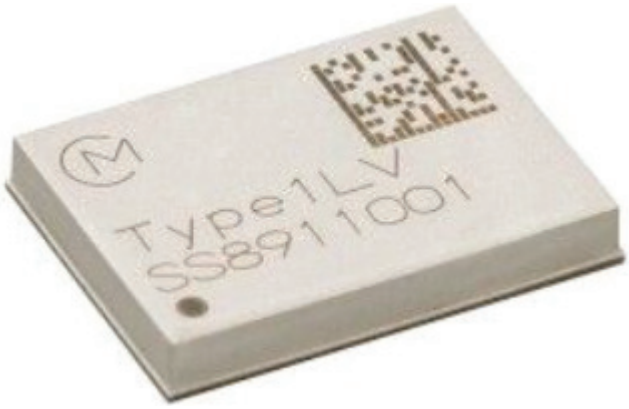
Hardware Application Note

Wi-Fi® + Bluetooth® Combo Module

Infineon Chipset for 802.11a/b/g/n, 11ac-friendly + Bluetooth 5.0

Hardware Application Note - Rev. 3.0

- Design Name: Type 1LV
- Module P/N: LBEE59B1LV



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About This Document

This Application Note covers hardware development and provides how to design the schematic and layout, and reference RF performance for engineers who will assemble the Type 1LV module. Refer to Type 1LV Datasheet for module specification.

Audience & Purpose

This document is targeted towards system integrators for Wi-Fi/Bluetooth solutions using Murata Type 1LV (CYW43012) module, based on IFX chipset.

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**: Introduction 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 Module Introduction

This section describes the module features and has hardware block design.

1.1 Features

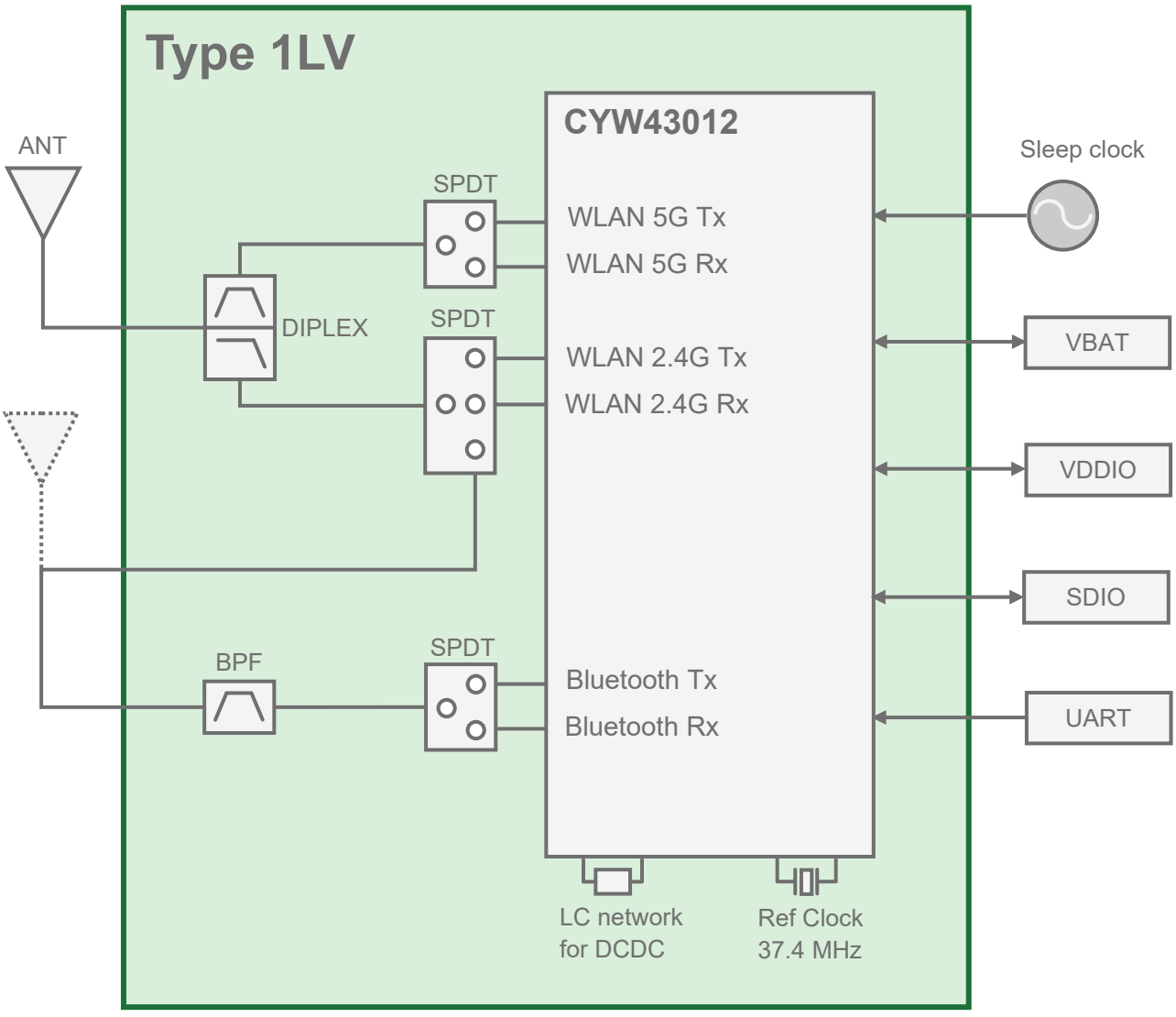
- WLAN (11a/b/g/n/ac-friendly) + BT/BLE (BT5.0) combo SIP module with Infineon CYW43012
- The package type is LGA (SM type)
- This module is covered with resin molding and fully shielded with metal.
- MAC and BD address are embedded in OTP.

IEEE 802.11ac full compliance requires support for 40 MHz and 80 MHz channel bandwidths. CYW43012 only supports 20 MHz channel bandwidth however it supports 802.11ac's 256-QAM for the 20 MHz channels in the 5GHz band enabling it to offer higher throughput and lower energy per bit than 802.11n only products.

1.2 Hardware Block Diagram

Figure 1 shows the Type 1LV hardware block diagram.

