2GF M.2 Module Datasheet (EAR00497 / EAR00502)

- Wi-Fi 5, 802.11 a/b/g/n/ac
- Bluetooth 5.4 BR/EDR/LE
- SDIO 3.0 interface, SDR50@80MHz
- Chipset: Infineon CYW43022

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

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Table of Contents

1 Document Information

This document applies to the following products.

Product Name	*Type Number*	*Murata Module*	*Chipset*	*Product Status*
2GF M.2 Module, rev PA4	EAR00497 / EAR00502	LBEE5WV2GF	Infineon CYW43022	Initial Production

This table below lists the product differences. All products are not stocked. Consult Embedded Artists for availability and lead time.

Type Number	*Product Name*	*Antenna*	*Packaging*
EAR00497	2GF M.2 Module	External antenna via u.fl.connector	Individual packing for evaluation
EAR00502	2GF M.2 Module	External antenna via u.fl.connector	Tray packing

1.1 Revision History

Revision	*Date*	*Description*
PA1	2024-08-23	First version.

2 Introduction

This document is a datasheet that specifies and describes the *2GF M.2 module* mainly from a hardware point of view.

The main component in the design is Murata's 2GF module (full part number: LBEE5WV2GF), which in turn is based on the Infineon CYW43022 chipset, respectively. The 2GF module enables Wi-Fi, Bluetooth and Bluetooth Low Energy (LE).

There are multiple application areas for the 2GF M.2 Module:

- Industrial and Buildings automation
- Asset management
- IoT applications
- Smart home: Voice assist device, smart printer, smart speaker, home automation gateway, and IP camera
- Retail/POS
- Healthcare and medical devices
- Smart city
- and many more…

2.1 Benefits of Using an M.2 Module to get Wireless Connectivity

There are several benefits 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 SDK) with responsive support from Murata.
- Supported by Embedded Artists' Developer's Kits for i.MX 8/9 development, including advanced debugging support on carrier boards
- Futureproofing the design – easy to replace with a newer module in the future
- One component to buy, instead of 40+
- No RF expertise is required
- Developed in close collaboration with Murata

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 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, UKCA, 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 2GF module (full part number: LBEE5WV2GF), which in turn is based around Infineon's CYW43022 chipset.

For a detailed specification, see the LBEE5WV2GF product page at Murata:
https://www.murata.com/products/connectivitymodule/wi-fi-bluetooth/overview/lineup/type2gf
For a full specification, see Murata's 2GF Module (LBEE5WV2GF) product page:
https://www.murata.com/products/productdata/8824592302110/type2gf.pdf

Module / Chipset	
Murata module	LBEE5WV2GF
Chipset	Infineon CYW43022

Wi-Fi	
Standards	802.11a/b/g/n/ac 1x1 SISO, Wi-Fi 5
Network	uAP and STA dual mode
Frequency	2.4GHz and 5 GHz band
Data rates	78 Mbps
Host interface	SDIO 3.0, SDR12@25MHz, SDR25@50MHz, SDR50@80MHz

Bluetooth	
Standards	5.4 BR/EDR/LE, 3Mbps PHY
Power Class	Class 1
Host interface	4-wire UART@4MBaud
Audio interface	PCM for audio

Powering				
Operating conditions on supply voltage to M.2 module		**Min**	**Typ**	**Max**
		0.0V minimum 3.15V operating and RF specification	3.3V	3.46V
Absolute maximum rating on supply voltage to M.2 module		**Min**		**Max**
Note: Do not exceed minimum or maximum voltage. Module will be permanently damaged above this limit!		0.0V		3.63V
Peak current	About 500 mA max	The power supply must be designed for this peak current, which typically happen during the startup calibration process.		
Receive mode current (WLAN)	30 mA typical max	Note that current consumption varies widely between different operational modes.		

Transmit mode current (WLAN)	450 mA typical max	Note that current consumption varies widely between different operational modes.

Environmental Specification	
Operational Temperature	-20 to +70 degrees Celsius
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.

Chipset signals PD_N (M.2 signal W_DISABLE1#) must be held low for at least 2 milliseconds after supply voltage has reached specification level before pulled high.

