AN13953

Integrating NFC Reader Library in a KW4x Bluetooth Low Energy Application

Rev. 1 — 30 May 2023 Application note

Document information

Information	Content
Keywords	AN13953, Bluetooth LE, KW45/KW47, NFC, Reader library, PN5180, CLRC663, NCF3320
Abstract	This document gives instructions on how to create a Bluetooth Low Energy project for the EVK-KW45 development board and MCUXpresso IDE, and how to integrate NFC Reader Library.

1 Introduction

This document gives instructions on how to create a Bluetooth Low Energy (Bluetooth LE) project for the EVK-KW45 development board and MCUXpresso IDE, and how to integrate NFC Reader Library.

This document guides software developers who want to use, adapt, and integrate the NFC Reader Library to an SDK wireless connectivity example.

1.1 NFC reader library overview

The NXP NFC Reader Library is a modular software library written in C language, which provides an API that enables customers to create their own software stack and applications for the NXP contactless reader ICs:

- PN512
- CLRC633 family
- PN7462 family
- PN5180

This API facilitates the most common operations required in NFC applications such as:

- reading or writing data into contactless cards or tags;
- exchanging data with other NFC-enabled devices;
- allowing NFC reader ICs to emulate cards.

The NFC Reader Library is designed in a way to be easily portable to many different microcontrollers with a multi-layered architecture:

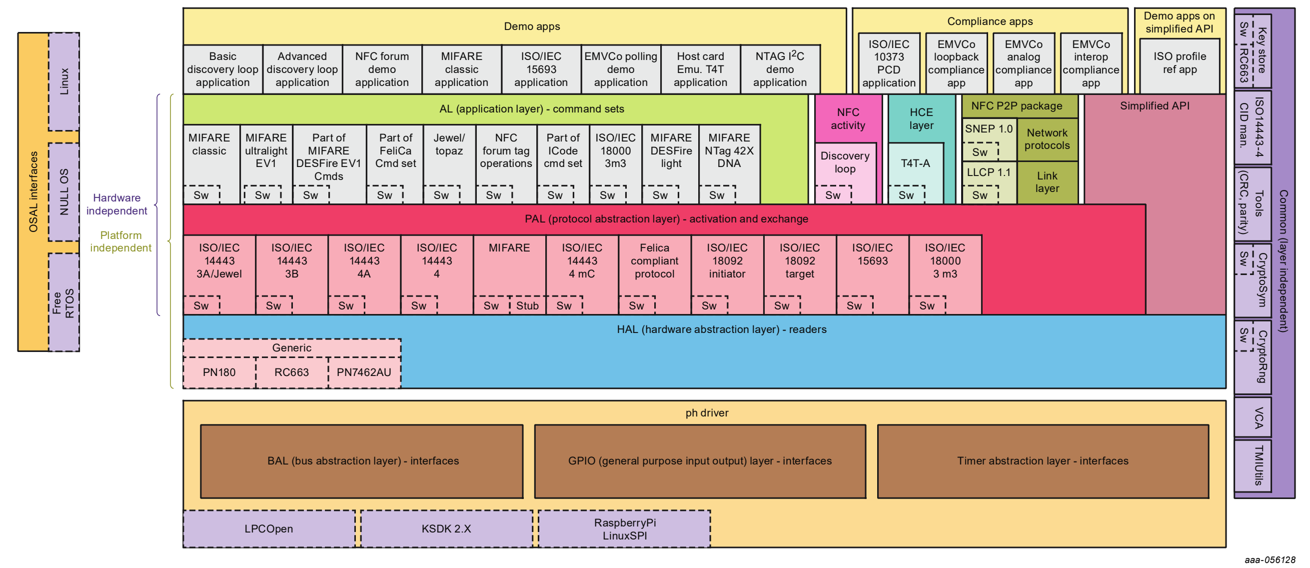


Figure 1. NFC reader library

As main blocks, we have:

- Application Layer (AL) - implements the command sets to interact with MIFARE cards and NFC tags;
- NFC activity - implements a configurable Discovery loop for the detection of contactless cards, NFC tags, or other NFC devices;
- HCE and P2P components, for the emulation of Type 4 tags and P2P data exchange respectively;
- Protocol abstraction layer (PAL) - contains the RF protocol implementation of the ISO14443, FeliCa, vicinity and NFC standards;

- Hardware abstraction layer (HAL) - implements the drivers for controlling the NFC front ends RF interface and capabilities;
- Driver Abstraction Layer (DAL) - implements the GPIO pinning, the timer configuration, and the physical interface (BAL) between the host MCU and the reader IC;
- OSAL module, in charge of abstracting the OS or RTOS specifics (tasks events, semaphores, and threads).

1.2 KW45 wireless microcontroller overview

The KW45 product family is a low-power, highly secure, and single-chip wireless MCU that integrates a high performance Bluetooth Low Energy version 5.3 radio and CAN FD for Automotive and Industrial applications.

The KW45 microcontroller is a low-power, highly secure, Arm Cortex-M33-based wireless device targeting these applications with up to 1 MB program Flash, 128 kB SRAM, and a 2.4 GHz upgradable radio supporting up to 24 simultaneous hardware connections in any central/peripheral combination.

For more details, see Bluetooth® Smart/Bluetooth Low Energy.

1.3 NFC reader library – integration with KW45B41Z-EVK overview

The current NFC Reader Library v5.22.01 does not support Kinetis KW4x MCU. For reference, see the K82 NFC Reader Library package.

To integrate the library, perform the following steps:

- Hardware preparation (the connection between KW45B41Z-EVK board and NFC reader board);
- Setting up the development environment (SDK download, workspace);
- Preparing adaptation files for KW45 board;
- Integrating NFC application to `wireless_uart` Bluetooth LE example;
- Running the demo.

2 Hardware setup

2.1 Hardware required

To perform the NFC integration to a `wireless_uart` Bluetooth LE example, the platforms below are needed:

- NCF3320 Antenna v1.0 board as an NFC transceiver;
- KW45B41Z-EVK board as host MCU, used to load and run the Bluetooth Low Energy Stack and NFC application logic.

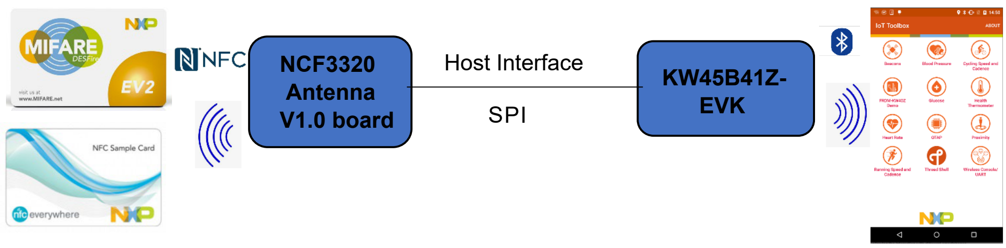


Figure 2. Hardware required for NFC integration

2.2 Pin configuration

The communication between the boards is via the SPI communication using the following pin configuration:

Table 1. Pin configuration

Master board (KW45B41Z-EVK)	Connects to	Slave board (NCF3320 Antenna v 1.0)
PTC0 (J2-pin10)	—	IRQ
PTC1 (J2-pin9)	—	Reset
PTA18 (J2-pin2)	—	MOSI
PTA17 (J1-pin2)	—	MISO
PTA19 (J1-pin5)	—	SCK
PTA16 (J1-pin1)	—	CS
GND (J3-pin7)	—	GND

2.3 Power configuration

The KW45 must be put in Bypass mode by placing the jumper JP5 in position 3-4 (its default position is 1-2, DCDC mode).

