Murata Module Specific

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1. If I need to evaluate Murata's Type 1DX, 1MW, 1LV and 1CX modules; which evaluation board should I use?

Murata has partnered with Embedded Artists to design a new Wi-Fi/BT M.2 EVB form factor.
Embedded Artists designs, builds, and distributes these new M.2 EVBs – all of which use Murata's modules. For more information, refer to attached **link**.

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2. Why was the M.2 interface selected for the new Wi-Fi/BT EVBs (Evaluation Boards)?

The new M.2 interface based EVBs provide many advantages:

i. **Implementation Price Point:** The M.2 interface is very economical when designing it into customer's prototype boards; with the M.2 connector being less than $0.80 USD. For more details on designing in the M.2 EVB for faster prototyping, refer to **downloaded documents by Embedded Artists**.

ii. **Industry standard interconnect:** The M.2 pinout adheres to the PCI Express M.2 Specification (Key E). As such, it is easier for customers to design it into their boards – by adhering to a known/published specification document.

iii. **Easy availability:** Customers can order the Embedded Artists' Wi-Fi/BT M.2 EVB through Distribution channel – based on Murata modules (1DX/1MW/1LV/1CX).

iv. **Enhance Debugging Options:** The Wi-Fi/BT M.2 EVBs provide numerous on-board test points that can be probed by end users. To map the test points to signals, please refer to Embedded Artists' M.2 EVB Datasheets. For example, the following datasheet is for **Type 1DX**

v. **Reference Certified Option:** The new Wi-Fi/BT M.2 EVBs use Murata reference certified PCB trace antenna. Customers copying this antenna design can greatly reduce their cost and time to market.

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3. How do I get the manufacturing test firmware for the Murata module I am using?

Send an email to **wirelessfaq@murata.com** with the production firmware version you are using currently. The version can be obtained by using the following command after board boots:

dmesg | grep brcmfmac
*>> brcmfmac: brcmf_c_preinit_dcmds: Firmware version = wl0: Jun 13 2018 23:24:39 version **7.45.98.52** (r691997 CY) FWID 018b9f8ef5*

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4. How do I modify the file system to load manufacturing test firmware?

Updating manufacturing test firmware with an USB thumb drive is the easiest solution. This method can be applied on both NXP and Embedded Artists' platforms, for copying any files to the file system. The following steps demonstrate how to copy the mfgtest firmware of 1CX to Embedded Artists' i.MX7 Dual COM with an USB thumb drive.

1. Contact Murata for the manufacturing test firmware you need. Keep it in a USB thumb drive (as can be seen inside the folder mfgtest-firmware in the example below).

2. Plug the thumb drive to the EVK board. Type command $ dmesg see how the thumb drive is enumerated. In the example below, the thumb drive is enumerated as sda1.

```
scsi 0:0:0:0: Direct-Access     SanDisk  Ultra           1.00 PQ: 0 ANSI: 6
sd 0:0:0:0: [sda] 60062500 512-byte logical blocks: (30.8 GB/28.6 GiB)
sd 0:0:0:0: [sda] Write Protect is off
sd 0:0:0:0: [sda] Mode Sense: 43 00 00 00
sd 0:0:0:0: [sda] Write cache: disabled, read cache: enabled, doesn't support DPO or FUA
 sda: sda1
sd 0:0:0:0: [sda] Attached SCSI removable disk
```

3. Create a mount point /media/usb for the thumb drive, and mount the thumb drive to the mount point.

```
root@imx7dea-com:~# mkdir /media/usb
root@imx7dea-com:~# mount /dev/sda1 /media/usb
```

4. Change the directory to the mount point. You can see the contents of the thumb drive here.

```
root@imx7dea-com:/media/usb# cd mfgtest-firmware/
root@imx7dea-com:/media/usb/mfgtest-firmware# ls
brcmfmac4356-pcie.bin
```

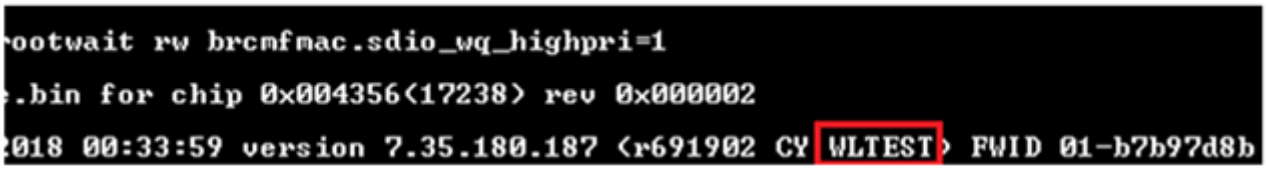
5. You can copy the mfgtool file to /lib/firmware/brcm/ now. This is the directory where firmware is kept on the EVK.

$ cp /media/usb/mfgtest-firmware/brcmfmac4356-pcie.bin/lib/firmware/brcm/

6. After you have copied all the files needed in the thumb drive, you can unmount the thumb drive.
   $ umount /media/usb

7. Reboot the platform to load the manufacturing test tool.
   $ reboot

8. You can check is the mfg tool is load by typing *$ dmesg | grep brcm*
   If you see “WLTEST” in the line of firmware version, it means mfgtest firmware is loaded.



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5. What is different about the kernel log output when running with manufacturing test firmware?

If the manufacturing test firmware is loaded correctly, the term WLTEST will appear in the dmesg log generated by the driver, as the following screenshot shows:

$ dmesg | grep brcm

*brcmfmac: brcmf_c_preinit_dcmds: Firmware version = wl0: Jun 7 2018 00:33:59 version 7.35.180.187 (r691902 CY **WLTEST**) FWID 01-b7b97d8b*

The rest of the output is same as in the production firmware:

$ dmesg | grep brcm

brcmfmac: brcmf_c_preinit_dcmds: Firmware version = wl0: Jun 7 2018 00:37:21 version 7.35.180.187 (r691902 CY) FWID 01-763b4d62

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6. Does my Murata module have a unique WLAN MAC address?

Yes, all Murata modules come with unique WLAN MAC address. Murata owns a range of MAC address from IEEE Standard Association for Murata's products. Each MAC address is unique in the world. On the production line, one MAC address will be assigned to each Murata's WLAN/BT module. This becomes the module's default MAC address.

If a customer want to use their own MAC address instead of the one assigned by Murata, they can write their MAC address to the OTP (One Time Programmable memory) of the module. Then the MAC in the OTP will be applied. Note that once the OTP is programmed, it cannot be changed.

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7. Why/when would I need the WLAN manufacturing test firmware for Murata modules?

The WLAN manufacturing test firmware is required to run the WLAN manufacturing test utility to assist with the regulatory certification. For a module based on Cypress chipset, the WLAN manufacturing test utility is known as wl_tool. For more information about using the wl_tool for the certification process, please refer to the **link**.

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8. How to try Murata's M.2 EVB with NXP's platform?

Murata has developed a uSD-M.2 Adapter for NXP's legacy platforms, to evaluate Murata's M.2 EVBs. For those NXP platforms which don't have M.2, the customer can buy a uSD-M.2 Adapter to evaluate M.2 EVBs. Minimum purchase order is 1.

For more detail, please refer to the following **link**

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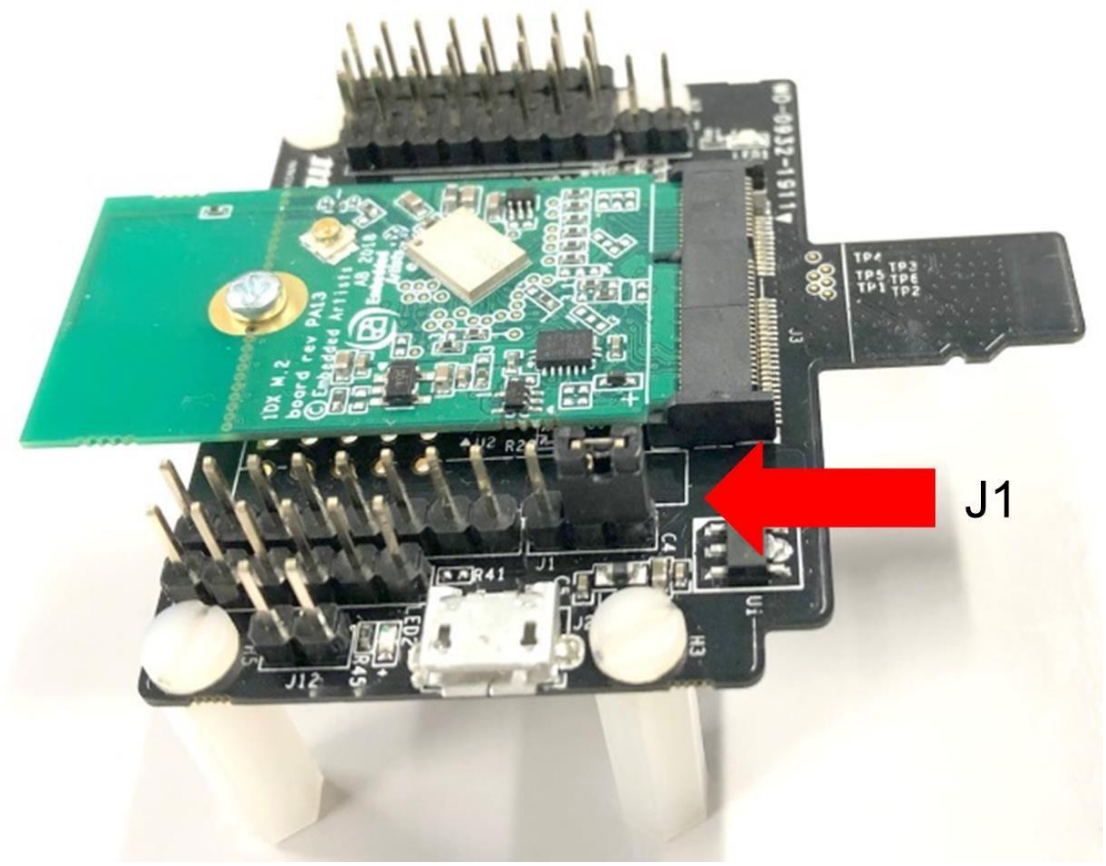
9. How is the Murata uSD-M.2 adapter powered?

