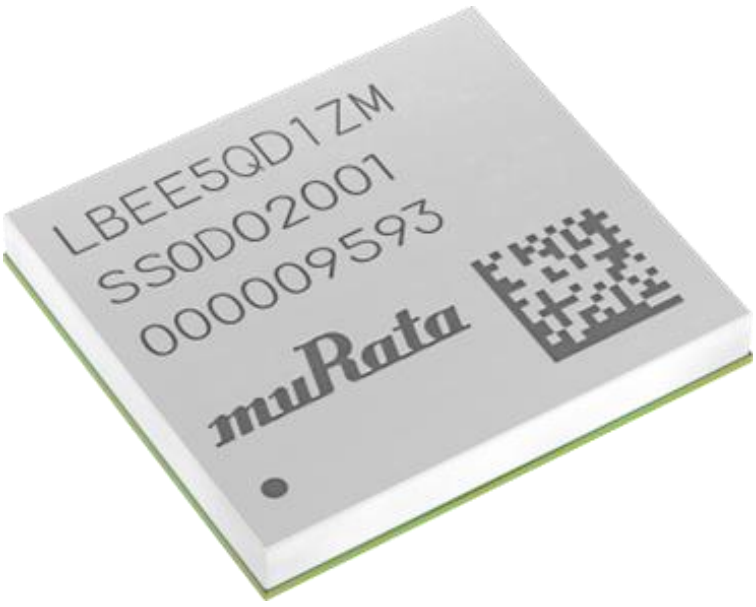
Hardware Application Note

Type 1ZM Wi-Fi® + Bluetooth® Module

NXP 88W8987 Chipset for 802.11a/b/g/n/ac + Bluetooth 5.1
Hardware Application Note - Rev. 3.0

- Design Name: Type 1ZM
- P/N: LBEE5QD1ZM-572



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About This Document

Murata's Type 1ZM is a small and high-performance module based on NXP's 88W8987 combo chipset, supporting IEEE 802.11a/b/g/n/ac + Bluetooth 5.1 BR/EDR/LE. This application note provides RF and hardware design guidance. Refer to Type 1ZM 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 Type 1ZM Datasheet for module specification.

2 Module Introduction

Type 1ZM is a high-performance module based on NXP 88W8987 combo chipset that supports Wi-Fi 802.11a/b/g/n/ac + Bluetooth 5.1 BR/EDR/LE for up to 433 Mbps PHY data rate on Wi-Fi and 3 Mbps PHY data rate on Bluetooth.

