Wi-Fi®/Bluetooth® (CYW) for i.MX

Linux User Manual - Rev. 9.1

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About This Document

The document describes in detail the Wi-Fi/Bluetooth solution offered by Murata for i.MX, in terms of usage and design.

The document uses NXP's i.MX 6/8 series-based Evaluation Kits (EVKs) as examples and all software referenced in the document are assumed to be used on such EVKs. Custom hardware-based solutions and /or unsupported Linux versions/software may require additional modifications and are outside the scope of this document.

Audience & Purpose

This document is targeted towards system developers of NXP i.MX application processor-based solutions, running Linux operating system.

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**: Embedded Artists AB 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 Introduction

Murata has partnered with NXP Semiconductors N.V. ⬀, Infineon Technologies ⬀ and Embedded Artists AB ⬀ to offer a complete Wi-Fi and Bluetooth connectivity environment for building world class Internet-connected products. The Murata Connectivity Modules enable developers to minimize the development time and effort for connectivity function implementation. This Linux User Manual provides details on building all necessary software for enabling Murata Wi-Fi/Bluetooth on reference NXP i.MX platforms. The latest release supports Linux 4.14.98 ⬀, Linux 5.4.47 ⬀, Linux 5.10.52 ⬀ and Linux 5.15.32 ⬀ BSP's for i.MX6/8. This manual details Murata's customized wireless Yocto layer which allows the user to easily build their desired i.MX image while pulling in the WLAN FMAC driver, configured/patched WPA supplicant & Hostapd, firmware files, NVRAM files, and Bluetooth patch files.

Table 2: Current NXP i.MX Platforms Supported

NXP i.MX EVK Part number	NXP i.MX EVK	Murata Modules Supported	Interconnect
MCIMX8QXP-CPU ⬀	i.MX 8QXP MEK	1XA	M.2
8MPLUSLPD4-EVK ⬀	i.MX 8MPLUS EVK	1DX[1], 1MW[2], 1LV, 2AE, 2BC, 2BZ, 1YN, 1XA	M.2 (WLAN Only)
MCIMX8M-EVKB ⬀	i.MX 8MQuad EVK	1CX[3], 1XA 1DX, 1MW, 1LV, 2AE, 2BC, 2BZ, 1YN,	1CX Soldered down, 1XA via M.2 1DX, 1MW, 1LV, 2AE, 2BC, 2BZ, 1YN via uSD-M.2 Adapter (WLAN Only)
8MMINILPD4-EVKB ⬀	i.MX 8M Mini EVK	1DX, 1MW, 1LV, 2AE, 2BC, 2BZ, 1YN, 1XA	1DX, 1MW, 1LV, 2AE, 2BC, 2BZ, 1YN via uSD-M.2 Adapter 1XA via M.2 (WLAN Only)
8MNANOD4-EVK ⬀	i.MX 8M Nano EVK	1DX, 1MW, 1LV, 2AE, 2BC, 2BZ, 1YN	1MW Soldered down 1DX, 1MW, 1LV, 2AE, 2BC, 2BZ, 1YN via uSD-M.2 Adapter
MCIMX6Q-SDB ⬀	i.MX 6Quad SDB	1DX, 1MW, 2AE, 2BC, 2BZ, 1YN	uSD-M.2 Adapter
MCIMX6UL-EVKB ⬀	i.MX 6UL EVK	1DX, 1MW, 1LV, 2AE, 2BC, 2BZ, 1YN	uSD-M.2 Adapter
MCIMX6ULL-EVK ⬀	i.MX 6ULL EVK[4]	1DX, 1MW, 1LV, 2AE, 2BC, 2BZ, 1YN	uSD-M.2 Adapter

A high-level connection Diagram for the Murata module interconnection (i.MX 6 platforms) is provided in **Figure 1**. All the Murata Wi-Fi/BT modules enabled by this release are shown. Murata enables this configuration by providing a newly designed uSD-M.2 Adapter board. Please refer to Murata User Guide ⬀, Murata uSD-M.2 Adapter Datasheet ⬀, and Murata Hardware User Manual ⬀ for more details.

> 🛑 Only i.MX6UL(L) EVK support 1.8V VIO signaling with J12 jumper on uSD-M.2 Adapter set to position 1-2. For more details on Wi-Fi throughput dependency on SDIO bus speed and hardware modifications necessary for 1.8V VIO signaling, please refer to the Murata Hardware User Manual ⬀.

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[1] This is a legacy module. Can use Type 1YN as suggested replacement.
[2] This is a legacy module. Can use 2AE/2BC as suggested replacement.
[3] This is a legacy module and no longer supported. Use Type 1XA as suggested replacement.
[4] i.MX 6ULL is used for evaluation of i.MX 6ULZ.

Figure 1: i.MX 6 EVK Wi-Fi/BT Interconnect Block Diagram

VBAT/GND via microSD

WLAN via microSD

SDIO_DATA0..3, SDIO_CLK, SDIO_CMD

Bluetooth via FFC

BT_UART_TX/RX/CTS/RTS (BT_PCM_IN/OUT/SYNC/CLK)

CTRL SIGNALS via FFC

WL_REG_ON, BT_REG_ON, WL_HOST_WAKE

NXP i.MX 6 EVK

Murata uSD-M.2 Adapter

Power WLAN BT, and CTRL via M.2

Embedded Artists' Wi-Fi/BT M.2 Module

1DX/1MW/1LV/2AE/ 2BC/2BZ/1YN

Signal names in parenthesis '()' are not connected on existing NXP i.MX 6 platforms
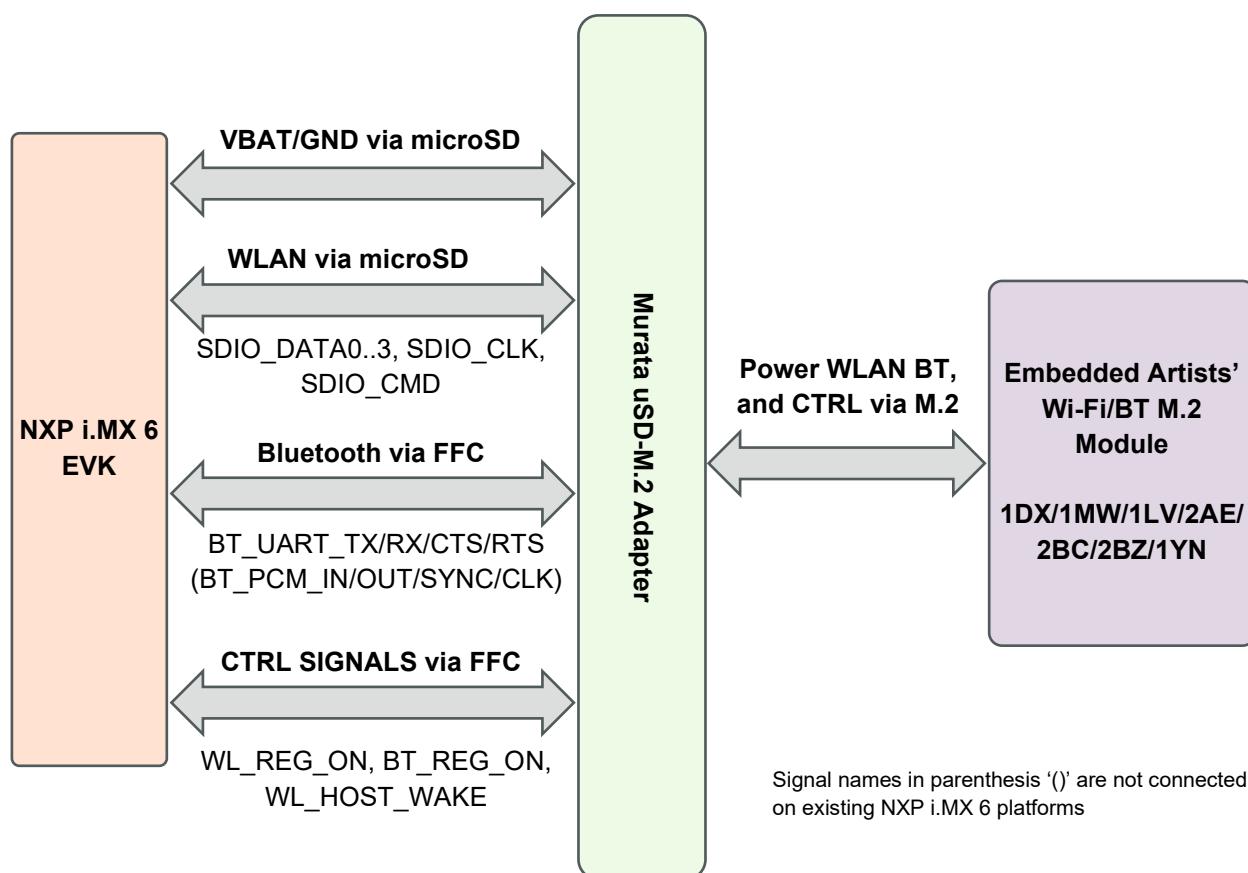
Figure 2 shows a simplified block diagram for the i.MX 8QXP MEK/8MQuad EVK Wi-Fi/BT interconnect. Currently, Type 1XA is supported with WLAN-PCIe interface.

No uSD-M.2 Adapter is used – just the Wi-Fi/BT M.2 EVB (Module).

Figure 2: i.MX 8QXP MEK or 8Mquad EVK Wi-Fi/BT PCIe Interconnect Block Diagram
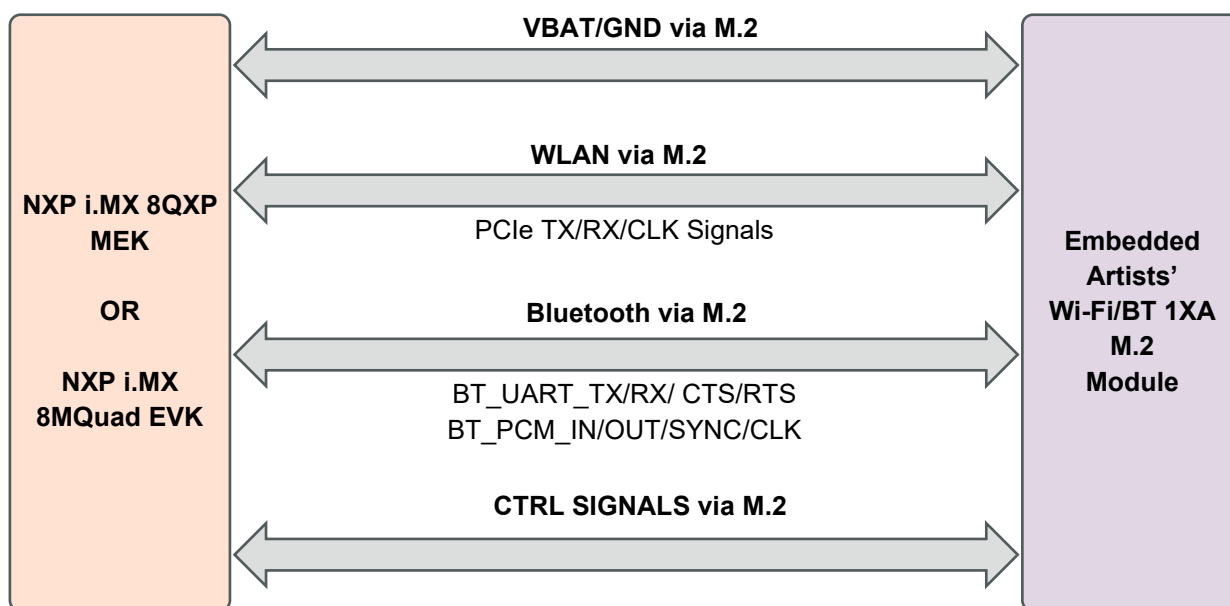
Figure 3 shows a simplified block diagram for the i.MX 8Mquad EVK Wi-Fi interconnect with Murata's uSD-M.2 Adapter option (with Embedded Artists' Wi-Fi/BT M.2 EVB). Only WLAN-SDIO based modules are supported in this configuration: 1MW, 1DX, 1LV, 2AE, 2BC, 2BZ and 1YN.

> 🛑 Only Wi-Fi is supported in this configuration.

Figure 3: i.MX 8MQuad EVK Wi-Fi/BT SDIO Interconnect Block Diagram
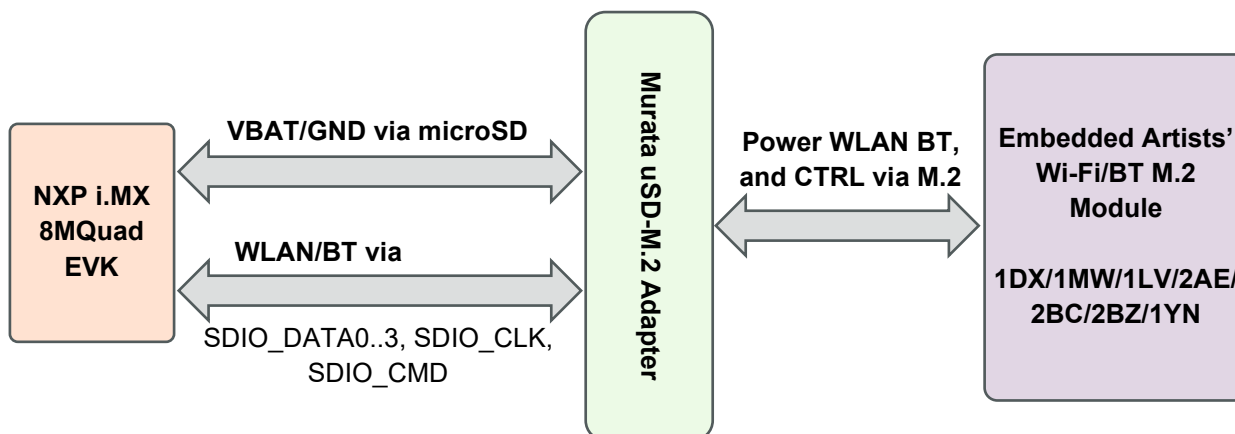
Figure 4 shows a simplified block diagram for the i.MX 8M Plus EVK Wi-Fi interconnect via the M.2 slot. Only WLAN-SDIO based modules are supported in this configuration: 1MW, 1DX, 1LV, 2AE, 2BC, 2BZ and 1YN. Note that only Wi-Fi is supported in this configuration.

> 🛑 Only Wi-Fi is supported in this configuration.

Figure 4: i.MX 8MPlus EVK Wi-Fi/BT Interconnect Block Diagram
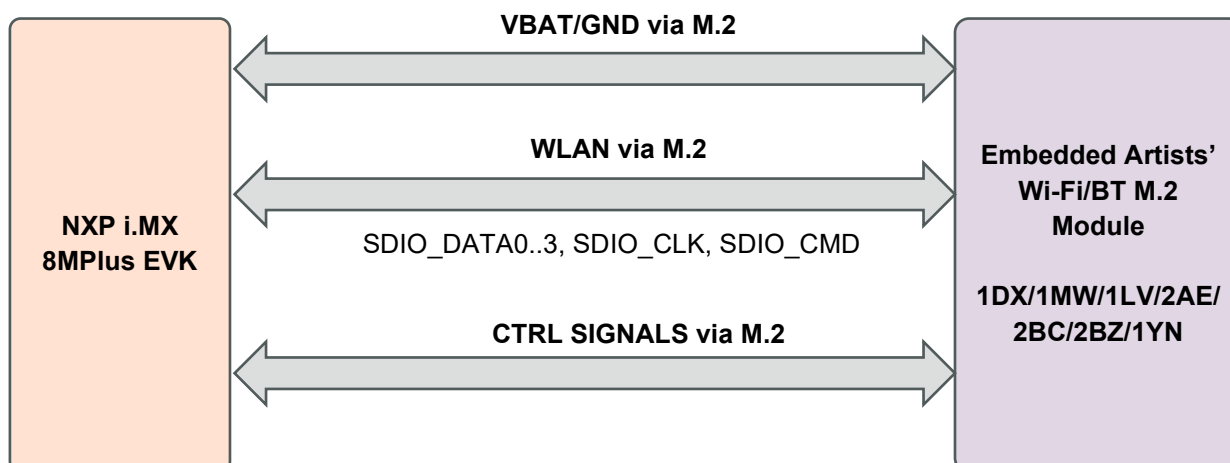
Figure 5 shows a simplified block diagram for the i.MX 8M Mini EVK Wi-Fi/BT interconnect via the M.2 slot. Currently, Type 1XA M.2 Module (WLAN Only) is supported with 2x2 802.11ac MIMO and WLAN-PCIe interface.

The NXP i.MX 8M Mini EVK does not bring out the Bluetooth signals to the M.2 connector – WLAN only.

Figure 5: i.MX 8M Mini EVK Wi-Fi/BT PCIe Interconnect Block Diagram
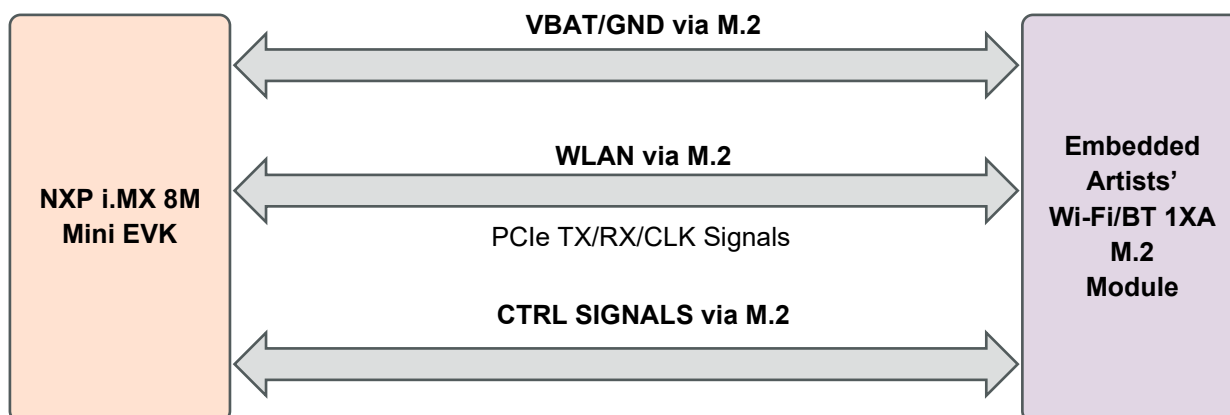
Figure 6 shows a simplified block diagram for the i.MX 8M Mini/Nano EVK interconnect with Murata's uSD-M.2 Adapter option (with Embedded Artists' Wi-Fi/BT M.2 EVB). Only WLAN-SDIO based modules are supported in this configuration: 1MW, 1DX, 1LV, 2AE, 2BC, 2BZ and 1YN. To properly support this (WLAN-SDIO VIO @1.8V; BT-UART VIO @3.3V) interconnect, Rev B1/B2 uSD-M.2 Adapter needs to be used given that it correctly level shifts the Bluetooth and WLAN/BT control signals between the M.2 EVB and the NXP i.MX 8M Mini EVK.

Figure 6: i.MX 8M Mini/Nano EVK Wi-Fi/BT SDIO Interconnect Block Diagram
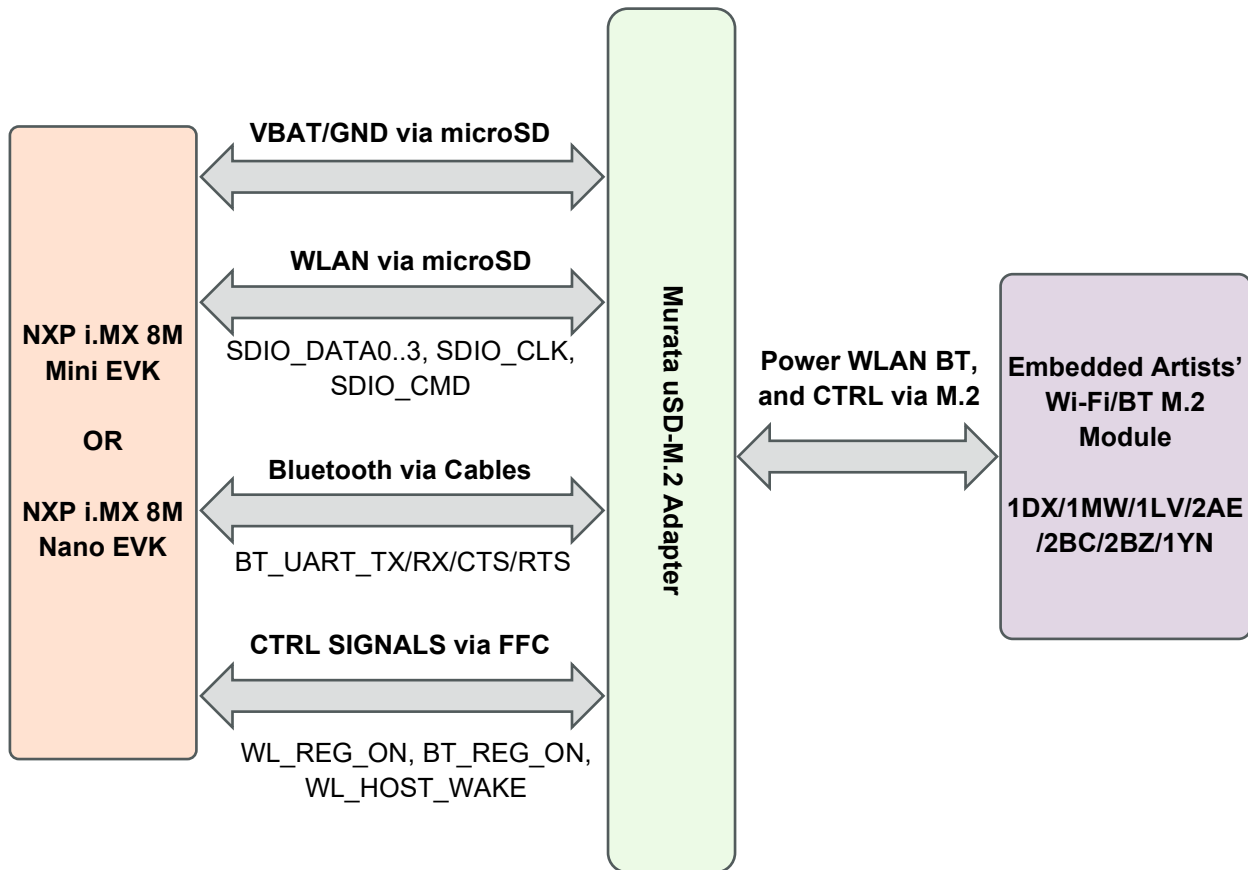
2 Murata's Customized i.MX Yocto Image Explained

2.1 Overview

The default 4.9.11 GA ⬀ BSP for i.MX6, Linux 4.9.88 ⬀ and Linux 4.9.123 ⬀ for i.MX6/8 integrate the legacy Infineon's WLAN "bcmdhd" driver and have limited Bluetooth support[5]. The new implementation of Infineon's WLAN driver is referred to as "FMAC". In NXP's Linux 4.14.98 ⬀, Linux 5.4.47 ⬀, Linux 5.10.52 ⬀ and Linux 5.15.32 ⬀ BSPs for i.MX6/8, FMAC has been integrated. Please note that there is a distinct difference between the "FMAC" driver, and "brcmfmac" open source community driver integrated into kernel.org Linux releases. The "FMAC" driver (as customized by Murata) is an official open source release from Infineon that is tested and verified. The "FMAC" release leverages the Linux Backports implementation to integrate the WLAN driver into the desired Linux kernel version.

