1ZM M.2 Module Datasheet

- 802.11 a/b/g/n/ac and BT/BLE 5.0
- SDIO 3.0 interface, SDR104@208MHz
- 22 x 44 mm with integrated trace antenna

Get Up-and-Running Quickly and
Start Developing Your Application On Day 1!

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1 Document Revision History

Revision	*Date*	*Description*
PA1	2020-06-23	First version.
PA2	2021-04-13	Added information about current measurment.

2 Introduction

This document is a datasheet that specifies and describes the *1ZM M.2 module* mainly from a hardware point of view. Software related issues, like the Linux and WICED drivers, are not addressed. There are separate documents for that.

2.1 Benefits of Using an M.2 Module to get Wi-Fi/BT Connectivity

There are several benefit to use an *M.2 module* to add connectivity to an embedded design:

- Drop-in, certified solution!
- Modular and flexible approach to evaluate different Wi-Fi/BT solutions - with different trade-offs around performance, cost, power consumption, longevity, etc.
- Access to maintained software drivers (Linux and WICED) with responsive support from Murata.
- Supported by Embedded Artists' Developer's Kits for i.MX RT/6/7/8 development, including advanced debugging support on carrier boards
- One component to buy, instead of 50+
- No RF expertise is required
- Developed in close collaboration with Murata and NXP
- M.2 pinning defined in close cooperation with Murata, NXP, Cypress+Infineon and Embedded Artists

2.2 More M.2 Related Information

For more information about the M.2 standard and Embedded Artists' adaptation, see: M.2 Primer

For more general information about the M.2 standard, see: https://en.wikipedia.org/wiki/M.2

The official M.2 specification (PCI Express M.2 Specification) is available from: www.pcisig.com

2.3 ESD Precaution and Handling

Please note that the M.2 module come without any case/box and all components are exposed for finger touches – and therefore extra attention must be paid to ESD (electrostatic discharge) precaution, for example use of static-free workstation and grounding strap. Only qualified personnel shall handle the product.

Make it a habit always to first touch the mounting hole (which is grounded) for a few seconds with both hands before touching any other parts of the boards. That way, you will have the same potential as the board and therefore minimize the risk for ESD.

In general touch as little as possible on the boards in order to minimize the risk of ESD damage. The only reasons to touch the board are when mounting/unmounting it on a carrier board.

Note that Embedded Artists does not replace modules that have been damaged by ESD.

2.4 Product Compliance

Visit Embedded Artists' website at http://www.embeddedartists.com/product_compliance for up to date information about product compliances such as CE, RoHS2/3, Conflict Minerals, REACH, etc.

3 Specification

This chapter lists some of the more important characteristics of the M.2 module, but it is not a full specification of performance and timing. The main component in the design is Murata's 1ZM module (full part number: LBEE5QD1ZM), which in turn is based around NXP/Marvell 88W8987 chipset.

For a full specification, see on Murata's 1MW Module (LBEE5QD1ZM) see Murata's 1ZM product page (url TBD) and the 1ZM datasheet (url TBD).

Module / Chipset	
Murata module	LBEE5QD1ZM
Chipset	NXP/Marvell 88W8987

Wi-Fi	
Standards	802.11a/b/g/n/ac
Network	AP and STA dual mode
Frequency	2.4GHz and 5 GHz band
Data rates	TBD
Host interface	SDIO 3.0, SDR12@24MHz, SDR25@50MHz, SDR50@100MHz, SDR104@208MHz, DDR50@50MHz

Bluetooth	
Standards	5.0 BDR/EDR/LE 3MPHY
Power Class	Class 1
Host interface	4-wire UART@4MBaud Supported bitrates by chipset: 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200, 230400, 460800, 500000, 921600, 1000000, 1382400, 1500000, 1843200, 2000000, 2100000, 2764800, 3000000, 3250000, 3692300, 4000000 bps
Audio interface	PCM for audio

Powering			
Supply voltage to M.2 module **Note: Do not exceed minimum or maximum voltage. Module will be permanently damaged above this limit!**	**Min**	**Typ**	**Max**
	TBD minimum 3.2 RF specification	3.3V	3.6V **Note** that LBEE5QD1ZM module specification has higher maximum voltage (4.8V), but other components on the M.2 module limits the maximum voltage.
Receive mode current (WLAN)	TBD mA typical max		
Transmit mode current (WLAN)	TBD mA typical max		

Environmental Specification		
Operational Temperature	-20 to +75 degrees Celsius	Functionally ok, but specification is derated at temperature extremes
Storage Temperature	-40 to +85 degrees Celsius	
Relative Humidity (RH), operating and storage	10 - 90% non-condensing	

3.1 Power Up Sequence

The supply voltage shall not rise (10 - 90%) faster than 40 microseconds and not slower than 100 milliseconds.

Signals WL_REG_ON must be held low for at least 1 milliseconds after supply voltage has reached specification level before pulled high.External Sleep Clock

The sleep clock signals can be applied to a powered and unpowered M.2 module.

Clock Specification	
Frequency	32.768 kHz
Slew rate limit	100ns maximum, 10-90%
Frequency accuracy	±250 ppm
Duty cycle	20 - 80%
Clock jitter	1.5 ns RMS, typical
Voltage level	3.3V logic, according to M.2 standard

3.2 Mechanical Dimensions

The M.2 module is of type: 2230-S3-E according to the M.2 nomenclature. This means width 22 mm, length 30mm (without trace antenna), top side component height 1.5 mm and key-E connector. The table below lists the different dimensions and weight.

M.2 Module Dimension	Value (±0.15 mm)	Unit
Width	22	mm
Height, with pcb trace antenna Height, without pcb trace antenna	44 30	mm mm
PCB thickness	0.8	mm
Maximum component height on top side	1.5	mm
Maximum component height on bottom side	0	mm
Ground hole diameter	3.5	mm
Plating around ground hole, diameter	5.5	mm
Module weight	1.5 ±0.5 gram	gram

Embedded Artists has added a non-standard feature to the 2230 M.2 modules designed together with Murata. The pictures below illustrates the how the standard module size has been extended by 14 mm in the length direction in order to include a pcb trace antenna.

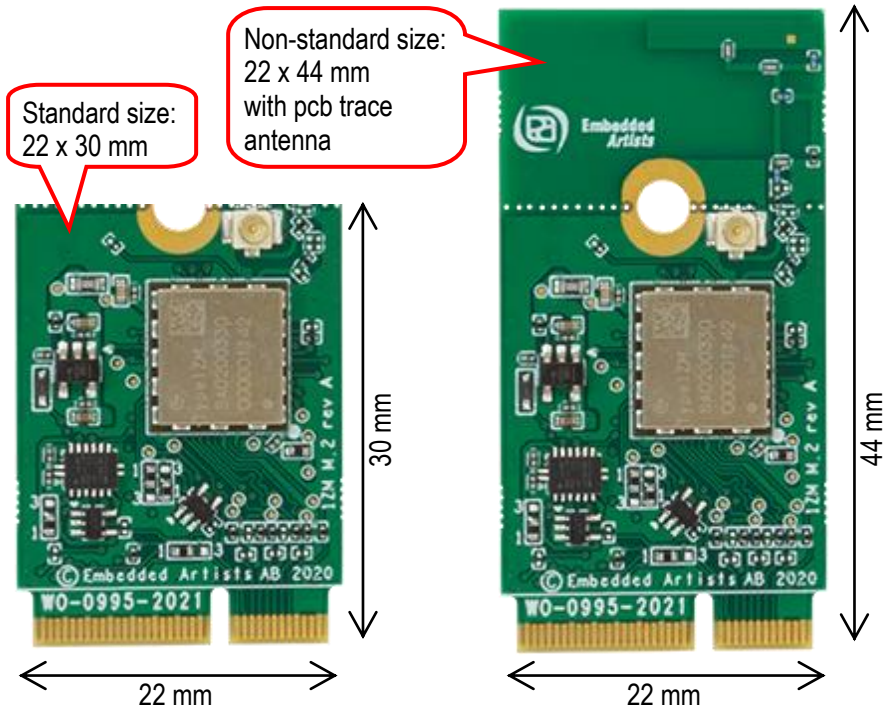

Figure 1 – M.2 Module with, and without, PCB Trace Antenna

The picture below gives dimensions for the grounded center (half) hole and the u.fl. antenna connector.