3.2 External Sleep Clock

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

Clock Specification	
Frequency	32.768 kHz
Frequency accuracy	±250 ppm including initial tolerance, aging, temperature, etc.
Duty cycle	30 - 70%
Voltage level	3.3V logic, according to M.2 standard

3.3 Mechanical Dimensions

The M.2 module is of type: 2230-D5-E according to the M.2 nomenclature. This means width 22 mm, length 30mm (without trace antenna), top and bottom 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, without pcb trace antenna	30	mm
PCB thickness	0.8	mm
Maximum component height on top side	1.5	mm
Maximum component height on bottom side	1.5	mm
Ground hole diameter	3.5	mm
Plating around ground hole, diameter	5.5	mm
Module weight	1.5 ±0.5 gram	gram

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

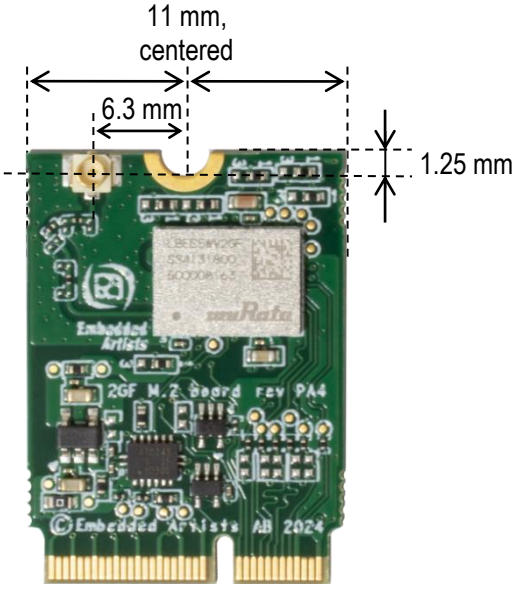

Figure 1 – M.2 Module Antenna Connector Measurements

3.4 M.2 Pinning

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

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

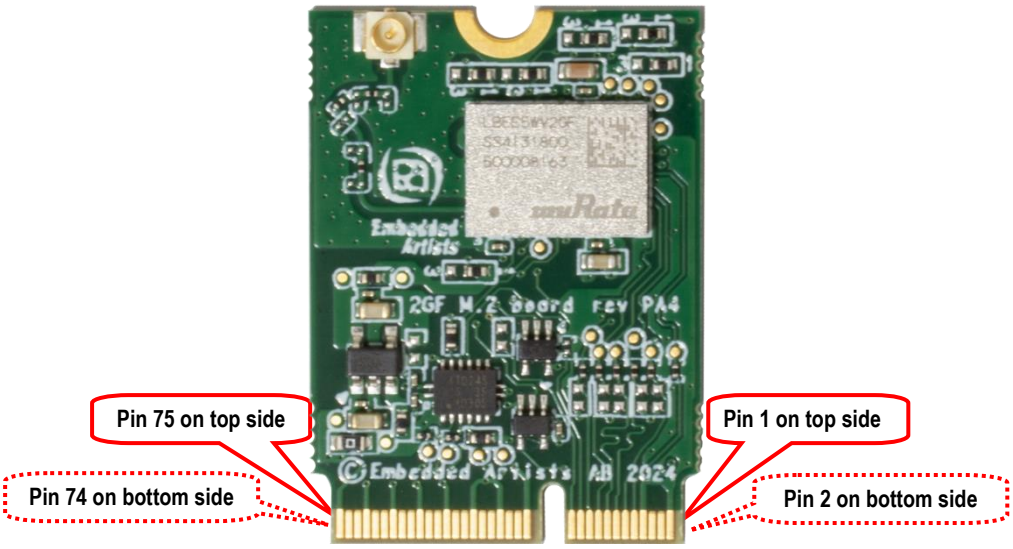

Figure 2 – M.2 Module Pin Numbering

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 2GF M.2 modules. The column "When is signal needed" signals four different categories:

- Always: These signals shall always be connected.
- Wi-Fi SDIO: These signals shall always be connected when the Wi-Fi interface is used.
- Bluetooth: These signals shall always be connected when 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: PCM_CLK Connected to 2GF module, signal BT_PCM_CLK, pad 85

