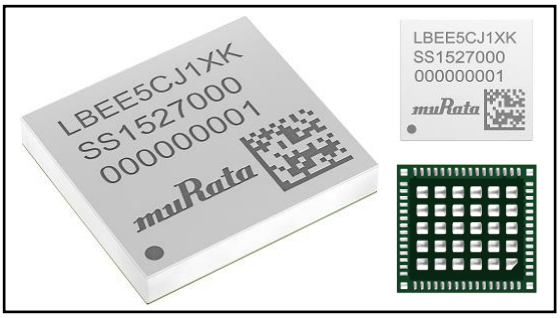
Murata Type 1XK/2XK (LBEE5CJ1XK/LBEE5CJ2XK)

Hardware Application Note



Revision History

Revision	Date	Section	Change Description
1	Oct. 14, 2021	-	First issue

Table of Contents

1 Scope

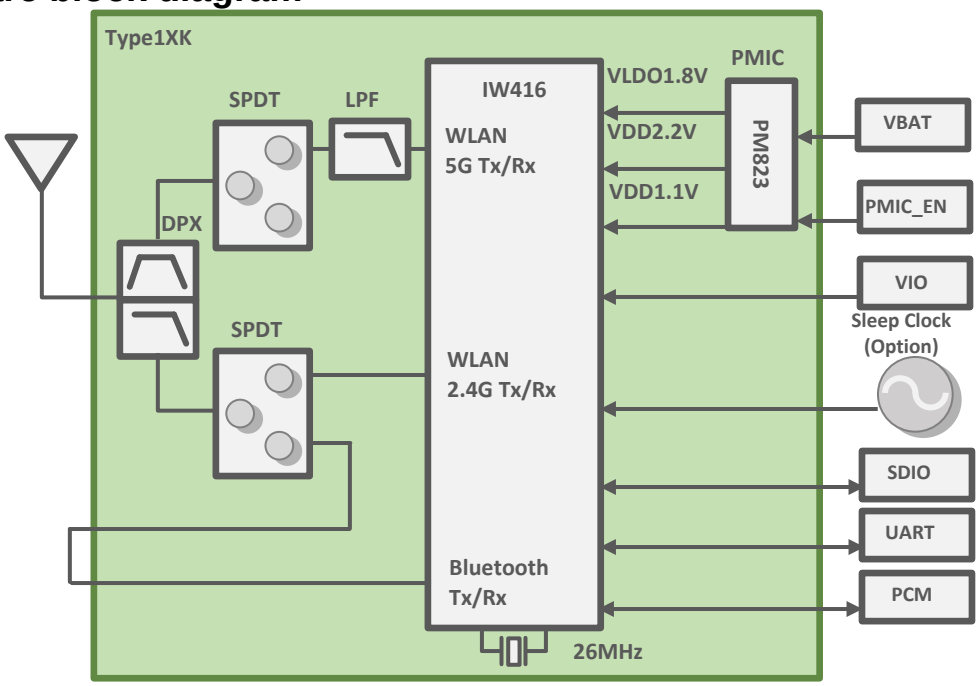
This Application Note covers HW development and provides how to design the Schematic and Layout, and reference RF performance. Refer to “type1zm_datasheet” for Module specification.

2 Module Introduction

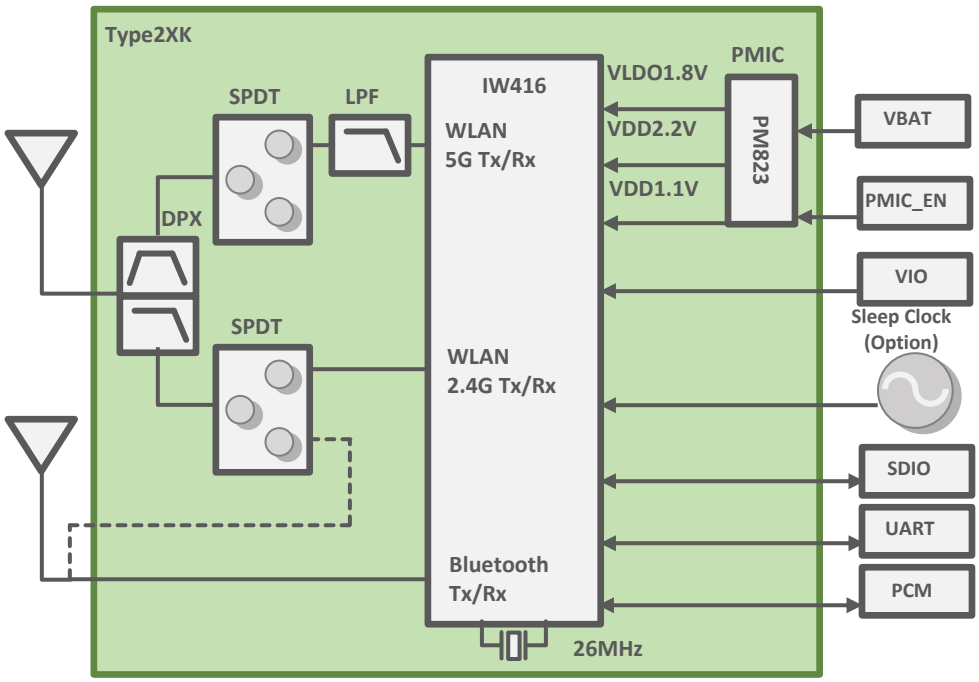
2.1 Features

- WLAN(11a/b/g/n) 1x1 SISO + Bluetooth and low energy (v5.2) combo SMD module with NXP IW416
- Small size LGA package with resin molding and metal shielding.
- SDIO3.0 for WLAN(/Bluetooth) and UART for Bluetooth as the host interface.
- MAC address and BD address are stored in OTP

2.2 Hardware block diagram



Type1XK (Shared Bluetooth Antenna)

