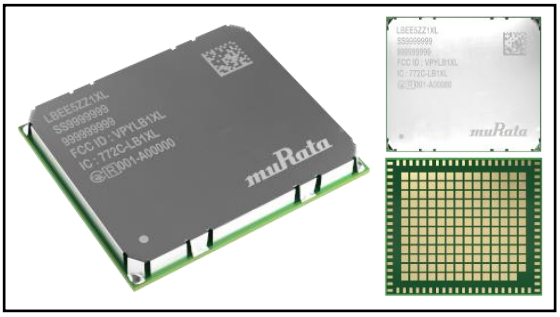
Murata Type 1XL/2XS
(LBEE5ZZ1XL/LBEE5ZZ2XS)

Hardware Application Note



Revision History

Revision	Date	Section	Change Description
1	Aug.29 '22	-	1st release

Table of Contents

1 Scope

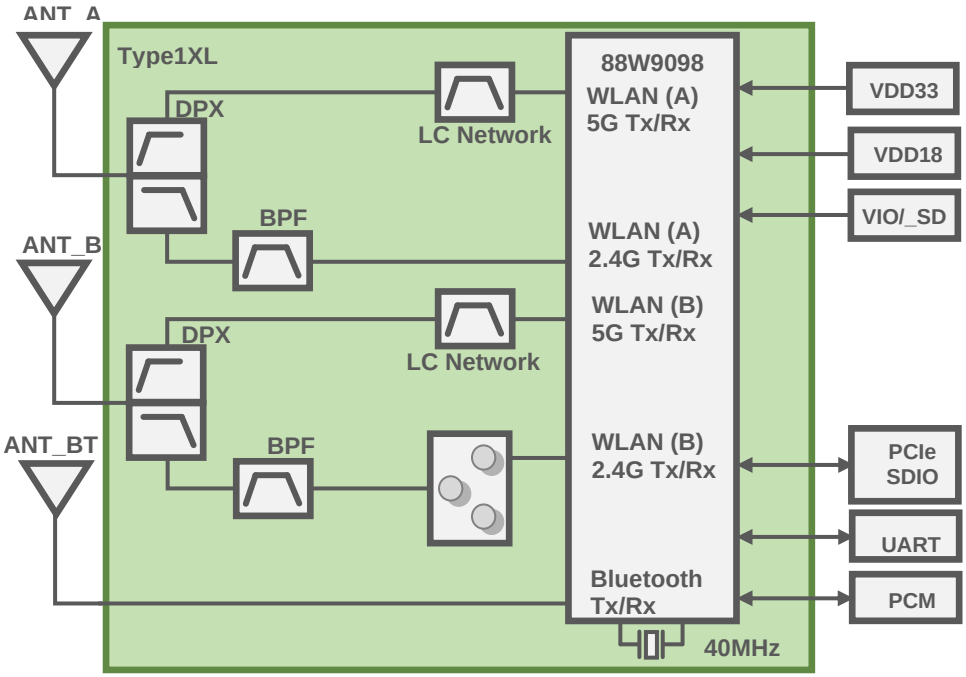
This Application Note covers HW development and provides how to design the Schematic and Layout, and reference RF performance. Refer to the datasheet “type1xl.pdf”/“type2xs.pdf” for Module specification.

