MT6628 CoB Hardware Design Application Note_V1.0

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MT6628 Application Note Version History

Version	Release Date	Note.	Author
V1.0	2012.04.18	V1.0 Release	MTK_SA

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Agenda

- ***MT6628 Performance & Feature Overview***
- ***MT6628 sub-system application circuit guide***
  - WiFi/BT Application Design
  - GPS Application Design
  - FM Receiver Application Design
  - PMU Application Design
  - WiFi/BT/GPS Dual/Single Antenna Design Guide
  - TCXO Design Guide
  - Host Interface Design
- **MT6628 CoB ATE instrument support**

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MT6628 Performance & Feature Overview

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MT6628 WiFi Feature and Performance

- WLAN general features
  - 802.11b/g /n MAC/BB/RF integrated
  - Built-in 21dBm WiFi PA with self-calibration
  - SDIO 2.0 (4-bits and 1-bit up to 50MHz)
  - Support WiFi Direct (WFA P2P standard)

@ MT6628 Chip-out

WiFi			
Item	Condition	Number	Unit
Rx current	2.4GHz, 1Mbps	49.5	mA
Rx current	2.4GHz, 54Mbps	53.7	mA
Rx current	2.4GHz, HT20 MCS7	53.5	mA
Rx current	2.4GHz, HT40 MCS7	63	mA
Rx current	Listen	47.3	mA
Rx current	Sleep	0.117	mA
Rx current	Power Saving, DTIM=1	0.56	mA
Tx current	2.4GHz, 1Mbps, 21dBm	210	mA
Tx current	2.4GHz, 54Mbps, 18dBm	185	mA
Tx current	2.4GHz, HT20 MCS7, 16dBm	172.5	mA
Tx current	2.4GHz, HT40 MCS7, 16dBm	181	mA

WiFi	Test @ Chip in/out		
Item	Condition	Number	Unit
Rx sensitivity	2.4GHz, 1Mbps	-98.5	dBm
Rx sensitivity	2.4GHz, 11Mbps	-91	dBm
Rx sensitivity	2.4GHz, 6Mbps	-95	dBm
Rx sensitivity	2.4GHz, 54Mbps	-77.5	dBm
Rx sensitivity	2.4GHz, HT20 MCS7	-75.5	dBm
Rx sensitivity	2.4GHz, HT40 MCS7	-72	dBm
Tx power	2.4GHz, 1Mbps	21	dBm
Tx power	2.4GHz, 11Mbps	21	dBm
Tx power	2.4GHz, 6Mbps	18	dBm
Tx power	2.4GHz, 54Mbps	18	dBm
Tx power	2.4GHz, HT20 MCS7	18	dBm
Tx power	2.4GHz, HT40 MCS7	16	dBm

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Bluetooth Feature and Performance

Bluetooth features

- Supported Bluetooth 4.0, BT Low Energy (LE)
- Bluetooth specification 3.0+HS compliance
- Bluetooth 4.0, BT Low Energy (LE)
- Integrated PA with 11dBm (class 1) transmit power

BT RF performance

Bluetooth	Test @ Chip in/out		
Item	Condition	Number	Unit
Rx sensitivity	BDR	-95	dBm
Rx sensitivity	2EDR	-94	dBm
Rx sensitivity	3EDR	-87	dBm
Rx sensitivity	BLE	-96	dBm
Tx power	BDR	10	dBm
Tx power	2EDR	7	dBm
Tx power	3EDR	7	dBm

BT/BLE Current consumption performance

Bluetooth			
Item	Condition	Number	Unit
Rx current	Max	21.1	mA
Tx current	@ 11dBm output	48.3	mA
Current	Sleep mode floor	0.12	mA
Current	I. scan 2.56s	0.26	mA
Current	P. scan 1.28s, I. scan 2.56s	0.53	mA
Current	Inquiry	22.2	mA
Current	Sniff 0.5s, (master or slave)	0.35	mA
Current	SCO-HFP/HSP w/ Sniff 0.5s and P(1.28s)/I (2.56s)scan	10.3	mA

Bluetooth BLE			
Item	Condition	Number	Unit
Current	500ms (3 Tx + 3 Rx) Undirected connectable advertise /ADV_IND	327.8	uA
Current	1280ms (3 Tx + 3 Rx) Undirected connectable advertise /ADV_IND	199.35	uA
Current	300ms (11.25ms Rx window) passive scan	926.7	uA
Current	1.28sec connection interval (MASTER) (1T + 1R)	184.2	uA
Current	1.28sec connection interval (SLAVE) (1R + 1T)	194.2	uA