Murata's customized Yocto layer "meta-murata-wireless" seamlessly disables the existing "bcmdhd" WLAN driver and pulls in the "FMAC" (officially supported) driver implementation. More specifically it provides the following enhancements/customizations:

- Pull Infineon "FMAC" driver and run backports tool during Yocto build to generate necessary driver modules.

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[5] Default BlueZ stack and Bluetooth driver is operational with Murata modules, but NXP default image does not include all the necessary or correct Bluetooth patch files.

- Additional/necessary patches to Infineon "FMAC" driver for i.MX implementation.

- i.MX Linux kernel customizations to support "FMAC" driver with OOB IRQ interrupts.

- WLAN production firmware files. For manufacturing test firmware (necessary for RF/regulatory testing), please contact Murata directly.

- Murata NVRAM files for correctly configuring WLAN RF.

- Example Bluetooth patch files.

- WL tool binary necessary for interoperability and RF testing.

- Hostapd (Version 2.9) configuration with specific patch release.

- Hostap-conf enablement.

- Hostap-utils enablement.

- WPA-supplicant (Version 2.9) configuration with specific patch release.

- Wi-Fi Direct (P2P) enablement.

There are six versions of "FMAC" currently supported: "v5.4 spiga", "v5.4 baragon", "v5.10 cynder", "v5.10 drogon", "v5.15 ebirah" and "v5.15 fafnir". "spiga", "baragon", "cynder", "drogon", "ebirah" and "fafnir" are the Infineon codenames denoting "FMAC" release version. "v5.4", "v5.10" and "v5.15" are the latest kernel versions supported by the releases (can be backported to kernel version 3.0). To abbreviate references to specific versions of "FMAC", Murata uses *just* the Infineon codename – i.e., "spiga", "baragon", "cynder", "drogon", "ebirah" or "fafnir".

> ✋ It is strongly recommended to use the latest "FMAC" release version: currently this is "ebirah"/"fafnir".

Murata's customized Yocto layer supports the following NXP i.MX EVKs as outlined in **Table 3**. "MACHINE=target" is a direct reference to Yocto build[6]. The "target" string is the keyword used to select hardware configuration for the build. With the newer EVKs (i.MX 8MQuad and i.MX 8M Mini), only certain kernel versions are supported.

Table 3: NXP i.MX EVK Part Number / Yocto (MACHINE) target / Kernel Version Matrix

NXP i.MX EVK Part #	NXP i.MX EVK	MACHINE=target	Kernel 4.14.98	Kernel 5.4.47	Kernel 5.10.52	Kernel 5.15.32
MCIMX8QXP-CPU ↗	i.MX 8QuadXPlus MEK	imx8qxpmek	✓	✓	✓	✓
8MPLUSLPD4-EVK ↗	i.MX 8MPlus EVK	imx8mp-lpddr4-evk	✓	✓	✓	✓
MCIMX8M-EVKB ↗	i.MX 8MQuad EVK	imx8mqevk	✓	✓	✓	✓
8MMINILPD4-EVKB ↗	i.MX 8M Mini EVK	imx8mmevk	✓	✓	✓	✓
8MNANOD4-EVK ↗	i.MX 8M Nano EVK	imx8mnddr4evk	✓	✓	✓	✓
MCIMX6Q-SDB ↗	i.MX 6Quad SDB	imx6qsabresd	✓	✓	✓	✓
MCIMX6UL-EVKB ↗	i.MX 6UL EVK	imx6ulevk	✓	✓	✓	✓
MCIMX6ULL-EVK ↗	i.MX 6ULL EVK	imx6ull14x14evk	✓	✓	✓	✓

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[6] Refer to Yocto Project User's Guide for your kernel version.

2.2 Murata GitHub: Cornerstone of "FMAC" Implementation

"THE CORNERSTONE IS THE FIRST STONE SET IN THE CONSTRUCTION OF A MASONRY FOUNDATION, IMPORTANT SINCE ALL OTHER STONES WILL BE SET IN REFERENCE TO THIS STONE, THUS DETERMINING THE POSITION OF THE ENTIRE STRUCTURE."

Murata GitHub is the cornerstone of the customized "FMAC" i.MX Yocto implementation. Refer to **Table 4** for a complete listing of the Murata repositories used to build the i.MX Yocto image. For each repository, all available branch and release/tag names are included. All repositories are hosted at Murata GitHub ⤢. Depending on the repository, the branch naming convention vary as follows:

- "FMAC" version ("cynder" / "baragon" / "spiga" / "drogon" / "ebirah" / "fafnir"). It is strongly recommended to use "ebirah" / "fafnir" (latest release).

- Linux kernel (equivalent to Yocto codename. i.e., "kirkstone", "hardknott") and "FMAC" versions.

- i.MX architecture (i.MX8 versus i.MX6/7), Linux kernel, and "FMAC" versions.

The release names follow the branch-naming convention. When deciding on using a branch versus release/tag, the user will want to consider the following points:

- Release/tag is strongly recommended for end users who want a stable/tested version of the customized "FMAC" release. Murata only "tags" a branch after having run through a testing cycle on the various i.MX/module configurations.

- If the user *just* needs to build a reference SD card image, then it is strongly recommended to use a release/tag.

- Branches are recommended for users who need the latest updates. Users can examine the latest git commits on GitHub for any given repository. The most up-to-date branch by default is "master". Note that Murata does limited testing on updates (new git commits) to a given branch. If the user runs into any unexpected difficulty, please report the errata back to Murata by posting on the Murata Community Forum ⤢.

- The "master" branch in "cyw-fmac" repository corresponds to the latest "FMAC" release – in this case "fafnir". If the user is checking for latest patches to "FMAC" driver, then it is recommended to check "drivers/net/wireless/broadcom/brcm80211" folder here ⤢.

Table 4: Murata GitHub Repositories used in "FMAC" build

Murata GitHub Repository Name	Branch Names	Latest Release / Tag Names	Contents
"meta-murata-wireless"	"master" "imx-kirkstone-fafnir" "imx-kirkstone-ebirah" "imx-hardknott-drogon" "imx-hardknott-cynder" "imx-zeus-baragon" "imx-sumo-baragon" "imx-rocko-mini-baragon" "imx-krogoth-baragon" "imx-zeus-spiga" "imx-sumo-spiga" "imx-rocko-mini-spiga" "imx-krogoth-spiga" GitHub Listing ⤢	"imx-kirkstone-fafnir_r1.0" "imx-kirkstone-ebirah_r1.0" "imx-hardknott-drogon_r1.0" "imx-hardknott-cynder_r1.0" "imx-zeus-baragon_r1.0" "imx-sumo-baragon_r1.0" "imx-rocko-mini-baragon_r1.0" "imx-krogoth-baragon_r1.0" "imx-zeus-spiga_r1.1" "imx-sumo-spiga_r1.0" "imx-rocko-mini-spiga_r1.0" "imx-krogoth-spiga_r1.0" GitHub Listing ⤢	*"meta-murata-wireless"* customized recipe layer. It drops into existing Yocto build environment. "master" branch only contains build script utilities – key starting point for user wanting to generate an image.

"cyw-fmac"	"master" "imx-kirkstone-fafnir" "imx-kirkstone-ebirah" "imx-hardknott-drogon" "imx-hardknott-cynder" "imx-zeus-cynder" "imx-rocko-cynder" "imx-krogoth-cynder" "imx-zeus-spiga" "imx-sumo-spiga" "imx-rocko-spiga" "imx-krogoth-spiga" GitHub Listing ↗	"imx-kirkstone-fafnir_r1.0" "imx-kirkstone-ebirah_r1.0" "imx-hardknott-drogon_r1.0" "imx-hardknott-cynder_r1.0" "imx-zeus-cynder_r1.0" "imx-rocko-cynder_r1.0" "imx-krogoth-cynder_r1.0" "imx-zeus-spiga_r1.0" "imx-sumo-spiga_r1.0" "imx-rocko-spiga_r1.0" "imx-krogoth-spiga_r1.0" GitHub Listing ↗	"**FMAC**" backports tarball extracted from official Infineon release with some modifications. Links to original Infineon releases provided below. Fafnir ↗ Ebirah ↗ Drogon ↗ Cynder ↗ Baragon ↗ Spiga ↗ "master" branch includes latest fixes on most recent "**FMAC**" release (i.e., "**fafnir**").
"cyw-fmac-fw"	"master" "fafnir" "ebirah" "drogon" "cynder" "baragon" "spiga" GitHub Listing ↗		WLAN production firmware files (including any applicable "CLM blob" files) for following modules: SN8000, 1FX, 1DX/1LN, 1BW, 1LV, ZP/1CK, 1MW/1LC/1HK, 1BB, 1CX/1DK, 2AE/2BC, 2BZ, 1YN and 1XA.
"cyw-fmac-nvram"	"master" "fafnir" "ebirah" "drogon" "cynder" "baragon" "spiga" GitHub Listing ↗		WLAN NVRAM files (customized by Murata with Infineon guidance) for following modules: SN8000, 1FX, 1DX/1LN, 1BW, 1LV, ZP/1CK, 1MW/1LC/1HK, 1BB, 1CX/1DK, 2AE/2BC, 2BZ, 1YN and 1XA.
"cyw-fmac-utils-imx32"	"master" "fafnir" "ebirah" "drogon" "cynder" "baragon" "spiga" GitHub Listing ↗		"wl" tool binary pre-compiled for i.MX 32-bit.
"cyw-fmac-utils-imx64"	"master" "fafnir" "ebirah" "drogon" "cynder" "baragon" "spiga" GitHub Listing ↗		"wl" tool binary pre-compiled for i.MX 64-bit.
"cyw-bt-patch"	"master" "kirkstone-fafnir" "kirkstone-ebirah" "hardknott-drogon" "hardknott-cynder" "zeus-cynder" "rocko-mini-cynder" "krogoth-cynder" "zeus-spiga" "sumo-spiga" GitHub Listing ↗		Bluetooth patch files (*.hcd) which are used during Linux/BlueZ "hciattach" call to configure BT core. Bluetooth patch files for following modules: 1DX/1LN, 1BW, 1LV, ZP/1CK, 1MW/1LC/1HK, 1BB, 1CX/1DK , 2AE/2BC, 2BZ, 1YN and 1XA.

Digging deeper into the Murata GitHub repositories:

- "meta-murata-wireless" repository is the "driver's seat". It determines which branches/releases of other branches are pulled into the Yocto build. This repository versions the Murata-customized Yocto layer which is copied into the Yocto "sources" sub-folder. In this Yocto build implementation, each i.MX/kernel/FMAC implementation is independent. As such, there can be no single "master" branch that is the latest/greatest for all these unique branches. However, the "master" branch does contain a unique sub-folder "script-utils" with Linux scripts for assisting the user on automatically building a customized i.MX image.

- "cyw-fmac" contains the backport tool source used to backport the "FMAC" driver and the actual WLAN "FMAC" driver code: see sub-folder "/drivers/net/wireless/broadcom/brcm80211/brcmfmac". The backport tool source is customized by Infineon to correct various issues/errata. Unlike the "brcmfmac" integrated into the Linux kernel GIT ⤤, this release is configured/tested/released by the Infineon team. The integrated backport tool ⤤ allows the "FMAC" driver to be "dropped into" any Linux kernel version from 3.0 to 4.14("manda")/4.14 ("kong")/5.4 ("zigra")/5.10 ("cynder")/ 5.15("ebirah")/5.15("fafnir"). The "meta-murata-wireless" layer uses this repository to dynamically backport the "FMAC" driver to the various supported i.MX kernel versions.

> ✋ The i.MX kernel does include "drivers/net/wireless/broadcom/brcm80211/brcmfmac" – please ignore this driver source code. It is very important that this internal "brcmfmac" driver is disabled to avoid any conflicts with the Infineon "FMAC" implementation.

- Except "master" (and minor revisions to "meta-murata-wireless"), there is a one-to-one mapping of branches between the "meta-murata-wireless" and "cyw-fmac" repositories. i.e., "imx-zeus-zigra" branch of "meta-murata-wireless" backports/compiles the "FMAC" source code from the same branch in "cyw-fmac".

> ✋ "meta-murata-wireless" does not compile the "FMAC" source from "master" branch of "cyw-fmac" repository. This is because each "meta-murata-wireless" branch is dependent not just on the "FMAC" version, but also the CPU selected (i.e., "imx8" or "imx") and the Yocto version (i.e., "krogoth", "rocko", "sumo", "zeus", "hardknott" or "kirkstone").

- The "cyw-bt-patch" repository uses branch names keying off the kernel (Yocto codename) and "FMAC" versions. This is done to better manage kernel-specific issues - particularly regarding BlueZ stack implementation (default i.MX Yocto stack implementation).

- The remaining repositories ("cyw-fmac-fw", "cyw-fmac-nvram", "cyw-fmac-utils-imx32", and "cyw-fmac-utils-imx32") key off the Infineon "FMAC" driver codename – in this case "fafnir", "ebirah", "drogon", "cynder", "baragon", or "spiga". "meta-murata-wireless" only pulls from the Infineon codename branch; it does not pull from "master". If the user needs the (not yet officially released) updates from a given "master" branch, they should download the files from Murata GitHub manually and install them on their Linux file system (or modify their own customized Yocto build).

- The "cyw-fmac-nvram" repository contains additional NVRAM files (text format) to provide comprehensive support for all Murata modules. This is necessary due to how the WLAN driver ("FMAC") is implemented.

  - For "FMAC" version older than "zigra", when the "FMAC" driver loads, it looks for specific filename formats for both WLAN NVRAM and optional regulatory conformance file (CLM Blob) in the "/lib/firmware/brcm" folder:

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

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

  - Starting from "FMAC" version, "zigra" and later, when the "FMAC" driver loads, it looks for specific filename formats for both WLAN NVRAM and optional regulatory conformance file (CLM Blob) in the "/lib/firmware/cypress" folder:

- o "cyfmac" + <CYW chipset number> + <"-sdio" or "-pcie"> + ".txt"

- o "cyfmac" + <CYW chipset number> + <"-sdio" or "-pcie"> + ".clm_blob"

There are additional NVRAM files which are not the "Infineon Chipset Default" module. The default modules include: ZP (CYW4339), and 1CX (CYW4356).

> The "FMAC" driver requires that if the user needs to use a "non-default" Murata module, then the NVRAM file being copied into the "/lib/firmware/brcm" folder needs to have the module-identifying string removed. For more details refer to the User Guide ⤢.

- The "cyw-bt-patch" repository contains additional Bluetooth patch files necessary to comprehensively support all Murata modules. This is necessary due to the BT Stack (BlueZ) implementation. To initialize the BT core, the BlueZ function "hciattach" is called and searches a Bluetooth patch file with format: "BCM" + <CYW chipset number> + <CYW chipset version> + <Additional Characters> + "hcd"

> "BCM" not "CYW" is first character string. The "Additional Characters" field provides flexibility, thereby allowing Murata to add the module name so Bluetooth patch files can be distinguished between different modules with same Infineon chipset. Unfortunately, this "free field" is not possible with the "FMAC" driver implementation. For more details refer to the User Guide ⤢.

2.3 "FMAC" Backport Implementation

Many users may already be familiar with "brcmfmac" open source driver. This WLAN driver is an established part of the Linux kernel. If the user clones the Linux kernel repository ⤢, the latest "brcmfmac" source code is at "/drivers/net/wireless/broadcom/brcm80211/brcmfmac". Infineon contributes to this release, pushing their latest code updates and fixes. By comparison to the true open source "brcmfmac" driver, the key attributes to consider regarding the Infineon "FMAC" release include:

- The driver release follows formal software development practices. It is configured, tested, and released every three (3) to four (4) months. Currently six releases are available: "fafnir", "ebirah", "drogon", "cynder", "baragon", and "spiga". It is recommended that the user updates to latest "FMAC" driver version.

- Key components such as WLAN firmware binaries, along with WPA supplicant and Hostapd (including patches) are tested and released with the "FMAC" driver.

- The "FMAC" driver release is integrated with Linux backport tool. For more details on backport refer to this link ⤢. The key attraction here is that the *same* Infineon "FMAC" source code release can be evaluated on different kernel versions. Also, the backport tool provides "automatic" porting – something which the "meta-murata-wireless" layer invokes dynamically during the Yocto i.MX image build.

- Lastly, Infineon and Murata only support the formal "FMAC" driver release.

2.4 "meta-murata-wireless": Pulling it All Together

2.4.1 What does "meta-murata-wireless" do exactly?

Quick recap on the essential ingredient in arriving at the correctly configured, "FMAC"-enabled i.MX image. Murata's customized Yocto layer "meta-murata-wireless" seamlessly disables the existing

"bcmdhd" WLAN driver and pulls in the "FMAC" driver implementation. More specifically it provides the following enhancements/customizations:

- Pull Infineon "FMAC" driver and run backports tool during Yocto build to generate necessary driver modules.

- Additional/necessary patches to Infineon "FMAC" driver for i.MX implementation.

- i.MX Linux kernel customizations to support "FMAC" driver with OOB IRQ interrupts.

- WLAN production firmware files.

- Murata NVRAM files for correctly configuring WLAN RF.

- Example Bluetooth patch files.

- WL tool binary necessary for interoperability and RF testing.

- Hostapd (Version 2.9) configuration with specific patch release.

- Hostap-conf enablement.

- Hostap-utils enablement.

- WPA-supplicant (Version 2.9) configuration with specific patch release.

- Wi-Fi Direct (P2P) enablement.

For a Yocto primer, please refer to this link ⌴↗. For specifics on the i.MX Yocto implementation and their project user's guide, please refer to **Table 17**.

2.4.2 The Contents of "meta-murata-wireless"

"meta-murata-wireless" is a Murata-customized Yocto layer. Each Yocto layer resides in the "sources" sub-folder. Murata's implementation follows the Yocto "norm" with some minor exceptions due to required backport implementation. If you are planning on customizing or porting the Murata implementation, please read this section carefully. Refer to **Table 6** for a description of important folders/files in the "meta-murata-wireless" layer.

- "script-utils/latest/": contains "Host_Setup_for_Yocto.sh" and "Murata_Wireless_Yocto_Build_CYW.sh" script files. Refer to Section 4.2 ⌴↖ for more details on how these script files accelerate the Linux image build process.

- "add-murata-layer-script/add-murata-wirless.sh": This is the "hook". When run, it will insert necessary code into the current i.MX Yocto build to pull in "meta-murata-wireless" layer. This script is run after i.MX Yocto build environment setup and i.MX target/graphics selection. It should only be run once for any given/unique build directory.

- "conf/layer.conf": setting priorities for layers pulled into the Yocto build is very important. "meta-murata-wireless" is set to the highest priority (9) which guarantees that it's packages will be compiled in if there is any conflict. As a specific example, there is "competition" between two WPA supplicant packages. One is included in "meta-murata-wireless" and the other is "meta" (i.MX default version). "meta" layer priority is 5, so the WPA supplicant package it pulls in will not be part of the image (version 2.5). Rather, the "meta-murata-wireless" WPA supplicant package (Version 2.9) with associated/configured/tested patches is compiled into the i.MX image.

- "freescale/<MACHINE>.conf": When compiling i.MX image for the following EVKs, these machine configuration files are critical.

Table 5: Config DTBs for EVKs

EVK Name	Machine File Name
i.MX6UL	imx6ulevk.conf
i.MX6ULL	imx6ull14x14evk.conf
i.MX 6Quad SDB	imx6qsabresd.conf
i.MX 8M Mini EVK	imx8_all.conf, layer.conf
i.MX 8M Nano EVK	imx8mnevk.conf, imx8mnddr4evk.conf, imx8mnlpddr4evk.conf

It pulls in the necessary DTB files to the image – otherwise the resulting SD card image would not have the correct Device Tree Blob (DTB) file to configure the kernel when the platform boots.

- "recipes-connectivity/hostapd": This folder contains the recipe file that configures the Hostapd version (i.e., "hostapd_2.9.bb" or "hostapd_2.6.bb"). The "hostapd" sub-folder contains Hostapd patches, and necessary configuration files.

> Every release of "FMAC" is configured for a specific Hostapd. As such, it is extremely important that the user does not deviate from this Hostapd configuration.

- "recipes-kernel/backporttool-linux/backporttool-linux_1.0.bb": This recipe dynamically backports the "FMAC" driver during the Yocto build. For more details, refer to Section 13 ↗.