2 Module Introduction

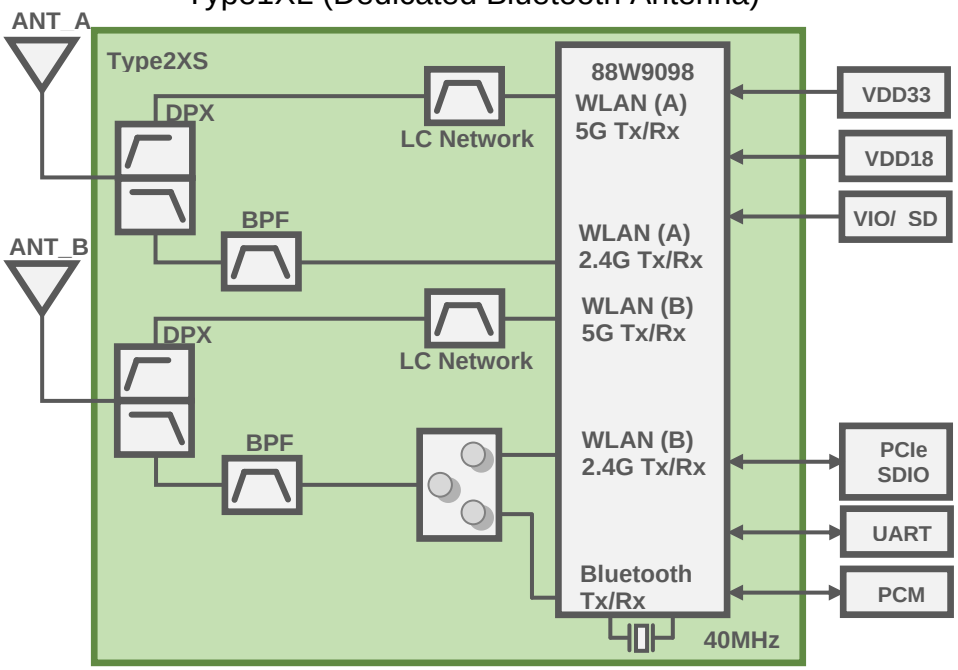
2.1 Features

- WLAN(11a/b/g/n/ac/ax) 2x2 MIMO + Bluetooth and low energy (v5.3) combo SMD module with NXP 88W9098
- Small size LGA package with metal shielding.
- PCIe3.0, SDIO3.0 for WLAN and UART for Bluetooth as the host interface.
- MAC address and BD address are stored in OTP

2.2 Hardware block diagram



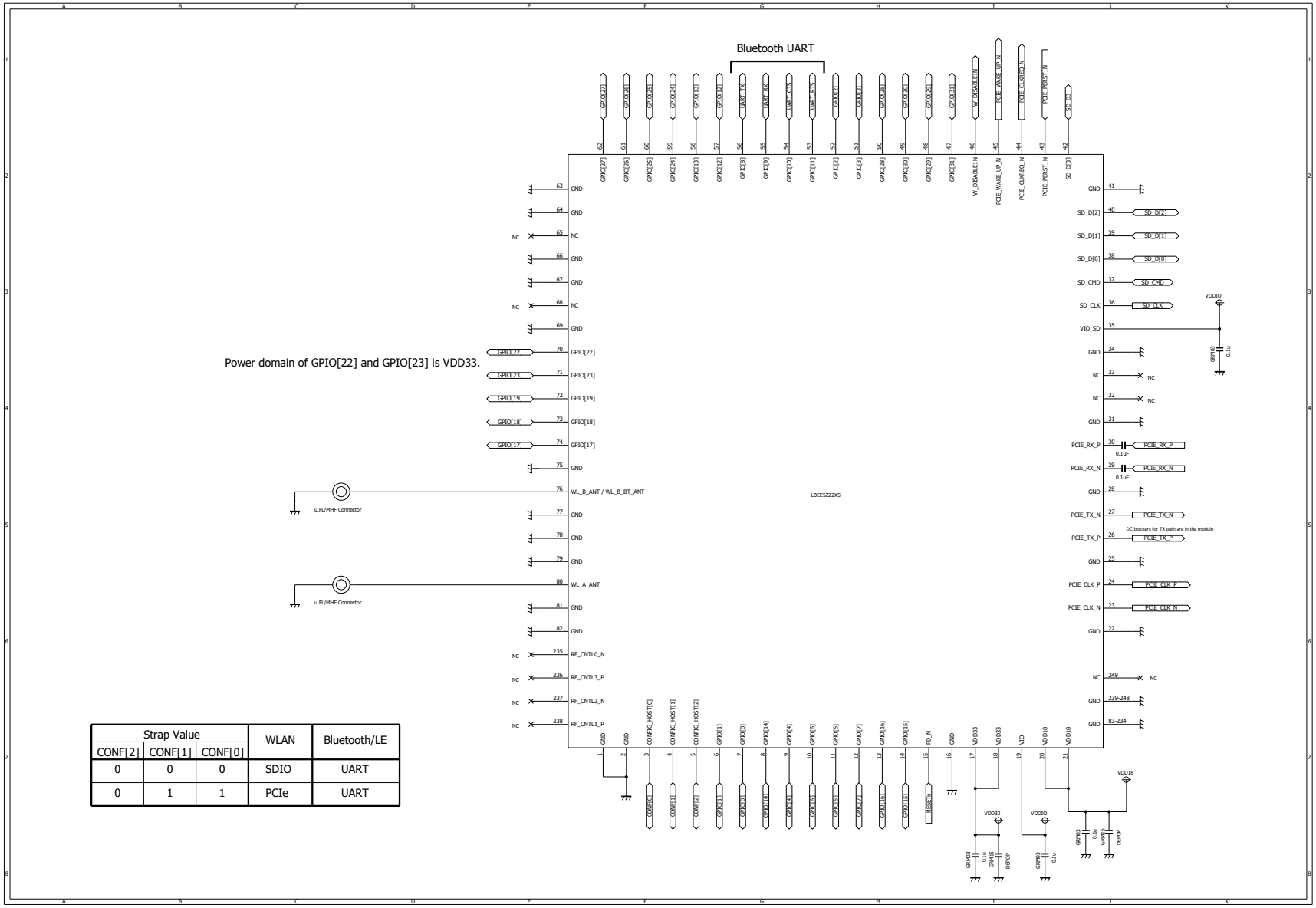
Type1XL (Dedicated Bluetooth Antenna)



