MCUXpresso SDK Documentation

Release 25.12.00-pvw2

NXP
Nov 14, 2025

Table of contents

This documentation contains information specific to the evkmimxrt1040 board.

Chapter 1

Middleware

1.1 Boot

1.1.1 MCUXpresso SDK : mcuxsdk-middleware-mcuboot_opensource

Overview

This repository is a fork of MCUboot (https://github.com/mcu-tools/mcuboot) for MCUXpresso SDK delivery and it contains the components officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository (mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

Documentation

Overall details can be reviewed here: MCUXpresso SDK Online Documentation

Visit MCUboot - Documentation to review details on the contents in this sub-repo.

Setup

Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest Getting Started with SDK - Detailed Installation Instructions

Contribution

Contributions are not currently accepted. If the intended contribution is not related to NXP specific code, consider contributing directly to the upstream MCUboot project. Once this MCUboot fork is synchronized with the upstream project, such contributions will end up here as well. If the intended contribution is a bugfix or improvement for NXP porting layer or for code added or modified by NXP, please open an issue or contact NXP support.

NXP Fork

This fork of MCUboot contains specific modifications and enhancements for NXP MCUXpresso SDK integration.

See *changelog* for details.

1.1.2 MCUboot

This is MCUboot version 2.2.0

MCUboot is a secure bootloader for 32-bits microcontrollers. It defines a common infrastructure for the bootloader and the system flash layout on microcontroller systems, and provides a secure bootloader that enables easy software upgrade.

MCUboot is not dependent on any specific operating system and hardware and relies on hardware porting layers from the operating system it works with. Currently, MCUboot works with the following operating systems and SoCs:

- Zephyr
- Apache Mynewt
- Apache NuttX
- RIOT
- Mbed OS
- Espressif
- Cypress/Infineon

RIOT is supported only as a boot target. We will accept any new port contributed by the community once it is good enough.

MCUboot How-tos

See the following pages for instructions on using MCUboot with different operating systems and SoCs:

- Zephyr
- Apache Mynewt
- Apache NuttX
- RIOT
- Mbed OS
- Espressif
- *Cypress/Infineon*

There are also instructions for the *Simulator*.

Roadmap

The issues being planned and worked on are tracked using GitHub issues. To give your input, visit MCUboot GitHub Issues.

Source files

You can find additional documentation on the bootloader in the source files. For more information, use the following links:

- boot/bootutil - The core of the bootloader itself.
- boot/boot_serial - Support for serial upgrade within the bootloader itself.
- boot/zephyr - Port of the bootloader to Zephyr.
- boot/mynewt - Bootloader application for Apache Mynewt.
- boot/nuttx - Bootloader application and port of MCUboot interfaces for Apache NuttX.
- boot/mbed - Port of the bootloader to Mbed OS.
- boot/espressif - Bootloader application and MCUboot port for Espressif SoCs.
- boot/cypress - Bootloader application and MCUboot port for Cypress/Infineon SoCs.
- imgtool - A tool to securely sign firmware images for booting by MCUboot.
- sim - A bootloader simulator for testing and regression.

Joining the project

Developers are welcome!

Use the following links to join or see more about the project:

- Our developer mailing list
- Our Discord channel Get your invite

1.2 eIQ

1.2.1 eIQ

eIQ TensorFlow Lite for Micro Library User Guide

- *Overview*
- *TensorFlow Lite for Microcontrollers*
- *Build Status*
  - *Official Builds*
  - *Community Supported TFLM Examples*
  - *Community Supported Kernels and Unit Tests*
- *Contributing*
- *Getting Help*
- *Additional Documentation*

- *RFCs*

Overview TensorFlow Lite is an open source software library for running machine learning models on mobile and embedded devices. For more information, see www.tensorflow.org/lite.

For memory constrained devices, the library contains TensorFlow Lite for Microcontrollers. For more information, see *www.tensorflow.org/lite/microcontrollers*.

The MCUXpresso Software Development Kit (MCUXpresso SDK) provides a comprehensive software package with a pre-integrated TensorFlow Lite for Microcontrollers based on version 25-04-08 (from the 8th of April 2025 with commit). This document describes the steps required to download and start using the library. Additionally, the document describes the steps required to create an application for running pre-trained models.

Note: The document also assumes knowledge of machine learning frameworks for model training.

TensorFlow Lite for Microcontrollers TensorFlow Lite for Microcontrollers is a port of TensorFlow Lite designed to run machine learning models on DSPs, microcontrollers and other devices with limited memory.

Additional Links:

- Tensorflow github repository
- TFLM at tensorflow.org

Build Status

- GitHub Status

Official Builds

Build Type	Status
CI (Linux)	Run-CI passing
Code Sync	Sync from Upstream TF passing

Community Supported TFLM Examples This table captures platforms that TFLM has been ported to. Please see *New Platform Support* for additional documentation.

Platform	Status
Arduino	CI no status Arduino examples tests no status
Coral Dev Board Micro	TFLM + EdgeTPU Examples for Coral Dev Board Micro
Espressif Systems Dev Boards	CI failing
Renesas Boards	TFLM Examples for Renesas Boards
Silicon Labs Dev Kits	TFLM Examples for Silicon Labs Dev Kits
Sparkfun Edge	CI no status
Texas Instruments Dev Boards	

Community Supported Kernels and Unit Tests This is a list of targets that have optimized kernel implementations and/or run the TFLM unit tests using software emulation or instruction set simulators.