- "recipes-connectivity/murata-binaries/murata-binaries_1.0.bb": This recipe installs the following files:

    - WLAN firmware/regulatory files from cyw-fmac-fw repository ↗ into "/lib/firmware/cypress" folder.

    - Bluetooth ("*.hcd") patch files from cyw-bt-patch repository ↗ into "/etc/firmware" folder.

    - WLAN NVRAM files from cyw-fmac-nvram repository ↗ into "/lib/firmware/cypress" folder.

    - "wl" tool binary from cyw-fmac-utils-imx32 repository ↗ or cyw-fmac-utils-imx64 repository ↗.

> The "wl" tool binary differs for i.MX 32-bit and 64-bit architecture.

- "recipes-connectivity/murata-binaries/murata-binaries/set_module.sh": This script file ensures automatic driver loading for Type 2AE/2BC modules. It is placed in the location, "/usr/sbin"

    Usage:

    ```
    set_module.sh 2AE|2BC
    ```

- "recipes-connectivity/wpa-supplicant": This folder contains the recipe file that configures the WPA Supplicant version (i.e., "wpa_supplicant_2.9.bb" or "wpa-supplicant_2.6.bb"). The "wpa-supplicant" sub-folder contains WPA Supplicant patches, and necessary configuration files.

> Every release of "FMAC" is configured for a specific WPA Supplicant. As such, it is extremely important that the user does not deviate from this WPA Supplicant configuration.

- "recipes-kernel/murata-firmware/murata-firmware_20190815.bbappend ": removes "lib/firmware/brcm" folder and all its contents. This ensures that a clean install (with correct NVRAM, firmware, and regulatory files) is done by the "murata-binaries_1.0.bb" recipe.

- "recipes-kernel/murata/murata-imx_<Kernel Version>.bbappend": This file patches the i.MX kernel and makes any necessary changes to the kernel configuration file (".config").

- "recipes-kernel/murata/murata-imx-<Kernel Version>/": This folder contains all the patches applied to the i.MX kernel. The "murata-imx_<Kernel Version>.bbappend" recipe selects which patches to apply.

Table 6: Important folders/files in "meta-murata-wireless"

"meta-murata-wireless" folder/file	Notes
script-utils/latest/	Murata automated script files for host setup and i.MX Yocto build.
add-murata-layer-script/ add-murata-wireless.sh	Script file which modifies "bblayer.conf" and "local.conf"; thereby enabling the Murata-customized "FMAC" implementation for current "target" build.
conf/layer.conf	Enable "meta-murata-wireless" bbappend files and set priority for "meta-murata-wireless" layer. Priority setting is important to avoid conflicts with multiple recipes in Yocto implementation such as WPA supplicant, Hostapd, etc.
freescale/imx6ulevk.conf freescale/imx6ull14x14evk.conf freescale/imx6dlsabresd.conf freescale/imx6qsabresd.conf freescale/imx8_all.conf freescale/imx8mnddr4evk.conf freescale/imx8mnevk.conf freescale/imx8mnlpddr4evk.conf freescale/layer.conf	Ensures that all necessary i.MX6UL(L), i.MX 6Quad SDB, i.MX 8M Mini EVK and i.MX 8M Nano EVK Device Tree Blob (DTB) files are included in boot folder of generated i.MX image.
recipes-connectivity/ hostapd/	Configure and patch Hostapd.
recipes-connectivity/ murata-binaries/murata-binaries_1.0.bb	Installs set_module script, WLAN firmware, Bluetooth patch, WLAN NVRAM, WLAN regulatory (CLM Blob), and "*wl*" binary files on root file system.
recipes-connectivity/ murata-binaries/murata-binaries/set_module.sh	Automatically switches WLAN driver loading for Type 2AE/2BC modules.
recipes-connectivity/ cyw-supplicant/	Configure and patch WPA supplicant for CYW.
recipes-connectivity/ wpa-supplicant/wpa-supplicant_%.bbappend	Renames default WPA supplicant as NXP WPA supplicant (wpa_supplicant.nxp).
recipes-kernel/ backporttool-linux/ backporttool-linux_1.0.bb	Recipe that generates WLAN driver files (including cross-compilation step) and copies them to root file system. From "/lib/modules/${KERNEL_VERSION}/kernel/" folder: • "drivers/net/wireless/broadcom/brcm80211/brcmfmac/brcmfmac.ko" • "drivers/net/wireless/broadcom/brcm80211/brcmutil/brcmutil.ko" • "compat/compat.ko" • "net/wireless/cfg80211.ko"

recipes-kernel/ linux-firmware/ linux-firmware_20190815.bbappend	Appends to the default i.MX recipe "poky/meta/recipes-kernel/murata-firmware/murata-firmware_git.bb" which pulls various firmware files and writes them to "/etc/firmware" folder. The bbappend file removes the "/lib/firmware/brcm" folder and all its contents. This is important so that only the specific configured contents (NVRAM, firmware, etc.) for the given "FMAC" driver implementation is written to this folder.
recipes-kernel/ linux/ linux-imx_<Kernel Version>.bbappend	Appends to the default i.MX recipe "meta-fsl-bsp-release/imx/meta-bsp/recipes-kernel/murata/murata-imx_<Kernel Version>.bb". This file patches the i.MX kernel and makes any necessary changes to the kernel configuration file (".config").

2.4.3 Dynamic "FMAC" Backport Steps Explained

This section explains the most difficult implementation piece of "meta-murata-wireless" – especially for individuals new to Yocto. There are two phases involved in building the "FMAC" driver using "backporttool-linux_1.0.bb" recipe. They are:

> 1st Phase: Generation of ".config" file.

> 2nd Phase: Generation of ".ko" (Kernel Object – WLAN driver) files.

Each of the two phases is broken down to three steps: input, build and output; with specific details on each step. To provide more specifics, we use the "imx-zeus-zigra_r1.0" release as an example. Refer to **Table 4** for more branch and release information or browse the branches/releases directly on Murata GitHub ⤴.

2.4.3.1 1st Phase: Generation of ".config" file

2.4.3.1.1 Input

Source file for building "FMAC" driver is fetched from Murata GitHub location:

git clone https://github.com/murata-wireless/cyw-fmac.git.

Yocto framework fetch the source files and places it in the following location:

"<fsl-bsp-release-dir>/<build-dir>/tmp/work/imx6ulevk-poky-linux-gnueabi/backporttool-linux/1.0-r0/git".

2.4.3.1.2 Build

2.4.3.1.2.1 Key instructions

1. The DEPENDS += "virtual/kernel" line notifies Yocto build framework to first compile Linux kernel and then compile "backporttool-linux" recipe.
2. Compilation of source code is performed using native make (x86_64-linux) to produce ".config" file through the functions do_configure_prepend and do_configure_append.

2.4.3.1.2.2 Steps for compilation

Function "do_configure_prepend()" performs the compilation and generates .config file.

Following commands are used to generate ".config" file:

```
CC=${BUILD_CC} oe_runmake defconfig-brcmfmac
```

Key Parameters are explained as follows:

- "oe_runmake": make compilation tool
- "defconfig-brcmfmac": default configuration file for using brcmfmac (AKA "FMAC")

2.4.3.1.3 Output

Generated ".config" file can be found in: "<fsl-bsp-release-dir>/<build-dir>/ tmp/work/imx6ulevk-poky-linux-gnueabi/backporttool-linux/1.0-r0/git".

2.4.3.2 2nd Phase: Generation of ".ko" (Kernel Object – WLAN Driver) files using "backporttool-linux_1.0.bb" recipe.

2.4.3.2.1 Input

All output files from 1st phase are used as input for 2nd phase.

- FROM: "<fsl-bsp-release-dir>/<build-dir>/ tmp/work/imx6ulevk-poky-linux-gnueabi/backporttool-linux/1.0-r0/git"
- TO: "<fsl-bsp-release-dir>/<build-dir>/ tmp/work/imx6ulevk-poky-linux-gnueabi/backporttool-linux/1.0-r0/git"

2.4.3.2.2 Build

2.4.3.2.2.1 Steps for compilation

The following commands are used to generate ".ko" files:

```
oe_runmake KERNEL_PATH=${STAGING_KERNEL_DIR}  \
          KERNEL_SRC=${STAGING_KERNEL_DIR}    \
          KERNEL_VERSION=${KERNEL_VERSION}    \
          CC="${KERNEL_CC}" LD="${KERNEL_LD}" \
          AR="${KERNEL_AR}" \
          ${MAKE_TARGETS}
```

During this stage, target toolchain (Ex: "imx6ulevk-poky-linux-gnueabi") is used to build the backports tool and produce necessary ".ko" ("compat", "cfg80211", "brcmutil", "brcmfmac") driver files.

2.4.3.2.2.2 Output

Generated "ko" files are found in sub-folders of "backporttool-linux-1.0":

- "compat.ko":   /compat/
- "cfg80211.ko":   /net/wireless/
- "brcmutil.ko":   /drivers/net/wireless/broadcom/brcm80211/brcmutil/
- "brcmfmac.ko":   /drivers/net/wireless/broadcom/brcm80211/brcmfmac/

2.4.4 Staging Directories: Important Note!

"backporttool-linux_1.0.bb" recipe use staged kernel directory paths. i.e., It needs kernel source and kernel build output paths used by "linux-imx" recipe.

The reason for using staged kernel directory is because "linux-imx" recipe makes the kernel source code and libraries available for use by other recipes through Staging.

"linux-imx" recipe removes the temporary build outputs after backport recipes finish building ".ko" WLAN driver files. Hence, it is recommended, that the user do not build the "FMAC" driver recipes standalone.

If any changes are made to the kernel source, it is strongly recommended that the user always builds the kernel using the command, "bitbake fsl-image-validation-imx". This will, in turn, build "FMAC" backports as well – because backports depends on "linux-imx" recipe.

3 i.MX HW/SW Configurations Supported by Murata Modules

Table 7 provides an overview of i.MX Reference versus Murata module matrix. An additional column is included to provide a quick Infineon chipset lookup. For a given i.MX platform and Murata module, you can quickly look up the compatibility. Providing more details on the terminology used in the table:

- "**NC**" means "No Connect". This is due to one or both of the following reasons:

  - VIO incompatible: Wi-Fi/BT M.2 Module requires VIO voltage level that the NXP i.MX Hardware cannot provide.

  - Physical bus (i.e., SDIO, PCIe, UART) and/or WLAN/Bluetooth control line interconnect is not available.

- "**MD**": Module Down. The Murata module in available on-board.

- "**uSD-M.2**": Murata's uSD-M.2 Adapter provides interconnect to the Embedded Artists' Wi-Fi/BT M.2 Module. NXP i.MX Host WLAN SDIO is configured for 1.8V VIO default. The Bluetooth UART, and WLAN/BT control signals from i.MX Host are configured at 3.3V VIO (hardware limitation due to fixed voltage rails). Rev B1/B2 Adapter level shifts the BT UART and some of the WLAN/BT control signals. Although Rev A Adapter does not level shift BT UART (and some WLAN/BT control signals), it can still be used where shown for the i.MX 6UL and i.MX 6ULL EVKs.

- "**uSD-M.2W**": Murata's uSD-M.2 Adapter provides interconnect to the Embedded Artists' Wi-Fi/BT M.2 Module. NXP i.MX Host WLAN SDIO is configured for 1.8V VIO default. The WLAN control signals from i.MX Host are configured at 3.3V VIO (hardware limitation due to fixed voltage rails). Rev B1/B2 Adapter level shifts some of the WLAN control signals. Although Rev A Adapter does not level shift WLAN control signals, it can still be used where shown for the i.MX 6UL and i.MX 6ULL EVKs. As such, there is no Bluetooth support – only WLAN.

- "**uSD-M.2P**": Murata's uSD-M.2 Adapter (Rev B1/B2) provides interconnect to the Embedded Artists' Wi-Fi/BT M.2 Module. However, additional cabling to connect Bluetooth UART and WLAN/BT control signals is required for NXP i.MX 8M Mini EVK and 8M Nano EVK. The cable (Jumper Wire F/F 6") is easily obtained through Distribution channel (example Digi-Key part numbers 1568-1644-ND or 1568-1513-ND).

- "**uSD-M.2-3.3V**": Murata's uSD-M.2 Adapter provides interconnect to the Embedded Artists' Wi-Fi/BT M.2 Module. NXP i.MX Host WLAN SDIO is configured for (fixed at) 3.3V VIO. The Bluetooth UART, and WLAN/BT control signals from i.MX Host are configured at 3.3V VIO. Either Rev B1/B2 or Rev A uSD-M.2 Adapter can be used in this case – with correct jumper setting for 3.3V override mode.

- "**M.2**": Only Embedded Artists' Wi-Fi/BT M.2 EVB is required. Then NXP i.MX EVK has a M.2 connector. Currently only WLAN-PCIe, BT-UART, and WLAN/BT CTRL signals are brought out on the M.2 connectors for these specific NXP i.MX EVKs. As such, only Wi-Fi/BT M.2 EVBs which support WLAN-PCIe (i.e., 1XA) can be used.

- "**M.2W**": Only Embedded Artists' Wi-Fi/BT M.2 EVB is required. Then NXP i.MX EVK has a M.2 connector. Currently only WLAN-PCIe, and WLAN CTRL signals are brought out on the M.2 connectors for these specific NXP i.MX EVKs. As such, there is no Bluetooth support – only WLAN.

> When using uSD-M.2 adapter, there are limitations on maximum SDIO clock frequency. 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 ↗.

Table 7: NXP i.MX EVK Part Number / Murata Module Interconnect

NXP i.MX EVK Part Number	1DX CYW 4343W	1MW CYW 43455	1LV CYW 43012	2AE CYW 4373E	2BC CYW 4373	2BZ CYW 54590	1YN CYW 43439	1XA CYW 54591
MCIMX8QXP-CPU	NC[7]	NC[7]	NC[7]	NC[7]	NC[7]	NC[7]	NC[7]	M.2[8]
8MPLUSLPD4-EVK	M.2W[9]	M.2W[9]	M.2W[9]	M.2W[9]	M.2W[9]	M.2W[9]	M.2W[9]	M.2W[9]
MCIMX8M-EVKB	uSD-M.2W[10]	uSD-M.2W[10]	uSD-M.2W[10]	uSD-M.2W[10]	uSD-M.2W[10]	uSD-M.2W[10]	uSD-M.2W[10]	M.2[8]
8MMINILPD4-EVKB	uSD-M.2P[11]	uSD-M.2P[11]	uSD-M.2P[11]	uSD-M.2P[11]	uSD-M.2P[11]	uSD-M.2P[11]	uSD-M.2P[11]	M.2W[9]
8MNANOD4-EVK	uSD-M.2P[11]	MD[12], uSD-M.2P[11]	uSD-M.2P[11]	uSD-M.2P[11]	uSD-M.2P[11]	uSD-M.2P[11]	uSD-M.2P[11]	NC[7]
MCIMX6Q-SDB	uSD-M.2-3.3V[13]	uSD-M.2-3.3V[13]	NC[7]	uSD-M.2-3.3V[13]	uSD-M.2-3.3V[13]	uSD-M.2-3.3V[13]	uSD-M.2-3.3V[13]	NC[7]
MCIMX6UL-EVKB	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	NC[7]
MCIMX6ULL-EVK	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	uSD-M.2[14]	NC[7]

4 Building i.MX Yocto Linux

4.1 i.MX Yocto Build: Overview

Certain Intellectual Property issues (for 3rd party drivers that are integrated into the baseline NXP i.MX image) prevents direct access to i.MX image binaries with built-in "FMAC" release. Therefore, it is necessary for the end user to arrive at their own "SD card" image. There are two paths to arrive at the necessary image:

1. Execute Murata automated build script. This is intended to ease the "startup" phase. However, the user needs to install Ubuntu on a machine (PC or virtual environment). If selecting this (easier option) then please refer to Section 4.2 ↗.

2. Follow manually documented steps. Intended for users with reasonable familiarity of Linux and Yocto: refer to Section 4.3 ↗. For users familiar with "meta-murata-wireless" implementation, all the steps from Section 4.3 ↗ are repeated in a condensed version as examples in Section 4.4 ↗ to Section 4.7 ↗.

---

[7] No Connection options available
[8] Wi-Fi/BT M.2 EVB plugs directly into M.2 connector
[9] Wi-Fi/BT M.2 EVB plugs directly into M.2 connector; but only WLAN is functional
[10] Works with uSD-M.2 Adapter (Rev B1/B2), but only WLAN is functional
[11] Works with uSD-M.2 Adapter (Rev B1/B2) with additional cabling
[12] Murata Module is soldered down
[13] Works with uSD-M.2 Adapter configured for 3.3V VIO override mode
[14] Works with uSD-M.2 Adapter configured for 1.8V VIO default

4.2 i.MX Yocto Build: The Fast Track (for Beginner Level Users)

4.2.1 Install Ubuntu

First step is to install Ubuntu 14.04, 16.04, 18.04 or 20.04 (Murata's build is verified on Ubuntu 20.04 64-bit install) on the host - native PC or virtual environment like VMware. Host PC typically used requires Ubuntu 20.04/18.04/16.04/14.04 installed with 50 GB free disk space (80 GB needed for i.MX8 build). For more information on the Ubuntu download, please refer to this link ↗. The Ubuntu installation manual is provided here ↗.

4.2.2 Download Murata's Script Files

With Ubuntu installed, we need to get the script files downloaded. There are two options:

1. Using "web browser" option to download "meta-murata-wireless" zip file and extract:

   - Click on "clone or download" button at Murata GitHub ↗.

   - Now select "Download ZIP" option.

   - Once the file is downloaded, extract it with "unzip" command or folder UI.

   - Now go to the "meta-murata-wireless-master/script-utils/latest" folder where the necessary README and script files are contained.

2. Use "wget" command to pull specific files from Murata GitHub.

> (i) We need to set script files as executable afterwards with "chmod a+x" command because "wget" does not maintain the file permissions correctly.

```
Wget --no-check-certificate --content-disposition
https://github.com/murata-wireless/meta-murata-
wireless/raw/master/script-utils/latest/README.txt

wget --no-check-certificate --content-disposition
https://github.com/murata-wireless/meta-murata-
wireless/raw/master/script-utils/latest/Host_Setup_for_Yocto.sh

wget --no-check-certificate --content-disposition
https://github.com/murata-wireless/meta-murata-
wireless/raw/master/script-
utils/latest/Murata_Wireless_Yocto_Build_CYW.sh

chmod a+x *.sh
```

4.2.3 Configure Ubuntu for i.MX Yocto Build

Next step is configuring Ubuntu for Yocto build. Please run Murata's host setup script (should already be downloaded at this stage): Host_Setup_for_Yocto.sh ⤴. To examine the plain ASCII text version, you can go to this link ⤴ or just hit the "Raw" button. For more information (README file), just go to the main folder ⤴. The "latest" folder is used to maintain the most recent/up-to-date script.

Murata's script installs necessary additional packages required for the Yocto build. For additional information, refer to NXP Yocto Project User's Guide (part of NXP Reference Documentation ⤴).

Murata's script will prompt user for password – as supervisory access is needed to install various packages. GIT is also configured so it can be used later during the build process. For more information on first-time GIT setup, you can refer to this link ⤴.

Running the script file is straightforward. Simply invoke at Ubuntu "terminal" prompt (folder location is not important):

```
./Host_Setup_for_Yocto.sh
```

The script goes through the following stages:

1. Verifying Host Environment
2. Verifying Host Script Version
3. Installing Essential Yocto host packages
4. GIT Configuration: verifying Username and email ID

For an example input/output sequence, refer to Appendix C ⤴.

4.2.3.1 Configure Ubuntu for bash

By default, Ubuntu sets the environment to use dash. It is mandatory that, User sets the default system shell to "No" when configuring dash. Follow the steps mentioned below for reconfiguring dash:

- Open "Terminal" App in Ubuntu 16.04 and enter the command, "sudo dpkg-reconfigure dash"

```
sudo dpkg-reconfigure dash
```

- Enter the password.
- Select "No" when "Configuring dash" screen appears as shown in **Figure 7**.

Figure 7: Configuring dash
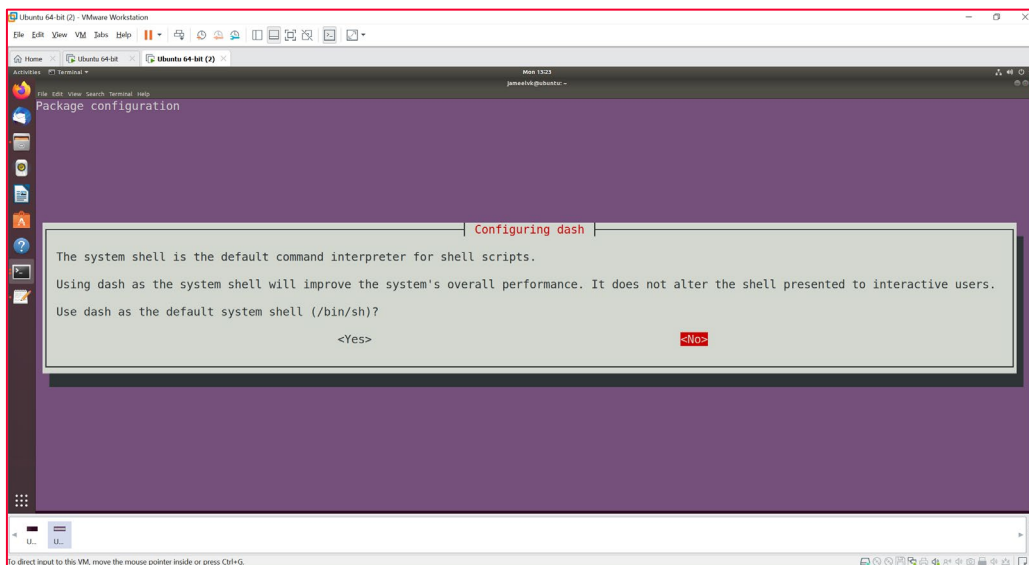
4.2.4 Murata's i.MX Yocto Build Script

With Ubuntu installed and configured to build i.MX Yocto, please run the build script (should already be downloaded at this stage): Murata_Wireless_Yocto_Build_CYW.sh ⬀. For plain ASCII text version, you can go to this link ⬀ or just hit the "Raw" button. For more information (README file), just go to the main folder ⬀. The "latest" folder is used to maintain the most recent/up-to-date script.