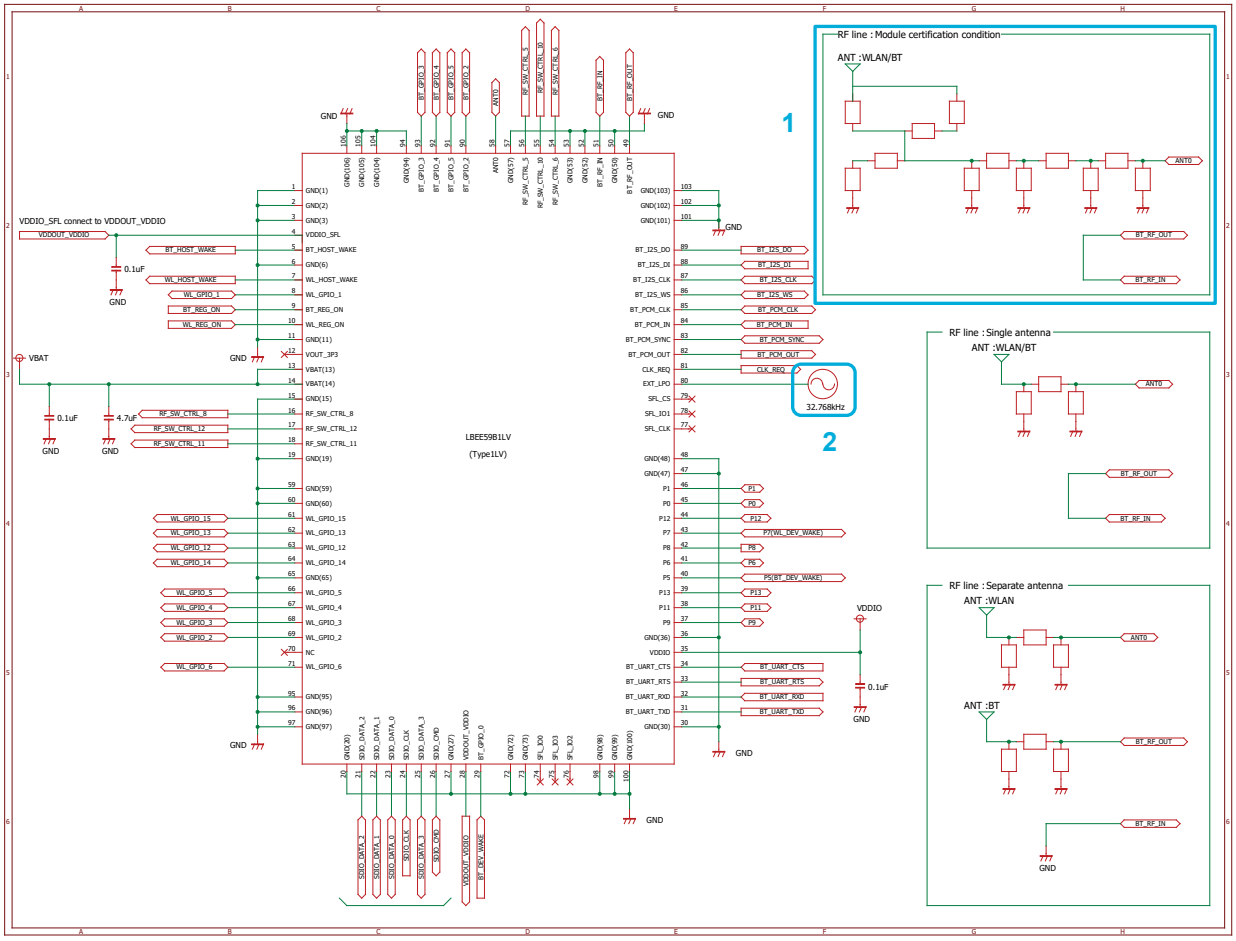
Figure 1: Block Diagram



1.3 Reference Circuit

Figure 2 shows the reference circuit.

Figure 2: Reference Circuit



1.4 Antenna Condition for Murata Radio Certification

Please add attenuator circuit between Type1LV and antenna matching if you use Murata Radio certification. If your antenna peak gain is higher than Murata application one, please reduce antenna gain by this pi-type attenuator.

1.5 SDIO

Please arrange SDIO lines with 50 Ω and put series-R, shunt-C parts to reject the noise if needed.

10k~100k Ω pull-ups are required on the four DATA lines and the COMD line. This requirement must be met during all operating states by using external pull-ups. This module does not have internal pull-ups on these lines. Please confirm the performance on your board.

1.6 Guidelines from Unused Pins

All I/O are not needed pull up/down for termination when you don’t use below I/O.

- P0~13
- WL_GPIO
- BT_GPIO
- FLASH
- BT_I2S/PCM
- CLK_REQ
- RF_SW_CTRL

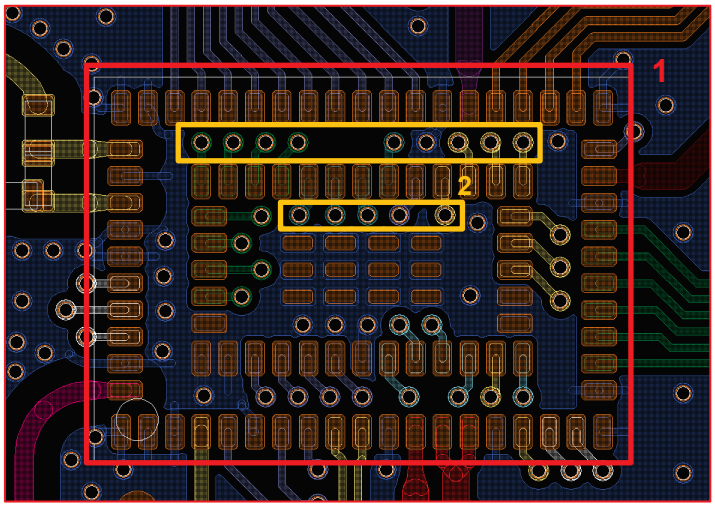
2 Hardware Design Guidelines

This section describes the hardware guidelines.

2.1 Underneath of Module

Figure 3 shows the underneath of Type 1LV module.

Figure 3: Underneath of Module



Please refer to Murata datasheet regarding to dimensions.

Murata is preparing DXF file (type1lv_module_footprint_topview.dxf) that is module footprint.