By default, the Murata uSD-M.2 adapter draws power from the microSD connector (3.1-3.3 V). The Power Supply Jumper (J1) is kept in position 2-3 for this configuration (shown in image below).



It is also possible to supply 5V power to the adapter via the micro USB connector (J2). The Power Supply Jumper (J1) must be kept in position 1-2 for this configuration. The on-board U1 Regulator steps down the 5V to 3.3 V VBAT.

On a related note, the uSD-M.2 adapter supports both 3.3 V and 1.8 V VIO operations for the M.2 modules. This is controlled by the J12 jumper in the uSD-M.2 adapter:

J12 closed: uSD-M.2 adapter is set to **3.3 V** VIO mode. A BLUE LED will glow, in addition to the GREEN LED.
J12 open: uSD-M.2 adapter is set to **1.8 V** VIO mode. Only the GREEN LED will glow.

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10. How to disable Bluetooth on Murata modules, using the uSD-M.2 adapter?

For WLAN-only mode operation, the J11 jumper can be installed on the uSD-M.2 adapter to disable BT. If you do not plan to use Bluetooth, it is suggested that you install the J11 jumper to optimize the power consumption, as otherwise the Bluetooth core will draw current needlessly.

- a: J11 = Optional BT Disable Jumper for WLAN -Only Mode
  - Installed - Drives BT_REG_ON signal low. BT core is disabled.
  - Not installed – BT core is enabled.

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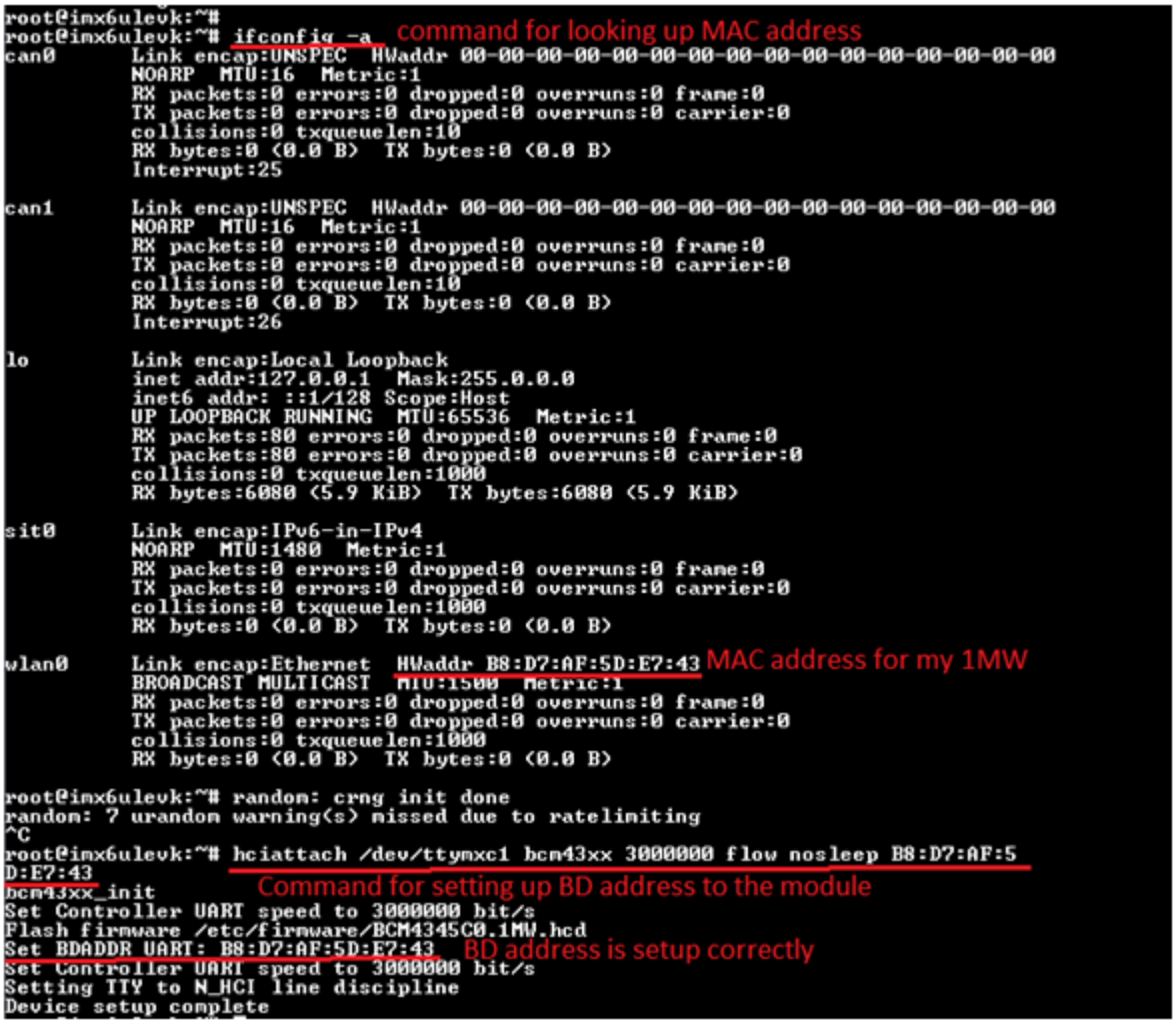
11. Does my Murata module have a unique BD address?

It is possible to procure Murata modules with or without unique BD address. In case unique
BD address is included with the Murata module, it is programmed in the OTP (One Time Programmable ROM) area. You would need a special .hcd file to read the area. Please raise a request with Murata **imxfaq@murata.com** to obtain the file. You can set any BD address to the module during BT setup using the command:

hciattach /dev/ttyS0 -t 10 bcm43xx 3000000 flow nosleep <MAC address>



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12. Which VIO voltages do Murata modules support: 3.3V or 1.8V?

All modules except for 1LV support 1.8/3.3V VIO. 1LV only supports 1.8V. Default VIO on i.MX 6 Legacy platforms using Murata uSD-M.2 Adapter is 3.3V. However, 1.8V VIO is necessary in any of the following cases:

- SDIO UHS (Ultra High Speed) modes are only supported by 1.8 V VIO. UHS SDIO modes are necessary for optimizing the WLAN throughput for 802.11ac modules, such as 1MW. For example Type 1MW supports sdr104 mode which has a SDIO clock frequency of 200 MHz.

- Some Murata modules only support 1.8 V VIO operations, such as 1LV.

- 1.8 V VIO typically provides a closer implementation to target hardware. The final hardware implementation usually uses 1.8V VIO signalling for both WLAN and Bluetooth interfaces.

- Note that, for those who use NXP's EVK with Murata's uSD-M2 adapter and M.2 EVBs, due to the interconnection, Murata limited the SDIO frequency to 50MHz. So even the 1.8V mode can't reach UHS.

NOTE: The M.2 specification is based on 1.8V. However, NXP i.MX6 legacy platforms only support a 3.3V VIO – requiring a M.2 "voltage override" option which sets the VIO at 3.3V. For more details refer to **Murata Hardware User Manual**. It should be noted that the NXP i.MX RT EVKs all run at the "correct" 1.8V VIO.

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13. I am looking for a Wi-Fi module to use for an IoT application, which is the recommended one?

If you need a basic IoT application in mind, which does not require very high speed data links, you can look at Murata **1DX** module. It provides 802.11n Wi-Fi and 4.2 Bluetooth.

In case you need lower power consumption (best of class), you can have a look at **1LV**. It provides 802.11a/b/g/n/"ac-friendly" and Bluetooth 5.0 capabilities.

For applications requiring higher throughput, such as for voice/audio/video streaming, Murata modules **1MW** (SDIO based) or **1CX** (PCIe based) will be more suitable.

You can also visit the **Murata wireless modules page** for details and comparisons.

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14. I want to select a Murata module that is going to be supported for a long time. Where can I find the planned support duration of the various Murata modules?

The longevity of Murata modules depends on two factors:

(1) The availability of Cypress' chipset,

(2) The demand for the module from customers.

As long as Cypress continues to manufacture the chipset, and there is customer's demand for the module, the module will be in active production and support. There is no hard longevity period for the Murata modules.

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15. What software components are maintained in the Murata github?

The Murata github maintains the following components:

i. **meta-murata-wireless:** Murata's customized Yocto layer which patches NXP's i.MX BSP baseline release. Also includes automated script files for initializing Linux machine and building specific Linux image for selected target.

ii. **cyw-fmac:** Contains the backport tool source used to backport the "fmac" driver and the actual WLAN "fmac" driver code.

iii. **cyw-fmac-fw:** WLAN production firmware files (including any applicable CLM blob
files)

iv. **cyw-fmac-nvram:** WLAN NVRAM files (customized by Murata)

v. **cyw-fmac-utils-imx32:** "wl" tool binary pre-compiled for i.MX 32-bit.

vi. **cyw-fmac-utils-imx64:** "wl" tool binary pre-compiled for i.MX 64-bit.

vii. **cyw-bt-patch:** Bluetooth patchfiles (*.hcd) to configure BT core.

viii. **cyw-fmac-v4.12-orga:** This is deprecated and should not be used.

ix. **qca-linux-calibration:** This is deprecated and should not be used.

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16. What is the distinction between a Murata module, a Murata EVB and an EVK?

In the Murata Wireless context, modules are Wi-Fi/BT components manufactured by Murata that are procured (in large batches) and used by OEMs (Original Equipment Manufacturers) in their final products. These are packaged in small shielded form factor, for surface mounting on PCBs (Printed Circuit Boards), and provide particular host interfaces (such as SDIO for WLAN and UART for Bluetooth).
You can find out more about Murata modules **here**

EVBs (Evaluation Boards) are mainly used during development phase. These are small PCBs that include the Wi-Fi/BT module as well as circuitry and logic to enable additional capabilities, such as industry standard plug-in interfaces (e.g. SD, M.2), reference certified trace antennas, UFL connectors, comprehensive test points etc. These bring multiple benefits to the OEM developers, as they can easily evaluate different professionally designed and proven Wi-Fi/BT solutions – just by switching the EVBs, allowing them to focus on core application, lower risks and costs as well as shorten time to market. Murata has partnered with Embedded Artists AB to bring EVBs for the modules to the market. You can find more information about Embedded Artists M.2 EVBs here.