Build Type	Status
Cortex-M	
Hexagon	
RISC-V	
Xtensa	
Generate Integration Test	

Contributing See our *contribution documentation*.

Getting Help A Github issue should be the primary method of getting in touch with the TensorFlow Lite Micro (TFLM) team.

The following resources may also be useful:

1. SIG Micro email group and monthly meetings.
2. SIG Micro gitter chat room.
3. For questions that are not specific to TFLM, please consult the broader TensorFlow project, e.g.:
   - Create a topic on the TensorFlow Discourse forum
   - Send an email to the TensorFlow Lite mailing list
   - Create a TensorFlow issue
   - Create a Model Optimization Toolkit issue

Additional Documentation

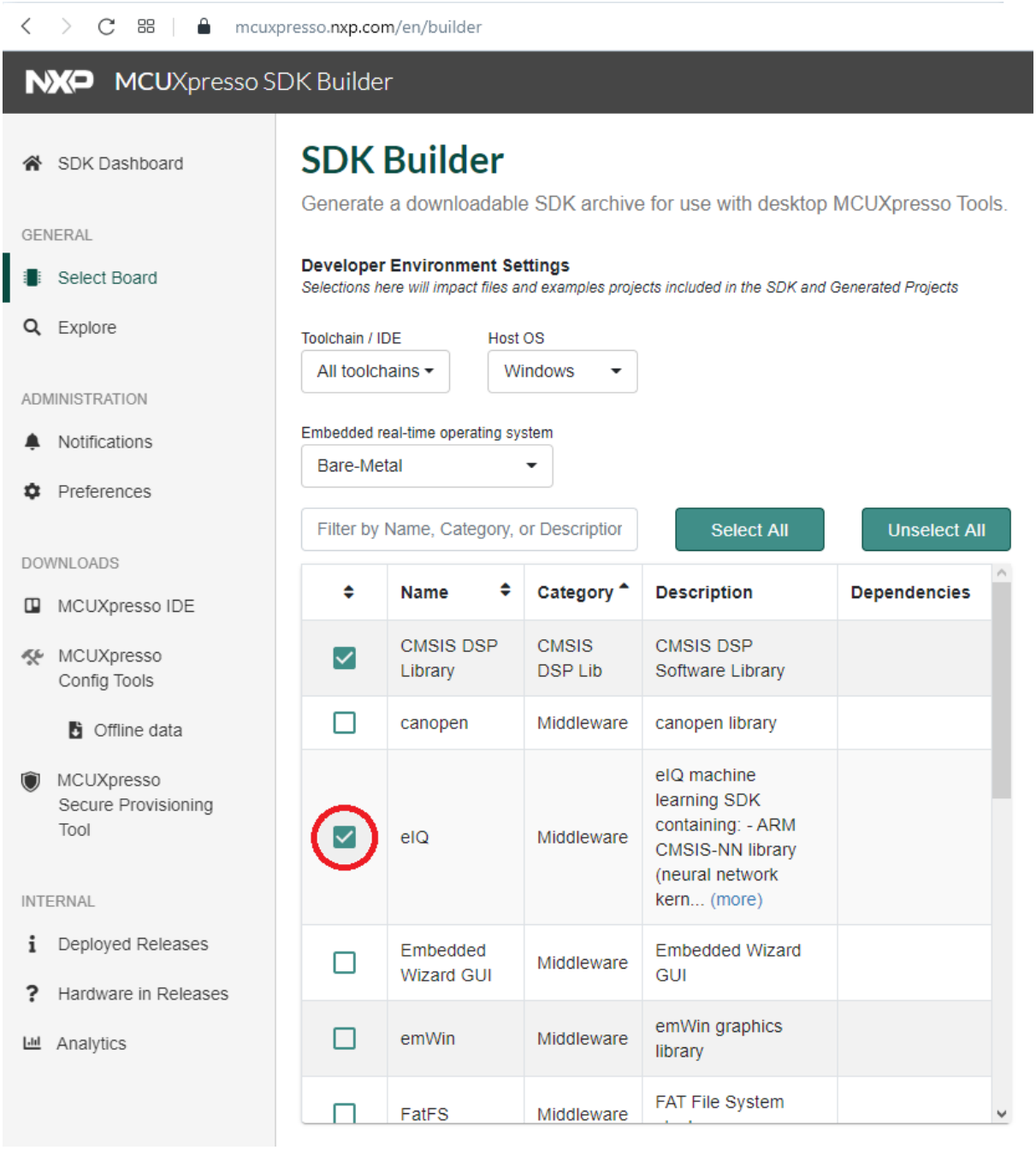
- *Continuous Integration*
- *Benchmarks*
- *Profiling*
- *Memory Management*
- *Logging*
- *Porting Reference Kernels from TfLite to TFLM*
- *Optimized Kernel Implementations*
- *New Platform Support*
- Platform/IP support
  - *Arm IP support*
- *Software Emulation with Renode*
- *Software Emulation with QEMU*