Prior to running Murata's build script, make sure you have completed the following:

- Installed 64-bit version of Ubuntu 20.04 (preferred), 18.04, 16.04, or 14.04.

- Ran Murata's host setup script in Section 4.2.3 ⬀ to add necessary packages for Yocto build and configure GIT.

- Created a i.MX BSP folder specific to the desired i.MX Yocto Release. The i.MX Yocto distribution cannot build different versions of Yocto (Linux kernel) in the same folder. Currently the following Yocto releases are supported:

  - 5.15.32_2.0.0 GA

  - 5.10.52_2.1.0

  - 5.4.47_2.2.0 GA

  - 4.14.98_2.3.0

- Creating the i.MX BSP folder is straightforward:

```
cd ~
mkdir 26urata-imx-bsp
cd 26urata-imx-bsp
cp <Script Path>/Murata_Wireless_Yocto_Build_CYW.sh .
```

- Once the build script successfully completes, the i.MX BSP folder will contain:

  - Yocto "sources" and "downloads" folder.

  - "meta-murata-wireless" folder – is a sub-folder of "sources".

- One or more i.MX build folders.

> When creating a i.MX BSP folder ($BSP_DIR or "27urata-imx-bsp" used to reference this all-important folder later in this document), make sure that no parent folder contains a ".repo" folder.

Murata's build script performs the following tasks:

- Verifies host environment (i.e., Ubuntu 14.04/16.04/18.04/20.04).

- Installs the 'repo' tool.

- Check to make sure script being run is the latest version.

- Prompts the user to select release type:

  - "**Stable**" corresponds to "meta-murata-wireless" release/tag (rather than a branch). Murata tests wireless functionality on i.MX platforms for each release/tag. This release type is recommended for baseline image builds or initial bring-up testing.

  - "**Developer**" corresponds to a branch which can be a "moving target". When performing the automated build, the script file pulls the latest branch contents – as opposed to a specific GIT commit on that branch. If the user wants the latest fixes, then this is the best option to go with.

    > Murata only runs "spot" tests before submitting fixes/enhancements to the branch. The "Developer" branch build may fail. In this case, the user is highly recommended to employ the "Stable" branch (formal tag release) and apply any necessary patches to it.

- Select i.MX Yocto release. As already pointed out the current i.MX BSP folder (from which script is being executed) can only support one i.MX Yocto release. If you need to test/evaluate different Yocto/kernel versions, then you must create additional folders.

- Select the "FMAC" release. The script displays both the "FMAC" codename and latest kernel version supported by that release. Currently, five "FMAC" releases are supported: "spiga", "baragon", "cynder", "drogon", "ebirah" and "fafnir" (most recent and up to date regarding fixes and enhancements).

  > Murata strongly recommends using "ebirah"/"fafnir" release.

  > For legacy builds (e.g., "mothra", "manda", "kong", "zigra" etc., the flag LEGACY_SUPPORT can be enabled on the script. However, these legacy builds are not supported by Murata and can be broken.

- Select i.MX target: refer to **Table 3** for more details.

- Regarding the "non-UHS" option, this forces the SDIO mode to not go "Ultra High Speed" or switch to SDIO 3.0 mode (even if the target supports it).

- Select "DISTRO and image". This configures the graphical driver and Yocto image. For more details refer to the Yocto documentation. It is recommended to go with Murata defaults on this step – Murata has tested/validated with these images.

- Name desired build target folder name. If re-running the Murata build script, this folder name must be unique.

- Review the final configuration and accept before moving forward.

- Accept the NXP End User's License Agreement (EULA). There is 3rd party IP included in the i.MX Yocto build. This step addresses the sub-licensing issue. During this step, the user must review a fair bit of legal documentation (by repeatedly entering space bar) or if already familiar with the EULA language, enter 'q' to bypass displaying the complete agreement. The final step of this EULA step prompts the user to enter "y" to accept.

- Last and final step is to confirm that user wants to kick off the final build process (invoke "bitbake <image>" command).

Running the script file is straightforward. Simply invoke from your i.MX BSP folder ($BSP_DIR or "murata-imx-bsp" – already created by this point):

```
./Murata_Wireless_Yocto_Build_CYW.sh
```

The script goes through the following stages:

- Verifying Host Environment

- Install the 'repo' tool.

- Verifying Script Version

- Select Release Type:

    - Stable: Murata tested/verified release tag. Stable is the recommended default.

    - Developer: Includes latest fixes on branch. May change at any time.

- Select "Linux Kernel"

- Select "FMAC" version

- Select Target

- Select DISTRO & Image

- Creation of Build directory

- Verify your selection

- Acceptance of End User License Agreement (EULA)

- Starting Build Now.

> ℹ️ Depending on machine type, build may take 1-7 hours to complete.

For an example input/output sequence, refer to Appendix D ⬏.

4.3 i.MX Yocto Build: Manual Steps (for Advanced Users)

The user should be very familiar with the NXP Yocto Project User's Guide (part of NXP Reference Documents release ⬏). We are only emphasizing some important steps in this section.

4.3.1 Host PC Preparation

First step is to install Ubuntu 20.04, 18.04, 16.04 or 14.04 on the host - native PC or virtual environment like VMware. Host PC typically used has Ubuntu 20.04/18.04/16.04/14.04 installed with 50 GB free disk space (80 GB needed for i.MX8 build).

> Murata has verified these build steps using Ubuntu 16.04, 18.04 (x64) and 20.04 (x64).

Next step is configuring Ubuntu for Yocto build. Refer to Yocto Project User's Guide ⤴ (Section 3 "Host Setup"). When following NXP's Yocto Project User's Guide, make sure that GIT is setup properly with the commands below:

```
git config --global user.name "Your Name"
git config --global user.email "Your Email"
git config --list
```

4.3.2 Yocto Project Setup

The NXP Yocto Project BSP Release directory contains a "sources" directory, which contains the recipes used to build, one or more build directories, and a set of scripts used to set up the environment. The recipes used to build the project come from both the community and NXP. The Yocto Project layers are downloaded to the source directory. This sets up the recipes that are used to build the project. The following example shows how to download the NXP Yocto Project Community BSP recipe layers. Rather than use a specific folder name, we use the variable "BSP_DIR" name to represent the base directory for Yocto Build.

Create a build directory and setup "BSP_DIR":

```
cd ~
mkdir murata-imx-bsp
cd murata-imx-bsp
export BSP_DIR=`pwd`
```

Now we are ready to download the NXP Yocto Project Community BSP recipe layers.

In this example, we are targeting Linux 5.4.47_2.2.0 release. Execute the following repo commands:

```
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-
linux-zeus -m imx-5.4.47-2.2.0.xml
repo sync
```

Once "repo sync" is completed, the source code is checked out into the directory "$BSP_DIR/sources". You can perform repo synchronization, with the command "repo sync", periodically to update to the latest code. If errors occur during repo initialization, try deleting the ".repo" directory and running the repo initialization command again. In Section 4.3.4, we add the customized "meta-murata-wireless" to "$BSP_DIR/sources".

4.3.3 Image Build Configuration with i.MX Target Selection

New platform supports are added at times with new kernel releases. Refer to the **Table 3** for a complete list of supported platforms.

Refer to the following table for the supported targets: i.MX reference interrupt configuration, DTB file, and hardware configuration are identified.

Table 8: i.MX6/8 Targets supported by Murata

Target (MACHINE)	Hardware Config	i.MX DTB File	Interrupt Config	3.3V VIO SDIO
imx8qxpmek	M.2[15]	fsl-imx8qxp-mek.dtb	N/A	N/A
imx8mp-lpddr4-evk	M.2W[16]	imx8mp-evk-usdhc1-m2.dtb	N/A	N/A
imx8mp-lpddr4-evk	M.2W[16]	imx8mp-evk.dtb	N/A	N/A
imx8mqevk	MD[17] (1CX)	fsl-imx8mq-evk.dtb	N/A	N/A
imx8mqevk	M.2[18]	fsl-imx8mq-evk-pcie1-m2.dtb	N/A	N/A
imx8mqevk	uSD-M.2W[19]	imx8mq-evk-usd-wifi.dtb	N/A	N/A
imx8mmevk	M.2W[16]	imx8mm-evk.dtb	N/A	N/A
imx8mmevk	uSD-M.2P[20]	imx8mm-evk-usd-m2-oob.dtb	OOB	N
imx8mmevk	uSD-M.2P[20]	imx8mm-evk-usd-m2.dtb	SDIO	N
imx8mnddr4evk	MD[17] (1MW)	imx8mn-ddr4-evk.dtb	OOB	N
imx8mnddr4evk	uSD-M.2P[20]	imx8mn-evk-usd-m2-oob.dtb	OOB	N
imx8mnddr4evk	uSD-M.2P[20]	imx8mn-evk-usd-m2.dtb	SDIO	N
imx6qsabresd	uSD-M.2-3.3V[21]	imx6q-sabresd-btwifi-m2-oob.dtb	OOB	**Y**
imx6qsabresd	uSD-M.2-3.3V[21]	imx6q-sabresd-btwifi-m2.dtb	SDIO	**Y**
imx6ulevk	uSD-M.2[22]	imx6ul-14x14-evk-btwifi-m2-oob.dtb	OOB	N
imx6ulevk	uSD-M.2[22]	imx6ul-14x14-evk-btwifi-m2.dtb	SDIO	N
imx6ull14x14evk	uSD-M.2[22]	imx6ull-14x14-evk-btwifi-m2-oob.dtb	OOB	N
imx6ull14x14evk	uSD-M.2[22]	imx6ull-14x14-evk-btwifi-m2.dtb	SDIO	N

To setup build directory for Linux 5.4.47_2.2.0, the following command syntax is used:

```
cd $BSP_DIR
DISTRO=<distro name> MACHINE=<machine name> source imx-setup-release.sh -b
<build dir>
```

One example is to build fb frame buffer end for i.MX 6UltraLite EVK:

```
cd $BSP_DIR
DISTRO=fsl-imx-fb MACHINE=imx6ulevk source imx-setup-release.sh -b build-
imx6ulevk-fb
```

> When specifying the build directory (-b <build dir>), it is better to specify a unique folder name (in this example "build-imx6ulevk-fb"). Otherwise, the next time you configure a Yocto build from the same folder (i.e., invoke "imx-setup-release.sh" script from "BSP_DIR", it will delete your previous build.

---

[15] Wi-Fi/BT M.2 EVB plugs directly into M.2 connector
[16] Wi-Fi/BT M.2 EVB plugs directly into M.2 connector; but only WLAN is functional
[17] Murata Module is soldered down
[18] Wi-Fi/BT M.2 EVB plugs directly into M.2 connector
[19] Works with uSD-M.2 Adapter (Rev B1/B2), but only WLAN is functional
[20] Works with uSD-M.2 Adapter (Rev B1/B2) with additional cabling
[21] Works with uSD-M.2 Adapter configured for 3.3V VIO override mode
[22] Works with uSD-M.2 Adapter configured for 1.8V VIO default

After invoking the "imx-release-setup.sh" script, the EULA (End User License Agreement) will be presented to the user for agreement. Press "space" bar repeatedly (or "q" to skip reading entire EULA) until you reach the bottom of the agreement. Enter 'y' to accept the EULA agreement:

```
2.3. For NXP Licensed Software provided to you in source code
Do you accept the EULA you just read? (y/n) y
EULA has been accepted.
```

In this example, the final expected output is (after accepting license agreement):

```
Your build environment has been configured with:
MACHINE=imx6ulevk
SDKMACHINE=i686
DISTRO=fsl-imx-fb
EULA=
BSPDIR=
BUILD_DIR=.
meta-freescale directory found
<username>@ubuntu:~/murata-imx-bsp/build-imx6ulevk-fb$
```

To make code examples easier going forward, let's create a variable for the build directory:

```
# In this example "~/murata-imx-bsp/build-imx6ulevk-fb"
$ export BUILD_DIR=`pwd`
```

4.3.4 Fetch "meta-murata-wireless" from GitHub and copy into "Sources"

Clone "meta-murata-wireless" git and checkout "imx-zeus-zigra_r1.0" release (Linux 5.4.47):

```
cd $BSP_DIR/sources
git clone  https://github.com/murata-wireless/meta-murata-wireless.git
cd meta-murata-wireless
git checkout imx-zeus-zigra_r1.0
```

"meta-murata-wireless" contains the following (refer to Section 2.4.2 ⧉ for more details):

- "add-murata-layer-script" folder
- "conf" folder
- "freescale" folder
- "recipes-connectivity" folder
- "recipes-kernel" folder
- files (COPYING.MIT, README, README.md)

4.3.5 Install Necessary "hooks" for "meta-murata-wireless"

To enable "meta-murata-wireless" into the selected i.MX target Yocto build, certain Yocto configuration files must be modified. Murata provides "add-murata-wireless.sh" script file:

```
cd $BSP_DIR
```

```
sh ./sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh build-imx6ulevk-fb
```

> *i*   "build-imx6ulevk-fb" is just the build folder name and not the directory.

If successful, the output will look like:

```
Welcome to Freescale Community BSP

The Yocto Project has extensive documentation about OE including a
reference manual which can be found at:
    http://yoctoproject.org/documentation

For more information about OpenEmbedded see their website:
    http://www.openembedded.org/

You can now run 'bitbake <target>'

Common targets are:
    core-image-minimal
    meta-toolchain
    meta-toolchain-sdk
    adt-installer
    meta-ide-support

# The following is a misleading statement23.
Your configuration files at build-imx6ulevk-fb have not been touched.
BSPDIR=
BUILD_DIR=.
meta-freescale directory found

# The following is an additional Murata logging to clarify file modifications.
CORRECTION: Murata modified the following files
  - bblayers.conf present in <BUILD_DIR>/conf
  - local.conf present in <BUILD_DIR>/conf
  - imx6ulevk.conf present in sources/meta-freescale/conf/machine
  - imx6ull14x14evk.conf present in sources/meta-imx/meta-bsp/conf/machine
  - imx6sxsabresd.conf ./sources/meta-freescale/conf/machine
  - imx6qsabresd.conf ./sources/meta-imx/meta-bsp/conf/machine
  - imx6qpsabresd.conf ./sources/meta-imx/meta-bsp/conf/machine
  - imx6dlsabresd.conf ./sources/meta-imx/meta-bsp/conf/machine
  - imx8mnevk.conf ./sources/meta-imx/meta-bsp/conf/machine
  - imx8_all.conf ./sources/meta-imx/meta-bsp/conf/machine
  - imx8mnddr4evk.conf ./sources/meta-imx/meta-bsp/conf/machine
  - imx8mnlpddr4evk.conf ./sources/meta-imx/meta-bsp/conf/machine
  - layer.conf ./sources/meta-imx/meta-bsp/conf
```

Murata-Wireless setup complete. Create an image with:

```
# No errors logged and here is the bitbake command
$ bitbake fsl-image-validation-imx
```

---

[23] "$BSP_DIR/sources/meta-fsl-bsp-release/imx/tools/fsl-setup-release.sh" generates the "have not been touched" message. Subsequently the "add-murata-wireless.sh" script modifies the "bblayer.conf" and "local.conf".

To double check on correct script execution, you can check the content of two files in "$BUILD_DIR/conf" folder: "bblayers.conf" and "local.conf". Verify last line in "$BUILD_DIR/conf/bblayers.conf" is:

```
BBLAYERS += " ${BSPDIR}/sources/meta-murata-wireless "
```

Verify the last two lines in "$BUILD_DIR/conf/local.conf" are:

```
CORE_IMAGE_EXTRA_INSTALL += " hostap-conf hostap-utils hostapd murata-binaries
iperf3 backporttool-linux kernel-modules-pcie8997 linux-firmware-pcie8997
kernel-modules-sdio8997 "
CORE_IMAGE_EXTRA_INSTALL += " bluez5 bluez5-noinst-tools bluez5-obex openobex
obexftp glibc-gconv-utf-16 glibc-utils cyw-supplicant python3"
```

4.3.6 Build Murata-Customized Yocto Image for Specific i.MX Target

Now that the "meta-murata-wireless" layer is "hooked" into the i.MX BSP Yocto build, we can invoke "bitbake" to build the default (Murata-verified) "fsl-image-validation-imx" image:

```
cd $BUILD_DIR
bitbake fsl-image-validation-imx
```

Things to watch out for:

- If any necessary source file cannot be fetched, the build process terminates. In such a scenario, re-execute the command "bitbake fsl-image-validation-imx" again to see if the problem resolves itself. If the problem persists, report the error to whoever maintains the failing git repository.

- The "bitbake" step is expected to take at least 1-7 hours to complete. This build process depends heavily on processor speed, RAM, hard drive access (i.e., SSD is optimal), and internet download speeds.

- Ensure that there is a minimum of 50 GB free disk space (80 GB needed for i.MX8 build).

4.4 i.MX Yocto Build: Manual Steps "Take 2" (Quick Recap)

This section is for users already familiar with the "meta-murata-wireless" implementation. It provides a condensed (i.e., repeat) version of Section 4.3 ⤢. The following example sequence shows all the necessary steps to build the Murata customized i.MX image for the following configuration:

- i.MX6UL or i.MX6ULL EVK at 1.8V VIO (both WLAN and BT interfaces).

- Murata uSD-M.2 Adapter is used, install J12 in 2-3 position for 3.3V setting, install J12 in 1-2 position for 1.8V setting.

- SDIO in-band (default) and OOB IRQ (WL_HOST_WAKE) both supported in DTB files. However due to i.MX hardware limitation, OOB IRQ is not guaranteed to work – testing has shown that it does "work". To configure for OOB IRQ, choose the "m2-oob" version of DTB file.

- WLAN interface is initialized during kernel boot. To bring up interface just invoke

- "ifconfig wlan0 up" or configure WPA supplicant, Hostapd, etc.

- Bluetooth UART is connected and is initialized by running "hciattach" command.

- Bluetooth PCM connection is not supported.

4.4.1 Initialize Linux i.MX Yocto Default Build Environment

```
cd ~
mkdir murata-imx-bsp
cd murata-imx-bsp
export BSP_DIR=`pwd`
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-
linux-zeus -m imx-5.4.47-2.2.0.xml
repo sync
```

4.4.2 Configuring the i.MX Target

```
# In this example BSP_DIR is "~/murata-imx-bsp"
cd $BSP_DIR
DISTRO=fsl-imx-fb MACHINE=imx6ulevk source imx-setup-release.sh -b build-
imx6ulevk-fb
```

This will bring the EULA (End User License Agreement). Press "space" bar repeatedly (or "q" to skip reading entire EULA) until you reach the bottom of the agreement. Enter 'y' to accept the EULA agreement:

```
2.3.     For NXP Licensed Software provided to you in source code
Do you accept the EULA you just read? (y/n) y
EULA has been accepted.
```

4.4.3 Add "meta-murata-wireless" Layer and Kick off the Build

```
# In this example, current directory is "~/murata-imx-bsp/build-imx6ulevk-fb"
export BUILD_DIR=`pwd`
cd $BSP_DIR/sources
git clone  https://github.com/murata-wireless/meta-murata-wireless.git
cd meta-murata-wireless
git checkout imx-zeus-zigra_r1.0
cd $BSP_DIR
sh ./sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh build-imx6ulevk-fb
```

```
cd $BUILD_DIR
bitbake fsl-image-validation-imx
```

4.5 i.MX Yocto Build: Manual Steps "Take 2" for "5.15.32" with FMAC "Fafnir"

4.5.1 For i.MX8 platform

```
cd ~
mkdir murata-imx-bsp
cd murata-imx-bsp
export BSP_DIR=`pwd`
```

```
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-
linux-kirkstone -m imx-5.15.32-2.0.0.xml
repo sync

cd $BSP_DIR
DISTRO=fsl-imx-wayland MACHINE=imx8mqevk source imx-setup-release.sh -b build-
imx8mqevk-wayland
export BUILD_DIR=`pwd`
cd $BSP_DIR/sources
git clone https://github.com/murata-wireless/meta-murata-wireless.git
cd meta-murata-wireless
git checkout imx-kirkstone-fafnir_r1.0

cd $BSP_DIR
sh ./sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh build-imx8mqevk-wayland

cd $BSP_DIR/sources/meta-murata-wireless/recipes-kernel/linux
cp linux-imx_5.15.bbappend.8MQ linux-imx_%.bbappend

cd $BUILD_DIR
bitbake fsl-image-validation-imx
```

4.5.2 For i.MX6/7 platforms

```
cd ~
mkdir murata-imx-bsp
cd murata-imx-bsp
export BSP_DIR=`pwd`
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-
linux-kirkstone -m imx-5.15.32-2.0.0.xml
repo sync
cd $BSP_DIR
DISTRO=fsl-imx-fb MACHINE=imx6ulevk source imx-setup-release.sh -b build-
imx6ulevk-fb
export BUILD_DIR=`pwd`
cd $BSP_DIR/sources
git clone https://github.com/murata-wireless/meta-murata-wireless.git
cd meta-murata-wireless
git checkout imx-kirkstone-fafnir_r1.0

cd $BSP_DIR
sh ./sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh build-imx6ulevk-fb

cd $BUILD_DIR
bitbake core-image-base
```

4.6 i.MX Yocto Build: Manual Steps "Take 2" for "5.10.52" with FMAC "Drogon"

4.6.1 For i.MX8 platform

```
cd ~
mkdir murata-imx-bsp
```

```
cd murata-imx-bsp
export BSP_DIR=`pwd`
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-
linux-hardknott -m imx-5.10.52-2.1.0.xml
repo sync

cd $BSP_DIR
DISTRO=fsl-imx-wayland MACHINE=imx8mqevk source imx-setup-release.sh -b build-
imx8mqevk-wayland
export BUILD_DIR=`pwd`
cd $BSP_DIR/sources
git clone https://github.com/murata-wireless/meta-murata-wireless.git
cd meta-murata-wireless
git checkout imx-hardknott-drogon_r1.0

cd $BSP_DIR
sh ./sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh build-imx8mqevk-wayland

cd $BSP_DIR/sources/meta-murata-wireless/recipes-kernel/linux
cp linux-imx_5.10.bbappend.8MQ linux-imx_%.bbappend

cd $BUILD_DIR
bitbake fsl-image-validation-imx
```

4.6.2 For i.MX6/7 platforms

```
cd ~
mkdir murata-imx-bsp
cd murata-imx-bsp
export BSP_DIR=`pwd`
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-
linux-hardknott -m imx-5.10.52-2.1.0.xml
repo sync
cd $BSP_DIR
DISTRO=fsl-imx-fb MACHINE=imx6ulevk source imx-setup-release.sh -b build-
imx6ulevk-fb
export BUILD_DIR=`pwd`
cd $BSP_DIR/sources
git clone https://github.com/murata-wireless/meta-murata-wireless.git
cd meta-murata-wireless
git checkout imx-hardknott-drogon_r1.0

cd $BSP_DIR
sh ./sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh build-imx6ulevk-fb

cd $BUILD_DIR
bitbake core-image-base
```

4.7 i.MX Yocto Build: Manual Steps "Take 2" for "4.14.98" with FMAC "Spiga"

4.7.1 For i.MX8 platform

```
cd ~
```

```
mkdir murata-imx-bsp
cd murata-imx-bsp
export BSP_DIR=`pwd`
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-
linux-sumo -m imx-4.14.98-2.0.0_ga.xml
repo sync

cd $BSP_DIR
DISTRO=fsl-imx-wayland MACHINE=imx8mqevk source ./fsl-setup-release.sh -b
build-imx8mqevk-wayland
export BUILD_DIR=`pwd`
cd $BSP_DIR/sources
git clone https://github.com/murata-wireless/meta-murata-wireless.git
cd meta-murata-wireless
git checkout imx-sumo-spiga_r1.0

cd $BSP_DIR
chmod 777 sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh
sh ./sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh build-imx8mqevk-wayland

cd $BSP_DIR/sources/meta-murata-wireless/recipes-kernel/linux
cp linux-imx_4.14.98.bbappend.8MQ linux-imx_4.14.98.bbappend
```

Renaming recipes files kernel-module-qca6174_2.0.bb and kernel-module-qca9377_2.0.bb, to kernel-module-qca6174_2.0.bbx and kernel-module-qca9377_2.0.bbx.

