Design Guide for Hardware of CMT453x Series Chips

Overview

This document is the summary of hardware design experiences of CMT453x series Bluetooth chips. It is the detailed specifications for chip hardware design, selection of some important components and cautions for PCB Layout.

Contents

1 Schematic design guide

1.1 Power supply

1) When the external power supply voltage is 1.8V～3.6V, it can be directly connected to chip VCC.

2) VCCRF, from which the maximum supply is 3.6V, is recommended to be connected to VCC pin in parallel.

3) Note the chip GND pin is at the bottom of the chip, and be sure to connect the square bonding pad at the bottom of the chip to GND network. See Chapter 3.3 for details.

1.2 Differences between two power supply modes

Two power supply modes are available for chips, and the main differences between the two modes are below:

Mode / Parameters	DCDC power supply mode	LDO power supply mode
BOM difference	4.7uh inductor required	4.7uh inductor not required
Active power consumption	1.8 mA	3.8 mA
Power consumption in Sleep mode	1.6 uA	1.6 uA
RFTX power consumption	4 mA	8 mA
RFRX power consumption	3.8 mA	7.8 mA
RFRX sensitivity	-96 dBm	-96 dBm
RFRX maximum power	+6 dBm	+6 dBm

1. 3 Reference schematic design for DCDC power supply mode

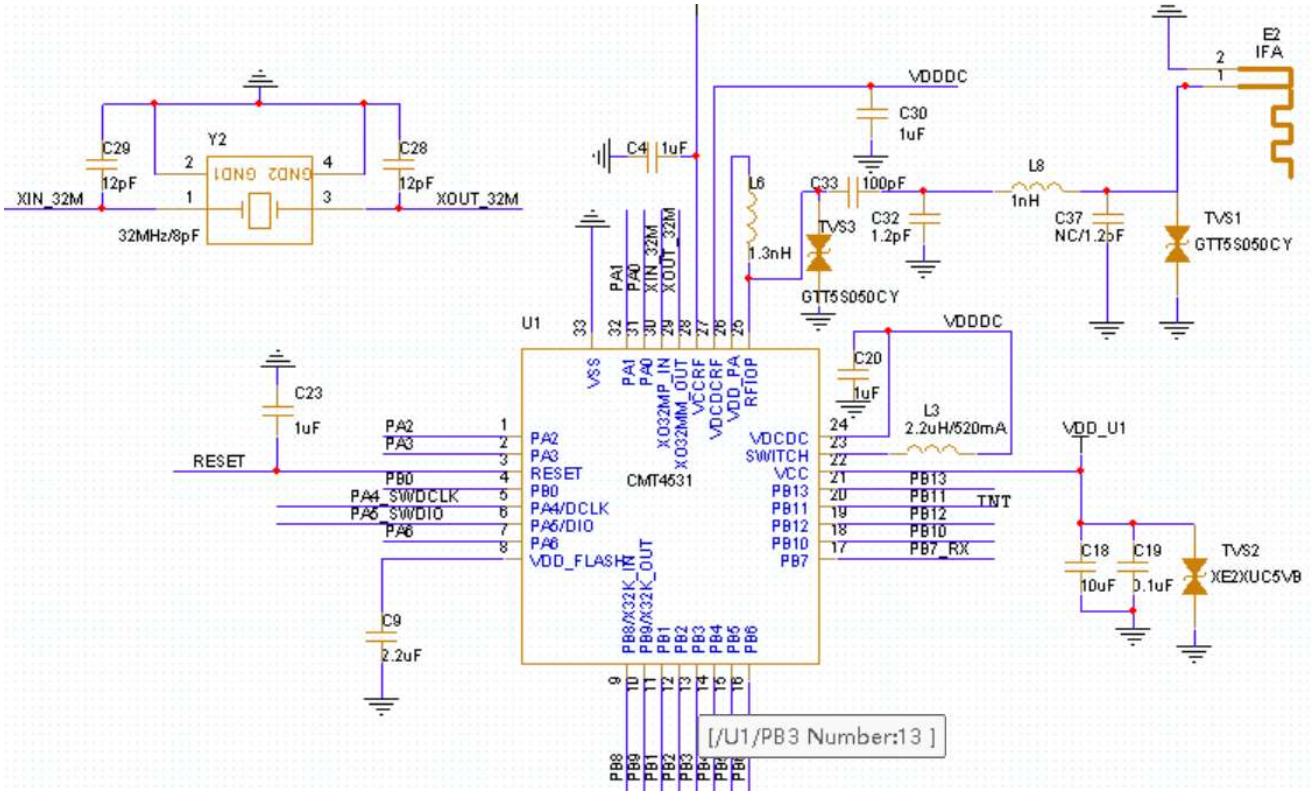

Figure. 1- 1 Reference Schematic design for DCDC Power Supply Mode

1.4 Reference schematic design for LDO power supply mode

