RTL8753BAU Hardware Instruction

V0.9

2020/05/29

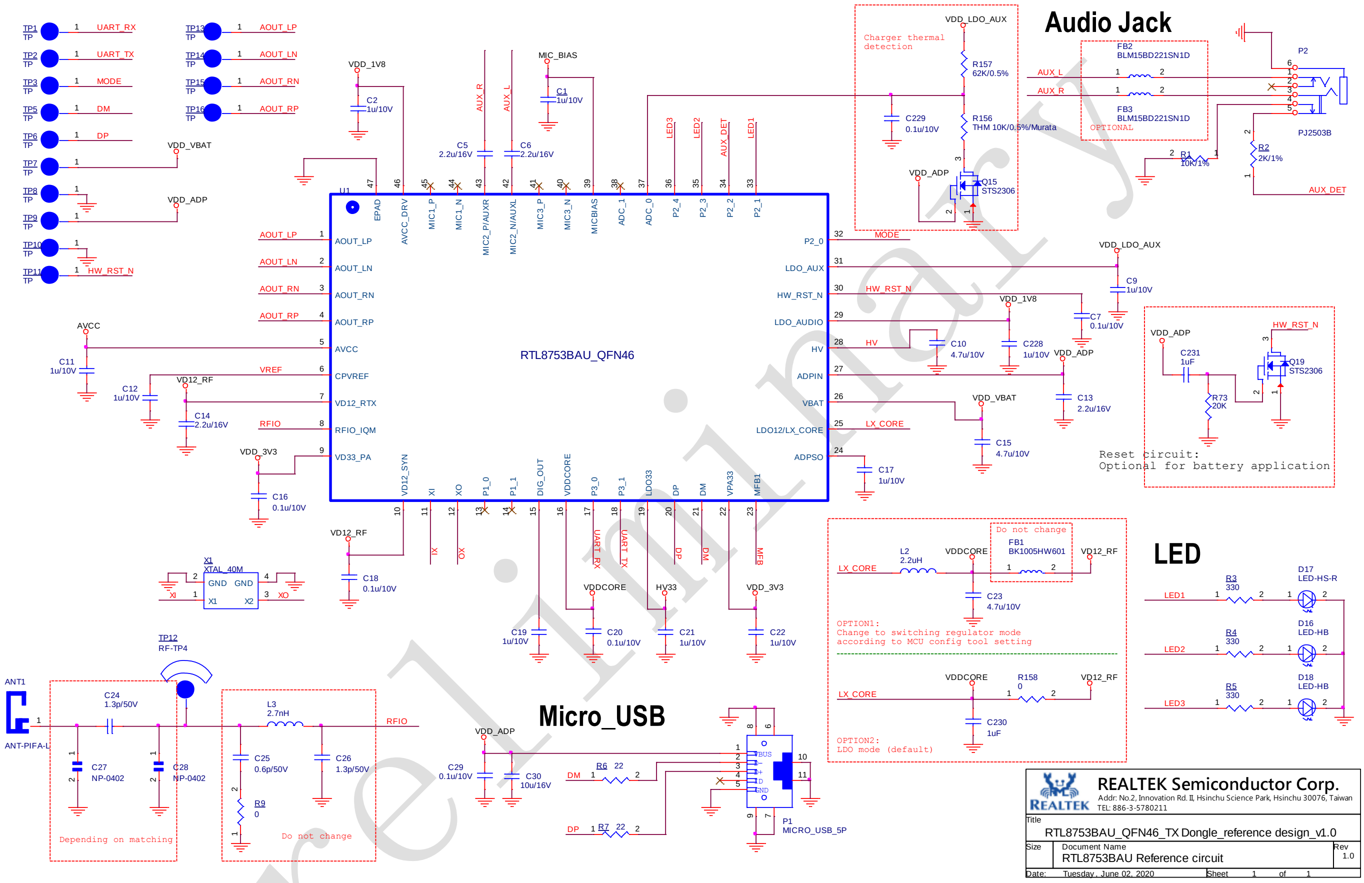
Version History

Version	Change list	Date	Notice
0.9	Initial	2020/05/29	

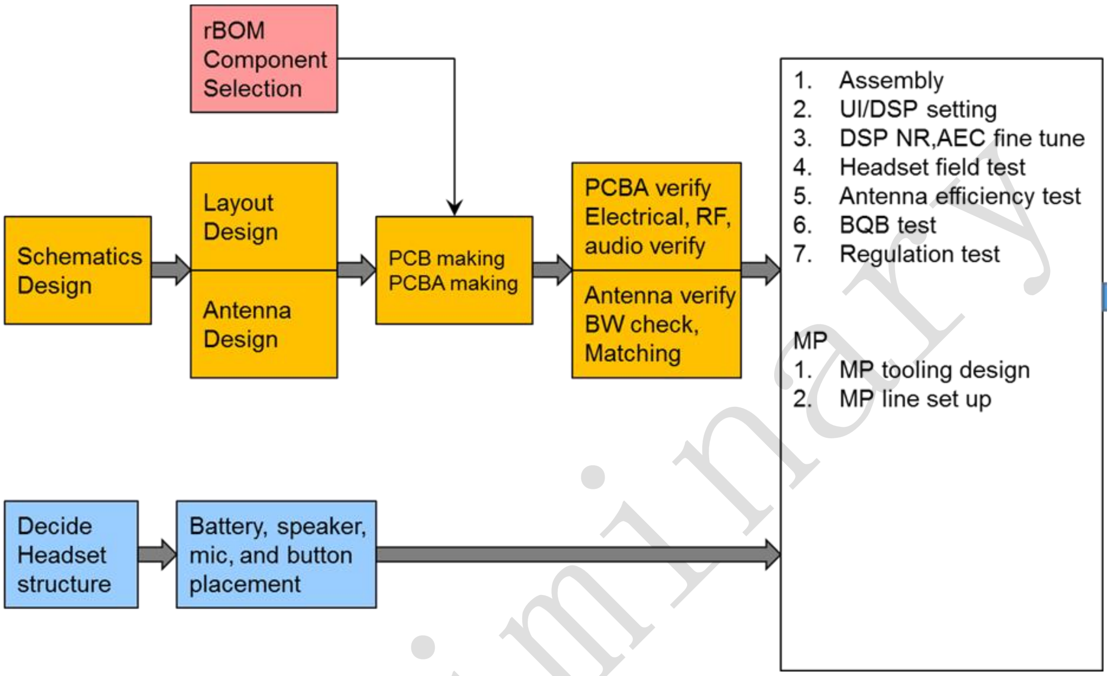
1. RTL8753BAU reference circuit

Below are the reference circuits for

- **RTL8753BAU for stereo Dongle**



2. Design procedure

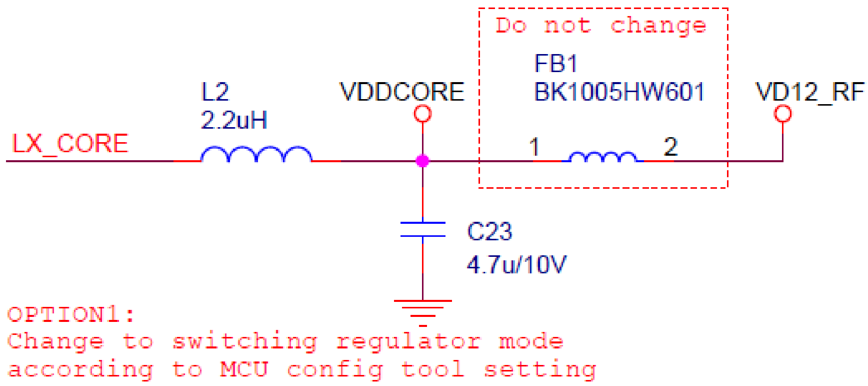


Application Circuit

2.1 Circuit notice

2.1.1 Bead selection

A bead BK1005HW601-T by TAIYO YUDEN is required to improve the digital noise immunity. Do not change the part number.