Via design between outside and inside module pad:

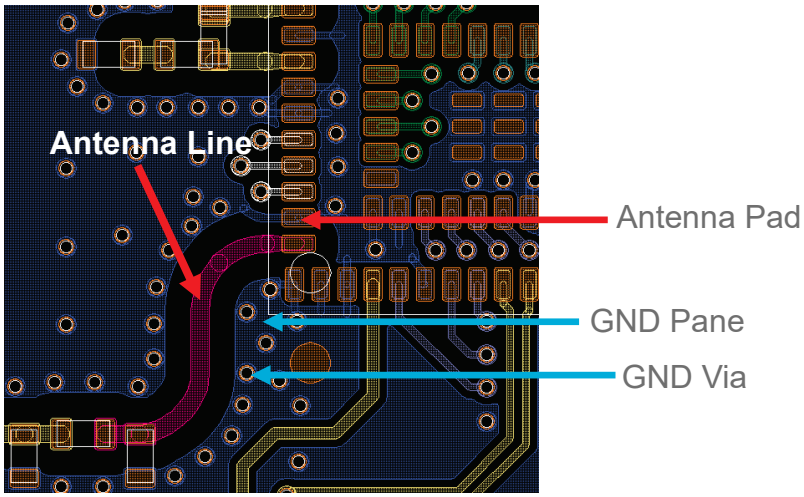
- Via Hole Φ250um
- Via Land Φ400um

2.2 Antenna Line

Antenna line should be 50 Ω (*). There should be enough GND via along with Antenna line.
Make sure that pi matching circuit is located right before the Wi-Fi antenna on the main board.

Figure 4 shows the antenna line.

Figure 4: Antenna Line



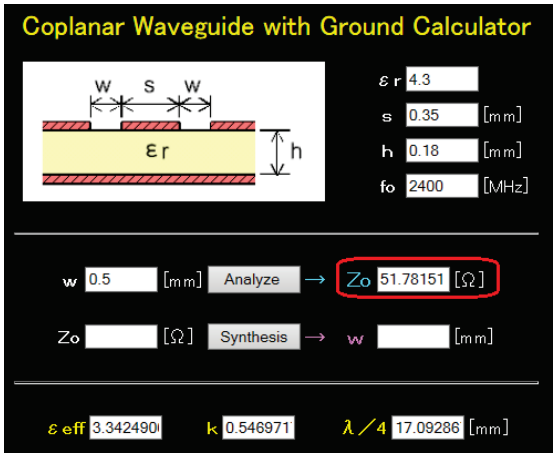
To know how to make 50 **Ω** Line, refer to I-Laboratory

An example of the conditions of 50 Ω lines of evaluation board is as below:

- Epsilon: 4.3
- RF trace width(s): 0.35mm
- GND gap(h): 0.18mm
- GND gap(w): 0.5mm
- The line impedance is Z0 = 51.8 Ω.

Figure 5 shows the coplanar waveguide with ground calculator.

Figure 5: Coplanar Waveguide with Ground Calculator



3 RF Measurement Result

This section describes the RF measurement result for Tx output power level and Rx minimum sensitivity level (at module antenna port) for Wi-Fi and Bluetooth.

3.1 Tx Output Power Level (at Module Antenna Port)

The Tx output power level (at module antenna port) for Wi-Fi and Bluetooth at 2.4 GHz and 5 GHz is explained in the 1LV datasheet.

3.2 Rx Minimum Sensitivity Level (at Module Antenna Port)

This section describes the Rx sensitivity level at module antenna port at 2.4 GHz and 5 GHz.

3.2.1 Wi-Fi

Condition:

- VBAT = 3.3V, VDDIO = 1.8V
- FW version: version 13.10.271.111

Table 2: Rx Minimum Sensitivity Level - WLAN at 2.4 GHz

Frequency [MHz]	Rx Minimum Sensitivity Level [dBm]					
	11b		11g		11n	
	1Mbps	11Mbps	6Mbps	54Mbps	MCS0	MCS7
2412	-98.8	-89.9	-94.4	-77.7	-94.3	-75.9
2442	-98.7	-89.9	-94.6	-77.8	-94.6	-76.0
2472	-99.0	-89.9	-94.6	-77.7	-94.8	-76.1

Table 3: Rx Minimum Sensitivity Level - WLAN at 5 GHz (20 MHz)

Frequency [MHz]	Rx Minimum Sensitivity Level [dBm]					
	11a		11n (HT20)		11ac (VHT20)	
	6Mbps	54Mbps	MCS0	MCS7	MCS0	MCS8
5180	-92.2	-75.1	-92.1	-73.4	-91.8	-71.0
5500	-91.2	-75.4	-91.2	-73.7	-91.1	-71.0
5825	-90.2	-75.6	-90.3	-73.7	-90.7	-71.1

3.2.2 Bluetooth

Conditions:

- VBAT = 3.3V, VDDIO = 1.8V
- Hcd file version: CYW43012C0_003.001.015.0064.0000_Generic_UART_37_4MHz_wlcsp_ref3_sLNA

Table 4: Rx Minimum Sensitivity Level - Bluetooth

Frequency	Rx Minimum Sensitivity Level [dBm]		
	DH5	3DH5	BLE

2402	-92.8	-90.8	-97.3
2440	-93.0	-90.4	-97.4
2480	-93.0	-90.3	-97.3

4 Current Consumption

This section describes the current consumptions for Wi-Fi and Bluetooth.

4.1 Current Consumption - Wi-Fi

This section describes the Tx/Rx consumption for Wi-Fi (2.4 GHz and 5GHz).

4.1.1 Tx/Rx Current Consumption

Conditions:

- VBAT = 3.3V, VDDIO = 1.8V
- WL_REG_ON: ON, BT_REG_ON: ON
- FW version: version 13.10.271.111

Table 5 describes the typical Tx/Rx current consumption for WLAN at 2.4 GHz.

Table 5: Typical Tx/Rx Current Consumption - WLAN at 2.4 GHz

Mode	Rate	Tx Current		Rx Current [mA][1]
		Setting Power	Tx Current [mA][2]	
11b	1Mbps	17.0	200	20
	11Mbps	17.0	200	
11g	6Mbps	17.0	195	20
	54Mbps	14.0	150	
11n	MCS0	17.0	195	20
	MCS0	13.0	140	

Table 6 describes the typical Tx/Rx consumption for WLAN at 5 GHz.

Table 6: Typical Tx/Rx Current Consumption - WLAN at 5 GHz

Mode	Rate	Tx Current		Rx Current [mA][1]
		Setting Power	Tx Current [mA][2]	
11a	6Mbps	16.0	300	20
	54Mbps	13.0	230	
11n (HT20)	MCS0	16.0	300	20
	MCS7	12.0	210	
11ac (VHT20)	MCS0	16.0	300	20
	MCS8	10.0	190	

[1] Carrier sense when no carrier present.
[2] Setting value: 1024 byte, 20 µs interval.