	P3V3 JP5	VDD_CORE JP15 [0.84 V - 1.21 V]	VDD_PA JP11	VDD_BRD JP10
DCDC mode	3 - 4	NC	Open	5 - 6
Bypass mode	3 - 4	NC	Open	4 - 3
PMIC mode	5 - 6	1-2	Ext supply	1 - 2

aaa-056129

Figure 3. Power configuration

3 Setting up the development environment

Follow the next steps to create an EVK-KW45 Bluetooth Low Energy project for MCUXpresso IDE (in which the NFC library is integrated) and to get the latest NFC Reader Library release. For this example, the version of SDK used is **SDK_2_12_2_KW45B41Z-EVK** and the **NFC Reader Library** version is **v5.22.01**.

1. Download and Install MCUXpresso IDE (for this example, we are using **MCUXpresso IDE v11.7.0 [Build 9198**]).
   - Go to the MCUXpresso-IDE webpage and download the latest version of IDE.

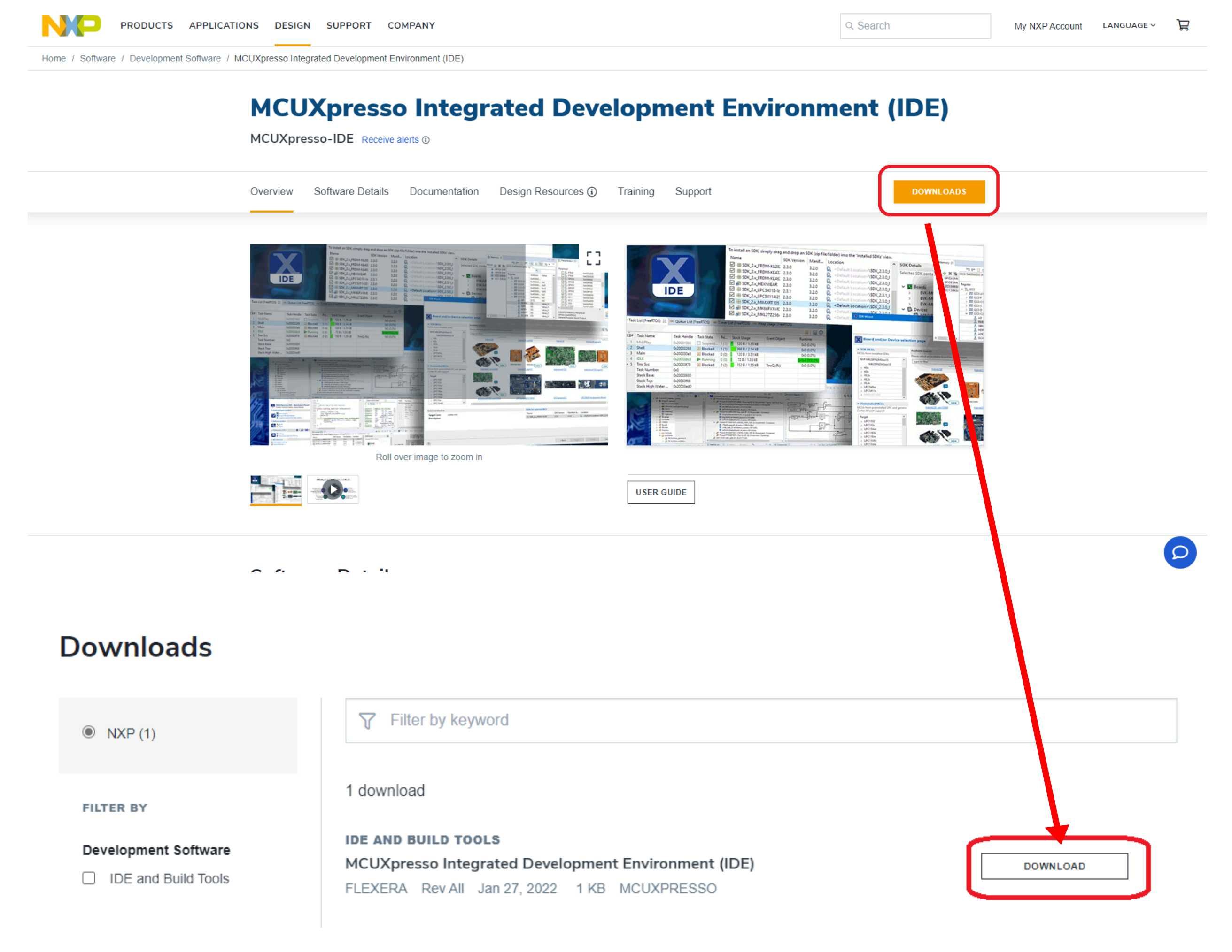


Figure 4. Download IDE

- Install the IDE.

2. Get the latest NFC Reader Library release (for this example, we are using v5.22.01)
   - Go to the NXP NFC Reader Library webpage.
   - Go to the **Downloads** tab.