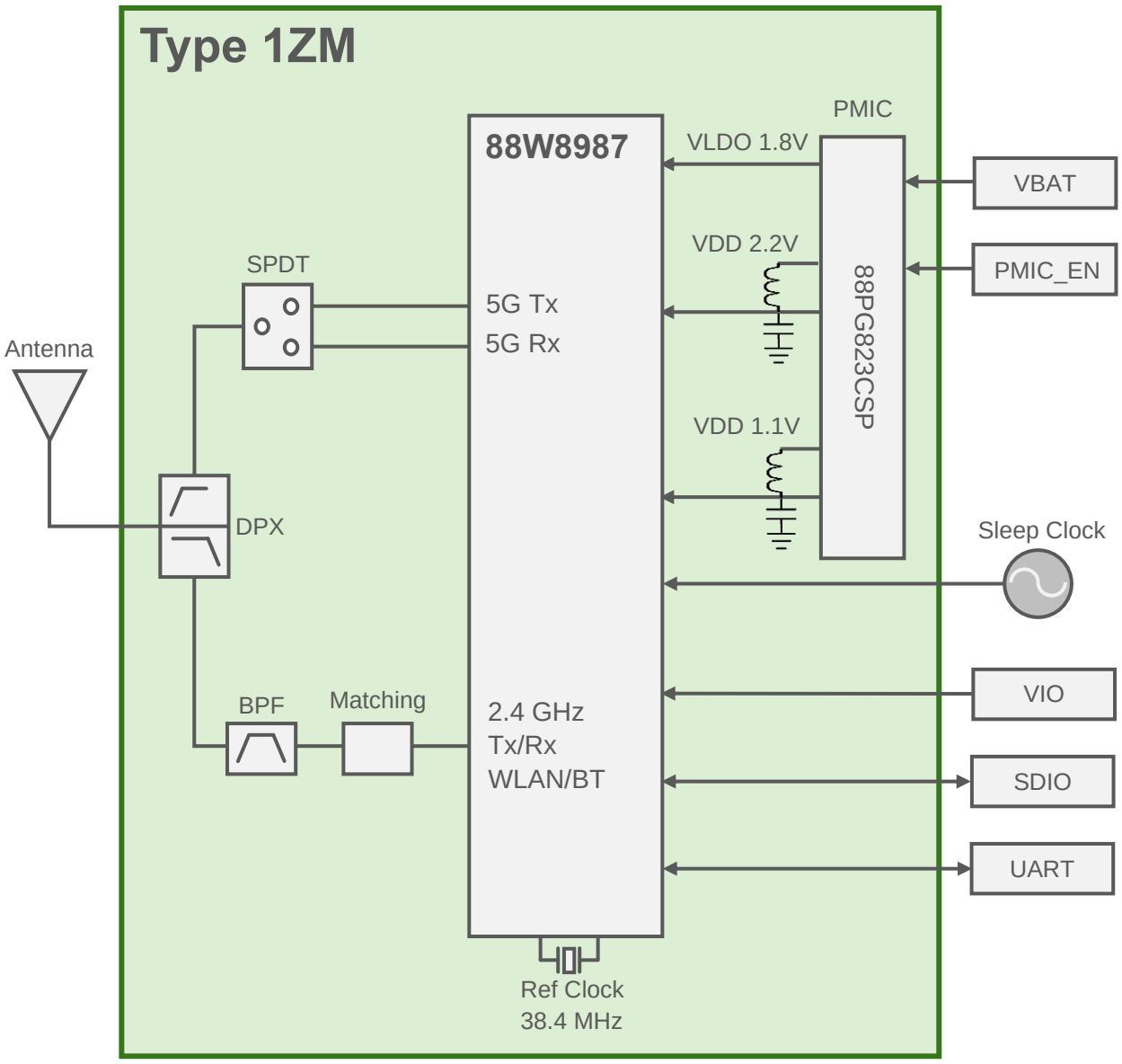
2.1 Features

- WLAN 802.11a/b/g/n/ac 1x1 SISO + Bluetooth Classic and Low Energy (Version 5.1) combo SMD module with NXP 88W8987
- Small size LGA package with resin molding and metal shielding.
- Host interfaces: SDIO 3.0 for WLAN; HCI UART, and PCM for Bluetooth.
- MAC address and BD address are stored in OTP

2.2 Hardware Block Diagram

Figure 1 shows the Type 1ZM module block diagram.

Figure 1: Block Diagram



3 Reference Design

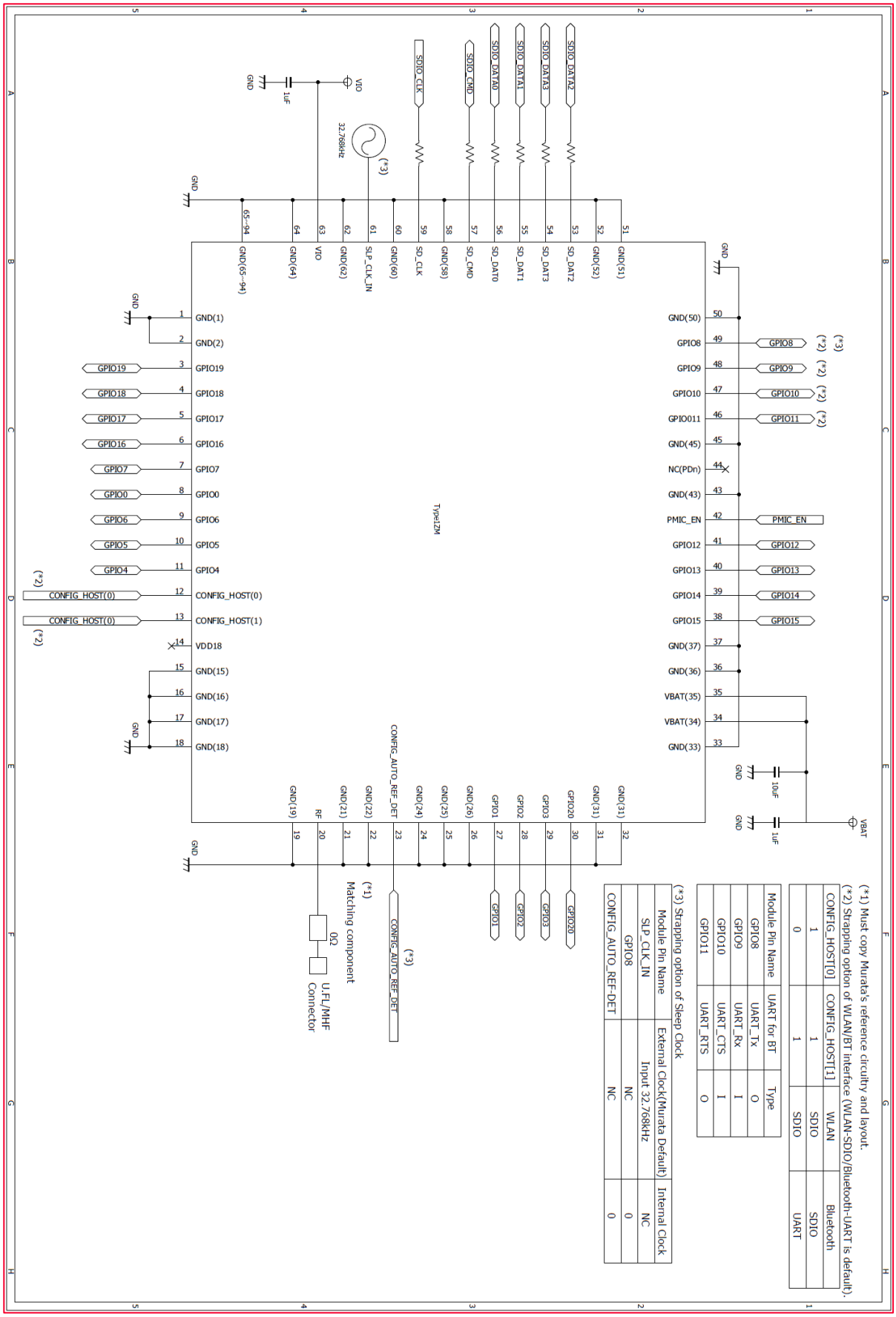
This section has the reference designs for Type 1ZM u.FL/MHF Connector and Trace Antenna.

