Hardware Application Note

Type 2AE/2BC Wi-Fi® + Bluetooth® Module

Infineon CYW4373E/CYW4373 Chipset for 802.11a/b/g/n/ac + Bluetooth 5.2

Hardware Application Note - Rev. 5.0

- Design Name: Type 2AE / Type 2BC
- P/N: LBEE5PK2AE-564 / LBEE5PK2BC-771

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About This Document

Murata's Type 2AE/2BC is a small and high-performance module based on IFX's CYW4373E/CYW4373 combo chipset, supporting IEEE 802.11a/b/g/n/ac + Bluetooth 5.2 BR/EDR/LE. This application note provides RF and hardware design guidance. For detailed module specification, refer to Type 2AE/2BC Datasheet.

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**: Murata 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 covers HW development and provides how to design the schematic and layout, and reference RF performance. Refer to Type 2AE/2BC Datasheet for detailed module specification.

2 Module Introduction

This section describes module features.

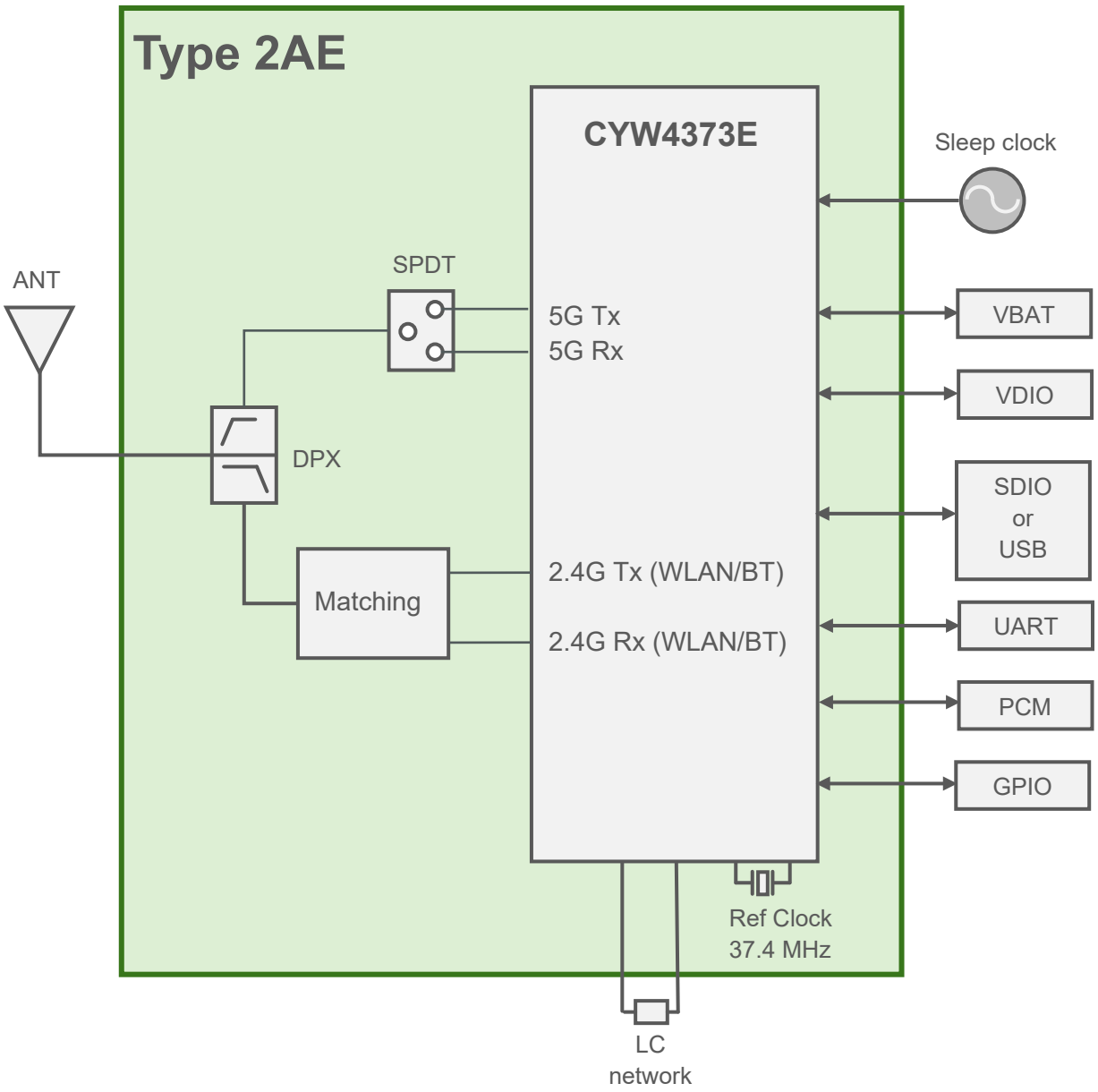
2.1 Features

- WLAN (11a/b/g/n/ac) 1x1 SISO + Bluetooth and low energy (v5.2) combo SMD module with Infineon CYW4373E / CYW4373
- Small size LGA package with resin molding and metal shielding.
- SDIO3.0/USB (shared) for WLAN and UART/USB (shared) for Bluetooth as the host interface.
- MAC address and BD address are stored in OTP.