- *Python Dev Guide*
- *Automatically Generated Files*
- *Python Interpreter Guide*

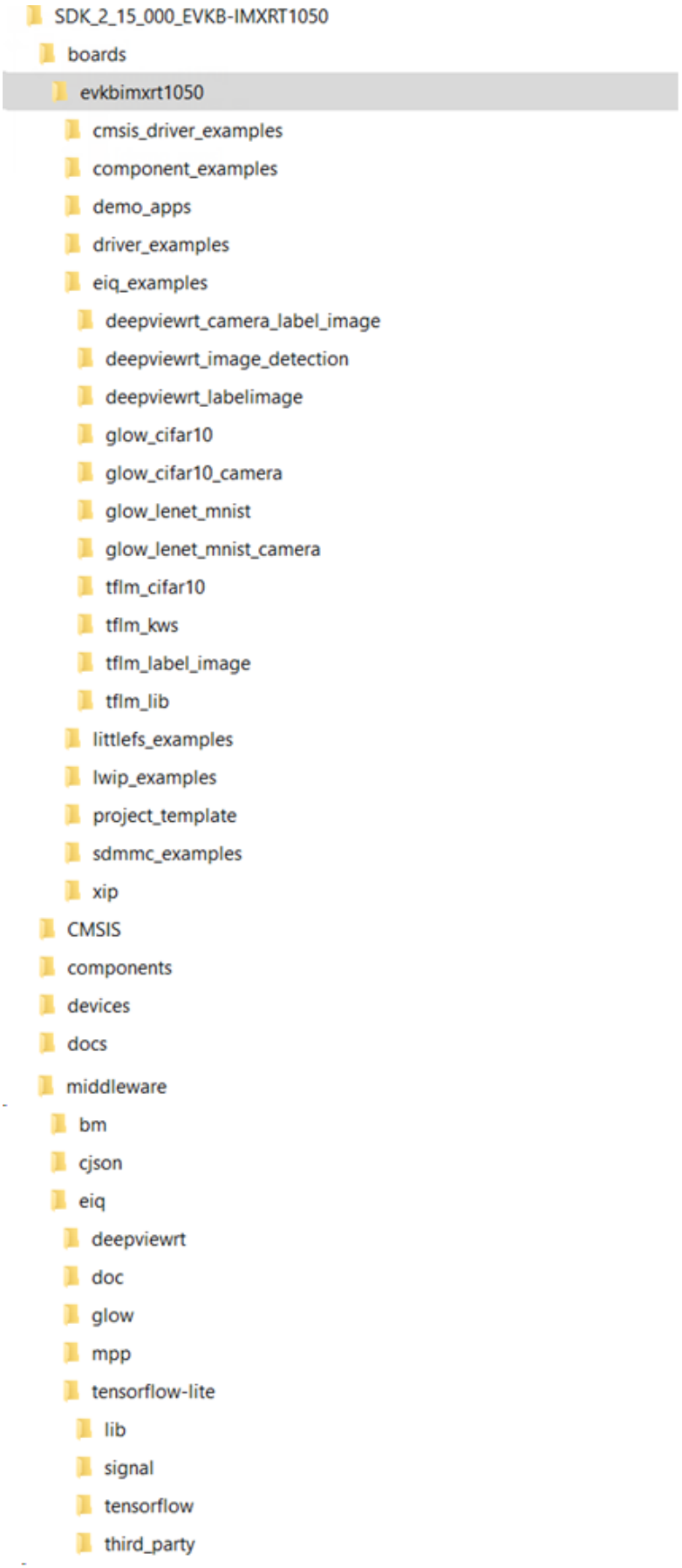
RFCs

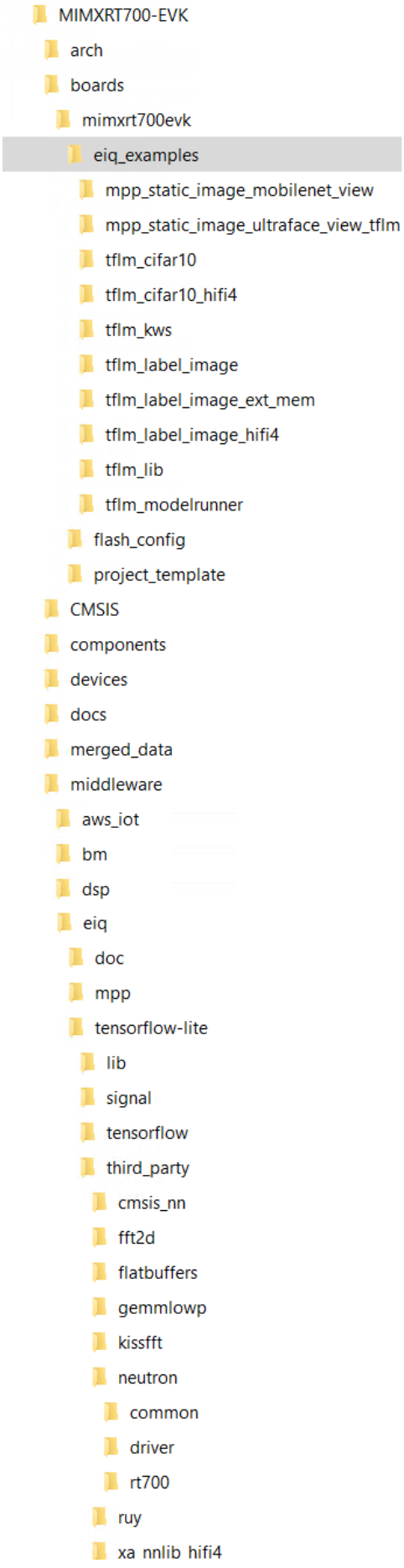
1. *Pre-allocated tensors*
2. *TensorFlow Lite for Microcontrollers Port of 16x8 Quantized Operators*