Type2XS (Shared Bluetooth Antenna)

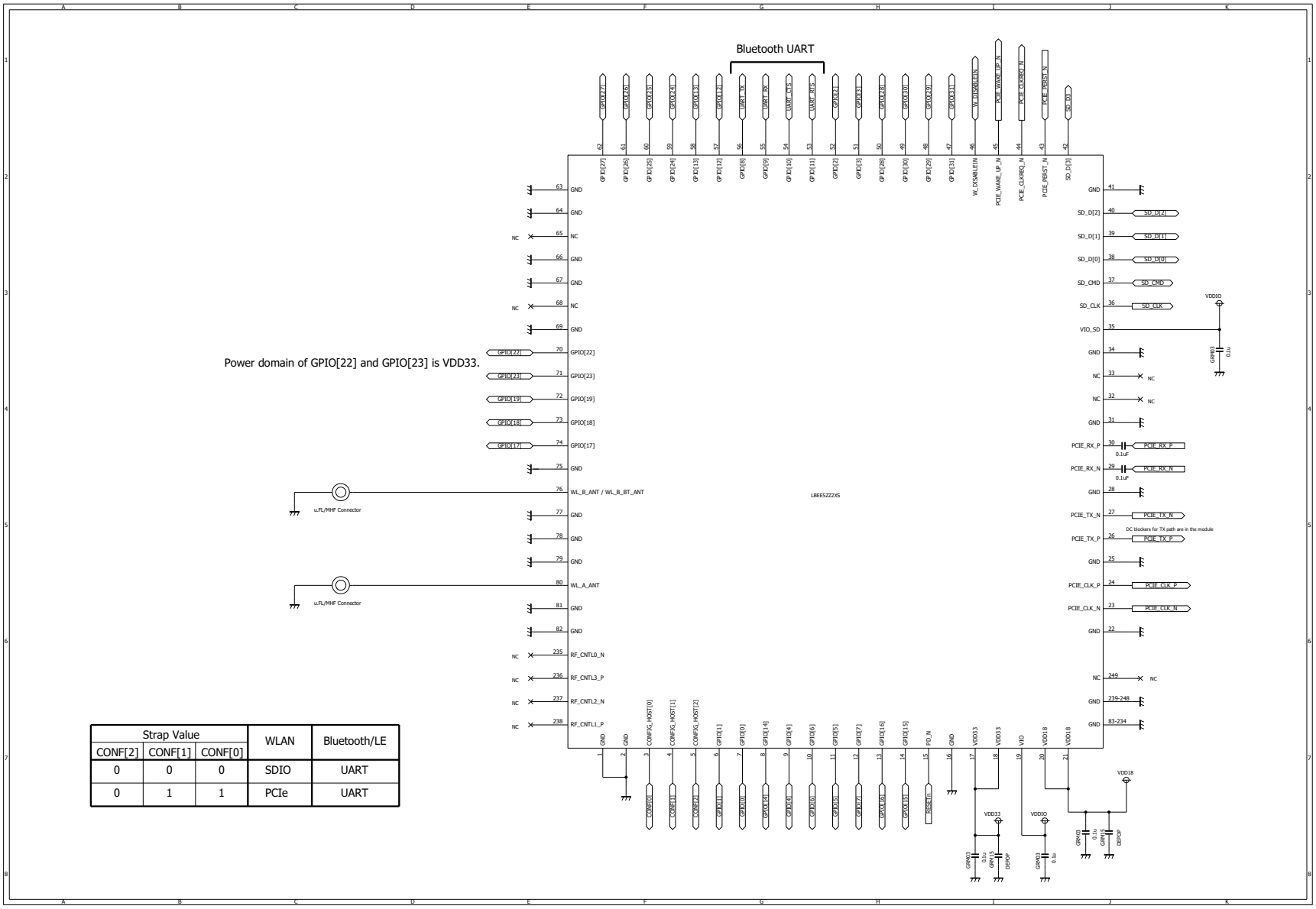
3 Reference design

3.1 Reference circuitry



Strap Value			WLAN	Bluetooth/LE
CONF[2]	CONF[1]	CONF[0]		
0	0	0	SDIO	UART
0	1	1	PCIe	UART