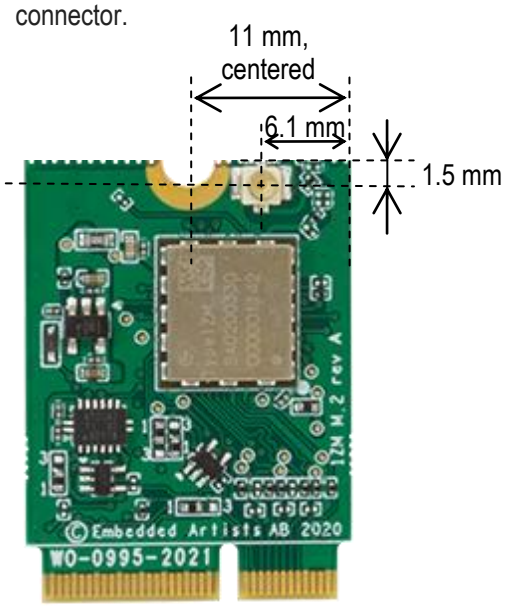

Figure 2 – M.2 Module, Antenna Connector Position

3.3 M.2 Pinning

This section presents the pinning used for the M.2 module. It is M.2 Key-E compliant. The pin assignment for specific control and debug signals has been jointly defined by Embedded Artists, Murata, NXP and Infineon/Cypress.

The picture below illustrates the edge pin numbering. It starts on the right edge and alternates between top and bottom side. The removed pads in the keying notch counts (but as obviously non-existing).

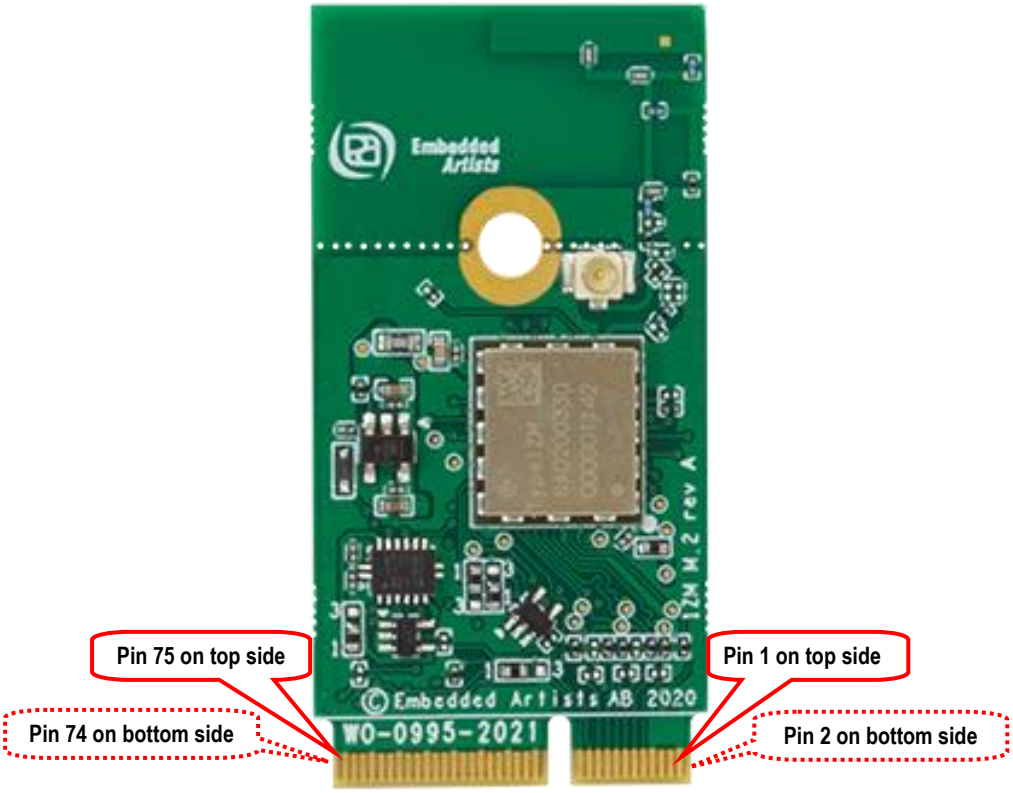

Figure 3 – M.2 Module Pin Numbering

The Wi-Fi interface uses the SDIO interface. The Bluetooth interface uses the UART interface for control and PCM interface for audio. The table below lists the pin usage for the 1ZM M.2 modules. The column "When is signal needed" signals four different categories:

- Always: These signals shall always be connected.
- Wi-Fi: These signals shall always be connected then the Wi-Fi interface is used.
- Bluetooth: These signals shall always be connected then the Bluetooth interface is used.
- Optional: These signals are optional to connect.

Pin #	Side of pcb	M.2 Name	Voltage Level and Signal Direction	When is signal needed	Note
1	Top	GND	GND	Always	Connect to ground
2	Bottom	3.3 V		Always	Power supply input. Connect to stable, low-noise 3.3V supply.
3	Top	USB_D+			Not connected.
4	Bottom	3.3 V		Always	Power supply input. Connect to stable, low-noise 3.3V supply.
5	Top	USB_D-			Not connected.
6	Bottom	LED_1#			Not connected.

7	Top	GND	GND	Always	Connect to ground.
8	Bottom	PCM_CLK	1.8V I/O	Bluetooth audio	For Bluetooth audio interface: BT_PCM_CLK
9	Top	SDIO CLK	1.8V Input to M.2	Wi-Fi SDIO	For Wi-Fi SDIO interface: SDIO_CLK
10	Bottom	PCM_SYNC	1.8V I/O	Bluetooth audio	For Bluetooth audio interface: BT_PCM_SYNC
11	Top	SDIO CMD	1.8V I/O	Wi-Fi SDIO	For Wi-Fi SDIO interface: SDIO_CMD Note: Require an external 10-100K ohm pullup
12	Bottom	PCM_OUT	1.8V output from M.2	Bluetooth audio	For Bluetooth audio interface: BT_PCM_OUT
13	Top	SDIO DATA0	1.8V I/O	Wi-Fi SDIO	For Wi-Fi SDIO interface: SDIO_D0 Note: Require an external 10-100K ohm pullup
14	Bottom	PCM_IN	1.8V input to M.2	Bluetooth audio	For Bluetooth audio interface: BT_PCM_IN
15	Top	SDIO DATA1	1.8V I/O	Wi-Fi SDIO	For Wi-Fi SDIO interface: SDIO_D1 Note: Require an external 10-100K ohm pullup
16	Bottom	LED_2#			Not connected.
17	Top	SDIO DATA2	1.8V I/O	Wi-Fi SDIO	For Wi-Fi SDIO interface: SDIO_D2 Note: Require an external 10-100K ohm pullup
18	Bottom	GND		Always	Connect to ground.
19	Top	SDIO DATA3	1.8V I/O	Wi-Fi SDIO	For Wi-Fi SDIO interface: SDIO_D3 Note: Require an external 10-100K ohm pullup
20	Bottom	UART WAKE#	3.3V OD output from M.2	Bluetooth	For Bluetooth UART interface: BT_HOST_WAKE_L Require an external 10K pullup resistor to 3.3V.
21	Top	SDIO WAKE#	1.8V OD output from M.2	Wi-Fi SDIO	For Wi-Fi SDIO interface WL_HOST_WAKE_L Note: Require an external 10K pullup resistor to 1.8V
22	Bottom	UART TXD	1.8V output from M.2	Bluetooth	For Bluetooth UART interface: BT_UART_TXD
23	Top	SDIO RESET#			Not connected.
24	Key, non existing				
25	Key, non existing				
26	Key, non existing				
27	Key, non existing				
28	Key, non existing				
29	Key, non existing				
30	Key, non existing				
31	Key, non existing				
32	Bottom	UART_RXD	1.8V input to M.2	Bluetooth	For Bluetooth UART interface: BT_UART_RXD
33	Top	GND		Always	Connect to ground.
34	Bottom	UART_RTS	1.8V output from M.2	Bluetooth	For Bluetooth UART interface: BT_UART_RTS
35	Top	PERp0			Not connected.
36	Bottom	UART_CTS	1.8V input to M.2	Bluetooth	For Bluetooth UART interface: BT_UART_CTS
37	Top	PERn0			Not connected.
38	Bottom	VENDOR DEFINED	1.8V I/O	Optional	JTAG_TDO (GPIO_17)
39	Top	GND		Always	Connect to ground.
40	Bottom	VENDOR DEFINED	1.8V I/O 1.8V input to M.2	Optional Wi-Fi SDIO	JTAG_TDI (GPIO_16) **Note:** Signal will be WL_DEV_WAKE (GPIO_13), also called