Deployment The eIQ TensorFlow Lite for Microcontrollers library is part of the eIQ machine learning software package, which is an optional middleware component of MCUXpresso SDK. The eIQ component is integrated into the MCUXpresso SDK Builder delivery system available on mcuxpresso.nxp.com. To include eIQ machine learning into the MCUXpresso SDK package, the eIQ middleware component is selected in the software component selector on the SDK Builder page when building a new package. See *Figure 1*.



Once the MCUXpresso SDK package is downloaded, it can be extracted on a local machine or imported into the MCUXpresso IDE. For more information on the MCUXpresso SDK folder structure, see the Getting Started with MCUXpresso SDK User's Guide (document: MCUXSDKGSUG). The package directory structure is similar to *Figure 2*. The eIQ TensorFlow Lite library directories are highlighted in red.


SDK_2_15_000_EVKB-IMXRT1050
boards
evkbimxrt1050
cmsis_driver_examples
component_examples
demo_apps
driver_examples
eiq_examples
deepviewrt_camera_label_image
deepviewrt_image_detection
deepviewrt_labelimage
glow_cifar10
glow_cifar10_camera
glow_lenet_mnist
glow_lenet_mnist_camera
tflm_cifar10
tflm_kws
tflm_label_image
tflm_lib
littlefs_examples
lwip_examples
project_template
sdmmc_examples
xip
CMSIS
components
devices
docs
middleware
bm
cjson
eiq
deepviewrt
doc
glow
mpp
tensorflow-lite
lib
signal
tensorflow
third_party


MIMXRT700-EVK
arch
boards
mimxrt700evk
eiq_examples
mpp_static_image_mobilenet_view
mpp_static_image_ultraface_view_tflm
tflm_cifar10
tflm_cifar10_hifi4
tflm_kws
tflm_label_image
tflm_label_image_ext_mem
tflm_label_image_hifi4
tflm_lib
tflm_modelrunner
flash_config
project_template
CMSIS
components
devices
docs
merged_data
middleware
aws_iot
bm
dsp
eiq
doc
mpp
tensorflow-lite
lib
signal
tensorflow
third_party
cmsis_nn
fft2d
flatbuffers
gemmlowp
kissfft
neutron
common
driver
rt700
ruy
xa_nnlib_hifi4