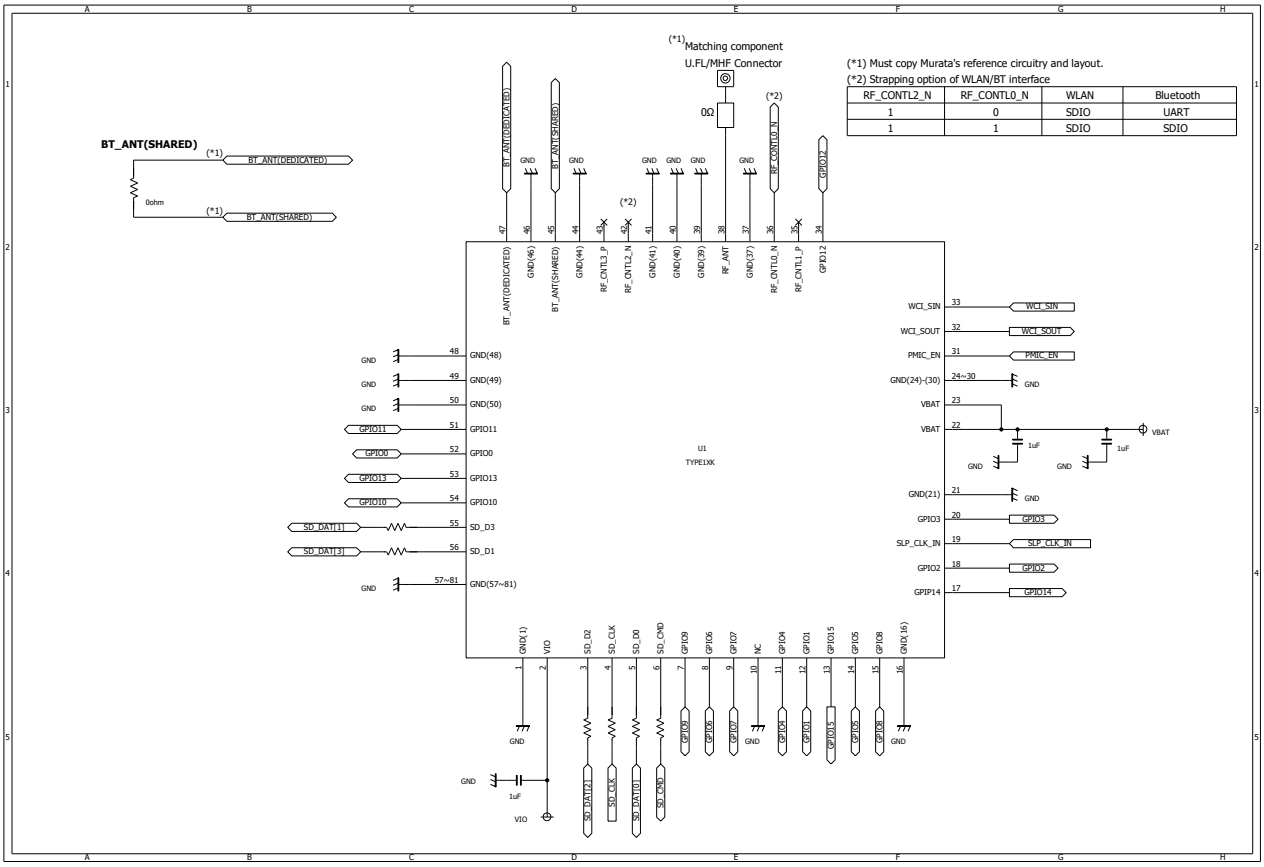


Type2XK (Dedicated Bluetooth Antenna)