EVKs (Evaluation Kits), in the Murata wireless context, typically refer to i.MX platform hardware. These run Linux/FreeRTOS and provide interface(s) to plug-in Murata EVBs for development. These are fully capable development systems containing MCU/MPU, memory, flash, various interfaces etc.

Given below is an example:

		
Murata Type 1LV module	Type 1LV M.2 EVB	Type 1LV M.2 EVB connected to an NXP i.MX 6UL EVK via uSD-M.2 Adapter

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17. What are the basic differences between the various Murata modules and associated EVBs?

Refer to the table below:

Module EVB	 1DX	 1LV	 1MW	 1CX
Cypress chipset	CYW4343W	CYW43012	CYW43455	CYW4356
Wi-Fi support	802.11 b/g/n	802.11 a/b/g/n/acfriendly™	802.11 a/b/g/n/ac	802.11a/b/g/n/ac 2x2 MIMO
Bluetooth support	BT/BLE 4.2	BT/BLE 5.0	BT/BLE 5.0	BT/BLE 5.0
WLAN Interface	SDIO 2.0 SDR25@50MHz	SDIO 3.0 SDR40@80MHz	SDIO 3.0 SDR100@200MHz, DDR50@50MHz	PCIe
Bluetooth interface	4-wire UART @ 3MBaud	4-wire UART @ 3MBaud	4-wire UART @ 3MBaud	4-wire UART @ 3MBaud
Module form factor	6.95 x 5.15 x 1.1 mm	10.0 x 7.2 x 1.4mm	7.9 x 7.3 x 1.1mm	11.5 x 8.8 x 1.05mm
EVB Form factor	22 x 44 mm	22 x 44 mm	22 x 44 mm	22 x 30 mm
Integrated trace antenna	Yes	Yes	Yes	No
UFL connector	1	2	1	2
Interface voltage (Vdc for VIO)	1.8 V or 3.3 V	1.8 V	1.8 V or 3.3 V	1.8 V or 3.3 V
Target application	Industrial IoT, Smart Home, Sensor Network, Gateway	Industrial IoT, Smart Home, Sensor Network, Gateway	Industrial IoT, Smart Home, Audio/ Video/ Voice, Gateway	Industrial IoT, Smart Home, Audio/ 4K Video/ Voice, Gateway

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18. How can I proceed with FCC certification using Murata Wi-Fi modules?

The customer has three methods of approaching certification (in ascending order of difficulty):

i. **Integration of Pre-certified modules:** The FCC requirement for reusing a modular certification includes adding specific label and user manual statements. For a specific module a user shall look for FCC ID installation information in the corresponding datasheet or user guide and check with the TCB test lab for guidance as well.

ii. **Integration of Reference-certified modules:** There are two options to integrate as Murata reference certified module into the user host device.

   a. **Fully adopt Murata reference antenna design:** In this case, the host device integrates the pre-certified module and copies the Murata antenna design exactly. Many of the FCC testing can be reused as-is so the host device certification could be quite straightforward.

   b. **Use custom Antenna Design:** If the host device uses a different antenna design pattern and peak gain, or uses an external antenna, it falls into socalled class II permissive changes. The radiated emission tests must be performed again to obtain a new FCC ID for this host device. Most conducted RF test results may still be reused to reduce the test cost. Customer shall check with the selected test lab for details.

iii. **Integration of non-certified modules:** If the host installs a Murata module that does not have a reference antenna available, the module requires a full regulatory certification.

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19. Where can I find the Bluetooth driver for my Murata Wi-Fi/BT module?

The Murata Wi-Fi/BT modules work with the HCI UART driver included with the BlueZ stack and do not need any separate driver. As long as you have the ‘hciattach’ tool in your system and the Murata Bluetooth patchfile in /etc/firmware, you can load the driver and use Bluetooth.

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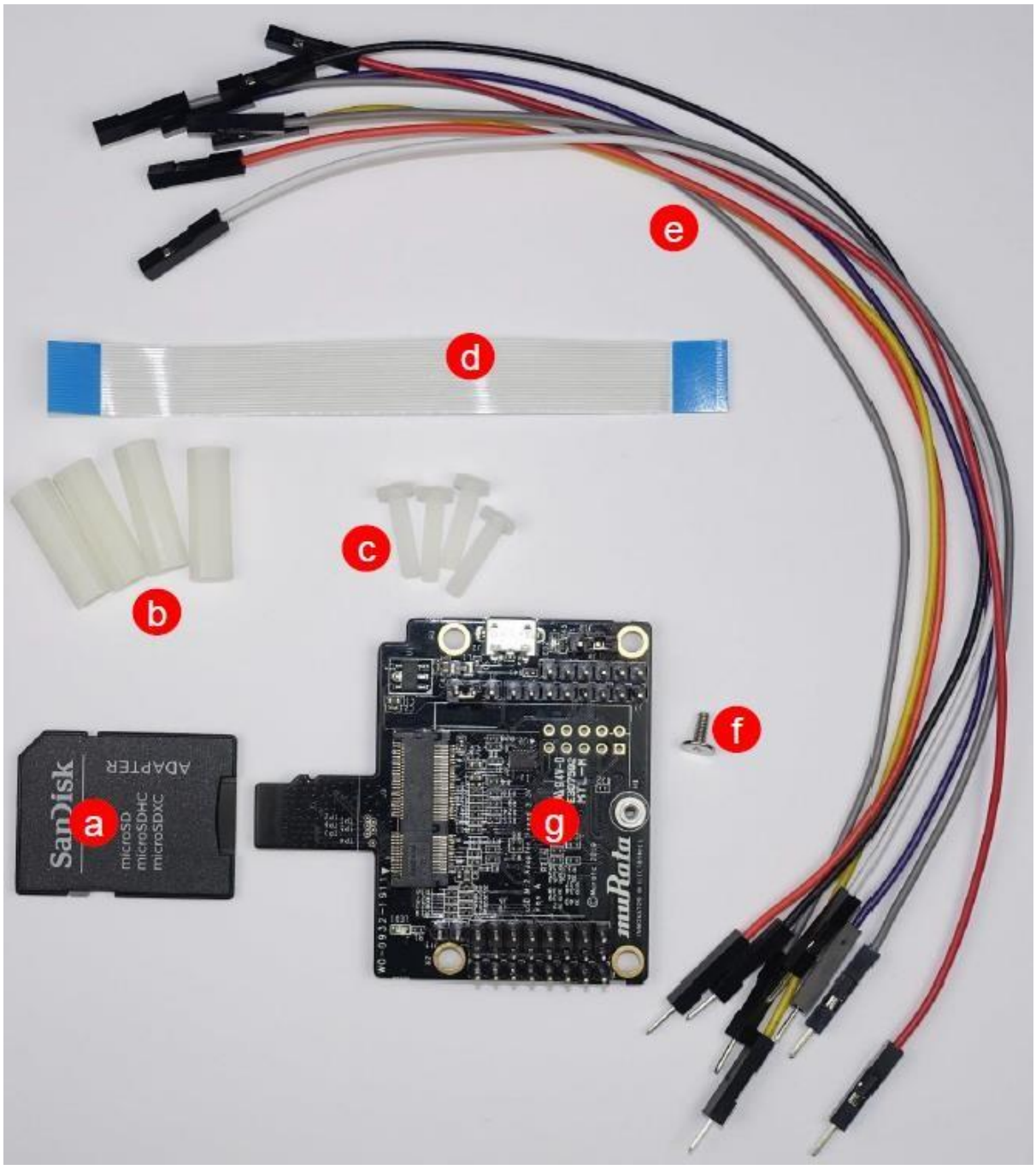
20. Where can I buy the Murata uSD-M.2 adapter and what comes in the box?

Go to the product page on **Murata website** -You will find Purchasing information there.

The Murata uSD-M.2 adapter kit contains the following:



a	1 x MicroSD to SD card adapter
b	4 x 19mm M3 stand offs (nylon)
c	4x M3 screws (nylon)
d	1x 75mm 20-pos, 0.5mm pitch flat/flex cable
e	13 x 200mm long male-to -female jumper cables (compatible wit
f	M.2 screw for attaching Wi-Fi/Bluetooth M.2 Evaluation Board (E
g	uSD-M.2 Adapter (Revision A)

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21. Where to place the FMAC FW and associated files for correct boot up of board with Murata module?

The following must be accessible on the board for Murata modules to operate correctly:

i. FMAC WLAN firmware:

The WLAN firmware should be in **/lib/firmware/brcm/** folder.

The naming convention for the firmware is:

"brcmfmac"+<CYW number>+"-sdio" or "-pcie"+".bin".

(e.g. *brcmfmac43455-sdio.bin* for 1MW)

ii. CLM blob:

The regulatory conformance file should be in **/lib/firmware/brcm/** folder.

The naming convention for the CLM blob is:

"brcmfmac"+<CYW number>+"-sdio" or "-pcie"+".clm_blob".

(e.g. *brcmfmac43455-sdio.clm_blob* For 1MW)

iii. NVRAM file:

Module/chipset configurations and default RF parameters file should be in **/lib/firmware/brcm/** folder.

The naming convention for the NVRAM file is:

"brcmfmac"+<CYW number>+"-sdio" or "-pcie"+".txt".

(e.g. *brcmfmac43455-sdio.txt* for 1MW)

iv. Bluetooth patchfile:

The Bluetooth patchfile should be in **/etc/firmware/** folder.

The naming convention for the Bluetooth patchfile is:

"BCM"+<Chip ID>+<Chip version>"."+<Module name>+".hcd".

(e.g. BCM4345C0.1MW.hcd for 1MW)

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22. Where can I find the specifications for implementing the M.2 interface described in the datasheet for the Wi-Fi/BT 1MW M.2 module?

Please refer to the **M.2 primer package**.

It includes full M.2 documentation in addition to M.2 interface schematic.

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23. In the M.2 specifications, what is the difference between pin#20 (BT_HOST_WAKE_L) and pin#42 (BT_DEV_WAKE_L)?

