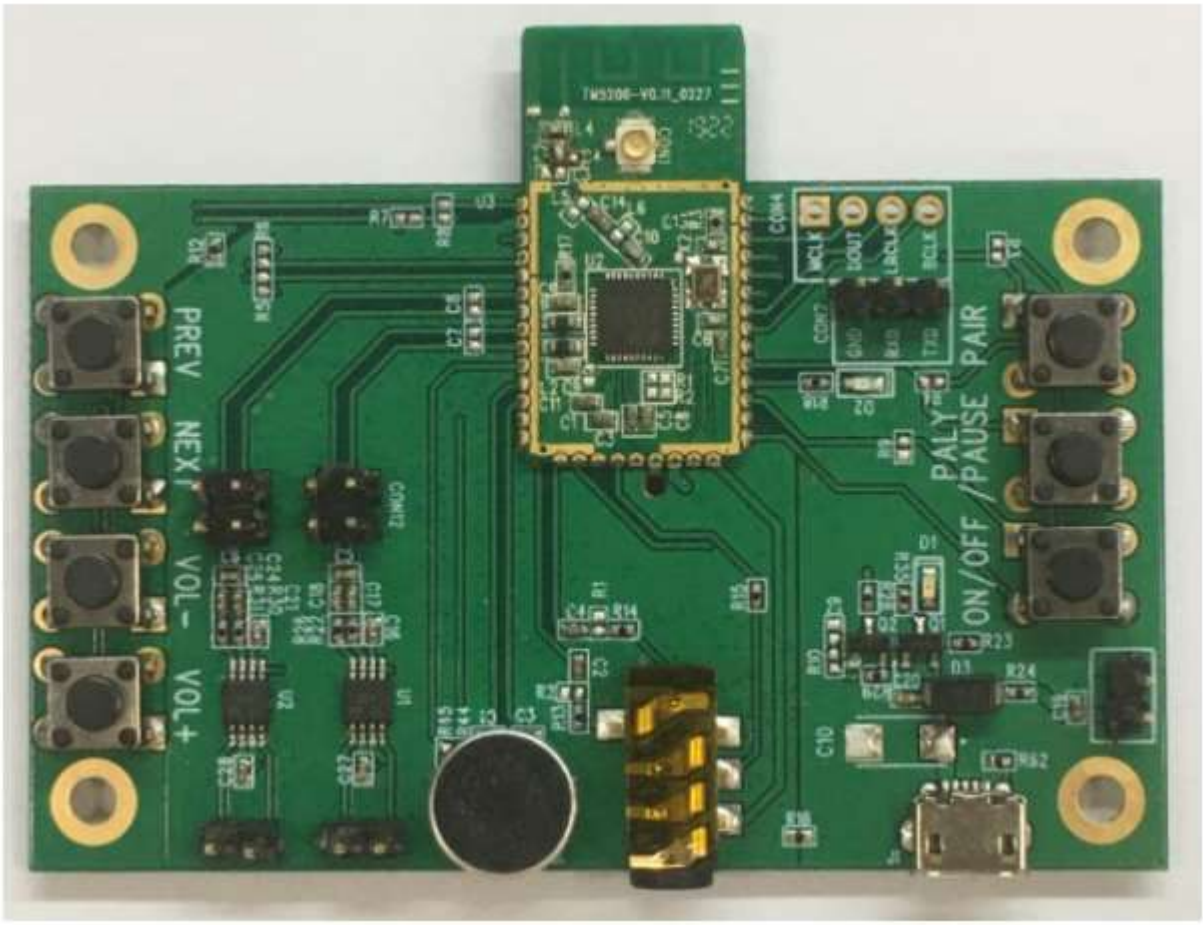


Differential Mode

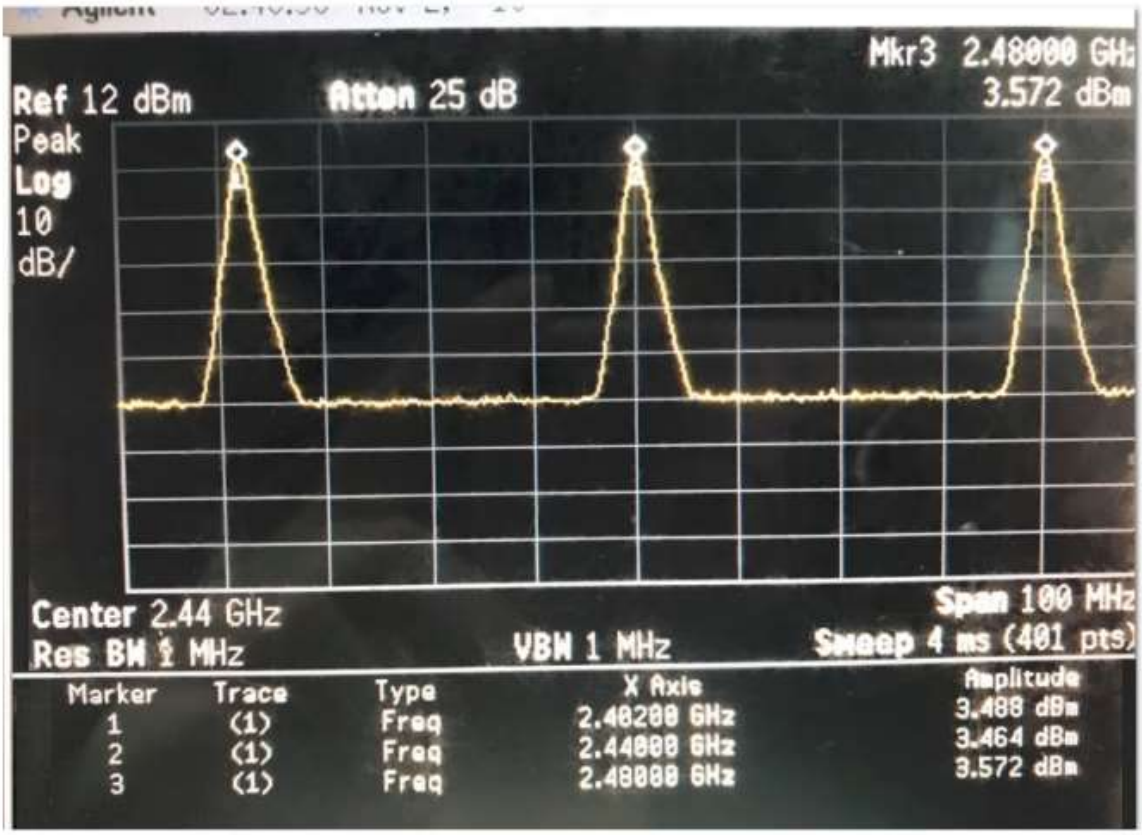


Single_End Mode

Demo board with EETM5200 module



9. Frequency Spectrum: Low Channel, Mid Channel and High Channel



10. AUX test data &test condition

Input & Output level :