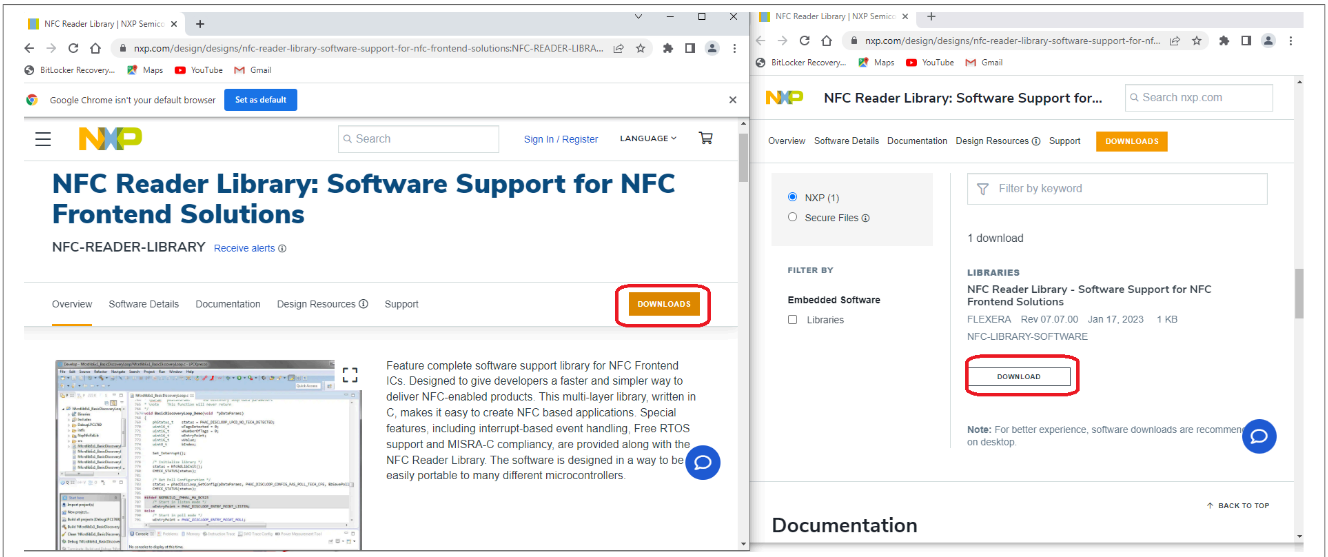
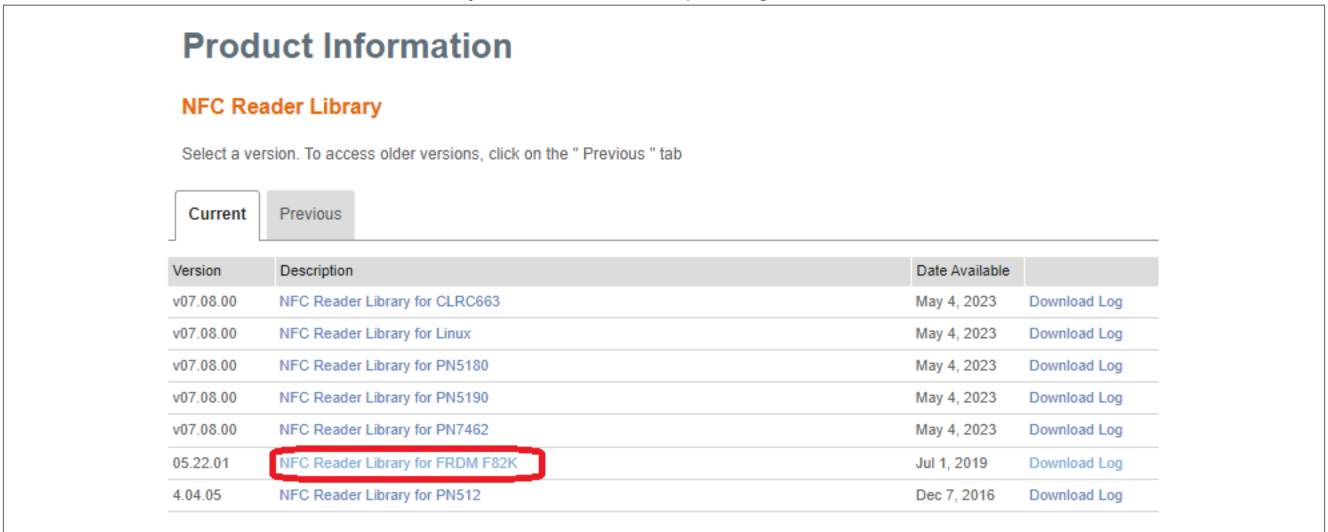


Figure 5. Downloads tab

- Download the NFC Reader Library for Kinetis K82F package.



Product Information

NFC Reader Library

Select a version. To access older versions, click on the " Previous " tab

Current | Previous

Version	Description	Date Available	
v07.08.00	NFC Reader Library for CLRC663	May 4, 2023	Download Log
v07.08.00	NFC Reader Library for Linux	May 4, 2023	Download Log
v07.08.00	NFC Reader Library for PN5180	May 4, 2023	Download Log
v07.08.00	NFC Reader Library for PN5190	May 4, 2023	Download Log
v07.08.00	NFC Reader Library for PN7462	May 4, 2023	Download Log
05.22.01	NFC Reader Library for FRDM F82K	Jul 1, 2019	Download Log
4.04.05	NFC Reader Library for PN512	Dec 7, 2016	Download Log

Figure 6. Download NFC reader library

3. Generate a downloadable SDK package for KW45B41Z-EVK board (**SDK_2_12_2_KW45B41Z-EVK**).
   - Navigate to Select Development Board webpage and search for KW45B41Z-EVK board.
   - Select **Build MCUXpresso SDK**.

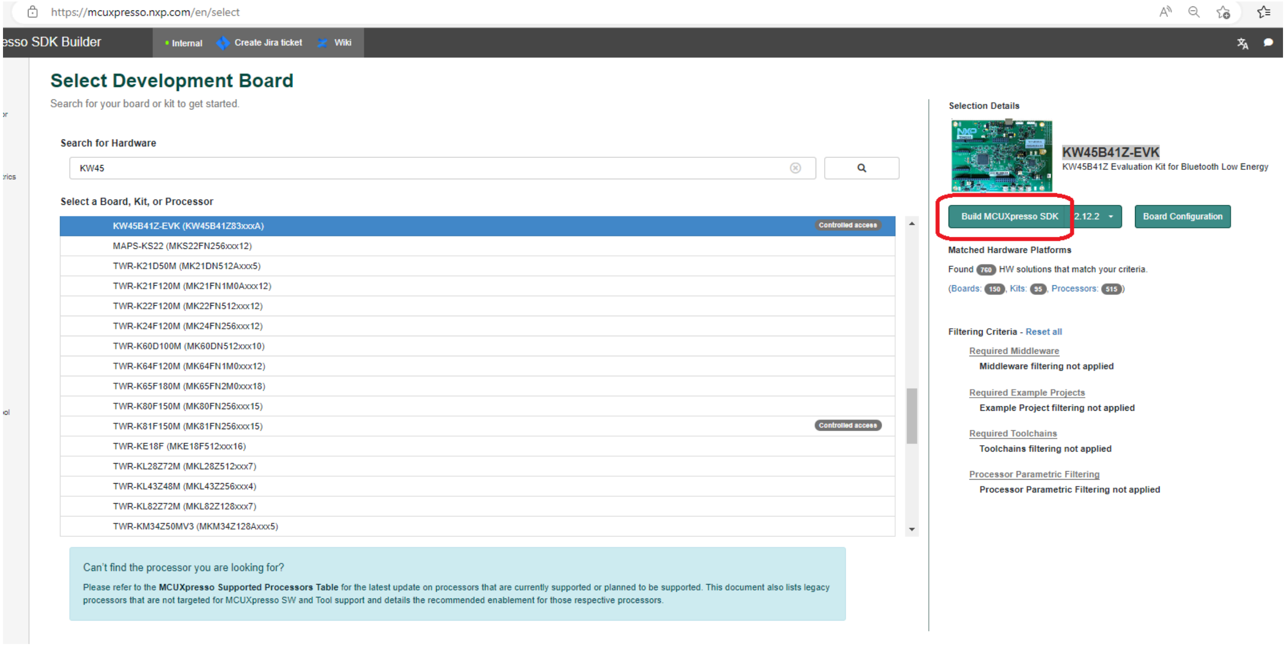


Figure 7. Select Development Board page

– As a toolchain, make sure that the MCUXpresso IDE is selected.

– Use the **Download SDK** button to start downloading SDK package.