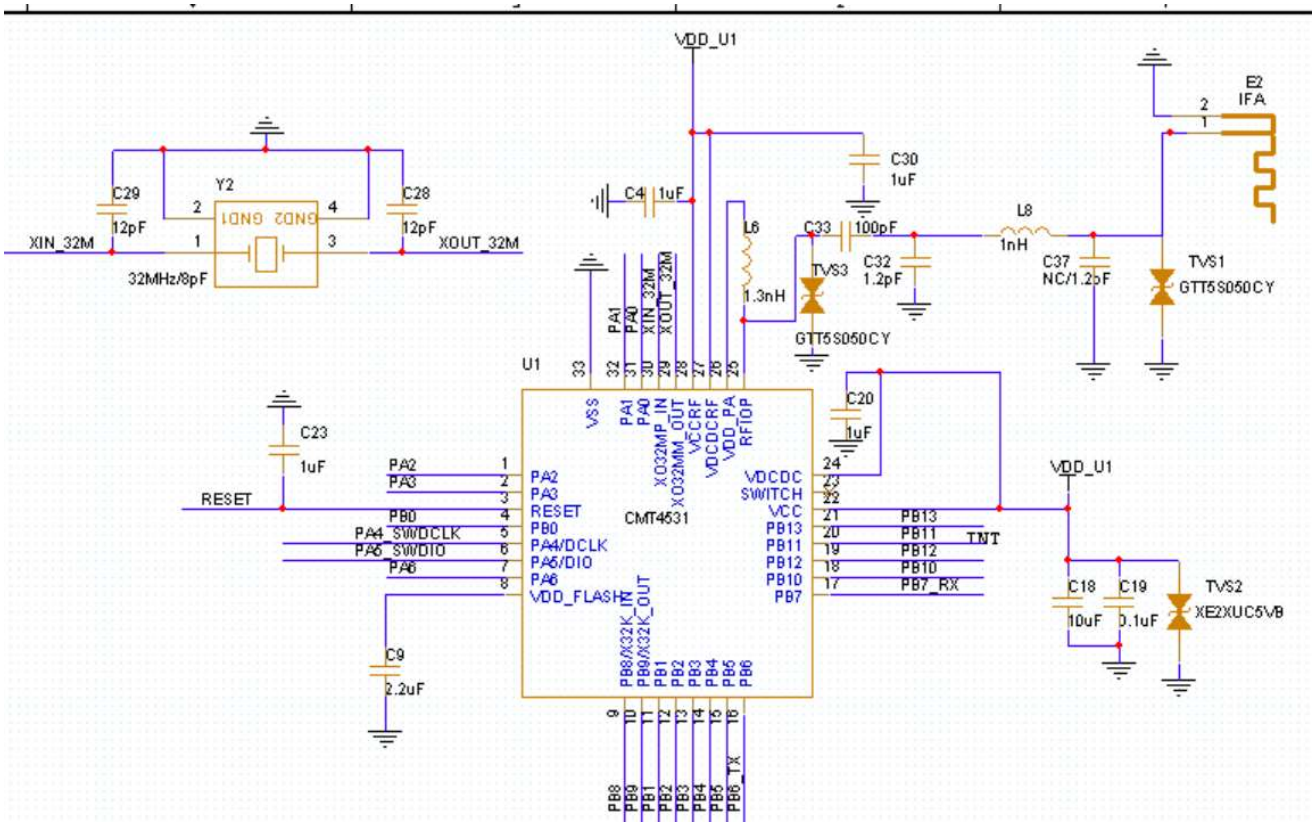

Figure. 1-2 Reference Schematic design for LDO Power Supply Mode

1.5 Reference minimum system BOM table

Item	Part Name	Description	REV	QTY	Reference
0001	CAP0402,105	CAP,CER,16V,1UF,X7R,10%,0402		4	C4,C20,C23,C30
0002	CAP0402,104	CAP,CER,16V,0.1UF,X7R,10%,0402		1	C19
0003	CAP0603,2.2uF	CAP,CER,10V,2.2UF,X7R,10%,0603		1	C9
0004	CAP0603,10uF	CAP,CER,10V,10UF,X7R,10%,0603		1	C18
0005	CAP0402,1.2PF	CAP,CER,50V,1.2PF,COG,5%,0402		1	C32
0006	CAP0402,12PF	CAP,CER,50V,12PF,COG,5%,0402		2	C28,C29
0007	CAP0402,100PF	CAP,CER,50V,100PF,COG,5%,0402		1	C33
008	CMT4531_QFN32	IC,CMT4531,QFN32,32PIN		1	U1
009	XTAL_32MHz	XTAL,32MHz,8PF,10PPM,SMD_1612,4PIN,-40℃～85℃(NDK, NX1612A-32MHz-STD-CIS-3)		1	Y2

0010	INDUCTOR_2.2UH	INDUCTOR, 2.2UH,±20%, power inductor, RDC(direct-current resistance) 250mΩ, Heat Rating Current 800mA, 0805, (MPH201210S4R7MT, Sunlord)		1	L3
0011	INDUCTOR_1.3nH	INDUCTOR, 1.3nH,±0.3nH, high-frequency inductor, RDC(direct-current resistance) 100mΩ, Rated Current 300mA, 0402, (SDCL1005C1N3STDF, Sunlord)		1	L6
0012	INDUCTOR_1nH	INDUCTOR, 1nH,±0.3nH, high-frequency inductor, RDC(direct-current resistance) 100mΩ, Rated Current 300mA, 0402, (SDCL1005C1N0STDF, Sunlord)		1	L8
0013	ESD Protection	IEC61000-4-2 (ESD) ±20kV (air), ±20kV (contact) Working voltage:3.3V` 5V ; Ultra Low Capacitance：0.3pF GTT5S050CY DFN1006-2L		3	TVS1 TVS2 TVS3