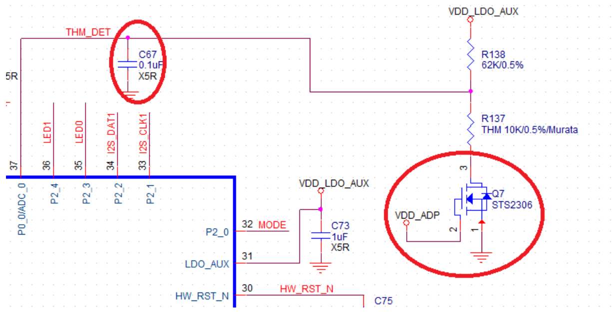
2.1.2 Capacitor selection

Two 4.7uF at HV and VDD_1V2 is suggested to use “P/N: ZRB15XR61A475ME01D” by MURATA.

2.1.3 LDO_AUX is 3.3V/1.8V selectable while while LDO_HV33 is 3.3V fixed..
User could select it in MCU config tool

2.1.4 Charger thermal detect

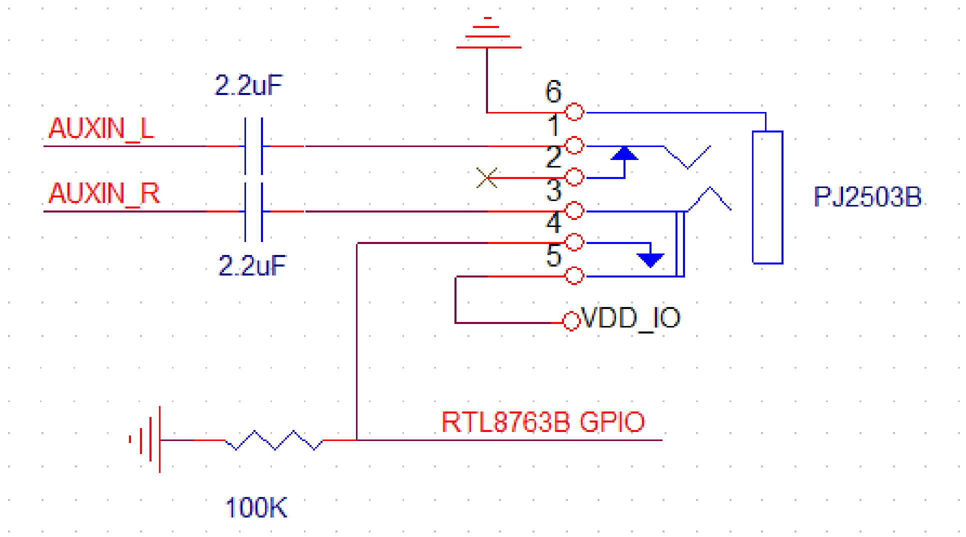
- A NMOS with 5V control is suggested to reduce the leakage current.
- A 0.1uF cap is suggested to improve the ADC stability



AUX-IN

RTL8753BAU provides an audio AUX-IN function, which is shared with MIC2_P/N.
Below is an application reference circuit. An extra GPIO can be used to indicate AUX-IN plug-in.
The aux-in priority could be defined in UI tool.
Generally, the priority: eSCO > AUX-IN > A2DP.
When in AUX-IN mode, the system could be switched back to eSCO link while a phone call comes.

In AUX-IN mode, the system could be auto switched off in a defined time interval if there is no audio signal existed, the power off threshold and time interval could be defined in DSP tool.



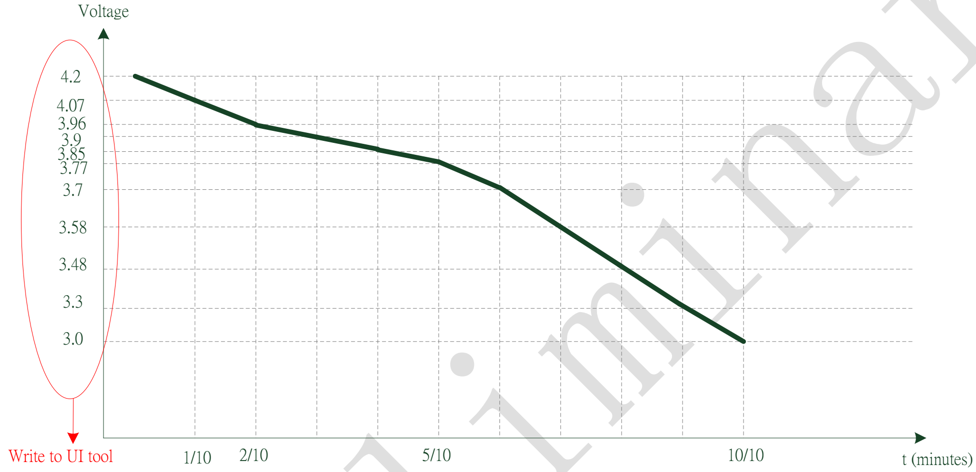
2.2 Charger

RTL8753BAU integrates an internal charger for Li-Ion battery application.
ADPIN can be connected to USB 5V, 5V DC power jack or any other 5V power source.
VBAT is connected to the battery.
The adapter input max rating is 6.5V, the design should make sure the adapter overshoot voltage not to exceed

this level, the external 4.7uF/X5R/16V is mandatory, an extra 4.7uF/X5R/16V or 10uF/X5R/16V is suggested to reserve as back up.
The supported charger current could be programmed in UI tool, with maximum to be 200mA with thermal protection. (check ambient detection chapter)

2.3 Battery Learning

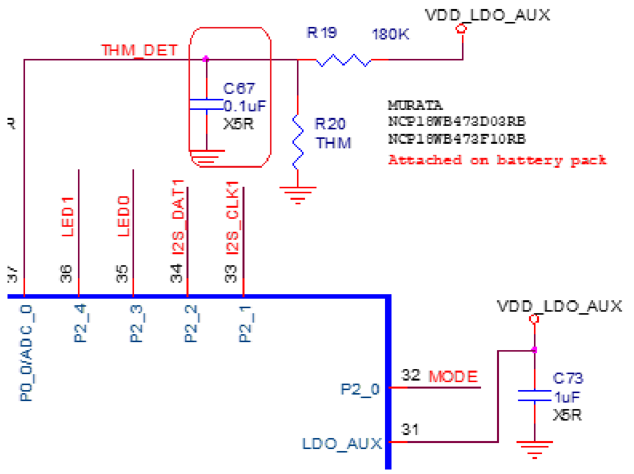
RTL8753BAU supports powerful battery reading capability.
It could be used to show the battery remains gauge in the APP.
Step1: to charge a battery used in a headset to full (4.2V)
Step2: to discharge the battery with 5mA-10mA loading, discharge from 4.2V to 3.0V, get the discharge raw data by a multi-meter.
Step3: to divide the discharge curve into 12, each level to configure in UI tool.
Example: to get a discharge curve and derive the voltage number.



2.4 Charger Thermal Detection

RTL8753BAU supports an excellent, high precision ambient detection algorithm design with the reference circuit below and with specified external thermistor located in battery pack. With this specified thermistor (QVL: Murata), the charger will do “Normal (defined charger current in MCU config tool) → ← warning range (half charger current) → ← error range (stop charger)” under defined condition and is possible to be within +/-2°C if user follow our design guide.
Refer to the reference circuit, R19 resistor and R20 thermistor is suggested to be with 1% or 0.5% tolerance.
C67 is recommend for better ADC detection stability.
Note that the ADC input should be 0-1V only with bypass mode.
Below is the reference circuit for ambient detection.

