UM12133

NXP NCP Application Guide for RW612 with MCU Host

Rev. 1.0 — 24 September 2024 User manual

Document information

Information	Content
Keywords	Wireless MCU RW612, RW612 EVK board, i.MX RT1060, network co-processor (NCP), hardware connection
Abstract	Describes the hardware connections/interfaces and software modifications to enable NCP mode on the NXP MCU target host.

1 About this document

1.1 Purpose and scope

This user manual describes:

- The NXP NCP application for RW612 with MCU host platform i.MX RT1060 as example.
- The hardware connections for one of the four supported interfaces to enable NCP mode on the NXP RW612 BGA V4 board (UART, USB, SDIO, or SPI).
- The method to build and run the NCP applications on both the NCP host (i.MX RT1060) and the NCP device (RW612). The applications apply to Wi-Fi, Bluetooth Low Energy and OpenThread (OT).

1.2 Considerations

This document does not include details about RW612 or i.MX RT1060. It is assumed that you are familiar with the following:

- RW612 wireless microcontroller:
  - Bring-up of Wi-Fi, Bluetooth, or 802.15.4 radios
  - Hardware interconnection
  - IDE setup
  - SDK download
- i.MX RT1060 board:
  - Board settings
  - Flashing of the BSP
  - IDE setup

For information about the Wi-Fi, Bluetooth, or 802.15.4 radios, hardware interconnection, board settings, bring-up, IDE setup, and SDK download for RW612, refer to [2].

For information about board settings, bring-up, IDE setup, SDK download for i.MX RT1060, refer to [3].

2 What is NCP mode?

Network co-processor (NCP) is a module designed to offload the network connectivity tasks from the main microcontroller to a wireless MCU. The connectivity tasks relate to Wi-Fi, Bluetooth LE, and OpenThread (OT). In this document, RW612 is the Wireless Microcontroller (MCU) and i.MX RT1060 is the application processor (MCU).

RW612 is a standalone device: no external processor is required to run TCP/IP, wireless stacks and application layers, lower layers (MAC/LL/PHY), drivers, security, filesystem, and application codes.

Figure 1 shows the diagram of standalone RW612.

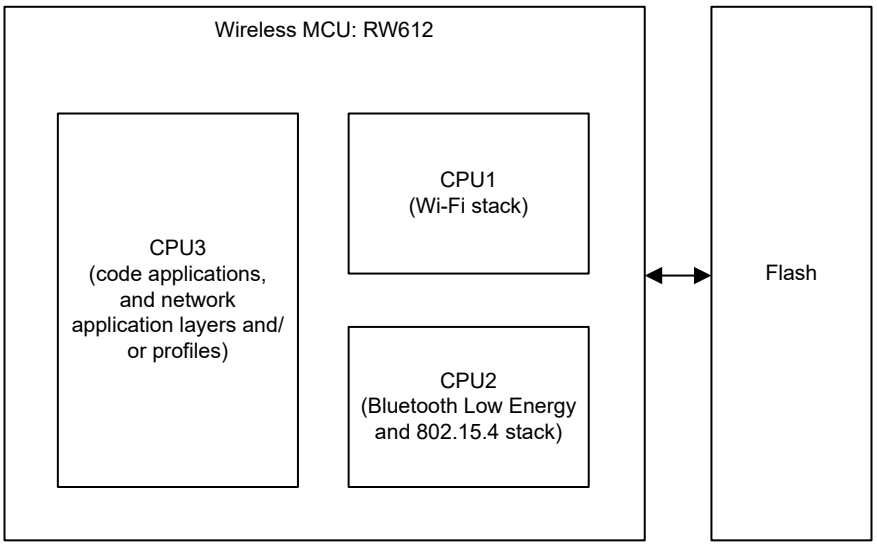

Figure 1. Block diagram of standalone RW612

With NCP mode, i.MX RT1060 manages the application code while RW612 handles Wi-Fi, Bluetooth Low Energy, and IEEE 802.15.4 stacks. The memory and processing power are split between RW612 and i.MX RT1060, which contributes to power and memory savings.

Figure 2 shows the block diagram of offloading with NCP mode.