2.2 Hardware Block Diagram

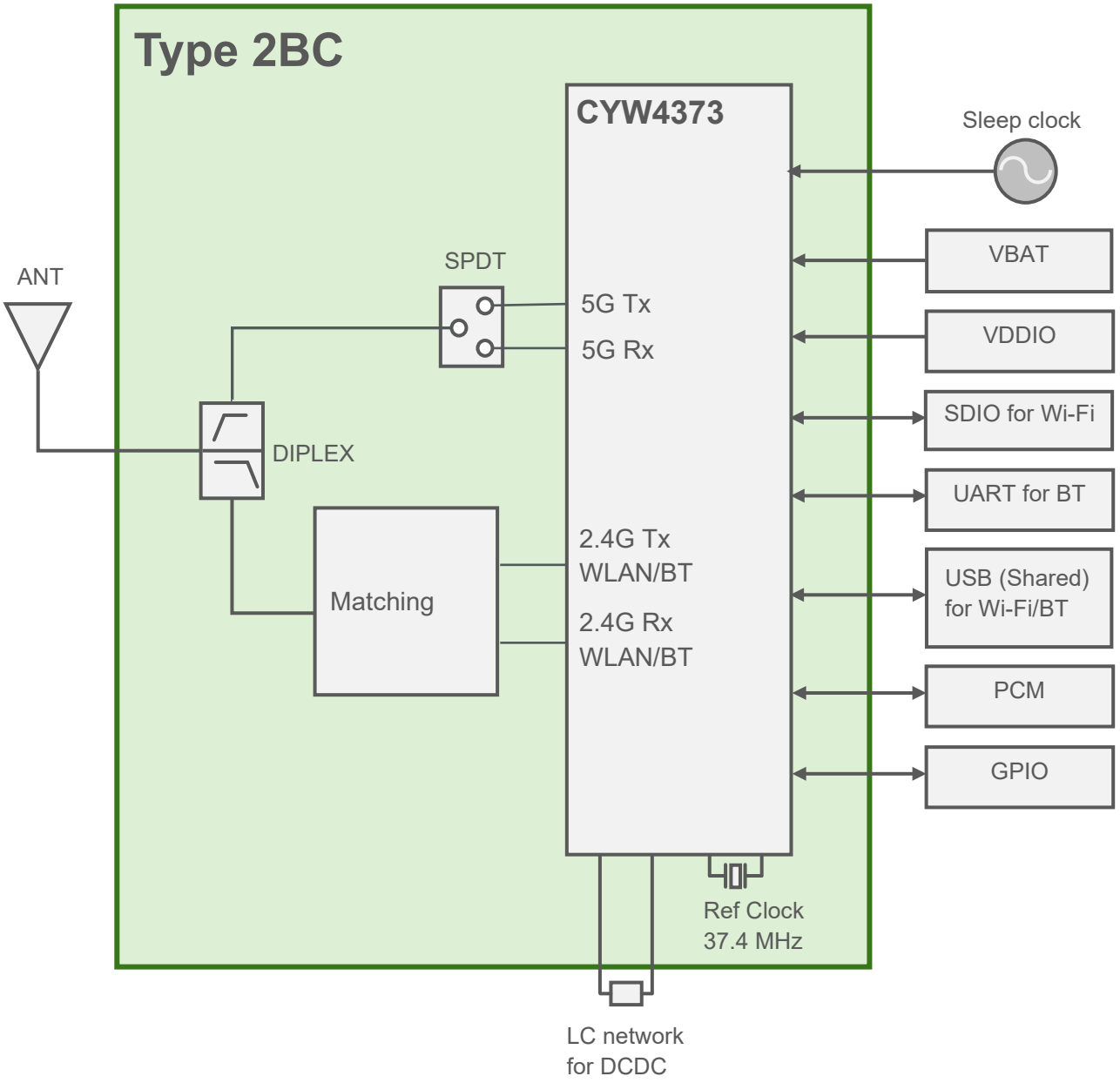
The type 2AE block diagram is shown in **Figure 1**.

Figure 1: Block Diagram - Type 2AE



The type 2BC block diagram is shown in **Figure 2**.

Figure 2: Block Diagram - Type 2BC



3 Reference Circuitry Design

This section describes reference circuit design for Type 2AE / 2BC module.

3.1 Reference Circuit

The reference circuits of Type 2AE are shown in **Figure 3** and **Figure 4.**

The reference circuits of Type 2BC are shown in **Figure 5** and **Figure 6**.

Figure 3: Type 2AE Module Reference Circuit

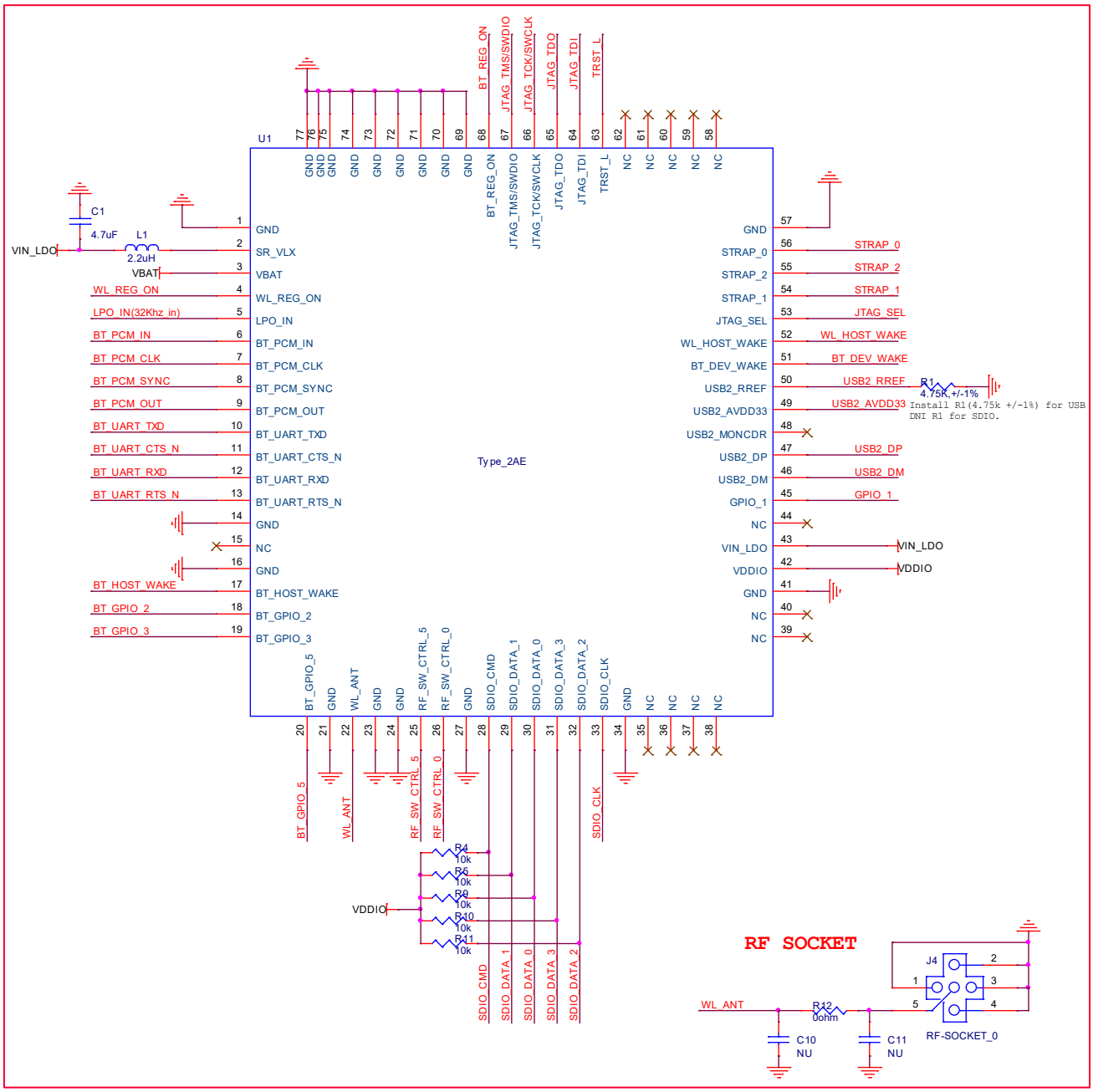
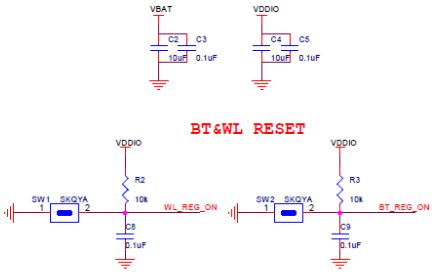
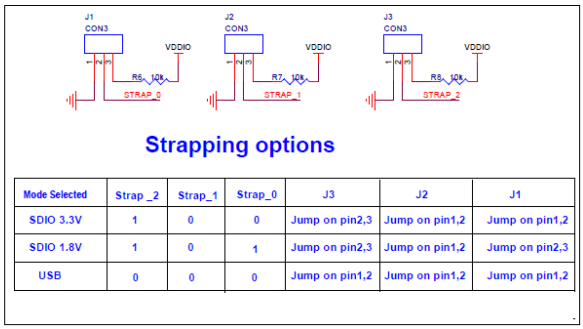