					HOST_WLAN_WAKE, in the next generation of this board
41	Top	PETp0			Not connected.
42	Bottom	VENDOR DEFINED	1.8V input to M.2	Bluetooth	BT_DEV_WAKE_L (GPIO_12), also called HOST_BT_WAKE
43	Top	PETn0			Not connected.
44	Bottom	COEX3	1.8V I/O	Optional	GPIO_2 **Note:** Signal will be JTAG_TDI (GPIO_16) in the next generation of this board
45	Top	GND		Always	Connect to ground.
46	Bottom	COEX_TXD	1.8V I/O	Optional	JTAG_TCK (GPIO_14)
47	Top	REFCLKp0			Not connected.
48	Bottom	COEX_RXD	1.8V I/O	Optional	JTAG_TMS (GPIO_15)
49	Top	REFCLKn0			Not connected.
50	Bottom	SUSCLK	3.3V input to M.2	Always	External sleep clock input (32.768kHz)
51	Top	GND		Always	Connect to ground.
52	Bottom	PERST0#			Not connected.
53	Top	CLKREQ0#			Not connected.
54	Bottom	W_DISABLE2#			Not connected.
55	Top	PEWAKE0#			Not connected.
56	Bottom	W_DISABLE1#	3.3V input to M.2	Always	WL_REG_ON, High = Wi-Fi/BT enabled, Low = Wi-Fi/BT disabled
57	Top	GND		Always	Connect to ground.
58	Bottom	I2C_SDA			Not connected.
59	Top	Reserved			
60	Bottom	I2C_CLK			Not connected.
61	Top	Reserved			
62	Bottom	ALERT#	1.8V I/O	Optional	GPIO_3
63	Top	GND		Always	Connect to ground.
64	Bottom	RESERVED		Optional	Not connected.
65	Top	Reserved			
66	Bottom	UIM_SWP	1.8V I/O	Wi-Fi SDIO	WL_DEV_WAKE (GPIO_13) **Note:** Signal will move to pin 40 in the next generation of this board
67	Top	Reserved			
68	Bottom	UIM_POWER_SNK	1.8V I/O	Optional	GPIO_18
69	Top	GND		Always	Connect to ground.
70	Bottom	UIM_POWER_SRC/GPIO_1	1.8V I/O	Optional	GPIO_0
71	Top	Reserved			
72	Bottom	3.3 V		Always	Power supply input. Connect to stable, low-noise 3.3V supply.
73	Top	Reserved			
74	Bottom	3.3 V		Always	Power supply input. Connect to stable, low-noise 3.3V supply.
75	Top	GND		Always	Connect to ground.

3.4 Test Points

There are some test points that can be of interest to probe for debugging purposes, as illustrated in the picture below.

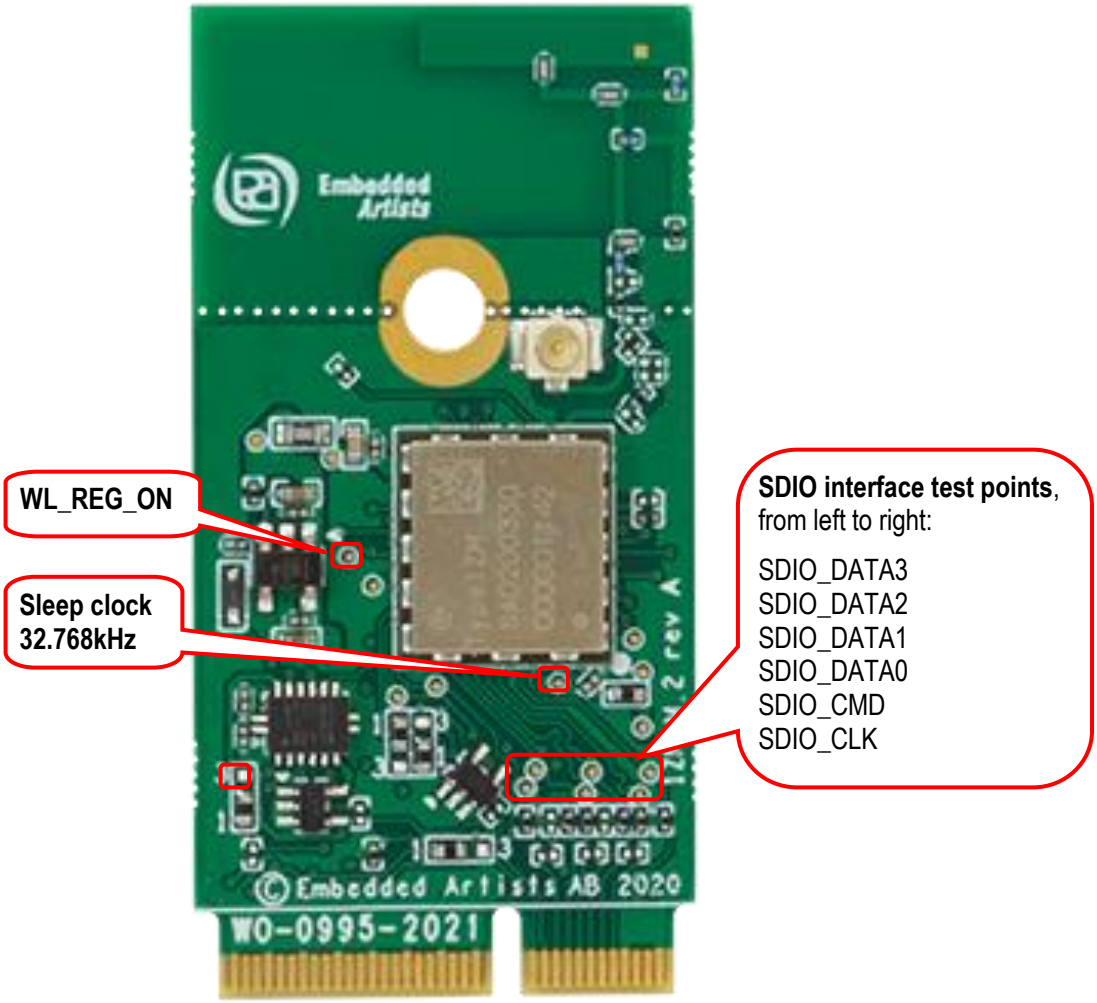

Figure 4 – 1ZM M.2 Module Test Points

3.5 VDDIO Override Feature Does Not Exists

The M.2 standard specify 1.8V logic level on several of the data and control signals. Other M.2 modules in the Embedded Artists' family supports VDDIO override to 3.3V instead.

Note that the 1ZM M.2 module does not support this feature because of limitations in the NXP 88W8987 chipset. The control signals that are 1.8V according to the M.2 standard must be 1.8V. This is also true for the SDIO voltage level. It must be 1.8V.

4 Antenna

This chapter address the antenna side of the module. There is an on-board, reference certified pcb trace antenna. This can be used for testing/evaluation purposes, but also for the final product. Also, for testing and evaluation purposes, it is possible to disconnect the on-board antenna and instead use an u.fl. connector to connect an external antenna.