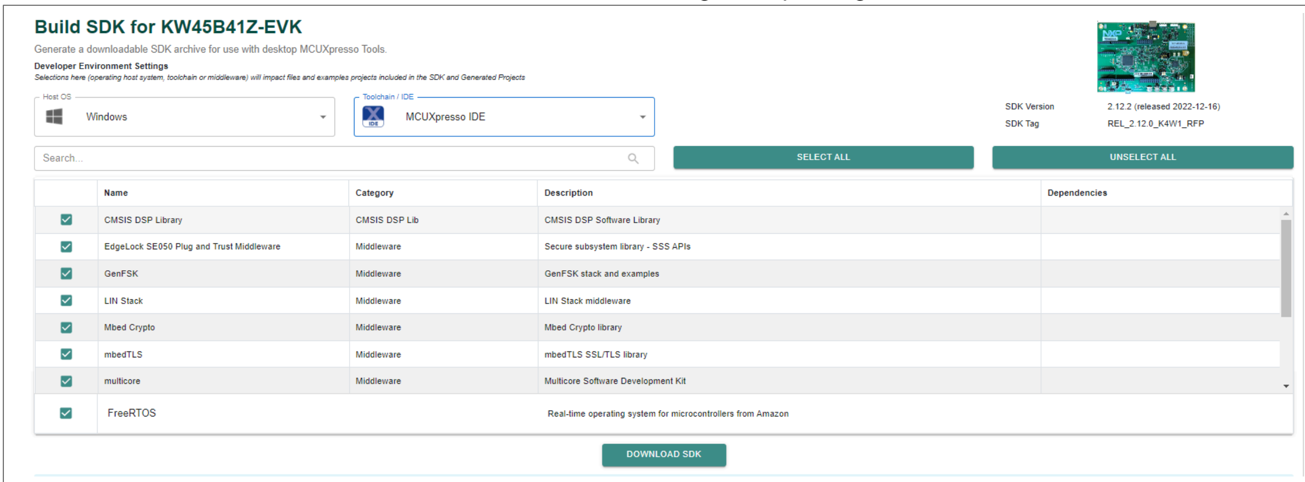


Figure 8. Start downloading

4. Create the MCUXpresso workspace.
   - Open MCUXpresso IDE and create a workspace.
   - Drag and drop **SDK_2_12_2_KW45B41Z-EVK** into the installed SDKs tab of the MCUXpresso IDE.

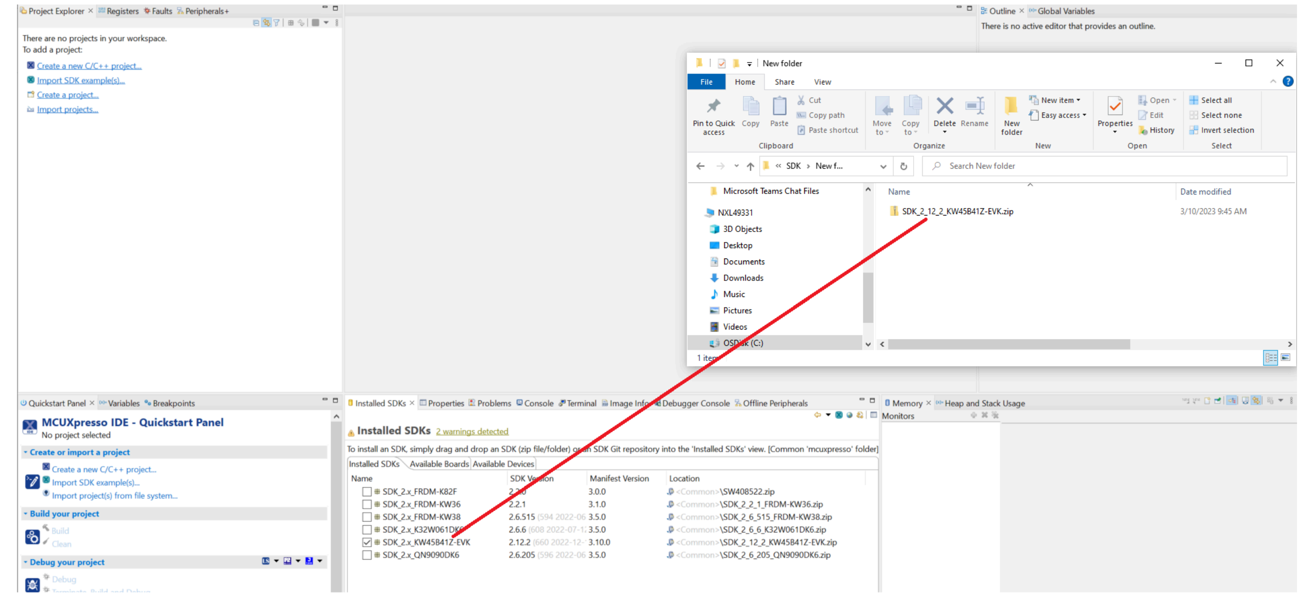


Figure 9. Dragging and dropping `SDK_2_12_2_KW45B41Z-EVK`

- Click **Import SDK example(s)** from the **Quickstart** panel.
- Search and select **kw45b41zevk** in the **board and/or device selection** page. Then, click **next**.