Figure 4: Type 2AE Power Supply and Configuration Reference Circuit

1.VBAT typical value is 3.3 +/-5% V
2.VDDIO can be provided 1.8V or 3.3V
3.LPO_IN must be provided
4.For L1 selection, recommanded inductor P/N is DFE201612E-2R2M(muRata)
5.JTAG_SEL should be kept NO CONNECT or connect to ground if
the JTAG interface is not used.
It must be high to select SWD OR JTAG





Strapping options

Mode Selected	Strap_2	Strap_1	Strap_0	J3	J2	J1
SDIO 3.3V	1	0	0	Jump on pin2,3	Jump on pin1,2	Jump on pin1,2
SDIO 1.8V	1	0	1	Jump on pin2,3	Jump on pin1,2	Jump on pin2,3
USB	0	0	0	Jump on pin1,2	Jump on pin1,2	Jump on pin1,2

Figure 5: Type 2BC Module Reference Circuit

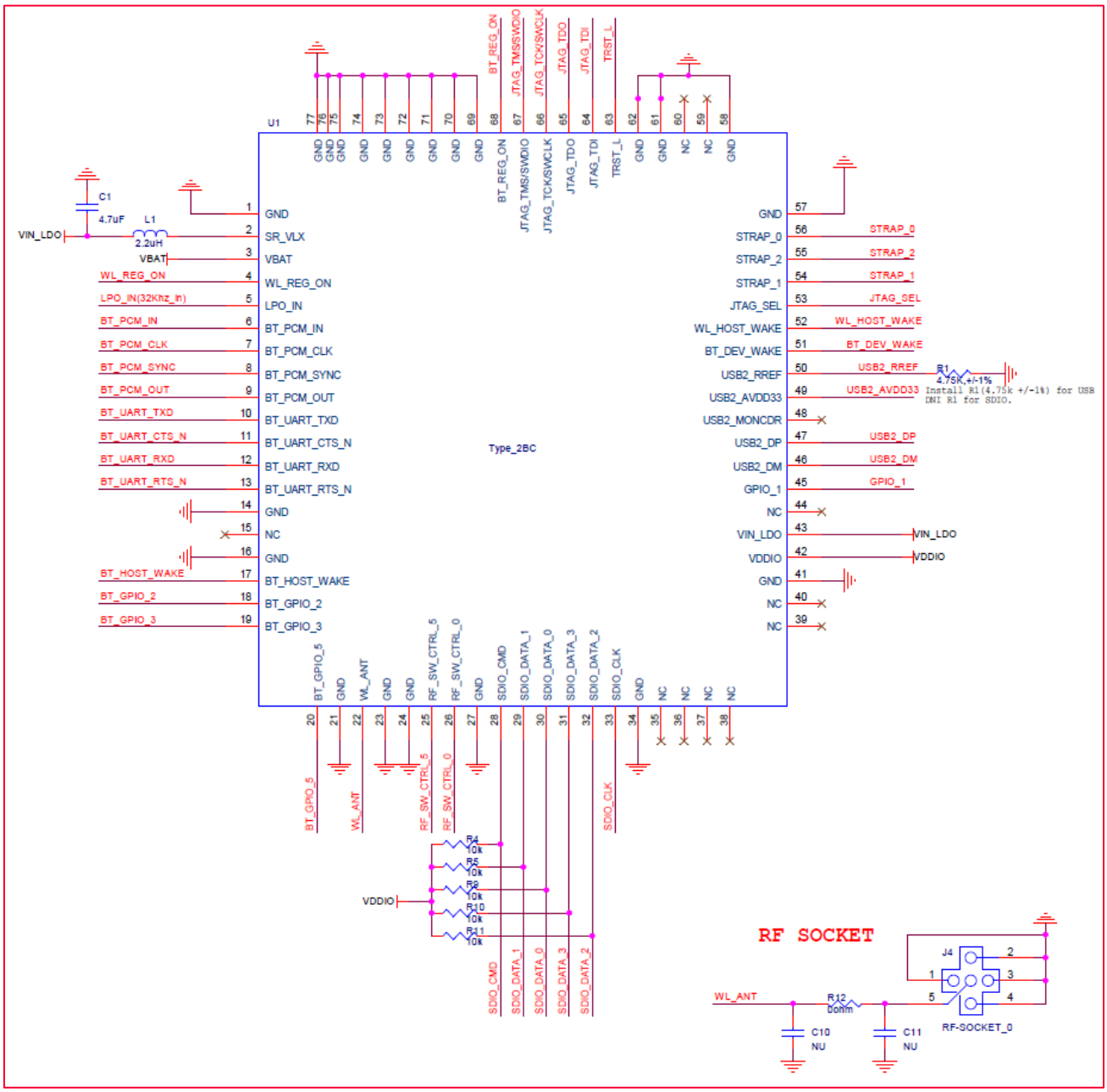
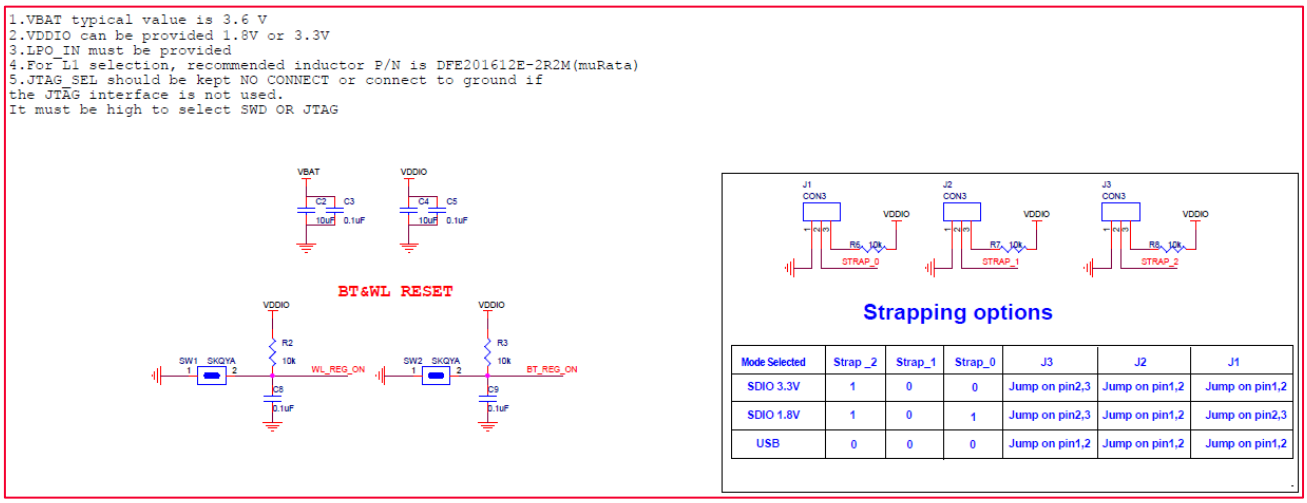