4.1.2 Sleep Current Consumption

Conditions

- VBAT = 3.3V, VDDIO = 1.8V
- WL_REG_ON: ON, BT_REG_ON: OFF
- FW version: 13.10.271.57

Table 7 describes the sleep current consumption.

Table 7: Sleep Current Consumption

Band	Mode	VBAT (3.3V) mA	VDDIO (1.8V) mA
	IEEE Power save, Inter Beacon[3]	0.024	120
2.4 GHz	IEEE Power Save: DTIM1[4]	0.479	119
	IEEE Power Save: DTIM3	0.149	119
	IEEE Power Save: DTIM5	0.099	119
5 GHz	IEEE Power Save: DTIM1	0.368	119
	IEEE Power Save: DTIM3	0.113	119
	IEEE Power Save: DTIM5	0.077	119

4.2 Bluetooth Low Energy Current Consumption

This section describes the sleep current consumption for Bluetooth low energy.

Conditions

- VBAT = 3.3V, VDDIO = 1.8V
- WL_REG_ON: OFF, BT_REG_ON: ON
- Hcd file version: CYW43012C0_003.001.015.0064.0000_Generic_UART_37_4MHz_wlcsp_ref3_sLNA.hcd

Table 8 describes the BLE current consumption.

Table 8: BLE Current Consumption

Mode	VBAT (3.3V)	VDDIO (1.8V)
	uA	uA
BLE Scan[5]	121	44
BLE Adv-Unconnectable 1.00 second	30	39
BLE connected 1sec	29	44

5 Throughput Performance

This section describes the throughput performance of Type 1LV module.

Table 9 describes the WLAN throughput performance data at 2.4 GHz.

[3] Idle, not associated, or inter-beacon
[4] Beacon Interval = 100 ms
[5] No devices present. A 1.28 second interval with a scan window of 11.25ms.

Table 9: WLAN Throughput Data - 2.4 GHz

11n_HT20_MCS7	Tx [Mbps]	Rx [Mbps]
TCP	51.2	47.8
UDP	57.2	56.9

Table 10 describes the WLAN throughput performance data at 5 GHz.

Table 10: WLAN Throughput Data - 5 GHz

11ac_VHT20_MCS8	Tx [Mbps]	Rx [Mbps]
TCP	60.8	66.8
UDP	68.9	69.7

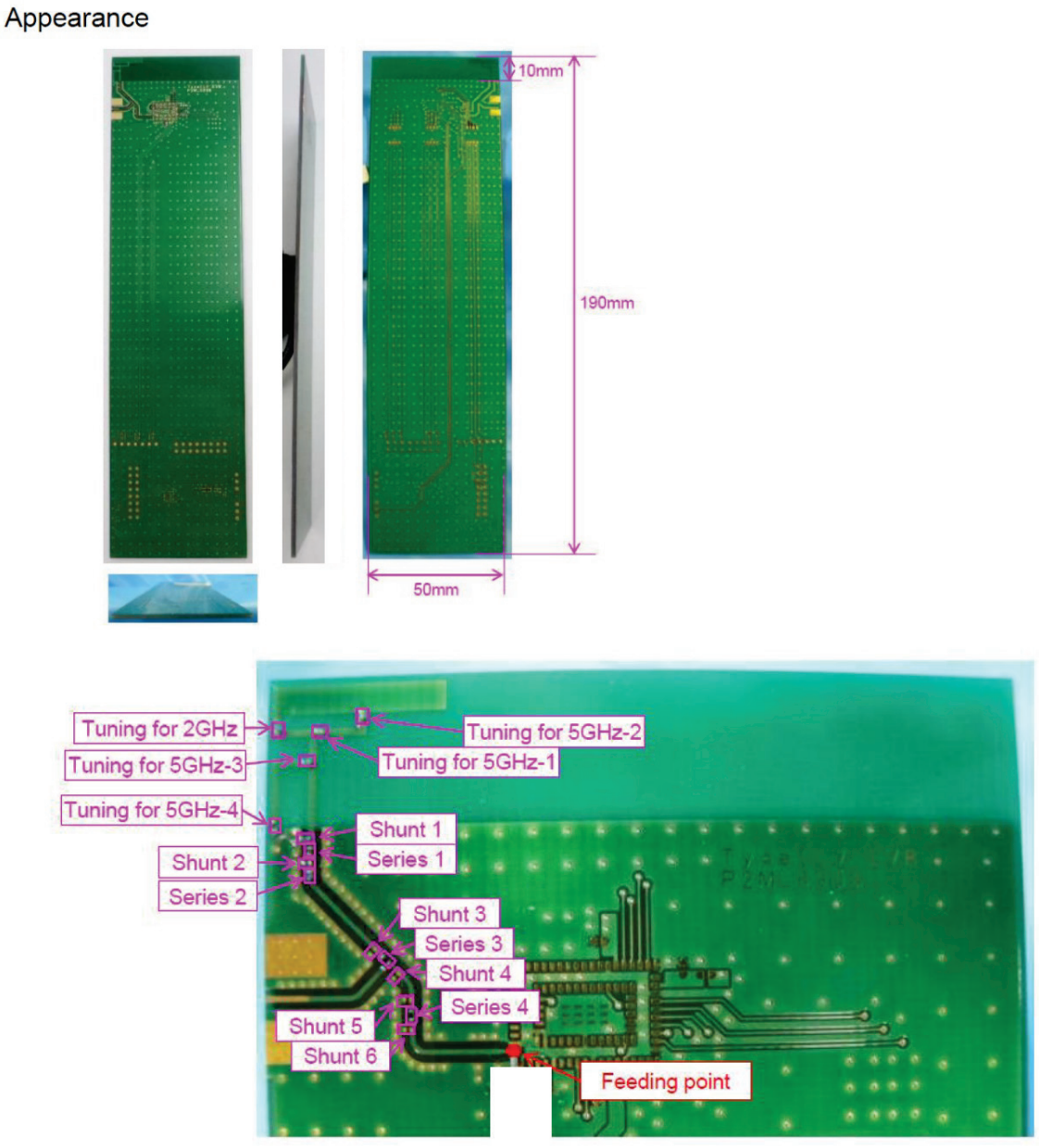
6 Antenna Information

This section describes the antenna information of Type 1LV module.

6.1 Appearance of the Antenna

Figure 6 shows the antenna design measurements.