4.1 Mounting and Clearance

Ideally, arrange the M.2 module so that the antenna is located at a corner of the product. Keep plastic case (i.e., non-metallic) away from the antenna area with at least 5 mm clearance (in all directions). Also keep any metal elements (e.g., connectors, battery, etc.) away from the antenna area with at least 5 mm clearance (in all directions). Keep a clearance area under and above the antenna area of at least 7.5mm , both under and over the PCB.

Human hands or body parts should be kept away (in the normal use case) from the antenna area.

The ground hole in the middle shall be grounded. Use a metal stand-off according to M.2 standard (height suitable for selected M.2 connector) and use metal screw to create a proper ground connection.

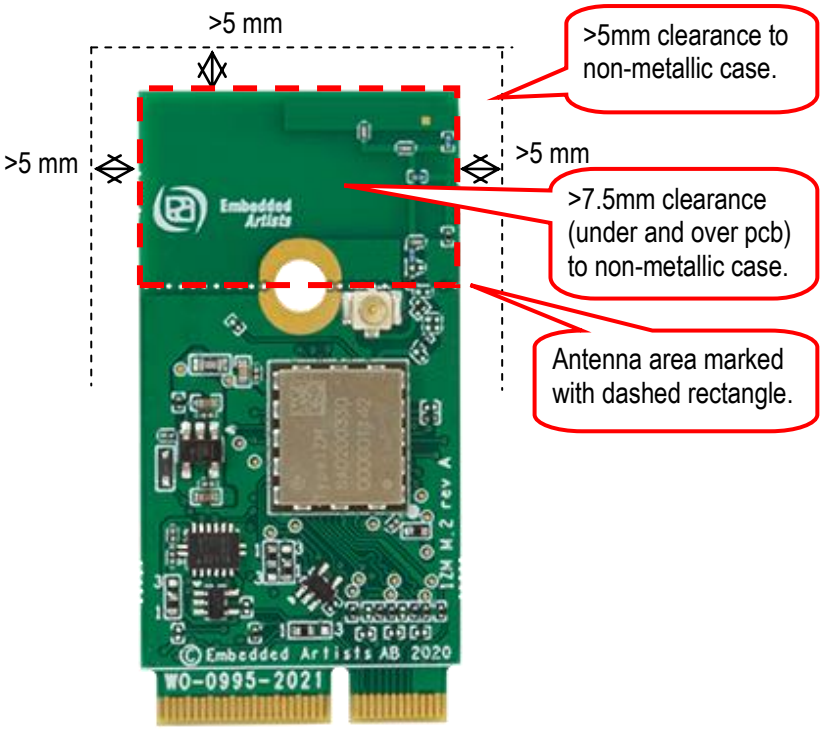

Figure 5 – M.2 Module Clearance Area

4.2 Overriding PCB Trace Antenna

The antenna connection from the 1ZM module be redirected to the u.fl. connector by just moving one zero ohm 0201 series resistor, see illustration below. The on-board trace antenna can be left as-is, or the antenna can be snapped-off.

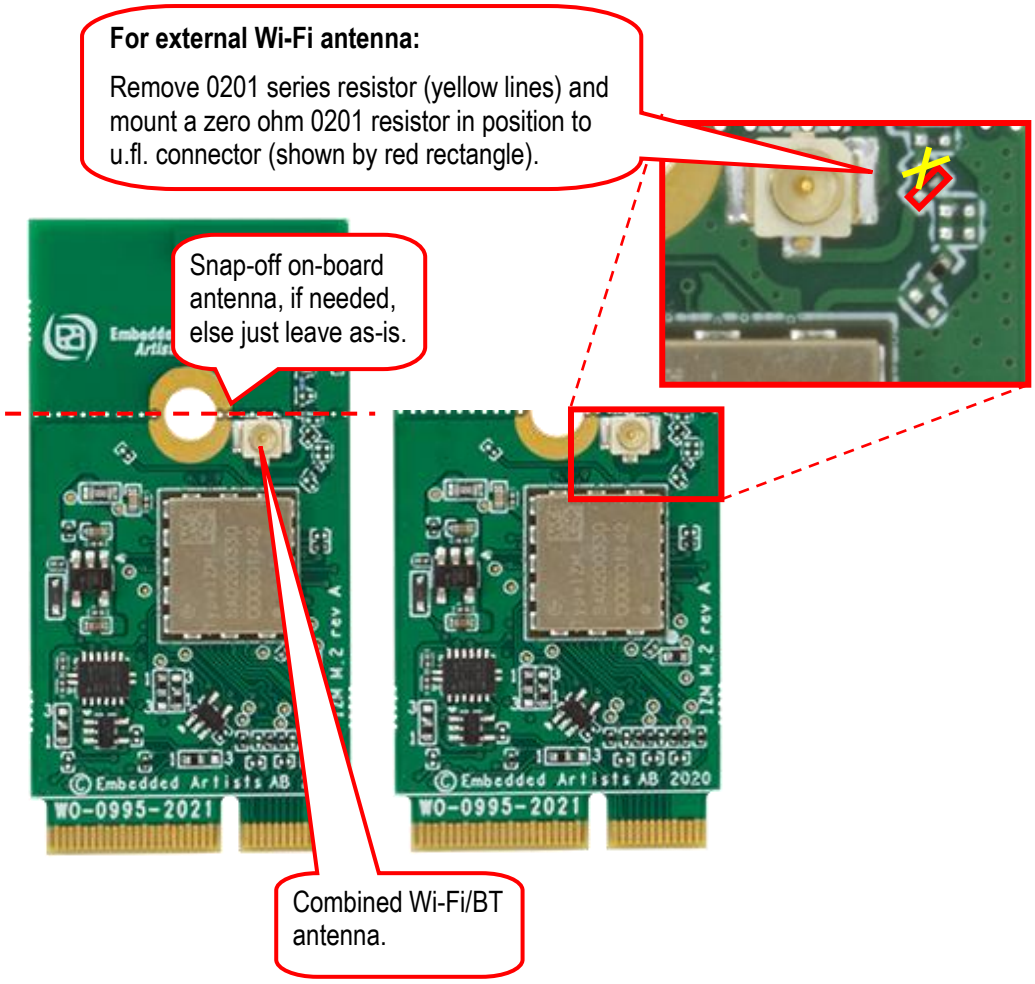

Figure 6 – Rework to Connect U.FL. Connector

4.3 Current Consumption Measurements

It is possible to measure the currents of the power supplies to the 1YM module, VBAT and VIO. VBAT is the 3.3V the is supplied to the M.2 interface and VIO is an on-board generated 1.8V. VIO is generated from the supplied 3.3V. If the supply voltage (3.3V) to the M.2 module is measured it will be both the VBAT and VIO currents that is measured. By measuring currents at the illustrated points blow it is possible to measure VBAT and VIO independently.

Note that zero ohm resistors are mounted by default. Select a series resistor with as low resistance as possible to keep the voltage drop to a minimum. Keep the drop below 100mV. VBAT can be slightly above 1 Amp in peak which means that maximum series resistance is 100 milliOhm for the VBAT resistor.