This will disable Qualcomm CLD recipe files.

```
mv $BSP_DIR/sources/meta-fsl-bsp-release/imx/meta-bsp/recipes-kernel/kernel-
modules/kernel-module-qca6174_2.1.bb $BSP_DIR/sources/meta-fsl-bsp-
release/imx/meta-bsp/recipes-kernel/kernel-modules/kernel-module-
qca6174_2.1.bbx
mv $BSP_DIR/sources/meta-fsl-bsp-release/imx/meta-bsp/recipes-kernel/kernel-
modules/kernel-module-qca9377_2.1.bb $BSP_DIR/sources/meta-fsl-bsp-
release/imx/meta-bsp/recipes-kernel/kernel-modules/kernel-module-
qca9377_2.1.bbx
```

Start the build

```
cd $BUILD_DIR
bitbake fsl-image-validation-imx
```

4.7.2 For i.MX6/7 platforms

```
cd ~
mkdir murata-imx-bsp
cd murata-imx-bsp
export BSP_DIR=`pwd`
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-
linux-sumo -m imx-4.14.98-2.3.0_ga.xml
repo sync
cd $BSP_DIR
DISTRO=fsl-imx-wayland MACHINE=imx6ulevk source ./fsl-setup-release.sh -b
build-imx6ulevk-wayland
export BUILD_DIR=`pwd`
cd $BSP_DIR/sources
```

```
git clone https://github.com/murata-wireless/meta-murata-wireless.git
cd meta-murata-wireless
git checkout imx-sumo-spiga_r1.0

cd $BSP_DIR
chmod 777 sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh
sh ./sources/meta-murata-wireless/add-murata-layer-script/add-murata-
wireless.sh build-imx6ulevk-wayland

cd $BUILD_DIR
bitbake core-image-base
```

5 Bluetooth Patch file Considerations

The Murata customized build configures example Bluetooth patch files ("*.hcd") in the "/etc/firmware" folder. Like WLAN, the file naming convention is very important. The default Bluetooth stack implementation is BlueZ. When the "hciattach" command is invoked, the BT core is interrogated for the Chip ID. That Chip ID is then used to select the correct Bluetooth patch file to download.

All Infineon customized Bluetooth patch files start with a "CYW" string which is changed by "meta-murata-wireless" to "BCM" (during file system build) for the "hciattach" call to work correctly. You can see a listing of the Bluetooth patch files here ⤴. Here is an example (Bluetooth bring-up/scan) sequence if you are using Type 1MW:

- First boot the platform and login as "root".

```
cd /etc/firmware
mv CYW4345C0.1MW.hcd BCM4345C0.1MW.hcd
hciattach /dev/ttymxc1 bcm43xx 3000000 flow -t 20   □ "/dev/ttymxc1" is correct
UART for i.MX6UL(L) EVK
hciconfig hci0 up
hcitool scan
```

> ℹ️ After kernel boot, no toggling of BT_REG_ON is necessary given the "modem" construct in the i.MX DTS file. i.e., The kernel boot sequence should guarantee correct toggling of BT_REG_ON during power on, so that the Bluetooth core is in the correct state.

6 Using "FMAC" driver

This section is intended to provide the user with a quick "how to" when using "FMAC" driver for the first time.

6.1 How-To on "FMAC" driver

Here is a quick overview on expected output when platform is correctly configured for Murata-Infineon WLAN solution. First off, let's go through a checklist:

- Murata-customized image correctly built and (micro) SD card flashed. Even without testing WLAN/BT, make sure your finished image allows the i.MX platform to boot correctly (use default i.MX "DTB" file).

- Correct WLAN firmware, CLM blob (if applicable), and WLAN NVRAM files in "/lib/firmware/cypress" folder.

- i.MX hardware correctly setup: i.e., for 1.8V VIO signaling image, make sure the uSD-M.2 Adapter is correctly configured.

- Select the correct "DTB" file by interrupting bootloader sequence. Refer to **Table 8** for selecting the right "DTB" (Device Tree Blob) file.

6.1.1 Using Set Modules Script File

> This step is needed only for loading Type 2AE or Type 2BC module. By default the 2BC module is loaded. Skip this step for all other modules.

The steps to load the correct driver files for the Type 2AE or Type 2BC M.2 boards are provided below.

- Boot into Linux by entering the command, "boot"

- Login in as "root" at the prompt.

- Run the script with the "2AE" or "2BC" string as parameter

```
set_module.sh 2AE|2BC

reboot
```

- Look for the following message after entering set_module.sh 2AE|2BC command.

```
Setting up of 2AE|2BC is complete:
```

- Reboot by entering the command, "reboot"

- M.2 board should now have been detected and the correct kernel modules gets loaded.

6.1.2 Successful "FMAC" load message

The "FMAC" driver consists of loadable modules. If the "DTB" file enables WLAN interface and the Murata WLAN hardware is connected, then the "FMAC" driver should automatically load during kernel boot. Look for the following key logging messages:

```
brcmf_c_preinit_dcmds: Firmware: BCM43012/2 wl0: May 26 2020 00:53:41 version
13.10.271.245 (fdac85a) FWID 01-3e4c636c
```

6.1.3 "wlan0" initialization

After the kernel boots, the "wlan0" interface can be initialized by one of the following methods.

- "ifconfig" command:

```
ifconfig wlan0 up
```

- WPA supplicant: First bring up WPA supplicant and then invoke "wpa_cli":

```
wpa_supplicant -i wlan0 -D nl80211 -c /etc/wpa_supplicant.conf -B
wpa_cli -i wlan0
```

7 Building Linux Kernel with FMAC Standalone

	This is for customer reference only. Murata only supports our releases as documented in **Table 17**.

The following steps show how to build "FMAC" driver standalone. Linux kernel version 4.14.52 with "manda" version of "FMAC" driver is used as an example.

1. Download Linux stable kernel (v4.14.52) source using following command.

```
wget https://cdn.kernel.org/pub/linux/kernel/v4.x/linux-4.14.52.tar.gz
tar zxvf linux-4.14.52.tar.gz
cd linux-4.14.52
```

2. Fetch Infineon patch files (cypress-patch-v4.14.52-2018_0928.tar.gz) for FMAC from the this public link ⬀. The patch file is available inside the downloaded zip file.

3. Copy the file (cypress-patch-v4.14.52-2018_0928.tar.gz) to the folder "linux-4.14.52".

4. Untar the file, cypress-patch-v4.14.52-2018_0928.tar.gz. Patch files will be placed in the folder, "cypress-patch".

5. In "linux-4.14.52" folder, apply Infineon patches with below bash commands

```
for i in cypress-patch/*.patch; do patch -p1 < $i; done
```

6. Source the necessary toolchain for arm 32 bit/64 bit.

```
source /opt/fsl-imx-x11/4.9.88-2.0.0/environment-setup-cortexa7hf-neon-
poky-linux-gnueabi
```

7. Use the default defconfig (imx_v6_v7_defconfig) to create .config file.

```
make imx_v6_v7_defconfig
```

8. Set kernel .config and enable below options, then compile kernel image

```
CONFIG_BRCMUTIL=y
CONFIG_BRCMFMAC=y
CONFIG_BRCMFMAC_PROTO_BCDC=y
CONFIG_BRCMFMAC_SDIO=y
CONFIG_BRCMFMAC_PCIE=y
# Add the following macro manually
CONFIG_BRCMFMAC_PROTO_MSGBUF=y
```

9. Build the new kernel image using the command.

```
make -j8 zImage modules dtbs
```

10. Create modules using the following command.

```
make modules_install INSTALL_MOD_PATH=/home/<user-name>/tempModules
```

11. Copy kernel to the boot folder. Copy the contents from "tempModules/lib/Modules" to rootfs (/lib/modules/).

12. Boot the system with the new kernel and modules

8 Applying Infineon Patches to Hostapd and WPA Supplicant

This section describes the building of "hostapd" and "wpa_supplicant" packages for "kong" release.

1. Download the source files for hostap_2_9.

```
wget https://w1.fi/cgit/hostap/snapshot/hostap_2_9.tar.gz
tar zxvf hostap_2_9.tar.gz
cd hostap_2_9
```

2. Fetch Infineon patch file tarball (cypress-hostap_2_9-2020_0115.tar.gz) for Integrated Hostapd + wpa_supplicant from this public link ⤴. Place it in the "hostap_2_9" folder.

3. Apply all the patches.

```
tar zxvf cypress-hostap_2_9-2020_0115.tar.gz
for i in cypress-hostap_2_9/*.patch; do patch -p1 < $i; done

----sample output---
patching file wpa_supplicant/wpa_supplicant.c
patching file wpa_supplicant/rrm.c
patching file src/drivers/driver_nl80211_event.c
patching file wpa_supplicant/wpas_glue.c
patching file src/drivers/nl80211_copy.h
patching file src/drivers/driver.h
patching file src/drivers/driver_nl80211_capa.c
patching file src/drivers/driver.h
patching file src/drivers/driver_nl80211.c
patching file wpa_supplicant/wpa_supplicant.c
patching file src/crypto/tls_openssl.c
patching file src/drivers/nl80211_copy.h
patching file src/drivers/driver.h
patching file src/drivers/driver_nl80211.c
patching file src/drivers/driver_nl80211_capa.c
patching file src/ap/beacon.c
patching file src/ap/hostapd.c
patching file src/ap/wpa_auth.c
patching file src/ap/wpa_auth.h
patching file src/ap/wpa_auth_glue.c
patching file src/drivers/driver.h
patching file src/drivers/driver_nl80211.c
patching file src/ap/beacon.c
patching file src/ap/wpa_auth.h
patching file src/ap/wpa_auth_glue.c
patching file src/ap/wpa_auth_ie.c
patching file src/ap/wpa_auth_glue.c
```

4. Source appropriate toolchain. Example shown below.

```
source /opt/fsl-imx-x11/4.9.11-1.0.0/environment-setup-cortexa7hf-neon-
poky-linux-gnueabi
```

5. Build hostapd

```
cd hostapd
cp defconfig .config
make clean
make

--sample output—
  LD  hostapd
  CC  hostapd_cli.c
  CC  ../src/common/wpa_ctrl.c
  CC  ../src/common/cli.c
  CC  ../src/utils/edit_simple.c
  LD  hostapd_cli
```

6. Build wpa_supplicant

```
cd ../wpa_supplicant
cp defconfig .config
make clean
make


-----sample output—
LD  wpa_supplicant
CC  wpa_cli.c
CC  ../src/common/wpa_ctrl.c
CC  ../src/common/cli.c
CC  ../src/utils/edit_simple.c
LD  wpa_cli
CC  wpa_passphrase.c
LD  wpa_passphrase
```
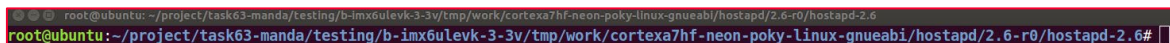
9 Building Hostapd through Yocto

1. After you have created a SD card image through the script or by any of the methods, enter the following command from the build directory.

```
<build-dir>$ bitbake -c devshell hostapd
```

2. This will open another new shell window as shown below.

Figure 8: Building Hostapd through Yocto

3. User can build "hostapd" using the new shell.

```
cd hostapd
make clean
make
```

10 Building WPA Supplicant through Yocto

1. After you have created a SD card image through the script or by any of the methods, enter the following command from the build directory. Example shown below.

```
<build-dir>$ bitbake -c devshell wpa-supplicant[24]
```

2. This will open another new shell window as shown below.

---

[24] You might have to source the setup-environment file to set up the build environment, if not done already.
    <linux-imx>$ source setup-environment <build_dir>

Figure 9: Building WPA Supplicant through Yocto

3. User can build "wpa_supplicant" using the new shell.

```
cd wpa_supplicant
make clean
make
```

11 Hierarchy of device tree source files for i.MX6/8 platforms

Device tree source files is a set of text files in the Linux kernel that describe the hardware of certain platform. For 32-bit platforms, they are located in /arch/arm/boot/dts/. For 64-bit platforms, they are located in /arch/arm64/boot/dts/freescale. DTS files come with two extensions, .dtsi and .dts. *.dtsi files are include files for device tree source. *.dts files are device tree source files. They can be used together to describe a target platform.

Since Murata launched uSD-M.2 Adapter, we also provide software support for this new hardware, which is done via new set of DTB files (a DTB file is the "compiled" binary version of a .dts file; this is the file that is actually used by the kernel). In addition to the standard DTB files, you can find DTB files that end with btwifi-m2-oob, or btwifi-m2 in Murata's customized images. These DTB files are developed to work with uSD-M.2 Adapter and are verified on several platforms that support uSD-M.2 Adapter, i.e., imx6ulevk, imx6ull14x14evk, imx6qsabresd, imx8mmevk, imx8mnevk. The following figures shows how these .dts files are organized in the hierarchy structures.
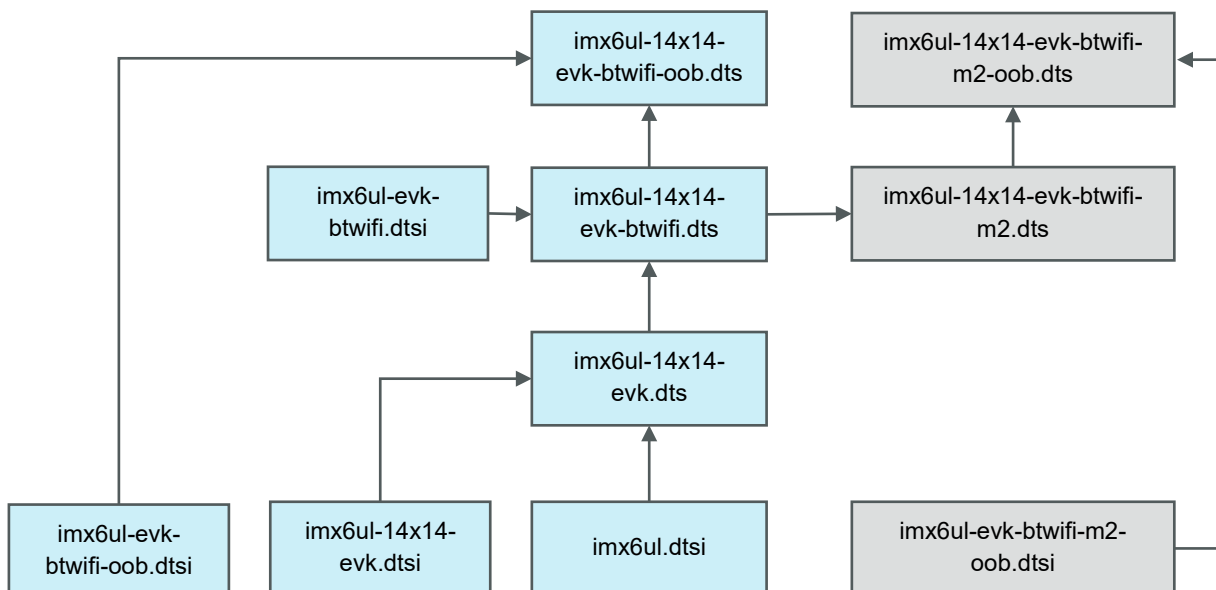
Figure 10: DTS hierarchy for imx6ulevk

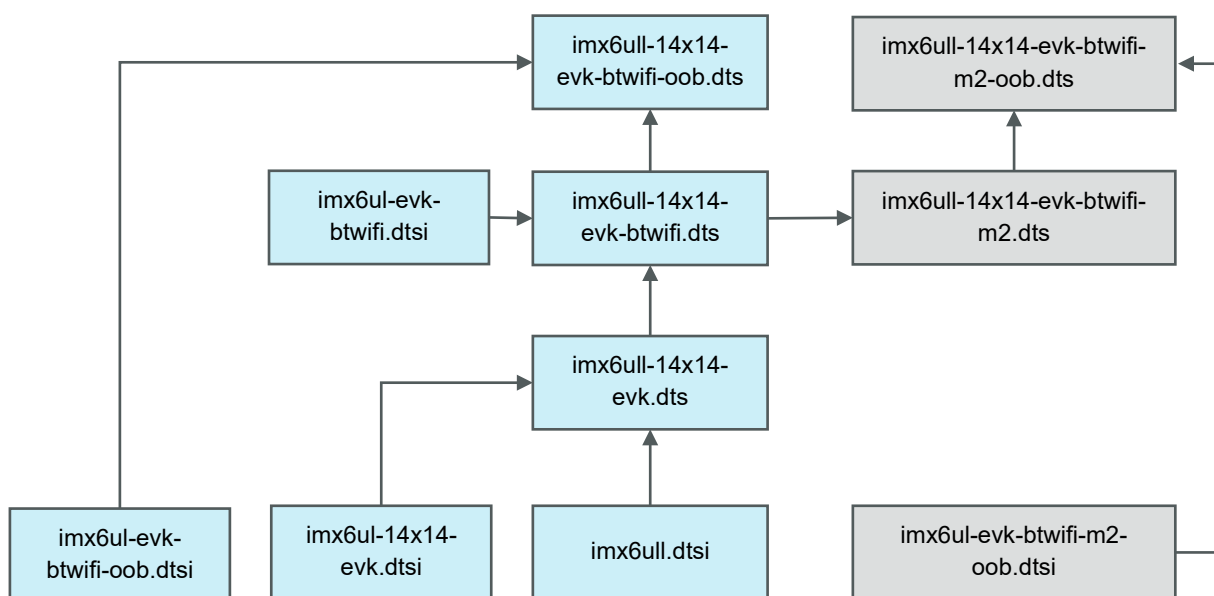**Figure 11: DTS hierarchy for imx6ull14x14evk**

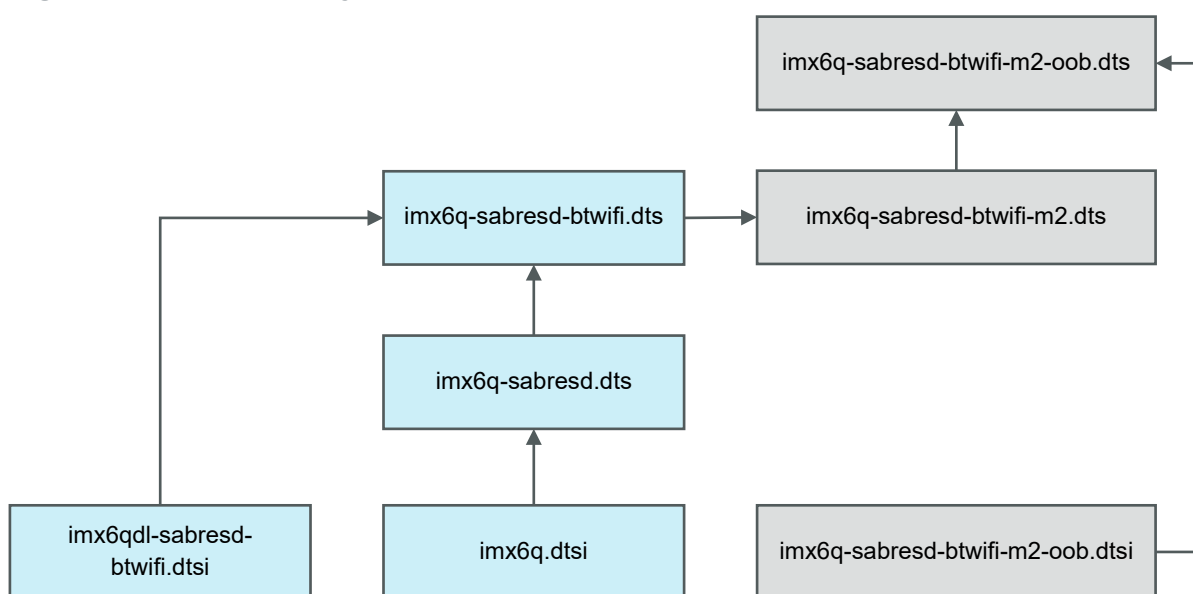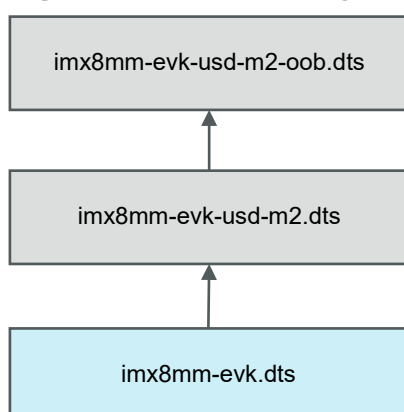**Figure 12: DTS hierarchy for imx6qsabresd**
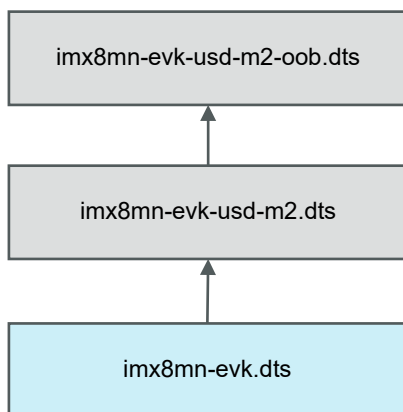

Figure 13: DTS hierarchy for imx8mmevk

Figure 14: DTS hierarchy for imx8mnevk

12 Embedded Artists' Solution

Murata has partnered with Embedded Artists to provide an easier solution for evaluating Wi-Fi/BT IOT modules. This solution is composed of three parts: Carrier board, Computer on Module (COM) board, and M.2 Evaluation board (EVB). **Figure 15** shows that the carrier board can work with a variety of NXP i.MX6/7/8 COM boards, and different Murata based EVBs. With this platform, users can easily evaluate multiple processors against multiple EVBs to find the best combination for their product. Also, Embedded Artists brings out all the test points you need for trouble shooting. With this platform, no adapter/interconnection is needed, therefore you can see the real potential of Murata's module.