Figure 6: Antenna Design Measurements



Tuning					Matching Cuicuit									
2GHz	5GHz-1	5GHz-2	5GHz-3	5GHz-4	Shunt1	Series1	Shunt2	Series2	Shunt3	Series3	Shunt4	Shunt5	Series4	Shunt6
1.0nH	0.3pF	0.3pF	3.0nH	0ohm	3.9nH	2.0pF	None	1.5nH	None	0ohm	None	None	0ohm	none

6.2 Antenna Measurement Directions

Figure 7 shows the antenna measurement directions.

Figure 7: Antenna Measurement Directions

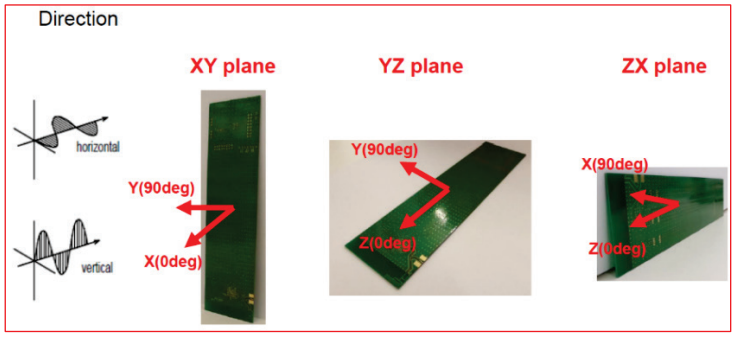
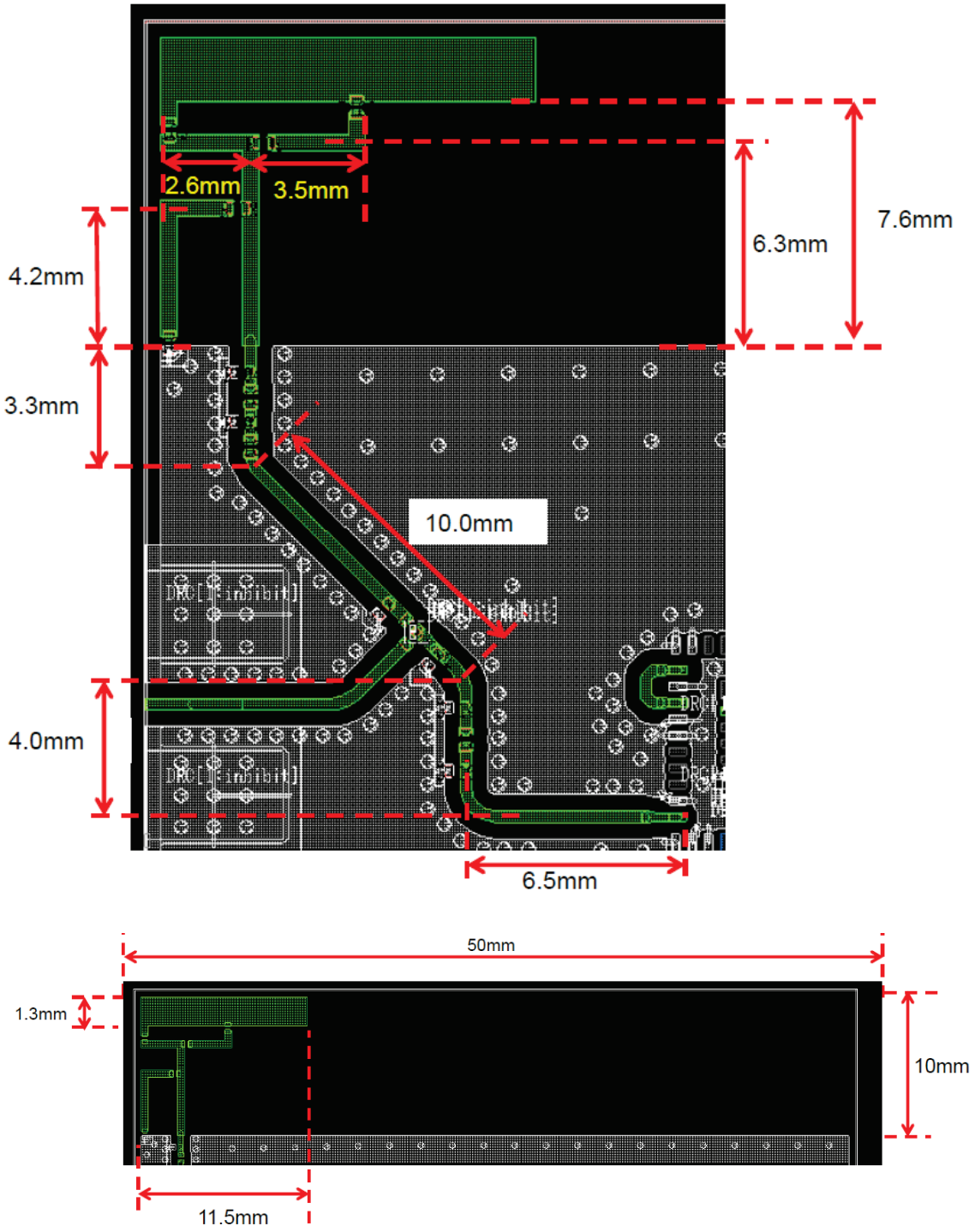


Figure 8 shows the antenna layout of Type 1LV module.