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GPS Features and Performance Overview

- **GPS features**
  - Support GPS/QZSS/SBAS(WAAS/MSAS/EGNOS/GAGAN)
  - Full A-GPS capability (E911/SUPL/EPO/BEE)
  - Best in class sensitivity performance
    - -165 dBm tracking sensitivity
    - -160 dBm hot start sensitivity

    - -148 dBm cold and warm start sensitivity

  - Lowest power consumption

SMPS Mode	MT6620	MT6628	Competitor
ACQ (mW)	54.62	38.04	Average 72
Track (mW)	40.58	28.72	

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FM Features & Performance Overview

- **FM features**
  - FM 76-108MHz band with 50KHz step and RDS/RBDS supported
  - Audio sensitivity 2dBµVemf at ((S+N)/N=26dB)
  - RDS sensitivity 16dBµVemf at RDS_Dev.=2KHz ,5% BLER
  - Digital audio interface (I^2S)

FM			
Item	Condition	Number	Unit
SINAD	Mono 22.5kHz	60	dB
Sensitivity	SINAD = 26dB	2	dBuVemf
THD	dev : 75KHz	0.05	%
ACI	@ -200KHz	55	dB
ACI	@ -400KHz	70	dB
AM supression		62	dB
Stereo separation ratio	Stereo 22.5kHz	40	dB

FM			
Item	Condition	Number	Unit
Rx current		12.4	mA

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WiFi/BT Application Design

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WiFi/BT Application Circuit

- Make star connection for AVDD16: connect D2&E1 to C1025; connect D4 to C1045; then connect C1025.2 to AVDD17_SMPS de-coupling cap C1026 and C1045.2 to C1027.
- RF differential-end trace needs to keep equal length and have solid ground plane
- Keep AVDD16_TRX_WBT, AVDD16_LF_WBT, AVDD16_SX_WBT away from noisy traces e.g. WLFDO 3.3V, SDIO bus, switching power supply, clock, and antenna control signals

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MT6628 WiFi/BT Differential Matching Topology

How to get peak power?

1. *Use RF peak power index to get the RF matching optimized point. OFDM peak power 26dBm*
2. **Adjust front-end matching C1024 and C1046. (Default setting C1046=2.2pF)**
3. **Set META tool WiFi TX power>20dBm and Rate 54M**
4. **Check WiFi peak power>26dBm from VSA**

Output

Result Averaging 10

	Current	Average(10)	Maximum	Minimum	Unit
Peak Power	26.38	26.48	26.82	-12.70	dBm
Avg. Power (all)	16.09	16.10	16.97	-17.88	dBm
Avg. Power (no gap)	17.41	17.41	18.29	-16.60	dBm
EVM All	-32.47	-32.66	-31.06	-33.46	dB
	2.38	2.33	2.80	0.00	%

Channel 7 (2442MHz)

TX test

Tx Power(dBm) 20

Pkt len 1024

Pkt cnt 0

continuous pkt tx

Rate 54M

Go Stop

Bandwidth

20MHz 40MHz U20MHz L20MHz Set

Guard Interval

400nS 800nS Set

802.11n Mode Select

Green Field Mixed Mode Set

MT6628 WiFi/BT Differential Matching Topology

Step	Check Item	Request	Unit
1	WiFi TX Psat request	>26	dBm
2	WiF TX avg. power at CCK 1M	>20	dBm
3	WiFi TX EVM at OFDM 54M avg. power 17dBm	<-30	dB
4	WiFi TX CCK 1M 20dBm spectrum mask margin	>3	dB
5	WiFi TX 2nd harmonic after filter at CCK 1M 20dBm	<-40	dBm
6	WiFi RX CCK 1M sensitvity	<-97.5	dBm
7	WiFI RX OFDM 54 sensitivity	<-76.5	dBm
8	BT TX GFSK power	>9	dBm
9	BT TX GFSK DH1/3/5 Freq. drift	<10	kHz
10	BT TX GFSK df1avg	147~167	kHz
11	BT TX GFSK df2max	>122	kHz
12	BT TX GFSK +/-2 MHz ACP	< -38	dBm
13	BT TX GFSK +/-3 MHz ACP	< -43	dBm
14	BT TX 3EDR w0	< 4	kHz
15	BT TX 3EDR RMS DEVM	< 8	%
16	BT TX 3EDR Peak DEVM	<15	%
17	BT RX GFSK sensitivity	<-94	dBm

Note: All value means MT6628 RF port.