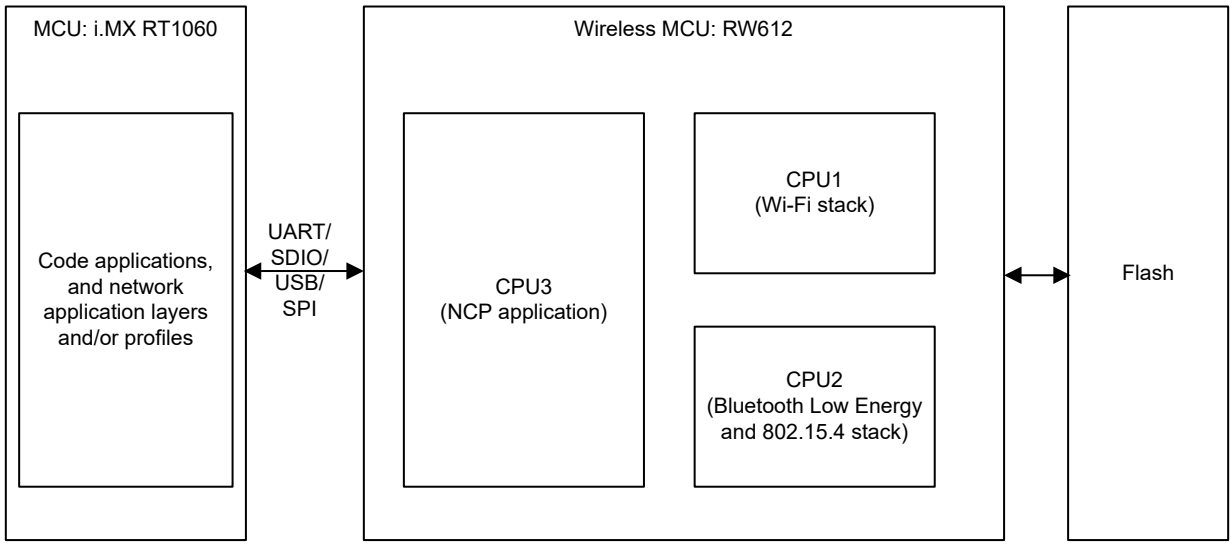

Figure 2. Diagram of offloading with NCP mode

3 Board setup

This section describes how to enable NCP mode between RW612 and the MCU host (i.MX RT1060). The NCP application on the RW612 is configurable at compile time, and supports one of the following host interfaces: UART, USB, SDIO, and SPI.

3.1 UART interface

3.1.1 Power supply of i.MX RT1060 EVK board

Two power supply methods are available for i.MX RT1060 EVK board:

- Using an external 5 V power supply.
- Enabling a 5 V power supply from the USB connector.

To enable the 5 V power supply from the USB connector, implement the following changes:

- Install R31 with 0 Ω.
- Connect J40 Pin5–6. Keep the other pins of J40 not connected.

Note: *In this document, the USB connector is used to power i.MX RT1060.*

3.1.2 Board configuration

To enable NCP mode over UART interface, configure the RW612 board.

- Disconnect JP19.
- Connect JP9 and JP23.
- Connect JP47 to GND.

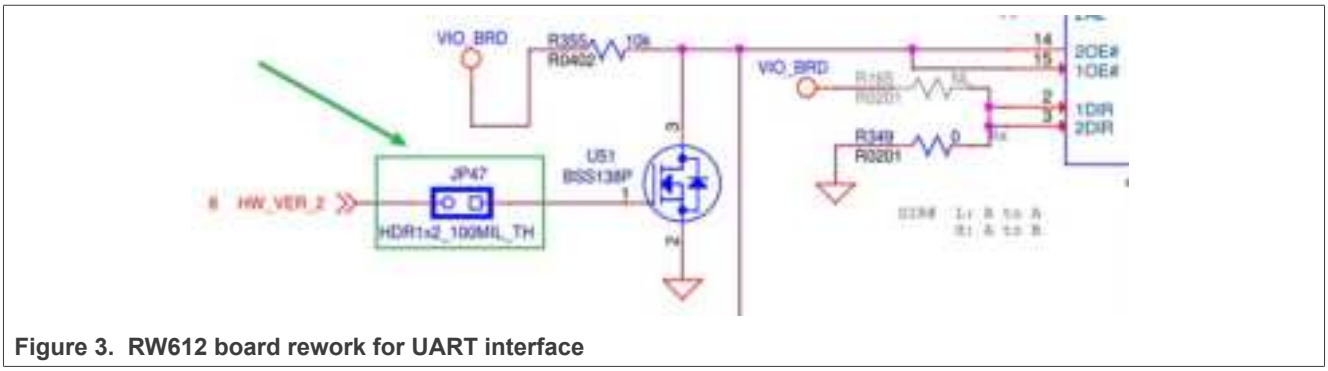

Figure 3. RW612 board rework for UART interface

Note:

- *The rework prevents the signal interfence from SPI to UART RX.*

3.1.3 Pin connections between RW612 and i.MX RT1060

Table 1 lists the pin connections between the Flexcomm0 UART interface on RW612 BGA V4 board and LPUART3 interface on i.MX RT1060 EVKB board.

Table 1. UART pin connections for RW612 and i.MX RT1060

RW612 BGA V4 board		i.MX RT1060 EVKB board	
Signal	**Board location**	**SIgnal**	**Board location**
UART_RXD	HD2 Pin3	UART_TXD	J16 Pin3
UART_TXD	HD2 Pin4	UART_RXD	J16 Pin2
UART_CTS	HD11 Pin14	UART_RTS	J33 Pin4
UART_RTS	HD11 Pin8	UART_CTS	J33 Pin1
GND	HD2 Pin15	GND	J2 Pin20

3.1.4 Hardware connection

Figure 4 shows the hardware connection between RW612 BGA V4 board and i.MX RT1060 EVKB board with UART interface.