Figure 6: Type 2BC Power Supply and Configuration Reference Circuit



3.2 Requirement for SDIO Signals

SDIO traces should be isometric zero delay routing with 50-ohm impedance. 10 to 100k ohm pull-ups are required on the four DATA lines and the CMD line. This requirement must be met during all operating states by using external pull-up resisters or properly programming internal SDIO Host pull-ups. The CYW4373E module (LBEE5PK2AE-564) / CYW4373 module (LBEE5PK2BC-771) does not have internal pull-ups on these lines. **Figure 7** shows the diagram for SDIO pullup requirements.

Figure 7: SDIO Pullup Requirements

3.3 Requirements for Unused signals

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

3.4 Module Footprint Design

Refer to dimensions in the Type 2AE/2BC 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 the regulatory certification body. To use Murata's regulatory certification, any user must follow the instructions below. The DXF File of the trace antenna is provided via website.

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

PCB type di-pole antenna with the co-axial connector guidelines are as below:

- Users must use recommended antennas. The approved vendor and its parameters for Di-pole antenna is shown in **Table 2**. However, an antenna of equivalent type that has less antenna gain than antenna gain of recommended antennas for US and EU can be used. However, it must be as per Class I permissive change approved by Murata. An example of a Class I permissive change capable antenna is shown in **Table 3**. The additional registered antennas in JP are shown in **Table 4**.

Table 2: Approved Vendor and its Parameters for Di-Pole Antenna

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

Table 3: An Example of Class I Permissive Change Capable Antenna

P/N	Vendor	Form factor	Type	2.4 GHz Gain	5 GHz Gain	Cable options
WT32D1-KX	Unictron	U.FL/PCB	Di-pole	3.0 dBi	4.0 dBi	130 mm (H2B1WD1A3B0200)

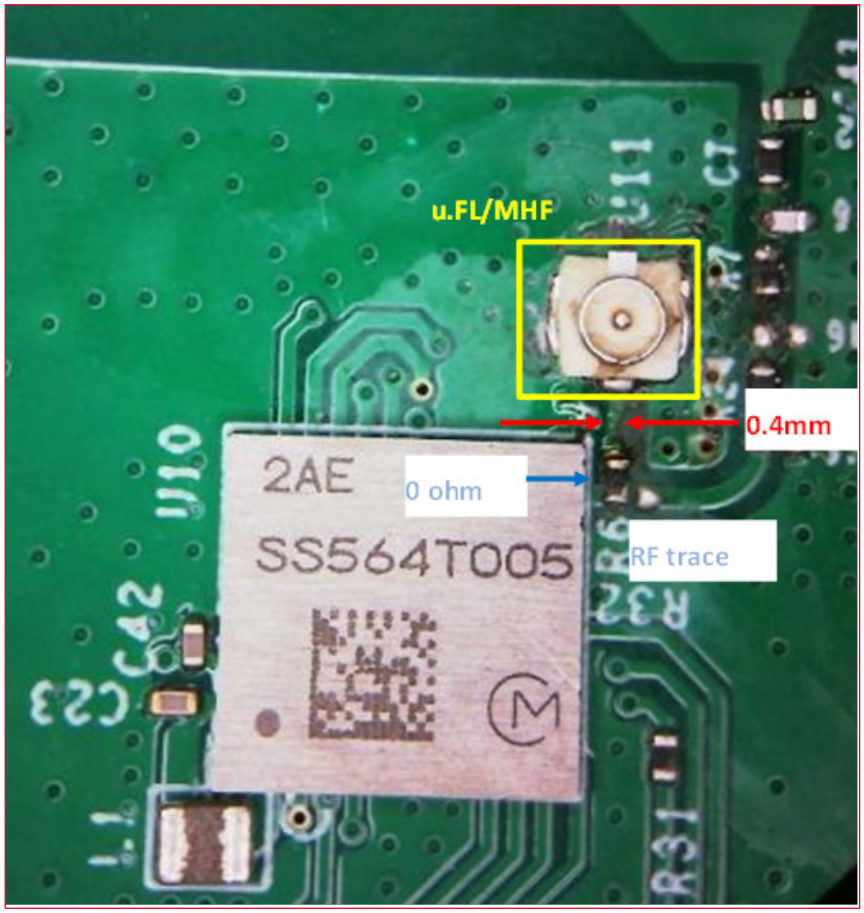
Table 4: Additional Registered Antennas in Japan Radio Law certification

P/N	Vendor	Form factor	Type	2.4 GHz Gain	5 GHz Gain	Cable options
WT32D1-KX	Unictron	U.FL/PCB	Di-pole	3.0 dBi	4.0 dBi	130 mm (H2B1WD1A3B0200)
146153	Molex	U.FL/PCB	Di-pole	3.2 dBi	4.25 dBi	050,100,150,200,250 and 300
219611	Molex	U.FL/PCB	Di-pole	2.67 dBi	3.67 dBi	050,100,150,200,250 and 300
FXP830.07.0100C	Taoglas	U.FL/PCB	Di-pole	2.5 dBi	4.7dBi	100 mm
SRF2W012	Antennova	U.FL/PCB	Di-pole	3.0 dBi	4.0 dBi	100 mm
STDANTEMD-013	Sansei	U.FL/PCB	Di-pole	1.9 dBi	2.8dBi	120 mm
EMF2471A3S	Laird	U.FL/PCB	Di-pole	2.2 dBi	4.4 dBi	100 mm
1001932FT	KVAX	U.FL/PCB	Di-pole	2.5 dBi	4.4 dBi	100 ~ 500 mm
1001932PT	KVAX	U.FL/PCB	Di-pole	2.03 dBi	4.45 dBi	100 ~ 500 mm

- 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 +/- 0.025 mm.
  - Stack height between GND layer and RF trace of 210 ~ 260 um (include inaccuracy of PCB).
  - Passive component location matching Murata design.
  - Necessary "Keep out" area around u.FL/MHF connector.