BT_HOST_WAKE_L (3.3V VIO) is driven (active low) by the chipset/module (such as the 1MW) to the host. It allows the MPU to power-save (go idle), leaving BT core on chipset active for next “wake up sequence”. BT_DEV_WAKE (active high – 1.8V VIO) is a “wake up” signal for chipset/module driven by host. It allows BT core to go idle (deep sleep mode). Both signals are configured/controlled by BT stack.

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24. I used 3.3 V VIO for testing Murata module Type 1MW on i.MX6UL EVK. Will I be able to test with 1.8 V VIO by configuring the uSD-M.2 adapter?

You will need to rebuild the image for 1.8 V VIO operation, in addition to setting up the uSD-M.2 adapter (remove jumper J12).

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25. Why do most Murata modules support two separate VIO levels (3.3V and 1.8 V)?

Since Murata works closely with NXP i.MX platforms, the supported voltage levels are in line with those of the i.MX platforms. NXP i.MX platforms support both 3.3 V and 1.8 V VIO (some support only one, but most of them support both). This is primarily to provide the users with flexibility in their design. Both 3.3V and 1.8V VIO has their merits, and the decision to use one over the other is dependent on the use case.

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26. Which Murata modules support SDIO UHS mode?

Murata module **Type 1MW** supports SDIO UHS mode when operated in 1.8 V VIO.

However, when using uSD-M2 adapter, the maximum SDIO clock frequency is only 50MHz for both 1.8V and 3.3V VIO. For UHS mode support (i.e. MAX SDIO clock is 200 MHz for Type 1MW) and for comprehensive signal support, Murata recommends the **Embedded Artists' i.MX Developer Kits**.

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27. I see Type 1LV is “ac-friendly”. What does it mean?

IEEE 802.11ac full-compliance requires support for 40 MHz and 80 MHz channel bandwidths. Type 1LV 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.

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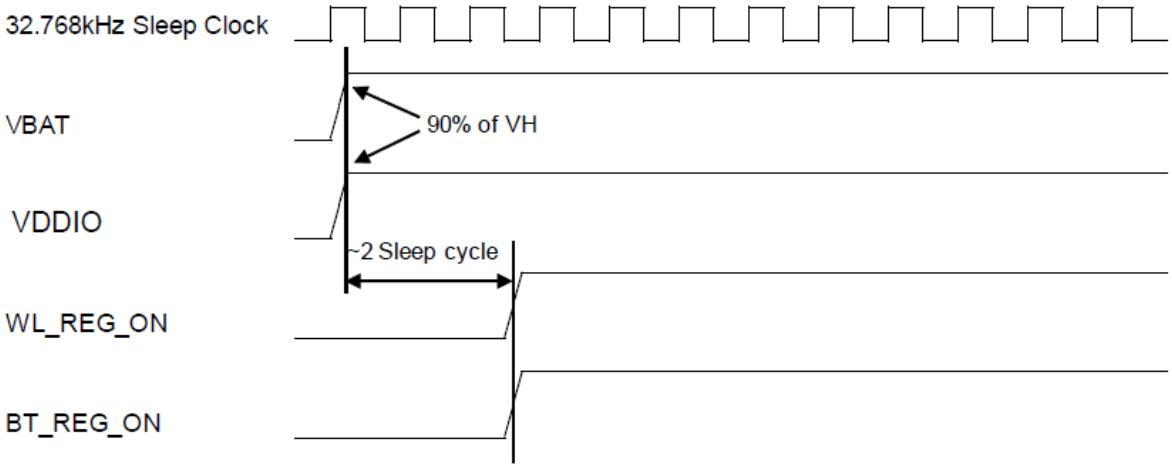
28. What is the Power ON sequence for Murata modules?

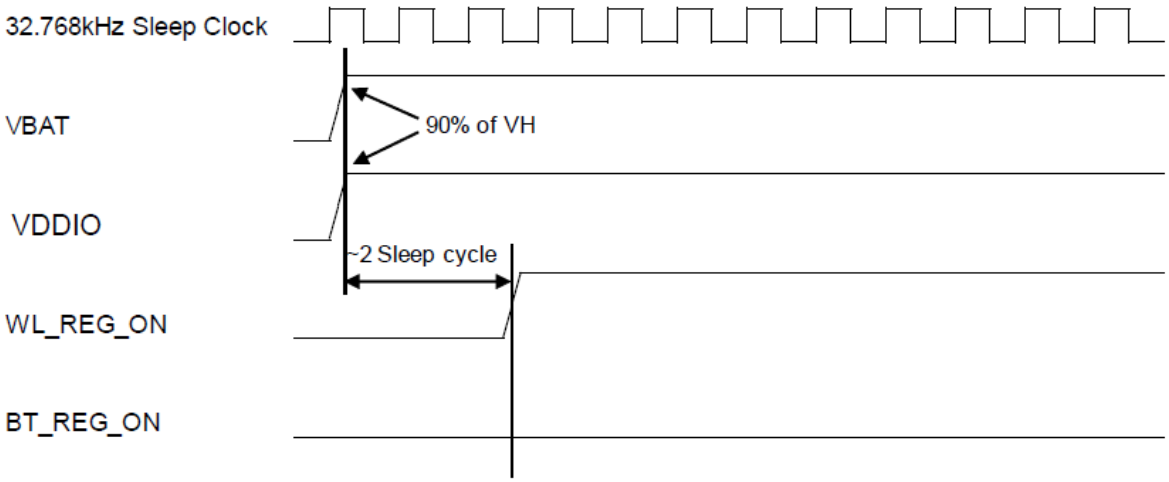
All currently listed Murata modules (1DX, 1MW, 1LV, 1CX) require the following Power On sequence for various configurations:

- VBAT should not rise 10%-90% faster than 40 microsecond.
- VBAT should be up before or at the same time as VDDIO/VIO. VDDIO/VIO should NOT be present first or be held high before VBAT is high.

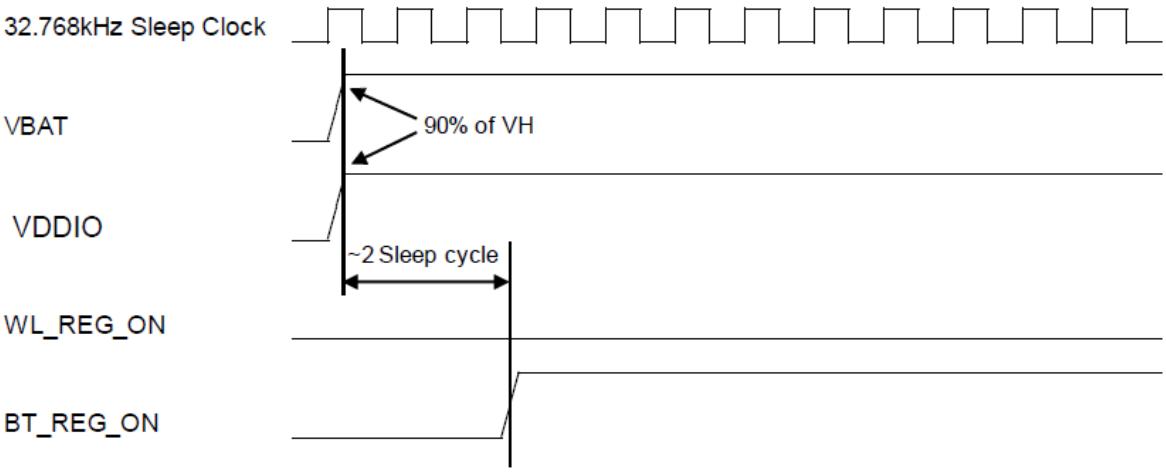
Power On Sequence for WLAN ON and BT ON



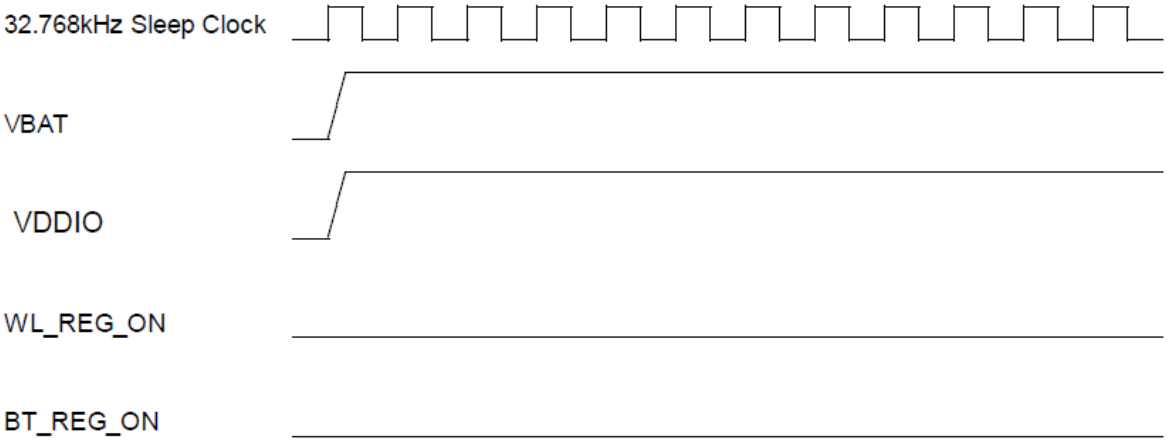
Power On Sequence for WLAN ON and BT Off



Power On Sequence for WLAN OFF and BT ON



Power On Sequence for WLAN OFF and BT OFF



N.B. For Power On sequence of other Murata Wi-Fi/BT modules, please refer to the respective datasheet.