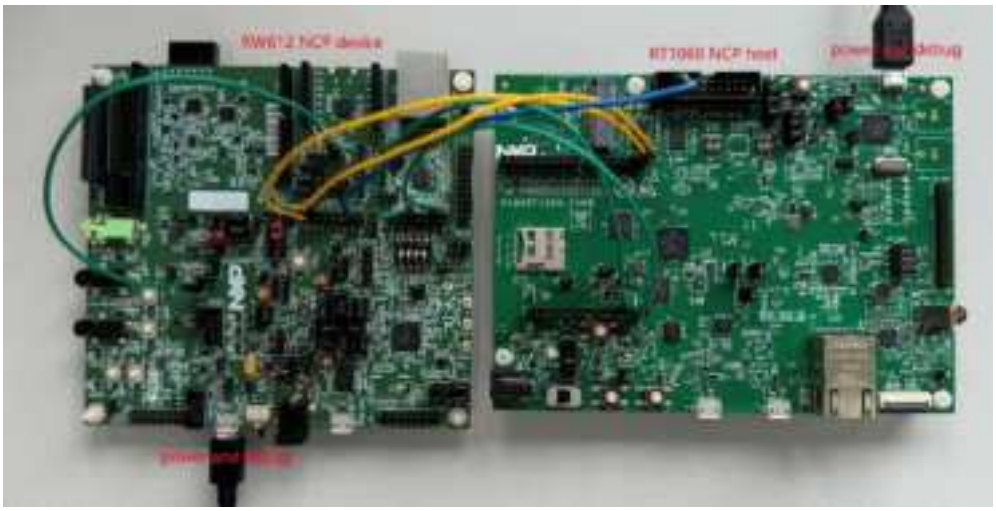

Figure 4. Connection of RW612 EVK to i.MX RT1060 EVKB over UART interface

3.2 USB interface

Figure 5 shows the connection between RW612 BGA V4 board and i.MX RT1060 EVKB board with USB interface.

- Connect the USB-OTG (J12) port on RW612 EVK board to J48 port on i.MX RT1060 EVK board via an USB-to-Micro-USB converter.

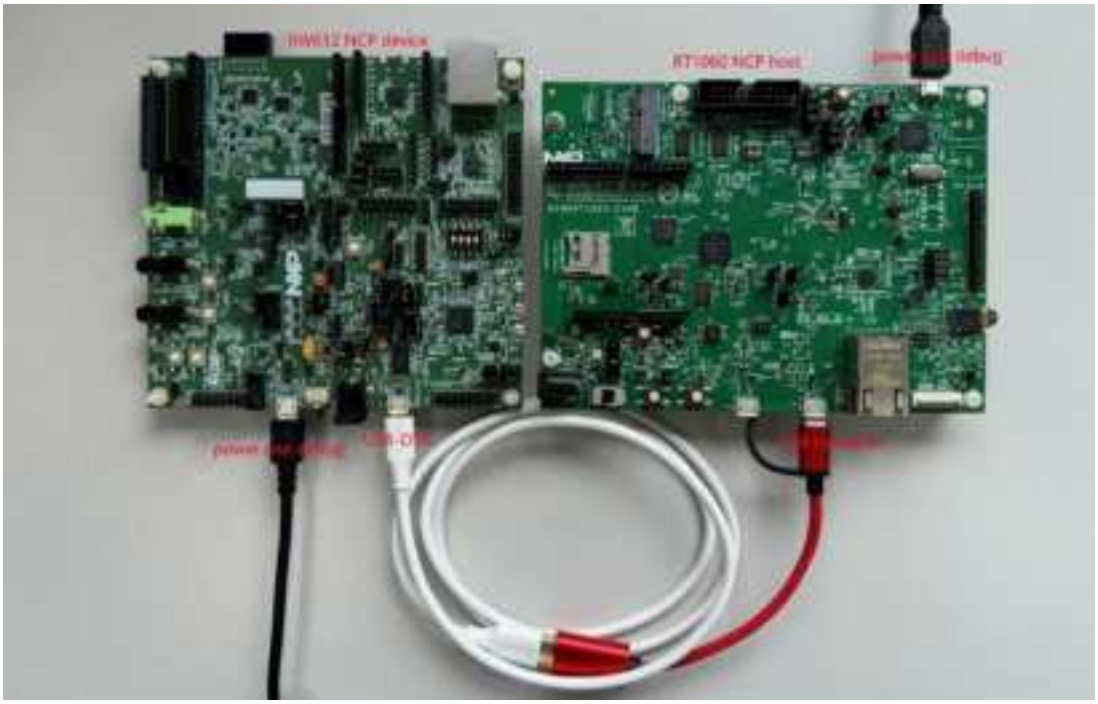

Figure 5. Connection between RW612 and i.MX RT1060 with USB interface

3.3 SPI interface

3.3.1 Board configuration

To enable NCP mode over SPI:

- Configure the RW612 EVK board (SPI target):
  - Connect JP30 1-2, JP9, JP19, JP23, and JP51.
  - Disconnect JP47 and connect JP47-1 to GND (for example HD3 pin 5)
  - Remove R97, R415, R594, and R656.
  - Install R409, R49, R13, R43, and R520.
- Configure i.MX RT1060 EVKB board (SPI controller):
  - Add R356, R350, R346, and R362.