3.1 Reference Circuit

Figure 2 shows the u.FL/MHF connector reference design. **Figure 3** shows the trace antenna reference design for Type 1ZM module. Note the default host interface configuration is WLAN-SDIO and Bluetooth-UART.

Although shown in reference circuits, Bluetooth-SDIO host interface may not be supported in software. Refer to Type 1ZM webpage or check 1ZM Community Forum page.

Figure 2: u.FL/MHF Connector



(*1) Must copy Murata's reference circuitry and layout.

(*2) Strapping option of WLAN/BT interface (WLAN-SDIO/Bluetooth-UART is default).

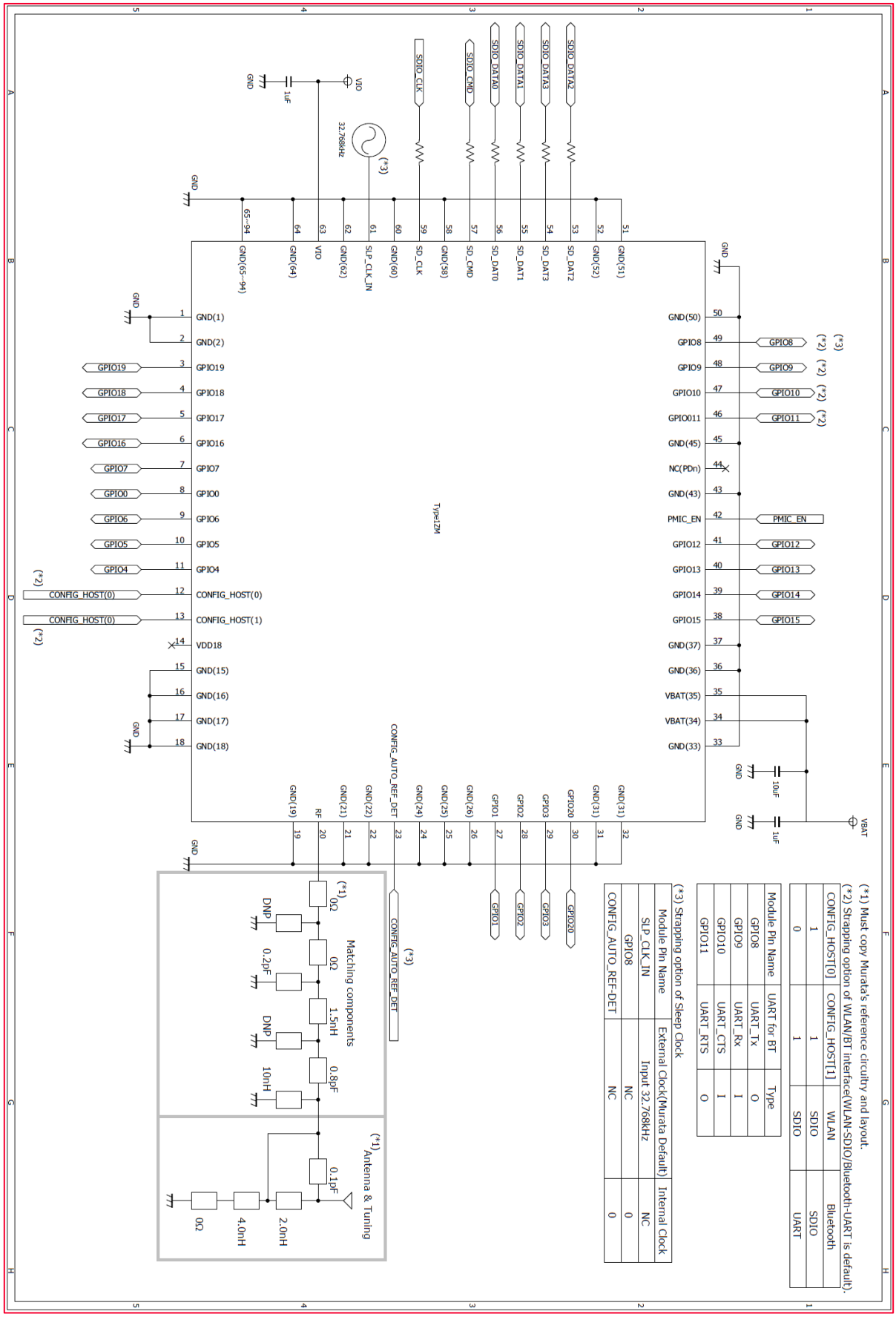
CONFIG_HOST[0]	CONFIG_HOST[1]	WLAN	Bluetooth
1	1	SDIO	SDIO
0	1	SDIO	UART