VDD_LDO_AUX=3.15V, R20=10Kohm/0.5%/MURATA NCP18XH103D03RB, R19=62Kohm/0.5%
VDD_LDO_AUX=1.8V, R20=47Kohm/0.5%/MURATA NCP18WB473D03RB, R19=180Kohm/0.5%



2.5 AUX ADC

RTL8753BAU integrates an AUX-ADC for general analog to digital conversion purpose.
RTL8753BAU FR supports high quality ADC input, design in 12-bit, 10.3bit ENOB and could be shared with digital GPIO function.

AUX ADC can work in single-end mode and differential mode.
For all ADC channels, maximum input voltage must not exceed VDDIO level.
AUX ADC full scale swing is 3.3V. (thermal detect is an exception which support bypass mode only with 1V max tolerance)

When ADC is turned on, there is an input impedance of 44Kohm.

For each ADC channel, there are two working mode available, one shot mode and continuous mode. ADC samples the input signal once and stops in one shot mode while in continuous mode it samples the input signal continuously until it's manually stopped.

The exact value of R1 and R2 should be chosen according to the battery voltage for the voltage on ADC input pin to fall within the required range.

In differential mode, ADC samples two channels simultaneously and outputs the voltage difference.

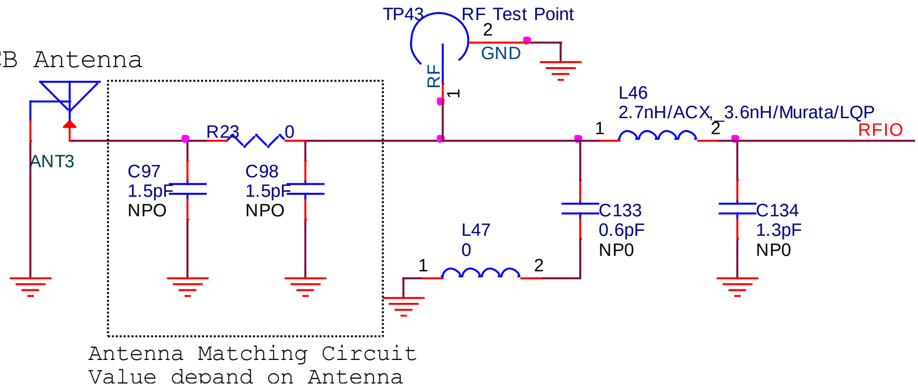
2.6Pogo pin for FW upgrade

RTL8753BAU supports four pogo pin application, that is, 5V, GND, UART_RX (P3_0), UART_TX (P3_1), the UART pin is good for FW upgrade, please refer to Four pogo pin guide →RTK-BBLite-4pin programing guide_20200107

2.7RF

RTL8753BAU reference circuit, the RF components and P/N is assigned, do not change it.

RFIO



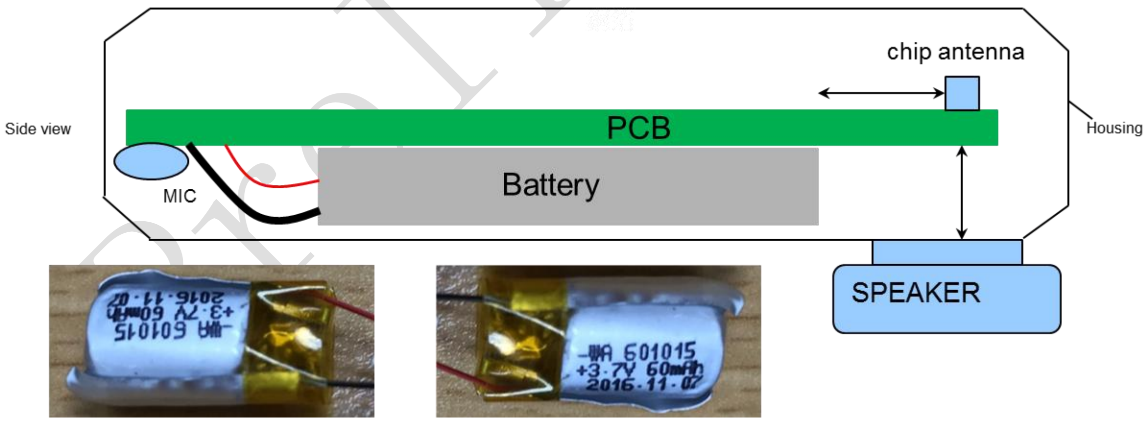
2.8Headset assembly

Headset structure

a) Battery
b) PCBA
c) SPEAKER, MIC
d) Housing

Require a reasonable arrangement of the mechanical parts!!

e) The battery and SPK should be as far away from antenna as possible.
f) Do not use metal as the housing materials
g) The clearance for the antenna is very limited, to survive in a tight corner, try to find out each possibility to maximize the clearance.



2.9PCB Antenna

A PCB antenna occupies PCB area, only could be used in stereo headset with bigger PCB.

An antenna is usually a quarter-wavelength straight wire. Although a meander wire antenna is often the case for a compact size in portable device applications. But for PCB antenna design, the antenna size is a trade-off. It is not possible to have a smaller antenna with larger bandwidth and higher efficiency. So the size of the clearance is a key issue in antenna design. It is strongly recommend to follow the antenna clearance guideline of PCB antenna document.