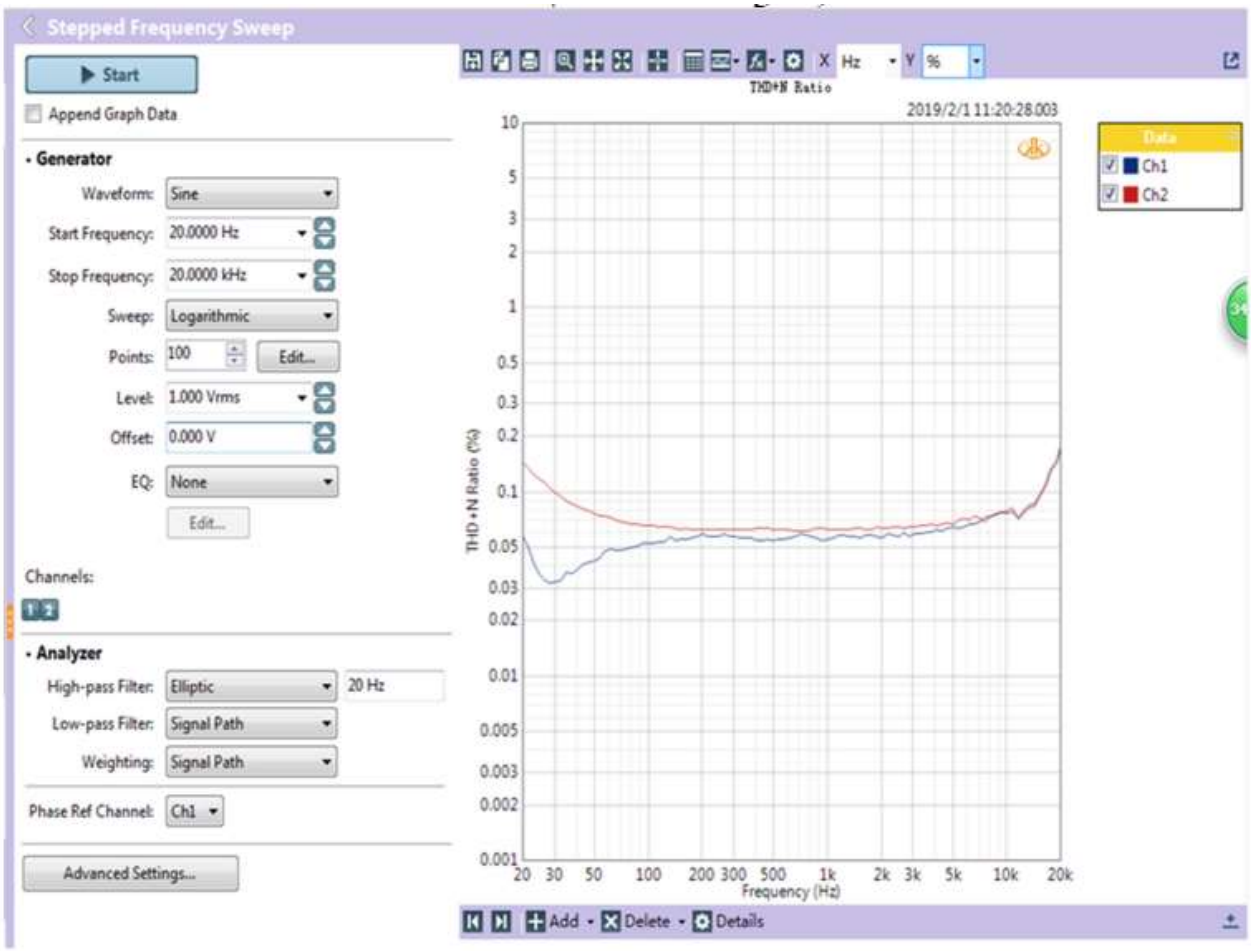
1. Input : 1V
2. Output : 1.001V/1.005V

background noise :