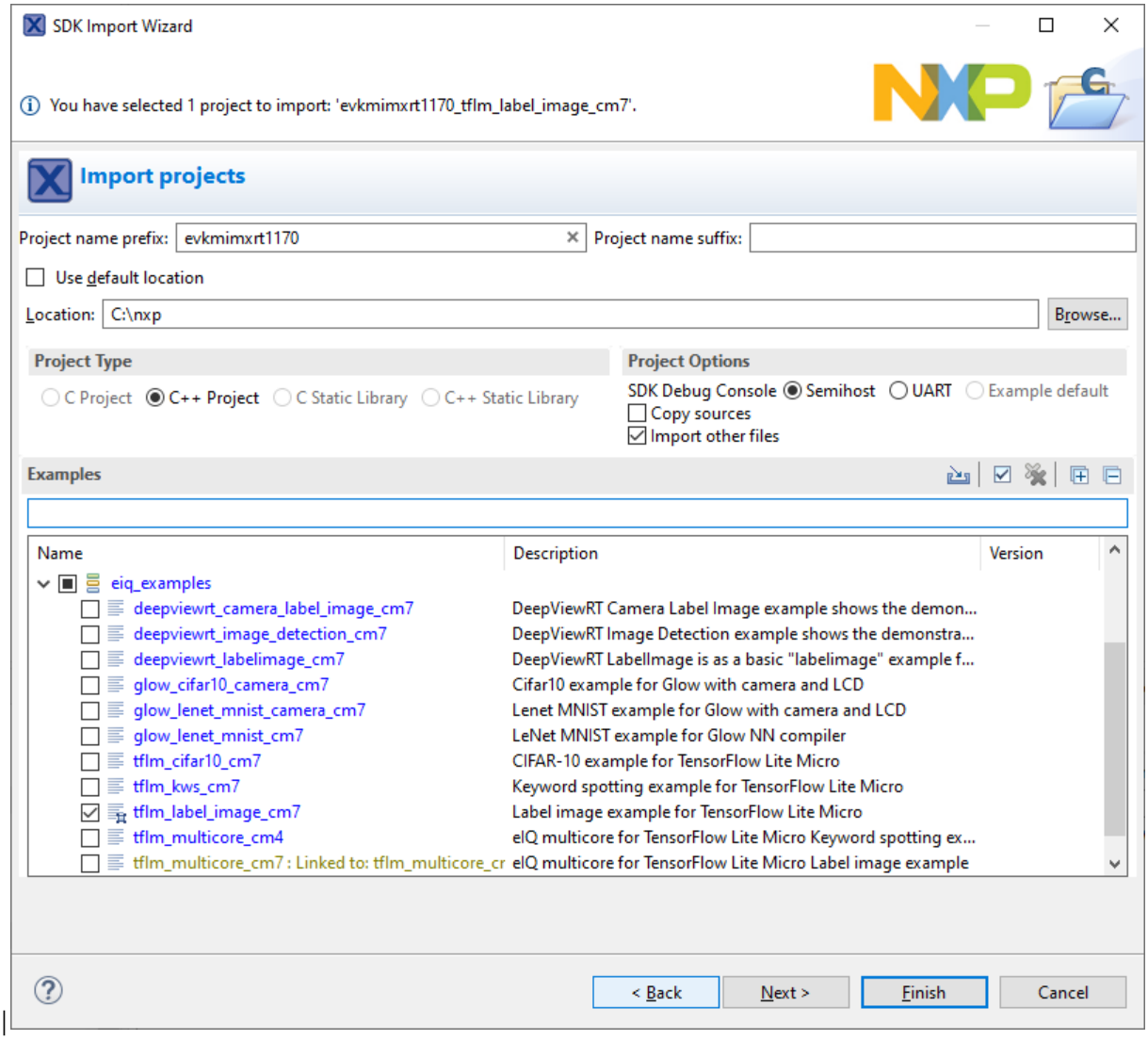
|

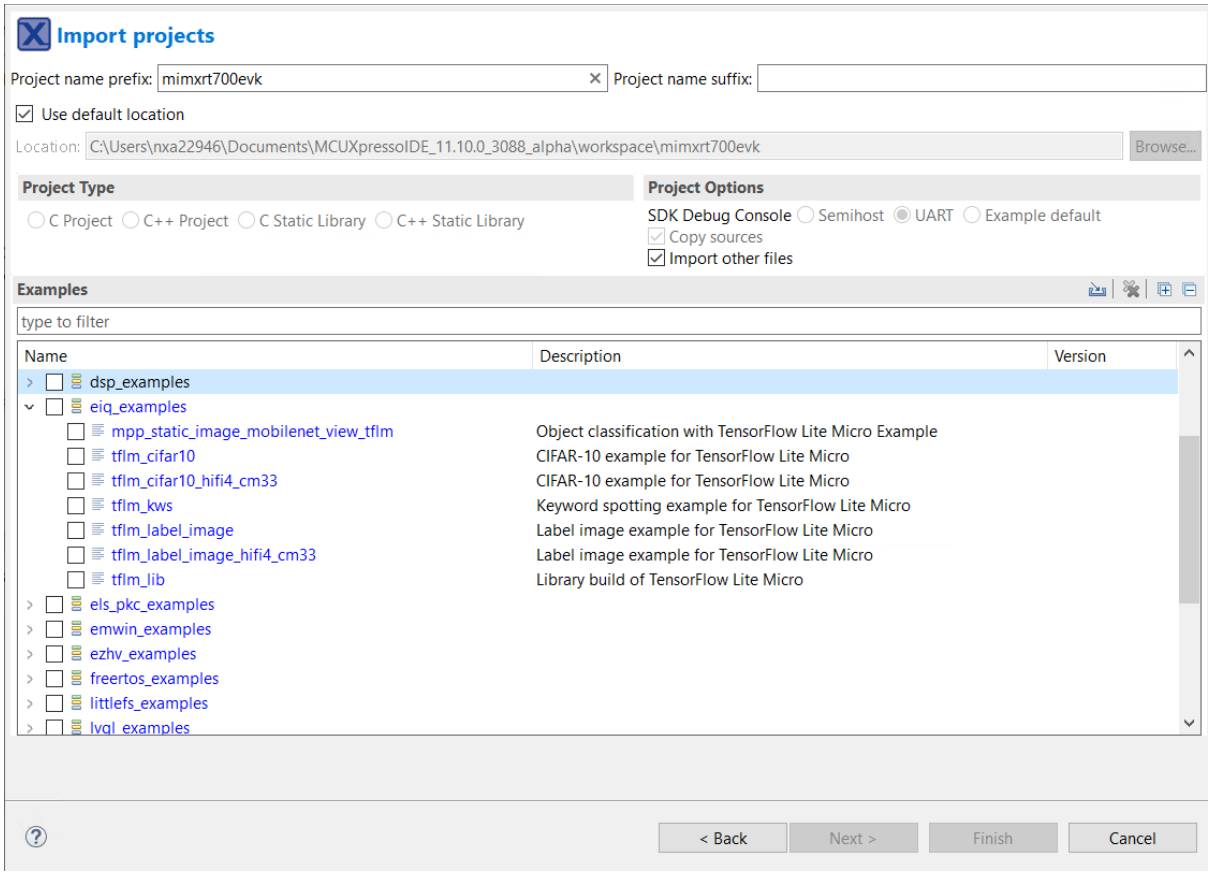
The *boards* directory contains example application projects for supported toolchains. For the list of supported toolchains, see the *MCUXpresso SDK Release Notes*. The *middleware* directory contains the eIQ library source code and example application source code and data.