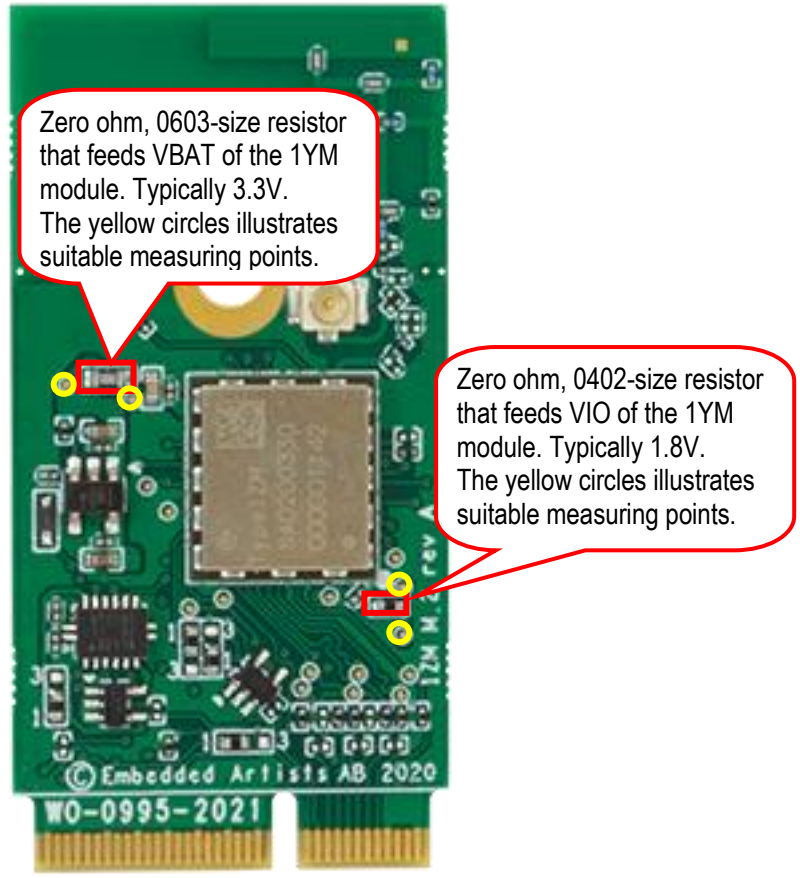

Figure 7 – Current Measurement

4.4 On-board Trace Antenna Performance

The on-board pcb trace antenna type is monopole. The 1ZM M.2 module has been measured both standalone and mounted on the iMX OEM Carrier Board (which is a typical carrier board design).

The table below lists total efficiency:

Measurement condition	**Frequency MHz**						**Total Efficiency in dB**		**Total Efficiency in %**	
	2400	2442	2484	5150	5500	5850	Average 2 GHz band	Average 5 GHz band	Average 2 GHz band	Average 5 GHz band
1ZM M.2 module mounted on iMX OEM Carrier Board	-2.1	-2.0	-1.8	-4.1	-4.1	-4.0	-2.0	-4.1	63.2	39.1
1ZM M.2 module mounted on COM Carrier Board	-2.2	-2.4	-2.5	-4.8	-4.7	-4.4	-2.4	-4.6	58.1	34.4

The table below lists peak gain:

Measurement condition	**Frequency MHz**						**Max dBi**	
	2400	2442	2484	5150	5500	5850	Max 2 GHz band	Max 5 GHz band
1ZM M.2 module mounted on iMX OEM Carrier Board	0.4	0.6	0.9	-1.0	-0.2	-0.8	0.9	-0.2
1ZM M.2 module mounted on COM Carrier Board	0.7	0.3	0.0	0.1	-0.2	-1.1	0.7	0.1

4.4.1 1ZM M.2 Module Mounted on iMX OEM Carrier Board

The 3D directivity measurements are presented below for the 2 GHz and 5GHz bands when the 1ZM M.2 module is mounted on the iMX OEM Carrier Board.