9	Top	SDIO CLK	1.8V Input to M.2	Wi-Fi	For Wi-Fi SDIO interface: SDIO_CLK Connected to 2GF module, signal SDIO_CLK, pad 24
10	Bottom	PCM_SYNC	1.8V I/O	Bluetooth audio	For Bluetooth audio interface: PCM_SYNC Connected to 2GF module, signal BT_PCM_SYNC, pad 83
11	Top	SDIO CMD	1.8V I/O	Wi-Fi	For Wi-Fi SDIO interface: SDIO_CMD Connected to 2GF module, signal SDIO_CMD, pad 26 Note: Require an external 10-100K ohm pullup
12	Bottom	PCM_OUT	1.8V output from M.2	Bluetooth audio	For Bluetooth audio interface: PCM_OUT Connected to 2GF module, signal BT_PCM_OUT, pad 82
13	Top	SDIO DATA0	1.8V I/O	Wi-Fi	For Wi-Fi SDIO interface: SDIO_D0 Connected to 2GF module, signal SDIO_DATA_0, pad 23 Note: Require an external 10-100K ohm pullup
14	Bottom	PCM_IN	1.8V input to M.2	Bluetooth audio	For Bluetooth audio interface: PCM_IN Connected to 2GF module, signal BT_PCM_IN, pad 84
15	Top	SDIO DATA1	1.8V I/O	Wi-Fi	For Wi-Fi SDIO interface: SDIO_D1 Connected to 2GF module, signal SDIO_DATA_1, pad 22 Note: Require an external 10-100K ohm pullup
16	Bottom	LED_2#			Not connected.
17	Top	SDIO DATA2	1.8V I/O	Wi-Fi	For Wi-Fi SDIO interface: SDIO_D2 Connected to 2GF module, signal SDIO_DATA_2, pad 21 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	For Wi-Fi SDIO interface: SDIO_D3 Connected to 2GF module, signal SDIO_DATA_3, pad 25 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 This is a wake signal for the Bluetooth interface from the device (Wi-Fi/BT chipset) to the host (CPU). Connected to 2GF module, via buffer, signal BT_HOST_WAKE, pad 5 Require an external 10K pullup resistor to 3.3V.
21	Top	SDIO WAKE#	1.8V OD output from M.2	Wi-Fi	For Wi-Fi SDIO interface WL_HOST_WAKE This is a wake signal for the Wi-Fi interface from the device (Wi-Fi/BT chipset) to the host (CPU). Connected to 2GF module, via buffer, signal WL_HOST_WAKE, pad 7 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: UART_TXD Connected to 2GF module, signal BT_UART_TXD, pad 31
23	Top	SDIO RESET#	1.8V input to M.2		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 Connected to 2GF module, signal BT_UART_RXD pad 32
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 Connected to 2GF module, signal BT_UART_RTS, pad 33
35	Top	PERp0			Not connected.
36	Bottom	UART_CTS	1.8V input to M.2	Bluetooth	For Bluetooth UART interface: BT_UART_CTS Connected to 2GF module, signal BT_UART_CTS, pad34
37	Top	PERn0			Not connected.
38	Bottom	VENDOR DEFINED	1.8V input to M.2	Optional	Connected to 2GF module, signal WL_GPIO_5, pad 66. Note: Signal can be JTAG_TDO
39	Top	GND		Always	Connect to ground.
40	Bottom	VENDOR DEFINED	1.8V output from M.2	Wi-Fi	For Wi-Fi SDIO interface WL_DEV_WAKE This is a wake signal for the Wi-Fi interface from the host (CPU) to the device (Wi-Fi/BT chipset). Connected to 2GF module, signal P5 (WL_DEV_WAKE), pad 43
41	Top	PETp0			Not connected.
42	Bottom	VENDOR DEFINED	1.8V input to M.2	Bluetooth	For Bluetooth UART interface: BT_DEV_WAKE This is a wake signal for the Bluetooth interface from the host (CPU) to the device (Wi-Fi/BT chipset). Connected to 2GF module, signal P5 (BT_DEV_WAKE), pad 40
43	Top	PETn0			Not connected.
44	Bottom	COEX3	1.8V I/O	Optional	Connected to 2GF module, signal WL_GPIO_4, pad 67. Note: Signal can be JTAG_TDI
45	Top	GND		Always	Connect to ground.
46	Bottom	COEX_TXD	1.8V I/O	Optional	Connected to 2GF module, signal WL_GPIO_2, pad 69. Note: Signal can be JTAG_TCK
47	Top	REFCLKp0			Not connected.
48	Bottom	COEX_RXD	1.8V I/O	Optional	Connected to 2GF module, signal WL_GPIO_3, pad 68. Note: Signal can be JTAG_TMS
49	Top	REFCLKn0			Not connected.
50	Bottom	SUSCLK	3.3V input to M.2	Always	External sleep clock input (32.768kHz) Connected to 2GF module, via buffer, signal EXT_LPO, pad 80
51	Top	GND		Always	Connect to ground.
52	Bottom	PERST0#			Not connected.
53	Top	CLKREQ0#			Not connected.
54	Bottom	W_DISABLE2#	3.3V input to M.2	Always	Independent reset signal for Bluetooth functionality. Connected to 2GF module, via buffer, signal BT_REG_ON, pad 9 W_DISABLE#2: High = Bluetooth part of module enabled/internally powered, Low = Bluetooth disabled/powered