A weighting，10uV/10uV(48 KHz sample)

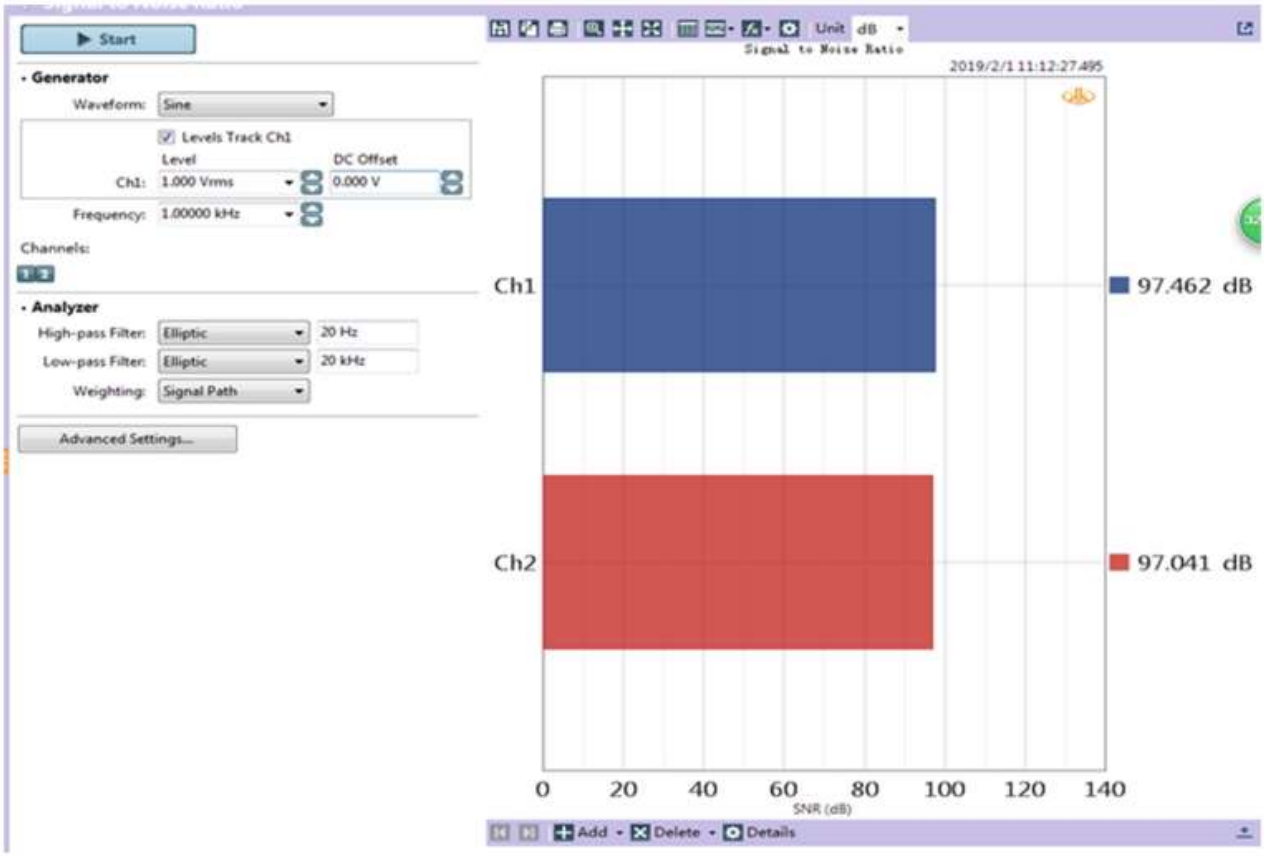
Distortion :