Note: *If the connection of JP19 causes UART3 to stop working, remove R101.*

3.3.2 Pin connections

Table 2 lists the pin connections required to route RW612 SPI signals (target) to i.MX RT1060 SPI signals (controller). For instance, connect RW612 J5 Pin5 to i.MX RT1060 J17 Pin5. See Section 3.3.3.

- GPIO1_17: The SPI target notifies the SPI controller to transmit.
- GPIO1_16: The SPI target notifies the SPI controller that Direct Memory Access (DMA) is ready and transmit can start.

Table 2. Pin connections between RW612 board and i.MX RT1060 EVK

SPI controller (i.MX RT1060 EVKB)		SPI target (RW612 EVK)	
Pin name	**Board location**	**Pin name**	**Board location**
CITO	J17 Pin5	CITO	J5 Pin5
COTI	J17 Pin4	COTI	J5 Pin4
SCK	J17 Pin6	SCK	J5 Pin6
CS	J17 Pin3	CS	J5 Pin3
GND	J17 Pin7	GND	J5 Pin7
GPIO1_17	J17 Pin10	GPIO27	HD2 Pin11
GPIO1_16	J17 Pin9	GPIO11	HD11 Pin13

3.3.3 Hardware connection

Figure 6 shows the connection of RW612 board with i.MX RT1060 EVK board with SPI interface.

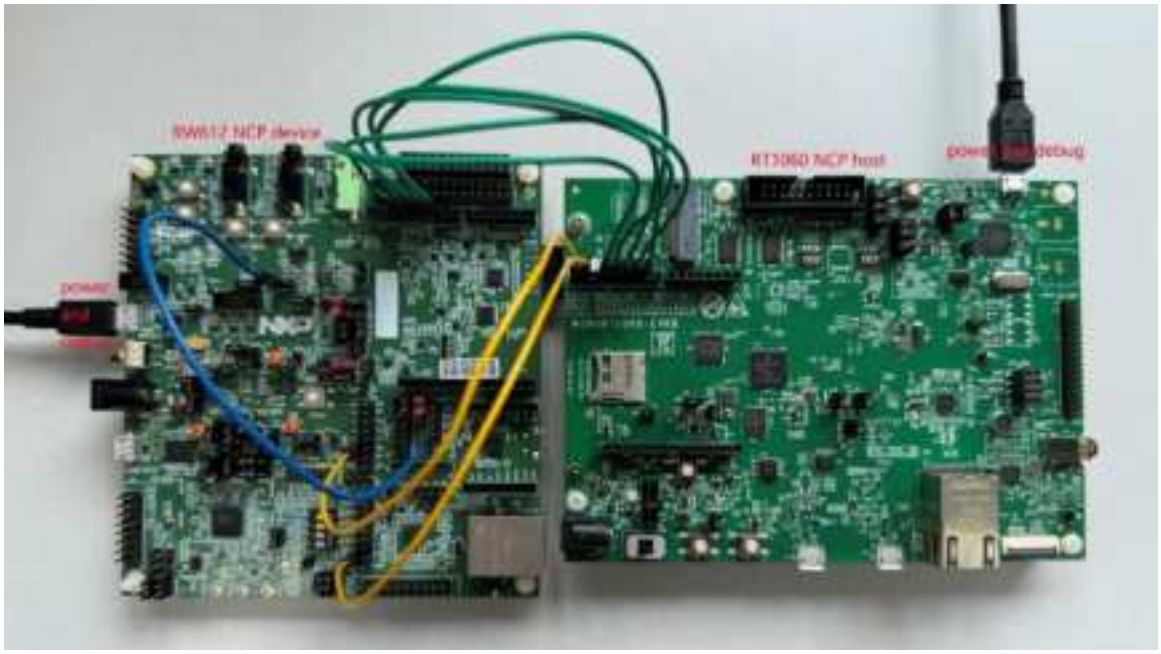

Figure 6. Connection between RW612 board and i.MX RT1060 EVK board over SPI

3.4 SDIO interface

3.4.1 Board configuration

To enable NCP mode over SDIO, configure the RW612 BGA board:

- Connect JP16 1-2

Note: *By default, RW612 BGA board works with 3.3 V IO voltage. To change IO voltage to 1.8 V, connect JP16 1-2.*

3.4.2 Hardware connection

Connect i.MX RT1060 board to RW612 board with the mini-SDIO cable (Figure 7).