Figure 8: Antenna Layout



Anntena trace width 0.5mm

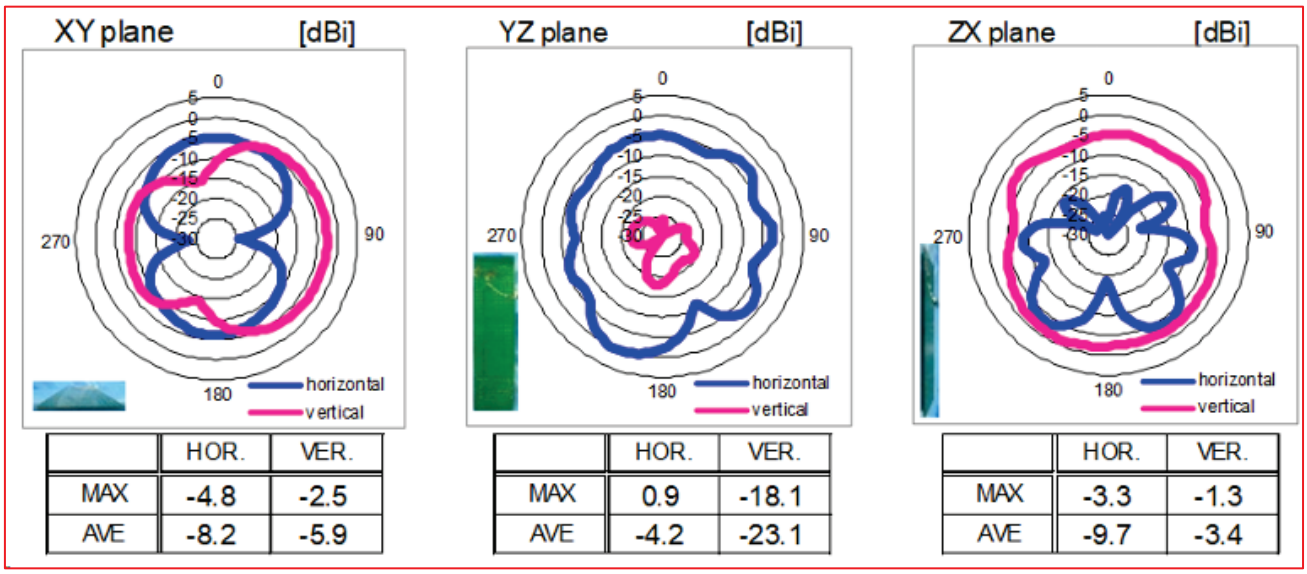
6.3 Antenna Performance

Table 11 and **Figure 9** describe the antenna performance for 2.4 GHz.

Table 11: Antenna Gain and Efficiency - 2.4 GHz

Linear Polarization		XY-Plane (dBi)		YZ-Plane (dBi)		ZX-Plane (dBi)		Total Efficiency (dB)
		Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	
2400 MHz	Maximum	-5.0	-3.3	-0.5	-18.7	-3.4	-1.5	-3.5
	Average	-8.3	-6.4	-4.4	-24.1	-9.6	-3.6	
2442 MHz	**Maximum**	**-4.8**	**-2.5**	**0.9**	**-18.1**	**-3.3**	**-1.3**	**-3.4**
	Average	**-8.2**	**-5.9**	**-4.2**	**-23.1**	**-9.7**	**-3.4**	
2484 MHz	Maximum	-4.5	-2.7	0.1	-18.9	-3.2	-1.1	-3.4
	Average	-8.0	-6.0	-4.2	-23.6	-9.7	-3.3	

Figure 9: Antenna Directivity - 2.4 GHz



Antenna Type: Monopole (pattern antenna)
Antenna Gain: 0.9dBi (peak)

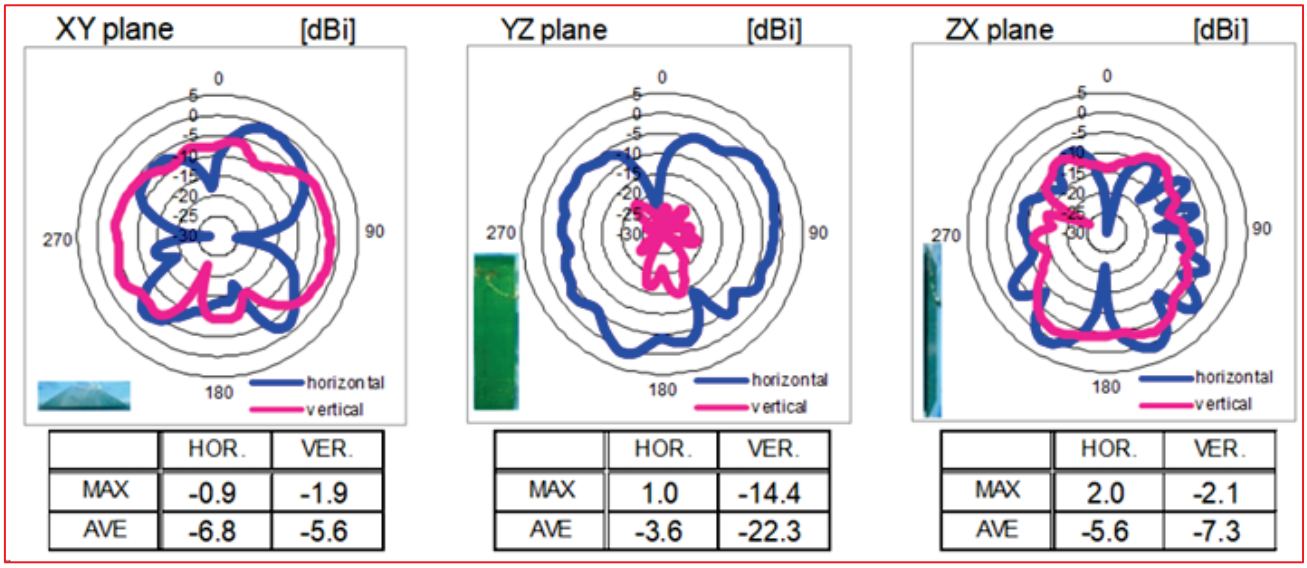
Table 12 and **Figure 10** describe the antenna performance at 5 GHz.

Table 12: Antenna Gain and Efficiency - 5 GHz

Linear Polarization		XY-Plane (dBi)		YZ-Plane (dBi)		ZX-Plane (dBi)		Total Efficiency (dB)
		Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	
5150 MHz	Maximum	-0.6	-2.6	1.3	-14.9	0.9	-0.1	-3.0
	Average	-6.4	-6.6	-3.6	-21.7	-6.6	-5.8	

Linear Polarization		XY-Plane (dBi)		YZ-Plane (dBi)		ZX-Plane (dBi)		Total Efficiency (dB)
		Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	
5500 MHz	**Maximum**	**-0.9**	**-1.9**	**-1.0**	**-14.4**	**2.0**	**-2.1**	**-3.0**
	Average	**-6.8**	**-5.6**	**-3.6**	**-22.3**	**-5.6**	**-7.3**	
5850 MHz	Maximum	-1.0	-2.7	0.6	-13.3	0.8	-2.6	-3.1
	Average	-6.8	-6.1	-3.8	-21.1	-6.3	-7.4	