Module Pin Name	UART for BT	Type
GPIO8	UART_Tx	O
GPIO9	UART_Rx	I
GPIO10	UART_CTS	I
GPIO11	UART_RTS	O

(*3) Strapping option of Sleep Clock

Module Pin Name	External Clock(Murata Default)	Internal Clock
SLP_CLK_IN	Input 32.768kHz	NC
GPIO8	NC	0
CONFIG_AUTO_REF-DET	NC	0

Figure 3: Trace Antenna



3.2 Requirements for SDIO Signals

SDIO traces should be isometric zero delay routing with 50 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 1ZM Datasheet. The DXF file of module footprint 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, users must follow the instructions given in the sections below.
The DXF files for module footprint and trace antenna are provided via website.

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

- Users should use recommended antennas only. 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.

  The recommended antenna gains are described in **Table 2**.

  Table 2: Recommended Antenna Gains

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 by adhering to below 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 4 shows the Murata reference RF Trace to u.FL/MHF connector.

Figure 4: Murata Reference RF Trace to u.FL/MHF Connector

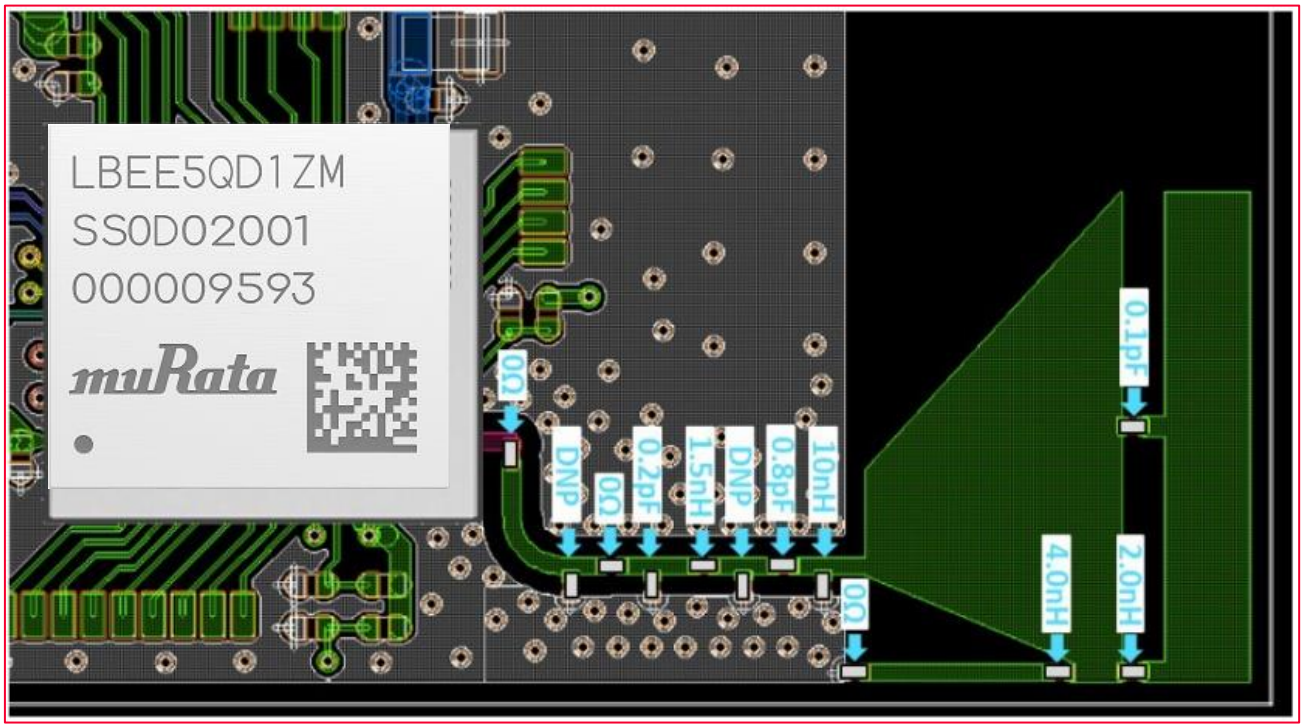
3.5.2 Trace Antenna

Users must:

- Copy antenna design from the antenna layout file provided by Murata.
- Copy RF trace to PCB trace antenna from the trace layout file provided by Murata, adhering to guidelines listed below:
  - Trace width accuracy within +/- 0.25 mm.
  - PCB thickness within 0.6 ~ 1.6 mm range (1.0 mm typical).
  - Stack height between GND layer and RF trace of 235 µm; keeping inaccuracy within +/- 0.5 µm.
  - Passive component location matching Murata design.