Figure 7. Connection between i.MX RT1060board and RW612 board with the mini-SDIO cable

4 Compile NCP host application

The NCP Application on i.MX RT1060 is called ncp_host. Download the i.MX RT1060 SDK (version 2.16.000 and above) from [4].

Path to the NCP host application example:

<i.MX RT1060-SDK-top-dir>\boards\evkbmimxrt1060\ncp_examples\ncp_host.

The suggested toolchains to compile NCP application are:

- IAR: 9.50.1
- ARMGCC: 12.3.1

4.1 Wi-Fi

Steps to build the NCP host application for Wi-Fi:

Step 1 – Open the example in IAR, or use ARMGCC as compilation tool.

Step 2 – Check that *CONFIG_NCP_WIFI* is defined in *ncp_host_config.h*.

Path to *ncp_host_config.h*:

<i.MX RT1060-SDK-top-dir>\boards\evkbmimxrt1060\ncp_examples\ncp_host\ncp_host_config.h

```
#define CONFIG_NCP_WIFI 1
```

Step 3 – Set the hardware interface in *ncp_host_config.h* based on the hardware connection.

```
/* Interface options */
#define CONFIG_NCP_UART 1
#define CONFIG_NCP_SPI 0
#define CONFIG_NCP_USB 0
#define CONFIG_NCP_SDIO 0
```

Note: *Multiple interfaces are not supported in parallel. Enable only one NCP interface at a time and disable the other interfaces.*

Step 4 – Set `CONFIG_NCP_SUPP` to 1 or 0 according to the setting of `ncp_device`. The value must be the same for the host and for the device.

```
#define CONFIG_NCP_SUPP 1
```

- `CONFIG_NCP_SUPP` is used to indicate whether wpa_supplicant is supported or not.
- If `CONFIG_NCP_SUPP` is defined for the NCP device, define the macro `CONFIG_NCP_SUPP` for NCP host.
- If `CONFIG_NCP_SUPP` is not defined for the NCP device, undefine the macro `CONFIG_NCP_SUPP` for the NCP host.

Step 5 – Compile the example and program the application image to i.MX RT1060. Find more details in [1].

4.2 Bluetooth Low Energy

The example for Bluetooth LE NCP host application is located in the directory:

<i.MXRT1060-SDK-top-dir>\boards\evkbmimxrt1060\ncp_examples\ncp_host.

Steps to build the NCP host application for Bluetooth LE:

Step 1 – Import the NCP example to IAR, or use ARMGCC as compilation tool.

Step 2 – Make sure *CONFIG_NCP_BLE* is defined as 1 in *ncp_host_config.h*.

```
#define CONFIG_NCP_BLE 1
```

Step 3 – Set the hardware interface in *ncp_host_config.h* based on the hardware connection.

Note: *Multiple interfaces are not supported in parallel. Enable only one NCP interface at a time and disable the other interfaces.*

```
/* Interface options */
#define CONFIG_NCP_UART 1
#define CONFIG_NCP_SPI 0
#define CONFIG_NCP_USB 0
#define CONFIG_NCP_SDIO 0
```

Step 4 – Compile the example and program the application image to i.MX RT1060. Find more details in [1].

4.3 Thread

The NCP host application for Thread located is available at: *https://github.com/NXP/ot-nxp/*.

Note: *For Thread, only ARMGCC can be used to compile NCP host (i.MX RT1060) and device (RW612) application.*

Step 1 – Clone the repository, update the SDK and compile the OT NCP host example:

```
$ git clone -b v1.4.0-pvw1 https://github.com/NXP/ot-nxp.git # Clone from GitHub
$ cd ot-nxp                                 # Switch to the ot-nxp folder
$ git submodule update --init               # Update submodules
$ cd third_party/github_sdk/                # Switch to the sdk folder for RW612
$ west init -l manifest --mf west.yml       # prepare for update RW612 SDK online
$ west update                               # update RW612 SDK online
$ cd <path-to-ot-nxp>l                      # Switch back to the ot-nxp folder
```

Step 2 – Move to the *ot-nxp* directory and build the NCP host application for different interfaces.

Command for the UART interface:

```
$ ./script/build_rt1060 rw612_ncp_host -DOT_NCP_RW612_INTERFACE=UART
```

Command for the USB interface:

```
$ ./script/build_rt1060 rw612_ncp_host -DOT_NCP_RW612_INTERFACE=USB
```

Command for the SDIO interface:

```
$ ./script/build_rt1060 rw612_ncp_host -DOT_NCP_RW612_INTERFACE=SDIO
```

Command for the SPI interface:

```
$ ./script/build_rt1060 rw612_ncp_host -DOT_NCP_RW612_INTERFACE=SPI
```

The OT NCP host application binary *ot-cli-rt1060.bin* is located in *build_rt1060/rw612_ncp_host/bin* directory.

5 Compile NCP device application

The NCP Application on RW612 is called *ncp_device*. The path to the source code of the application in RW612 SDK is:

<RW612-SDK-top-dir>\boards\rdRW612bga\ncp_examples\ncp_device.