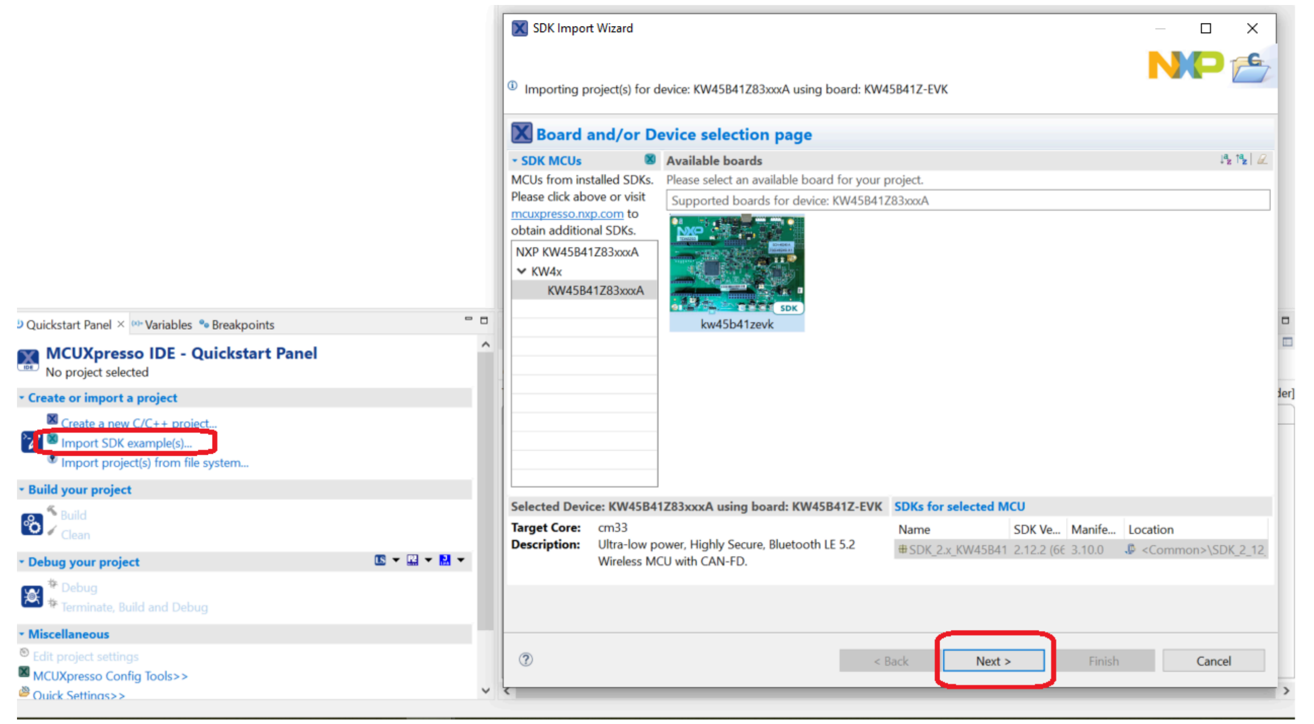


Figure 10. Select `kw45b41zevk`

- Select **wireless_uart_freertos** Bluetooth LE project。

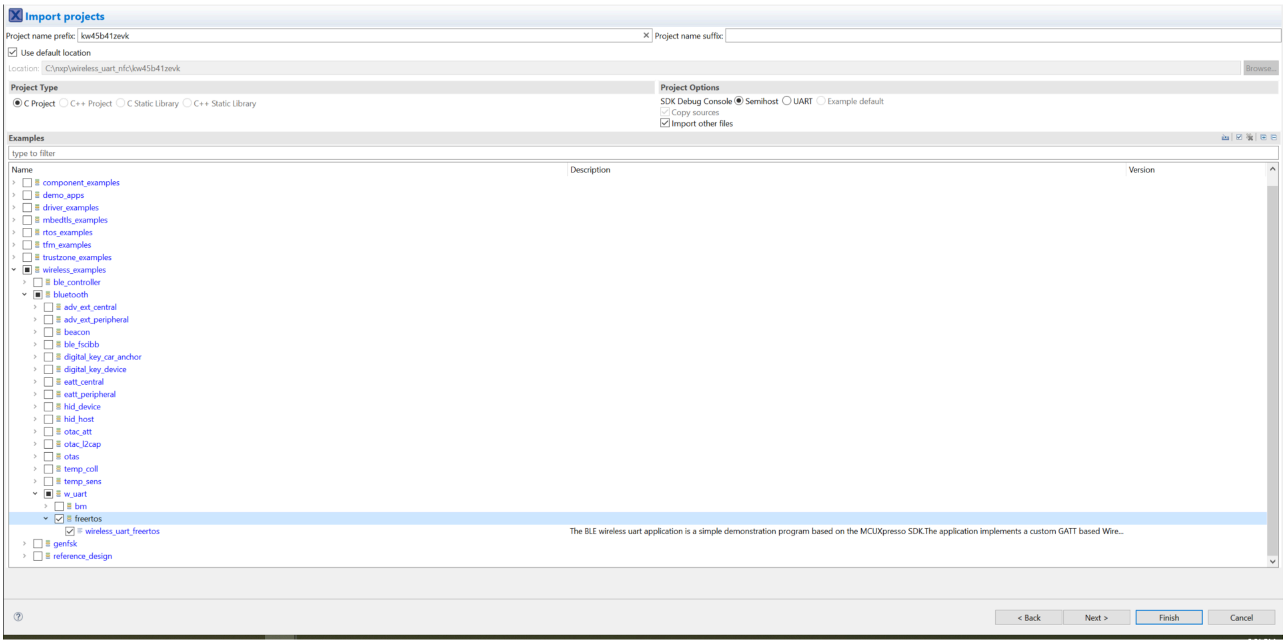


Figure 11. Selecting `wireless_uart_freertos`

4 Preparing adaptation files for KW45B41Z-EVK board

After unzipping the NFC Reader Library, create an equivalent file for KW45B41Z-EVK (*Board_FRDM_KW45FRc663.h*) by setting the right configuration for GPIOs and handlers.

The following files below must also be adapted:

- `DAL\cfg\BoardSelection.h`: include the new header file created.
- `DAL\src\KinetisSDK\phbalReg_KinetisSpi`: configure low-power SPI, include the LPIT driver, and add the SPI initialization afferent to K45 as follows:

```
        lpspi_master_config_t g_masterConfig;

     if ( (pDataParams == NULL) || (sizeof(phbalReg_Type_t) !=
  wSizeOfDataParams))
     {
         return (PH_DRIVER_ERROR | PH_COMP_DRIVER);
     }
     ((phbalReg_Type_t *)pDataParams)->wId      = PH_COMP_DRIVER |
  PHBAL_REG_KINETIS_SPI_ID;
     ((phbalReg_Type_t *)pDataParams)->bBalType = PHBAL_REG_TYPE_SPI;
     memset(&g_masterConfig, 0, sizeof(lpspi_master_config_t));
     g_masterConfig.baudRate = PHDRIVER_KSDK_SPI_DATA_RATE;
     g_masterConfig.bitsPerFrame = 8U;
     g_masterConfig.cpol = kLPSPI_ClockPolarityActiveHigh;
     g_masterConfig.cpha = kLPSPI_ClockPhaseFirstEdge;
     g_masterConfig.direction = kLPSPI_MsbFirst;
     g_masterConfig.pcsToSckDelayInNanoSec = 1000000000U /
  PHDRIVER_KSDK_SPI_DATA_RATE;
     g_masterConfig.lastSckToPcsDelayInNanoSec = 1000000000U /
  PHDRIVER_KSDK_SPI_DATA_RATE;
     g_masterConfig.betweenTransferDelayInNanoSec = 1000000000U /
  PHDRIVER_KSDK_SPI_DATA_RATE;
     g_masterConfig.whichPcs = kLPSPI_Pcs0;
```

```
    g_masterConfig.pcsActiveHighOrLow = kLPSPI_PcsActiveLow;

    /*Set clock source for LPSPI and get master clock source*/
   CLOCK_SetIpSrc(kCLOCK_Lpspi0, kCLOCK_IpSrcFro192M);
   CLOCK_SetIpSrcDiv(kCLOCK_Lpspi0, kSCG_SysClkDivBy16);
   phbalReg_SpiInit();
    /* Initialize the DSPI peripheral */
    LPSPI_MasterInit(PHDRIVER_KSDK_SPI_MASTER, &g_masterConfig,
 CLOCK_GetIpFreq(PHDRIVER_KSDK_SPI_CLK_SRC));
```