Table. 1-1 Reference BOM Table

1.6 Reference schematic design for external crystal

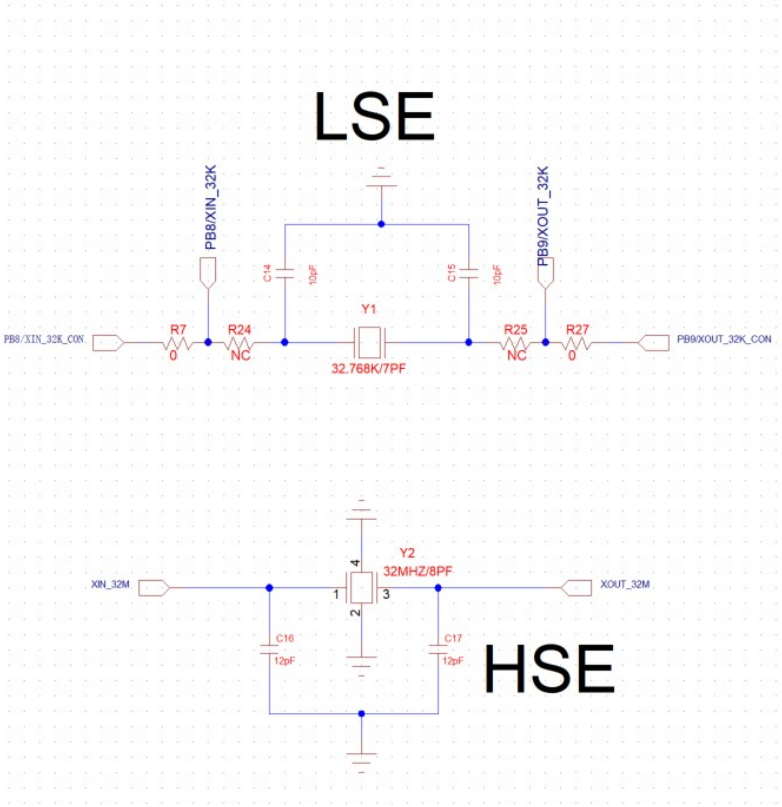

Figure.1-3 Reference Schematic design for External Crystal

1.7 Reference schematic design for reset circuit

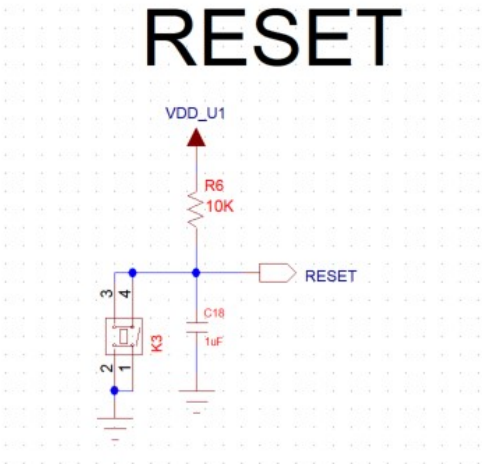

Figure. 1-4 Reference Schematic design for Reset Circuit

1.8 Reference schematic design for microphone circuit

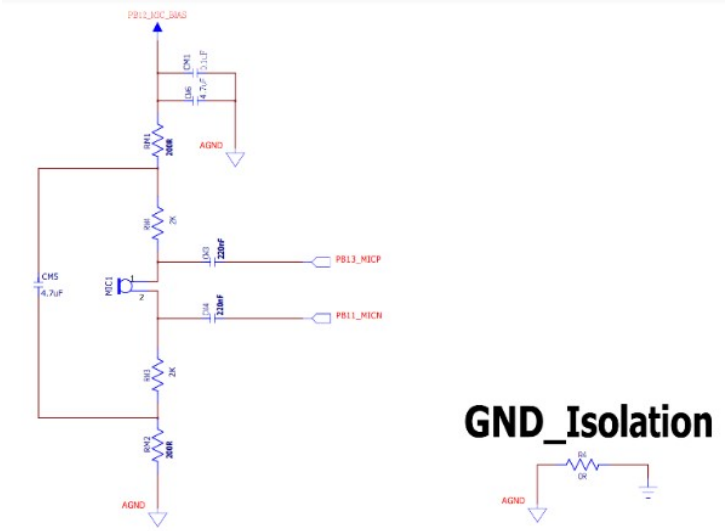

Figure. 1-5 Reference Schematic design for Microphone Circuit

1. 9 Reference Schematic design for Infrared Transmitter Circuit

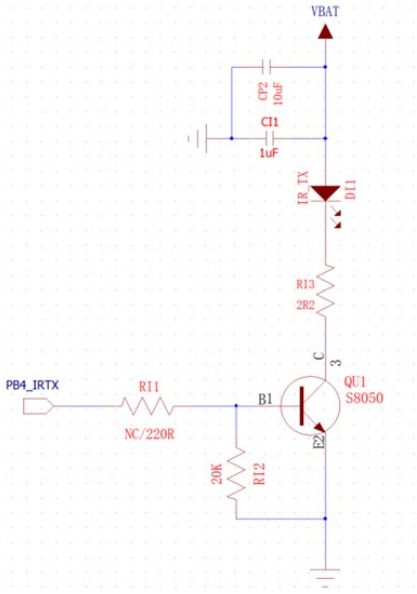

Figure. 1-6 Reference Schematic design for Infrared Transmitter Circuit

1. 10 Reference Design for Conduction/Radiation Certification (CE/FCC) test

The circuit below has a better harmonic suppression performance compare with the default design introduced in section 1.3 and 1.4.