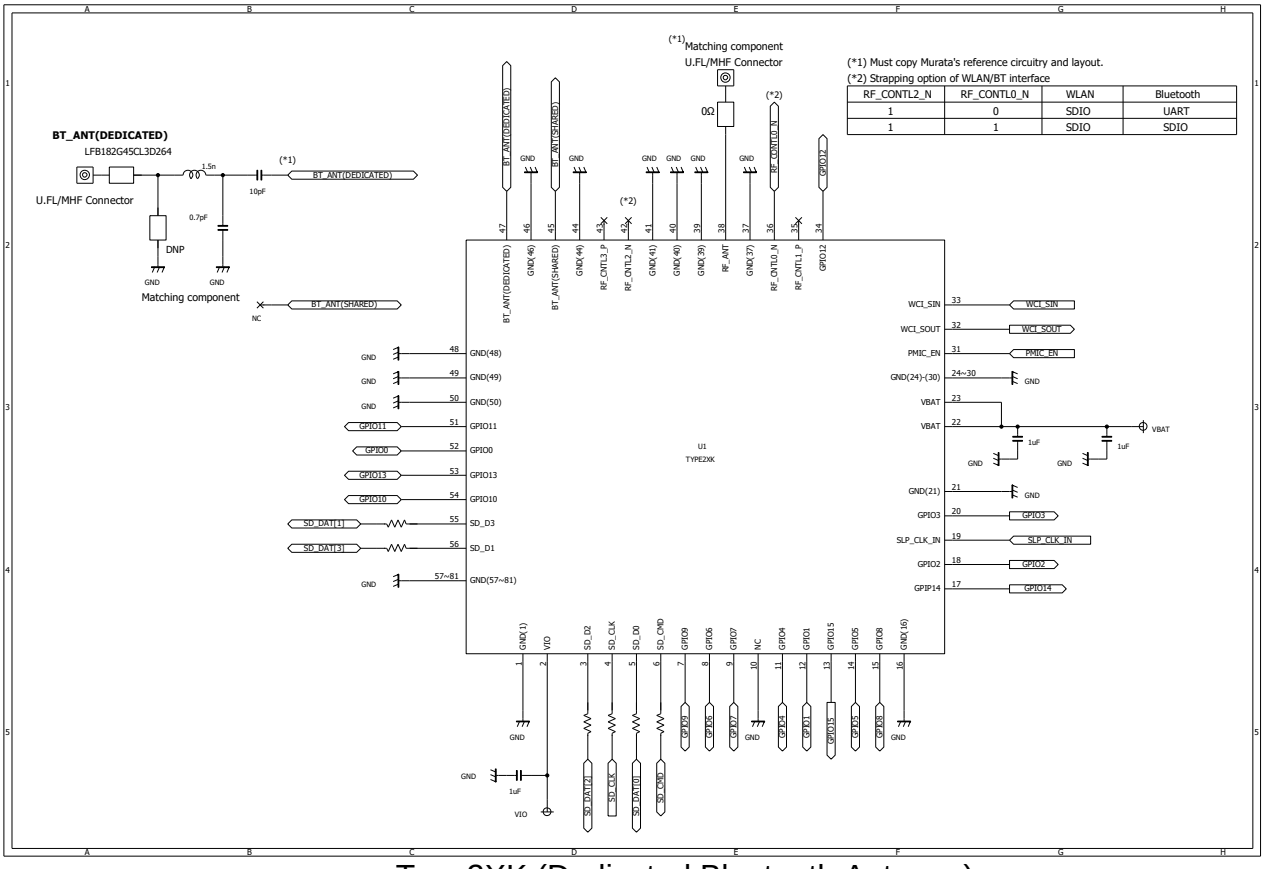
3 Reference design

3.1 Reference circuitry

U.FL/MHF connector

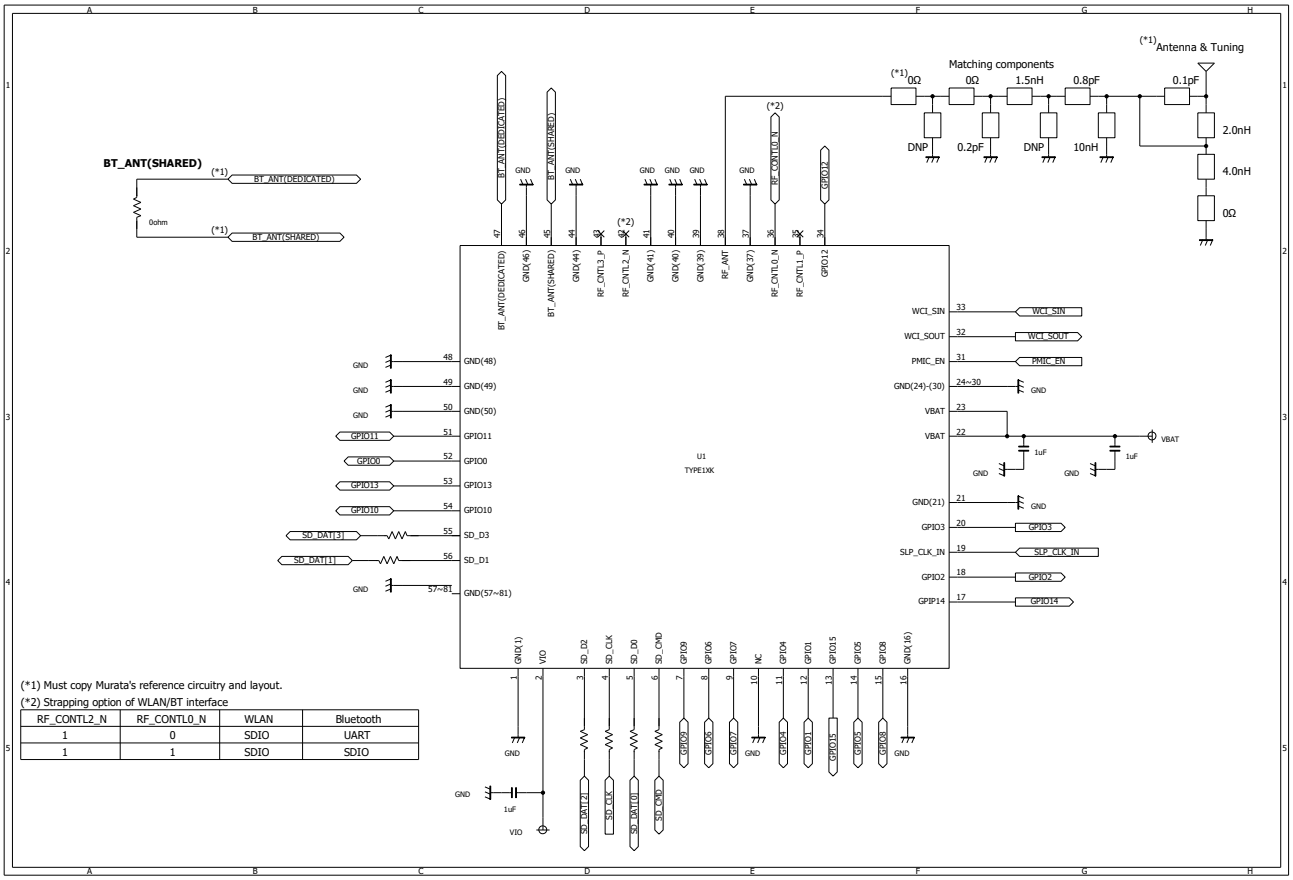


Type1XK (Shared Bluetooth Antenna)



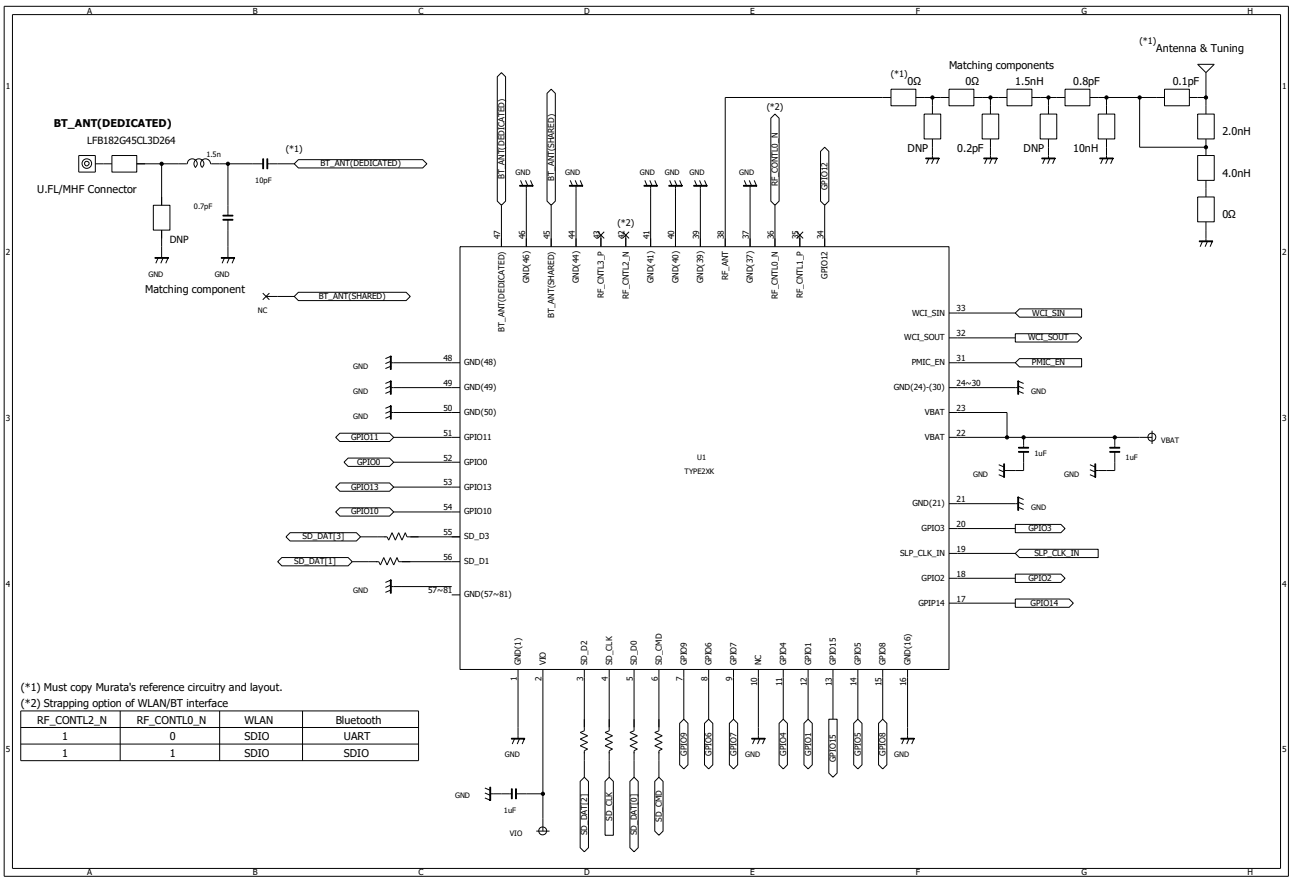
Type2XK (Dedicated Bluetooth Antenna)

Trace antenna



RF_CONTL2_N	RF_CONTL0_N	WLAN	Bluetooth
1	0	SDIO	UART
1	1	SDIO	SDIO

Type1XK (Shared Bluetooth Antenna)



RF_CONTL2_N	RF_CONTL0_N	WLAN	Bluetooth
1	0	SDIO	UART
1	1	SDIO	SDIO

Type2XK (Dedicated Bluetooth Antenna)

3.2 Requirements for SDIO signals

SDIO traces should be isometric zero delay routing with 50-ohm impedance.

3.3 External sleep clock requirements

External sleep clock (LPO) is necessary if internal sleep clock is not used. The following table shows requirements for external sleep clock.