Figure 8 shows the Murata reference RF trace to u.FL/MHF connector.

Figure 8: Murata Reference RF Trace to u.FL/MHF Connector



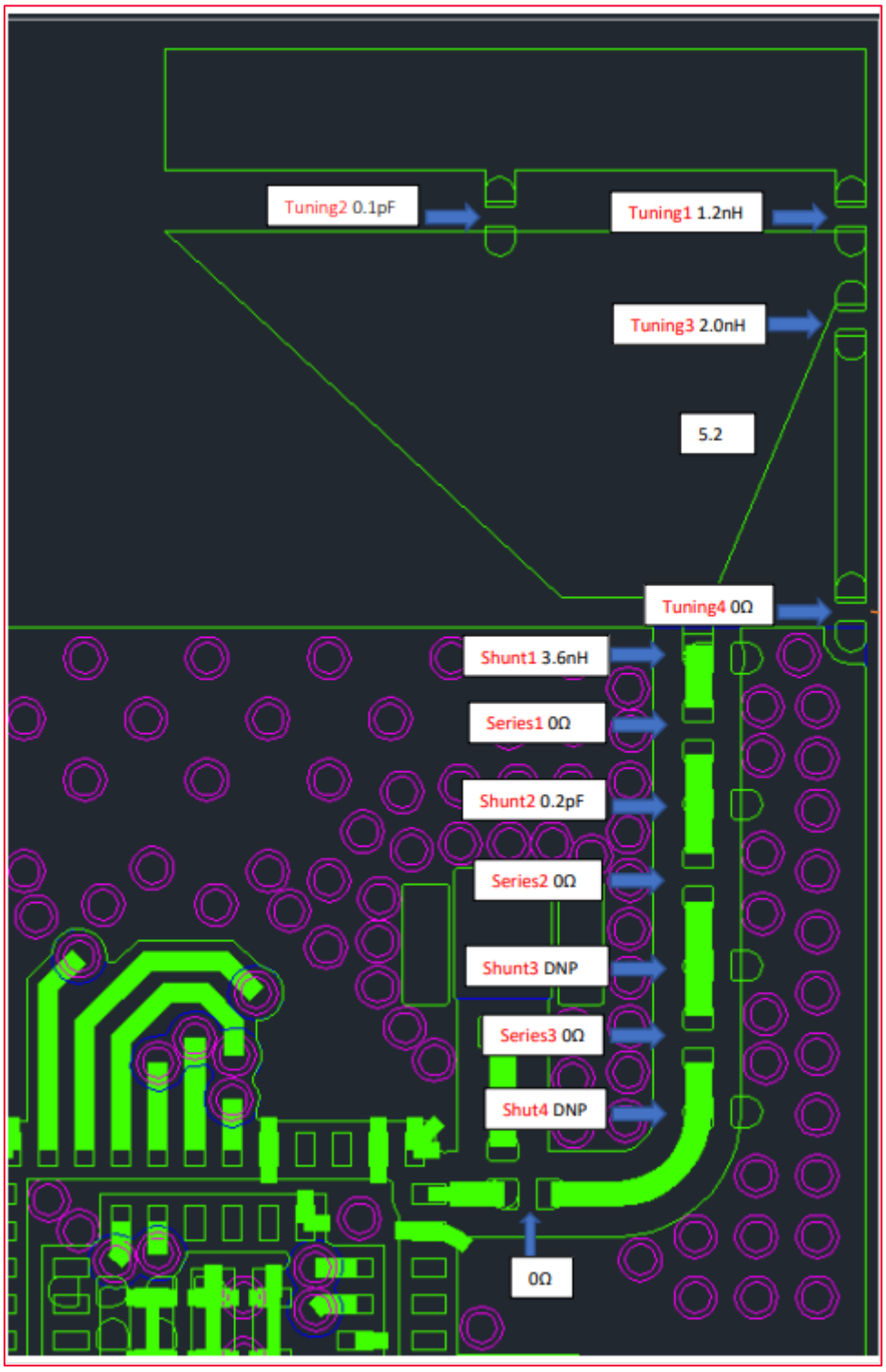
3.5.2 Trace Antenna

Users must follow the antenna guidelines listed below:

- 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 below guidelines on:
  - Trace width accuracy within +/- 0.025 mm.
  - PCB thickness within 0.6 ~ 1.6 mm range (0.8 mm typ.).
  - Stack height between GND layer and RF trace of 235 ums; keeping inaccuracy within +/-25 um.
  - Passive component location matching Murata design.

Figure 9 shows the locations of Murata reference passive components.

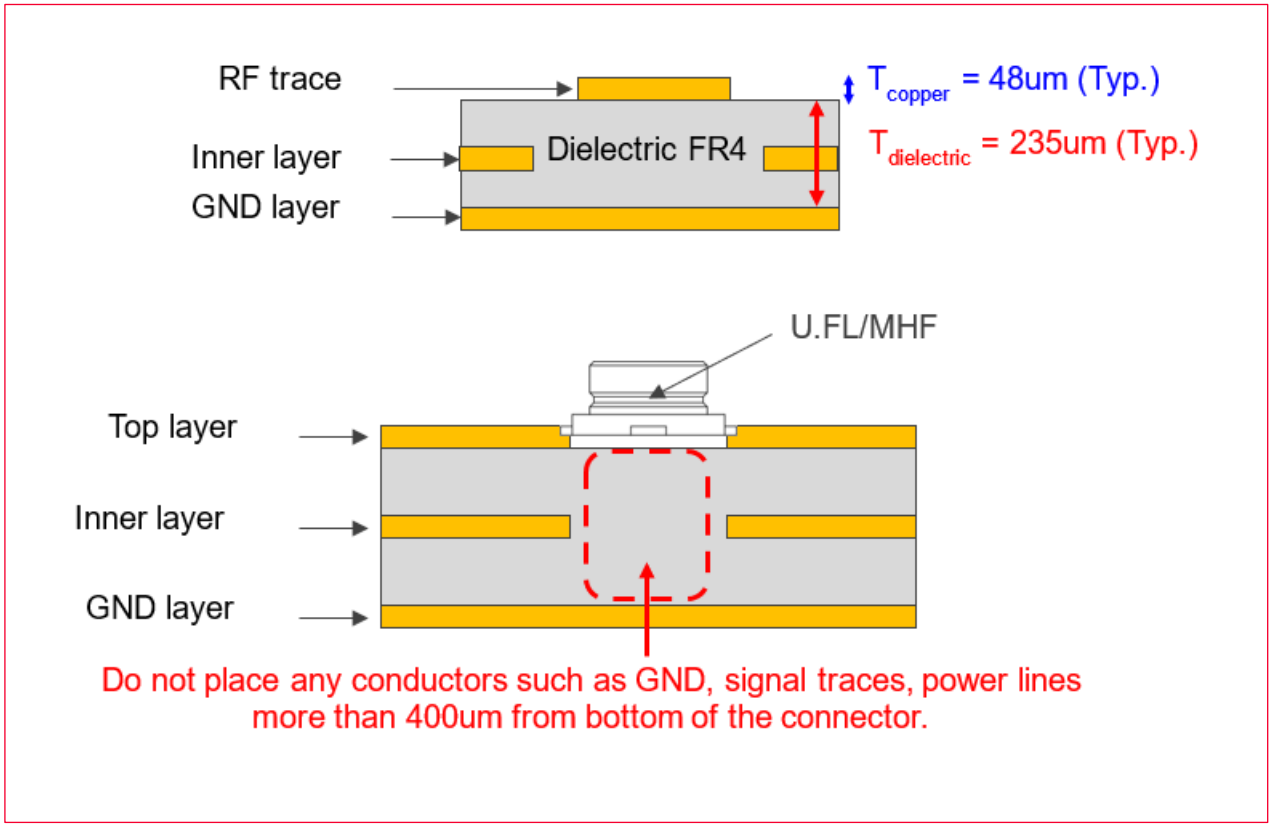
Figure 9: Murata Reference Passive Component Locations



