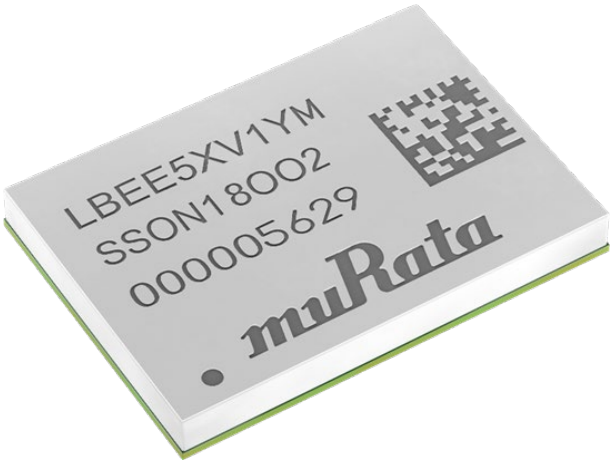
Hardware Application Note

Type 1YM Wi-Fi® + Bluetooth® Module

NXP 88W8997 Chipset for 802.11a/b/g/n/ac 2x2 MIMO + Bluetooth 5.2 Hardware Application Note - Rev. 4.0

- Design Name: Type 1YM
- P/N: LBEE5XV1YM-574



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About This Document

Murata's Type 1YM is a small and high-performance module based on NXP 88W8997 combo chipset, supporting IEEE 802.11a/b/g/n/ac 2x2 MIMO + Bluetooth 5.2 BR/EDR/LE. This application note provides RF and hardware design guidance. Refer to Type 1YM Datasheet for module specification.

Audience & Purpose

Intended audience includes any customer looking to integrate this module into their product. In particular, RF, hardware, systems, and software engineers.

Document Conventions

Table 1 describes the document conventions.

Table 1: Document Conventions

Conventions	Description
	**Warning Note** Indicates very important note. Users are strongly recommended to review.
	**Info Note** Intended for informational purposes. Users should review.
	**Menu Reference** Indicates menu navigation instructions. **Example**: Insert➔Tables➔Quick Tables➔Save Selection to Gallery 
	**External Hyperlink** This symbol indicates a hyperlink to an external document or website. **Example**: Embedded Artists AB Click on the text to open the external link.
	**Internal Hyperlink** This symbol indicates a hyperlink within the document. **Example**: Scope Click on the text to open the link.
`Console input/output or code snippet`	**Console I/O or Code Snippet** This text ***Style*** denotes console input/output or a code snippet.
`# Console I/O comment` `// Code snippet comment`	**Console I/O or Code Snippet Comment** This text ***Style*** denotes a console input/output or code snippet comment. • Console I/O comment (preceded by "#") is for informational purposes only and does not denote actual console input/output. • Code Snippet comment (preceded by "//") may exist in the original code.

1 Scope

This application note provides detailed information on schematic/layout design, and references RF performance benchmarks. Refer to for Type 1YM Datasheet for module specification.

2 Module Introduction

Type 1YM is a high-performance module based on NXP 88W8997 combo chipset, which supports Wi-Fi 802.11a/b/g/n/ac 2x2 MIMO + Bluetooth 5.2 BR/EDR/LE up to 866 Mbps PHY data rate on Wi-Fi and 3 Mbps PHY data rate on Bluetooth.

The 88W8997 implements highly sophisticated enhanced collaborative coexistence hardware mechanisms and algorithms, that ensure that WLAN and Bluetooth collaboration is optimized for maximum performance.