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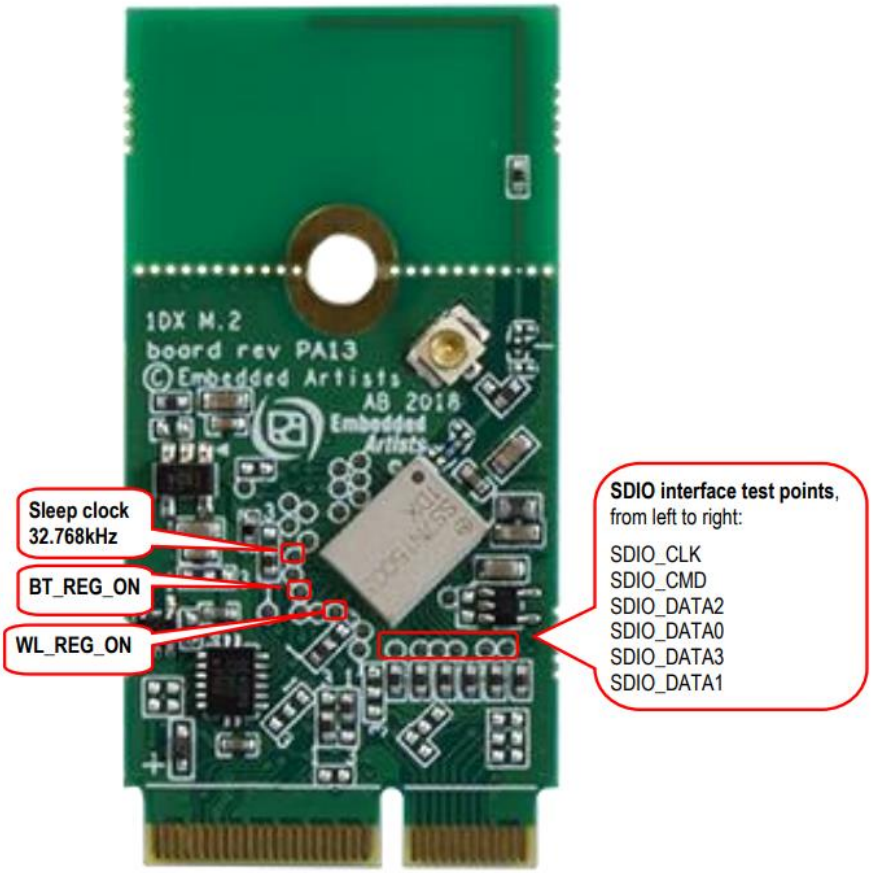
29. What are the test points available on the 1DX module?

There are multiple test points available on the Embedded Artists' 1DX module, which can be probed for debugging purpose. These are shown below:



*Credit: Image taken from Embedded Artists' **1DX datasheet**.*

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30. How do I override the VDDIO level on 1DX module?

The M.2 standard specifies 1.8V logic level on several of the data and control signals. However, it is possible to override the voltage level for these signals to 3.3V, via the pin 64. Just apply a 3.3V/100mA supply to pin 64.

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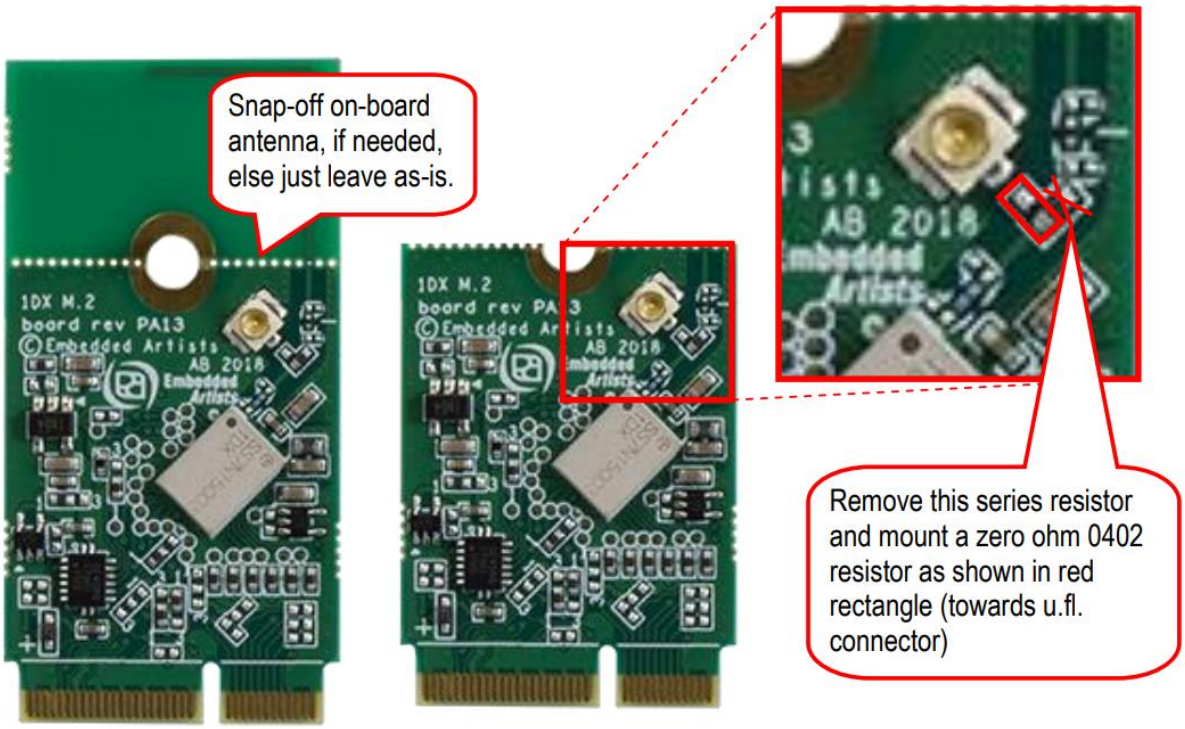
31. How do I override the PCB trace antenna in 1DX module?

If you want to use an external antenna connected to the on-board UFL connector, you can redirect the antenna connection by removing one zero ohm 0402 resistor, as shown below. The on-board trace antenna can be left as-is, or can be snapped off.



*Credit: Image taken from Embedded Artists' **1DX datasheet**.*

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32. What type of performance can I expect from the 1DX module's on-board trace antenna?

The 1DX module's on-board trace antenna is of type monopole. The laboratory measured efficiency for the antenna (both as standalone and mounted on an i.MX OEM carrier board) are as shown below:

Condition	Frequency [MHz]			Average dB	Average %
	2400	2442	2484		
M.2 module mounted on reference carrier board	-2.5	-2.3	-2.2	-2.3	58.4
M.2 module standalone	-2.9	-2.8	-2.7	-2.8	52.3

The table below lists peak gain:

Condition	Frequency [MHz]			Max dBi
	2400	2442	2484	
M.2 module mounted on reference carrier board	0.0	-0.1	0.1	0.1
M.2 module standalone	-0.5	-0.1	0.2	0.2

*Date source: Embedded Artists' **1DX datasheet**.*

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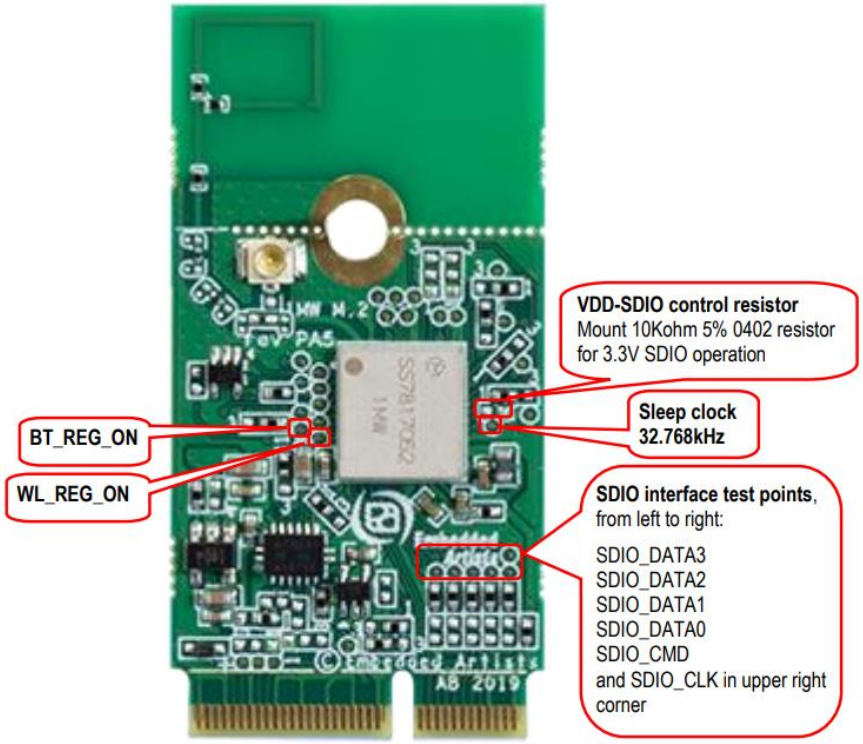
33. What are the test points available on the 1MW module?

There are multiple test points available on the Embedded Artists' 1MW module, which can be probed for debugging purpose. These are shown below:



*Credit: Image taken from Embedded Artists' **1MW datasheet**.*

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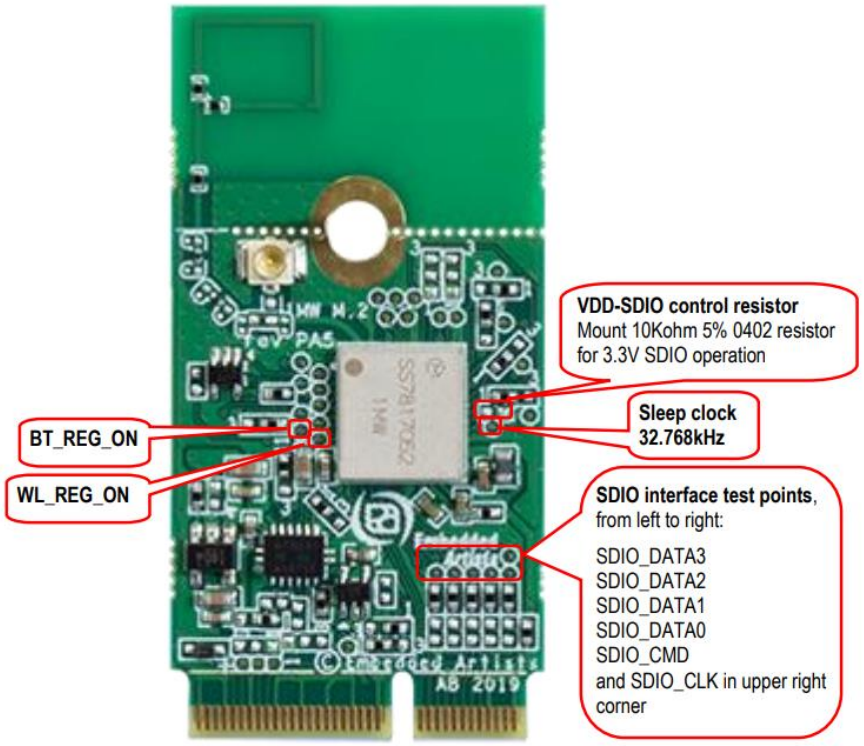
34. How do I override the VDDIO level on 1MW module?