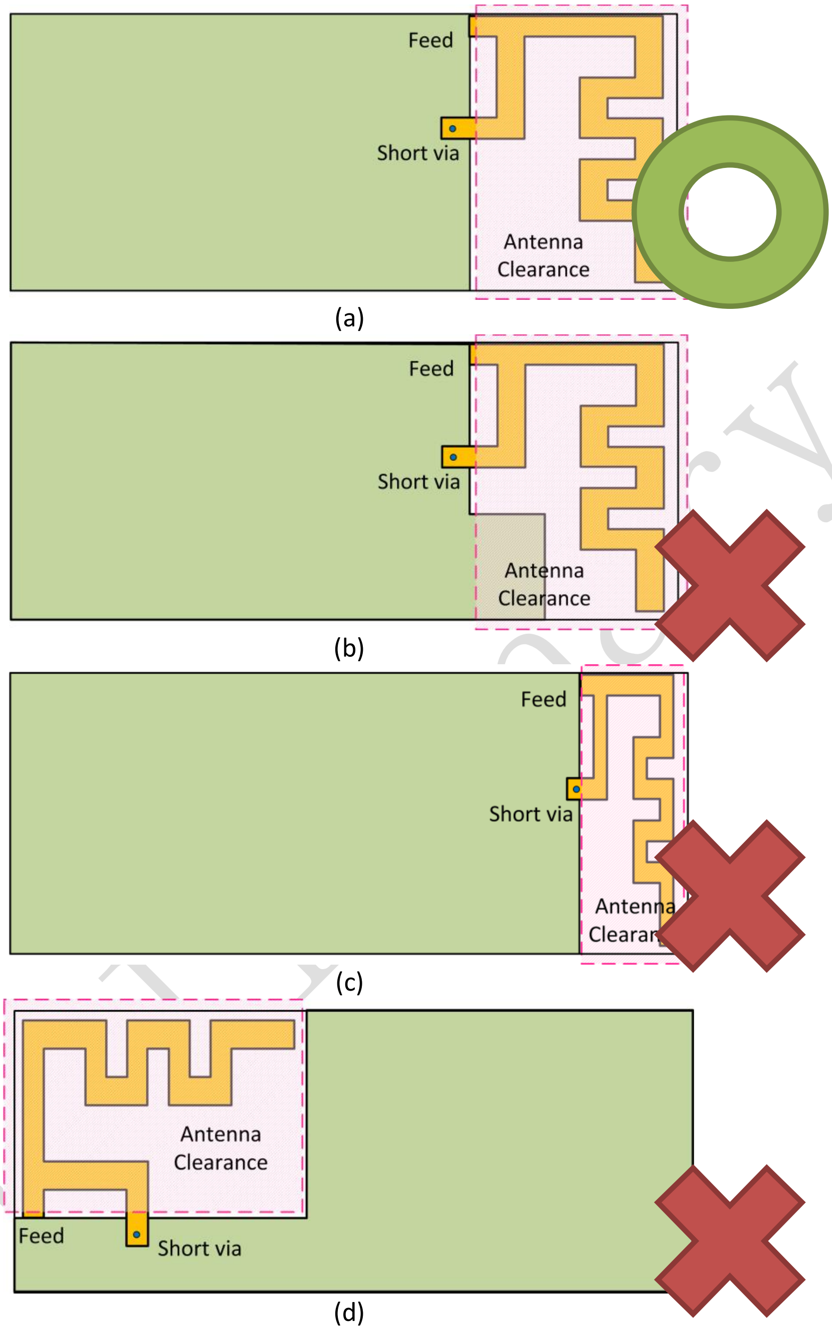


Fig. Antenna design

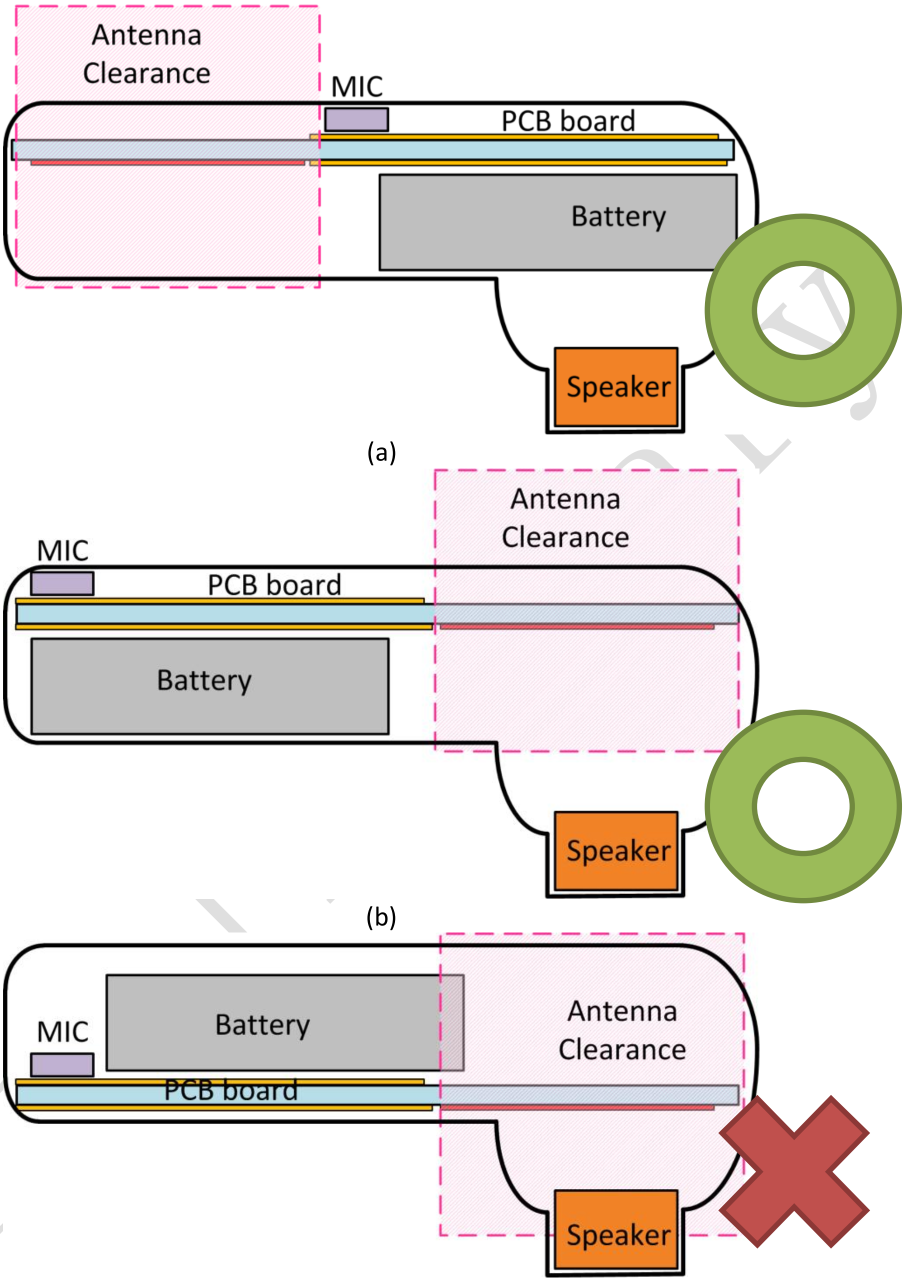
The clearance region is a defined area where no other metal material, except for the antenna itself, is allowed to enter. Fig.(a) – Fig.(d) are 4 different designs. Fig.(a) has the best performance of all. It has a reasonable clearance and ground plane is removed.

If the size of the clearance is too small, as illustrated in fig.(c), the performance and bandwidth will be limited, even though the wire length is about 1/4-wavelength.

As a rule of thumb, metal must be kept out of the clearance region. Otherwise, the performance of the antenna will be heavily degraded.

Although the design in fig.(d) satisfy the above requirements, the performance is not as good as the design in fig.(a), because the ground plane is located at the radiation direction of the antenna.

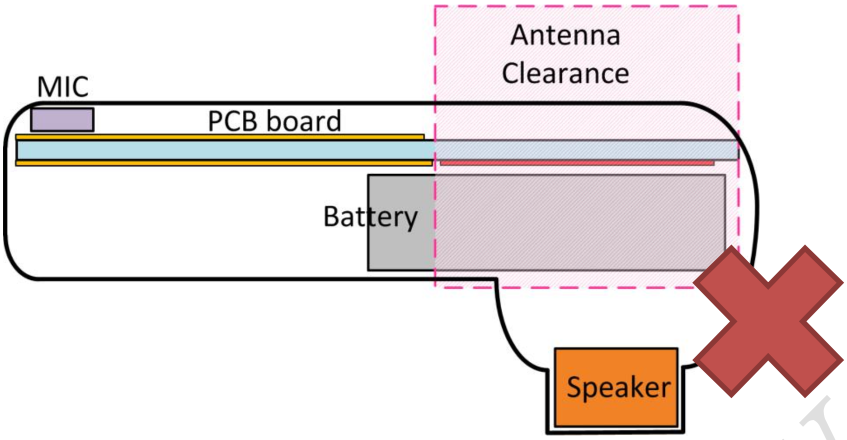
The antenna could not be directly shrink or enlarged, if the clearance is too small, try to find another PCB antenna or use chip type antenna instead.



(a)

(b)

(c)



(d)

Fig. Antenna placement

There are 2 points to keep in mind when placing the antenna:

1. Keep the antenna as far from human body as possible.
2. Keep any metal material away from the clearance region.

Fig.(a) has the best performance of all in antenna point of view, for it best satisfies the descriptions above. As a trade-off, MIC is moved away and thus sacrifices the recording performance. The design in Fig.(a) is recommended in applications where MIC is not necessary.

Fig.(b) is also a good design, compare to Fig.(c) which antenna is too closer to human body and the speaker.

Fig.(d) is forbidden since it against the rule of thumb. Notice that the clearance is actually a 3-dimensional region, so the battery must not be placed beneath the antenna.