2.1 Features

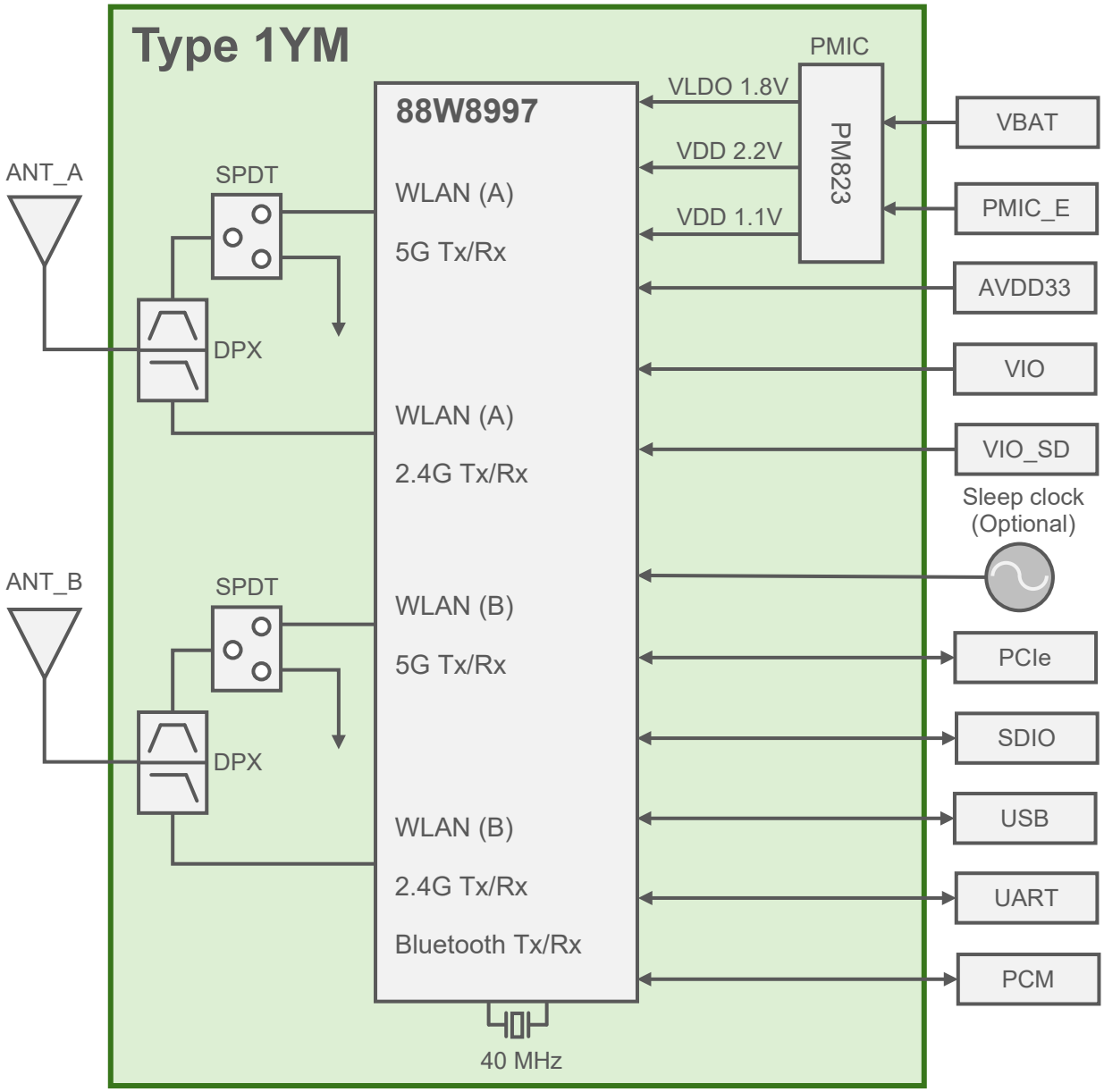
- WLAN 802.11a/b/g/n/ac 2x2 MIMO + Bluetooth Classic and Low Energy (Version 5.2) combo SMD module with NXP 88W8997
- Small size LGA package with resin molding and metal shielding.
- Host interfaces: PCIe 3.0, SDIO 3.0, and USB 2.0/3.0 for WLAN; and HCI UART, SDIO 3.0, USB 2.0/3.0, and PCM for Bluetooth.
- MAC address and BD address are stored in OTP.

WLAN-USB, Bluetooth-SDIO, and Bluetooth-USB interfaces may not be supported in software. Refer to Type 1YM webpage or check 1YM Community Forum page.

2.2 Block Diagram

Figure 1 shows the block diagram of Type 1YM module. “ANT_B” is shared between WLAN and Bluetooth, whereas “ANT_A” is dedicated to WLAN.

Figure 1: Block Diagram



3 Reference Design

This section describes the reference design for Type 1YM.