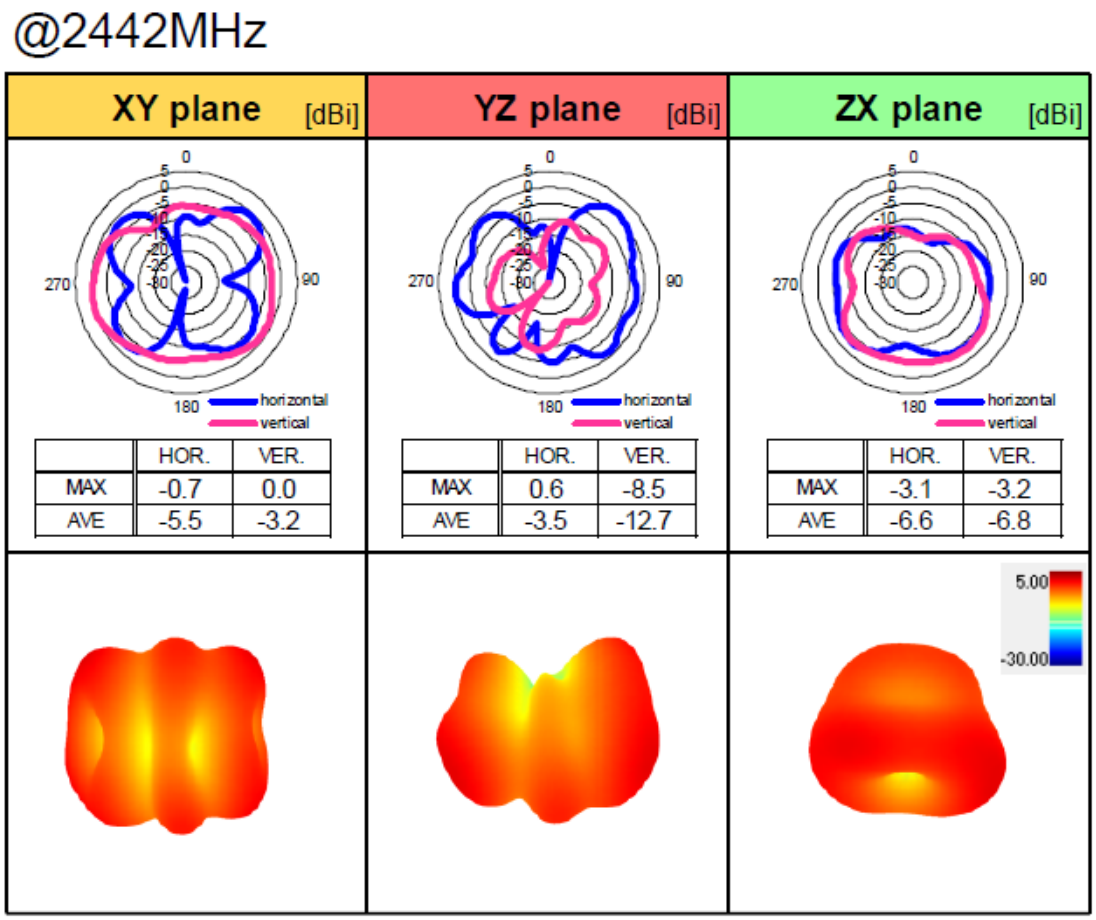

Figure 8 – 3D Directivity Measurements in 2 GHz Band

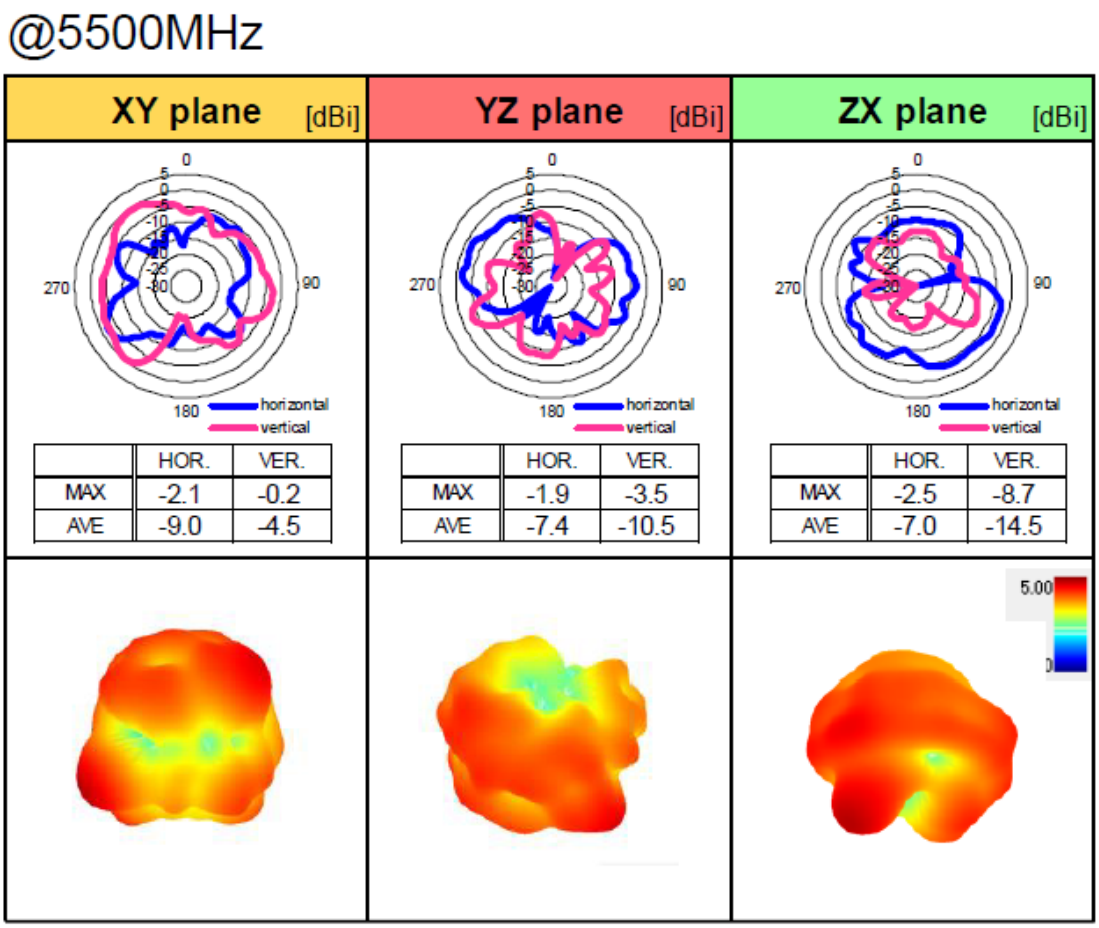

Figure 9 – 3D Directivity Measurements in 5 GHz Band

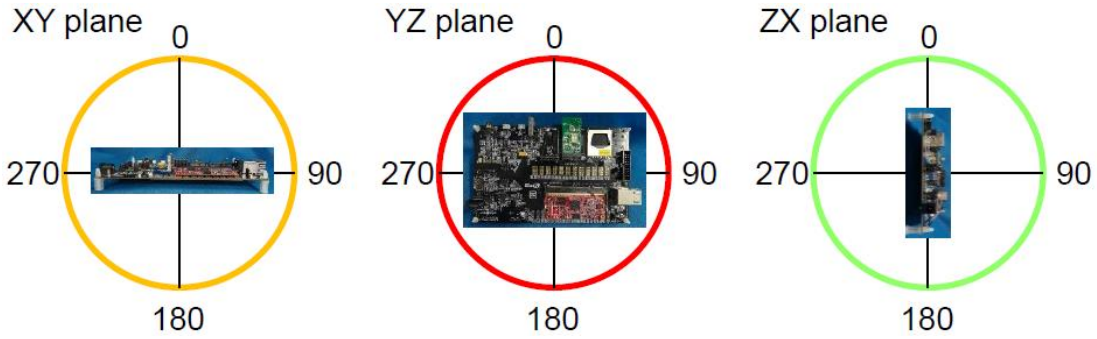

Figure 10 – 3D Directivity Measurements Plane Orientations

The pictures below illustrates the return loss, efficiency and directivity when the 1ZM M.2 module is mounted on the iMX OEM Carrier Board.

<Return Loss>

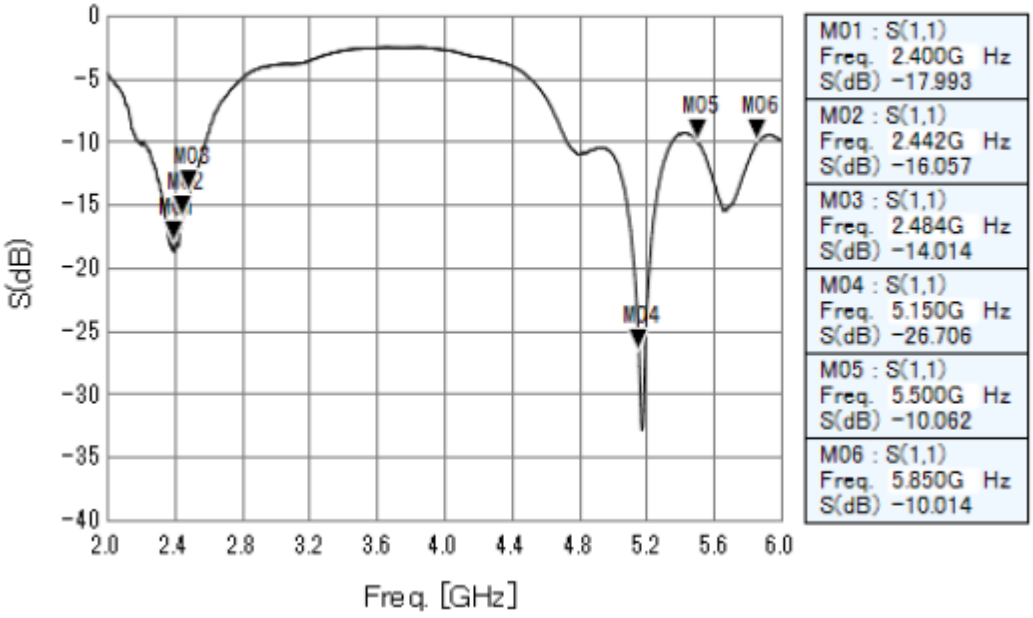

Figure 11 – Return Loss for 1ZM M.2 Module Mounted on iMX OEM Carrier Board

<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.	-1.2	0.1	0.4	-8.8	-2.9	-2.4	
	AVE.	-5.6	-3.0	-3.4	-12.5	-6.8	-6.3	-2.1
2442 MHz	**MAX.**	**-0.7**	**0.0**	**0.6**	**-8.5**	**-3.1**	**-3.2**	
	AVE.	**-5.5**	**-3.2**	**-3.5**	**-12.7**	**-6.6**	**-6.8**	**-2.0**
2484 MHz	MAX.	-0.2	-0.4	0.9	-8.6	-2.7	-3.3	
	AVE.	-5.4	-3.4	-3.5	-12.9	-6.3	-7.0	-1.8

[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.	-4.0	-1.0	-1.2	-2.1	-2.5	-10.1	
	AVE.	-9.5	-5.2	-8.4	-10.0	-7.6	-15.5	-4.1
5500 MHz	**MAX.**	**-2.1**	**-0.2**	**-1.9**	**-3.5**	**-2.5**	**-8.7**	
	AVE.	**-9.0**	**-4.5**	**-7.4**	**-10.5**	**-7.0**	**-14.5**	**-4.1**
5850 MHz	MAX.	-3.8	-0.8	-1.7	-5.3	-1.5	-7.7	
	AVE.	-9.5	-4.6	-6.7	-11.1	-7.1	-11.6	-4.0