1. Output : 1KHz/1V; 0.05/0.06%
2. 20Hz-20KHz(As shown in Figure)



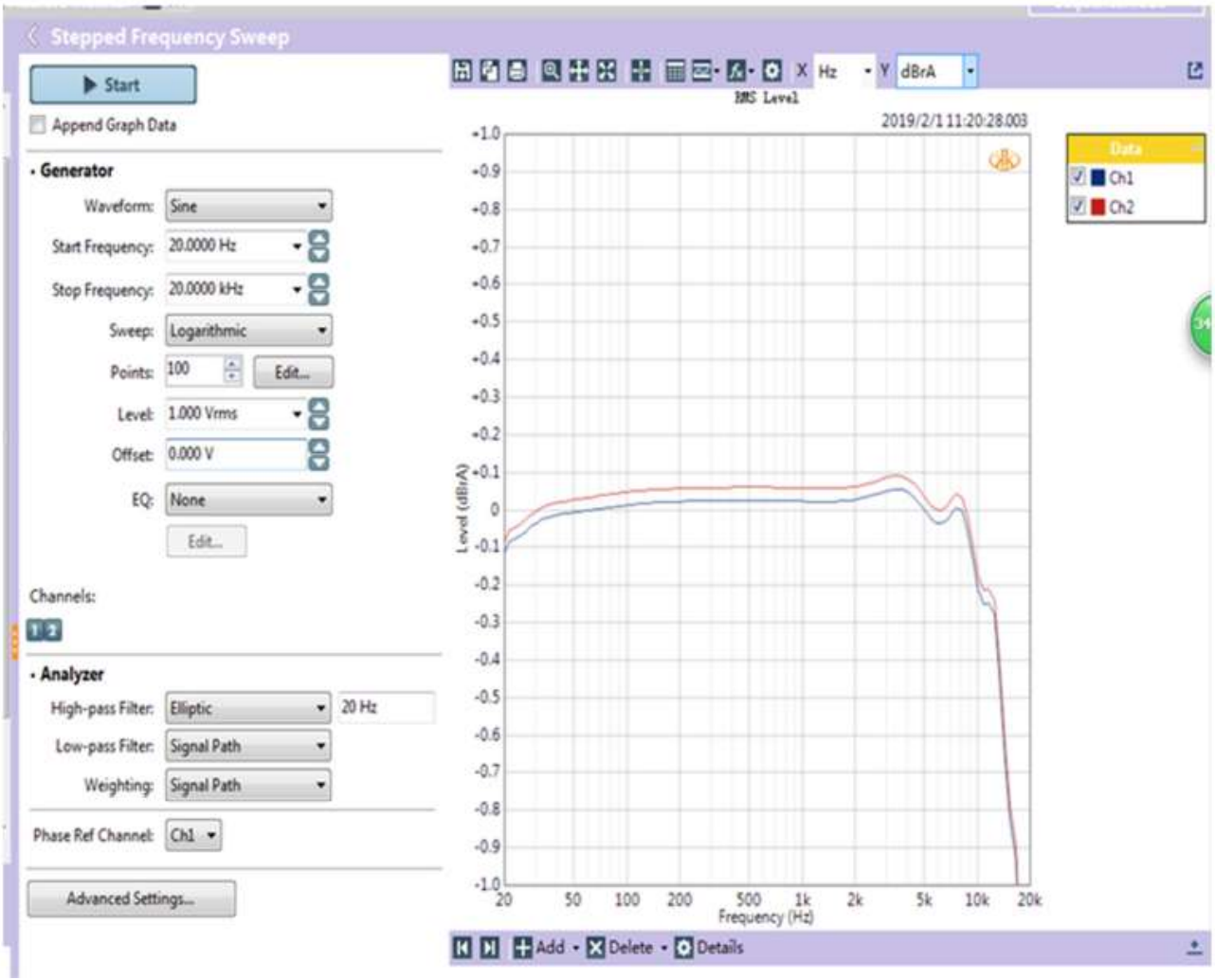
SNR :