The 2.4GHz WiFi/BT Design Guide (1/4)

- **ISM/GPS Single Antenna**

- **The RF layout is critical to 2.4GHz WiFi TX**
- **Shielding cover is must for MT6620 and place BPF in shielding can is necessary.**
- **(Optional) reserve L=39nH at C1026 for ESD protection**
- **Check List**
  - Route 2.4GHz RF traces **on top layer** with well-controlled 50ohm line, avoid transition between layers
  - Check **return loss (S_{11})** toward antenna at C1024 and C1037
    - -15dB (typ.)
    - -10dB (max.)
  - Check **insertion loss (S_{21})**:
    - CON1001-to-C1024 insertion loss=3dB (typ.)
    - CON1001-to-C1037 insertion loss=2dB (typ.)

The 2.4GHz WiFi/BT Design Guide (4/4)

- ***ISM/GPS Dual Antenna***

- **The RF layout is critical to 2.4GHz WiFi TX**
- **Shielding cover is must for MT6620 and place BPF in shielding can is necessary.**
- **(Optional) reserve L=39nH at C1026 for ESD protection**
- **Check List**
  - Route 2.4GHz RF traces **on top layer** with well-controlled 50ohm line, avoid transition between layers
  - Check **return loss (S_{11})** toward antenna at C5and C1023
    - -15dB (typ.)
    - -10dB (max.)
  - Check **insertion loss (S_{21})**:
    - CON1003-to-C1023 insertion loss=2.5dB (typ.)
    - CON1004-to-C5 insertion loss=1.5dB (typ.)

MT6628 WiFi 2.4GHz Power Control

- Built-in transmitter signal strength indicator (TSSI) circuit enables calibration-free power control
- Power Control Accuracy:
  - +/- 1.0dB across channels at 25ºC with 50ohm load
  - +/-1.5dB at VSWR = 2:1
  - +/-1.5dB across -40~85ºC range

Block Diagram of CMOS PA with TSSI

Pout across channels (HT20, 16dBm)

TSSI vs Pout

TSSI @ VSWR 2:1 CH7

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GPS Application Design

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GPS Application Circuit

- ***External LNA is necessary for GPS due to system integration variation.***
- ***Use host GPIO to control GPS external LNA enable pin.***
- ***Place decoupling capacitor close to external LNA power pin.***
- ***Place matching components close to external LNA input.***

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GPS Application Circuit

- ***Please use MTK Qualified TCXO components.***
- ***Avoid the noise interference for frequency stability.***
- ***Add 1nF DC block capacitor between TCXO output and MT6628 clock input.***
- ***For TCXO layout , please refer to TCXO layout guide for more detail.***

TCXO VCC :

Avoid the noise interference for frequency stability

TCXO DC Block

Place TCXO voltage bypass capacitor close to TCXO VCC

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GPS Application Circuit

- ***Please use MTK Qualified SAW Filter components.***
- ***Reserve 39nF at GPS antenna port for ESD protection.***
- ***Reserve GPS antenna matching components.***

GPS Application Circuit

- ***Place GPS LNA input matching components close to MT6628 GPS RF input pin.***
- ***Place decoupling capacitor close to MT6628 power pin.***
- ***All GPS RF trace needs to do 50ohm impedance control and well GND shielding.***
- ***GPS RF path near WiFi/BT RF path is forbidden and away from noisy traces and via.***
- ***For more detail, please refer to MT6628 HW check list .***

LNA Input Matching :

Please place these components close to MT6628 GPS RF input pin

Please place these components close to MT6628 power pin

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GPS Application Circuit

- ***If the location of GPS function block is far away from GPS antenna pad, please place the first-stage SAW filter and external LNA close to GPS antenna port for reducing RF path loss.***