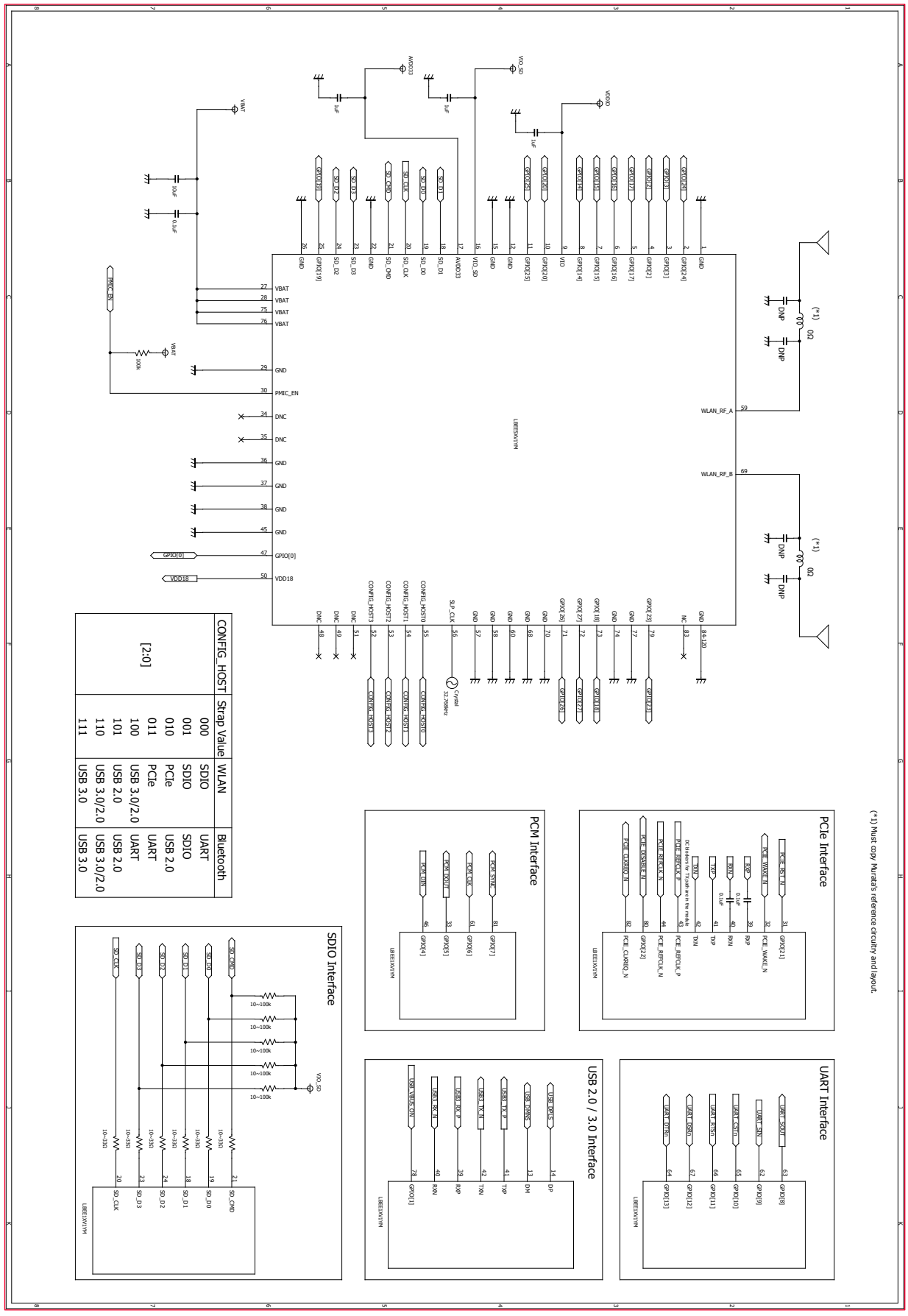
3.1 Reference Circuitry

Figure 2 shows the u.FL/MHF connector reference design for Type 1YM module.

When interfacing WLAN-PCIE, DC blocker 0.1 µF capacitors on both PCIe RXP and RXN signals should be located very close to the transmission point – i.e. close to the host processor PCIe transmit lines.

Although multiple variations of WLAN/Bluetooth host interface configurations are shown, WLAN-USB, Bluetooth-SDIO, and Bluetooth-USB interfaces may not be supported in software. Refer to Type 1YM webpage or check 1YM Community Forum page.

Figure 2: u.FL/MHF Connector



3.2 Requirements for High-Speed Digital Signals

- **SDIO:** SDIO traces should be isometric zero delay routing with 50 Ω impedance.
- **PCIe:** TxP/N, RxP/N and CLKP/N signals should be differential 100 Ω impedance. DC blockers are necessary on RxP/N (these should be located very close to the transmission point – i.e., close to the host processor PCIe transmit lines).
- **USB:** DP/DM should be differential 90 Ω impedance.

3.3 Requirements for Unused Signals

No pull-up/down is necessary (floating) for GPIO [0..20] if these signals are not used.

3.4 Module Footprint Design

Refer to dimensions in the Type 1YM Datasheet. The DXF File of module footprint "type1ym_module_footprint_topview.dxf" is provided on the website.

3.5 Recommended Antenna

This module is certified with an antenna solution by regulatory certification body. To use Murata's regulatory certification, any user must follow below instructions. The DXF File "Type1YM_u.FL.dxf" is provided via web site.

3.5.1 PCB Type Di-pole Antenna with the Co-axial Connector

- Users should use recommended antennas only. However, any equivalent type of antenna with less antenna gains than the antenna gain of recommended antennas for US and EU under approval of Class I Permissive Change by Murata can also be used.

The recommended antennas with gains are described in **Table 2**.