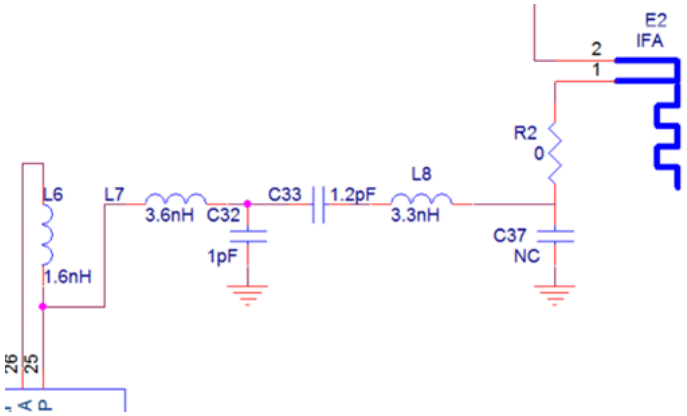

Fig. 1-7 Reference Schematic design for Conduction/Radiation Certification(CE/FCC) test

2 Specifications on chip pins in the schematic

2.1 Power supply pins

- PIN24(VDCDC) is the power supply pin receiving internal DCDC generated voltage, its typical voltage is 1.15V, it needs to be connected with 1uF decoupling capacitor, and 2.2uH power inductor needs to be provided in series between PIN24(VDCDC) pin and PIN23(SWITCH).
- PIN27(VDCDCRF) is the internal RF power supply pin receiving internal DCDC generated voltage, can be directly connected to PIN24(VDCDC), its typical voltage is 1.15V and it needs to be connected with 1uF decoupling capacitor.
- PIN28(VCCRF) is external power supply pin, needs to be connected with 1uF decoupling capacitor, and its external voltage range is 1.8V～3.6 V.
- PIN22(VCC) is external power supply pin, needs to be connected with 0.1uF and 10uF decoupling capacitors, and its external voltage range is1.8V～3.6V。
- PIN8(VDD_FLASH) is the internal FLASH power supply pin, needs to be connected only with 2.2uF decoupling capacitors without external power supply.

2.2 RF pins

- PIN25(RFIOP) is RF pin.
- PIIN26(VDD_PA) receives the bias voltage with a range of 0.9V ～ 1.7V generated by internal RF_PA, depending on the internal register configuration, the transmit power is different, and the bias voltage generated is different.

2.3 Crystal oscillator pins

- PIN29(XO32MM) and PIN30(XO32MP) are Bluetooth reference clock pins and need to be connected with 32MHz crystals. As the Bluetooth requirement for frequency deviation is high, the frequency deviation of the crystal oscillators should be ≤±10ppm. Note that external 32MHz crystals must be provided for using the

Bluetooth function.

- PIN9(XO32KP_IN) and PIN10(XO32KM_OUT) are low-frequency reference clock pins, can also be used as general purpose IO interfaces and need to be connected with 32.768KHz crystals when they are used as clock pins.

2.4 Debug pins

- PIN5(PA4/SWDCLK) and PIN6(PA5/SWDIO) are SWD pins and can also be used as general purpose IO interfaces. When they are used as SWD pins, they can be used to download applications.
- PIN16(PB6/TX) and PIN17(PB7/RX) are UART serial port pins, and can also be used as general purpose IO interfaces. They can be used for print when being used as serial port pins.

2.5 AMIC audio pins

- PIN20(PB11/AMIC_N) and PIN21(PB13/AMIC_P) are MIC input pins supporting single-ended input and differential input with adjustable gain.
- PIN19(PB12/AMIC_BIAS) is the pin for outputting MIC bias voltage, it outputs adjustable MICBIAS voltage with a range of 1.6～2.3V and a typical voltage of 2V.

2.6 IO interface

- For the specific definition of IO interface, see *CMT453x Datasheet*

3 Design specifications on PCB Layout

3. 1 Requirements for RFIOP wiring design

- In order to ensure minimum loss, RF routing should be as short as possible, components should be as compact as possible, and RF routing should be as straight as possible and should not be right angle. The routing width and the space between the route and the peripheral GND equivalent to the recommended value 0.5mm. As PCB material influences the RF routing impedance, the routing width and the space between the route and the peripheral GND can be adjusted properly to ensure RF routing impedance is 50Ω.
- The wires around RF should ideally be filled with GND metal and the resulting section on the top and bottom layers should be connected with as many vias as possible.
- The zone around antenna front and back must be separated from other routes, to ensure the space between GND and the antenna is 3mm or above and no metal component is in the space.
- Normally, the antenna length is about 30mm, equivalent to 1/4 of the Bluetooth signal wavelength.
- In order to enhance ESD protection capacity, be sure to coat the antenna surface with a solder mask rather than exposing it to the outside, It's better to add another silk screen layer on the top of the antenna.
- Considering that the ESD in the production line of the PCB is not well controlled during the production period, it is required to add a TVS component to the antenna port for protection, the value of the TVS diode capacitance should be as low as possible. For products within a distance of 10m, the TVS component can be replaced with a 0 ohm resistor to improve ESD protection capability. The position of the TVS component or 0 ohm resistance is shown in the figure below.