The suggested toolchains to compile NCP device application are:

- IAR: 9.50.1
- ARMGCC: 12.3.1

5.1 Wi-Fi

Steps to compile the *ncp_device* application for Wi-Fi:

Step 1 – Import the example to IAR, or use ARMGCC as compilation tool.

Step 2 – Make sure `CONFIG_NCP_WIFI` is defined as 1 in *app_config.h*.

The path to *app_config.h* file is:

<RW612-SDK-top-dir>\boards\rdRW612bga\ncp_examples\ncp_device\app_config.h

Step 3 – Choose the hardware interface in *app_config.h* file based on the hardware connection.

```
#define CONFIG_NCP_UART 1
#define CONFIG_NCP_SPI 0
#define CONFIG_NCP_USB 0
#define CONFIG_NCP_SDIO 0
```

Note: *Multiple interfaces are not supported in parallel. Enable only one NCP interface at a time and disable the other interfaces.*

Step 4 – Define *CONFIG_NCP_SUPP* to 1 or 0 according to the setting of NCP host side. The value should be the same on the host and on the device sides.

```
#define CONFIG_NCP_SUPP  1
```

CONFIG_NCP_SUPP is defined in *wifi_config.h* file.

The path to *wifi_config.h* file is:

<RW612-SDK-top-dir>\boards\rdRW612bga\ncp_examples\ncp_device\wifi\wifi_config.h

Step 5 – Compile the example and program the application image to RW612. Find more details in [2].

5.2 Bluetooth Low Energy

The path to the source code of the Bluetooth LE application in RW612 SDK is:

<RW612-SDK-top-dir>\boards\rdRW612bga\ncp_examples\ncp_device

Steps to compile the ncp_device application for Bluetooth LE:

Step 1 – Import the example to IAR, or use ARMGCC as compilation tool.

Step 2 – Make sure `CONFIG_NCP_BLE` is defined in *app_config.h*.

```
#define CONFIG_NCP_BLE 1
```

Step 3 – Choose the hardware interface in *app_config.h* file based on the hardware connection.

```
/* Interface options */
#define CONFIG_NCP_UART 1
#define CONFIG_NCP_SPI 0
#define CONFIG_NCP_USB 0
#define CONFIG_NCP_SDIO 0
```

Note: *Multiple interfaces are not supported in parallel. Enable only one NCP interface at a time and disable the other interfaces.*

Step 4 – Compile the example and program the application image to RW612. Find more details in [2].

5.3 Thread

The NCP device application for Thread is located at: *https://github.com/NXP/ot-nxp/*

Note: *For Thread, only ARMGCC can be used to compile NCP host (i.MX RT1060) and device (RW612) application.*

Step 1 – Clone the repository, update the SDK and compile the OT NCP device example:

```
$ git clone -b v1.4.0-pvw1 https://github.com/NXP/ot-nxp.git # Clone the Git repo
$ cd ot-nxp                                                  # Switch to the ot-nxp directory
$ git submodule update --init                                # Update submodules
$ cd third_party/github_sdk/                                 # Switch to the sdk directory for RW612
$ west init -l manifest --mf west.yml                        # prepare for update RW612 SDK online
$ west update                                                # update RW612 SDK online
$ cd <path-to-ot-nxp>                                        # Switch back to the ot-nxp directory
```

Step 2 – Move to the *ot-nxp* directory and build the NCP device application for the different interfaces.

Command for the UART interface:

```
$ ./script/build_rw612 ot_cli -DOT_NCP_RADIO=ON -DOT_NXP_NCP_UART_INTERFACE=ON
```

Command for USB interface:

```
$ ./script/build_rw612 ot_cli -DOT_NCP_RADIO=ON -DOT_NXP_NCP_USB_INTERFACE=ON
```

Command for SDIO interface:

```
$ ./script/build_rw612 ot_cli -DOT_NCP_RADIO=ON -DOT_NXP_NCP_SDIO_INTERFACE=ON
```

Command for the SPI interface:

```
$ ./script/build_rw612 ot_cli -DOT_NCP_RADIO=ON -DOT_NXP_NCP_SPI_INTERFACE=ON
```

The NCP device application binary located in *build_rw612/rw612_ot_cli/bin* directory.

6 Run NCP host application

6.1 Wi-Fi

Step 1 - Load the NCP device image on RW612 board with the specified interface (Section 3).

Table 3 shows the image load addresses.

Table 3. Image load addresses for Wi-Fi NCP device application

Image	Load address
Bluetooth LE/802.15.4 combo firmware	0x085e0000
NCP device application binary	0x08000000

Step 2 – Program the NCP host image on i.MX RT1060 board with the specified interface.

Step 3 – Connect RW612 to i.MX RT1060 with the specified interface. Refer to section 3.

Step 4 – Power on i.MX RT1060 board and RW612 board.