Figure 15 shows how this platform works with COM boards and M.2 Wi-Fi/BT EVBs.

Figure 15: Combine i.MX COM with Wi-Fi/BT M.2 EVB
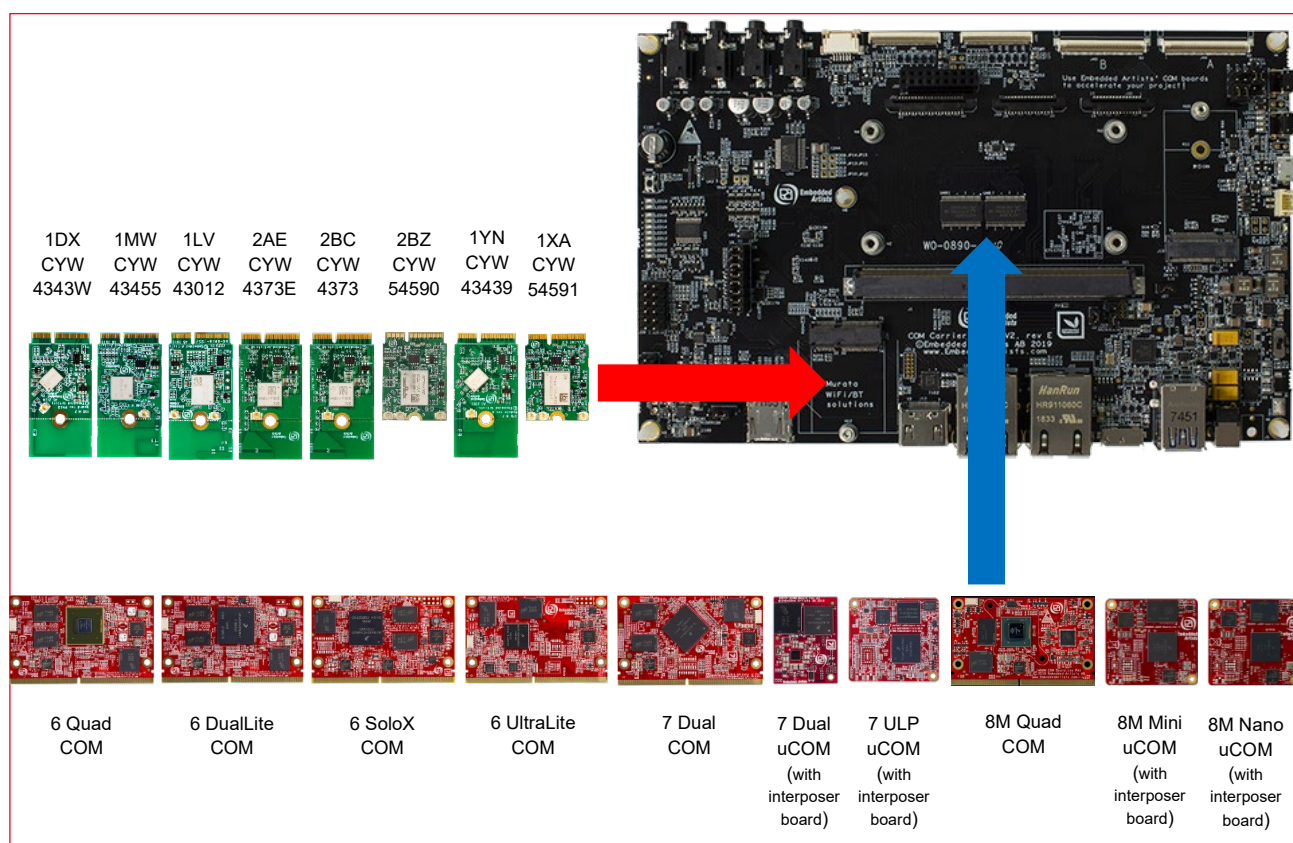
Table 9 provides an i.MX Reference Platform versus Murata module compatibility matrix. An additional column is included to provide a quick Infineon chipset lookup. Beside the well-designed hardware, Embedded Artists also provides all the document you need on their website. **Table 10** provides the list of landing pages you might need during the evaluation process.

Table 9: Embedded Artists' i.MX Interconnect

EA i.MX (u)COM	1DX	1MW	1LV	2AE	2BC	2BZ	1YN	1XA
	CYW 4343W	CYW 43455	CYW 43012	CYW 4373E	CYW 4373	CYW 54590	CYW 43439	CYW 54591
iMX8M Quad COM ↗	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]
iMX8M Mini uCOM V2 ↗	M.2[25]	M.2[25] / MD[26]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]
iMX8M Mini uCOM V3 ↗	M.2[25]	M.2[25] / MD[26]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]
iMX8M Nano uCOM ↗	M.2[25]	M.2[25] / MD[26]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	NC[27]
iMX7 Dual COM ↗	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]
iMX7 Dual uCOM ↗	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]

---

[25] Works with onboard M.2 slot.
[26] Module soldered down.
[27] No Connect.

iMX7ULP uCOM ↗	M.2[25]	M.2[25]	M.2[25] / MD[26]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	NC[27]
iMX6 Quad COM ↗	M.2[25]	M.2[25]	M.2V[28]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]
iMX6 DualLite COM ↗	M.2[25]	M.2[25]	M.2V[28]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]
iMX6 SoloX COM ↗	M.2[25]	M.2[25]	M.2V[28]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]
iMX6 UltraLite COM ↗	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	M.2[25]	NC[27]

Table 10: Embedded Artists' Landing Pages

Landing Pages	Notes
Embedded Artists' Website ↗	The Art of Embedded Systems Development – made EASY™
i.MX 6/7/8 COM Boards ↗	Listing of Computer-on-Module boards.
i.MX 6/7/8 COM Carrier Board V2 ↗	Main baseboard which all the COM boards plug into.
Getting Started with i.MX 6/7/8 Developer's Kit V2 ↗	How to bring up i.MX 6/7/8 Dev Kit (V2).
M.2 Module Family ↗	Top level listing of 1DX, 1LV, 1MW, 2AE, 2BC, 2BZ, 1YN and 1XA M.2 EVB.
Application Development on an i.MX Developer's Kit ↗	Description of C/C++, Python, Node.js, and Qt5 development.
Devices and Peripherals on an i.MX Kit ↗	Description of how to work with peripherals and devices.

Table 11 includes links to Wi-Fi/BT M.2 Module datasheets, COM Carrier Board schematic and datasheet, reference WLAN-SDIO and WLAN-PCIe schematics, and (u)COM board specifications.

Table 11: Embedded Artists' Datasheets and Schematics

Datasheets and Schematics	Notes
i.MX 6/7/8 COM Carrier Board V2 Datasheet ↗	Comprehensive definition of COM Carrier (baseboard).
i.MX6/7/8 COM Carrier Board V2 Schematics ↗	Complete schematics including clear definition of uSD-M.2 Adapter.
M.2 SDIO Interface Schematic ↗	Reference schematic for customers designing in WLAN-SDIO M.2 EVB.
M.2 PCIe Interface Schematic ↗	Reference schematic for customers designing in WLAN-PCIe M.2 EVB.
EACOM Board Specification Guide ↗	Comprehensive definition of Embedded Artists' Computer-On-Module's.
1DX M.2 Module Datasheet ↗	Comprehensive details on 1DX Wi-Fi/BT M.2 Module.
1LV M.2 Module Datasheet ↗	Comprehensive details on 1LV Wi-Fi/BT M.2 Module.
1MW M.2 Module Datasheet ↗	Comprehensive details on 1MW Wi-Fi/BT M.2 Module.
2AE M.2 Module Datasheet ↗	Comprehensive details on 2AE Wi-Fi/BT M.2 Module.
2BC M.2 Module Datasheet ↗	Comprehensive details on 2BC Wi-Fi/BT M.2 Module.
2BZ M.2 Module Datasheet ↗	Comprehensive details on 2BZ Wi-Fi/BT M.2 Module.
1YN M.2 Module Datasheet ↗	Comprehensive details on 1YN Wi-Fi/BT M.2 Module.
1XA M.2 Module Datasheet ↗	Comprehensive details on 1XA Wi-Fi/BT M.2 Module.

---

[28] These platforms have fixed 3.3 V VIO for WLAN-SDIO. Although 1LV is 1.8V only, testing has yielded reliable results.

Table 12 provides links to all the key software documentation and pre-built images. Embedded Artists maintains their own custom Linux release on GitHub. Their document "Working with Yocto to Build Linux" very much simplifies the Linux build process for customers.

Murata also supports any of the wireless solutions on Embedded Artists' Developer Kits on Murata Community Forum ⤢. Customers are welcome to register and post any questions they may have.

Table 12: Embedded Artists' User Manuals and Software

User Manuals and Software	Notes
Getting Started With M.2 Modules and i.MX 6/7/8 ⤢	Comprehensive document covering all major topics associated with using Wi-Fi/BT M.2 EVBs on EA's i.MX 6/7/8 Dev Kits.
i.MX Working with Yocto ⤢	Comprehensive guide on building Linux images using Yocto framework.
Linux i.MX Images Download ⤢	Pre-compiled images using "uuu" tool: allows users to easily flash i.MX platforms with latest Linux images with integrated Wi-Fi/BT support.
Wi-Fi/BT M.2 EVB Primer ⤢	Introduction and drill-down on M.2 interface.

13 Dynamic Backporting

The backporting steps are documented in Infineon's README file in their tar ball release. To make it clearer, the whole process is explained in detail below. Infineon's Varan FMAC release is used as an example (i.e., backport FMAC driver to Linux Kernel 4.9.88). The hardware configuration for this example is NXP's i.MX6ULL EVK with Murata uSD-M.2 Adapter and Embedded Artists' 1MW M.2 EVB.

13.1 Install stand-alone toolchain for cross-compiling

1. Create a build directory and get the BSP

```
$ mkdir imx-yocto-bsp
$ cd imx-yocto-bsp
$ repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b
imx-linux-rocko -m imx-4.9.88-2.0.0_ga.xml
$ repo sync

----sample output---

…
remote: Total 135491 (delta 85), reused 149 (delta 75), pack-reused
135309
Fetching projects:  77% (7/9) meta-openembeddedremote: Enumerating
objects: 6048, done.
remote: Total 6048 (delta 0), reused 0 (delta 0), pack-reused 6048
Fetching projects:  88% (8/9) meta-freescale-3rdpartyremote: Total 481470
(delta 360371), reused 481006 (delta 360028)
Fetching projects: 100% (9/9), done.
Checking out projects: 100% (9/9), done.
repo sync has finished successfully.
```

2. Configure the build

```
$ DISTRO=fsl-imx-x11 MACHINE=imx6ull14x14evk source fsl-setup-release.sh
-b build-imx6ull14x14evk-x11
```

3. Accept EULA by entering y

```
1.4. "Software Content Register" means the documentation accompanying the

Do you accept the EULA you just read? (y/n) y
EULA has been accepted.

----sample output---

Welcome to Freescale Community BSP

The Yocto Project has extensive documentation about OE including a
reference manual which can be found at:
    http://yoctoproject.org/documentation

For more information about OpenEmbedded see their website:
    http://www.openembedded.org/

You can now run 'bitbake <target>'

Common targets are:
    core-image-minimal
    meta-toolchain
    meta-toolchain-sdk
    adt-installer
    meta-ide-support

Your build environment has been configured with:

    MACHINE=imx6ull14x14evk
    SDKMACHINE=i686
    DISTRO=fsl-imx-x11
    EULA=
BSPDIR=
BUILD_DIR=.
meta-freescale directory found
```

4. Build the image for populating toolchain

```
$ bitbake meta-toolchain

----sample output---

NOTE: Your conf/bblayers.conf has been automatically updated.
Parsing recipes: 100%
|#####################################################################
#####################################################################
#######| Time: 0:00:37
Parsing of 2423 .bb files complete (0 cached, 2423 parsed). 3264 targets,
218 skipped, 8 masked, 0 errors.
NOTE: Resolving any missing task queue dependencies

Build Configuration:
BB_VERSION           = "1.36.0"
BUILD_SYS            = "x86_64-linux"
NATIVELSBSTRING      = "ubuntu-16.04"
TARGET_SYS           = "arm-poky-linux-gnueabi"
MACHINE              = "imx6ull14x14evk"
DISTRO               = "fsl-imx-x11"
DISTRO_VERSION       = "4.9.88-2.0.0"
```

```
TUNE_FEATURES           = "arm armv7ve vfp thumb neon callconvention-hard
cortexa7"
TARGET_FPU              = "hard"
meta
meta-poky               = "HEAD:0ec241873367e18f5371a3ad9aca1e2801dcd4ee"
meta-oe
meta-multimedia         = "HEAD:dacfa2b1920e285531bec55cd2f08743390aaf57"
meta-freescale          = "HEAD:49ac225a38f6d84519798e3264f2e4d19b84f70a"
meta-freescale-3rdparty = "HEAD:1d6d5961dbf82624b28bb318b4950a64abc31d12"
meta-freescale-distro = "HEAD:0ec6d7e206705702b5b534611754de0787f92b72"
meta-bsp
meta-sdk                = "HEAD:d65692ecb3a4136fc1cc137152634e8633ddb3c6"
meta-browser            = "HEAD:d6f9aed41c73b75a97d71bff060b03a66ee087b1"
meta-gnome
meta-networking
meta-python
meta-filesystems        = "HEAD:dacfa2b1920e285531bec55cd2f08743390aaf57"
meta-qt5                = "HEAD:32bb7d18a08d1c48873d7ab6332d4cc3815a4dff"


Initialising tasks: 100%
|#####################################################################
#####################################################################
####| Time: 0:00:10
NOTE: Executing SetScene Tasks
NOTE: Executing RunQueue Tasks
WARNING: chrpath-native-0.16-r0 do_fetch: Failed to fetch URL
https://alioth.debian.org/frs/download.php/file/3979/chrpath-0.16.tar.gz,
attempting MIRRORS if available
WARNING: bzip2-native-1.0.6-r5 do_fetch: Checksum mismatch for local file
/home/skerr/dynamic_backporting/imx-yocto-bsp/downloads/bzip2-
1.0.6.tar.gz
Cleaning and trying again.
WARNING: bzip2-native-1.0.6-r5 do_fetch: Renaming
/home/skerr/dynamic_backporting/imx-yocto-bsp/downloads/bzip2-
1.0.6.tar.gz to /home/skerr/dynamic_backporting/imx-yocto-
bsp/downloads/bzip2-1.0.6.tar.gz_bad-
checksum_ce39c4c60f64756a23010c2718754245
WARNING: bzip2-native-1.0.6-r5 do_fetch: Checksum failure encountered
with download of http://www.bzip.org/1.0.6/bzip2-1.0.6.tar.gz - will
attempt other sources if available
WARNING: popt-native-1.16-r3 do_fetch: Checksum mismatch for local file
/home/skerr/dynamic_backporting/imx-yocto-bsp/downloads/popt-1.16.tar.gz
Cleaning and trying again.
WARNING: popt-native-1.16-r3 do_fetch: Renaming
/home/skerr/dynamic_backporting/imx-yocto-bsp/downloads/popt-1.16.tar.gz
to /home/skerr/dynamic_backporting/imx-yocto-bsp/downloads/popt-
1.16.tar.gz_bad-checksum_9e09d0bf772649c5ba385c48ba2d3547
WARNING: popt-native-1.16-r3 do_fetch: Checksum failure encountered with
download of http://rpm5.org/files/popt/popt-1.16.tar.gz - will attempt
other sources if available
WARNING: nativesdk-libpng-1.6.31-r0 do_fetch: Failed to fetch URL
http://downloads.sourceforge.net/project/libpng/libpng16/1.6.31/libpng-
1.6.31.tar.xz, attempting MIRRORS if available
WARNING: nativesdk-shadow-4.2.1-r0 do_fetch: Failed to fetch URL
http://pkg-shadow.alioth.debian.org/releases/shadow-4.2.1.tar.xz,
attempting MIRRORS if available
NOTE: Tasks Summary: Attempted 3090 tasks of which 0 didn't need to be
rerun and all succeeded.

Summary: There were 9 WARNING messages shown.
```

After the build is done, fsl-imx-x11-glibc-x86_64-meta-toolchain-cortexa7hf-neon-toolchain-4.9.88-2.0.0.sh can be found in <build dir>/tmp/deploy/sdk.

This file will be used to install the cross-compile toolchain for Linux Kernel 4.9.88.