The M.2 standard specifies 1.8V logic level on several of the data and control signals. However, it is possible to override the voltage level for the 1.8V signals via pin 64. Apply a 3.3V / 100 mA supply to pin 64 in order to get 3.3V voltage level on all data and control signals.

Note that it is not enough to connect a 3.3V supply to pin 64. The VDD-SDIO control resistor must also be mounted (10Kohm, 5%, 0402 resistor), see the image below for location of this resistor.

Note that using the 3.3V VIO option will limit SDIO clock to 50 MHz, thereby limiting throughput. Running at 1.8V VIO will support up to 200 MHz SDIO clock which is ultimately needed for maximum 802.11ac throughput.



*Credit: Image taken from Embedded Artists' **1MW datasheet**.*

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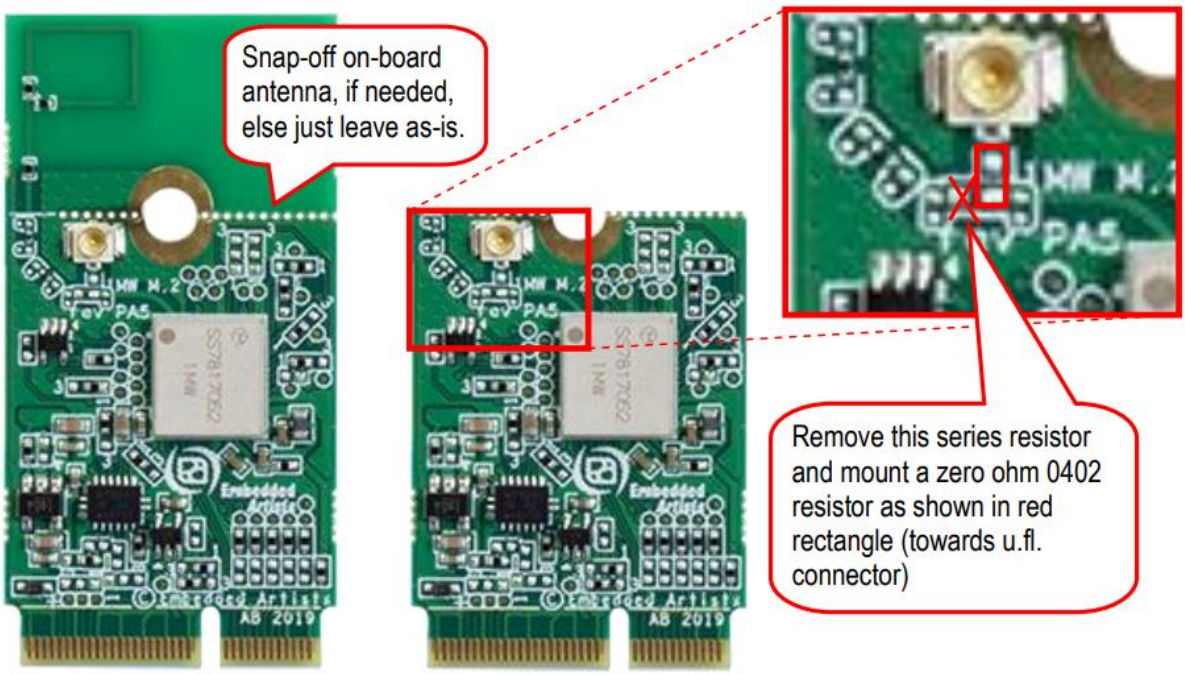
35. How do I override the PCB trace antenna in 1MW module?

If you want to use an external antenna connected to the on-board UFL connector, you can redirect the antenna connection by removing one zero ohm 0402 resistor, as shown below. The on-board trace antenna can be left as-is, or can be snapped off.



*Credit: Image taken from Embedded Artists' **1MW datasheet**.*

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36. What type of performance can I expect from the 1MW module's on-board trace antenna?

The 1MW module's on-board trace antenna is of type monopole. The laboratory measured efficiency for the antenna (both as standalone and mounted on an i.MX OEM carrier board) are as shown below:

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
1MW M.2 module mounted on iMX OEM Carrier Board	-5.5	-5.3	-5.2	-6.3	-5.7	-6.5	-5.3	-6.1	29.2	24.3
1MW M.2 module standalone	-4.6	-4.6	-4.6	-5.4	-5.2	-5.2	-4.6	-5.3	34.6	29.7

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
1MW M.2 module mounted on iMX OEM Carrier Board	-2.3	-2.0	-1.7	-2.7	-1.3	-1.2	-1.7	-1.2
1MW M.2 module standalone	-1.7	-1.5	-1.5	-3.0	-2.5	-2.8	-1.5	-2.5

*Date source: Embedded Artists' **1MW datasheet**.*

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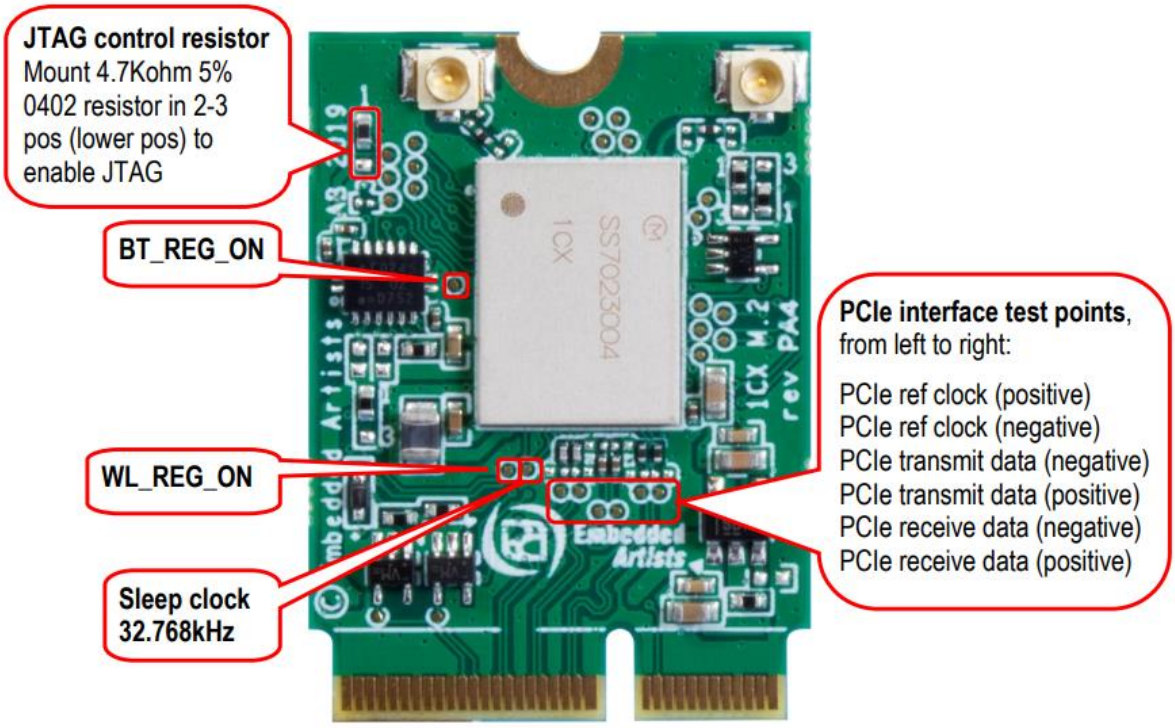
37. What are the test points available on the 1CX module?

There are multiple test points available on the Embedded Artists' 1CX module, which can be probed for debugging purpose. These are shown below:



*Credit: Image taken from Embedded Artists' **1CX datasheet**.*

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38. How do I override the VDDIO level on 1CX module?

The M.2 standard specifies 1.8V logic level on several of the data and control signals. However, it is possible to override the voltage level for these signals to 3.3V, via the pin 64. Just apply a 3.3V/100mA supply to pin 64.

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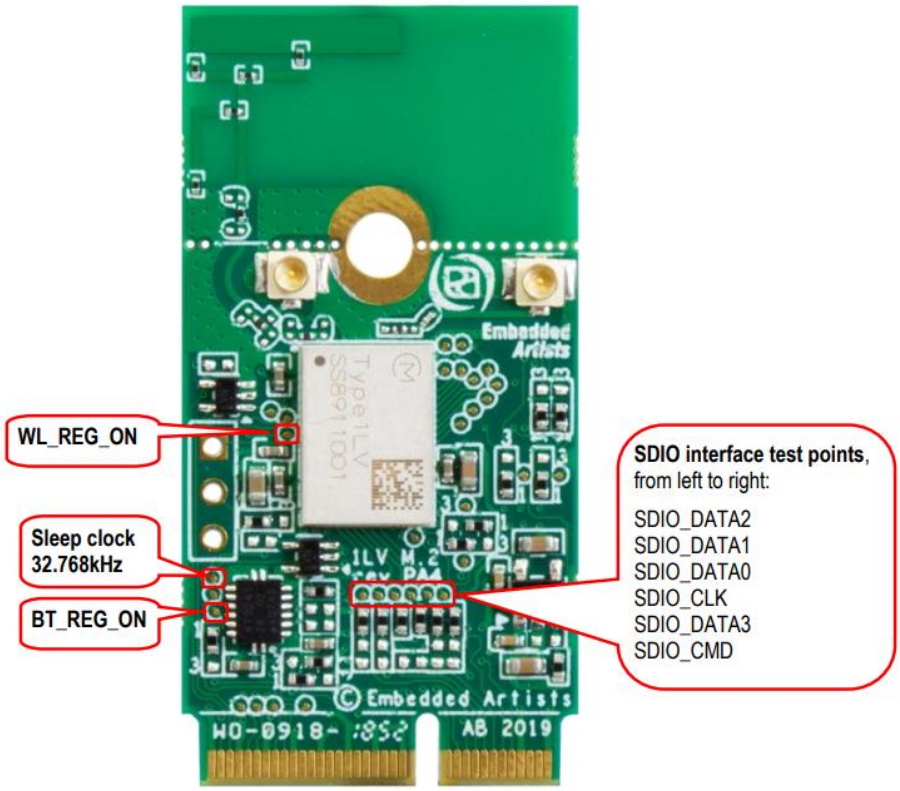
39. What are the test points available on the 1LV module?