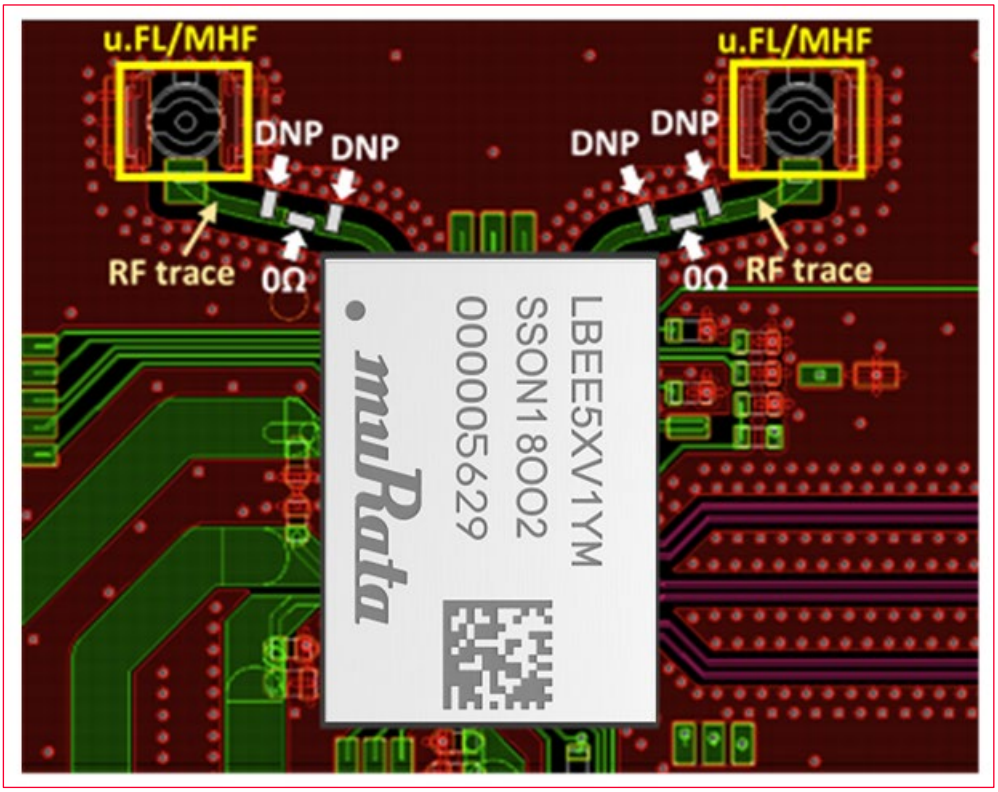
Table 2: Recommended Antennas

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

- Users must copy RF trace to u.FL/MHF connector from the trace layout file provided by Murata in adherence to the guidelines on:
  - Trace width accuracy within +/- 0.25 mm.
  - Stack height between GND layer and RF trace of 230 ~ 240 µm (Exclude inaccuracy of PCB).
  - Passive component location matching Murata design.
  - Necessary "Keep out" area around u.FL/MHF connector.

Figure 3 shows the Murata reference RF trace to u.FL/MHF connector.

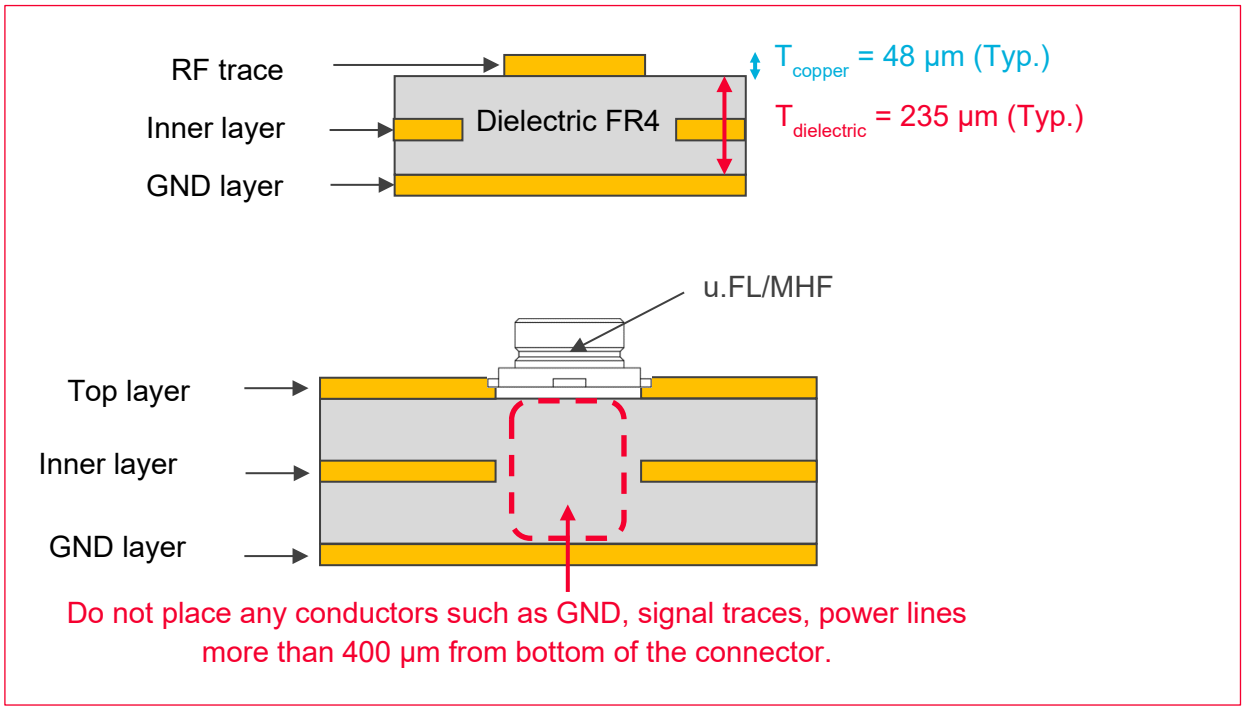
Figure 3: Murata Reference RF Trace to u.FL/MHF Connector