- `DAL\src\KinetisSDK\phDriver_KinetisSDK.c`: include the `lpit` driver, update interrupt types, and initialize the `lpit` timer as follows:

```

    lpit_chnl_params_t lpitChannelConfig;
    lpitChannelConfig.chainChannel          = false;
    lpitChannelConfig.enableReloadOnTrigger = false;
    lpitChannelConfig.enableStartOnTrigger  = false;
    lpitChannelConfig.enableStopOnTimeout   = false;
    lpitChannelConfig.timerMode             = kLPIT_PeriodicCounter;
    /* Set default values for the trigger source */
    lpitChannelConfig.triggerSelect = kLPIT_Trigger_TimerChn0;
    lpitChannelConfig.triggerSource = kLPIT_TriggerSource_External;

    LPIT_SetupChannel(PH_DRIVER_KSDK_PIT_TIMER,
 PH_DRIVER_KSDK_TIMER_CHANNEL,&lpitChannelConfig);
    LPIT_StopTimer(PH_DRIVER_KSDK_PIT_TIMER, PH_DRIVER_KSDK_TIMER_CHANNEL);
    LPIT_ClearStatusFlags(PH_DRIVER_KSDK_PIT_TIMER, kLPIT_Channel0TimerFlag);
    LPIT_EnableInterrupts(PH_DRIVER_KSDK_PIT_TIMER,
 kLPIT_Channel0TimerInterruptEnable);

    /* Configure timer period */
    LPIT_SetTimerPeriod(PH_DRIVER_KSDK_PIT_TIMER, PH_DRIVER_KSDK_TIMER_CHANNEL,
 (uint32_t)qwTimerCnt);
```

Also in this source an equivalent function for PIT IRQ Handler is needed:

```
void PIT_DriverIRQHandler(void)
{
    /* Clear interrupt flag.*/
    LPIT_ClearStatusFlags(PH_DRIVER_KSDK_PIT_TIMER, kLPIT_Channel0TimerFlag);

    /* Single shot timer. Stop it. */
    LPIT_StopTimer(PH_DRIVER_KSDK_PIT_TIMER, PH_DRIVER_KSDK_TIMER_CHANNEL);
    LPIT_DisableInterrupts(PH_DRIVER_KSDK_PIT_TIMER,
 kLPIT_Channel0TimerInterruptEnable);

    pPitTimerCallBack();

}
```

- In *NxpNfcRdLib\types\ph_NxpBuild_Platform.h*, add a definition for KW45 board.

For additional changes that are not outlined in this chapter, see the source code.

5 Integrating NFC application to `Wireless_UART` Bluetooth LE example

This chapter introduces how to integrate the `BasicDiscoveryLoop` NFC example to `Wireless_UART` Bluetooth LE application.

For the integration, perform the following steps:

- Add `pit` drivers in the project.
- On the `wireless_uart` project location, create an **nfc** folder.

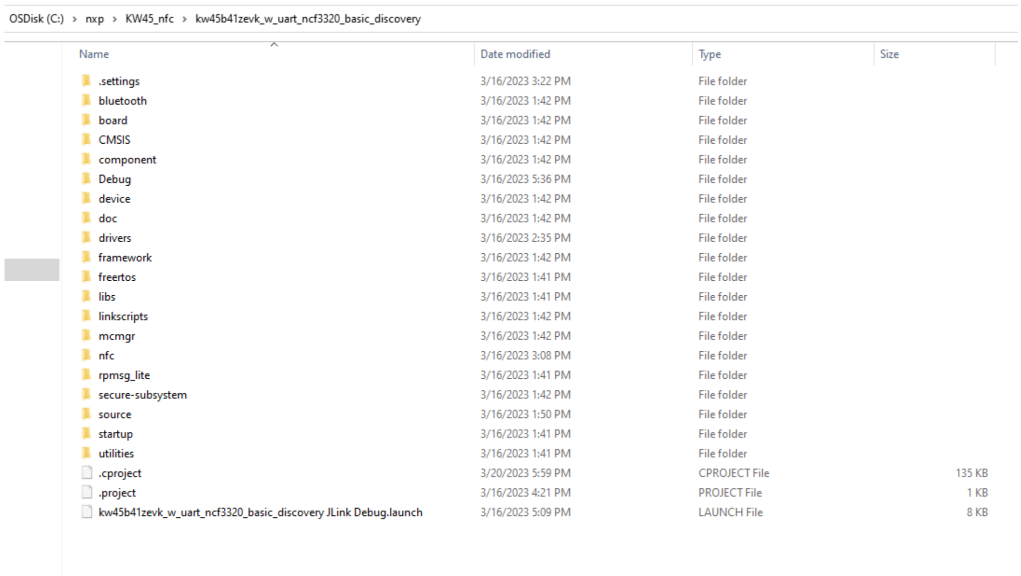


Figure 12. Creating an *nfc* folder

- Copy the *DAL*, *NxpNfcRdLib*, and *phOsal* folders from the modified NFC Reader Library.

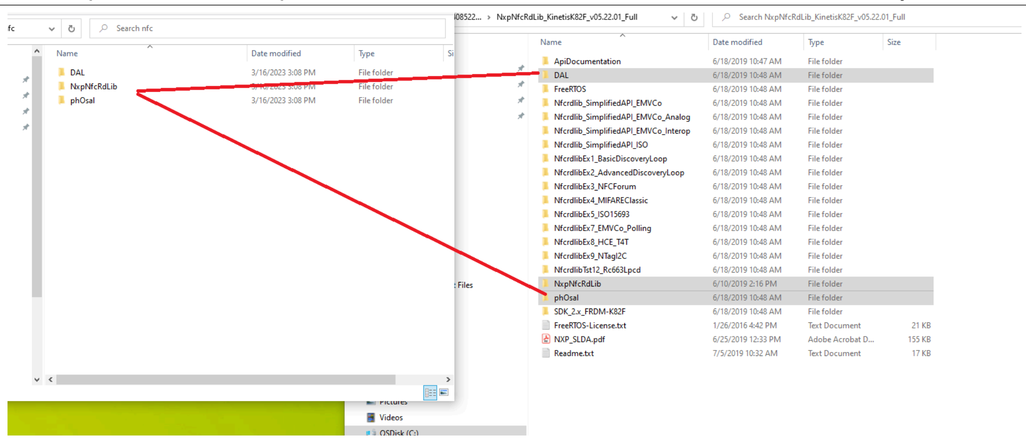


Figure 13. Copy folders

- On the `wireless_uart` project location, the *source* folder, create an *nfc* subfolder to integrate the `BasicDiscovery` loop files from *NfcrdlibEx1_BasicDiscoveryLoop* folder.

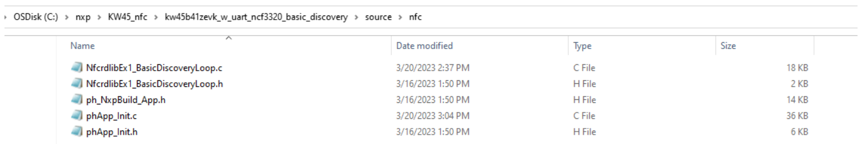


Figure 14. Source folder

These files require the changes below:

- In *NfcrdlibEx1_BasicDiscoveryLoop.c* file, rename main function to `NFC_BasicDiscoveryLoop_Start` and remove OS initialization.
- In *NfcrdlibEx1_BasicDiscoveryLoop.h*, declare `NFC_BasicDiscoveryLoop_Start` function.
- In *ph_NxpBuild_App.h*, add the definition for KW45,

– In *phApp_Init.h*, add the definition for `ph` driver.
– In *phApp_Init.c*, include the needed headers add the CPU initialization for KW45 in *phApp_CPU_Init* function and add the IRQ handler as follows:

```
IRQ_HANDLE_ARRAY_DEFINE(g_IrqHandle, 1);
#define gBoardIrqHandle ((irq_handle_t)g_IrqHandle[0])

void CLIF_HalIRQHandler(void *param)
{
    CLIF_IRQHandler();
}
```