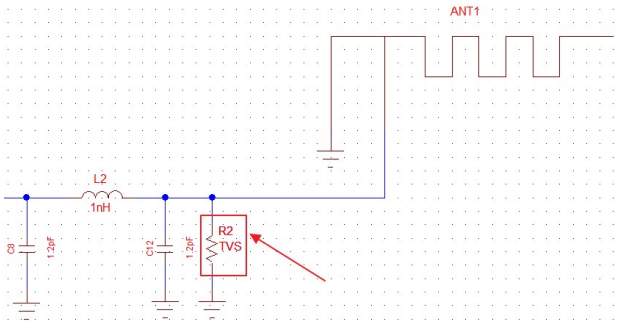

Fig. 3-1 Reference Schematic design with TVS or 0 Ohm resistor

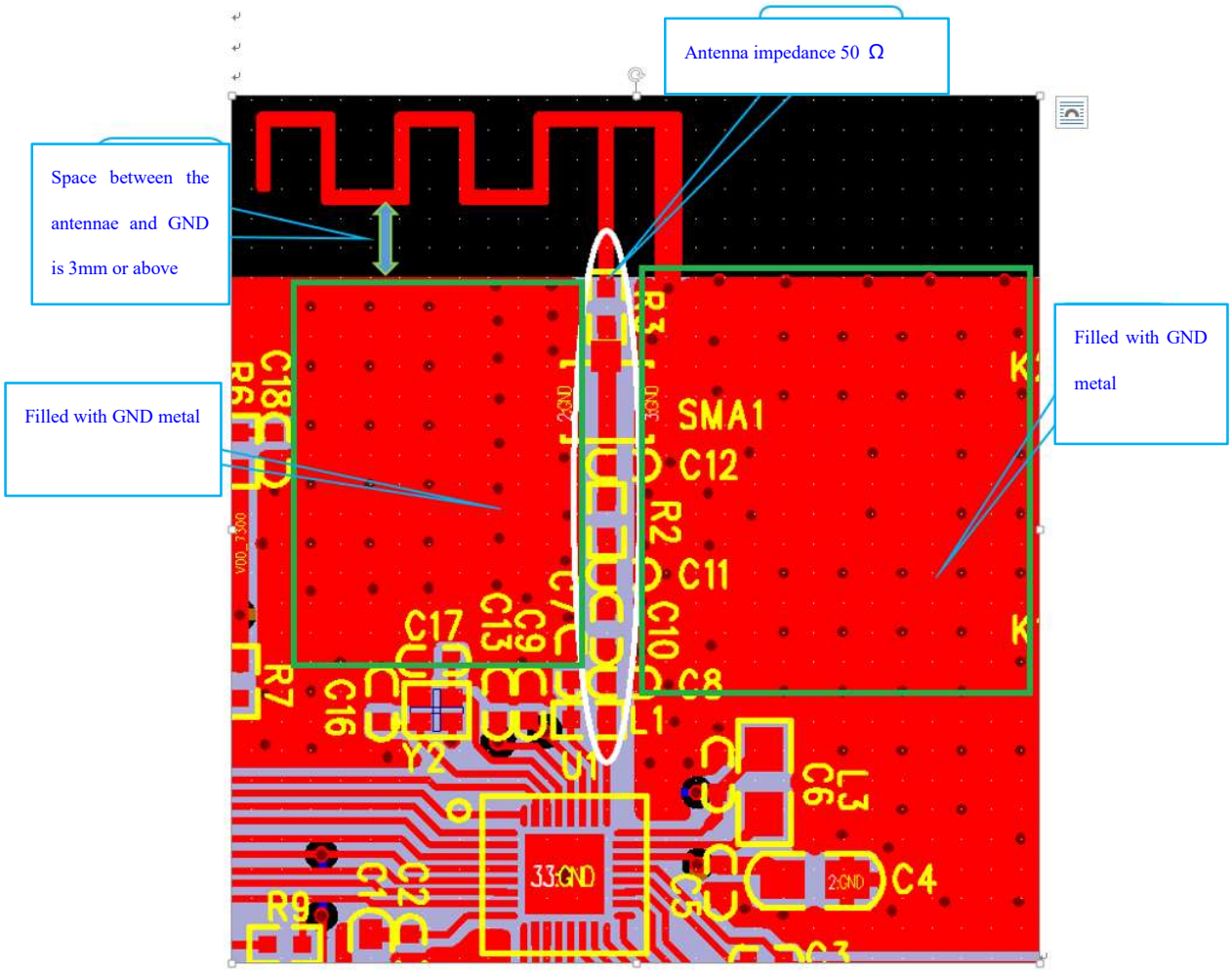

Figure. 3-2 Layout of the RF Section

3. 2 Requirements for routing of 32MHz crystal oscillator

- The two crystal oscillator routes should be as short as possible and as equivalent in length as possible, with the areas around them be filled with GND metal.
- Try not to route wires under the crystal oscillator, especially the VDCDCRF wires cannot be routed from below, as the DC voltage generated by Bluetooth broadcast affects the stability of the crystal oscillator frequency.