There are multiple test points available on the Embedded Artists' 1LV module, which can be probed for debugging purpose. These are shown below:



*Credit: Image taken from Embedded Artists' **1LV datasheet**.*

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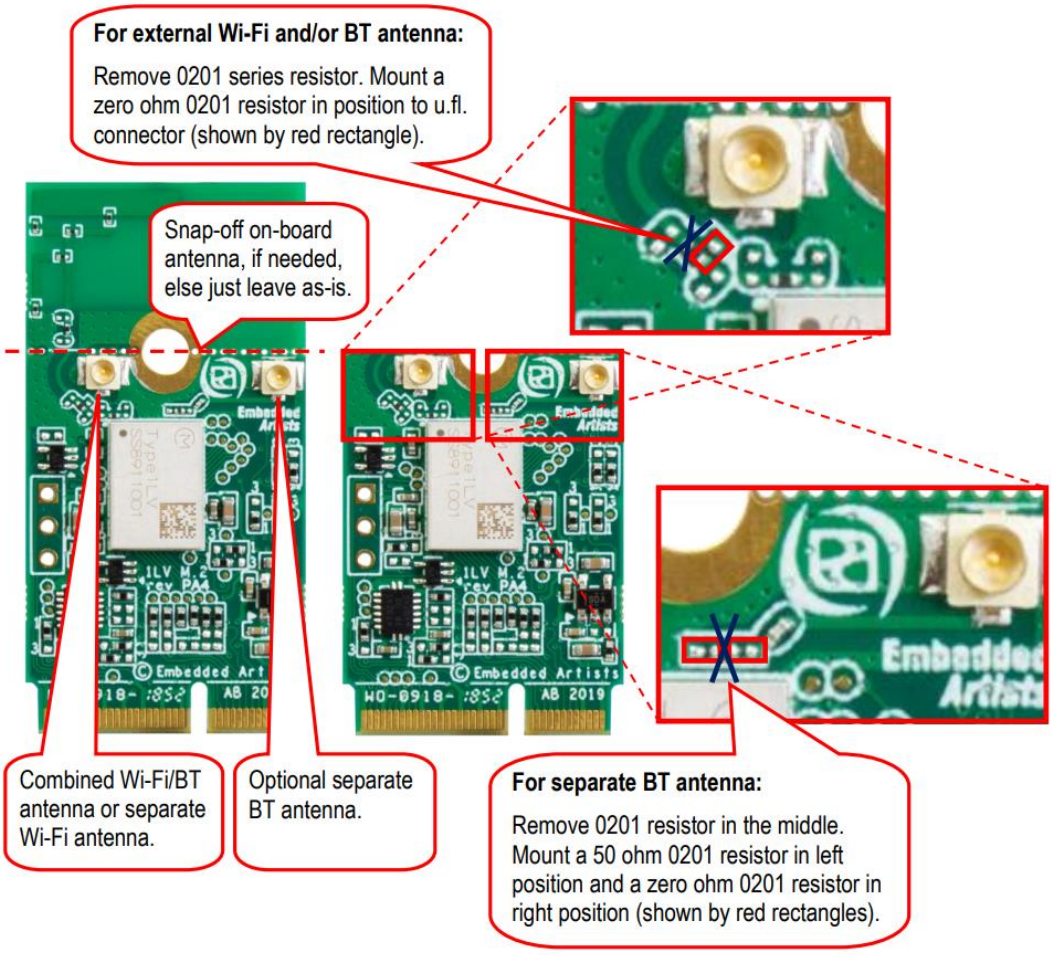
40. How do I override the PCB trace antenna in 1LV module?

If you want to use an external antenna connected to the on-board UFL connector, you can redirect the antenna connection by removing one zero ohm 0402 resistor, as shown below. The on-board trace antenna can be left as-is, or can be snapped off.

The left UFL antenna will be a combined Wi-Fi/BT antenna by default. However, it is possible to separate the Wi-Fi and BT antenna with some hardware rework. Once the rework is done (as per the image below), the right UFL connector becomes the BT antenna connector, while the left UFL connector becomes the Wi-Fi antenna connector.



*Credit: Image taken from Embedded Artists' **1LV datasheet**.*

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41. What type of performance can I expect from the 1LV module's on-board trace antenna?

The 1LV module's on-board trace antenna is of type monopole. The laboratory measured efficiency for the antenna (both as standalone and mounted on an i.MX OEM carrier board) are as shown below:

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
1LV M.2 module mounted on iMX OEM Carrier Board	-3.4	-3.3	-3.0	-3.9	-3.6	-4.2	-3.2	-3.9	47.8	40.6
1LV M.2 module standalone	-3.1	-3.1	-3.0	-3.5	-3.4	-3.5	-3.1	-3.5	49.4	45.0

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
1LV M.2 module mounted on iMX OEM Carrier Board	-0.4	-0.1	0.3	0.8	1.4	-0.2	0.3	1.4
1LV M.2 module standalone	-0.2	-0.2	-0.1	-0.8	-0.6	-1.2	-0.1	-0.6

*Date source: Embedded Artists' **1LV datasheet**.*

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42. What external sleep clock signals can be applied to Murata modules?

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

Clock Specification	
Frequency	32.768 kHz
Frequency accuracy	±200 ppm
Duty cycle	30 - 70%
Clock jitter	<10000 ppm
Voltage level	3.3V logic, according to M.2 standard

*Date source: Embedded Artists' **1LV datasheet**.*

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43. What precaution should I take while handling a Murata module?

Murata M.2 modules come without any case or box, and all components are exposed for finger touches. Therefore, in addition to be careful not to damage any components, extra attention must be paid to ESD (Electrostatic Discharge) precaution. Use of static-free workstation and grounding strap are suggested. The module should be handled by qualified personnel only.

It is good practice 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, warranty does not cover boards damaged by ESD.

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44. How much current consumption can I expect on 1DX module?

Refer to the following table for Wi-Fi current consumption:

CONDITION:

- **VBAT = 3.6 V**
- **VDDIO = 3.3 V**
- **WL_REG_ON = HIGH**
- **BT_REG_ON = LOW**

		Vbat: 3.6V, VIO: 3.3V, 25deg.C	(Typ)
Mode	Rate	Vbat (mA)	VIO (uA)
Sleep Mode			
Leakage (off)	N/A	0.005	1
Sleep (Idle)	N/A	0.008	251
IEEE PS DTIM3	N/A	0.7	-
Active Mode			
Rx active (1024byte, 20usec interval)	11b 11Mbps	47	-
	11g 54Mbps	47	-
	11n MCS7	47	-
Tx (1024byte, 20usec interval)	11b@ 17dBm	320	-
	11g@ 13dBm	270	-
	11n@ 12dBm	260	-

Refer to the following table for Bluetooth current consumption:

CONDITION:

- **VBAT = 3.6 V**
- **VDDIO = 3.3 V**
- **WL_REG_ON = LOW**
- **BT_REG_ON = HIGH**

	Vbat: 3.6V, VIO: 3.3V, 25deg.C		(Typ)
Operation mode	Vbat	VIO	Unit
Bluetooth 2.1+EDR			
BDR DH5	28	-	mA
EDR 2DH5	25	-	mA
EDR 3DH5	25	-	mA
Bluetooth 4.0			
Sleep (Idle)	20	107	uA
Inquiry scan (1.28s)	275	180	uA
Tx @ 7.5dBm	34	-	mA
Rx	13.4	-	mA

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45. What are the typical TX output power levels for 1DX module?

The following TX output power levels are typically available at the module antenna port:

- Wi-Fi 2.4 GHz
  - 11b: 17 dBm
  - 11g: 13 dBm
  - 11n: 12 dBm
- Bluetooth: 8 dBm
- BLE: 8 dBm

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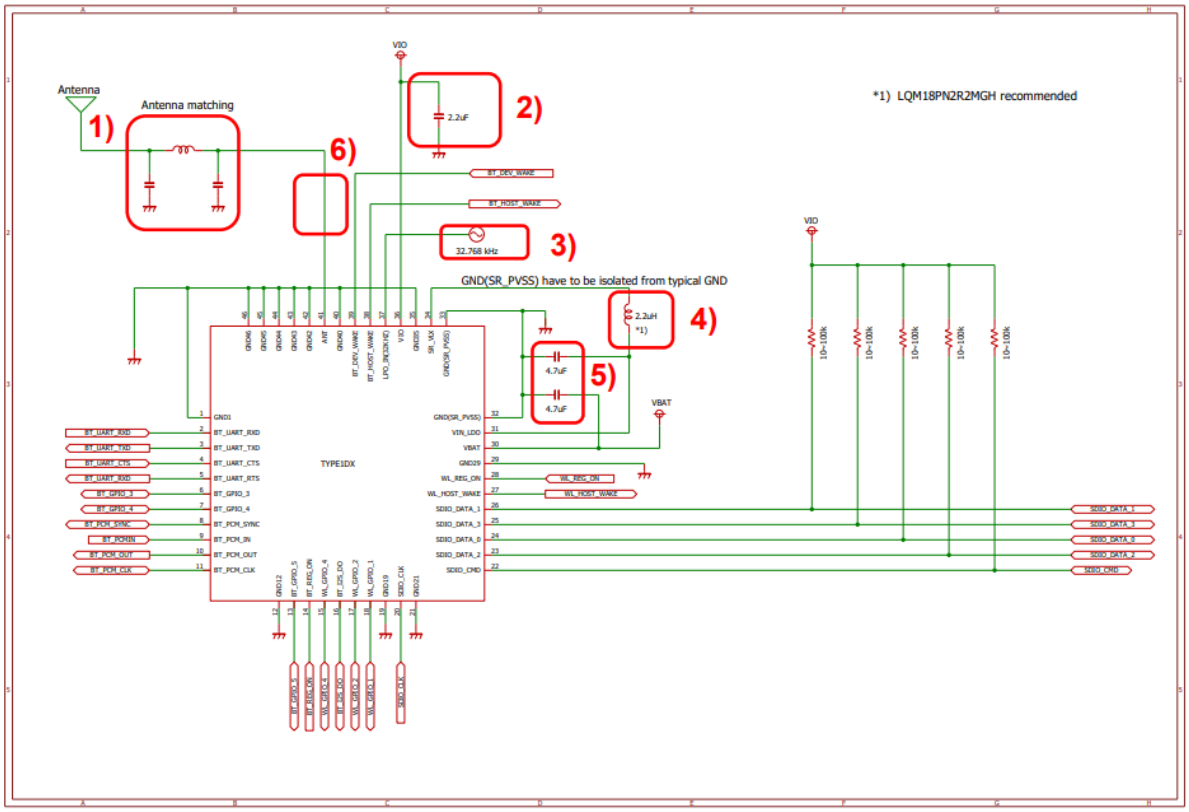
46. What external components do I need to integrate the 1DX module to my design?