Other things that worth mention is:

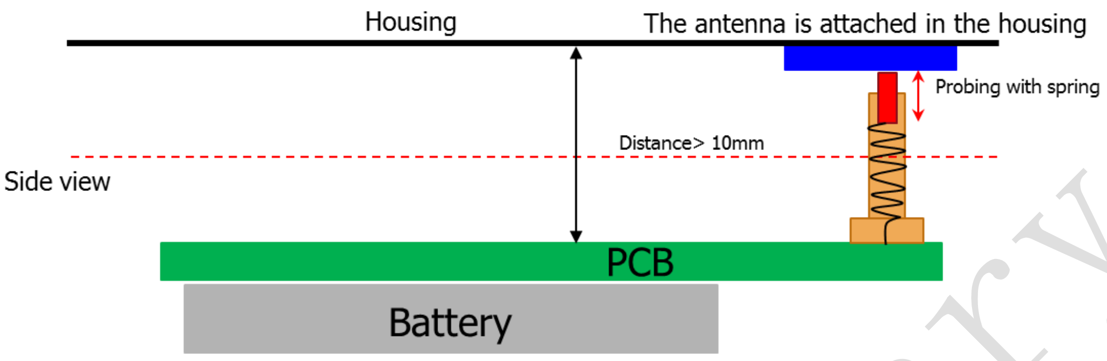
- Antenna performance is affected by the size the ground plane and the overall design of product.
- Usually, a larger ground will lead to a larger bandwidth (And also a slight shift in resonance frequency), and vice versa.
- Battery is considered as a part of the ground.
- Pi-matching network is required for fine-tuning at later stage of the design process.
- As a key radiating element for wireless device, the antenna must be considered at early stage of the design, and fine-tuning should be performed at later stage of the design.

2.10 Chip type antenna

If the antenna clearance is too limited, please use chip type antenna instead.
For RWS headset design, chip antenna is preferred due to its limited antenna area and mechanical parts close by. Try to use a biggest antenna that could be fitted into the headset, generally, the bandwidth of 8010 type chip antenna is wider than that of 5320/5020/3216 type. If the bandwidth is wider, we could get more advantage to fit on different head model and different use case.

2.11 Thimble antenna

Thimble antenna is also a solution in Bluetooth headset, it is a good way to keep the antenna far away from the human head, there is a limitation in the housing, the distance from the housing to the PCB must be larger than 10mm to keep a good antenna radiation pattern.



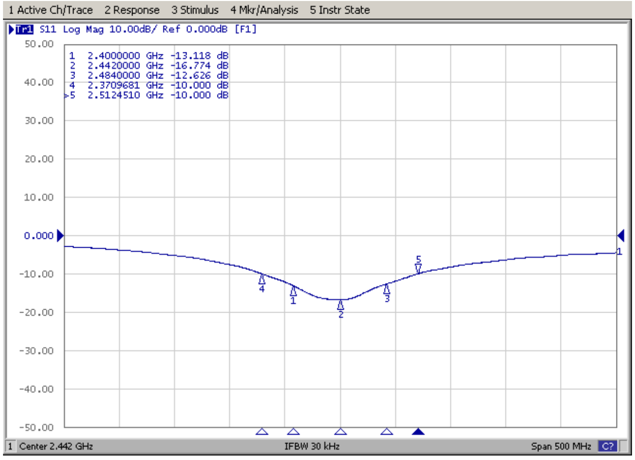
2.12 LDS antenna

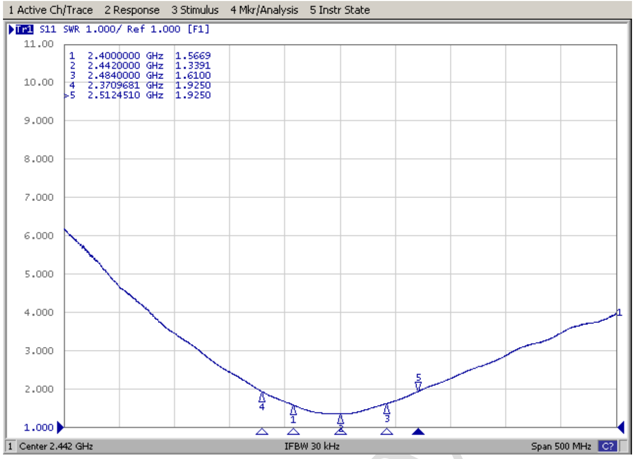
LDS antenna is with good RF performance which is printed on the housing and good immunity for the PCB, which is a distance from PCB.

2.13 Fine tune the antenna bandwidth and S11

2.14 Antenna measurement

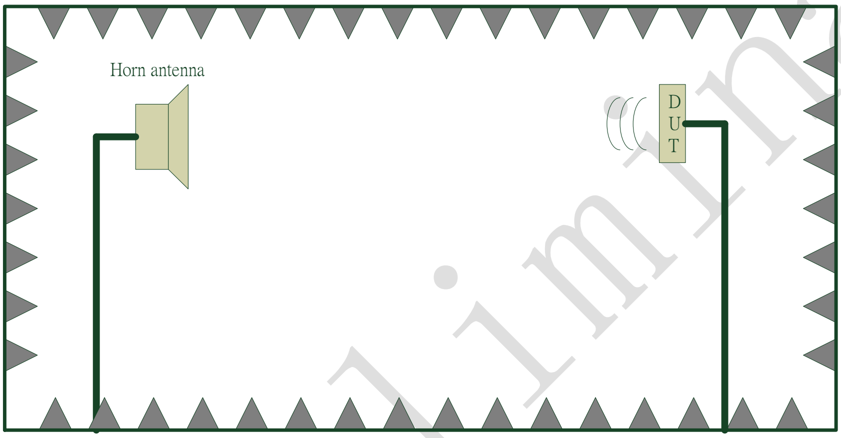
Antenna measurement flow:
Step1:
Fine tune the antenna bandwidth and resonance frequency with network analyzer, better to wear the headset on fake head to fine tune.
The sample should be as complete as possible, like a complete headset, not to fine tune on a bare PCB.



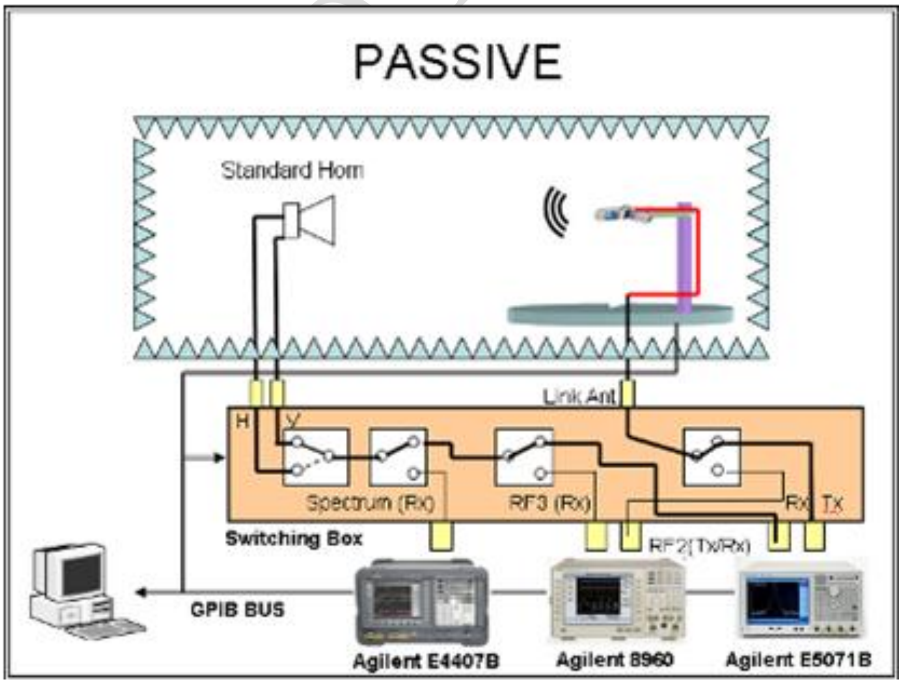


Step2:

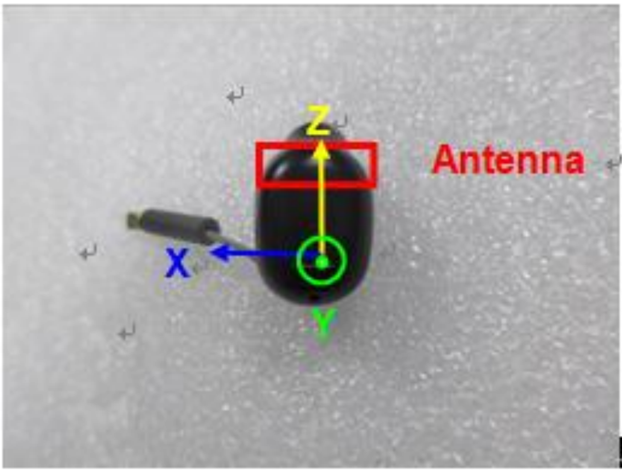
Antenna pattern check: tested with a standard horn antenna, this test should be completed in an antenna lab. The radiation pattern should be carefully checked to get the best performance.