Figure 5 shows the locations of Murata reference passive components.

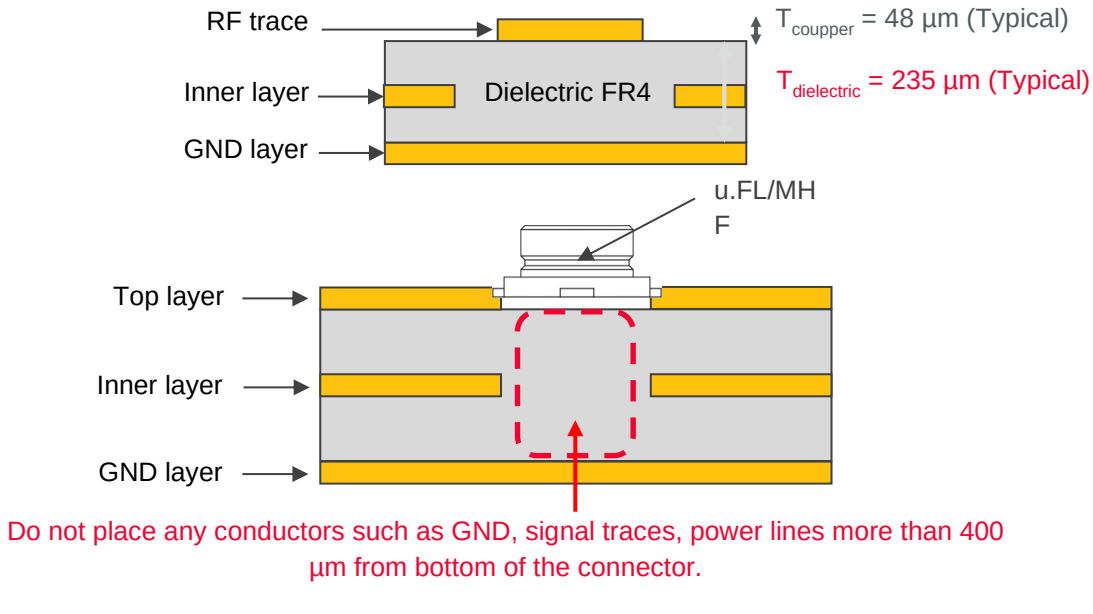
Figure 5: Murata Reference Passive Component Locations



3.5.3 PCB Stack-up

Figure 6 shows the PCB stack-up layers.

Figure 6: PCB Stack-up Layers



3.5.4 Trace Antenna Performance

Figure 7 shows the trace antenna performance for Type 1ZM module.

Figure 7: Trace Antenna Performance

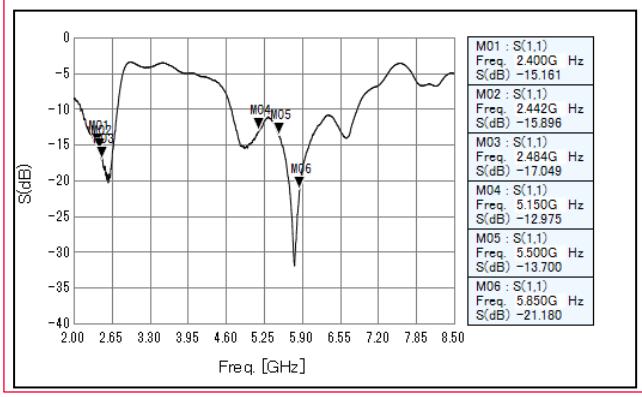
(Gain and Efficiency)

[dBi] [dB]

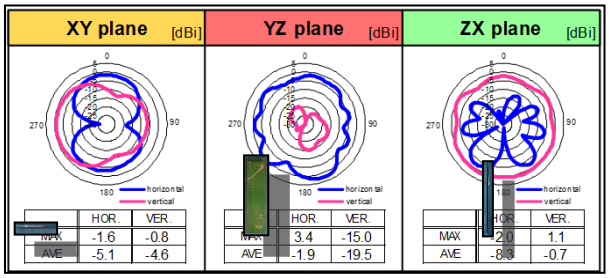
LINEAR POLARIZATION		XY-plane hor.	XY-plane ver.	YZ-plane hor.	YZ-plane ver.	ZX-plane hor.	ZX-plane ver.	Total Efficiency
2400 MHz	MAX.	-1.6	-0.9	2.6	-16.3	-2.2	1.0	
	AVE.	-4.9	-4.6	-2.0	-20.4	-8.3	-0.9	-1.0
2442 MHz	**MAX.**	**-1.6**	**-0.8**	**2.4**	**-15.0**	**-2.0**	**1.1**	
	AVE.	**-5.1**	**-4.6**	**-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