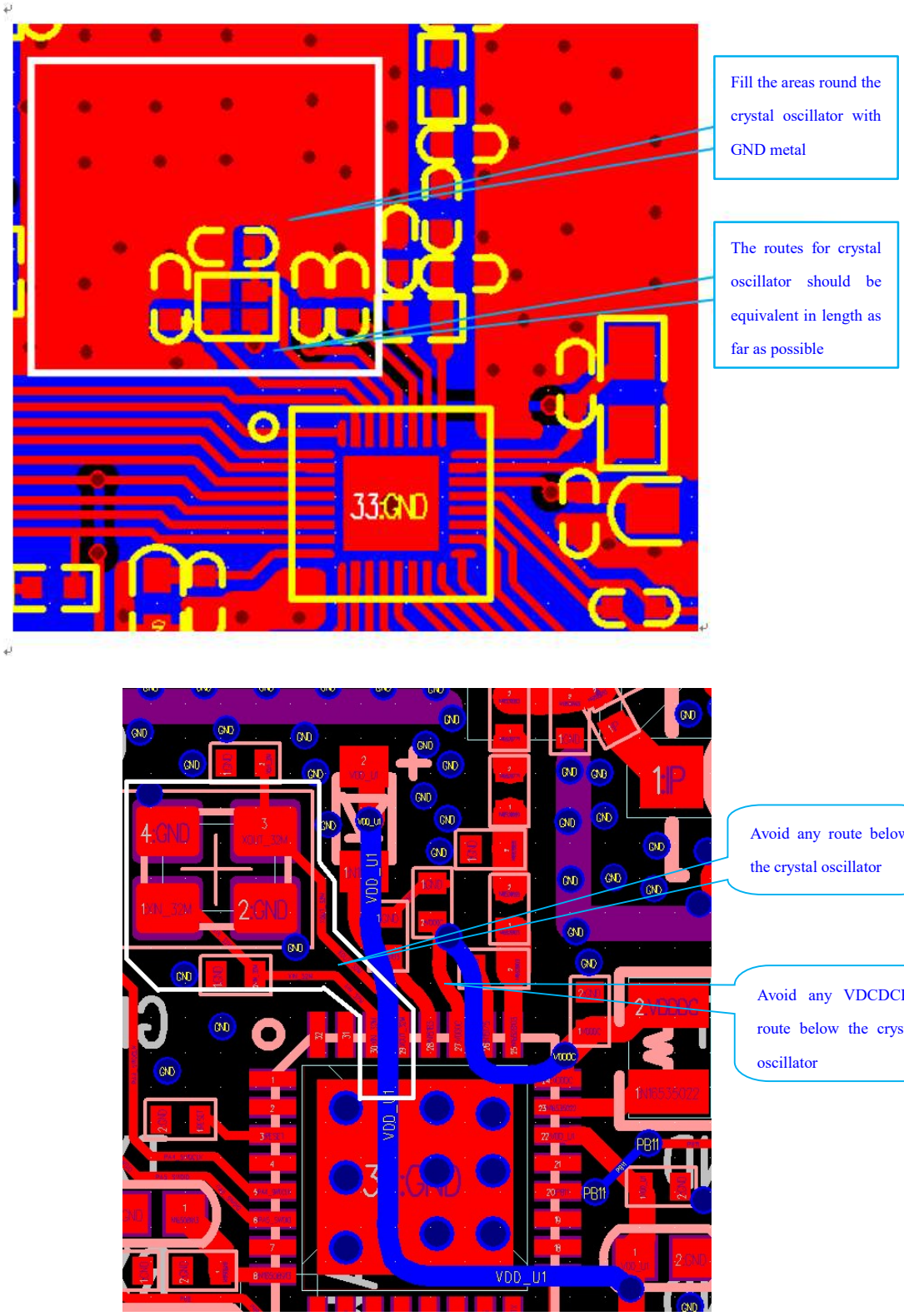

Figure. 3-3 Layout of 32MHz Crystal Oscillator

3. 3 Requirements for routing of chip grounding

- The 32 pins of this chip do not have GND, and its GND is at the bottom of the chip.
- The chip packaging center is required to be cladded by a square copper sheet. The space between the copper sheet and the chip pin should be ≥0.3mm and ≤0.5mm， connect the copper sheet with GND via **9 holes**. The hole may be 0.5mm/0.3mm. The holes should not be too large to avoid tin leaking and consequent insufficient solder.