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AGPS HW Design Notice

- ***If AGPS IOT or AGPS OTA certification is necessary, recommend to reserve an external GPS LNA to increase 1 ~ 2 dB margin***
- ***For AGPS OTA certification, recommend to use two antennas design for BT/WiFi/GPS. One is for GPS ; the other is for BT/WiFi.***
  - *IL of BT/WiFi/GPS Diplexer SAW is larger than that of GPS SAW*
  - *GPS RF frontend could have better CNR as compared with single antenna design for BT/WiFi/GPS*
- ***Recommend to use PIFA or magnetic antenna for GPS antenna design to avoid phantom effect from AGPS OTA BHHR(Beside Head + Hand Right) test condition***
- ***In order to easily pass AGPS OTA certification, recommend GPS antenna efficiency in free space as below***
  - *Total isotropic antenna efficiency ≧ 50%*
  - *Upper hemisphere isotropic antenna efficiency ≧20%*

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FM Receiver Application Design

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MT6628 FM Application Circuit

- *Keep the FM_RX_N and FM_RX_P in differential trace to connect to audio jack.*
- *Keep FM Antenna RF path away from power source.*
- *SANT_IN_N_VSS short to ground near chip.*

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MT6628 FM Application Circuit

- ***Place de-coupling caps C1052 as close as possible to MT6620 .***
- ***Reserve FM bead (ex.600ohm at 100MHz) at AVDD28_FM.***
- ***Please shunt 50K resistors near MT6573/6575 for the FM_RX audio path.***

MT6628 FM Application Circuit

MT6628 FM Audio Interface selection

--FM current consumption with audio interface is <u>less than</u> I2S interface due to additional current consumption from baseband digital circuit.

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MT6628 FM De-sense Note

- ***Add a LPF(chip out series 27nH, than parallel 10pF) on FM long Antenna trace, for WLAN/BT out band blocking de-sense.***
- ***Keep FM Antenna(audio jack/ usb/FPC) and RF traces away from power source and other Antenna like WLAN/BT/GSM Antenna, to avoid de-sense.***
- ***RF Traces should be far away and well- grounded from Vbat / VDDK and any other VDD traces.***
- ***VFM trace should be well ground shielding.***

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PMU Application Design

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MT6628 PMU Application Circuit

- PMU VBAT operating range:2.3~4.5
  - PMU_EN Range:1.4~3.6V
  - WiFi/BT LDOs bypass mode: VBAT<3.5V
- PMU Power Domain
  - CLDO: 1.2V
  - WF_PA_LDO: 3.3V
  - TLDO &TLDO_SW: 2.8V
  - BUCK : 1.7V
- Keep power trace rule as below (important)
  - WF_PA_LDO(L4): 20mil,
  - VBAT input (L2&K3):25mil,
  - LXBK(L3):20 mil,
  - OUTBK (J2): 20mil,
  - CLDO (K2): 15mil,
  - LDO (J1): 10mil,
  - TLDO_SW (H1): 6mil
- Buck Information
  - Buck efficiency >82% @PWM mode.
  - PFM/PWM mode switch point:35mA@VBAT=3.8V

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MT6628 PMU Application Circuit

- ***VREF and AVDD28 PLL application note***
  - Place C1007 close to L1
  - Let C1007 Pin.2 net to Main GND (important)
  - Place C1006 close to L5
  - Keep K5 as short as possible net to C1006 Pin2 GND first, then route to Main GND (important)

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MT6628 PMU Application Circuit

■*VBAT input application note*

- ➢Place C1003 close to L2
- ➢Keep K1 as short as possible net to C1003 Pin.2 GND first and to Main GND (important)
- ➢Place C1008 close to K3
- ➢ Keep J4 as short as possible connect to cap C1008 Pin.2 GND first and to Main GND (important)
- ➢ Keep the parasitic resistance smaller than 0.2 ohm
- ➢ Instead of sharing ground plane with RF. (important)

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MT6628 PMU Application Circuit

- ***BUCK application note***
  - LXBK(L3) inductor spec. is 2.2UH, 400mA, DCR < 0.15ohm (important)
  - Place L1001 and C1009 on same layer and close to LXBK(L3) (important)
  - Buck output current loop (L3 & J2) keep as short as possible (important)

Place L1001 and C1009 on same layer and close to LXBK

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WiFi/BT/GPS Dual/Single Antenna Design Guide

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The ISM/GPS Antenna Topology

- ***ISM/GPS Dual Antenna***

- ***ISM/GPS Single Antenna***

- ***Summary***
  - 2.4GHz/1.575GHz **dual antenna** shows **better performance** with **less insertion loss**
  - 2.4GHz/1.575GHz **single antenna** is optional for **compact layout** with **less BOM count**
  - Cost does not show much difference