Type1XL (Dedicated Bluetooth Antenna)



Strap Value			WLAN	Bluetooth/LE
CONF[2]	CONF[1]	CONF[0]		
0	0	0	SDIO	UART
0	1	1	PCIe	UART

Type2XS (Shared Bluetooth Antenna)

3.2 Requirements for high-speed digital signals

- SDIO: SDIO traces should be isometric zero delay routing with 50-ohm impedance.
- PCIe: TxP/N, RxP/N and CLKP/N signals should be differential 100-ohm impedance. DC blockers is necessary on RxP/N.

3.3 Requirements for unused signals

Any pull-up/down is not necessary (floating) for GPIO [0..31] if these signals are not used.

3.4 Module footprint design

Refer to dimensions in the datasheet “type1xl.pdf”/“type2xs.pdf”. The DXF file of module footprint “type1xl_2xs_footprint_topview.dxf” is provided via website.

3.5 Recommended antenna

This module is certified with two types of antenna solution by regulatory certification body. To use Murata’s regulatory certification, any user must follow below instructions. The DXF file “Type1XL_2XS_u.FL.dxf” is provided via web site.

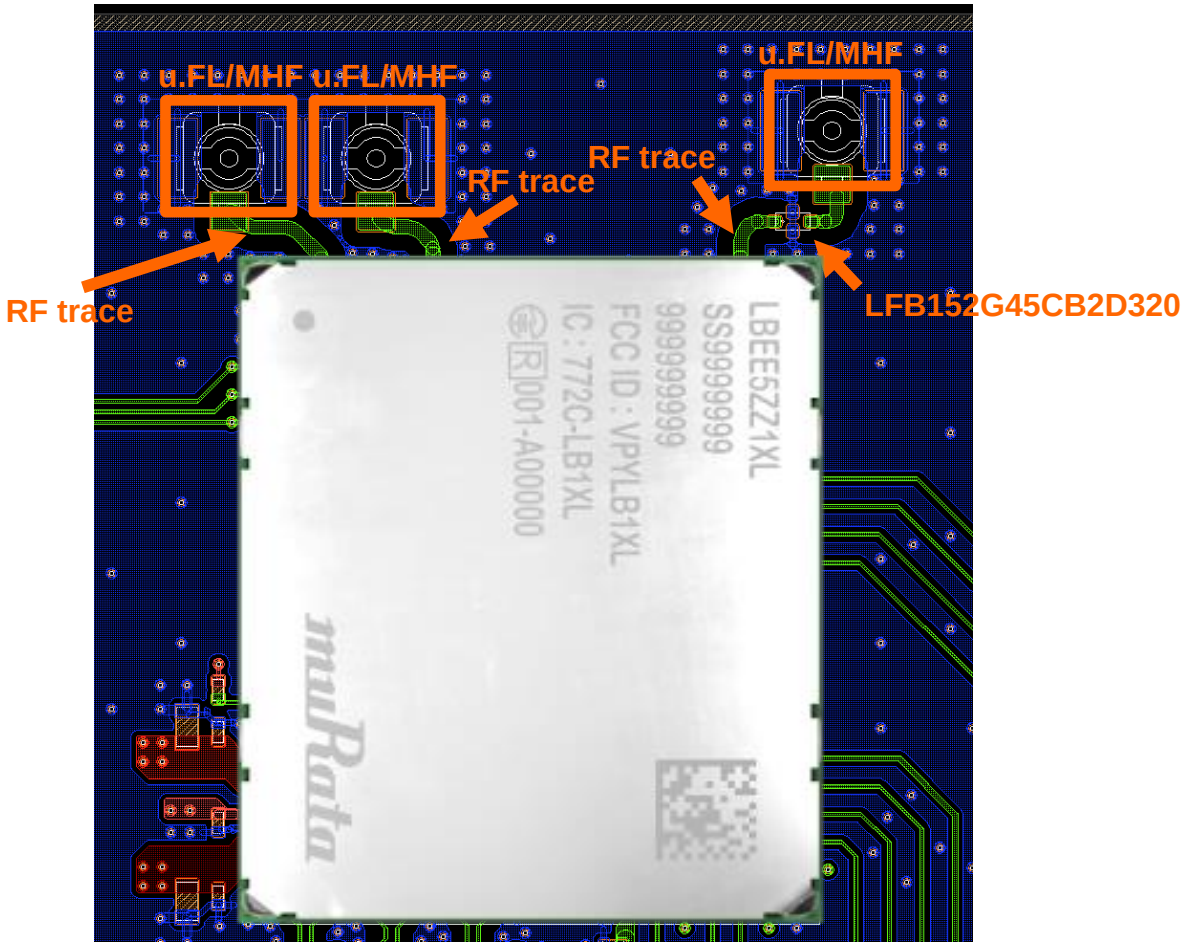
3.5.1 PCB Type Di-pole Antenna with the co-axial connector