Symbol	Parameter	Min	Typ	Max	Unit
CLK	Clock frequency range/accuracy CMOS input clock signal type ±250 ppm (initial , aging, temperature)	-	32.768	-	kHz
V_{IH}	Input levels, where VIO=1.8V	0.7*VIO	-	VIO+0.4	V
V_{IL}		-0.4	-	0.3*VIO	V
PN	Phase Noise Requirement (@ 100kHz)	-	-125	-	dBc/Hz
Jc	Cycle jitter	-	1.5	-	ns(RMS)
SR	Slew rate limit (10-90%)	-	-	100	ns
DC	Duty cycle tolerance	20	-	80	%

3.4 Requirements for unused signals

Any pull-up/down is not necessary (floating) for GPIO [0..15] if these signals are not used.

3.5 Module footprint design

Refer to dimensions in the datasheet “type1xk_2xk.pdf”. The DXF file of module footprint “type1xk_2xk_footprint_topview.dxf” is provided via website.

3.6 Recommended antenna

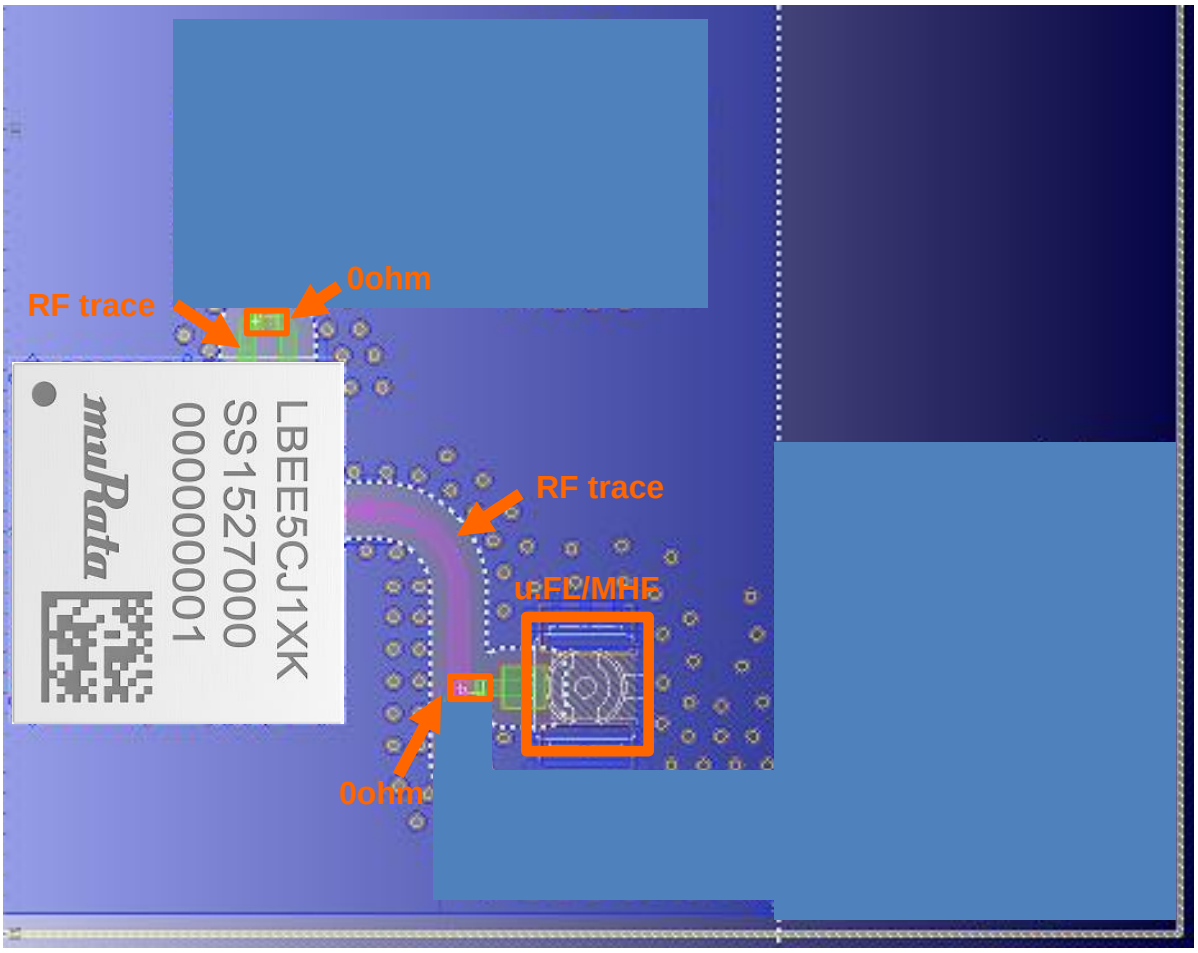
This module is certified with two types of antenna solution by regulatory certification body. To use Murata's regulatory certification, any user must follow below instructions. The DXF file "Type1XK_Trace_u.FL.dxf" is provided via web site.

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

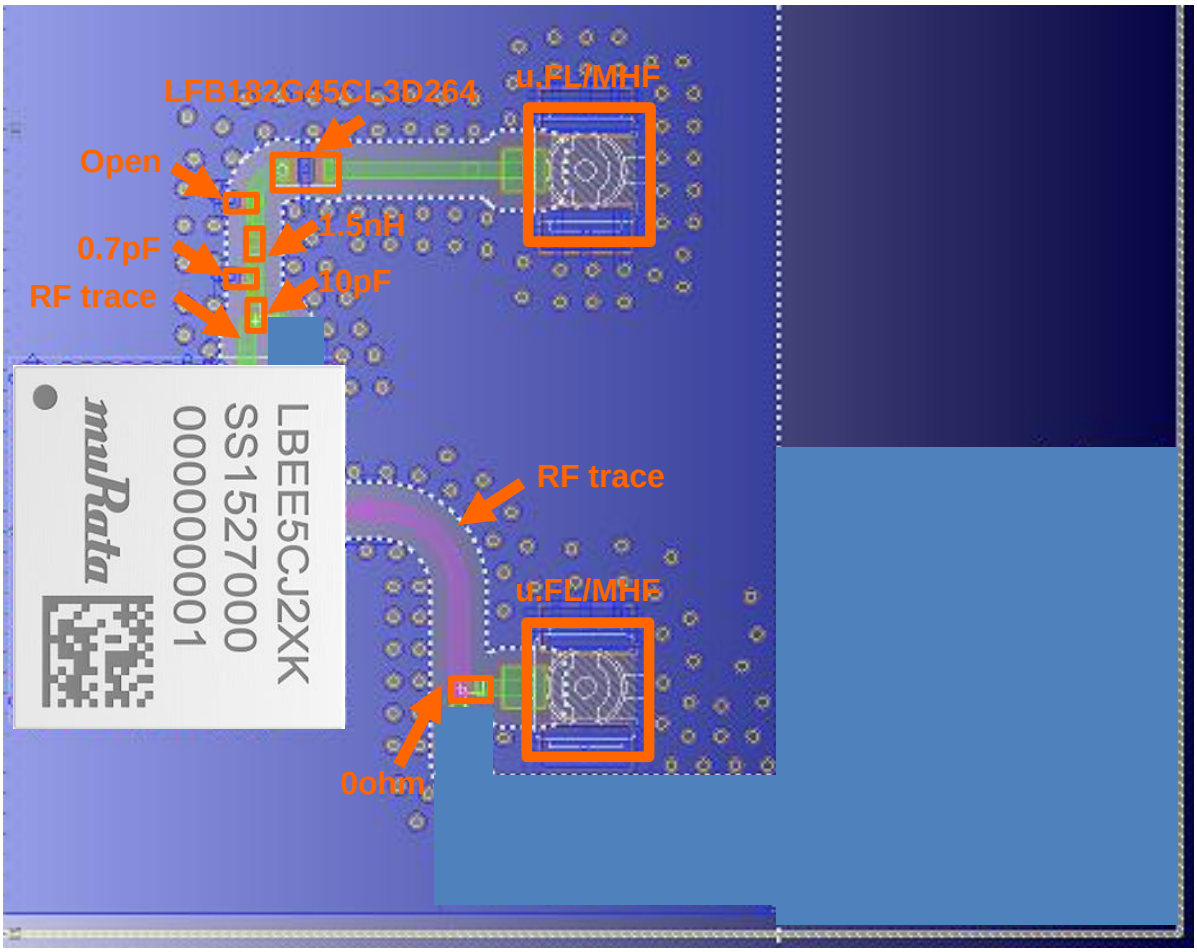
- Any users must use recommended antennas. However, user can use any equivalent type antenna with less antenna gain than antenna gain of recommended antennas for US and EU under approval of Class I Permissive Change by Murata.