3.5.2 PCB Stack-Up

Figure 4 shows the PCB stack-up design.

Figure 4: PCB Stack-Up



3.5.3 Antenna Design and Configuration

Table 3 shows the antenna list.

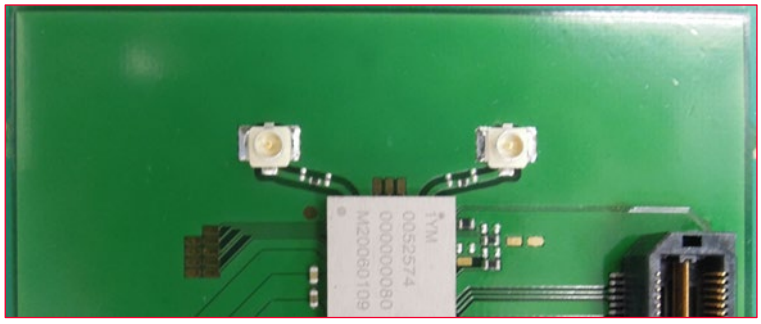
Table 3: Antenna List

No	Maker	Support Antenna						
		Pin	Form Factor	Type	Gain		Size	Detail
					2.4 GHz	5 GHz		
1	Molex	146153	u.FL/flexible	Dipole	3.2	4.25	35 x 9 x 0.1 mm	Flexible//horizontal
2	Molex	146187	u.FL/flexible	Dipole	3.4	4.75	40.95 x 9 x 0.7 mm	Rigid//horizontal

Do not mix two antenna ports with the P/N of another antenna. There is only one set of trace line patterns between the u.FL connector and the module RF OUT PIN.

50 Ω line (microstrip line pattern) certification tests are conducted in the patterns as shown in **Figure 5**.

Figure 5: 50 Ω Line (Microstrip Line Pattern) Certification Test



The 50 Ω microstrip line needs to be copied when module is installed in the end product.

Murata provides set makers with gerber data or something similar. **Figure 6** shows the port names.

Figure 6: Port Names

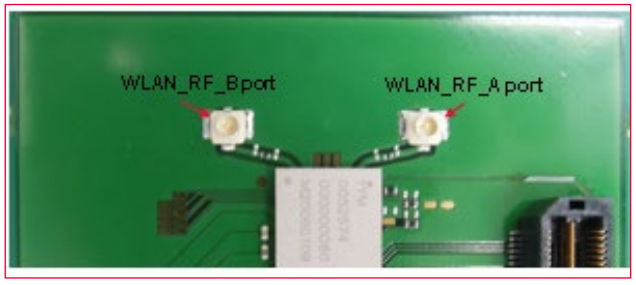


Table 4 shows the antenna ports for the module.

Table 4: Antenna Ports

JIG ANT Port Name	Function
WLAN_RF_A port	WLAN
WLAN_RF_B port	WLAN and BT (LE)

4 Setup Configuration Files

To enable Murata's regulatory certification, the configuration stated below file should be initially loaded. Murata will provide configuration files through Murata GitHub Link (XX is the country code). For more regulatory information, refer to section 11 of Linux User Guide.

4.1 WLAN Configuration Files for Linux

The files listed in **Table 5** should be used to meet the regulatory requirements if user wants to use Murata regulatory certification.

Table 5: WLAN Configuration Files - Linux

Names	Country	Country Code	Configuration Files
WLAN Tx power configuration files	USA	US	txpower_US.bin
	Canada	CA	txpower_CA.bin
	Europe	DE	txpower_EU.bin
	Japan	JP	txpower_JP.bin
WLAN Carrier Sense / Adaptivity threshold configuration file			ed_mac.bin
WLAN regulatory limitation configuration file			db.txt

NXP IC based module **must use** CRDA mechanism which is provided by Linux-wireless. Compile the new regulatory.bin file from "db.txt" that is provided by Murata with following manner of wireless-regdb.