- Any users must use recommended antennas. However, user can use any equivalent type antenna with less antenna gain than antenna gain of recommended antennas for US and EU under approval of Class I Permissive Change by Murata.

Series	Vendor	Form factor	Type	2.4GHz Gain	5GHz Gain	Cable options
146153	Molex	U.FL/PCB	Di-pole	3.2dBi	4.25dBi	050 (50mm) or longer cable
WT32D1-KX	Unictron	U.FL/PCB	Di-pole	3dBi	4dBi	150mm (H2B1WD1A 3B0200)

*206994 : Only for Japan

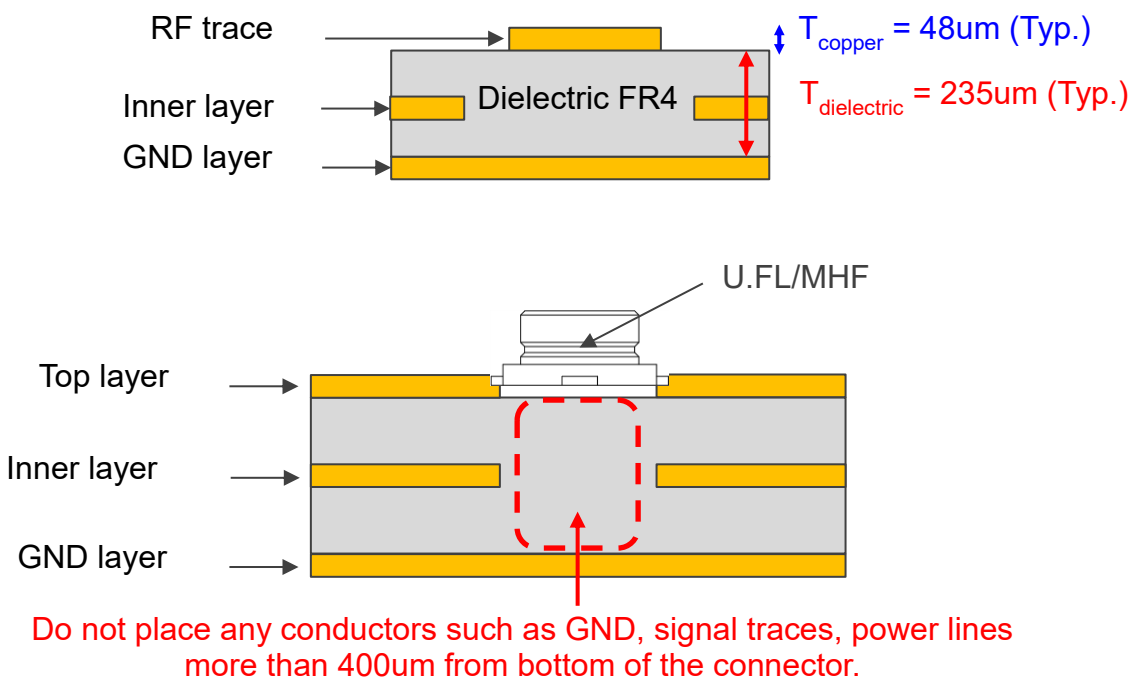
- Any users must copy RF trace to U.FL/MHF connector from the trace layout file provided by Murata; adhering to below guidelines on:
    - Trace width accuracy within +/- 0.25 mm.
    - Stack height between GND layer and RF trace of 230 ~ 240 um (Exclude inaccuracy of PCB).
    - Passive component location matching Murata design.
    - Necessary “Keep out” area around U.FL/MHF connector.