5. Install the toolchain

```
$ cd <build dir>/tmp/deploy/sdk
$ sudo ./ fsl-imx-x11-glibc-x86_64-meta-toolchain-cortexa7hf-neon-
toolchain-4.9.88-2.0.0.sh
```

If you select the default settings the toolchain will be installed in

/opt/fsl-imx-x11/4.9.88-2.0.0. You can select a different folder using the option flag -d

```
$ sudo ./ fsl-imx-x11-glibc-x86_64-meta-toolchain-cortexa7hf-neon-
toolchain-4.9.88-2.0.0.sh -d <target folder path>
```

13.2 Build the kernel image

1. Get the BSP kernel source available. Clone the linux-imx repository from code aurora and checkout the imx_4.9.88_2.0.0_ga branch.

```
$ git clone https://source.codeaurora.org/external/imx/linux-imx
$ cd linux-imx
$ git checkout imx_4.9.88_2.0.0_ga


----sample output---
$ git clone https://source.codeaurora.org/external/imx/linux-imx
Cloning into 'linux-imx'...
remote: Enumerating objects: 9247082, done.
remote: Counting objects: 100% (9247082/9247082), done.
remote: Compressing objects: 100% (1355205/1355205), done.
remote: Total 9247082 (delta 7843647), reused 9240870 (delta 7837444)
Receiving objects: 100% (9247082/9247082), 1.52 GiB | 18.06 MiB/s, done.
Resolving deltas: 100% (7843647/7843647), done.
Checking connectivity... done.
Checking out files: 100% (38165/38165), done.

$ cd linux-imx/
$ git checkout imx_4.9.88_2.0.0_ga
Checking out files: 100% (61743/61743), done.
Branch imx_4.9.88_2.0.0_ga set up to track remote branch
imx_4.9.88_2.0.0_ga from origin.
Switched to a new branch 'imx_4.9.88_2.0.0_ga'
```

2. Set up build environment and kernel configuration

```
$ source /opt/fsl-imx-x11/4.9.88-2.0.0/environment-setup-cortexa7hf-neon-
poky-linux-gnueabi
$ make imx_v7_defconfig


----sample output---

  HOSTCC  scripts/basic/fixdep
  HOSTCC  scripts/kconfig/conf.o
  SHIPPED scripts/kconfig/zconf.tab.c
  SHIPPED scripts/kconfig/zconf.lex.c
  SHIPPED scripts/kconfig/zconf.hash.c
```

```
   HOSTCC   scripts/kconfig/zconf.tab.o
   HOSTLD   scripts/kconfig/conf
#
# configuration written to .config
#
```

3. Edit .config to build cfg80211 as module, by making the following two changes on .config file.

```
CONFIG_CFG80211=m
CONFIG_BCMDHD=n
```

4. Set up the kernel configuration

```
$ make oldconfig

----sample output---
*
* Restart config...
*
*
* Wireless LAN
*
Wireless LAN (WLAN) [Y/n/?] y
  ADMtek devices (WLAN_VENDOR_ADMTEK) [Y/n/?] y
  Atheros/Qualcomm devices (WLAN_VENDOR_ATH) [Y/n/?] y
    Atheros wireless debugging (ATH_DEBUG) [N/y/?] n
    Atheros 802.11n wireless cards support (ATH9K) [N/m/?] n
    Atheros HTC based wireless cards support (ATH9K_HTC) [N/m/?] n
    Linux Community AR9170 802.11n USB support (CARL9170) [N/m/?] n
    Atheros mobile chipsets support (ATH6KL) [N/m/?] n
    Atheros AR5523 wireless driver support (AR5523) [N/m/?] n
    Atheros 802.11ac wireless cards support (ATH10K) [N/m/?] n
    Qualcomm Atheros WCN3660/3680 support (WCN36XX) [N/m/?] n
  Atmel devices (WLAN_VENDOR_ATMEL) [Y/n/?] y
    Atmel at76c503/at76c505/at76c505a USB cards (AT76C50X_USB) [N/m/?] n
  Broadcom devices (WLAN_VENDOR_BROADCOM) [Y/n/?] y
    Broadcom 43xx wireless support (mac80211 stack) (B43) [N/m/?] n
    Broadcom 43xx-legacy wireless support (mac80211 stack) (B43LEGACY)
[N/m/?] n
    Broadcom IEEE802.11n PCIe SoftMAC WLAN driver (BRCMSMAC) [N/m/?] n
    Broadcom IEEE802.11n embedded FullMAC WLAN driver (BRCMFMAC) [N/m/?]
n
  Broadcom FullMAC wireless cards support v1.141 (BCMDHD) [N/m/y/?] n
    Broadcom FullMAC wireless cards support v1.363 (BCMDHD_1363)
[N/m/y/?] (NEW)
  Cisco devices (WLAN_VENDOR_CISCO) [Y/n/?] y
  Intel devices (WLAN_VENDOR_INTEL) [Y/n/?] y
  Intersil devices (WLAN_VENDOR_INTERSIL) [Y/n/?] y
    IEEE 802.11 for Host AP (Prism2/2.5/3 and WEP/TKIP/CCMP) (HOSTAP)
[Y/n/m/?] y
      Support downloading firmware images with Host AP driver
(HOSTAP_FIRMWARE) [N/y/?] n
    Softmac Prism54 support (P54_COMMON) [N/m/?] n
  Marvell devices (WLAN_VENDOR_MARVELL) [Y/n/?] y
    Marvell 8xxx Libertas WLAN driver support (LIBERTAS) [N/m/?] n
    Marvell 8xxx Libertas WLAN driver support with thin firmware
(LIBERTAS_THINFIRM) [N/m/?] n
    Marvell WiFi-Ex Driver (MWIFIEX) [N/m/?] n
  MediaTek devices (WLAN_VENDOR_MEDIATEK) [Y/n/?] y
    MediaTek MT7601U (USB) support (MT7601U) [N/m/?] n
  Ralink devices (WLAN_VENDOR_RALINK) [Y/n/?] y
```

```
    *
    * Ralink driver support
    *
    Ralink driver support (RT2X00) [N/m/?] n
  Realtek devices (WLAN_VENDOR_REALTEK) [Y/n/?] y
    Realtek 8187 and 8187B USB support (RTL8187) [N/m/?] n
    *
    * Realtek rtlwifi family of devices
    *
    Realtek rtlwifi family of devices (RTL_CARDS) [N/m/?] n
    RTL8723AU/RTL8188[CR]U/RTL819[12]CU (mac80211) support (RTL8XXXU)
[N/m/?] n
  Redpine Signals Inc devices (WLAN_VENDOR_RSI) [Y/n/?] y
    Redpine Signals Inc 91x WLAN driver support (RSI_91X) [N/m/?] n
  STMicroelectronics devices (WLAN_VENDOR_ST) [Y/n/?] y
    CW1200 WLAN support (CW1200) [N/m/?] n
  Texas Instrument devices (WLAN_VENDOR_TI) [Y/n/?] y
    TI wl1251 driver support (WL1251) [N/m/?] n
    TI wl12xx support (WL12XX) [N/m/?] n
    TI wl18xx support (WL18XX) [N/m/?] n
    TI wlcore support (WLCORE) [N/m/?] n
  ZyDAS devices (WLAN_VENDOR_ZYDAS) [Y/n/?] y
    USB ZD1201 based Wireless device support (USB_ZD1201) [N/m/?] n
    ZyDAS ZD1211/ZD1211B USB-wireless support (ZD1211RW) [N/m/?] n
  Simulated radio testing tool for mac80211 (MAC80211_HWSIM) [N/m/?] n
  Wireless RNDIS USB support (USB_NET_RNDIS_WLAN) [N/m/?] n
#
# configuration written to .config
#
```

5. Build the Linux kernel image

```
$ make zImage -j 8

----sample output---
…
  LDS     arch/arm/boot/compressed/vmlinux.lds
  AS      arch/arm/boot/compressed/head.o
  LZO     arch/arm/boot/compressed/piggy_data
  CC      arch/arm/boot/compressed/misc.o
  CC      arch/arm/boot/compressed/decompress.o
  CC      arch/arm/boot/compressed/string.o
  SHIPPED arch/arm/boot/compressed/hyp-stub.S
  SHIPPED arch/arm/boot/compressed/lib1funcs.S
  SHIPPED arch/arm/boot/compressed/bswapsdi2.S
  SHIPPED arch/arm/boot/compressed/ashldi3.S
  AS      arch/arm/boot/compressed/hyp-stub.o
  AS      arch/arm/boot/compressed/lib1funcs.o
  AS      arch/arm/boot/compressed/ashldi3.o
  AS      arch/arm/boot/compressed/bswapsdi2.o
  AS      arch/arm/boot/compressed/piggy.o
  LD      arch/arm/boot/compressed/vmlinux
  OBJCOPY arch/arm/boot/zImage
  Kernel: arch/arm/boot/zImage is ready
```

13.3 Build the Infineon driver/ backports modules

1. Download Infineon's Varan release here ↗

2. Unzip cypress-fmac-v4.14.77-2019_1031.zip

3. Untar the Infineon backports package

```
$ tar zxvf cypress-backports-v4.14.77-2019_1031-module-src.tar.gz
```

   A folder named v4.14.77-backports will be created.

```
$ cd v4.14.77-backports
```

4. (Native) compile local tools and generate .config (in a new terminal without sourcing Yocto toolchain settings)

```
$ MY_KERNEL=~/BackportDemo/linux-imx/
$ make KLIB=$MY_KERNEL KLIB_BUILD=$MY_KERNEL defconfig-brcmfmac

----sample output---

make[2]: 'conf' is up to date.
#
# configuration written to .config
#
```

5. (Cross) compile kernel modules

```
$ source /opt/fsl-imx-x11/4.9.88-2.0.0/environment-setup-cortexa7hf-neon-
poky-linux-gnueabi
$ make KLIB=$MY_KERNEL KLIB_BUILD=$MY_KERNEL modules

----sample output---
…
  LD [M]  /home/skerr/v4.14.77-backports /net/wireless/cfg80211.o
  Building modules, stage 2.
  MODPOST 4 modules
  CC      /home/skerr/v4.14.77-backports/compat/compat.mod.o
  LD [M]  /home/skerr/v4.14.77-backports/compat/compat.ko
  CC      /home/skerr/v4.14.77-
backports/drivers/net/wireless/broadcom/brcm80211/brcmfmac/brcmfmac.mod.o
  LD [M]  /home/skerr/v4.14.77-
backports/drivers/net/wireless/broadcom/brcm80211/brcmfmac/brcmfmac.ko
  CC      /home/skerr/v4.14.77-
backports/drivers/net/wireless/broadcom/brcm80211/brcmutil/brcmutil.mod.o
  LD [M]  /home/skerr/v4.14.77-
backports/drivers/net/wireless/broadcom/brcm80211/brcmutil/brcmutil.ko
  CC      /home/skerr/v4.14.77-backports/net/wireless/cfg80211.mod.o
  LD [M]  /home/skerr/v4.14.77-backports/net/wireless/cfg80211.ko
```

6. The built kernel modules are available here

   o compat/compat.ko

   o net/wireless/cfg80211.ko

   o drivers/net/wireless/broadcom/brcm80211/brcmutil/brcmutil.ko

   o drivers/net/wireless/broadcom/brcm80211/brcmfmac/brcmfmac.ko

13.4 Device tree

In this example, we use uSD-M.2 Adapter with 1MW EVB. To make it work on NXP's i.MX6ULL, we need DTB files for it. Murata has a patch file on GitHub for Linux Kernel 4.9.88. It will generate .dts file for uSD-M.2 Adapter. The following steps show how to download it, apply it, and then build .dtb file for uSD-M.2 Adapter.

1. Get the patch file for DTB files from Murata's GitHub and place it in the linux-imx folder.

```
$ wget https://raw.githubusercontent.com/murata-wireless/meta-murata-
wireless/imx-rocko-manda/recipes-kernel/linux/linux-imx-4.9.88/0002-
murata-dts-3.3v.patch
$ cp 0002-murata-dts-3.3v.patch $MY_KERNEL
```

2. Apply the patch file

```
$ cd $MY_KERNEL
$ patch -p1 < 0002-murata-dts-3.3v.patch


----sample output---

patching file arch/arm/boot/dts/Makefile
patching file arch/arm/boot/dts/imx6dl-sabresd-btwifi-m2-oob.dts
patching file arch/arm/boot/dts/imx6dl-sabresd-btwifi-m2.dts
patching file arch/arm/boot/dts/imx6dqscm-qwks-rev3-btwifi.dtsi
patching file arch/arm/boot/dts/imx6q-sabresd-btwifi-m2-oob.dts
patching file arch/arm/boot/dts/imx6q-sabresd-btwifi-m2-oob.dtsi
patching file arch/arm/boot/dts/imx6q-sabresd-btwifi-m2.dts
patching file arch/arm/boot/dts/imx6qdl-sabresd-btwifi-m2.dtsi
patching file arch/arm/boot/dts/imx6qdl-sabresd-btwifi.dtsi
patching file arch/arm/boot/dts/imx6qp-sabresd-btwifi-m2-oob.dts
patching file arch/arm/boot/dts/imx6qp-sabresd-btwifi-m2.dts
patching file arch/arm/boot/dts/imx6sx-sdb-btwifi-m2-oob.dts
patching file arch/arm/boot/dts/imx6sx-sdb-btwifi-m2-oob.dtsi
patching file arch/arm/boot/dts/imx6sx-sdb-btwifi-m2.dts
patching file arch/arm/boot/dts/imx6sx-sdb-btwifi-m2.dtsi
patching file arch/arm/boot/dts/imx6sx-sdb-btwifi.dts
patching file arch/arm/boot/dts/imx6sxscm-evb-btwifi.dtsi
patching file arch/arm/boot/dts/imx6ul-14x14-evk-btwifi-m2-oob.dts
patching file arch/arm/boot/dts/imx6ul-14x14-evk-btwifi-m2.dts
patching file arch/arm/boot/dts/imx6ul-14x14-evk.dts
patching file arch/arm/boot/dts/imx6ul-evk-btwifi-m2-oob.dtsi
patching file arch/arm/boot/dts/imx6ul-evk-btwifi-oob.dtsi
patching file arch/arm/boot/dts/imx6ul-evk-btwifi.dtsi
patching file arch/arm/boot/dts/imx6ull-14x14-evk-btwifi-m2-oob.dts
patching file arch/arm/boot/dts/imx6ull-14x14-evk-btwifi-m2.dts
patching file arch/arm/boot/dts/imx6ull-14x14-evk.dts
patching file arch/arm/boot/dts/imx7d-sdb.dts
```

3. Build .dtb files. DTB files that end with m2 or m2-oob are developed for uSD-M.2 Adapter. We will use imx6ull-14x14-evk-btwifi-m2.dtb in this example.

```
$ make dtbs


----sample output---
…
  DTC     arch/arm/boot/dts/imx6ull-14x14-ddr3-arm2-wm8958.dtb
  DTC     arch/arm/boot/dts/imx6ull-14x14-evk.dtb
  DTC     arch/arm/boot/dts/imx6ull-14x14-evk-btwifi.dtb
  DTC     arch/arm/boot/dts/imx6ull-14x14-evk-btwifi-oob.dtb
  DTC     arch/arm/boot/dts/imx6ull-14x14-evk-btwifi-m2.dtb
  DTC     arch/arm/boot/dts/imx6ull-14x14-evk-btwifi-m2-oob.dtb
  DTC     arch/arm/boot/dts/imx6ull-14x14-evk-emmc.dtb
  DTC     arch/arm/boot/dts/imx6ull-14x14-evk-gpmi-weim.dtb
```

```
    DTC        arch/arm/boot/dts/imx6ull-14x14-evk-usb-certi.dtb
…
```

13.5 Driver and related files

Firmware, NVRAM and CLM Blob files are needed to make the Murata module work. This example uses 1MW EVB whose chip id is 43455. The following three files are needed.

- brcmfmac43455-sdio.bin: Firmware file for Murata Type 1MW EVB. This file can be found in Infineon's tarball release, cypress-fmac-v4.14.77-2019_1031.zip.

- brcmfmac43455-sdio.clm_blob: CLM Blob for Murata Type 1MW EVB. This file can be found in Infineon's tarball release, cypress-fmac-v4.14.77-2019_1031.zip.

- brcmfmac43455-sdio.txt: NVRAM file for Murata Type 1MW EVB. This file can be found on Murata's GitHub ⬀. Make sure to rename it correctly to take effect. The naming convention is: brcmfmac<chip id>-sdio.txt. and the renamed file should be kept with the firmware file and CLM Blob for later usage.

13.6 Flash a demo image

At this point, we have all the files needed for backporting ready which are kernel image, DTB file for uSD-M.2 Adapter, driver, NVRAM, and CLM Blob file for 1MW EVB, and the four .ko files. Now we need a uSD card to flash NXP's demo image there and then drop in the files we have prepared. For convenience, lets get the demo image for imx6ullevk from NXP. Please visit this webpage ⬀ for the demo image.

> ⓘ The demo image on NXP's website is a hybrid one. It can be used for i.MX6UltraLite, i.MX6ULL, and i.MX 7Dual. So, we need to flash the right u-boot image for i.MX6ULL.

Figure 16: Download i.MX 6ULL Demo Image
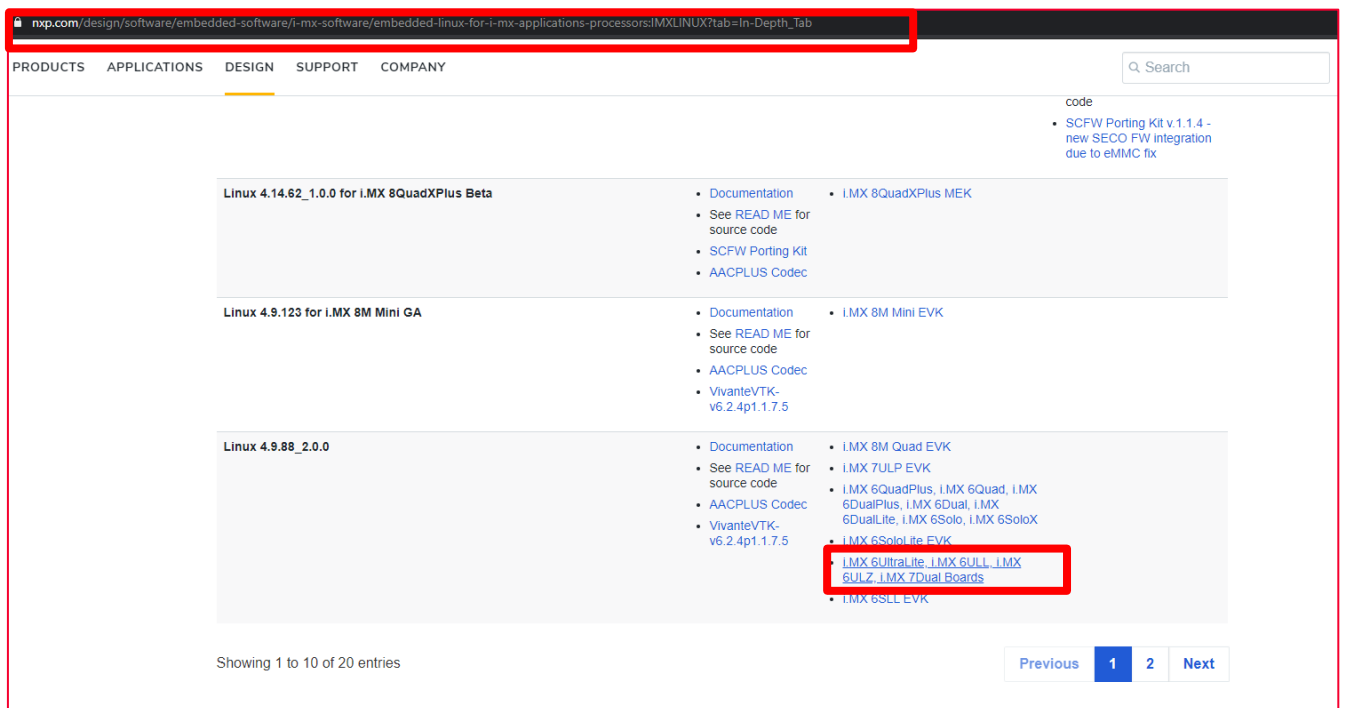
1. Unzip the image, flash it to SD card.

```
$ bunzip2 -dk -f fsl-image-validation-imx-xwayland-imx6ul7d.sdcard.bz2
```

2. Flash the image. Before doing that, please use "dmesg" command to make sure you point to the right name. In this case, the uSD card is enumerated as sdb, but it might be different on your machine. So, modify the command accordingly.

```
$ sudo dd if=fsl-image-validation-imx-xwayland-imx6ul7d.sdcard
of=/dev/sdb bs=1M conv=fsync
```

3. Flash the uboot image.

```
$ sudo dd if=u-boot-imx6ull14x14evk_sd.imx of=/dev/sdb bs=1k seek=1
conv=fsync
```

13.7 Modify Bootloader

1. Copy kernel image and the .dtb file to boot loader.

```
$ cd $MY_KERNEL
$ sudo cp arch/arm/boot/zImage /media/skerr/Boot\ imx6ul/
$ sudo cp arch/arm/boot/dts/imx6ull-14x14-evk-btwifi-m2.dtb
/media/skerr/Boot\ imx6ul/
```

13.8 Modify filesystem

1. In the SD card, create a folder 4.9.88 under /lib/modules/, then drop in the four .ko files built in Section 13.3 ⤴ here.

2. In the SD card, create a brcm folder under /lib/firmware. Then drop in the firmware, NVRAM, and CLM Blob files obtained in Section 13.5 ⤴ here.

3. The SD card is now ready to be used to boot the platform.

13.9 Load driver

1. Power on the platform.

2. Interrupt the booting and select the right .dtb file. Check the screenshot below for an example.

Figure 17: Select the Right DTB File

3. Insmod the four .ko files.

```
$ insmod /lib/modules/4.9.88/compat.ko
$ insmod /lib/modules/4.9.88/cfg80211.ko
$ insmod /lib/modules/4.9.88/brcmutil.ko
$ insmod /lib/modules/4.9.88/brcmfmac.ko
```

The following screenshot shows the messages displayed on success.

Figure 18: Insmod the Modules

4. Test the Wi-Fi module to make sure it is up and running.

Figure 19: Test Wi-Fi Functionality


```
root@imx6ull14x14evk:~# ifconfig wlan0 up
IPv6: ADDRCONF(NETDEV_UP): wlan0: link is not ready
root@imx6ull14x14evk:~# ifconfig wlan0 up
root@imx6ull14x14evk:~# iw dev wlan0 connect TC1_5G
root@imx6ull14x14evk:~# IPv6: ADDRCONF(NETDEV_CHANGE): wlan0: link becomes ready

root@imx6ull14x14evk:~# udhcpc -i wlan0
udhcpc (v1.24.1) started
Sending discover...
Sending select for 192.168.1.103...
Lease of 192.168.1.103 obtained, lease time 86400
/etc/udhcpc.d/50default: Adding DNS 192.168.1.1
root@imx6ull14x14evk:~# ping 192.168.1.1
PING 192.168.1.1 (192.168.1.1): 56 data bytes
64 bytes from 192.168.1.1: seq=0 ttl=64 time=12.449 ms
64 bytes from 192.168.1.1: seq=1 ttl=64 time=12.873 ms
64 bytes from 192.168.1.1: seq=2 ttl=64 time=12.037 ms
64 bytes from 192.168.1.1: seq=3 ttl=64 time=13.257 ms
64 bytes from 192.168.1.1: seq=4 ttl=64 time=7.835 ms
64 bytes from 192.168.1.1: seq=5 ttl=64 time=12.833 ms
64 bytes from 192.168.1.1: seq=6 ttl=64 time=13.450 ms
64 bytes from 192.168.1.1: seq=7 ttl=64 time=13.631 ms
64 bytes from 192.168.1.1: seq=8 ttl=64 time=13.084 ms
64 bytes from 192.168.1.1: seq=9 ttl=64 time=13.313 ms
64 bytes from 192.168.1.1: seq=10 ttl=64 time=12.854 ms
```

14 Acronyms

Acronym	Meaning
AP	Access Point
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
BSP	Board Support Package
BT	Bluetooth
CE	Conformité Européenne
CLI	Command Line Interface
CLK	Clock
CMD	Command
COM	Computer on Module
CPU	Central Processing Unit
CRDA	Central Regulatory Domain Agent
CTRL	Control
CTS	Clear to Send
CYW	Cypress, now Infineon
DHCP	Dynamic Host Configuration Protocol
DIP	Dual In-line Package
DTB	Device Tree Blob: Kernel reads in at boot time for configuration.
DTS	Device Tree Source
EA	Embedded Artists designs, manufactures and distributes current Wi-Fi/BT M.2 EVBs ↗. EA also have enhanced i.MX developer kits which provide comprehensive support for Murata modules ↗.
eMMC	Embedded Multi-Media Controller: integrated flash memory and controller on single die.
EULA	End User License Agreement
EVB	Evaluation Board (Embedded Artists' Wi-Fi/BT module)
EVK	Evaluation Kit (includes EVB + Adapter)
EVKB	Evaluation Kit Board
FCC	Federal Communications Commission
FFC	Flat Flex Cable
FW	Firmware
GIT	Global Information Tracker
GND	Ground
GPIO	General Purpose Input/Output
HCI	Host Controller Interface
I2S	Inter-IC Sound
IC	Industry Canada
IFX	Infineon
IRQ	Interrupt Request Line
LED	Light Emitting Diode
MAC	Medium Access Control
MEK	Multisensory Enablement Kit
MIMO	Multiple Input Multiple Output
NVRAM	Non-Volatile Random-Access Memory
OOB	Out of Band
O/S	Operation System
P2P	Peer-to-Peer
PC	Personal Computer
PCB	Printed Circuit Board
PCIe	PCI Express
PCM	Pulse Code Modulation
PSK	Pre-Shared Key
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
RTS	Request to Send
RX	Receive

SABRE	Smart Application Blueprint for Rapid Engineering
SD	Secure Digital
SDB	SABRE Development Board
SDIO	Secure Digital Input Output
SSID	Service Set Identifier
STA	Station
SW	Software
SYNC	Synchronization
TELEC	Telecom Engineering Center
TX	Transmit
UART	Universal Asynchronous Receiver/Transmitter
UHS	Ultra-High Speed
UI	User Interface
USB	Universal Serial Bus
uSD	Micro SD
uSD-M.2	Micro SD to M.2 Adapter
VBAT	Voltage of the Battery
VIO	Input Offset Voltage
VMware	Virtual Machine Software
Wi-Fi	Wireless LAN: "Wi-Fi" is a registered trademark of Wi-Fi Alliance
WLAN	Wireless Local Area Network
WPA	Wi-Fi Protected Access

15 Technical Support Contact

Table 13 lists all the support resources available for the Murata Wi-Fi/BT solution.