4.2 Bluetooth Configuration Files

Bluetooth Tx power configuration script file should 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

This section describes the reference performance data for WLAN and Bluetooth with respect to different countries.

5.1 Typical Rx Minimum Sensitivity Level at Module Antenna Port

This section describes the Typical Rx Minimum Sensitivity Level at module antenna port is for WLAN and Bluetooth.

5.1.1 WLAN

Conditions:

- VBAT = 3.3V, VIO = 1.8V
- Combo FW: 16.80.205p146

Table 6 describes the typical Rx minimum sensitivity level for Wi-Fi at 2.4 GHz.

Table 6: Typical Rx Minimum Sensitivity Level for Wi-Fi - 2.4 GHz

Frequency in MHz	Rx Minimum Sensitivity Level in dBm					
	11b		11g		11n	
	1 Mbps	11 Mbps	6 Mbps	54 Mbps	MCS0	MCS7
2412	-98	-89	-89	-75	-89	-74
2442	-98	-89	-89	-75	-89	-74
2472	-98	-89	-88	-75	-88	-73

Table 7, Table 8 and **Table 9** describes the typical Rx minimum sensitivity level for 5 GHz Wi-Fi at 20 MHz, 40 MHz and 80 MHz bandwidth.

Table 7: Typical Rx Minimum Sensitivity Level for Wi-Fi - 5 GHz (HT/VHT 20)

Frequency in MHz	Rx Minimum Sensitivity Level in dBm					
	11a		11n (HT20)		11ac (VHT20)	
	6 Mbps	54 Mbps	MCS0	MCS7	MCS0	MCS8
5180	-87	-72	-87	-70	-87	-67
5500	-87	-72	-87	-70	-87	-67
5825	-87	-72	-87	-70	-87	-67

Table 8: Typical Rx Minimum Sensitivity Level for Wi-Fi - 5 GHz (VHT 40)

Frequency in MHz	Rx Minimum Sensitivity Level in dBm	
	11ac (VHT40)	
	MCS0	MCS9
5190	-83	-64
5510	-83	-64
5795	-84	-64

Table 9: Typical Rx Minimum Sensitivity Level for Wi-Fi - 5 GHz (VHT 80)

Frequency in MHz	Rx Minimum Sensitivity Level in dBm	
	11ac (VHT80)	
	MCS0	MCS9
5180	-79	-60
5500	-79	-60
5825	-79	-60

5.1.2 Bluetooth

Conditions:

- VBAT = 3.3V, VDDIO = 1.8V
- Combo FW: 16.80.205p146

Table 10 describes the typical Rx minimum sensitivity level for Bluetooth.

Table 10: Typical Rx Minimum Sensitivity Level - Bluetooth

Frequency in MHz	Rx Minimum Sensitivity Level in dBm				
	DH5	2DH5	3DH5	LE 1M	LE 2M
2412	-94	-92	-89	-100	-98
2442	-95	-94	-89	-100	-95
2472	-94	-92	-89	-97	-93

5.2 Typical Tx/Rx Current Consumption

This section describes the Typical Tx/Rx current consumption for WLAN and Bluetooth.

5.2.1 WLAN

Conditions:

- Host IF: PCIe
- VBAT = 3.3V, VIO = 1.8V
- Combo FW: 16.80.205p146
- Current definition

Figure 7: Typical Tx/Rx Current Consumption for WLAN

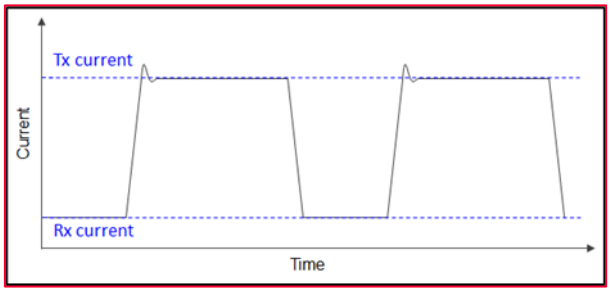


Table 11 and **Table 12** describe the typical Tx/Rx current consumption in WLAN PCIe mode for 2.4 GHz and 5 GHz.

Table 11: Typical Tx/Rx Current Consumption for Wi-Fi - 2.4 GHz (2SS/PCIe)

Mode	Rate	Setting Power in dBm	Current in mA	
			Tx	Rx
11b	1 Mbps	17.0	720	120
11g	6 Mbps	16.0	640	120
11n	MCS0	15.0	590	130

Table 12: Typical Tx/Rx Current Consumption for Wi-Fi - 5 GHz (2SS/PCIe)

Mode	Rate	Setting Power in dBm	Current in mA	
			Tx	Rx
11a	6 Mbps	14.0	640	140
11n/ac-20	MCS0	14.0	650	150
11n/ac-40	MCS0	13.0	610	170
11n/ac-80	MCS0	12.0	590	190

Table 13 and **Table 14** describe the typical Tx/Rx current consumption in WLAN SDIO mode for 2.4 GHz and 5 GHz.