					down
55	Top	PEWAKE0#			Not connected.
56	Bottom	W_DISABLE1#	3.3V input to M.2	Always	Independent reset signal for Wi-Fi functionality. Connected to 2GF module, via buffer, signal WL_REG_ON, pad 10 W_DISABLE1#: High = The module is enabled/internally powered, Low = The modules is disabled/powered down
57	Top	GND		Always	Connect to ground.
58	Bottom	I2C_SDA	1.8V I/O		Not connected.
59	Top	Reserved			Not connected.
60	Bottom	I2C_CLK	1.8V input to M.2		Not connected.
61	Top	Reserved			Not connected.
62	Bottom	ALERT#	1.8V OD output from M.2		Not connected.
63	Top	GND		Always	Connect to ground.
64	Bottom	RESERVED			Not connected.
65	Top	Reserved			Not connected.
66	Bottom	UIM_SWP			Not connected.
67	Top	Reserved			Not connected.
68	Bottom	UIM_POWER_SNK			Not connected.
69	Top	GND		Always	Connect to ground.
70	Bottom	UIM_POWER_SRC/GPIO_1			Not connected.
71	Top	Reserved			Not connected.
72	Bottom	3.3 V		Always	Power supply input. Connect to stable, low-noise 3.3V supply.
73	Top	Reserved			Not connected.
74	Bottom	3.3 V		Always	Power supply input. Connect to stable, low-noise 3.3V supply.
75	Top	GND		Always	Connect to ground.

3.5 SDIO Interface

The SDIO interface conforms to the SDIO v3.0 specification, including the UHS-I modes, and is backward compatible with SDIO v2.0.

SDIO bus speed modes	Max SDIO clock frequency	Max bus speed	Signaling voltage according to M.2 specification
DS (Default speed)	25 MHz	12.5 MByte/s	1.8 V
HS (High speed)	50 MHz	25 MByte/s	1.8 V
SDR12	25 MHz	12.5 MByte/s	1.8 V
SDR25	50 MHz	25 MByte/s	1.8 V
SDR50	80 MHz	40 MByte/s	1.8 V

Note that SDR104 and DDR50 modes are not supported.