P/N	Vendor	Form factor	Type	2.4GHz Gain	5GHz Gain	Cable options
146153	Molex	U.FL/PCB	Di-pole	3.2dBi	4.25dBi	050,100,150,200,250 and 300
146187	Molex	U.FL/PCB	Di-pole	3.4dBi	4.75dBi	050,100,150,200,250 and 300

- 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.



Type1XK (Shared Bluetooth Antenna)



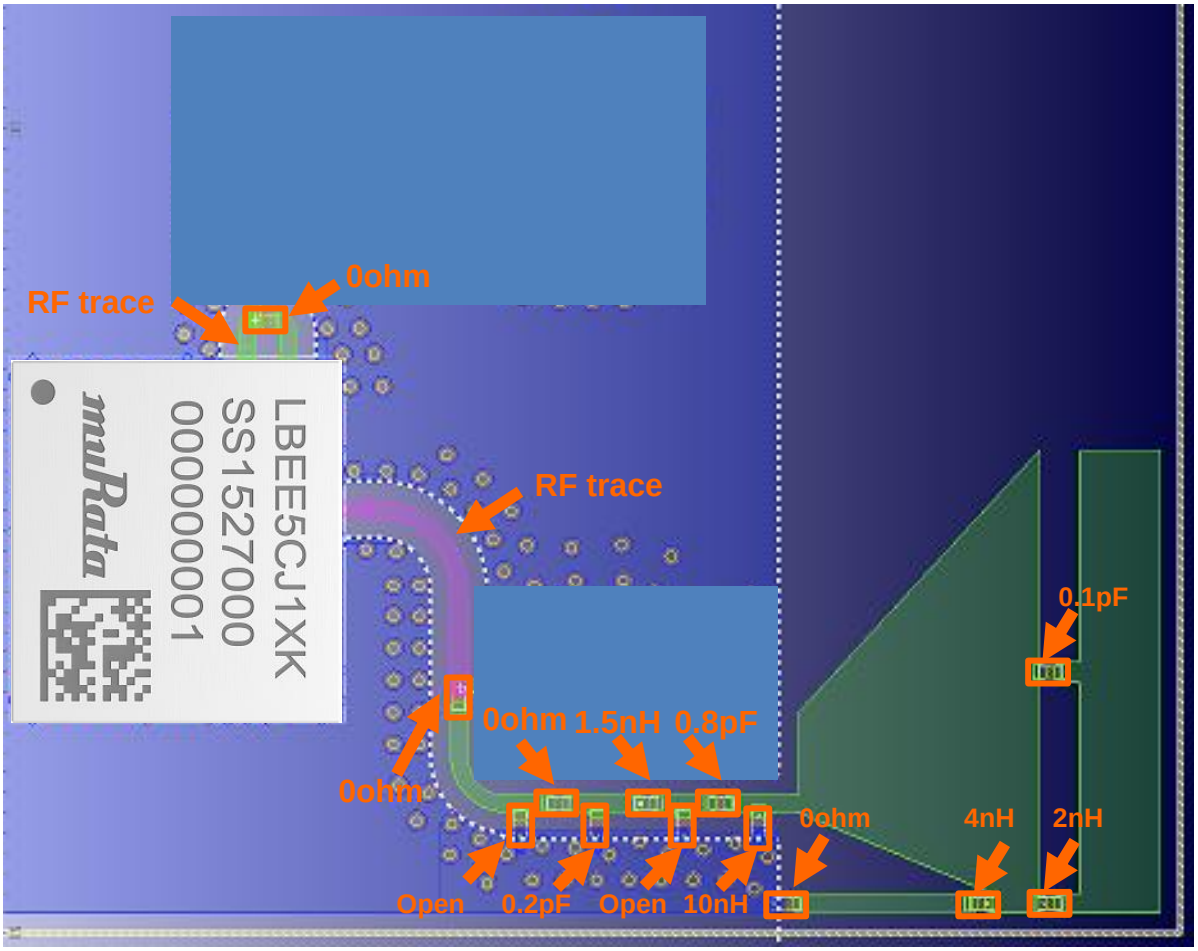
Type2XK (Dedicated Bluetooth Antenna)