3.5.3 PCB Stack-up

Figure 10 shows the PCB stack-up layers.

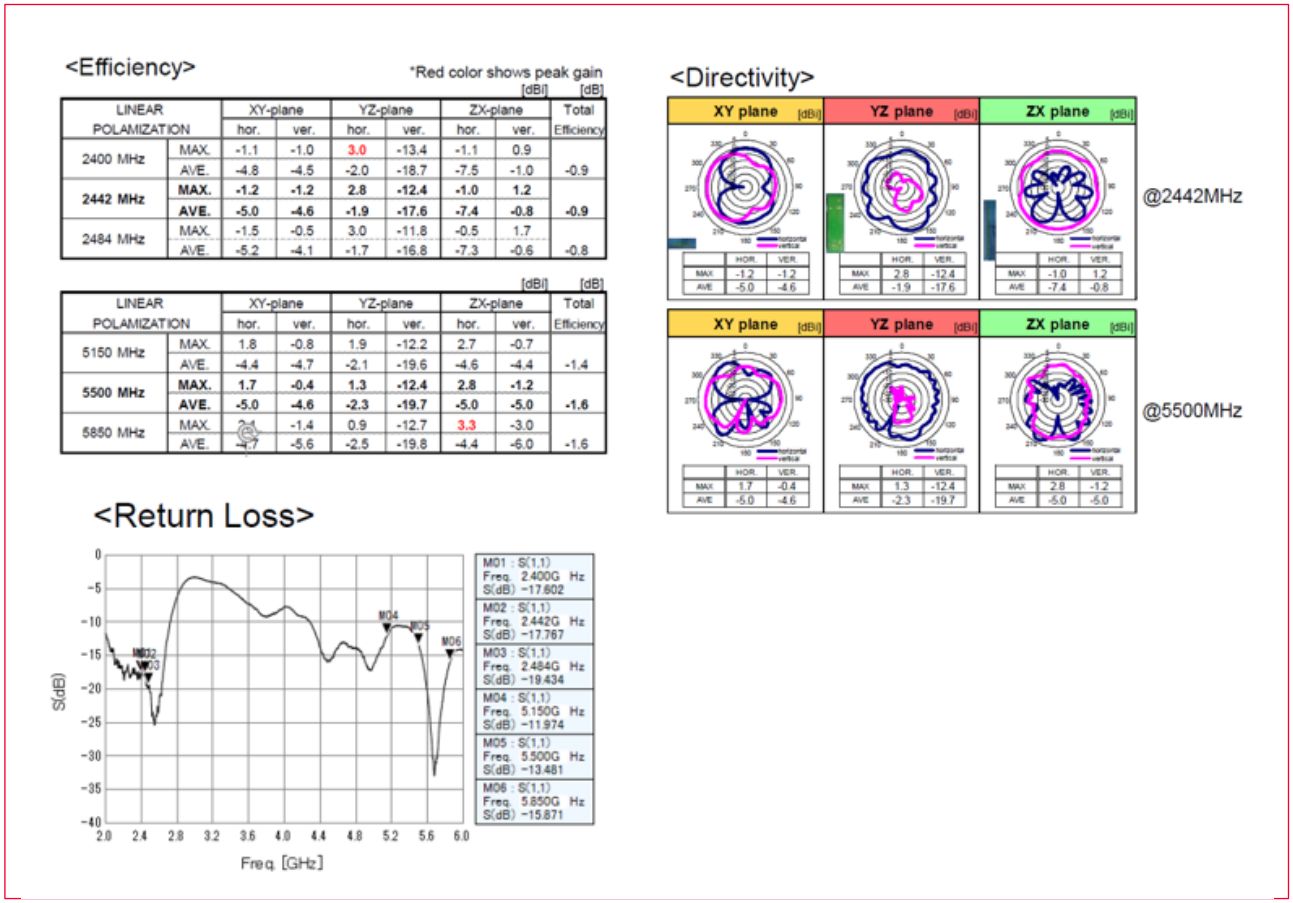
Figure 10: PCB Stack-up Layers



3.5.4 Trace Antenna Performance

Figure 11 shows the trace antenna performance for type 2AE/2BC module.

Figure 11: Trace Antenna Performance



3.5.5 Trace Antenna Installation

Keep board size and clearance to metal/GND and Dielectric around the trace antenna for good antenna performance. The specifications are presented in **Table 5**.