Example applications The eIQ TensorFlow Lite library is provided with a set of example applications. For details, see *Table 1*. The applications demonstrate the usage of the library in several use cases.

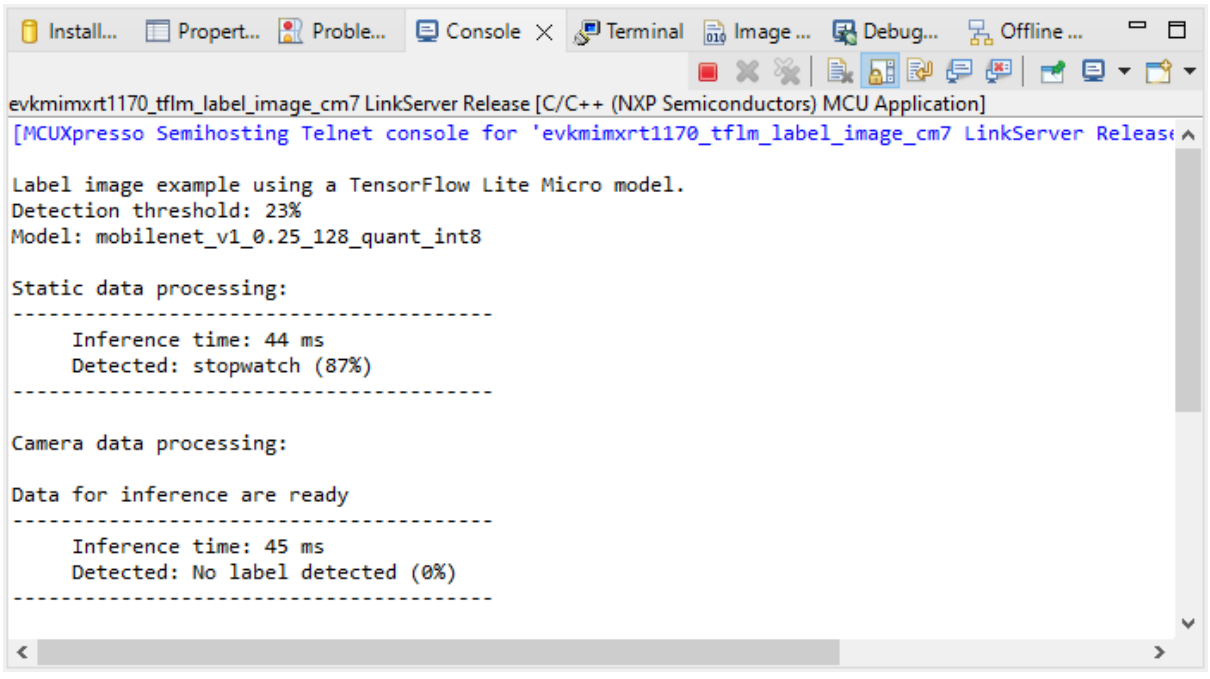
Name	Description	Availability
tflm_c	CIFAR-10 classification of 32 × 32 RGB pixel images into 10 categories using a small Convolutional Neural Network (CNN).	MCX-N947-EVK (no camera and display support) MCX-N947-FRDM (no camera and display support) MCX-N547-EVK (no camera and display support) MIMXRT700-EVK (no camera and display support)
tflm_k	Keyword spotting application using a neural network for word detection in pre-processed audio input.	MCX-N947-EVK (no audio support) MCX-N947-FRDM (no audio support) MCX-N547-EVK (no audio support) MIMXRT700-EVK (no audio support)
tflm_l	Image recognition application using a MobileNet model architecture to classify 128 × 128 RGB pixel images into 1000 categorieswith eIQ Neutron NPU.	MCX-N947-EVK (no camera and display support) MCX-N947-FRDM (no camera and display support) MCX-N547-EVK (no camera and display support) MIMXRT700-EVK (no camera and display support)
tflm_l	Image recognition application using a MobileNet model architecture to classify 224 × 224 RGB pixel images into 1000 categorieswith eIQ Neutron NPU. In this example, it demonstrates how to fetch model's weight from external memory(xSPI flash) to internal SRAM for Neutron NPU execution.	MIMXRT700-EVK (no camera and display support)
tflm_c	CIFAR-10 classification of 32 × 32 RGBpixel images into 10 categories using a small Convolutional Neural Network. In this example, M33 core0 starts HiFi4 DSP core with HiFi4 DSP image. HiFi4 DSP does the inference for CIFAR-10 classification.	MIMXRT700-EVK (no camera and display support)
tflm_l	Image recognition application using a MobileNet model architecture to classify 128 × 128 RGB pixel images into 1000 categories. In this example, M33 core0 starts HiFi4 DSP core with HiFi4 DSP image. HiFi4 DSP does the inference for image recognition application.	MIMXRT700-EVK (no camera and display support)

For details on how to build and run the example applications with supported toolchains, see *Getting Started with MCUXpresso SDK User's Guide* (document: MCUXSDKGSUG). When using MCUXpresso IDE, the example applications can be imported through the SDK Import Wizard as shown in *Figure 1*.