Type1XL (Dedicated Bluetooth Antenna)

Type2XS (Shared Bluetooth Antenna)

3.5.2 PCB Stack-up



4 Setup configuration files

To enable Murata's regulatory certification, below configuration file shall be loaded initially. Murata will provide configuration files via Murata's GitHub. (https://github.com/murata-wireless/nxp-linux-calibration)

4.1 WLAN configuration files for Linux

The following files shall be used to satisfy regulatory requirements if user wants to use Murata regulatory certification.

WLAN Tx power configuration files
- US : txpower_US.bin, rutxpower_limit_US.bin
- Canada : txpower_CA.bin, rutxpower_limit_CA.bin
- EU : txpower_EU.bin, rutxpower_limit_EU.bin
- Japan : txpower_JP.bin, rutxpower_limit_JP.bin

WLAN Carrier Sense / Adaptivity threshold configuration file
- ed_mac.bin

WLAN regulatory limitation configuration file
- db.txt

NXP IC based module shall use CRDA mechanism which is provided by Linux-wireless. Compile the new regulatory.bin file from "db.txt" which is provided by Murata with following manner of wireless-regdb. (https://wireless.wiki.kernel.org/en/developers/regulatory/crda)

4.2 Bluetooth configuration files for Linux

Bluetooth Tx power configuration script file shall be loaded after Bluetooth device initialization.

Bluetooth Tx power configuration files
- bt_power_config_1.sh

Command example

```
# sh bt_power_config_1.sh
```

Content of shell script file "bt_power_config_1.sh"

```
hcitool -i hci0 cmd 0x3f 0x00ee 0x01
```

** Bluetooth Tx power is configured by using hcitool.*

5 Reference performance data

5.1 Typical Tx output power level (at module antenna port)

Refer to “type1xl_2xs_datasheet(Appendix)” for Tx output power setting.

5.2 Typical Rx minimum sensitivity level (at module antenna port)

5.2.1 WLAN

<Condition>

- VDD33=3.3V, VDD18=1.8V, VIO=1.8V
- Combo FW : 17.80.200.p204

2.4GHz

Frequency in MHz	Rx minimum sensitivity level in dBm							
	11b		11g		11n(HT20)		11ax(HE20)	
	1Mbps	11Mbps	6Mbps	54Mbps	MCS0	MCS7	MCS0	MCS11
2412	-97	-89	-91	-75	-90	-72	-90	-62
2442	-97	-88	-91	-74	-90	-72	-90	-62
2472	-96	-88	-90	-74	-90	-72	-90	-62

Frequency in MHz	Rx minimum sensitivity level in dBm			
	11n (HT40)		11ax (HE40)	
	MCS0	MCS7	MCS0	MCS11
2422	-88	-70	-88	-60
2442	-88	-70	-88	-59
2462	-88	-70	-88	-59

5GHz

Frequency in MHz	Rx minimum sensitivity level in dBm							
	11a		11n(HT20)		11ac(VHT20)		11ax(HE20)	
	6Mbps	54Mbps	MCS0	MCS7	MCS0	MCS8	MCS0	MCS11
5180	-88	-72	-88	-70	-88	-66	-88	-60
5500	-88	-72	-88	-70	-88	-66	-88	-60
5825	-88	-72	-88	-70	-88	-66	-88	-60

Frequency in MHz	Rx minimum sensitivity level in dBm					
	11n(HT40)		11ac(VHT40)		11ax(HE40)	
	MCS0	MCS7	MCS0	MCS9	MCS0	MCS11
5190	-86	-68	-86	-62	-86	-57
5510	-86	-68	-86	-62	-86	-57
5795	-86	-68	-86	-62	-86	-57

Frequency in MHz	Rx minimum sensitivity level in dBm			
	11ac(VHT80)		11ax(HE80)	
	MCS0	MCS9	MCS0	MCS11
5210	-83	-59	-83	-55
5530	-83	-59	-83	-55
5775	-82	-59	-83	-55