Table 13: 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.

16 Appendix A: Useful "git" commands

Git is a free and open source distributed version control system. It is important for the user to have a reasonable understanding of Git because Murata's "FMAC" implementation relies heavily on GitHub ↗: a remote Git repository. Some people may be new to using "git" commands or to remote Git repositories such as GitHub. Here is a good primer ↗ on using "git". For more details, refer to the main Git page ↗. Commonly used "git" commands are shown in **Table 14**.

Table 14: Useful "git" commands:

"*git*" command	Description
git config --list	List Git identity: username and email address.
git config --global --unset-all user.name	Remove Git username setting.
git config --global --unset-all user.email	Remove Git user email address setting.
git config --global user.name "<User Name>"	Configure Git username. Is done as part of first-time Git setup. Example: git config --global user.name "Fred Jones"
git config --global user.email "<User Email>"	Configure Git user email address. Is done as part of first-time Git setup. Example: git config --global user.email "fj@gmail.com"
git clone <remote_URL>	Creates a local working copy of an existing remote repository.
git branch -a	Lists all available branches of current local repository.
git tag	Lists all the available release tags.
git checkout <branch_name>	Check out a specific branch or release/tag in local repository.
git status	Lists the current branch (which is checked out) in local repository.
git reset --hard	Reset current Git repository content to default branch settings. NOTE: there are two "-" characters before "hard" switch.
git log	Shows the chronological commit history for local repository.
git clean -fd	Will remove all untracked directories and the files within them. It will start at the current working directory and will iterate through all subdirectories.

Providing more details on certain "git" commands:

- "**git config**" commands: Git needs to be configured prior to using it. At a minimum, the username and email address must be configured. For more details refer here ↗.

- "**git clone**": This command is one of the key steps in building the customized Murata i.MX Yocto image. After configuring the baseline i.MX Yocto environment, the user must install the "meta-murata-wireless" layer in the Yocto "sources" folder by invoking "git clone https://github.com/murata-wireless/meta-murata-wireless.git".

- "**git branch -a**": This command is useful to see which branches are currently available. Once you have the correct spelling of a given branch, then you can invoke the "git checkout" command to pull your desired release.

- "**git tag**": For users who want to use formal configured/tested release. This command will list all the current release tags. Typically run only in "meta-murata-wireless" and "cyw-fmac" repositories.

- "**git checkout**": This command checks out a given branch or release tag. It can only be run after a git repository is created. In the Murata-customized build flow, we are invoking "git

checkout" after "git clone" which creates a local copy of the "meta-murata-wireless" repository. "git clone/checkout" are also useful to pull specific versions of NVRAM, firmware, or patch files. "git checkout" can be used to easily switch branches in any given repository.

- "**git status**": This confirms which branch/release you are on. It also indicates if there have been any changes to the files: both tracked (files checked out as part of the current branch) and un-tracked (new files that you may have added).

- "**git reset --hard**": This command resets the content of the current Git repository to the default for current "<branch_name>". This is a useful command if you implemented certain changes that you want to back out. You can also invoke "git reset <filename>" to reset (restore) just that one file.

> ⛔ Note the double "-" character entry before "hard" switch.

17 Appendix B: Useful "bitbake" commands

Quoting from the BitBake User Manual:

"FUNDAMENTALLY, BITBAKE IS A GENERIC TASK EXECUTION ENGINE THAT ALLOWS SHELL AND PYTHON TASKS TO RUN EFFICIENTLY AND IN PARALLEL WHILE WORKING WITHIN COMPLEX INTER-TASK DEPENDENCY CONSTRAINTS. ONE OF BITBAKE'S MAIN USERS, OPENEMBEDDED , TAKES THIS CORE AND BUILDS EMBEDDED LINUX SOFTWARE STACKS USING A TASK-ORIENTED APPROACH."

Or to be more succinct, BitBake is the "Swiss Army Knife" when using Yocto or OpenEmbedded.

Table 15 provides a list of essential "bitbake" commands.

Table 15: Useful "bitbake" commands

Yocto commands	Description
bitbake -c devshell virtual/kernel	To access kernel source
bitbake <recipe> -c devshell	Open a new shell where necessary system values already defined for recipe
bitbake-layers show-layers	To see the layers and their priorities.
bitbake -e <recipe> | grep ^PV	To check which version actually got selected for the recipe.
bitbake -c fetch <recipe>	To fetch source code. Source code can be found in downloads folder.
bitbake -b <recipe.bb> -c compile -D	To force compilation of the selected recipe.
bitbake -b <recipe.bb>	To perform build on the selected recipe.
bitbake -b <recipe.bb> -c clean	To perform clean on the selected recipe.
bitbake fsl-image-validation-imx	To create SD card image.
bitbake virtual/kernel -c menuconfig	Interactive kernel configuration
bitbake <image > -g -u depexp	Show the package dependency for image.

> ⛔ "bitbake" commands must be invoked from the Yocto build directory.

18 Appendix C: Example of running Host Setup for Yocto Script

```
$ ./Host_Setup_for_Yocto.sh
Murata: setup script to check Ubuntu installation and install
        additional host packages necessary for Yocto build
=======================================================================

1) Verifying Host Environment
-----------------------------
Murata: Verified Linux Distribution:  Ubuntu
Murata: Verified Ubuntu Release:      16.04

2) Verifying Host Script Version
--------------------------------
Fetching latest script from Murata Github.
Cloning "https://github.com/murata-wireless/meta-murata-wireless.git"
Creating "meta-murata-wireless" subfolder.
Latest:  06182018
Current: 06182018........PASS

3) Installing Essential Yocto host packages
-------------------------------------------

Murata: Installing Essential Yocto Project host packages.
        sudoers-priviledged user will be prompted for password...
[sudo] password for skerr:
Reading package lists... Done
Building dependency tree
Reading state information... Done
build-essential is already the newest version (12.1ubuntu2).
diffstat is already the newest version (1.61-1).
gawk is already the newest version (1:4.1.3+dfsg-0.1).
gcc-multilib is already the newest version (4:5.3.1-1ubuntu1).
unzip is already the newest version (6.0-20ubuntu1).
chrpath is already the newest version (0.16-1).
socat is already the newest version (1.7.3.1-1).
texinfo is already the newest version (6.1.0.dfsg.1-5).
git-core is already the newest version (1:2.7.4-0ubuntu1.9).
libsdl1.2-dev is already the newest version (1.2.15+dfsg1-3ubuntu0.1).
wget is already the newest version (1.17.1-1ubuntu1.5).
0 upgraded, 0 newly installed, 0 to remove and 342 not upgraded.
Murata: Installing i.MX layers host packages...
Reading package lists... Done
Building dependency tree
Reading state information... Done
autoconf is already the newest version (2.69-9).
automake is already the newest version (1:1.15-4ubuntu1).
g++ is already the newest version (4:5.3.1-1ubuntu1).
gcc is already the newest version (4:5.3.1-1ubuntu1).
libglu1-mesa-dev is already the newest version (9.0.0-2.1).
make is already the newest version (4.1-6).
sed is already the newest version (4.2.2-7).
xterm is already the newest version (322-1ubuntu1).
asciidoc is already the newest version (8.6.9-3).
docbook-utils is already the newest version (0.6.14-3ubuntu1).
groff is already the newest version (1.22.3-7).
help2man is already the newest version (1.47.3).
lzop is already the newest version (1.03-3.2).
```

```
python-pysqlite2 is already the newest version (2.7.0-1).
repo is already the newest version (1.12.32-2).
texi2html is already the newest version (1.82+dfsg1-5).
coreutils is already the newest version (8.25-2ubuntu3~16.04).
curl is already the newest version (7.47.0-1ubuntu2.15).
cvs is already the newest version (2:1.12.13+real-15ubuntu0.1).
desktop-file-utils is already the newest version (0.22-1ubuntu5.2).
libgl1-mesa-dev is already the newest version (18.0.5-0ubuntu0~16.04.1).
libsdl1.2-dev is already the newest version (1.2.15+dfsg1-3ubuntu0.1).
subversion is already the newest version (1.9.3-2ubuntu1.3).
mercurial is already the newest version (3.7.3-1ubuntu1.2).
0 upgraded, 0 newly installed, 0 to remove and 342 not upgraded.
Murata: Installing i.MX layers host packages for a Ubuntu 16.04 or 14.04 host
setup only...
Reading package lists... Done
Building dependency tree
Reading state information... Done
u-boot-tools is already the newest version (2016.01+dfsg1-2ubuntu5).
0 upgraded, 0 newly installed, 0 to remove and 342 not upgraded.
Murata: Ubuntu Linux host environment verified, necessary host packages
installed...

4) GIT Configuration:
--------------------
Scott Kerr
skerr@murata.com

user.name : Scott Kerr
user.email: *********@murata.com

Do you want to proceed with user name and email ID? Y/n: Y
Murata: please verify git username and email address prior to running Yocto
build.
Currently configured as...
user.name=Scott Kerr
user.email=*********@murata.com
Murata: ready to build "meta-murata-wireless" customized i.MX Linux image!
```

19 Appendix D: Example of running Murata Wireless Build

The following shows the output of building an image for NXP i.MX 6ULL EVK ⤤, with Murata 1MW module ⤤, running 5.4.47 ⤤ kernel release, using the Murata build script.

1. Start the build by running Murata's build script.

   ```
   ./Murata_Wireless_Yocto_Build_CYW.sh
   ```

2. Install the repo tool.

   ```
   Do you want to continue? Y/n: Y
   ```

3. Select Stable build (this is Murata's tested release).

   ```
   Select Stable ( 'n'=Developer )? Y/n: Y
   Stable release selected
   ```

4. Select Zeus Yocto release running Linux 5.4.47.

   ```
   Select which entry? 2
   ```

```
Selected : 5.4.47
```

5. Select "Baragon" FMAC version.

```
Select which entry? 1
Selected : baragon
```

6. Select i.MX 6ULL EVK as target platform.

```
Select your entry: 2
Selected target: imx6ull14x14evk
```

7. Proceed with the default distro and image selections.

```
Murata default DISTRO & Image pre-selected are:
DISTRO: fsl-imx-fb
Image:  core-image-base

Proceed with this configuration? Y/n: Y
Proceeding with Murata defaults.
```

8. Enter build-imx6ullevk as build directory name.

```
Enter build directory name: build-imx6ullevk
```

9. Verify selection and start the build.

```
i.MX Yocto Release              : 5.4.47_2.2.0 GA
Yocto branch                    : zeus
fmac version                    : baragon
Target                          : imx6ull14x14evk
NXP i.MX EVK Part Number        : MCIMX6ULL-EVK
meta-murata-wireless Release Tag: imx-zeus-baragon_r1.0
DISTRO                          : fsl-imx-fb
Image                           : core-image-base
Build Directory                 : build-imx6ullevk

Please verify your selection
Do you accept selected configurations ? Y/n: Y
```

10. Accept the End User License Agreement (EULA).

```
Do you want to continue? Y/n: Y
```

11. Accept the third-party EULA (press 'space' to read next page, 'q' to quit reading).

```
Do you accept the EULA you just read? (y/n) y
EULA has been accepted.
```

12. Start the build. Typically, this takes 2~4 hours to complete. Ensure that there is a minimum of 50 GB free disk space.

```
Do you want to start the build ? Y/n: Y
```

13. Once the build is complete, the image will be available in ~/linux-imx/build-imx6ullevk/tmp/deploy/images/imx6ullevk/folder. Look for the file with ".wic.bz2" extension.

20 References

This section reviews all the key reference documents that the user may like to refer to. Note that the references also include Embedded Artists and NXP links.

20.1 Murata's i.MX Wireless Solutions Landing Page

This website landing page ⌁ provides latest/comprehensive information on Murata's i.MX Wireless solutions which use the uSD-M.2 Adapter as a key enabler so customers can easily evaluate Murata's modules on i.MX processors.

20.2 Murata uSD-M.2 Adapter Datasheet (Rev B2)

This datasheet ⌁ documents the Rev B2 version of the Murata's latest uSD-M.2 adapter hardware and its interfacing options. This adapter is equivalent to the Rev B1, with a slightly modified sleep clock.

20.3 Murata uSD-M.2 Adapter Datasheet (Rev B1)

This datasheet ⌁ documents the Rev B1 version of the Murata' latest uSD-M.2 adapter hardware and its interfacing options.

20.4 Murata uSD-M.2 Adapter Datasheet (legacy Rev A)

This datasheet ⌁ documents the legacy version of the Murata' uSD-M.2 adapter hardware and its interfacing options. This adapter version is no longer manufactured.

20.5 Murata Wi-Fi/BT Solution for i.MX Hardware User Manual

The Hardware User Manual ⌁ describes the Murata uSD-M.2 Adapter hardware. All interface signals to the NXP i.MX RT, 6, 7, and 8 EVKs are described. Specifics on interfacing each i.MX EVK to Murata uSD-M.2 Adapter are provided.

20.6 Murata Wi-Fi/Bluetooth for i.MX Linux User Guide for CYW-based Module

The User Guide ⌁ details steps to get Murata Wi-Fi/BT Infineon chipset-based solution up and running quickly on i.MX 6/8 EVKs.

20.7 Murata Wi-Fi/Bluetooth for i.MX Linux Quick Start Guide for CYW-based Module

The Quick Start Guide ⌁ provides quick steps to get started with Murata Wi-Fi/BT Infineon chipset-based solution with the help of an example.

20.8 Murata's Community Forum Support

Murata's Community provides online support for the Murata Wi-Fi/Bluetooth modules on various i.MX platforms. Refer to this link ⬈ for the Forum's main Wi-Fi/Bluetooth landing page.

20.9 Embedded Artists' Reference Documentation

Embedded Artists designed the 1DX/1MW/1LV/2AE/2BC/2BZ/1YN/1XA M.2 EVBs in close collaboration with Murata. Refer to this main landing page ⬈ for more information.

> ⓘ Embedded Artists manufactures and distributes the Wi-Fi/BT M.2 EVBs.

Table 16 lists some relevant documents published by Embedded Artists.

Table 16: Embedded Artists Documentation Listing

Documentation Filename	Note
Wi-Fi/BT M.2 EVB Primer ⬈	Introduction and drill-down on M.2 interface
M.2 SDIO Interface Schematic ⬈	Reference schematic for customers designing in WLAN-SDIO M.2 EVB.
M.2 PCIe Interface Schematic ⬈	Reference schematic for customers designing in WLAN-PCIe M.2 EVB.
1DX M.2 Module Datasheet ⬈	Comprehensive details on 1DX Wi-Fi/BT M.2 Module.
1MW M.2 Module Datasheet ⬈	Comprehensive details on 1MW Wi-Fi/BT M.2 Module.
1LV M.2 Module Datasheet ⬈	Comprehensive details on 1LV Wi-Fi/BT M.2 Module.
2AE M.2 Module Datasheet ⬈	Comprehensive details on 2AE Wi-Fi/BT M.2 Module.
2BC M.2 Module Datasheet ⬈	Comprehensive details on 2BC Wi-Fi/BT M.2 Module.
2BZ M.2 Module Datasheet ⬈	Comprehensive details on 2BZ Wi-Fi/BT M.2 Module.
1YN M.2 Module Datasheet ⬈	Comprehensive details on 1YN Wi-Fi M.2 Module.
1XA M.2 Module Datasheet ⬈	Comprehensive details on 1XA Wi-Fi M.2 Module.

20.10 NXP Reference Documentation

Some of the key NXP reference documentation for Linux includes the following:

- Yocto Project User's Guide: This document describes how to build an image for an NXP i.MX platform by using a Yocto Project build environment. It describes the NXP release layer and the NXP-specific usage.

- i.MX Linux User's Guide: This document explains how to build and install the NXP Linux O/S BSP on the i.MX platform. It also covers special NXP features and how to use them.

- i.MX Linux Reference Manual: This document supports porting the i.MX Linux O/S BSP to customer-specific products. Intended audience should have a working knowledge of Linux O/S kernel internals, driver models and i.MX processors.

- i.MX Linux Release Notes: This document contains important information about the package contents, supported features, known issues, and limitations in the release.

Table 17 provides the following information on all releases supported:

Table 17: NXP Reference Documentation Listing

Kernel release	NXP documentation link	Yocto name	FMAC code name	Release information
5.15.32_2.0.0	Rev. L5.15.32_2.0.0_BSP ⬀	Kirkstone	Fafnir Ebirah	imx-kirkstone-fafnir_r1.0 imx-kirkstone-ebirah_r1.0
5.10.52_2.1.0	Rev. L5.10.52_2.1.0_BSP ⬀	Hardknott	Drogon Cynder	imx-hardknott-drogon_r1.0 imx-hardknott-cynder_r1.0
5.4.47_2.2.0	Rev. L5.4.47_2.2.0_BSP ⬀	Zeus	Baragon Spiga	imx-zeus-baragon_r1.0 imx-zeus-spiga_r1.0
4.14.98_2.3.0	Rev. L4.14.98_2.3.0_BSP ⬀	Sumo	Baragon Spiga	imx-sumo-baragon_r1.0 imx-sumo-spiga_r1.1

Each archive downloadable (NXP documentation link) contains the following:

- i.MX_Yocto_Project_User's_Guide.pdf / IMXLXYOCTOUG
- i.MX_Linux_User's_Guide.pdf / IMXLUG
- i.MX_Linux_Reference_Manual.pdf / IMXLXRM
- i.MX_Linux_Release_Notes.pdf / IMXLXRN

Revision History

Revision	Date	Author	Change Description
1.0	Sep 07, 2015	S Kerr	Initial Release.
2.0	Nov 7, 2015	S Kerr	Changes for L3.14.38_6UL GA BSP Release and support modified Murata Wi-Fi/BT EVK Definition.
3.0	Mar 1, 2016	S Kerr	Incorporated changes for NXP Linux 3.14.52 GA BSP Release. Added support for hostapd and Broadcom firmware package.
4.0	Feb 14, 2017	S Kerr	Renamed document to "Murata Wi-Fi/BT Solution for i.MX Linux User Manual". Incorporated changes for NXP Linux 4.1.15_2.0.0 GA BSP release. Modified NXP Linux 3.14.52_1.1.0 GA BSP release to build in bcmdhd WLAN driver, thereby matching 4.1.15_2.0.0 configuration. Added instructions for Murata source patch release which addresses errata/features on both releases. Added support for new i.MX 7Dual SDB, i.MX 6ULL EVK and Murata Type 1CK.
5.0	Dec 23, 2017	S Kerr J Kareem	Complete revision for integrating new Infineon "FMAC" driver release. Added support for SDIO/UART 1.8V VIO signaling on i.MX6UL(L) and i.MX6SX platforms. Rollout of Murata customized Yocto build for i.MX BSP L4.9.11_1.0.0 release.
5.1	Jan 12, 2018	S Kerr J Kareem	Revise for "murata-wireless" GitHub and revised branches/releases. Add support for i.MX 7ULP EVK.
5.2	March 23, 2018	S Kerr J Kareem	Add support for new "FMAC" release, codename "battra". Support latest i.MX hardware: NXP i.MX8MQuad EVK. Provide quick/easy steps for generating Linux image with automated scripting. Update build steps with Code Aurora repository paths. Provide explanation of how "meta-murata-wireless" customized layer works. Add support for i.MX Yocto Linux 4.1.15 "krogoth" branch.
5.3	April 24, 2018	S Kerr	Updated hyperlink to "FMAC battra" release on Infineon website.
5.4	June 19, 2019	S Kerr	Updated for Linux 4.9.88 and "manda" version of "FMAC" driver.
6.0	Jan 29, 2021	TF	Updated for Linux 4.9.123, 4.14.98 and 5.4.47. Added Embedded Artists' hardware solution, i.MX6 DTS file hierarchy, reference to 1XA and detailed backport steps. Changed document name from "Murata Wi-Fi & Bluetooth Solution for i.MX User Manual (Linux)".
7.0	Jan 10, 2022	TF	Updated for Linux 5.10.52.
8.0	May 16, 2022	TF	Migrated to template 1.0.
9.0	Nov 23, 2022	TF	Migrated to template 2.0.
9.1	Feb 02, 2023	TF	Added support for kernel 5.15.32, FMAC "ebirah" and "fafnir". Removed support for kernel 4.9.123. Added modules 2BC and 2BZ. Replaced 'switch_module' script usage with 'set_module'.