SDK Import Wizard
You have selected 1 project to import: 'evkmimxrt1170_tflm_label_image_cm7'.
Import projects
Project name prefix: evkmimxrt1170
Project name suffix:
Use default location
Location: C:\nxp
Browse...
Project Type
C Project
C++ Project
C Static Library
C++ Static Library
Project Options
SDK Debug Console
Semihost
UART
Example default
Copy sources
Import other files
Examples
Name
Description
Version
eiq_examples
deepviewrt_camera_label_image_cm7
DeepViewRT Camera Label Image example shows the demon...
deepviewrt_image_detection_cm7
DeepViewRT Image Detection example shows the demonstra...
deepviewrt_labelimage_cm7
DeepViewRT LabelImage is as a basic "labelimage" example f...
glow_cifar10_camera_cm7
Cifar10 example for Glow with camera and LCD
glow_lenet_mnist_camera_cm7
Lenet MNIST example for Glow with camera and LCD
glow_lenet_mnist_cm7
LeNet MNIST example for Glow NN compiler
tflm_cifar10_cm7
CIFAR-10 example for TensorFlow Lite Micro
tflm_kws_cm7
Keyword spotting example for TensorFlow Lite Micro
tflm_label_image_cm7
Label image example for TensorFlow Lite Micro
tflm_multicore_cm4
eIQ multicore for TensorFlow Lite Micro Keyword spotting ex...
tflm_multicore_cm7 : Linked to: tflm_multicore_cr
eIQ multicore for TensorFlow Lite Micro Label image example
< Back
Next >
Finish
Cancel



After building the example application and downloading it to the target, the execution stops in the *main* function. When the execution resumes, an output message displays on the connected terminal. For example, *Figure 2* shows the output of the tflm_label_image_cm7``tflm_label_image example application printed to the MCUXpresso IDE Console window when semihosting debug console is selected in the SDK Import Wizard.



```
Label image example using a TensorFlow Lite Micro model.
Detection threshold: 23%
Model: mobilenet_v1_0.25_128_quant_int8_npu

Static data processing:
---------------------------------------
     Inference time: 3987 us
     Detected: stopwatch (87%)
---------------------------------------
```

|

Model Conversion to TensorFlow Lite Format The eIQ® Toolkit provides a comprehensive end-to-end environment for machine learning (ML) model development and deployment. Designed for NXP EdgeVerse processors, the toolkit includes both an intuitive GUI-based tool (eIQ Portal) and command-line utilities for advanced workflows.

One key component, the eIQ ModelTool, enables seamless conversion of ML models from popular formats such as TensorFlow, PyTorch, and ONNX into the TensorFlow Lite (TFLite) format. These converted models can be further optimized and deployed on NXP platforms for inference acceleration.

Model Conversion for NXP eIQ Neutron NPU To leverage the NXP eIQ Neutron NPU for hardware acceleration, models must undergo additional processing using the Neutron Converter Tool. This tool transforms standard quantized TensorFlow Lite models into a format optimized for execution on the Neutron NPU.

The key steps involved in this process are as follows:

1. Convert to Quantized TensorFlow Lite Model: Ensure the model is in a quantized TFLite format before running the Neutron Converter.
2. Run the Neutron Converter Tool: The Neutron Converter analyzes the TFLite model, identifies supported operators, and replaces them with specialized NPU-compatible nodes. Unsupported operations are executed using fallback mechanisms, such as:

- CMSIS-NN for optimized CPU execution
- Reference Operators for unsupported cases

3. Execute on Target Platform: The converted model runs efficiently on the Neutron NPU using a custom TFLite Micro-operator implementation.

Example: Converting a Quantized TensorFlow Lite Model for Neutron NPU The following is a sample command-line invocation for the Neutron Converter tool:

```
neutron-converter --input mobilenet_v1_0.25_128_quant.tflite \
                  --output mobilenet_v1_0.25_128_quant_npu.tflite \
                  --target imxrt700 \
                  --dump-header-file-output
```

Note: This will convert the source tflite model to neutron compatable model, meanwhile, it will dump the model as one headfile name as “mobilenet_v1_0.25_128_quant_npu.h”.

Run and debug eIQ HiFi4 and HiFi1 DSP examples using Xplorer IDE This section lists the steps to Prepare CM33 Core for the examples and Prepare DSP core for the examples.

Prepare CM33 Core for the examples

1. The tflm_cifar10_hifi4 and tflm_label_image_hifi4 examples consist of two separate applications that run on the CM33 core0 and DSP core. The CM33 core0 application initializes the DSP core and starts it.