3.6.2 Trace Antenna

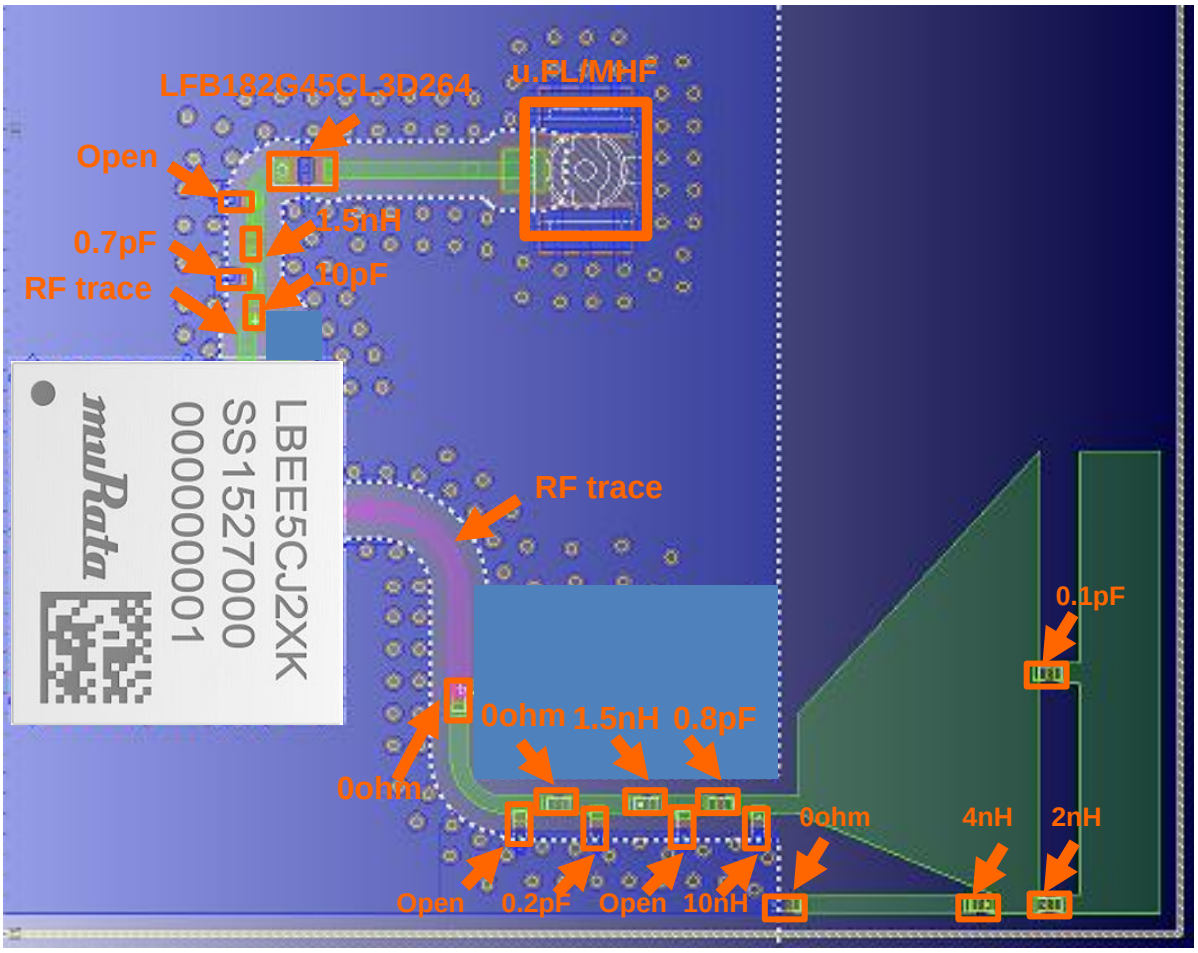
- Any users must copy antenna design from the antenna layout file provided by Murata.

- Any users must copy RF trace to PCB trace antenna from the trace layout file provided by Murata; adhering to below guidelines on:

    - Trace width accuracy within +/- 0.25 mm.
    - PCB thickness within 0.6 ~ 1.6 mm range (1.0 mm typ.).
    - Stack height between GND layer and RF trace of 235 um; keeping inaccuracy within +/-0.5 um.
    - Passive component location matching Murata design.

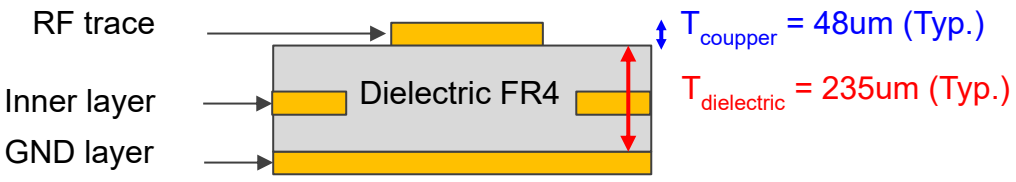


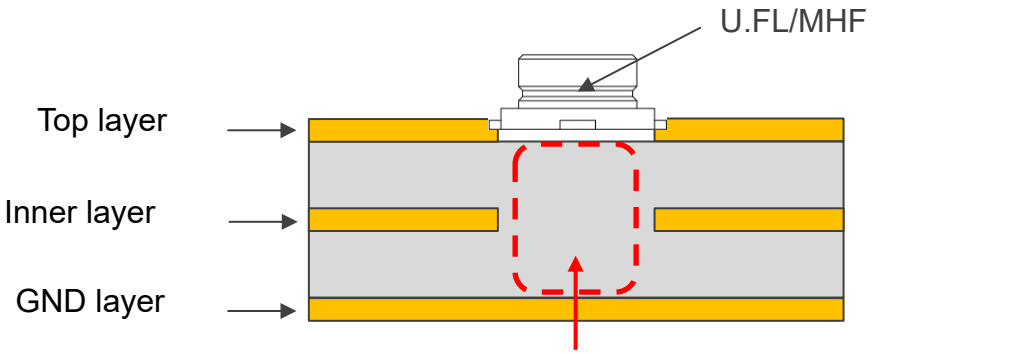
Type1XK (Shared Bluetooth Antenna)



Type2XK (Dedicated Bluetooth Antenna)

3.6.3 PCB Stack-up





3.6.4 Trace Antenna Performance

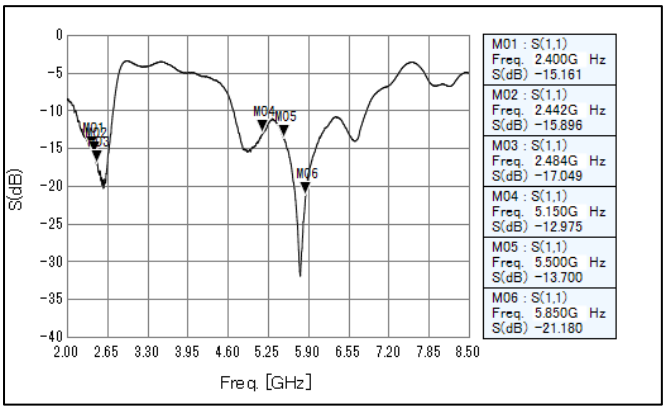
(Gain and Efficiency)

[dBi] [dB]

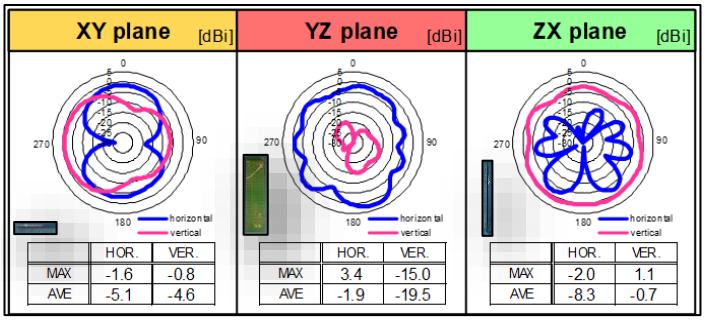
LINEAR POLARIZATION		XY-plane hor.	XY-plane ver.	YZ-plane hor.	YZ-plane ver.	ZX-plane hor.	ZX-plane ver.	Total Efficiency
2400 MHz	MAX.	-1.6	-0.9	2.6	-16.3	-2.2	1.0	
	AVE.	-4.9	-4.6	-2.0	-20.4	-8.3	-0.9	-1.0
2442 MHz	**MAX.**	**-1.6**	**-0.8**	**2.4**	**-15.0**	**-2.0**	**1.1**	
	AVE.	**-5.1**	**-4.6**	**-1.9**	**-19.5**	**-8.3**	**-0.7**	**-1.0**
2484 MHz	MAX.	-1.7	-0.7	2.5	-13.6	-1.7	1.6	
	AVE.	-5.2	-4.5	-1.6	-18.7	-8.2	-0.5	-0.9