Table 5: Trace Antenna Installing Specification

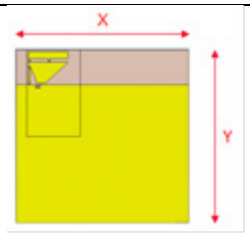
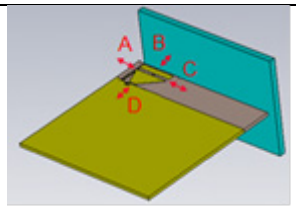
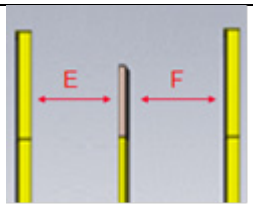
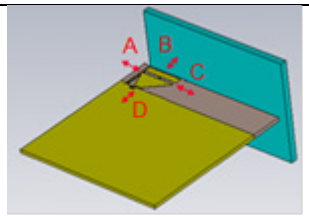
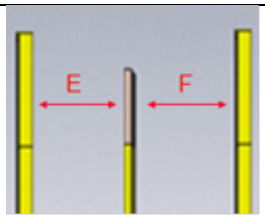
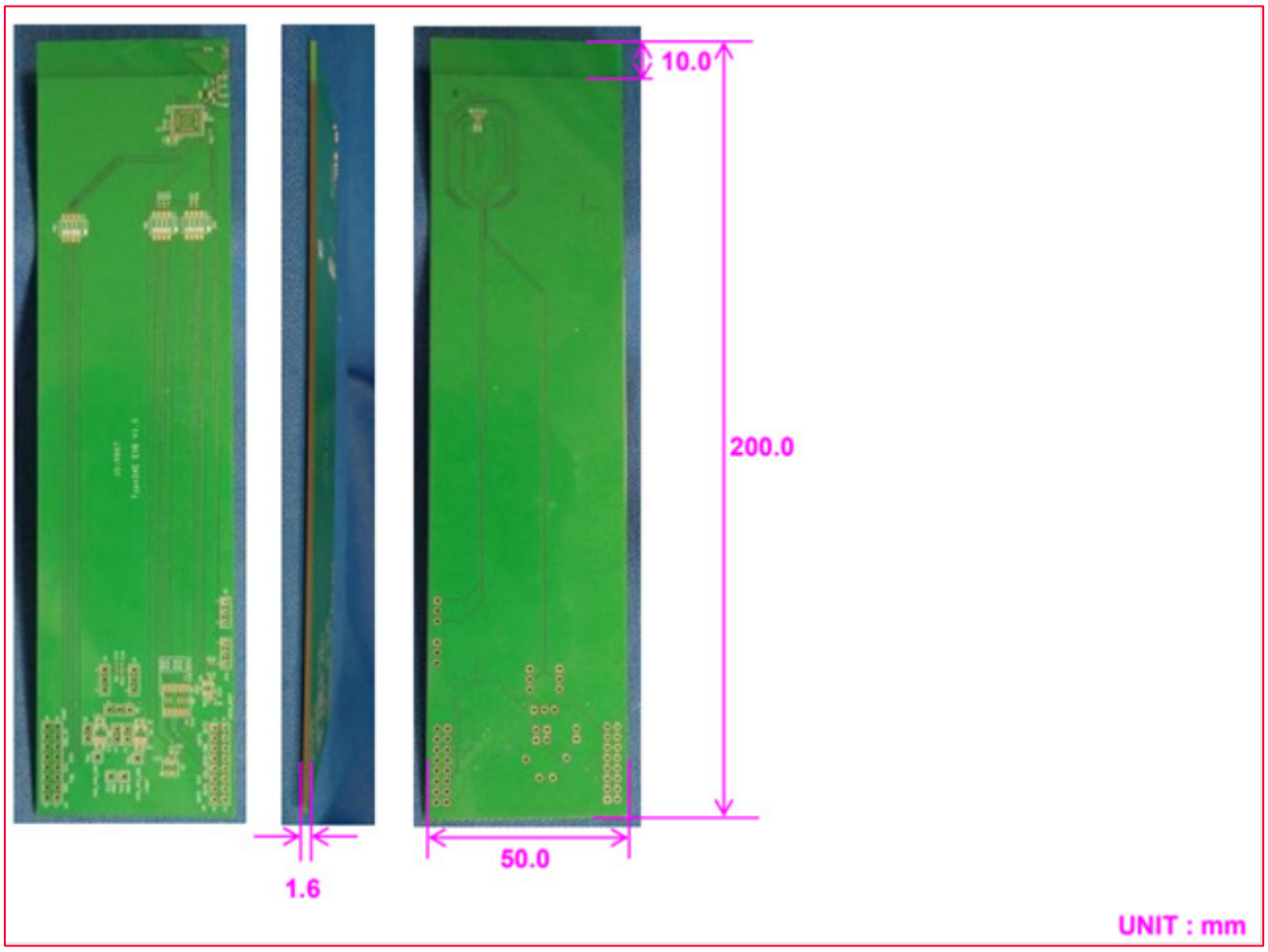
Board Size			X ≥ 40 mm Y ≥ 40 mm
Clearance to Metal/GND			A ≥ 20 mm B ≥ 20 mm C ≥ 20 mm D ≥ 20 mm E/F ≥ 20 mm
Clearance to Dielectric			A ≥ 4 mm B ≥ 4 mm C ≥ 4 mm D ≥ 4 mm E/F ≥ 4 mm

Figure 12 shows the antenna specifications.

Figure 12: Antenna Specifications



4 Setup Configuration Files

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

4.1 WLAN configuration files for Linux

The files listed in **Table 6** shall be used to satisfy regulatory requirements if user wants to use Murata regulatory certification. For more regulatory information, refer to Section 11 of Linux User Guide.

Table 6: WLAN Configuration Files - Linux

Names	Configuration Files
WLAN configuration file	cyfmac4373-sdio.2AE.txt cyfmac4373-sdio.2BC.txt
WLAN regulatory configuration file	cyfmac4373-sdio.2AE.clm.blob cyfmac4373-sdio.2BC.clm.blob

4.2 Bluetooth configuration files for Linux

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

The files listed in **Table 7** shall be used to satisfy regulatory requirements if user wants to use Murata regulatory certification.

Table 7: Bluetooth Configuration Script Files - Linux

Names	Country	Configuration Files
Bluetooth configuration files	USA	BCM4373A0_001.001.025.0103.0155.FCC.CE.2AE.hcd BCM4373A0_001.001.025.0103.0155.FCC.CE.2BC.hcd
	Canada	BCM4373A0_001.001.025.0103.0155.FCC.CE.2AE.hcd BCM4373A0_001.001.025.0103.0155.FCC.CE.2BC.hcd
	Europe	BCM4373A0_001.001.025.0103.0155.FCC.CE.2AE.hcd BCM4373A0_001.001.025.0103.0155.FCC.CE.2BC.hcd
	Japan	BCM4373A0_001.001.025.0103.0156.JRL.2AE.hcd BCM4373A0_001.001.025.0103.0156.JRL.2BC.hcd

5 Reference Performance Data

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, VDDIO = 1.8V
  - FW: 13.10.246.261

Table 8, Table 9, Table 10, and Table 11 describe the typical Rx minimum sensitivity level at module antenna port for WLAN at 2.4 GHz and 5 GHz.