5.2.2 Bluetooth

<Condition>

- VDD33=3.3V, VDD18=1.8V, VIO=1.8V
- Combo FW : 17.80.200.p204

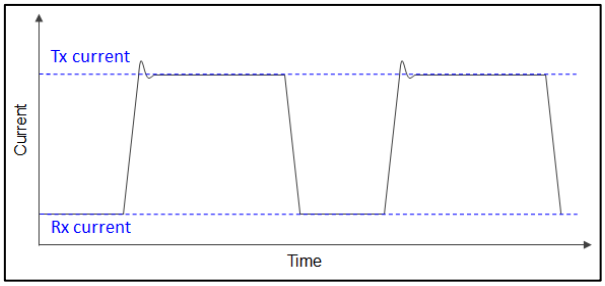
Frequency in MHz	Rx minimum sensitivity level in dBm						
	DH5	2DH5	3DH5	LE 125K	LE 500K	LE 1M	LE 2M
2402	-92	-92	-86	-106	-104	-100	-98
2441	-92	-92	-86	-105	-104	-100	-98
2480	-91	-90	-84	-103	-102	-99	-97

5.3 Typical Tx/Rx current consumption

5.3.1 WLAN

<Condition>

- VDD33=3.3V, VDD18=1.8V, VIO=1.8V
- Combo FW : 17.80.200.p204
- Current definition



2.4GHz(1SS)

Mode	Data Rate	Setting Tx Power (dBm)	Current in mA			
			Tx		Rx	
			VDD18	VDD33	VDD18	VDD33
11b	1Mbps	18	280	210	280	0.2
11g	6Mbps	17	300	200	280	0.2
11n(HT20)	MCS0	16	300	190	280	0.2
11ax(HE20)	MCS0	16	300	190	280	0.2
11n(HT40)	MCS0	14	310	150	300	0.2
11ax(HE40)	MCS0	14	310	160	300	0.2

2.4GHz(2SS)

Mode	Data Rate	Setting Tx Power (dBm)	Current in mA			
			Tx		Rx	
			VDD18	VDD33	VDD18	VDD33
11b	1Mbps	18	370	450	300	0.2
11g	6Mbps	17	410	450	300	0.2
11n(HT20)	MCS0	16	410	380	300	0.2
11ax(HE20)	MCS0	16	420	390	300	0.2
11n(HT40)	MCS0	14	430	330	320	0.2
11ax(HE40)	MCS0	14	430	330	320	0.2

5GHz(1SS)

Mode	Data Rate	Setting Tx Power (dBm)	Current in mA			
			Tx		Rx	
			VDD18	VDD33	VDD18	VDD33
11a	6Mbps	17	430	260	320	0.2
11n(HT20)	MCS0	16	400	250	320	0.2
11ac(VHT20)	MCS0	16	400	250	320	0.2
11ax(HE20)	MCS0	16	400	250	320	0.2
11n(HT40)	MCS0	16	410	250	320	0.2
11ac(VHT40)	MCS0	16	410	250	320	0.2
11ax(HE40)	MCS0	16	420	250	320	0.2
11ac(VHT80)	MCS0	15	400	230	350	0.2
11ax(HE80)	MCS0	15	400	230	350	0.2

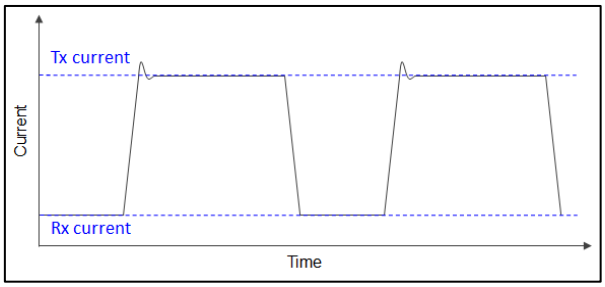
5GHz(2SS)

Mode	Data Rate	Setting Tx Power (dBm)	Current in mA			
			Tx		Rx	
			VDD18	VDD33	VDD18	VDD33
11a	6Mbps	17	610	510	320	0.2
11n(HT20)	MCS0	16	630	470	320	0.2
11ac(VHT20)	MCS0	16	640	470	320	0.2
11ax(HE20)	MCS0	16	640	480	320	0.2
11n(HT40)	MCS0	16	650	470	350	0.2
11ac(VHT40)	MCS0	16	650	470	350	0.2
11ax(HE40)	MCS0	16	660	480	350	0.2
11ac(VHT80)	MCS0	15	630	440	420	0.2
11ax(HE80)	MCS0	15	640	440	420	0.2

5.3.2 Bluetooth

<Condition>

- VDD33=3.3V, VDD18=1.8V, VIO=1.8V
- Combo FW : 17.80.200.p204
- Current definition