Table 13: Typical Tx/Rx Current Consumption for Wi-Fi - 2.4 GHz (2SS/SDIO)

Mode	Rate	Setting Power in dBm	Current in mA	
			Tx	Rx
11b	1 Mbps	17.0	700	85
11g	6 Mbps	16.0	620	90
11n	MCS0	15.0	570	90

Table 14: Typical Tx/Rx Current Consumption for Wi-Fi - 5 GHz (2SS/SDIO)

Mode	Rate	Setting Power in dBm	Current in mA	
			Tx	Rx
11a	6 Mbps	14.0	600	110
11n/ac-20	MCS0	14.0	610	120
11n/ac-40	MCS0	13.0	560	140
11n/ac-80	MCS0	12.0	540	160

5.2.2 Bluetooth

Conditions:

- VBAT = 3.3V, VIO = 1.8V
- Host IF: UART
- Combo FW: 16.80.205p146
- Current definition

Figure 8: Typical Tx/Rx Current Consumption for Bluetooth

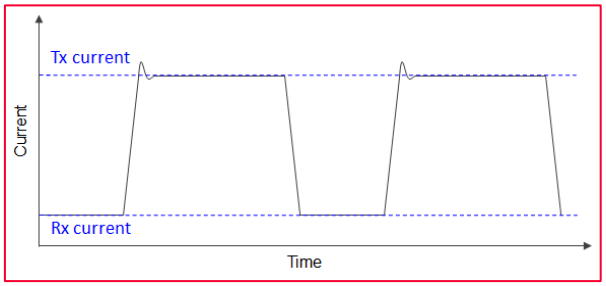


Table 15 describes the typical Tx/Rx current consumption for Bluetooth.

Table 15: Typical Tx/Rx Current Consumption for Bluetooth

Mode	Rate	Setting Power in dBm	Current in mA	
			Tx	Rx
BR	DH5	3.0	70	70
EDR	3DH5	0	70	70
LE	LE	3.0	70	70

5.3 Typical Sleep Current Consumption

This section describes the typical sleep current consumption for Wi-Fi and Bluetooth.

5.3.1 WLAN

Conditions:

- VBAT = 3.3V, VIO = 1.8V
- Target: NXP iMX8MQ-EVK (MCIMX8M-EVK)
- WLAN FW: W16.68.10.p56
- Beacon Interval = 100 ms
- SDIO Signal = SDR104 mode @1.8V VIO
- SD Clock off/on (# mlanutl mlan0 sdioclock0, #mlanutl mlan0 sdioclock1)

Table 16 describes the typical sleep current consumption data for Wi-Fi.

Table 16: Typical Sleep Current Consumption - Wi-Fi

Band	Mode	VBAT (3.3V) in mA PCIe mode	VBAT (3.3V) in mA SDIO (Clock off)	VBAT (3.3V) in mA SDIO (Clock on)
	Chip deep sleep	0.51	0.90	1.28
2.4 GHz	IEEE Power Save: DTIM1	4.07	3.30	3.67
	IEEE Power Save: DTIM3	1.70	1.69	2.08
	IEEE Power Save: DTIM5	1.22	1.37	1.76
5 GHz	IEEE Power Save: DTIM1	2.23	2.53	2.92
	IEEE Power Save: DTIM3	1.08	1.44	1.83
	IEEE Power Save: DTIM5	0.85	1.22	1.61

5.3.2 Bluetooth

Conditions:

- VBAT = 3.3V, VIO = 1.8V
- Target: NXP iMX6SoloX-SABRE (MCIMX6SX-SDB)
- WLAN FW: W16.68.10.p22
- SDIO Signal = SDR104 mode @1.8V VIO
- SD Clock off/on (# mlanutl mlan0 sdioclock0, #mlanutl mlan0 sdioclock1)

Table 17 describes the parameters for typical sleep current consumption for Bluetooth in SDIO mode and **Table 18** describes the parameters for typical sleep current consumption for Bluetooth in PCIe mode.

Table 17: Typical Bluetooth Sleep Current Consumption - Wi-Fi SDIO Mode

Wi-Fi SDIO	Current Consumption VBAT (3.3V) in mA			
	50 MHz		200 MHz	
	Disable	Enable	Disable	Enable
SDIO Mode	0.29	0.36	0.95	1.34

Table 18: Typical Bluetooth Sleep Current Consumption - Wi-Fi PCIe Mode

	Current Consumption VBAT (3.3V) in mA
UART Mode	0.43

5.4 Typical Bluetooth Advertise Current Consumption

This section describes the typical Bluetooth advertise current consumption for Bluetooth.