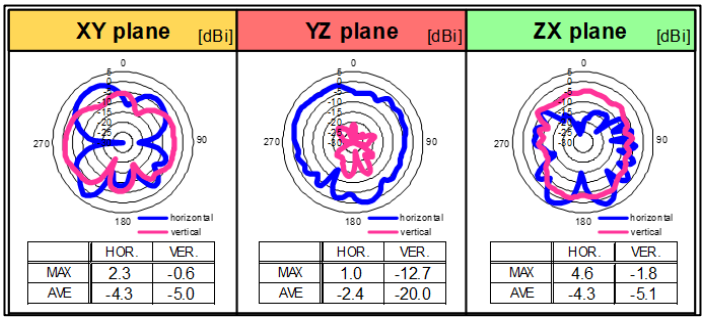
[dBi] [dB]

LINEAR POLARIZATION		XY-plane hor.	XY-plane ver.	YZ-plane hor.	YZ-plane ver.	ZX-plane hor.	ZX-plane ver.	Total Efficiency
5150 MHz	MAX.	2.3	0.1	2.2	-11.4	3.5	-0.2	
	AVE.	-4.1	-4.5	-2.0	-19.2	-3.9	-3.9	-1.3
5500 MHz	**MAX.**	**2.3**	**-0.6**	**1.0**	**-12.7**	**3.6**	**-1.8**	
	AVE.	**-4.3**	**-5.0**	**-2.4**	**-20.0**	**-4.3**	**-5.1**	**-1.6**
5850 MHz	MAX.	2.3	-0.7	1.0	-12.9	3.5	-1.6	
	AVE.	-4.1	-5.4	-2.4	-19.8	-4.2	-5.5	-1.5



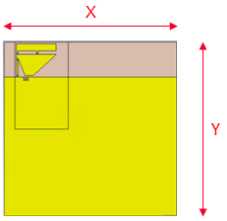
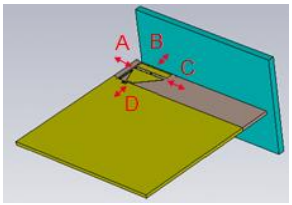
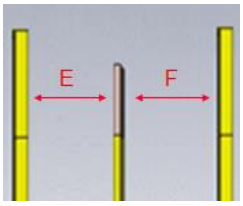
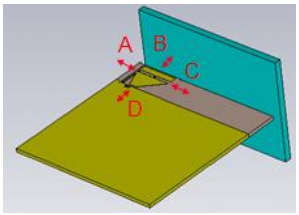
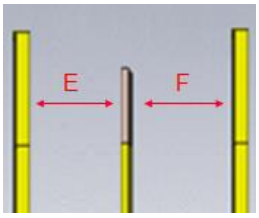
(Directivity)





3.6.5 Trace Antenna Installation

Keep board size and clearance to Metal/GND and Dielectric around the trace antenna for good antenna performance.

Board Size		X ≥ 40 mm Y ≥ 40 mm
Clearance to Metal/GND	 	A ≥ 20 mm B ≥ 20 mm C ≥ 20 mm D ≥ 20 mm E/F ≥ 20 mm
Clearance to Dielectric	 	A ≥ 4 mm B ≥ 4 mm C ≥ 4 mm D ≥ 4 mm E/F ≥ 4 mm

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
- Canada : txpower_CA.bin
- EU : txpower_EU.bin
- Japan : txpower_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.*

4.3 WLAN configuration files for freeRTOS

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

WLAN Tx power configuration files
- US : wlan_txpwrlimit_cfg_US.c
- Canada : wlan_txpwrlimit_cfg_CA.c
- EU : wlan_txpwrlimit_cfg_EU.c
- Japan : wlan_txpwrlimit_cfg_JP.c

WLAN Carrier Sense / Adaptivity threshold configuration file
- wlan.c

WLAN regulatory limitation configuration file
- txpwrlimit_cfg_US.bin
- txpwrlimit_cfg_CA.bin
- txpwrlimit_cfg_EU.bin
- txpwrlimit_cfg_JP.bin

4.4 Bluetooth configuration for freeRTOS

Bluetooth power must be set 3dBm typ. for BR/LE mode, and 0dBm typ. for LE mode on MCUXpresso SDK.

5 Reference performance data

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

5.1.1 WLAN

<Condition>

- VBAT=3.3V, VIO=1.8V
- Tx output power setting is defined by “txpower_XX.bin” which is provided at Murata GitHub. https://github.com/murata-wireless/nxp-linux-calibration (XX is country code)

US/Canada (txpower_US.bin/ txpower_CA.bin)

2.4GHz

Mode	Data Rate	Output Power in dBm (typ.)		
		Ch.1-3	Ch.4-8	Ch.9-11
11b	1,2,5.5,11M	17	17	17
11g	6,9,12,18M	14	17	14
	24,36M	14	16	14
	48,54M	14	16	14
11n-20	MCS0,1,2	13	16	13
	MCS3,4	13	15	13
	MCS5,6,7	13	15	13

5GHz

Mode	Data Rate	Output Power in dBm (typ.)							
		Ch.36	Ch.40-48	Ch.52-60	Ch.64	Ch.100	Ch.104-140	Ch.144	Ch.149-165
11a	6,9,12,18M	14	16	16	14	14	15	14	15
	24,36M	14	16	16	14	14	15	14	15
	48,54M	14	16	16	14	14	15	14	15
11n-20	MCS0,1,2	13	15	15	13	13	14	14	14
	MCS3,4	13	15	15	13	13	14	14	14
	MCS5,6,7	13	15	15	13	13	14	14	14
Mode	Data Rate	Ch.38	Ch.46	Ch.54	Ch.62	Ch.102	Ch.110-140	Ch.142	Ch.151-159
11n-40	MCS0,1,2	12	14	14	12	12	14	12	14
	MCS3,4	12	14	14	12	12	14	12	14
	MCS5,6,7	12	14	14	12	12	14	12	14

( ) : Only US/FCC

EU (txpower_EU.bin)

2.4GHz

Mode	Data Rate	Output Power in dBm (typ.)
		Ch.1-13
11b	1,2,5.5,11M	14
11g	6,9,12,18M	14
	24,36M	14
	48,54M	14
11n-20	MCS0,1,2	14
	MCS3,4	14
	MCS5,6,7	14

5GHz

Mode	Data Rate	Output Power in dBm (typ.)		
		Ch.36-64	Ch.100-144	Ch.149-165
11a	6,9,12,18M	15	15	7
	24,36M	15	15	7
	48,54M	15	15	7
11n-20	MCS0,1,2	14	14	7
	MCS3,4	14	14	7
	MCS5,6,7	14	14	7
Mode	**Data Rate**	**Ch.38-62**	**Ch.102-142**	**Ch.151-159**
11n-40	MCS0,1,2	14	14	7
	MCS3,4	14	14	7
	MCS5,6,7	14	14	7

Japan (txpower_JP.bin)
2.4GHz

Mode	Data Rate	Output Power in dBm (typ.)
		Ch.1-13
11b	1,2,5.5,11M	16
11g	6,9,12,18M	17
	24,36,48,54M	16
	48,54M	16
11n-20	MCS0,1,2	16
	MCS3,4	15
	MCS5,6,7	15

5GHz

Mode	Data Rate	Output Power in dBm (typ.)	
		Ch.36-64	Ch.100-144
11a	6,9,12,18M	14	15
	24,36M	14	15
	48,54M	14	15
11n-20	MCS0,1,2	14	14
	MCS3,4	14	14
	MCS5,6,7	14	14
Mode	Data Rate	Ch.38-62	Ch.102-142
11n-40	MCS0,1,2	14	14
	MCS3,4	14	14
	MCS5,6,7	14	14

5.1.2 Bluetooth

<Condition>

- VBAT=3.3V, VIO=1.8V
- Tx output power setting is defined by “bt_power_config_1.sh” which is provided at Murata GitHub.