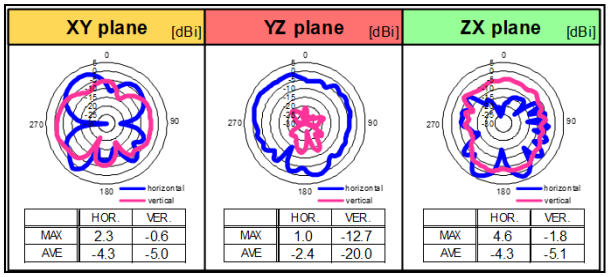
[dBi] [dB]

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)

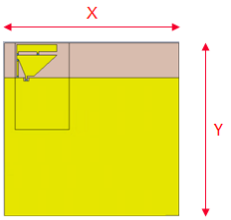
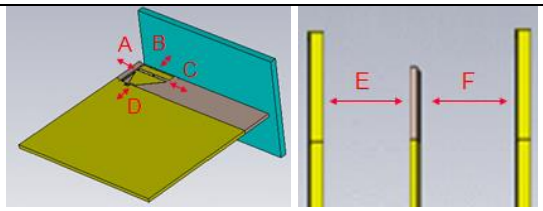


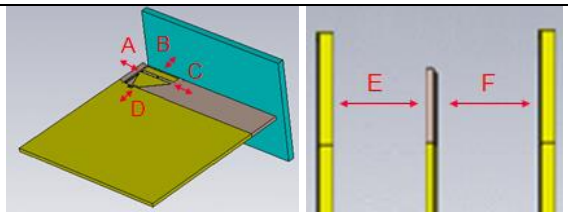


3.5.5 Trace Antenna Installation

For good antenna performance, keep the board size and clearance to metal/GND and dielectric around the trace antenna as illustrated in **Table 3**.

Table 3: Trace Antenna Installation Guide

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

3.5.6 Antenna Design and Configuration

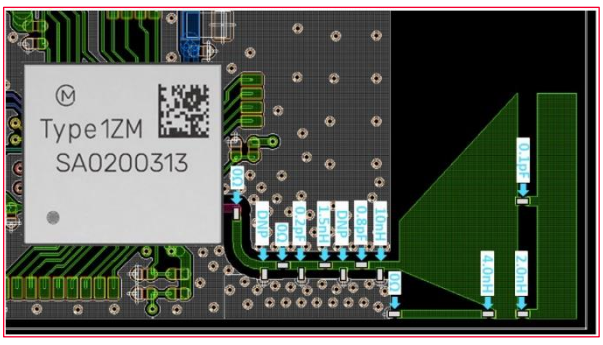
Table 4 shows the antenna list for Type 1ZM module.

Table 4: Antenna List

No.	Maker	Support Antenna						
		P/N	Form factor	Type	Gain		Size	Detail
					2.4 GHz	5 GHz		
1	Molex	146153	u.FL/flexible	Dipole	3.2	4.25	35x9x0.1 mm	Flexible//horizontal
2	Molex	146187	u.FL/flexible	Dipole	3.4	4.75	40.95x9x0.7 mm	Rigid//horizontal
3	Murata	LBEE5QD1ZM-Antenna	N/A	Monopole	3.6	4.6		Pattern Antenna

50 Ω line (microstrip line pattern)

Certification tests are conducted in the following patterns.



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.

4 Setup Configuration Files

To enable Murata's regulatory certification, the configuration stated below file should be initially loaded. The transmit power files are hosted at Murata GitHub for Linux and FreeRTOS.

4.1 WLAN Configuration Files for Linux

The files listed in **Table 5** shall be used to meet the regulatory requirements if user wants to use Murata regulatory certification. For more regulatory information, refer to section 11 of Linux User Guide.

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 shall use CRDA mechanism which is provided by Linux-wireless. Compile the new regulatory.bin file from "db.txt" that is provided by Murata as per of wireless regdb.

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 files listed in **Table 6** shall be used to meet the regulatory requirements if user wants to use Murata regulatory certification.