MT6628 WiFi/BT/GPS Single ANT Solution

- *EPCOS SAW diplexer , B9106 is single source.*
- *Suggest to reserve the footprint of external GPS SAW filter for LTCC diplexer + GPS SAW filter single antenna design to replace B9016 if B9016 shortage occur. (LTCC diplexer is pin-to-pin compatible with B9016)*
- *GPS Antenna total efficiency >50%, Efficiency in hemisphere>20%*
- *WIFI /BT Antenna total efficiency >50%*

- *The FE using LTCC diplexer (integrated ISM BPF) plus external GPS SAW filter can replace EPCOS B9106 and LTCC diplexer is pin-to-pin compatible with B9106.*

MT6620 WiFi/BT/GPS Dual ANT Solution

- ***Base on customer's design, MT6628 also support Dual antenna design***

- ***MT6620 SAW QVL for GPS only using***

Component	Part Number	Manufacturer	Vendor
SAW	SAFEB1G57KE0F00	Murata	Murata
	B9440(LV01A)	EPCOS	EPCOS
	856561	SAWTEK	SAWTEK
	TA0757A	TAI_SAW	TAI_SAW

Antenna Placement 1 (Recommended)

- ***GPS/BT/WiFi Co-Antenna* Application is *recommended* for effective space utilization and antenna location arrangement.**
- ***The best antenna location of Combo Antenna is in the top of the mobile phone.***
- ***It is also recommended the phone jack and FM short antenna pad near combo chip and in the proper side of combo chip for shortening FM RF traces.***
- ***The combo antenna is recommended to be a dual-band PIFA for GPS and ISM band. Reserve enough space (at least 200 mm^2 x 6 mm) for dual-band PIFA.***
- ***For better radiation pattern in GPS band, the antenna trace of GPS along top edge is recommended.***
- ***Keep more than 5 mm spacing between combo antenna and other metal and ferromagnetic material components.***
- ***Combo antenna trace can NOT overlap with audio jack or USB connector, otherwise it would cause FM de-sense.***

● *Antenna Feed*

Antenna Placement 2

- *BT/WiFi Co-Antenna application with a GPS Patch Antenna is also an antenna solution.*
- *The best antenna location of Combo Antenna and GPS Antenna are in the top of the mobile phone.*
- *It is also recommended the phone jack and FM short antenna pad near combo chip and in the proper side of combo chip for shortening FM RF traces.*

● *Antenna Feed*

Criteria

- ***GPS Antenna***
  - VSWR < 2, Return Loss < -10 dB
  - Total Efficiency > 50 %
  - Efficiency in hemisphere > 20%
- ***BT/WiFi Antenna***
  - VSWR < 2, Return Loss < -10 dB
  - Total Efficiency > 50 %

TCXO Design Guide

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Outline

- ***MT6628 TCXO Layout Guide (Main PAs Distance > 5cm)***
- ***MT6628 TCXO Layout Guide (Main PAs Distance < 5cm)***
- ***Example for Bad and Good TCXO Placement***

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Preface

- ***Since GPS clock quality is more critical than that of BT/WiFi , MT6628 TCXO layout guide will pay more attention about GPS application***
- ***Main threat on GPS clock is thermal transient from heat source on PCB***
  - All active chipsets are heat source and should be far away from TCXO in any direction including TCXO backside.
    - Heat source with on/off current difference over 100mA is 1st took care
      - Main PAs such as 2G/3G/LTE PA and so on.
    - Heat source with on/off current difference smaller than 100mA is 2nd took care
  - GPS clock quality is critical on field trial when GPS is under weak signal
  - Need to specially take care by PCB layout rule

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Case1: If TCXO and Main PAs Distance > 5cm

1. ⓪①②③④⑤ is TCXO possible (suggested) Placement related to MT6628
2. GND clearance "a ": 3 mm
3. GND clearance "b" : 2 mm
4. GND clearance "c" : 1.5 mm