Frequency in MHz	Output Power [dBm]						
	DH5	2DH5	3DH5	LE1M	LE2M	125K	500K
2402	3	0	0	3	3	3	3
2440	3	0	0	3	3	3	3
2480	3	0	0	3	3	3	3

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

5.2.1 WLAN

<Condition>

- VBAT=3.3V, VIO=1.8V
- Combo FW : 16.80.210.p231

2.4GHz

Frequency in MHz	Rx minimum sensitivity level[dBm]					
	11b		11g		11n	
	1Mbps	11Mbps	6Mbps	54Mbps	MCS0	MCS7
2412	-98	-89	-90	-75	-90	-72
2442	-98	-89	-90	-75	-90	-72
2472	-98	-89	-90	-75	-90	-72

5GHz

Frequency in MHz	Rx minimum sensitivity level in dBm			
	11a		11n (HT20)	
	6Mbps	54Mbps	MCS0	MCS7
5180	-88	-73	-87	-70
5500	-88	-73	-87	-70
5825	-87	-72	-86	-70

Frequency in MHz	Rx minimum sensitivity level in dBm	
	11n (VHT40)	
	MCS0	MCS7
5190	-84	-70
5510	-84	-70
5795	-83	-69

5.2.2 Bluetooth

<Condition>

- VBAT=3.3V, VDDIO=1.8V
- Combo FW : 16.80.210.p231

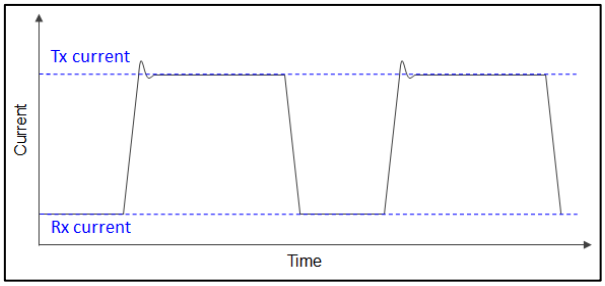
Frequency In MHz	Rx minimum sensitivity level in dBm						
	DH5	2DH5	3DH5	LE 1M	LE 2M	125K	500K
2412	-93	-93	-87	-101	-99	-106	-104
2442	-94	-94	-77	-101	-99	-106	-104
2472	-93	-92	-87	-101	-98	-106	-104

5.3 Typical Tx/Rx current consumption

5.3.1 WLAN

<Condition>

- VBAT=3.3V, VIO=1.8V
- Combo FW : 16.80.210.p231
- Current definition



2.4GHz

Mode	Rate	Setting Power in dBm	Current in mA	
			Tx	Rx
11b	1Mbps	17.0	370	64
11g	6Mbps	17.0	366	64
11n	MCS0	16.0	342	64

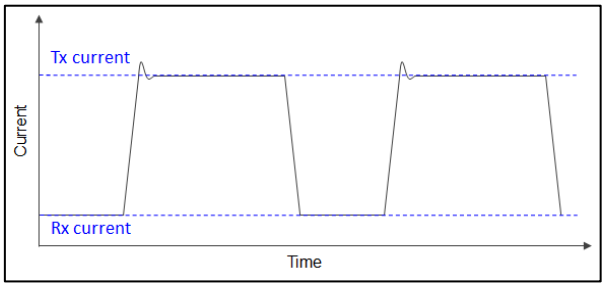
5GHz

Mode	Rate	Setting Power in dBm	Current in mA	
			Tx	Rx
11a	6Mbps	15.0	408	79
11n-20	MCS0	14.0	386	79
11n-40	MCS0	14.0	388	91

5.3.2 Bluetooth

<Condition>

- VBAT=3.3V, VIO=1.8V
- Combo FW : 16.80.210.p231
- Current definition



2.4GHz

Mode	Rate	Setting Power in dBm	Current in mA	
			Tx	Rx
BR	DH5	3.0	91	61
EDR	3DH5	0	87	61
LE	LE	3.0	90	60

5.4 Typical sleep current consumption

5.4.1 WLAN

<Condition>

- VBAT=3.3V, VIO=1.8V
- Target: NXP iMX6SoloX-SABRE
- WLAN FW : 16.91.10.p105
- Beacon Interval = 100ms
- SDIO Signal Level = 1.8V
  SD Clock off/on (# mlanutl mlan0 sdioclock0, #mlanutl mlan0 sdioclock1)

		Current consumption VBAT (3.3V) in mA			
Band	SD clock speed	50MHz		200MHz	
	Clock enablement	Disable	Enable	Disable	Enable
-	Chip deep sleep	0.169	0.224		
2.4GHz	IEEE Power Save:DTIM1	1.42	1.48		
	IEEE Power Save:DTIM3	0.58	0.64		
	IEEE Power Save:DTIM5	0.42	0.47		
5GHz	IEEE Power Save:DTIM1	1.00	1.05		
	IEEE Power Save:DTIM3	0.44	0.5		
	IEEE Power Save:DTIM5	0.33	0.39		

5.4.2 Bluetooth

<Condition>

- VBAT=3.3V, VIO=1.8V
- Target: NXP iMX6SoloX-SABRE
- WLAN FW : BSP 5.10.52_2.1.0
- SDIO Level = 1.8V
  SD Clock off/on (# mlanutl mlan0 sdioclock0, #mlanutl mlan0 sdioclock1)

	Current consumption VBAT (3.3V) in mA	
WLAN SD clock speed	50MHz	
Clock enablement	Disable	Enable
UART mode	0.17	0.23

5.5 Typical Bluetooth Advertise current consumption

<Condition>

- VBAT=3.3V, VIO=1.8V
- Target: NXP iMX6SoloX-SABRE
- WLAN FW : BSP 5.10.52_2.1.0
- Advertise interval = 1.28 sec
- SDIO Signal = SDR104/1.8V
  SD Clock off/on (# mlanutl mlan0 sdioclock0, #mlanutl mlan0 sdioclock1)

	Current consumption VBAT (3.3V) in mA	
WLAN SD clock speed	**50MHz**	
Clock enablement	**Disable**	**Enable**
UART mode	0.34	0.43

5.6 Typical throughput

Test Configuration:

- VBAT=3.3V, VIO=1.8V
- **Target:** i.MX6 SoloX
- **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 11n HT20	53.6	55.4	60.9	56.6
5GHz 11n HT40	92	113	113	135