Figure 10: Antenna Directivity - 5 GHz



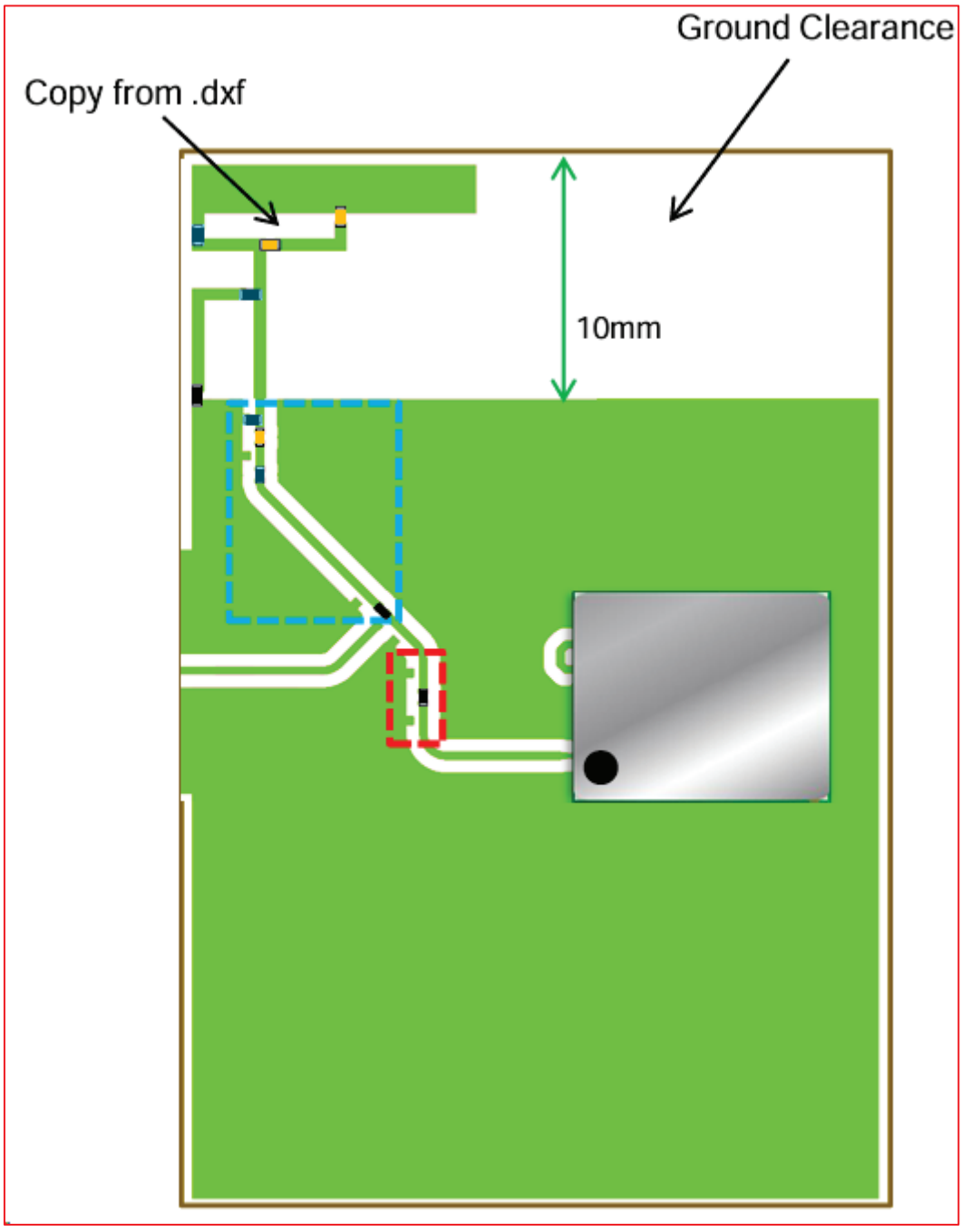
Antenna Type: Monopole (pattern antenna)
Antenna Gain: 2.0dBi (peak)

6.4 Layout Guide for Good Antenna Performance

- Place the antenna on top-left (or right) corner.
- Keep GND clearance all long the top edge.
- Place metal stuff as far as possible.
- Place pi-network + one component for matching.
  - Put appropriate value of C/L/R depends on actual performance.
- Place pi-network for attenuating.
  - Put 0ohm in series and no load in parallel on the initial design.
  - Put appropriate value of R depends on actual performance.

Figure 11 shows the antenna layout guide.

Figure 11: Antenna Layout Guide



Please follow Installation manual.

6.5 Antenna Design

Please perform the antenna design as per the certified antenna specifications below.

- The signal line between an antenna and a module is a 50 Ω line design.
- Fine tuning of return loss etc. can be performed using a matching network. However, in that case, it is required to check "Class1 change" and "Class2 change" defined by the authorities.

The concrete contents of a check are the following three points.

- It is the same type as the antenna type of antenna specifications.
- The antenna gain is lower than the gain given in antenna specifications.
- The emission level is not getting worse.

50 Ω line (microstrip line length)

50 Ω line length	Tested at 23.8 mm as a representative

Figure 12 shows the antenna design and **Figure 13** shows the antenna design details. Please follow the type1lv_antenna_p2ml6906.dxf file.