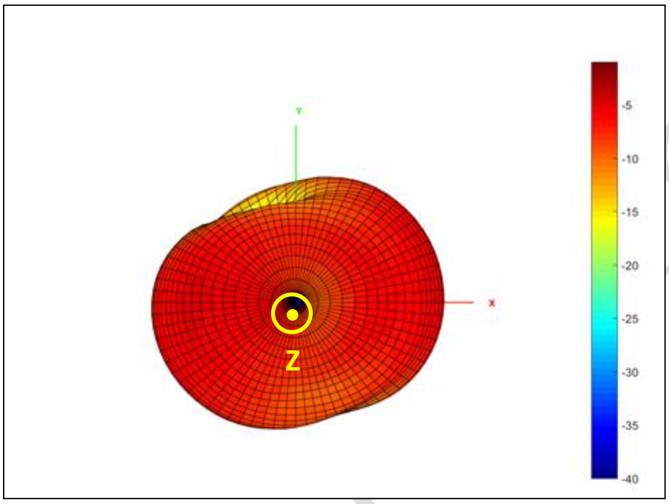


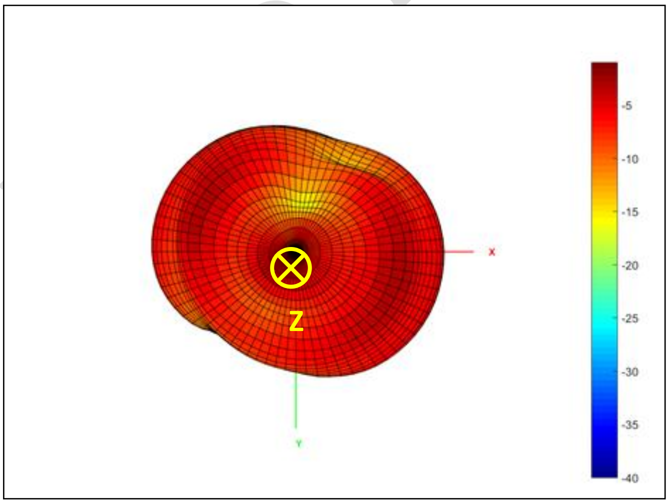
Instrument

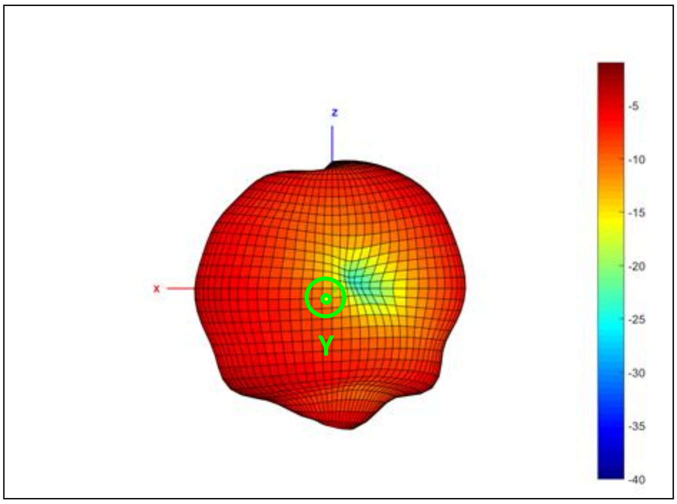


Antenna radiation pattern check

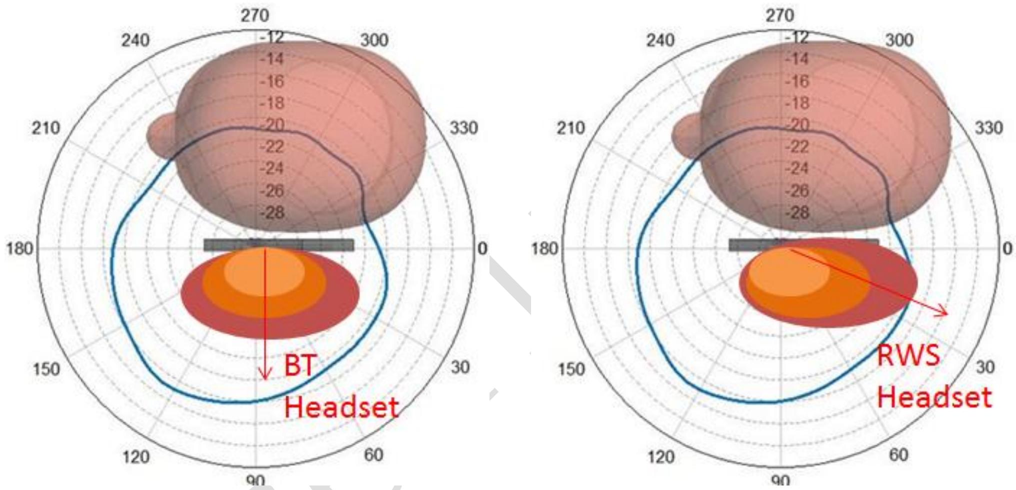








Radiation pattern suggestion:



2.15 RF Notice

RF power pin

VD33_PA, VD33_SYN, VD12_PA, VD12_SYN and VD12_RTX are the power input pin for RF transmitter and receiver.

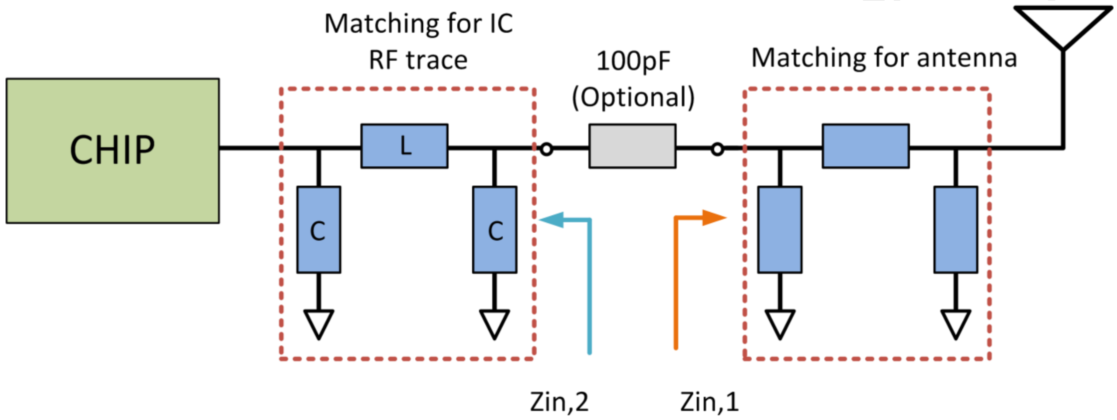
VD33_PA and VD33_SYN should be applied with 3.3V which sources from VPA33 with internal-built LDO.