Figure 12 – Efficiency for 1ZM M.2 Module Mounted on iMX OEM Carrier Board

<Directivity>

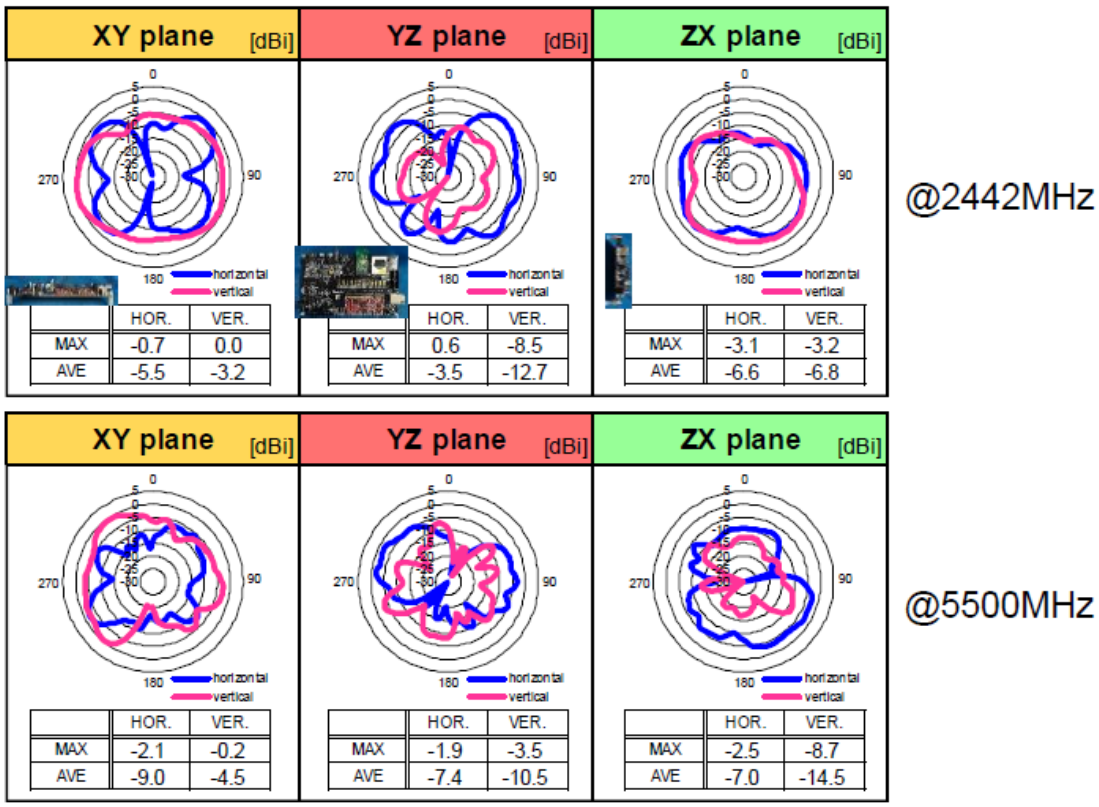

Figure 13 – Directivity for 1ZM M.2 Module Mounted on iMX OEM Carrier Board

4.4.2 1ZM M.2 Module Mounted on COM Carrier Board

The 3D directivity measurements are presented below for the 2 GHz and 5GHz bands when the 1ZM M.2 module is mounted on the COM Carrier Board.

@2442MHz

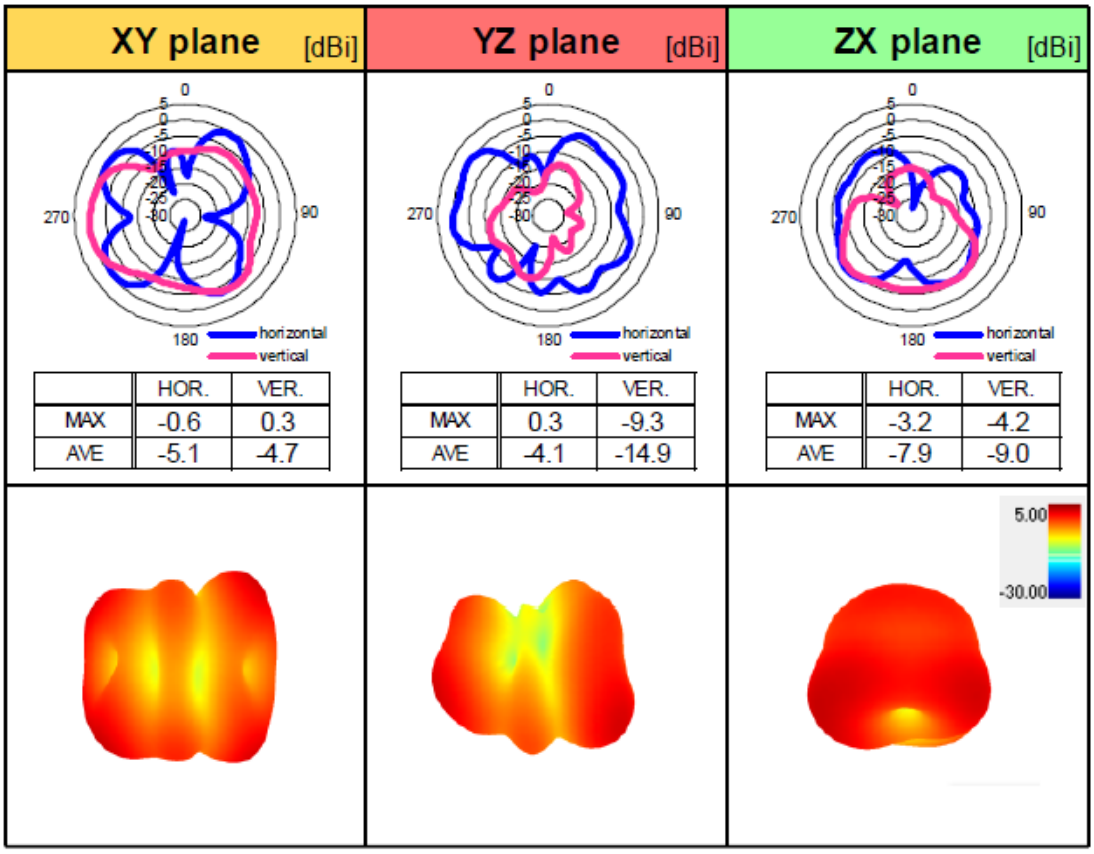

Figure 14 – 3D Directivity Measurements in 2 GHz Band

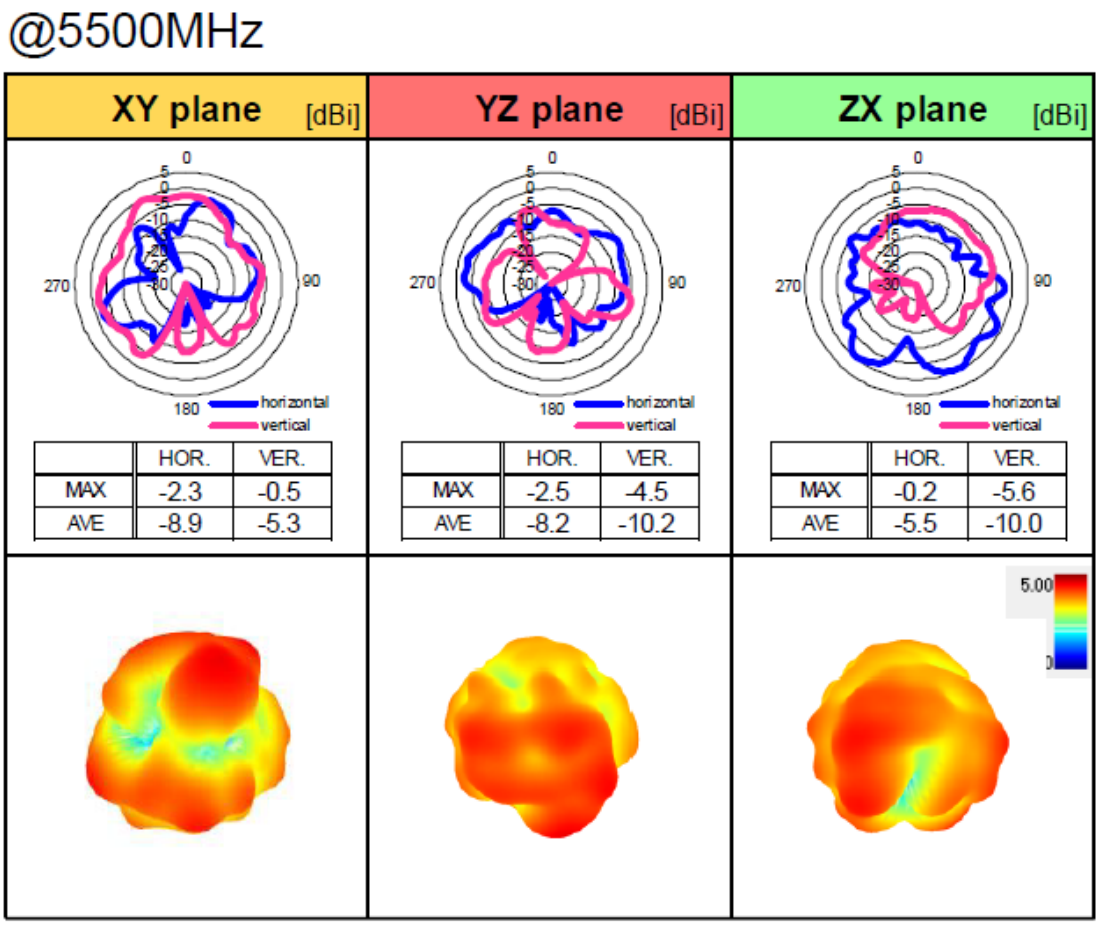

Figure 15 – 3D Directivity Measurements in 5 GHz Band

The pictures below illustrates the return loss, efficiency and directivity when the 1ZM M.2 module is mounted on the COM Carrier Board.