Given below is an external component BOM (Bill of Materials) for 1DX module:

Block	Components	Value	pcs	Note
1)	L or C	TBD	3	Depend on PCB structure / design (for Antenna matching)
2)	C	2.2 uF	1	-
3)	LPO	32.768kHz	1	Pls see the required spec on the module datasheet
4)	L	2.2uH	1	LQM18PN2R2MGH recommended. (1.05 A, DCR=0.25 ohm)
5)	C	4.7uF	2	4.7uF
6)	Connector	-	1	In case of testing RF conductive performance. (right next to the module)



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47. How much current consumption can I expect on 1MW module?

Refer to the following table for Wi-Fi TX/RX current consumption:

CONDITION:

- **VBAT = 3.3 V**
- **VIO = 1.8 V**
- **WL_REG_ON = ON**
- **BT_REG_ON = ON**
- **FW version = 7_45_86**
- **Setting value: 1024 bytes, 20 usec interval**

2.4GHz

Mode	Rate	Tx current		Rx current[mA]*b)
		setting power	Tx current[mA]*a)	
11b	1Mbps	17	324	58
11g	6Mbps	16	331	58
11n	MCS0	14	304	58

*a) Setting value:1024byte, 20usec interval

*b) Carrier sense when no carrier present.

5GHz

Mode	Rate	Tx current		Rx current[mA]*b)
		setting power	Tx current[mA]*a)	
11a	6Mbps	15	301	75
11n(HT40)	MCS0	15	320	85
11ac(VHT80)	MCS0	12	328	110

*a) Setting value:1024byte, 20usec interval

*b) Carrier sense when no carrier present.

Refer to the following table for Wi-Fi sleep current consumption:

CONDITION:

- **VBAT = 3.3 V**
- **VIO = 1.8 V**
- **WL_REG_ON = ON**
- **BT_REG_ON = OFF**
- **FW version = 7.45.59.4**

Band	Mode	VBAT(3.3V) mA	VDDIO(1.8V) uA
-	IEEE Power save, Inter Beacon*a)	0.09	180
2.4GHz	IEEE Power Save:DTIM1*b)	1.77	180
	IEEE Power Save:DTIM3	0.62	180
	IEEE Power Save:DTIM5	0.43	180
5GHz	IEEE Power Save:DTIM1	0.91	180
	IEEE Power Save:DTIM3	0.40	180
	IEEE Power Save:DTIM5	0.30	180

*a). Idle, not associated, or inter-beacon.

*b). Beacon Interval = 100ms

Refer to the following table for Bluetooth (BLE) current consumption:

CONDITION:

- **VBAT = 3.3 V**
- **VIO = 1.8 V**
- **WL_REG_ON = OFF**
- **BT_REG_ON = ON**
- **Hcd file version: BCM4345C0_003.001.025.0139.0234.hcd**

Mode	VBAT(3.3V) uA	VDDIO(1.8V) uA
BLE Scan *a)	213	155
BLE Adv-Uncounnectable 1.00sec	98	155
BLE connected 1sec	42	159

*a) No devices present. A 1.28 second interval with a scan window of 11.25ms.

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48. What are the typical TX output power levels for 1MW module?

The following TX output power levels are defined in the Murata NVRAM file:

Wi-Fi:

2.4GHz

Mode	Data Rate	Output Power[dBm]
11b	1M	17.0
	2M	17.0
	5.5M	17.0
	11M	17.0
11g	6M	16.0
	9M	16.0
	12M	16.0
	18M	16.0
	24M	16.0
	36M	13.0
	48M	13.0
	54M	13.0
11n	MCS0	14.0
	MCS1	14.0
	MCS2	14.0
	MCS3	14.0
	MCS4	14.0
	MCS5	12.0
	MCS6	12.0
	MCS7	12.0

5GHz

Mode	Data Rate	Output Power[dBm]
11a	6M	15.0
	9M	15.0
	12M	15.0
	18M	15.0
	24M	15.0
	36M	13.0
	48M	13.0
	54M	13.0
11n HT20	MCS0	15.0
	MCS1	15.0
	MCS2	15.0
	MCS3	15.0
	MCS4	13.0
	MCS5	13.0
	MCS6	13.0
	MCS7	13.0
11ac VHT20	MCS0	15.0
	MCS1	15.0
	MCS2	15.0
	MCS3	15.0
	MCS4	13.0
	MCS5	13.0
	MCS6	13.0
	MCS7	13.0
	MCS8	13.0

Mode	Data Rate	Output Power[dBm]
11n HT40	MCS0	15.0
	MCS1	15.0
	MCS2	15.0
	MCS3	15.0
	MCS4	13.0
	MCS5	13.0
	MCS6	13.0
	MCS7	13.0
11ac VHT40	MCS0	15.0
	MCS1	15.0
	MCS2	15.0
	MCS3	15.0
	MCS4	13.0
	MCS5	13.0
	MCS6	13.0
	MCS7	13.0
	MCS8	10.0
	MCS9	10.0

Mode	Data Rate	Output Power[dBm]
11ac VHT80	MCS0	12.0
	MCS1	12.0
	MCS2	12.0
	MCS3	12.0
	MCS4	12.0
	MCS5	10.0
	MCS6	10.0
	MCS7	10.0
	MCS8	10.0
	MCS9	10.0

Bluetooth:

Condition:

- **VBAT = 3.3 V**
- **VIO = 1.8 V**
- **Hcd file version: BCM4345C0_003.001.025.0139.0234.hcd**

Frequency[MHz]	Output Power [dBm]		
	DH5	3DH5	BLE
2402	6.3	1.5	4.9
2440	6.0	2.0	5.1
2480	5.2	0.9	4.1

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49. How much current consumption can I expect on 1LV module?

Refer to the following table for Wi-Fi TX/RX current consumption:

CONDITION:

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

2.4GHz

Mode	Rate	Tx current		Rx current[mA]*b)
		setting power	Tx current[mA]*a)	
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	

*a) Setting value: 1024byte, 20usec interval.

*b) Carrier sense when no carrier present.

5GHz

Mode	Rate	Tx current		Rx current[mA]*b)
		setting power	Tx current[mA]*a)	
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	

*a) Setting value:1024byte, 20usec interval.

*b) Carrier sense when no carrier present.

Refer to the following table for Wi-Fi sleep current consumption:

CONDITION:

- **VBAT = 3.3 V**
- **VDDIO = 1.8 V**

- **WL_REG_ON = ON**
- **BT_REG_ON = OFF**
- **FW version = 13.10.271.57**

Band	Mode	VBAT(3.3V) mA	VDDIO(1.8V) uA
-	IEEE Power save, Inter Beacon*a)	0.024	120
2.4GHz	IEEE Power Save:DTIM1*b)	0.479	119
	IEEE Power Save:DTIM3	0.149	119
	IEEE Power Save:DTIM5	0.099	119
5GHz	IEEE Power Save:DTIM1	0.368	119
	IEEE Power Save:DTIM3	0.113	119
	IEEE Power Save:DTIM5	0.077	119

*a). Idle, not associated, or inter-beacon.

*b). Beacon Interval = 100ms

Refer to the following table for Bluetooth (BLE) current consumption:

CONDITION:

- **VBAT = 3.3 V**
- **VDDIO = 1.8 V**
- **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**

Mode	VBAT(3.3V) uA	VDDIO(1.8V) uA
BLE Scan *a)	121	44
BLE Adv-Uncounnectable 1.00sec	30	39
BLE connected 1sec	29	44

*a) No devices present. A 1.28 second interval with a scan window of 11.25ms.

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50. What are the typical TX output power levels for 1LV module?

The following TX output power levels are defined in the Murata NVRAM file:

Wi-Fi:

2.4GHz

Mode	Data Rate	Output Power[dBm]
11b	1M	17.0
	2M	17.0
	5.5M	17.0
	11M	17.0
11g	6M	17.0
	9M	17.0
	12M	16.0
	18M	16.0
	24M	16.0
	36M	15.0
	48M	15.0
	54M	14.0
11n	MCS0	17.0
	MCS1	17.0
	MCS2	17.0
	MCS3	16.0
	MCS4	15.0
	MCS5	15.0
	MCS6	14.0
	MCS7	13.0

5GHz

Mode	Data Rate	Output Power[dBm]
11a	6M	16.0
	9M	16.0
	12M	16.0
	18M	16.0
	24M	15.0
	36M	15.0
	48M	14.0
	54M	13.0
11n HT20	MCS0	16.0
	MCS1	16.0
	MCS2	16.0
	MCS3	15.0
	MCS4	15.0
	MCS5	14.0
	MCS6	13.0
	MCS7	12.0
11ac VHT20	MCS0	16.0
	MCS1	16.0
	MCS2	16.0
	MCS3	15.0
	MCS4	15.0
	MCS5	14.0
	MCS6	13.0
	MCS7	12.0
	MCS8	10.0

Bluetooth:

Condition:

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

Frequency[MHz]	Output Power [dBm]		
	DH5	3DH5	BLE
2402	9.4	5.0	5.0
2440	9.4	5.5	5.2
2480	9.1	5.7	5.3

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