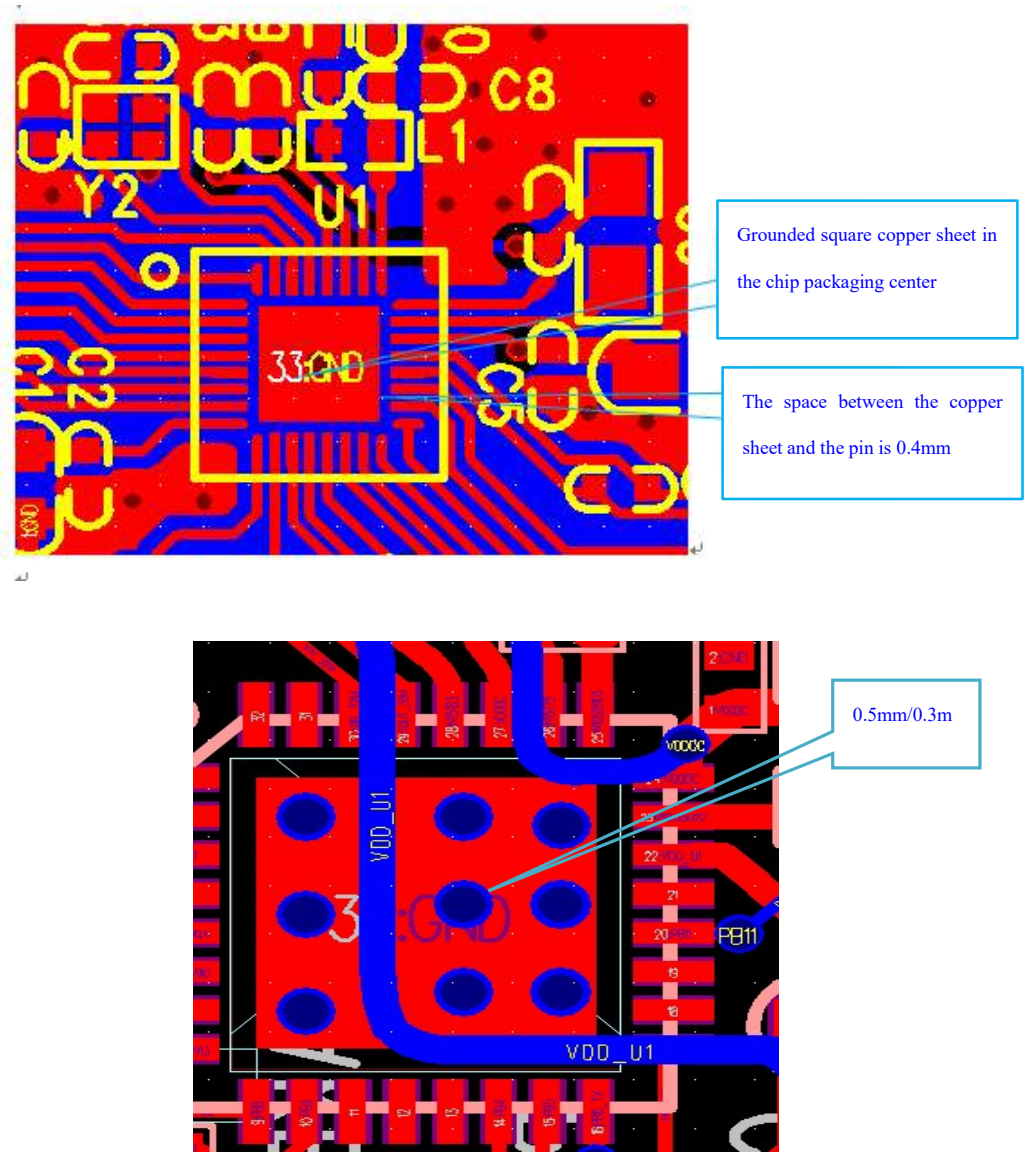

Figure. 3-4 Layout of Chip Ground Routing

3. 4 Requirements for power supply routing

- The power supply wire for the chip should be as thick and short as possible, with the decoupling capacitor as close as possible to the chip.
- If two decoupling capacitors with difference capacity are used, the smaller one should be closer to the chip than the larger one.