VD12_PA, VD12_SYN and VD12_RTX should be applied with 1.2V, and could source from LX_CORE.

Decoupling capacitor should be added and placed right in front of the power input pin.

Matching circuit

In order to achieve efficient power transfer from RFIO to antenna, a matching circuit is required. For a return loss greater than 10 dB means that 90% of the power is transmitted to the antenna.



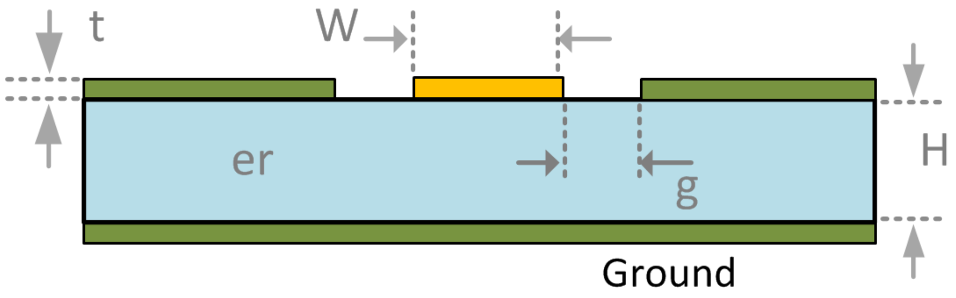
In the above figure, 3 components are used for matching the IC RF trace and 3 components are for matching the antenna. The target is to have 50 ohm input impedance for both Zin,1 and Zin,2. The 100pF capacitor for DC blocking may be optional only if the chosen antenna is PCB or chip antenna.

The matching network in IC RF trace is also designed for harmonic suppression. The suggested value is 1.2pF-3.9nF-1.2pF. It is strongly recommended to follow Realtek HDK document, and choose exactly the same material from QVL. Otherwise, the performance may not be guaranteed.

The chosen value for antenna matching depends on the design. Sometimes, antenna matching can be achieved by using only 2 components. However, the space for 3 components should be saved, because fine-tuning is performed at the later stage of the design.

RF trace impedance

The trace for RF signal should be designed for 50 ohm. The impedance depends on the following factors and should be design carefully:



1. Trace width
   Smaller W will lead to higher impedance.
2. Height from trace to ground
   The impedance decreases when H is increased.
3. The gap between RF trace and adjacent ground
   The impedance decreases when g is decreased. Noticed that gap must be symmetrical on both sides of the trace.
4. Copper thickness
   The impedance increases when t is decreased.
5. Substrate dielectric constant
   Larger er will leads to smaller impedance.

The above parameters for RF trace should be considered. Several free impedance calculators could be found online. Use these calculators to calculate for a proper designed geometry for RF trace.

The impedance must be constant throughout the RF signal trace. Therefore, trace width and the gap between RF trace and adjacent ground should be maintained.

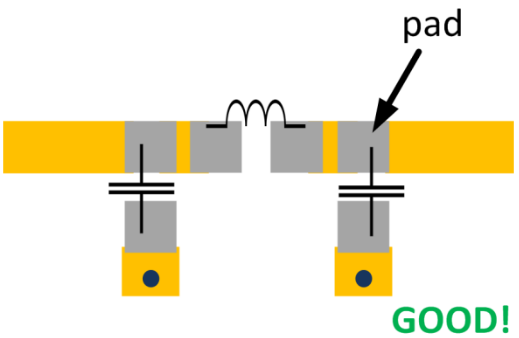
Different from other signal traces, the RF trace must be guarded with ground, such that it forms a CPWG guided wave structure. Any other traces must not be placed close to the RF trace. Otherwise, mutual coupling between traces will cause severe inference problem.

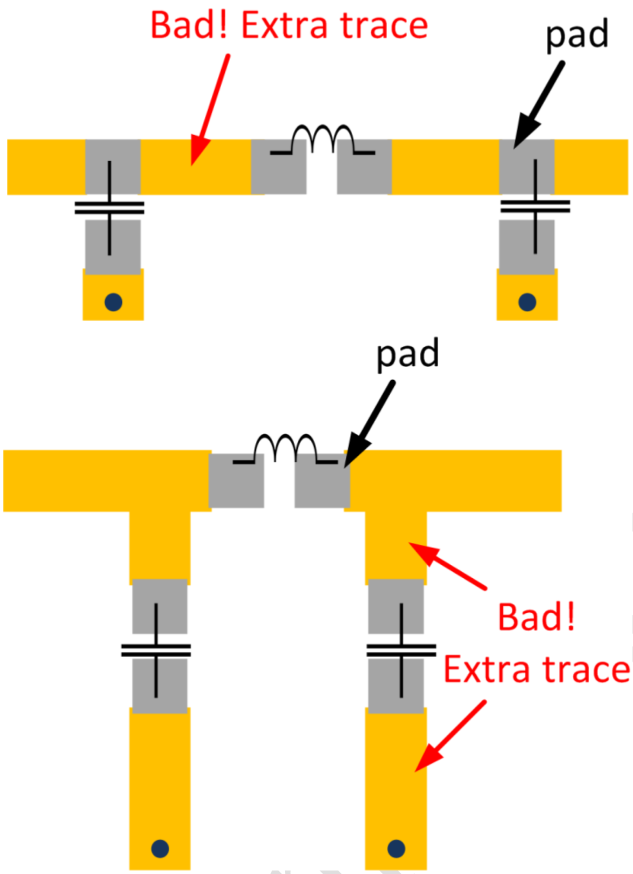
RF trace layout

As a rule of thumb, ground plane beneath the RF signal trace must not be split in any condition.

Generally speaking, the total length of the RF signal trace (from RFIO to the antenna) should be as short as possible, so that the transmission loss can be minimized. Also, RF trace should be on the top layer. Do not penetrate through other layer by via.

Layout for matching network is illustrated as below. Components should be placed close to each other and there must not be extra connecting line. For shunt components, it is best to place the soldering pad right on the RF signal trace.




Bad! Extra trace
pad
pad
Bad!
Extra trace

RF Test interface

It used HCI UART as RF test interface, P0_6 is UART RX (input); P0_7 is UART TX(output). These pins should connect to BT Tester before RF Test by UART. It may be add level shifter board because different signal level.

RF should connect to BT Tester by cable, and cable loss should be calculated in result.

HCI UART parameter:

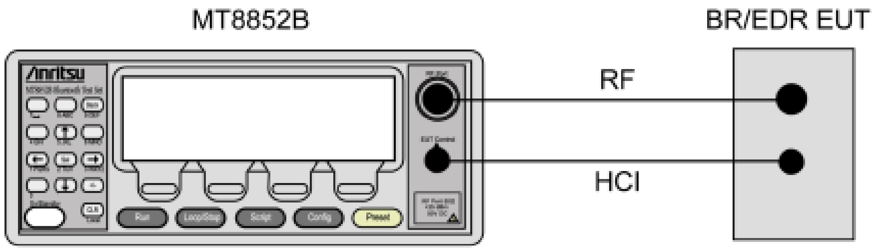
Baud rate: 115200

Data length: 8bits

Stop bits:1 bit

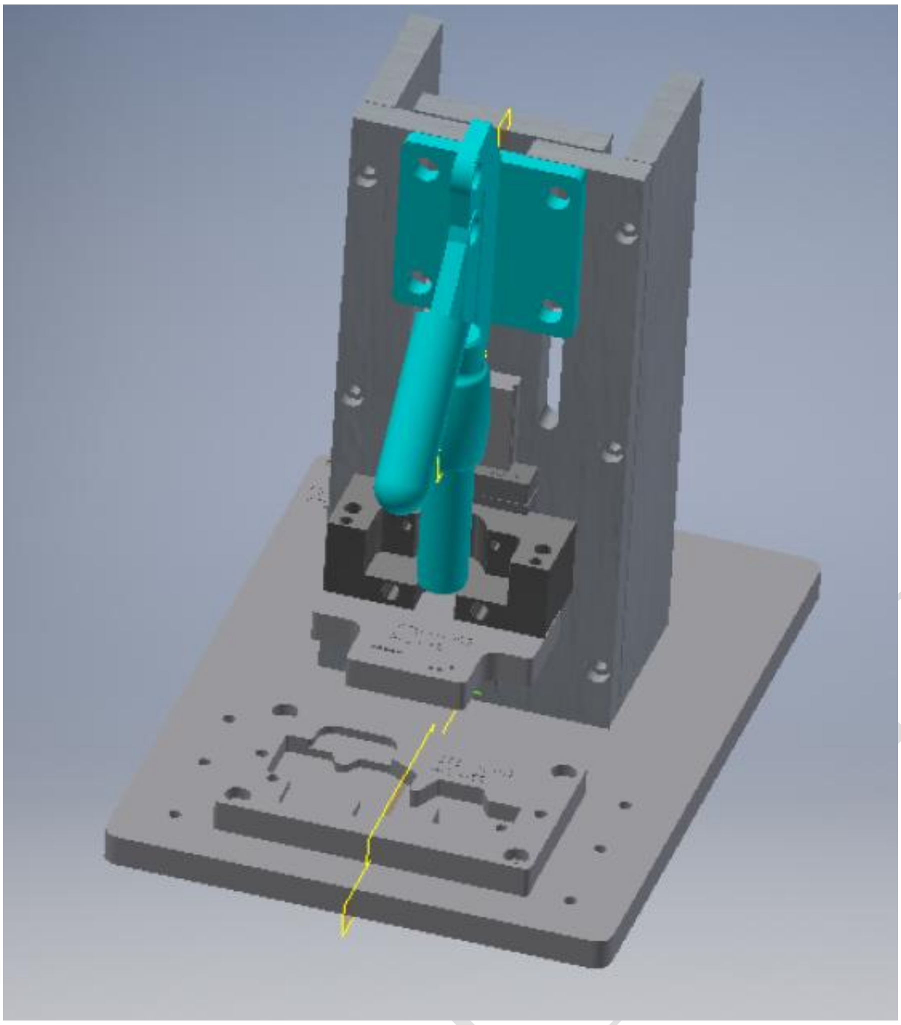
Parity bit: none

HW flow control: No



2.16 Mass production

The customer is encouraged to make a robust mass production tooling. It could help to improve the yield and the correctness of the PCBA measurement. REALTEK designed MP controller board "GENESIS" is a convenient tooling to control the mass production flow, include power on/off sequence, PMU, RF calibration. For the detail, please refer to mass production document.



3 Key part selection guide & QVL

3.1 40MHz Crystal

Spec:

	Min.	Typ.	Max
Frequency (MHz)	-	40	-
Frequency tolerance (ppm)	-	-	±10
Frequency stability (ppm)	-	-	±10
Load capacitance (pF)	-	9 or 7	-
Drive Level (uW)	-	-	300
Equivalant Series Resitance (Ohm), C_L=7pF	-	-	50Ω
Equivalant Series Resitance (Ohm), C_L=9pF	-	-	40Ω
Insulation Resistance (MOhm)	500	-	-

QVL:
http://www.taisaw.com/en/index.php
http://www.siward.com.tw/en/
http://www.hele.com.tw/
https://www.ndk.com/

XTAL_40M	3225 type	40MHz/CL=7pF crystal, +/-5ppm, -40 °C ~85°C , +/-15ppm	TZ0882D	TST
	2520 type		TZ1181B	
	1612 type		TZ3220A (-30~85)	
	2016type	40MHz/CL=7pF crystal, +/-20ppm over -40 °C ~85°C	EXS00A-CS10301	NDK
	1612type		EXS00A-CS10300	
	2016type	40MHz/CL=7pF crystal	FXQM-190070 (XRCGB40M000F1S2DR0)	Murata
	2016type		9S40000062	惠伦
	3225 type	40MHz/CL=9pF crystal, +/-5ppm, -40 °C ~85°C , +/-15ppm	XTL571150-R53-026	Siward
			TZ0308D (-30~85)	TST
	2520 type		XTL581150-R53-027	Siward
			TZ0733E	TST
	2016 type		XTL501150-R53-028	Siward

			TZ1269D	TST
	1612 type		XTL901150-R53-029	Siward
	2520 type	40MHz/CL=7pF crystal, +/-5ppm, -40 °C ~85°C , +/-15ppm	X2B040000AZ1H-HS	HELE
	2520type	40MHz/CL=9pF crystal, +/-20ppm over -40 °C ~85°C	X2B040000A91H-HS	HELE
	2016type		X2C040000A91H-HS	HELE

3.2 Switching regulator inductor

Spec:
2.2uH Power Inductor for DC-DC SWR

- 2.2uH Inductor Spec
- Inductor Type: Power inductor
- L=2.2uH +-20%
- Self-resonant frequency > 40MHz
- DCR<1ohm (better if 0.5ohm is available)
- Saturation current > 0.5A

QVL:
http://www.zenithtek.com.tw/
http://www.t-yuden.com/
http://www.maglayers.com.tw/
http://www.gotrend.com.tw/

	Footprint	Inductance Tolerance	DCR	Part Number	Vendor
2.2uH	L2520	±20%	0.093Ω	ZADK-252012SB-2R2M	ZenithTek
	L0603	±10%	0.56Ω	ZWP-0603-2R2K	ZenithTek
	L0603	±10%	0.56Ω	MLCD-161008-2R2	MAG. LAYER
	L0603	±10%	0.56Ω	GNLC1610PR-2R2K	GOTREND
	L-L3W3	±20%	0.17Ω	NRH3010T2R2MN	TAIYO YUDEN
	L0603	±20%	0.3Ω	MBKK1608T2R2M	TAIYO YUDEN

3.3 RF inductor

QVL:
http://www.acxc.com.tw/
http://www.toko.co.jp/top/en/index.html

	Footprint	Tolerance	Part Number	Vendor
3.9nH 2.7nH	L0402	0.3nH,Y	HI1005-series	ACX
	L0201	0.3nH,Y	HI0603-series	ACX
	L0402	0.3nH,Y	LL1005-FH3N9S	TOKO

3.4 RF antenna

QVL:

1. Unicton 詠業

詠業科技股份有限公司
威力思通科技（深圳）有限公司
WirelessCom Technologies(Shenzhen)Co. Ltd
公司地址:深圳市南山区桃源街道留仙大道 1268 号
众冠红花岭工业北区 4 栋 6 楼西 B（10 号电梯上 6 楼）

手机:+86-15875589778、13332994580 +886-932654730
电话: +86-755-26410707 传真 : +86-755-26410701
网址: www.unictron.com 邮编:518055
e-mail : frankchuang@unictron.com
Skype: michael_0405
QQ:2369749453

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www.yageo.com

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https://www.unictron.com/index2016/
http://www.yageo.com/NewPortal/_en/index.jsp
http://www.passivecomponent.com/product-search/Antenna/
http://www.onewave.com.tw/
http://www.inpaq.com.tw/rw_1d8317861c8d1e45df12bd6df6c44025

3.5 Passive component

QVL:
http://www.passivecomponent.com/
http://www.yageo.com/NewPortal/_en/index.jsp
http://www.darfon.com.tw/English/

Value	Footprint	Spec	Vendor
4.7uF	0402	X5R, 6.3V	Walshin, Yageo, Darfon
4.7uF	0402	X5R, 10V	Walshin, Yageo, Darfon
4.7uF	0603	X5R, 6.3V	Walshin, Yageo, Darfon
4.7uF	0603	X5R, 10V	Walshin, Yageo,

			Darfon
1uF	0402	X5R, 6.3V	Walshin, Yageo, Darfon