Configure the GPIO pins in the `phApp_Configure_IRQ` function:

```
#if !gAppButtonCnt_c
    NVIC_SetPriority(EINT_IRQn, EINT_PRIORITY);
    NVIC_ClearPendingIRQ(EINT_IRQn);
    EnableIRQ(EINT_IRQn);
#else
#include "fsl_adapter_gpio.h"
    static const hal_gpio_pin_config_t g_IrqConfig = {
    kHAL_GpioDirectionIn,
    PHDRIVER_IRQ_GPIO_PIN_DEFAULT_STATE,
    PHDRIVER_IRQ_GPIO_PORT_INSTANCE,
    PHDRIVER_IRQ_GPIO_PIN
    };
        if(kStatus_HAL_GpioSuccess !
=HAL_GpioInit((hal_gpio_handle_t)gBoardIrqHandle,

 (hal_gpio_pin_config_t *)&g_IrqConfig))
    {
        return PH_ERR_ABORTED;
    }
    (void)HAL_GpioInstallCallback(gBoardIrqHandle,CLIF_HalIRQHandler, NULL);
```

Also, call `BleApp_SendNfcCardInfo` in `phApp_PrintTagInfo` function.
– In *wireless_uart.h*, define the `nfcCardInfo_tag` structure, declare `BleApp_SendNfcCardInfo` function, and define a `HexToAscii` function:

```
typedef struct nfcCardInfo_tag
{
 uint8_t technology;
 uint8_t uid[8];
}nfcCardInfo_t;

extern nfcCardInfo_t gNfcCardInfo;

void BleApp_SendNfcCardInfo(void);
#define HexToAscii(hex) (uint8_t)( ((hex) & 0x0F) + ((((hex) & 0x0F) <= 9) ?
 '0' : ('A'-10)) )
```

– In *wireless_uart.c*, call the initializations for `pit` module and the `nfc` basic discovery start and add definitions for `BleApp_SendNfcCardInfoHandler` and `BleApp_SendNfcCardInfo` functions.

```
static void BleApp_SendNfcCardInfoHandler(void *pParam)
{
 static uint8_t dataToSend = 1;
 uint8_t *pString;
 uint8_t stringSize;
 uint8_t index = 0;
```

```
 uint8_t hexString1[13] = {"Card Detected"};
 uint8_t hexString2[12] = {"Technology=A"};
 uint8_t hexString3[20] = {"UID=0000000000000000"};

 if(dataToSend == 1)
 {
  pString = hexString1;
  stringSize = 13;
  dataToSend = 2;
 }
 else if (dataToSend == 2)
 {
  hexString2[11] = gNfcCardInfo.technology;
  pString = hexString2;
  stringSize = 12;
         dataToSend = 3;
 }
 else
 {
  index = 4;
  for(uint8_t i = 0; i < 8; i++)
  {
   hexString3[index++] = HexToAscii( (gNfcCardInfo.uid[i])>>4 );
   hexString3[index++] = HexToAscii( gNfcCardInfo.uid[i] );
  }
  pString = hexString3;
  stringSize = 20;
  dataToSend = 1;
 }

 BleApp_SendUartStream(pString, stringSize);

 if(dataToSend!=1)
 {

 (void)App_PostCallbackMessage((appCallbackHandler_t)BleApp_SendNfcCardInfo,
 NULL);
 }
}

void BleApp_SendNfcCardInfo(void)
{
    (void)App_PostCallbackMessage(BleApp_SendNfcCardInfoHandler, NULL);
}
```

– In *main.c*, include board.

– In *board.c*, include *fsl_lpit.h* and initialize `pit` module.

```
void BOARD_InitPitModule(void)
{
 lpit_config_t pitConfig;         /* Structure of initialize PIT */
           CLOCK_SetIpSrc(kCLOCK_Lpit0, kCLOCK_IpSrcFro6M);
 LPIT_GetDefaultConfig(&pitConfig);
 LPIT_Init(LPIT0, &pitConfig);
}
```

– In **board.h**, declare pit initialization.

- Update the linker information (**Project Properties** -> **C/C++ Build** -> **Settings**) and preprocessor defines (**Project Properties** -> **C/C++ Build** -> **Preprocessor**).