Table 6: WLAN Configuration Files - FreeRTOS

Names	Country	Country Code	Configuration Files
WLAN Tx power configuration files	USA	US	wlan_txpwrlimit_cfg_murata_1ZM_US.h
	Canada	CA	wlan_txpwrlimit_cfg_murata_1ZM_CA.h
	Europe	DE	wlan_txpwrlimit_cfg_murata_1ZM_EU.h
	Japan	JP	wlan_txpwrlimit_cfg_murata_1ZM_JP.h
WLAN Carrier Sense / Adaptivity threshold configuration file			wlan.c
WLAN regulatory limitation configuration file	USA	US	txpwrlimit_cfg_US.bin
	Canada	CA	txpwrlimit_cfg_CA.bin
	Europe	DE	txpwrlimit_cfg_EU.bin
	Japan	JP	txpwrlimit_cfg_JP.bin

4.4 Bluetooth Configuration for FreeRTOS

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

5 Reference Performance Data

This section describes the typical Rx minimum sensitivity level (at module antenna port) at different frequencies.

5.1 Typical Rx Minimum Sensitivity Level at Module Antenna Port

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

5.1.1 WLAN

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

Table 7 describes the typical Rx minimum sensitivity level at module antenna port for WLAN at 2.4 GHz for 20 MHz bandwidth. **Table 8**, **Table 9** and **Table 10** describe the typical Rx minimum sensitivity level at module antenna port for WLAN at 5 GHz for 20 MHz, 40 MHz and 80 MHz bandwidth.

Table 7: Rx Minimum Sensitivity Level - WLAN at 2.4 GHz (20 MHz)

Frequency [MHz]	Rx Minimum Sensitivity Level [dBm]					
	11b		11g		11n	
	1 Mbps	11 Mbps	6 Mbps	54 Mbps	MCS0	MCS7
2412	-97	-88	-89	-74	-89	-71
2442	-96	-88	-88	-73	-88	-70
2472	-98	-89	-90	-75	-90	-72

Table 8: Rx Minimum Sensitivity Level - WLAN at 5 GHz (20 MHz)

Frequency [MHz]	Rx Minimum Sensitivity Level [dBm]					
	11a		11n (HT20)		11ac (VHT20)	
	6 Mbps	54 Mbps	MCS0	MCS7	MCS0	MCS8
5180	-89	-75	-89	-71	-89	-68
5500	-89	-75	-89	-71	-89	-68
5825	-89	-75	-89	-71	-89	-68

Table 9: Rx Minimum Sensitivity Level - WLAN at 5 GHz (40 MHz)

Frequency [MHz]	Rx Minimum Sensitivity Level [dBm]	
	11ac (VHT40)	
	MCS0	MCS9
5190	-86	-64
5510	-86	-64
5795	-86	-64

Table 10: Rx Minimum Sensitivity Level - WLAN at 5 GHz (80 MHz)

Frequency [MHz]	Rx Minimum Sensitivity Level [dBm]	
	11ac (VHT80)	
	MCS0	MCS9
5180	-82	-60
5500	-82	-60
5825	-82	-60

5.1.2 Bluetooth

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

Table 11 describes the typical Rx minimum sensitivity level for Bluetooth.

Table 11: Rx Minimum Sensitivity Level - Bluetooth

Frequency [MHz]	Rx Minimum Sensitivity Level [dBm]				
	DH5	2DH5	3DH5	LE 1M	LE 2M
2412	-95	-93	-90	-101	-99
2442	-95	-93	-90	-101	-97
2472	-95	-93	-90	-98	-94

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

Figure 8: Typical Tx/Rx Current Consumption for WLAN

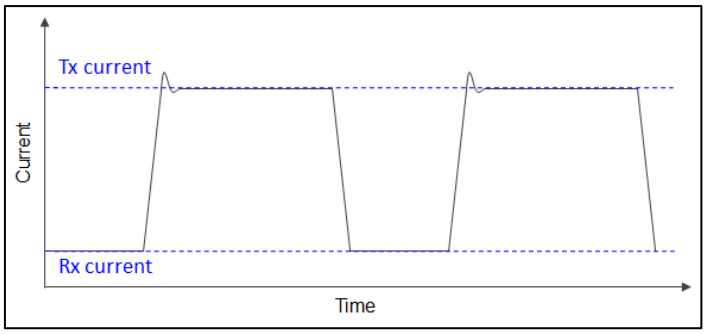


Table 12 describes the typical Tx/Rx current consumption for WLAN at 2.4 GHz.

Table 12: Typical Tx/Rx Current Consumption - WLAN at 2.4 GHz

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

Table 13 describes the typical Tx/Rx current consumption for WLAN at 5 GHz.