Conditions:

- VBAT = 3.3V, VIO = 1.8V
- Target: NXP iMX6SoloX-SABRE (MCIMX6SX-SDB)
- WLAN FW: W16.68.10.p56
- Advertise interval = 1.28 sec
- SDIO Signal = SDR104 mode @1.8V VIO
- SD Clock off/on (# mlanutl mlan0 sdioclock0, #mlanutl mlan0 sdioclock1)

Table 19 and **Table 20** describe the parameters for typical advertise current consumption for Bluetooth in SDIO and PCIe modes.

Table 19: Typical Bluetooth Advertise Current Consumption - Wi-Fi SDIO Mode

Wi-Fi SDIO	Current Consumption VBAT (3.3V) in mA			
	50 MHz		200 MHz	
	Disable	Enable	Disable	Enable
SDIO Mode	0.35	1.16	0.40	1.60

Table 20: Typical Bluetooth Advertise Current Consumption - Wi-Fi PCIe Mode

UART Mode	Current Consumption VBAT (3.3V) in mA
	1.70

5.5 Typical Throughput

Test Configuration:

- VBAT = 3.3V, VIO = 1.8V
- **Target:** Embedded Artists' i.MX8M Mini uCOM Developer's Kit (Part Number - EAK00347)
- **Access Point:** Linksys EA9500 V2
- Distance between Access Point and the Target is around 3 ft.
- PCIe mode running at 200 MHz with 5.4.47 software release.
- SDIO mode running at 100 MHz with 5.4.47 software release.
- **UDP commands:** Bit rate was set at more than 20% of observed corresponding TCP throughput.
  - **Sample UDP command:**

```
iperf3 <server-ip-addr> -u -b <20%-of-TCP>M -P1 -t 60
```

Table 21 and **Table 22** describes the typical throughput values for WLAN in PCIe and SDIO modes.

Table 21: Typical Throughput - Wi-Fi PCIe Mode

Mode	TCP Throughput in Mbps		UDP Throughput in Mbps	
	Tx	Rx	Tx	Rx
2.4 GHz 11n HT20	114	123	123	127
5 GHz 11ac VHT80	428	565	502	602

Table 22: Typical Throughput - Wi-Fi SDIO Mode

Mode	TCP Throughput in Mbps		UDP Throughput in Mbps	
	Tx	Rx	Tx	Rx
2.4 GHz 11n HT20	114	123	122	125
5 GHz 11ac VHT80	185	236	214	227

6 References

Table 23 reviews all the key reference documents that the user may like to refer to.

Table 23: Reference Table

Support Site	Notes
Murata Type 1YM Module Datasheet	Murata Type 1YM module datasheet (type1ym.pdf)
Murata Type 1YM Module Footprint	Murata Type 1YM module footprint (type1ym_module_footprint_topview.dxf)
Murata Type 1YM Antenna	Murata Type 1YM module antenna (Type1YM-u-FL.DXF)
Murata's GitHub	Murata GitHub link for Linux transmit power files
wireless-regdb	Regulatory database used by Linux
Linux User Guide	Murata Linux User Guide for NXP modules (Murata Wi-Fi & BT (NXP) Solution for i.MX Linux User Guide.pdf). Murata website to be updated soon.

In case Murata website does not have the updated document, please refer to the Connectivity Module page on the Murata Community Forum. This contains a pinned post with all the updated documents.

7 Technical Support Contacts

Table 24 lists all the support resources available for the Murata Wi-Fi/BT solution.

Table 24: List of Support Resources

Support Site	Notes
Murata Community Forum	**Primary support point for technical queries.** This is an open forum for all customers. Registration is required.
Murata i.MX Landing Page	No login credentials required. Murata documentation covering hardware, software, testing, etc. is provided here.
Murata uSD-M.2 Adapter Landing Page	Landing page for uSD-M.2 Adapter. In conjunction with Murata i.MX Landing Page, this should provide the user with comprehensive getting started documentation.
Murata Module Landing Page	No login credentials required. Murata documentation covering all Infineon-based Wi-Fi/BT modules is provided here.

Revision History

Revision	Date	Section	Change Description
1.0	Apr. 29, 2021		First issue
2.0	Oct.1, 2021	• 2.2 Hardware block diagram • 5.4 Typical Sleep current consumption • 5.5 Typical Bluetooth Advertise current consumption	• Updated 3D graphics. • Updated block diagram. • Added 5.4.2 Bluetooth • Added this section
3.0	Dec.24, 2021	3. Reference Circuitry	• Corrected DC blocker position of PCIE
4.0	Jan 26, 2023	Updated to new format	• Moved transmit power table for all region to the 1YM datasheet. • Added the antenna section 3.5.3. • Removed external sleep clock requirements section 3.3. It is present in datasheet.