Table 8: Rx Minimum Sensitivity Level - WLAN at 2.4 GHz

Frequency in MHz	Rx Minimum Sensitivity Level [dBm]					
	11b		11g		11n (HT 20)	
	1 Mbps	11 Mbps	6 Mbps	54 Mbps	MCS0	MCS7
2412	-95	-87	-92	-74	-92	-73
2442	-95	-87	-92	-74	-91	-73
2472	-96	-88	-91	-74	-91	-73

Table 9: Rx Minimum Sensitivity Level - WLAN at 5 GHz (20 MHz)

Frequency in MHz	Rx Minimum Sensitivity Level [dBm]					
	11a		11n (HT 20)		11ac (VHT 20)	
	6 Mbps	54 Mbps	MCS0	MCS7	MCS0	MCS8
5180	-93	-76	-92	-75	-92	-71
5500	-92	-74	-91	-73	-91	-69
5825	-92	-74	-91	-73	-91	-69

Table 10: Rx Minimum Sensitivity Level - WLAN at 5 GHz (40 MHz)

Frequency in MHz	Rx Minimum Sensitivity Level [dBm]			
	11n (HT 40)		11ac (VHT 40)	
	MCS0	MCS7	MCS0	MCS9
5190	-90	-73	-91	-67
5510	-89	-71	-89	-65
5795	-89	-71	-89	-65

Table 11: Rx Minimum Sensitivity Level - WLAN at 5 GHz (80 MHz)

Frequency in MHz	Rx Minimum Sensitivity Level [dBm]	
	11ac (VHT 80)	
	MCS0	MCS9
5210	-87	-63
5530	-85	-62
5775	-85	-61

5.1.2 Bluetooth

- Conditions
  - VBAT = 3.3V, VDDIO = 1.8V
  - hcd file: BCM4373A0_001.001.025.0103.0155.FCC.CE.2AE.hcd

Table 12 describes the typical Rx minimum sensitivity level for Bluetooth.

Table 12: Rx Minimum Sensitivity Level – Bluetooth

Frequency in MHz	Rx Minimum Sensitivity level[dBm]			
	DH5	2DH5	3DH5	LE 1M
2412	-89	-92	-87	-92
2442	-89	-92	-87	-92
2472	-89	-92	-87	-92

5.2 Typical Tx/Rx Current Consumption

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

5.2.1 WLAN

Typical Tx/Rx current consumption for Wi-Fi has certain conditions as described below.

- Conditions
  - VBAT = 3.3V, VDDIO = 1.8V
  - FW: 13.10.246.261
  - Current definition: 1024byte, 20usec interval

Table 13 describes the typical Tx/Rx current consumption for WLAN at 2.4 GHz.

Table 13: Typical Tx/Rx Current Consumption - WLAN at 2.4 GHz

Mode	Data Rate	Setting Tx Power [dBm]	Current [mA]	
			Tx	Rx
			VBAT	VBAT
11b	1 Mbps	17	330	55
11g	6 Mbps	18	360	55
11n (HT20)	MCS0	16	315	55

Table 14 describes the typical Tx/Rx current consumption for WLAN at 5 GHz.

Table 14: Typical Tx/Rx Current Consumption - WLAN at 5 GHz

Mode	Data Rate	Setting Tx Power [dBm]	Current [mA]	
			Tx	Rx
			VBAT	VBAT
11a	6 Mbps	16	310	65
11n (HT20)	MCS0	16	310	65
11ac (VHT20)	MCS0	16	310	65
11n (HT40)	MCS0	14	335	75
11ac (VHT40)	MCS0	14	335	75
11ac (VHT80)	MCS0	13	365	105

5.2.2 Bluetooth

Typical Tx/Rx current consumption for Bluetooth has certain conditions as described below.

- Conditions
  - VBAT = 3.3V, VDDIO = 1.8V
  - hcd file: BCM4373A0_001.001.025.0103.0155.FCC.CE.2AE.hcd
  - Current definition: Tx/Rx fully occupied.

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

Table 15: Typical Tx/Rx Current Consumption - Bluetooth

Mode	Setting Tx Power [dBm]	Current [mA]
		VBAT
BR (1DH5)	9	50
EDR (3DH5)	5	40
LE 1M	8	8

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, VDDIO = 1.8V
  - WL_REG_ON: ON, BT_REG_ON: OFF
  - Platform: NXP MCIMX8MQuad-EVK
  - FW: 13.10.246.265
  - WLAN I/F: SDIO
  - Beacon Interval = 100 ms

Table 16 describes the typical sleep current consumption for WLAN.

Table 16: Typical Sleep Current Consumption - WLAN

Band	Mode	Current consumption VBAT [mA]
-	Chip deep sleep	0.003
2.4 GHz	IEEE Power Save: DTIM1	2.7
	IEEE Power Save: DTIM3	0.9
	IEEE Power Save: DTIM5	0.6
5 GHz	IEEE Power Save: DTIM1	1.7
	IEEE Power Save: DTIM3	0.6
	IEEE Power Save: DTIM5	0.4

5.3.2 Bluetooth

- Conditions
  - VBAT = 3.3V, VDDIO = 1.8V
  - WL_REG_ON: OFF, BT_REG_ON: ON
  - Platform: Windows PC/CyBluetool
  - Hcd file: BCM4373A0_001.001.025.0103.0155.FCC.CE.2AE.hcd
  - Bluetooth I/F: UART

Table 17 describes the typical sleep current consumption for Bluetooth.

Table 17: Typical Sleep Current Consumption - Bluetooth

Mode	Current consumption VBAT [uA]
Deep Sleep (BT Only)	2.4
BT Page Scan 1.28 s	193
BT Page & Inquiry Scan 1.28 s	397
BT Master Sniff mode 500 ms	153
Advertise 1.28 s	79
BLE Scan 1.28 s	115
LE Link Master 1 s	59

5.4 Typical Throughput

The typical throughput test configurations are:

- VBAT = 3.3V, VDDIO = 1.8V
- Target: NXP 8MMINILPD4-EVKB
- FW: 13.10.246.265
- 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 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	54	57	60	60
5 GHz 11ac VHT80	284	251	331	338

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 2AE Module Datasheet	Murata Type 2AE module datasheet (type2ae.pdf)
Murata Type 2BC Module Datasheet	Murata Type 2BC module datasheet (type2bc.pdf)
Murata Type 2AE Module Footprint	Murata Type 2AE module footprint (type2AE-module-footprint-topview.dxf)
Murata Type 2BC Module Footprint	Murata Type 2BC module footprint (2BC-Module-terminal-pin.dxf)
Murata Type 2AE Antenna	Murata Type 2AE module trace antenna (type2AE-antenna-JS-0967.dxf)
Murata Type 2BC Antenna	Murata Type 2BC module trace antenna (Type2BC-antenna-JS-0967.dxf)
Linux WLAN Configuration	Murata GitHub link for Linux NVRAM file for 2AE and 2BC
Linux WLAN Regulatory Configuration	Murata GitHub link for Linux CLM_BLOB file for 2AE and 2BC
Linux Bluetooth Configuration	Murata GitHub link for Linux HCD files for 2AE and 2BC
Linux User Guide	Murata Linux User Guide for Infineon modules (Murata Wi-Fi & BT (IFX) Solution for i.MX Linux User Guide.pdf).

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	Change	Change Description
1.0	Nov 4, 2021		First Issue
2.0	Aug 7, 2023	5.Reference Performance Data	Added RF reference performance data
3.0	Dec 1, 2023	Figure 3: Power Supply and Configuration Reference Circuit	Corrected Jumper reference number on table of strapping options Updated to new format.
4.0	Feb 20, 2024		Merged 2AE and 2BC hardware app note.
5.0	Mar 22, 2024	3.5 recommended antenna	Added reference antenna list for Japan.