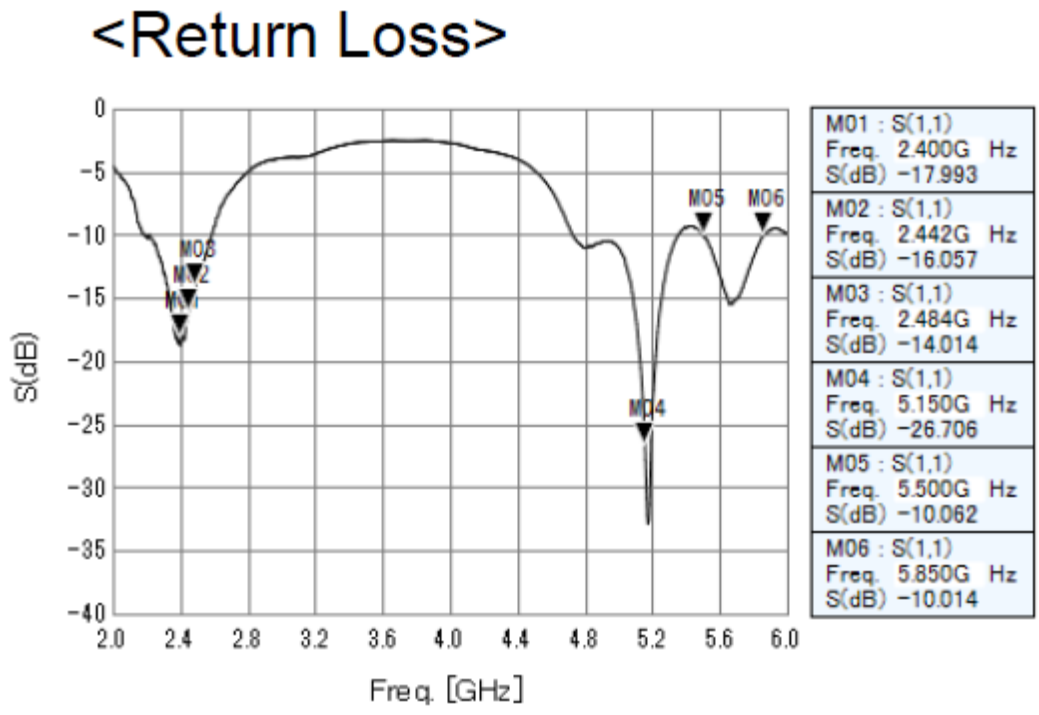

Figure 16 – Return Loss for 1ZM M.2 Module Mounted on COM Carrier Board

<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.	-0.2	0.7	0.7	-10.1	-2.7	-3.4	
	AVE.	-4.9	-4.1	-3.9	-15.4	-7.9	-8.2	-2.2
2442 MHz	**MAX.**	**-0.6**	**0.3**	**0.3**	**-9.3**	**-3.2**	**-4.2**	
	AVE.	**-5.1**	**-4.7**	**-4.1**	**-14.9**	**-7.9**	**-9.0**	**-2.4**
2484 MHz	MAX.	-0.3	0.0	0.0	-9.5	-3.4	-5.0	
	AVE.	-5.2	-5.1	-4.4	-14.5	-7.7	-9.7	-2.5

[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.	-2.5	-1.7	-1.5	-6.2	0.1	-8.2	
	AVE.	-7.7	-6.2	-9.5	-10.9	-5.4	-13.5	-4.8
5500 MHz	**MAX.**	**-2.3**	**-0.5**	**-2.5**	**-4.5**	**-0.2**	**-5.6**	
	AVE.	**-8.9**	**-5.3**	**-8.2**	**-10.2**	**-5.5**	**-10.0**	**-4.7**
5850 MHz	MAX.	-3.1	-1.9	-2.1	-6.2	-1.1	-2.8	
	AVE.	-9.0	-6.0	-6.7	-11.5	-6.9	-8.3	-4.4

Figure 17 – Efficiency for 1ZM M.2 Module Mounted on COM Carrier Board

<Directivity>

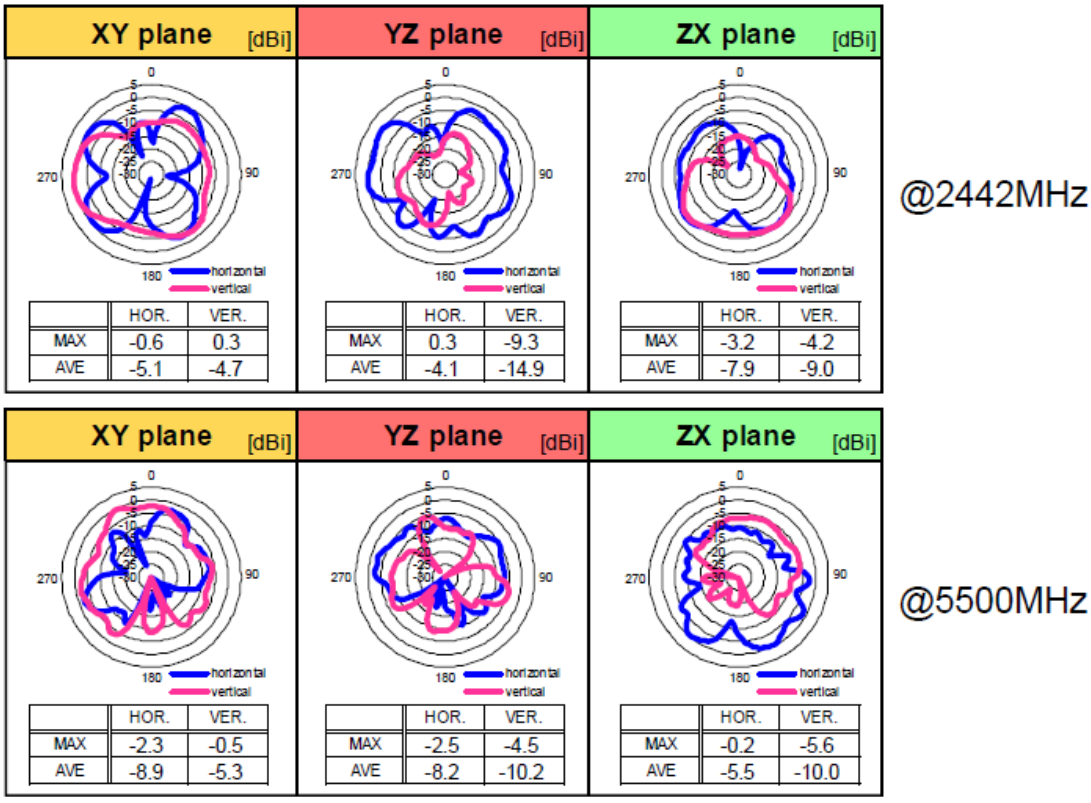

Figure 18 – Directivity for 1ZM M.2 Module Mounted on COM Carrier Board

5 Regulatory

<TBC>

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