Note:

- *If RW612 board and i.MX RT1060 EVKB are connected over UART, i.MX RT1060 EVKB must be powered on first. The requirement for i.MX RT1060 EVKB power-on timing is that the core must be powered on before the I/O.*
  - *If RW612 is powered on first, RW612 UART TX drives the voltage to the IO of the i.MX RT1060 EVKB UART RX.*
  - *If I/O is powered on before the core on the i.MX RT1060 SOC, the startup of i.MX RT1060 is affected.*
- *If RW612 and i.MX RT1060 EVKB are connected over SDIO, RW612 must be powered on first.*

Step 5 – Run the NCP host application on i.MX RT1060 board and get the list of supported Wi-Fi commands (Figure 8).

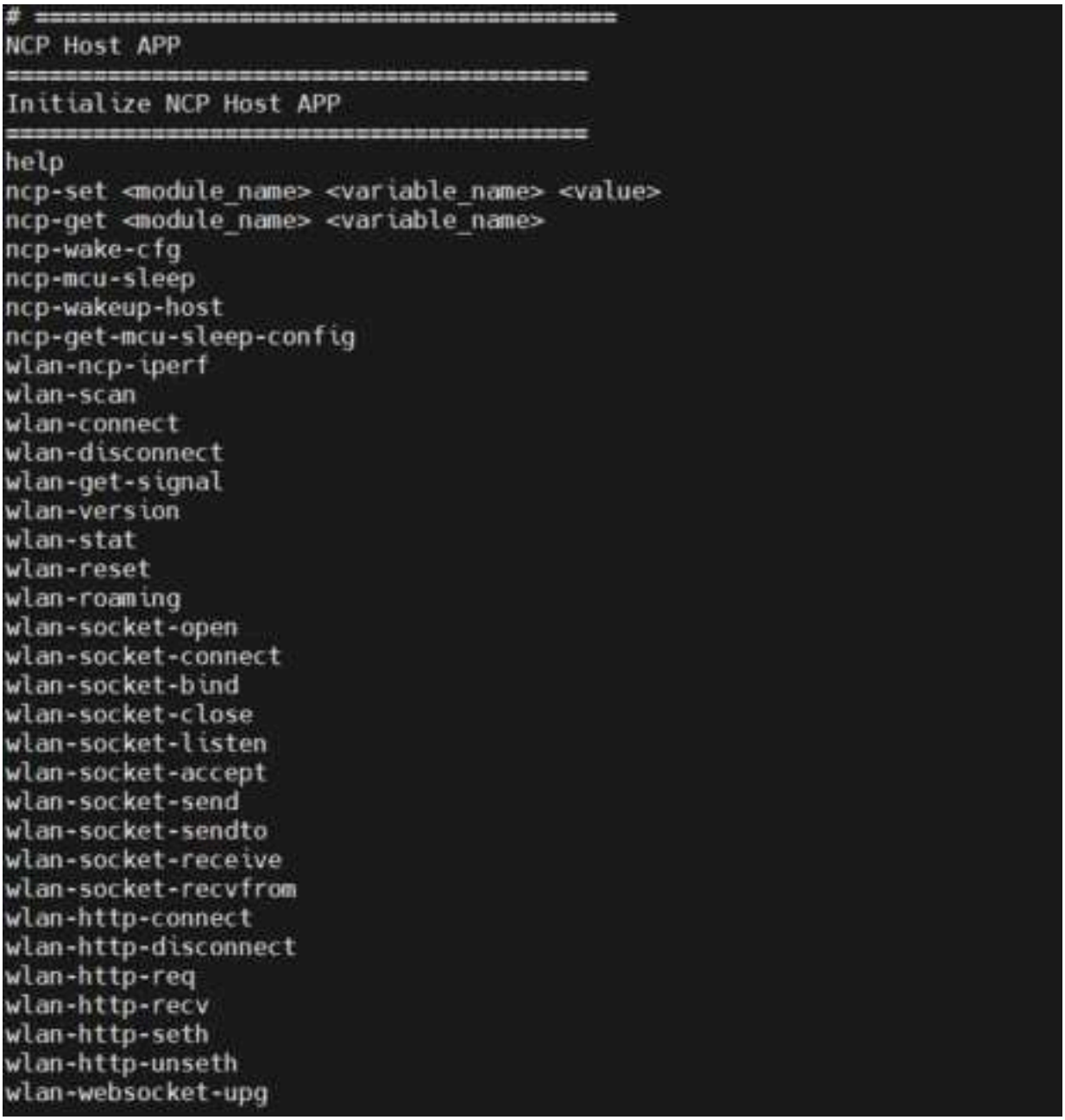

Figure 8. List of supported Wi-Fi commands on MCU NCP host application

Step 6 – Issue the Wi-Fi commands on the NCP host side.

The commands are sent to the NCP device. The command response shows on the NCP host side. Figure 9 shows an example of `wlan-version` command issued on the NCP host side.