3.6 Test Points and Expansion Header

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

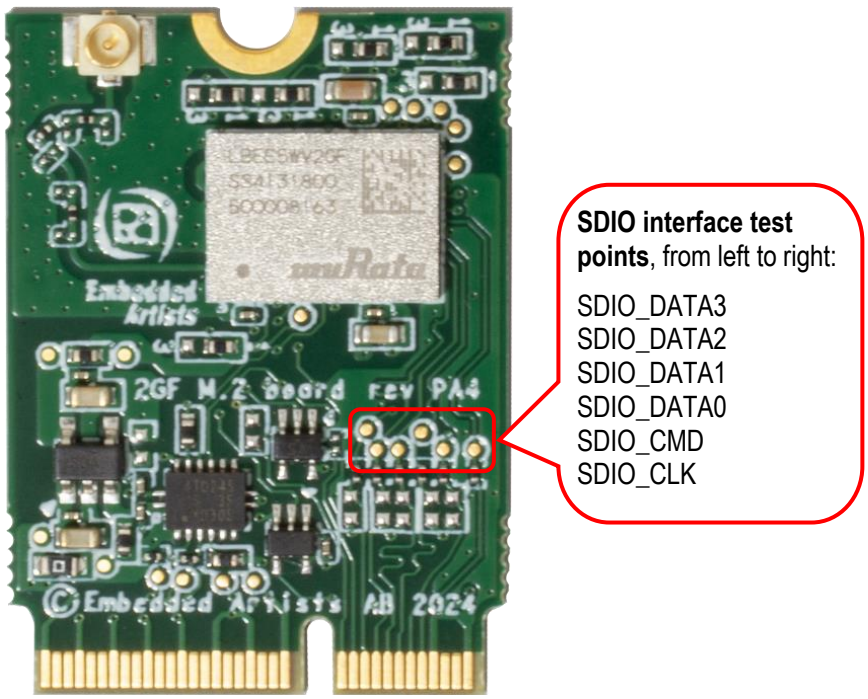

Figure 3 – 2GF M.2 Module Test Points

3.7 Current Consumption Measurements

It is possible to measure the currents of the power supplies to the 2GF module, VBAT and VDDIO. VBAT is the 3.3V that is supplied directly from the M.2 interface and VDDIO is an on-board generated 1.8V. VDDIO is generated from the supplied 3.3V via a linear regulator. If the external supply voltage (3.3V) to the M.2 module is measured it will be both the VBAT and VDDIO power consumption that is measured. It is also possible to measure the VBAT+VDDIO and VDDIO currents at points illustrated in the picture below.

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+VDDIO can be about 500 milli ampere in peak which means that maximum series resistance is 100 milliOhm for the VBAT resistor. The maximum VDDIO current is much lower, only about 5mA. A suitable range for a resistor for this current is 1-10 ohm.

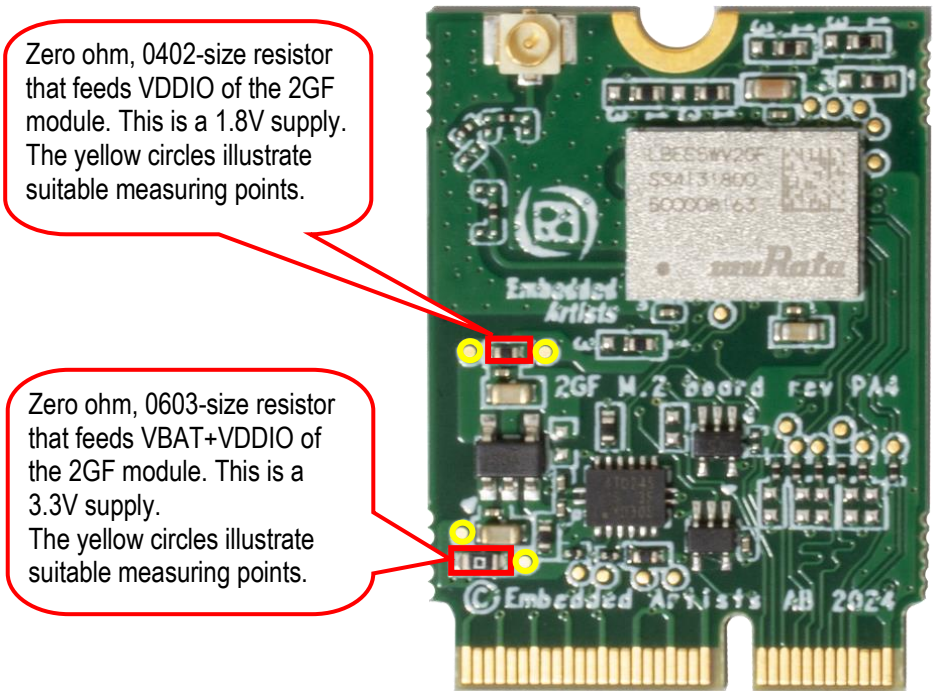

Figure 4 – Current Measurement

4 Antenna

The module does not have any on-board antenna. An external antenna is needed. For reference certification, the Unictron H2B1WD1A3B0200 Wi-Fi 6 & 6E antenna has been used. The antenna is also referenced to as WT32D1-KX 001.