1KHz，Output 1V ; 97.4/97.0dB(As shown in Figure)



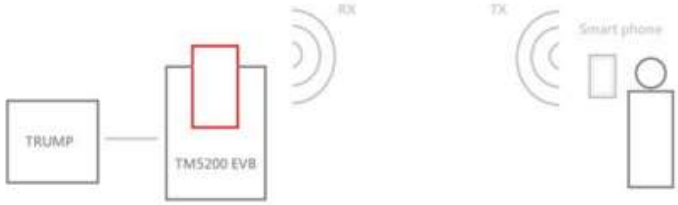
Isolation :

1. 100Hz, Output 1V，74/75dB
2. 1KHz，Output 1V，76/77dB
3. 10KHz，Output 1V，67/68dB(As shown in Figure)



Field Test Results

TEST BLOCK

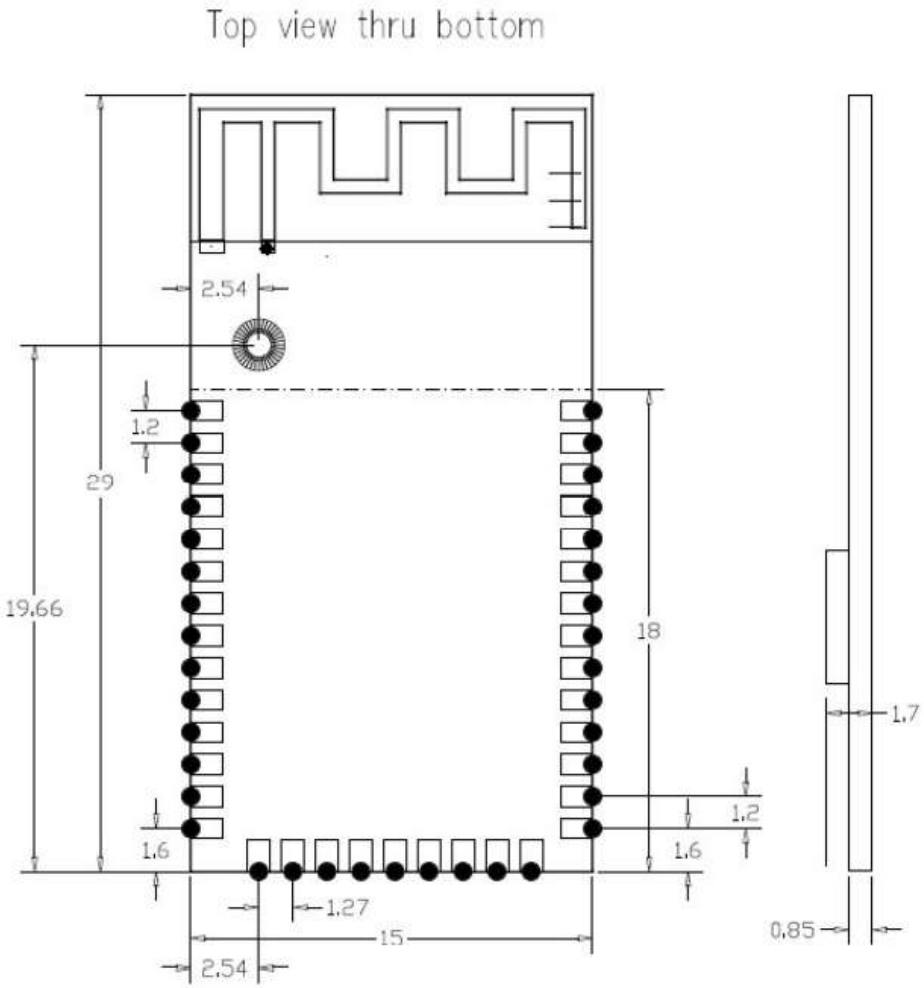


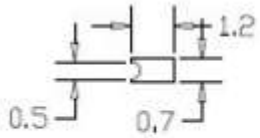
Smart phone playing continue music

Location & Distance

130Meter linked in Line of Sight

11. Module Dimension



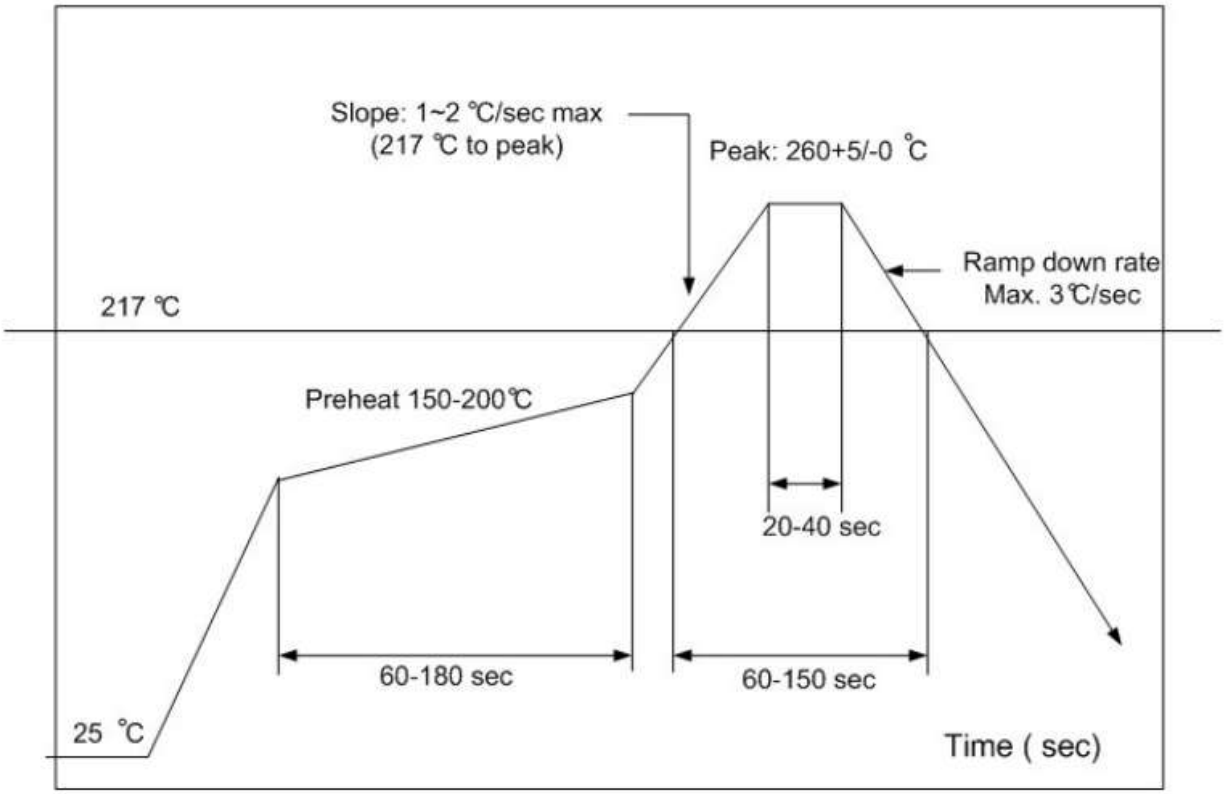


Pad Detail

Dimensions are in millimeters

Tolerances: PCB Dimensions +/− **10%**

12. Reflow Profile



Notices:

1. The stereo module was assembled using standard lead-free reflow profile.
2. The module can be soldered on the main PCB using standard leaded and lead-free solder reflow profile.
3. Do not exceed peak temperature.
4. Use non-clean solder paste.
5. Don’t not was as moisture can be trapped under the shield can.
6. Use only flow. If the PCB requires multiple flows, apply the module on the final flow.