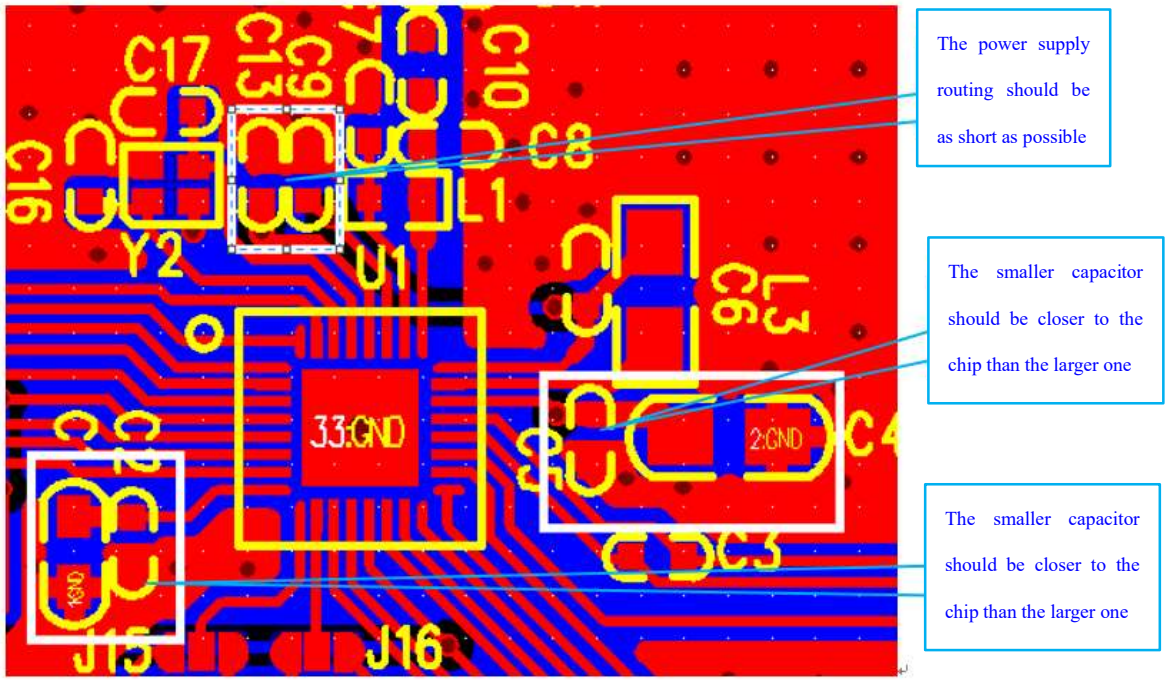

Figure. 3-5 Layout of Power Supply Routing

3. 5 Requirements for AMIC audio routing

- PB11/AMIC_N and PB13/AMIC_P support single-ended input and differential input, and their routes should be differential type. The differential wires should be as short and equivalent in spacing as possible, with proper shielding by ground wire for avoiding other signal interference.
- The inside of their audio module should be grounded first and then they are connected with the peripheral ground to avoid the interference from ground wire.

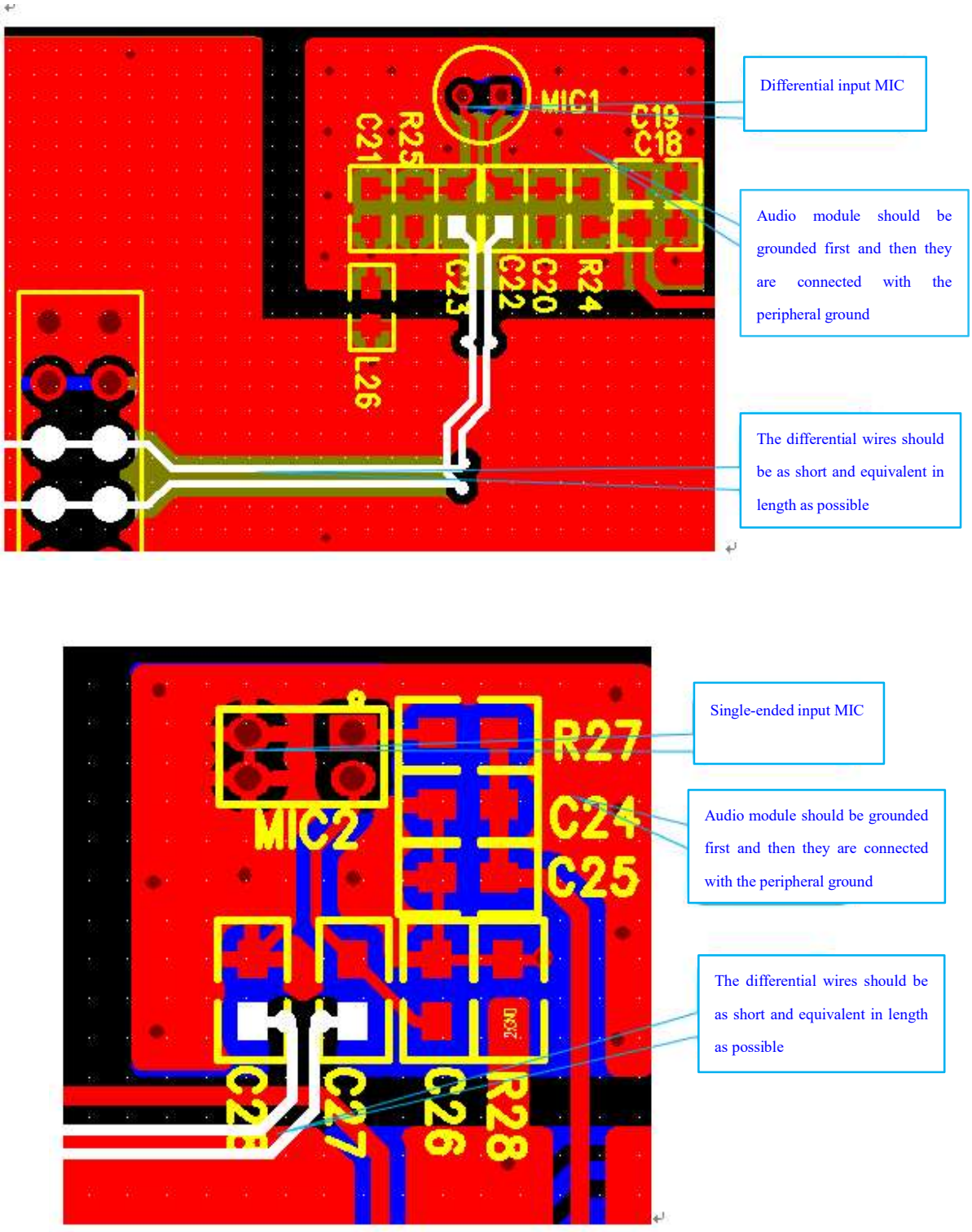

Figure. 3-6 Audio Routing Layout

4 Version history

Date	Version	Modifications
2023.05.23	V1.3	Initial version
2023.07.28	V1.4	Update the reference schematic design in section 1.3, 1.4, and update the BOM table in section 1.5.

5 Notice

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Contact Information

Shenzhen Hope Microelectronics Co., Ltd.

Address: 30th floor of 8th Building, C Zone, Vanke Cloud City, Xili Sub-district, Nanshan, Shenzhen, GD, P.R. China

Tel: +86-755-82973805

Post Code: 518055

Email: sales@hoperf.com

Website: www.hoperf.com