Unictron H2B1WD1A3B0200 is a balanced, dipole-type, high efficiency antenna. It is ground plane independent, tripple band antenna that supports the 2400-2485MHz, 5150-5850MHz and 5925-7125 MHz frequency bands. The physical size is 32 x 13 x 1.5mm. The antenna cable is 119 ±5 mm and the connector is MHF-I, which is a U.FL compatible connector.

Figure 5 – Reference Certified Antenna

4.1 Antenna Connector

The M.2 standard specifies a 1.5 mm outer ring diameter male connector, which is compatible with the Murata MSC and IPEX MHF4 connector specifications. This connector is not used since our M.2 modules also target industrial users, where the Hirose U.FL. connector standard is more commonly used. U.FL. is compatible with the IPEX MHF1 connector specification.

5 Software and Support

This chapter contains information about software and support.

5.1 Software Driver

The CYW43022 chipset does not contain any persistent software. A firmware image must be downloaded by the host at start-up. This is the responsibility of the operating system driver.

There are three different cases, depending on which host processor is used:

1. **Embedded Artists' Computer-on-Modules, (u)COM, as host processor**
   Embedded Artists' Linux BSPs and SDKs for the different (u)COM board contains all drivers available and pre-configured. Everything has been tested and works out-of-the-box on the different iMX Developer's Kits.

iMX Developer's Kit	2GF M.2 support
iMX93 uCOM	Support in Linux BSP v5.15.32 only
iMX8M Mini uCOM	Support in Linux BSP v5.15.32 only
iMX8M Nano uCOM	Support in Linux BSP v5.15.32 only
iMX8M COM	No
iMX7 Dual COM	No
iMX7 Dual uCOM	No
iMX7ULP uCOM	No
iMX6 Quad COM	No
iMX6 DualLite COM	No
iMX6 SoloX COM	No
iMX6 UltraLite/ULL COM	No
iMX RT1176 uCOM	No
iMX RT1166 uCOM	No
iMX RT1064 uCOM	No
iMX RT1062 OEM	No

2. **Other i.MX based, for example NXP's EVKs**
   Murata has created documentation how to compile the Linux kernel for the NXP EVKs https://wireless.murata.com/products/rf-modules-1/wi-fi-bluetooth-for-nxp-i-mx.html#Linux

3. **Non-i.MX host processor**
   There is no ready-to-go driver exist. Contact Murata to check driver availability on the hardware platform used.

5.2 Support

Embedded Artists supports customers that use our M.2 module in combination with Embedded Artists' Computer-on-Modules, (u)COM, based on NXP's i.MX 8/9 families.

For other platforms, support is provided by Murata via their Community Support Forum:
https://community.murata.com/s/topic/0TO5F0000002TLWWA2/connectivity-modules

6 Regulatory

The Murata 2GF module is reference certified. See the LBEE5WV2GF datasheets from Murata for details.

6.1 European Union Regulatory Compliance

EUROPEAN DECLARATION OF CONFORMITY (Simplified DoC per Article 10.9 of the Radio Equipment Directive 2014/53/EU)

This apparatus, namely 2GF M.2 module (pn EAR00497 / EAR00502) conforms to the Radio Equipment Directive (RED) 2014/53/EU. The full EU Declaration of Conformity for this apparatus can be found at this location: https://www.embeddedartists.com/products/2gf-m-2-module/, see document *2GF M.2 module Declaration of Conformity*.

The following information is provided per Article 10.8 of the Radio Equipment Directive 2014/53/EU:

(a) Frequency bands in which the equipment operates.

(b) The maximum RF power transmitted.

PN	RF Technology	(a) Frequency Ranges (EU)	(b) Max Transmitted Power
EAR00497 / EAR00502	Bluetooth BR/EDR/LE	2400 MHz – 2484 MHz	13 dBm
EAR00497 / EAR00502	Wi-Fi IEEE 802.11b/g/n	2400 MHz – 2484 MHz	19 dBm
EAR00497 / EAR00502	Wi-Fi IEEE 802.11a/n/ac	5150 MHz – 5850 MHz	17.5 dBm

The 2GF M.2 module complies with the Directive 2011/65/EU (EU RoHS 2) and its amendment Directive (EU) 2015/863 (EU RoHS 3).

7 Disclaimers

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