2.4GHz

Mode	Setting Tx Power (dBm)	Current in mA			
		Tx		Rx	
		VDD18	VDD33	VDD18	VDD33
BR(1DH5)	3	45	0.2	20	0.2
EDR(3DH5)	0	45	0.2	20	0.2
LE 125K	3	60	0.2	20	0.2
LE 500K	3	60	0.2	20	0.2
LE 1M	3	60	0.2	20	0.2
LE 2M	3	60	0.2	20	0.2

5.4 Typical sleep current consumption

5.4.1 WLAN

<Condition>

- VDD33=3.3V, VDD18=1.8V, VIO=1.8V
- Platform: NXP MCIMX8MQuad-EVK
- Combo FW : 17.68.1.p81
- WLAN I/F : PCIe
- Beacon Interval = 100ms

Band	Mode	Current consumption VDD18 in mA
-	Chip deep sleep(L1.2)	1.21
2.4GHz	IEEE Power Save:DTIM1	7.88
	IEEE Power Save:DTIM3	4.29
	IEEE Power Save:DTIM5	3.57
5GHz	IEEE Power Save:DTIM1	6.41
	IEEE Power Save:DTIM3	3.80
	IEEE Power Save:DTIM5	3.28

5.4.2 Bluetooth

<Condition>

- VDD33=3.3V, VDD18=1.8V, VIO=1.8V
- Platform: NXP MCIMX8MQuad-EVK
- Combo FW : 17.26.1.p109
- Bluetooth I/F : UART

Mode	Current Consumption in mA
Deep Sleep(BT Only)	1.51
BT Page Scan 1.28s	1.61
BT Page & Inquiry Scan 1.28s	1.51
BT Master Sniff mode 1.28s	1.79
Advertise 1s	1.29
BLE Scan 1.28s	1.44
LE Link Master 1s	1.77

5.5 Throughput

5.5.1 Typical throughput

<Condition>

- VDD33=3.3V, VDD18=1.8V, VIO=1.8V
- Platform: NXP MCIMX8MQuad-EVK
- Combo FW : 17.68.1.p81
- Access Point：RT-AX88U (ASUS)
- Distance between Access Point and the Target is around 3 ft.
- UDP commands：Bit rate was set at more than 20% of observed correspondingTCP throughput.
  Sample UDP command: *iperf3 <server-ip-addr> -u -b <20%-of-TCP>M -P1 -t 60*

Mode	TCP Throughput in Mbps		UDP Throughput in Mbps	
	Tx	Rx	Tx	Rx
2.4GHz 11ax HE40 MIMO	318	311	340	363
5GHz 11ax HE80 MIMO	879	668	934	947

5.5.2 Concurrent throughput

<Condition>

- VDD33=3.3V, VDD18=1.8V, VIO=1.8V
- Platform: NXP MCIMX8MQuad-EVK
- Combo FW : 17.68.1.p81
- Access Point：2.4GHz RT-AX88U (ASUS)
  5GHz Nighthawk AX12 (NETGEAR)
- Distance between Access Point and the Target is around 3 ft.
- UDP commands：Bit rate was set at more than 20% of observed correspondingTCP throughput.
  Sample UDP command: *iperf3 <server-ip-addr> -u -b <20%-of-TCP>M -P1 -t 60*

STA(2.4GHz) – STA(5GHz) configuration

Mode	TCP Throughput in Mbps		UDP Throughput in Mbps	
	Tx	Rx	Tx	Rx
STA 2.4GHz 11n HT40 MIMO	228	206	238	230
STA 5GHz 11ax HE80 MIMO	854	683	954	813

STA(2.4GHz) – AP(5GHz) configuration

Mode	TCP Throughput in Mbps		UDP Throughput in Mbps	
	Tx	Rx	Tx	Rx
STA 2.4GHz 11n HT40 MIMO	225	226	255	202
AP 5GHz 11ax HE80 MIMO	709	569	915	783

AP(2.4GHz) – STA(5GHz) configuration

Mode	TCP Throughput in Mbps		UDP Throughput in Mbps	
	Tx	Rx	Tx	Rx
STA 2.4GHz 11n HT40 MIMO	222	216	229	221
AP 5GHz 11ax HE80 MIMO	820	738	925	920

AP(2.4GHz) – AP(5GHz) configuration

Mode	TCP Throughput in Mbps		UDP Throughput in Mbps	
	Tx	Rx	Tx	Rx
STA 2.4GHz 11n HT40 MIMO	219	200	219	220
AP 5GHz 11ax HE80 MIMO	727	680	944	889