1. TCXO placement is 1st priority when MT6628 placement starts in portable device
2. TCXO had better locate in less traces routing area for each PCB layer. This will make layout rule implantation easier
3. The blue frame around TCXO is PCB forbidden area for L1 to Ln-1. n is PCB total layer No. GND clearance suggestions are shown as left.
4. Avoid other signal traces passing TCXO forbidden area
5. Avoid other heat sources putting on opposite PCB surface layer nearby TCXO
6. To put R/L/C components in TCXO forbidden area is allowed
7. Recommend TCXO package size : 2520 or 2016
8. Any signal trace/power trace/GND trace route to TCXO with 4mil trace width
9. Route TCXO clock trace with well GND shielding as possible
10. TCXO should be in the shielding cover
11. TCXO PCB footprint with 4 pads is better than that with 6 pads for thermal isolation consideration
12. Use 4mil trace to connect TCXO GND pad and then using 4 mil trace connect to surface GND layer with less heat .
13. Put TCXO VCC bypass cap near forbidden area edge in TCXO VCC pad direction and to be grounding via surface layer. Then using 4mil trace connect to TCXO VCC pad.
14. The lower percentage layout rule realization, the poorer GPS thermal immunity. i.e. GPS performance will degrade to some extent

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Case2 : If TCXO and Main PAs Distance < 5cm

1. ⓪①②③④⑤ is TCXO possible (suggested) placement related to MT6628
2. GND clearance "a ": 3 mm
3. GND clearance "b" : 2 mm
4. GND clearance "c" : 2 mm

1. Main PAs and other heat sources that operation current over 200mA has to be 2cm at least away from TCXO
2. Other heat sources should be put outside forbidden area
3. Other layout rule please refer to previous page "MT6628 TCXO Layout Guide (Main PAs Distance > 5cm) " .

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Example for Bad and Good TCXO Placement

Bad TCXO Placement

Good TCXO Placement

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Host Interface Design

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SDIO Interface

- Please reserve damping resisters on SDIO_CMD and SDIO_CLK and place them close to MT6628 for optimizing SDIO performance.
- Make SDIO_CLK, CMD and Data in a layout group.
- SDIO_CLK is a high speed signal and it must be shielded by GND plan for reducing noise.

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MT6628 UART interface for BT/FM/GPS

- Except SDIO interface, MT6628 also support Host UART interface for BT/FM/GPS application.
- Please add Pull-down resister for UART mode strap.

	Host Interface	UART_RTS
BT/FM/GPS Host Interface	SDIO (Default)	1
	UART	0

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MT6628 I/O Power Domain

MT6628 I/O power domain is listed as following table.

Power Domain	Pin Name	Direction (reset)	
		Duration	After
DVDDIO(1.8V/2.8V)	XTEST		I
	SYSRST_B		I / PU
T_LDO(2.8V)	ANTSEL2	I / PD	O / PD
	ANTSEL1	I / PD	O / PD
	ANTSEL0	I / PD	O / PD
DVDDIO(1.8V/2.8V)	AUXADC_I / RF_I_CAL		I / PU
	OSC_EN		O
DVDD_SDIO (1.8V/2.8V)	SDIO_CLK		I
	SDIO_CMD		I/O
	SDIO_DAT3		I/O
	SDIO_DAT2		I/O
	SDIO_DAT1		I/O
	SDIO_DAT0		I/O
DVDDIO (1.8V/2.8V)	UART_RXD		I / PU
	UART_TXD		O / PU
	UART_RTS		O / PU
	UART_CTS		I / PU
	PCM_CLK		I/O / PD
	PCM_SYNC		I/O / PD
	PCM_OUT	I / PD	O / PD
	PCM_IN		I / PD
	AGPS_SYNC		I / PD
	I2S_CLK		I / PD
	I2S_WS		I / PD
	I2S_DATA_OUT		I / PD
	WIFI_INT_B		O / PU
	BGF_INT_B		O / PU

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MT6628 ATE Test Instrument Support

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MT6628 MP ATE Support

- *Support parallel test, which performs WiFi, BT, GPS and FM test simultaneously.*
- *Support BT signaling / non-signaling mode testing.*

Functionality	Test Item	Instrument Support
WiFi	- 11b/g/n TX/RX Performance - Non-signaling test support	- Agilent N4010A - Litepoint IQ2010 - R&S CMW
Bluetooth	- BDR/EDR TX performance and Sensitivity - Non-signaling test support	-R&S CBT - Litepoint IQ2010 - R&S CMW
FM	RX Performance (Audio SINAD, Sensitivity, RSSI)	-Litepoint IQ2010 - R&S CMW
GPS	CNR, Clock stability	-Litepoint IQ2010 - R&S CMW - Areoflex GPS-101

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