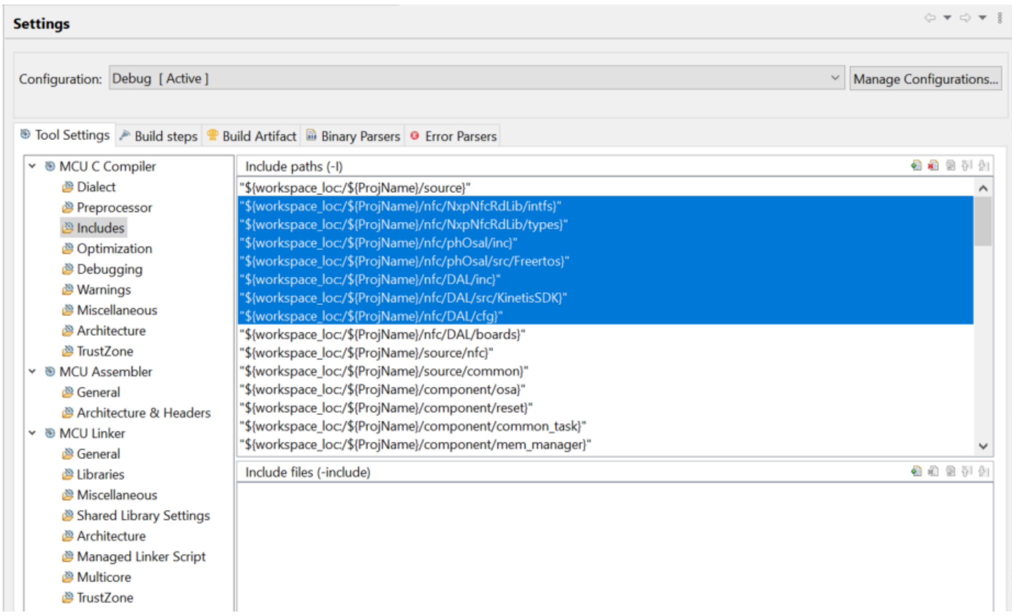


Figure 15. Updating linker information 1

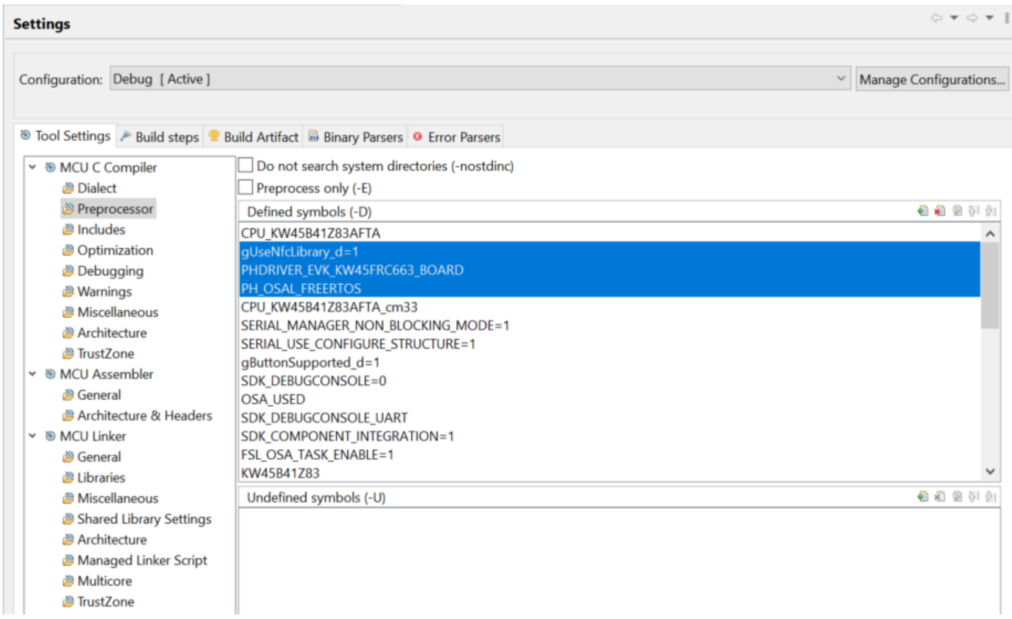


Figure 16. Updating linker information 2

6 Running the demo

To run the demo, perform the following steps:

- Create hardware connection based on Section 2.
- Open a serial terminal on the corresponding COM port for KW45 board. The baud rate used is 115200.
- Start advertising.
- Open **Mobile APP** - **IoT toolbox** - **Wireless UART**. The KW45 board is listed as **NXP_WU**.

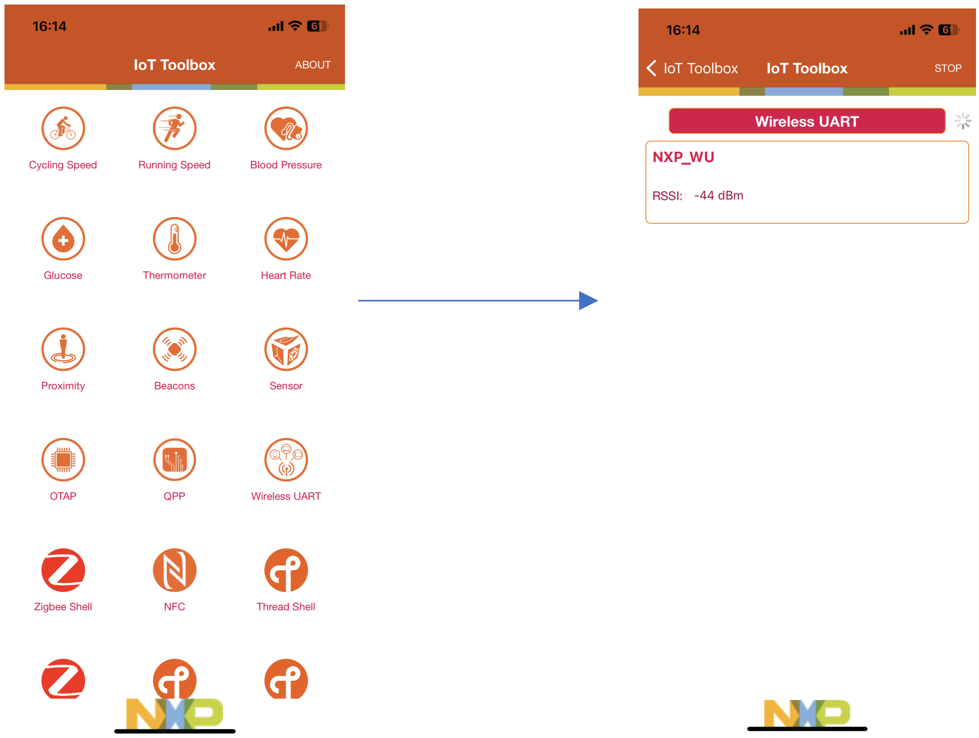


Figure 17.

- Create Bluetooth LE connection. The serial log contains the log for Bluetooth LE operations.

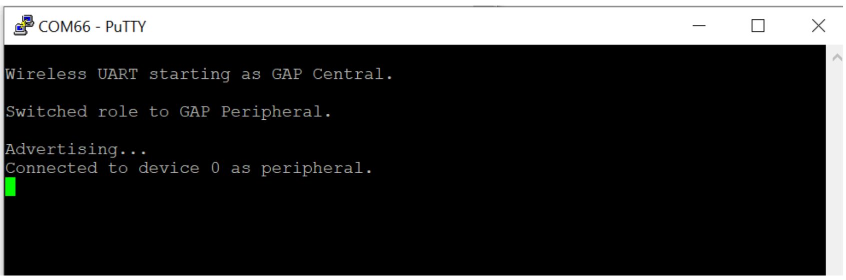


Figure 18. Serial log

- To initiate discovery demo, use NFC cards close to NCF3320 Antenna v1.0 board.
- Once the card is detected, an event is sent to the mobile application including technology and UUID of the card.

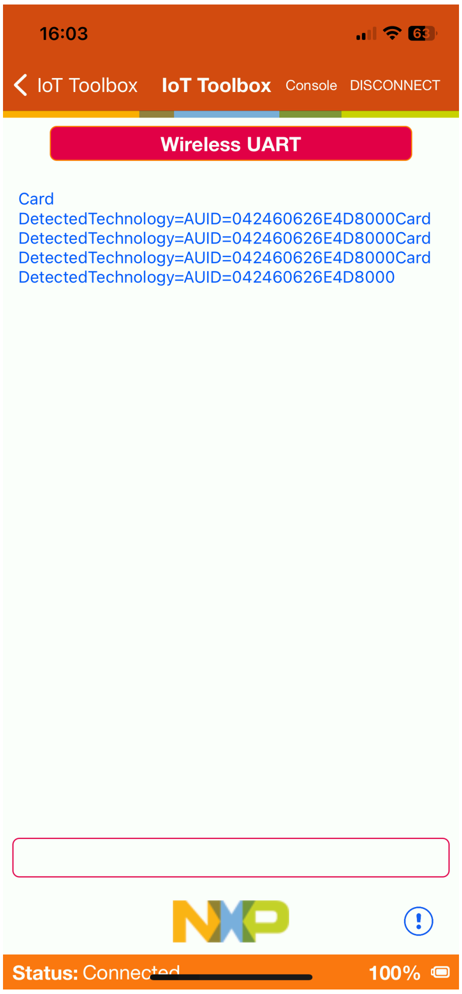


Figure 19.

7 Reference

- NFC Reader Library
- NCF3320
- CLRC663 plus
- FRDM- KW41Z board
- KW45B41Z-EVK SDK
- MCUXpresso IDE

8 Note about the source code in the document

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9 Revision history

Table 2 summarizes the revisions to this document.

Table 2. Revision history

Document ID	Release date	Description
AN13953 v.1	30 May 2024	Initial public release

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