Table 13: Typical Tx/Rx Current Consumption - WLAN at 5 GHz

Mode	Rate	Setting Power in dBm	Current in mA	
			Tx	Rx
11a	6 Mbps	15.0	408	79
11n/ac-20	MCS0	14.0	386	79
11n/ac-40	MCS0	14.0	388	91
11n/ac-80	MCS0	14.0	406	102

5.2.2 Bluetooth

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

Figure 9: Typical Tx/Rx Current Consumption for Bluetooth

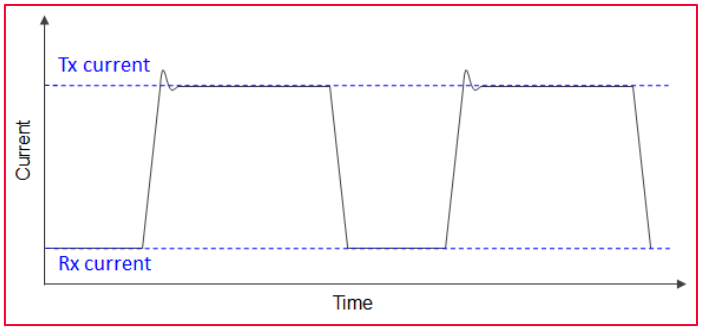


Table 14 describes the typical Tx/Rx current consumption for Bluetooth.

Table 14: Typical Tx/Rx Current Consumption - Bluetooth

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

5.3 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 iMX6SoloX-SABRE (MCIMX6SX-SDB)
  - WLAN FW: W16.68.10.p22
  - Beacon Interval = 100 ms
  - SDIO Signal Level = 1.8V
    SD Clock off/on (# mlanutl mlan0 sdioclock0, #mlanutl mlan0 sdioclock1)

Table 15 describes the typical sleep current consumption for WLAN.

Table 15: Typical Sleep Current Consumption - WLAN

Band		Current Consumption VBAT (3.3V) in mA			
	SD Clock Speed	50 MHz		200 MHz	
	Clock Enablement	Disable	Enable	Disable	Enable
-	Chip deep sleep	0.27	0.34	1.05	1.78
2.4 GHz	IEEE Power Save: DTIM1	1.93	1.99	2.63	3.04
	IEEE Power Save: DTIM3	0.82	0.89	1.58	1.99
	IEEE Power Save: DTIM5	0.60	0.66	1.37	1.78
5 GHz	IEEE Power Save: DTIM1	1.33	1.38	2.19	2.60
	IEEE Power Save: DTIM3	0.62	0.67	1.43	1.85
	IEEE Power Save: DTIM5	0.48	0.55	1.28	1.70

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@1.8V
    SD Clock off/on (# mlanutl mlan0 sdioclock0, #mlanutl mlan0 sdioclock1)

Table 16 describes the typical sleep current consumption for Bluetooth.

Table 16: Typical Sleep Current Consumption - Bluetooth

Wi-Fi SDIO	Current Consumption VBAT (3.3V) in mA			
	50 MHz		200 MHz	
	Disable	Enable	Disable	Enable
UART mode	0.24	0.31	0.94	1.39
SDIO mode	0.24	0.30	0.94	1.38

5.4 Typical Bluetooth Advertise Current Consumption

This section describes the typical Bluetooth advertise current consumption.

- Conditions
  - VBAT = 3.3V, VIO = 1.8V
  - Target: NXP iMX6SoloX-SABRE (MCIMX6SX-SDB)
  - WLAN FW: W16.68.10.p22
  - Advertise interval = 1.28 sec
  - SDIO Signal = SDR104@1.8V
    SD Clock off/on (# mlanutl mlan0 sdioclock0, #mlanutl mlan0 sdioclock1)

Table 17 describes the typical Bluetooth advertise current consumption.

Table 17: 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	0.28	0.38	1.03	1.44
UART mode	0.35	0.41	1.14	1.56

5.5 Typical Throughput

The typical throughput test configurations are:

- VBAT = 3.3V, VIO = 1.8V
- **Target**: Embedded Artists' i.MX8M Mini uCOM
- **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.
- **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 18 shows the typical throughput data for the modules.

Table 18: WLAN Typical Throughput Data

Mode	TCP Throughput in Mbps		UDP Throughput in Mbps	
	Tx	Rx	Tx	Rx
2.4 GHz 11n HT20	56.8	62.4	62.3	64.3
5 GHz 11ac VHT80	235	330	282	346

6 References

Table 19 reviews all the key reference documents that the user may like to refer to.

Table 19: Reference Table

Support Site	Notes
Murata Type 1ZM Module Datasheet	Murata Type 1ZM module datasheet (type1zm.pdf)
Murata Type 1ZM Module Footprint	Murata Type 1ZM module footprint (type1zm_module_footprint_topview.dxf)
Murata Type 1ZM Trace Antenna	Murata Type 1ZM module trace antenna (Type1ZM-trace-antenna.dxf)
Linux	Murata GitHub link for Linux transmit power files for 1ZM
FreeRTOS	Murata GitHub link for FreeRTOS transmit power files for 1ZM
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 20 lists all the support resources available for the Murata Wi-Fi/BT solution.

Table 20: 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	Top page 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	Jan 26, 2023	Updated to new format	• Moved transmit power table to 1ZM Datasheet. • Added the antenna section 3.5.6. • Removed the external sleep clock requirement section.