Figure 12: Antenna Design

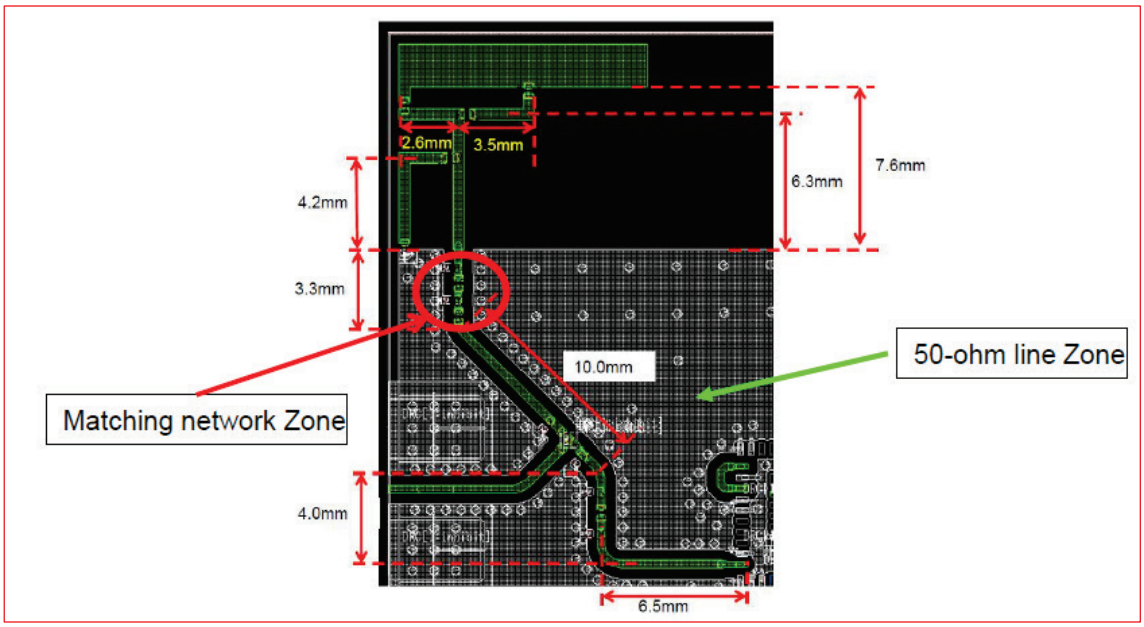
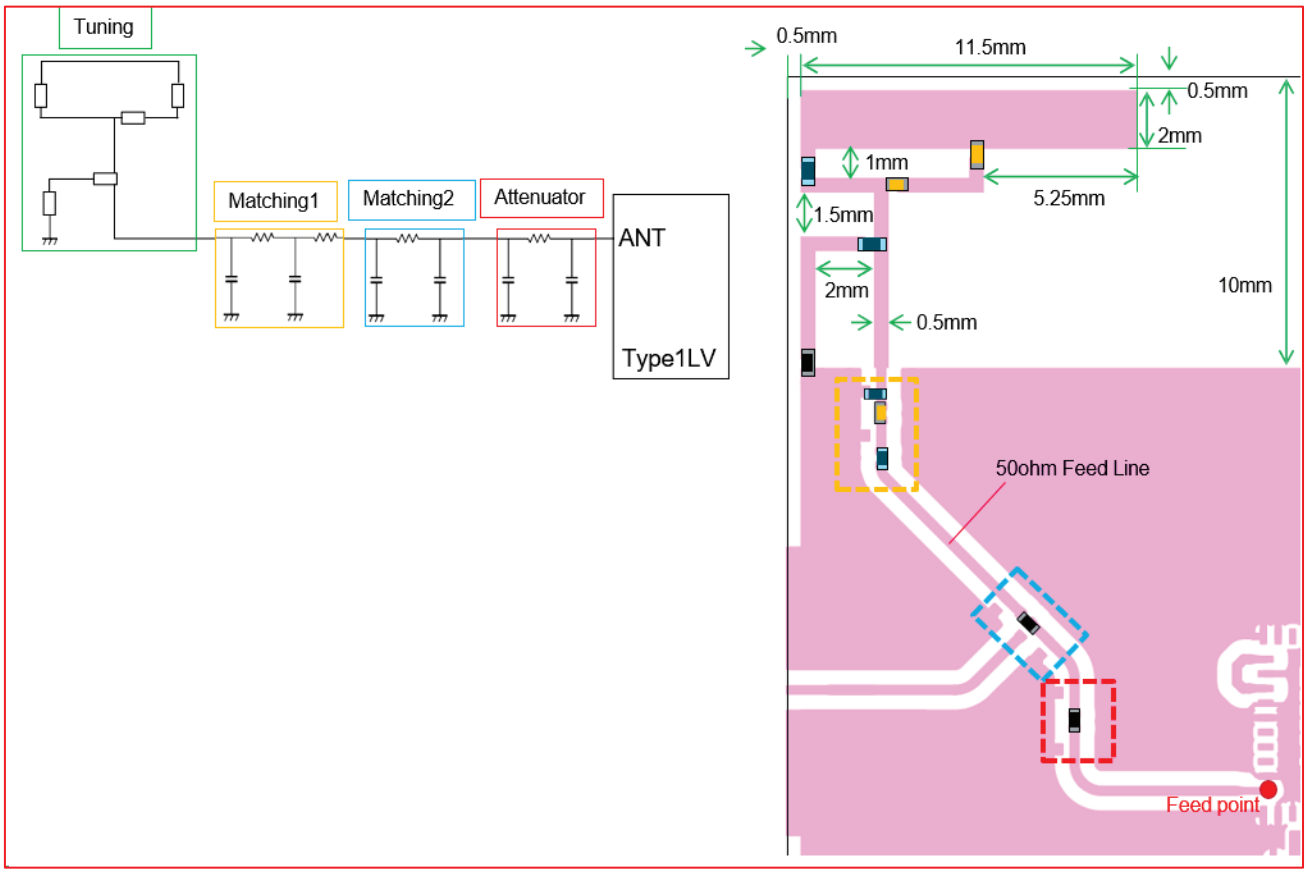


Figure 13: Antenna Design Details



"Attenuator" part should be pi-network as above. Appropriate value of R depends on the design of the product. Put 0 ohm in series and no load in parallel on the initial design.

"Matching2" part should be pi-network as above. Only matching1 might achieve the antenna tuning, but if you have a place to have this part, please add it. Appropriate value of L/C/R depends on the design of the product. Put 0 ohm in series and no load in parallel on the initial design.

"Matching1" part should be pi-network + 1 series component as above. Appropriate value of L/C/R depends on the design of the product. *Refer to the next page for Murata Certification board condition.

"Tuning" part should follow Antenna DXF file. Appropriate value of L/C/R depends on the design of the product. *Refer to the next page for Murata Certification board condition.

7 References

Table 13 reviews all the key reference documents that the user may like to refer to.

Table 13: Reference Table

Support Site	Notes
Murata Type 1LV Module Datasheet	Murata Type 1LV module datasheet (type1lv.pdf)
Murata Type 1LV Module Footprint	Murata Type 1LV module footprint (type1lv_module_footprint_topview.dxf)
Murata Type 1LV Antenna	Murata Type 1LV module trace antenna (type1lv_antenna_p2ml6906.dxf)
Linux WLAN Configuration	Murata GitHub link for Linux NVRAM file for 1LV
Linux WLAN Regulatory Configuration	Murata GitHub link for Linux CLM_BLOB file for 1LV
Linux User Guide	Murata Linux User Guide for Infineon modules (Murata Wi-Fi & BT (IFX) Solution for i.MX Linux User Guide.pdf).

8 Technical Support Contacts

Table 14 lists all the support resources available for the Murata Wi-Fi/BT solution.

Table 14: 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	Mar 26, 2019		First Release
2.0	Nov 21, 2019	1.3 Reference Circuit	Updated module Pin layout based on module datasheet RevL
3.0	June 10, 2022		Revised Silicon vendor name Updated to new format