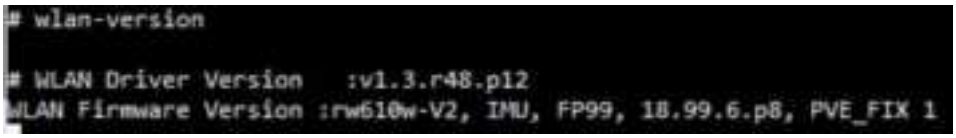

Figure 9. Example of `wlan-version` command output

6.2 Bluetooth Low Energy

Step 1 – Load the NCP device image on RW612 board with the specified interface (section 3).

Table 4 shows the load address for Bluetooth LE NCP device application.

Table 4. Load address of the images for Bluetooth LE NCP device application

Images	Load address
Bluetooth LE/15.4 combo firmware	0x085e0000
NCP device application binary	0x08000400

Step 2 – Program the NCP host image on i.MX RT1060 board with the specified interface.

Step 3 – Connect RW612 to i.MX RT1060 with the specified interface (section 3).

Step 4 – Power on i.MX RT1060 board and RW612 board.

Step 5 – Run the NCP host application on i.MX RT1060 board and get the list of supported Bluetooth LE commands (Figure 10).

```
========================================
NCP Host APP
========================================
Initialize NCP Host APP
========================================
help
ncp-set <module_name> <variable_name> <value>
ncp-get <module_name> <variable_name>
ncp-wake-cfg
ncp-mcu-sleep
ncp-wakeup-host
ncp-get-mcu-sleep-config
ncp-usb-pm-cfg <1/2>
ble-set-adv-data <adv_data>
ble-start-adv
ble-stop-adv
ble-set-scan-params <filter_option> <interval> <window>
ble-start-scan <scan_type>
ble-stop-scan
ble-connect <addr_type> <addr>
ble-disconnect <addr_type> <addr>
ble-set-data-len <addr_type> <addr> <tx_max_len> [optional<tx_max_time>]
ble-set-phy <addr_type> <addr> <tx_phy> <rx_phy>
ble-conn-param-update <addr_type> <addr> <max_interval> <min_interval> <latency> <timeout>
ble-set-filter-list <filter_addr_num> <addr_type> <addr> ... <addr_type> <addr>
ble-start-encryption <addr_type> <addr>
ble-set-value <uuid_len> <uuid> <value_len> <value ...>
ble-read-characteristic <addr_type> <addr> <handle>
ble-set-power-mode <0/1>
ble-host-svc-add
ble-register-service <num_of_service> <service id_1> <service id_2> ...
ble-start-service <profile_name[hts/htc/hrs/hrc/bas]>
ble-cfg-subscribe <indicate/notify> <addr_type> <addr> <enable[0/1]> <ccc_handle>
ble-l2cap-connect <addr_type> <addr> <psm>
ble-l2cap-disconnect <addr_type> <addr>
ble-l2cap-send <addr_type> <addr> <times>
ble-l2cap-register <psm>
host init finished
========================================
```

Figure 10. List of supported Bluetooth LE commands on the MCU NCP host application

6.3 Thread

Step 1 – Load the NCP device image to RW612 on RW612 board with the specified interface (section 3). Table 5 shows the image load addresses.

Table 5. Image load addresss for OT NCP device application

Image	Load address
Bluetooth LE/802.15.4 combo firmware	0x085e0000
NCP device application binary	0x08000400

Step 2 – Program the NCP host image on i.MX RT1060 board with the specified interface.

Step 3 – Connect RW612 to i.MX RT1060 with the specified interface (Section 3.

Step 4 – Power on i.MX RT1060 board and RW612 board.

Step 5 – Run the NCP host application on i.MX RT1060.

- Input `help` to get the list of supported commands.
- Input `version` to get the current OpenThread version and check that NCP feature is working (Figure 11).

Figure 11. List of supported Thread commands on MCU NCP host application

7 Acronyms and abbreviations

Table 6. Acronyms and abbreviations

Acronym	Definition
CITO	Controller input target output[1]
CLI	Command line interface
COTI	Controller output target input[1]
EVK	Evaluation kit
FW	Firmware
HW	Hardware
IDE	Integrated development environment
NCP	Network co-processor
SDK	Software development kit
SW	Software

[1] The master/slave replacement in this document follows the recommendation of NXP.

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9 References

[1] User guide - Getting Started with MCUXpresso SDK for MIMXRT1060-EVKB (available in the *docs* directory in i.MX RT1060 SDK)

[2] User manual – UM11798 – Getting Started with Wireless on RW61x Evaluation Board Running RTOS (link)

[3] Web page – i.MX-RT1060: Crossover MCU with Arm® Cortex®-M7

[4] Web page - NXP MCUXpresso SDK Builder (link)

10 Revision history

Table 7. Revision history

Document ID	Release date	Description
UM12133 v.1.0	24 September 2024	• Initial version

11 Contact us

Please refer to following links for more product details, queries and support.

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