   To debug the application:

   1. Set up and execute the CM33 application using an environment of your choice.
   2. Build and execute the examples located in:

      <SDK_ROOT>/boards/mimxrt700evk/eiq_examples/tflm_cifar10_hifi4/cm33/

      <SDK_ROOT>/ boards/mimxrt700evk/eiq_examples/tflm_label_image_hifi4/cm33/

2. The tflm_cifar10_hifi1 example consists of three separate applications that run on the CM33 core0, CM33 core1, and DSP core. The CM33 core0 application initializes the CM33 core1 core and starts it. The CM33 core1 application initializes the DSP core and starts it.

   To debug the application:

   1. Set up and build the CM33 core1 application using an environment of your choice.
   2. Set up and execute the CM33 core0 application using an environment of your choice.
   3. Build and execute the example located in:

      <SDK_ROOT>/boards/mimxrt700evk/eiq_examples/tflm_cifar10_hifi1/cm33_core1/

      <SDK_ROOT>/boards/mimxrt700evk/eiq_examples/tflm_cifar10_hifi1/cm33_core0/

      Note: ARMGCC toolchain and IAR Embedded Workbench are both supported. To enable compatibility with RT700, IAR Embedded Workbench may require a patch. There are default DSP core images in the SDK. For details on how to build the examples, refer to Prepare DSP core for the examples.

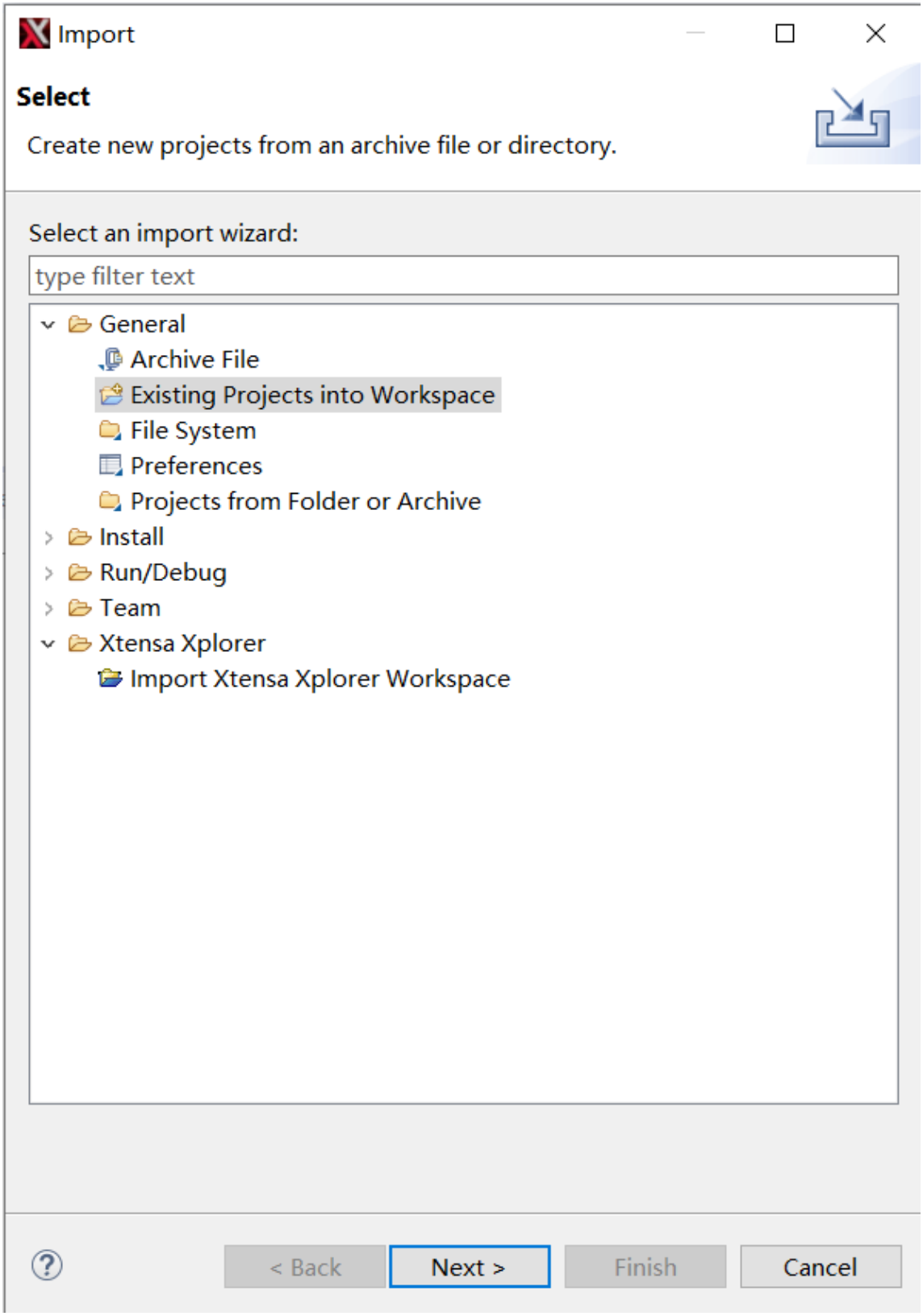
Parent topic:*Run and debug eIQ HiFi4 and HiFi1 DSP examples using Xplorer IDE*

Prepare DSP core for the examples

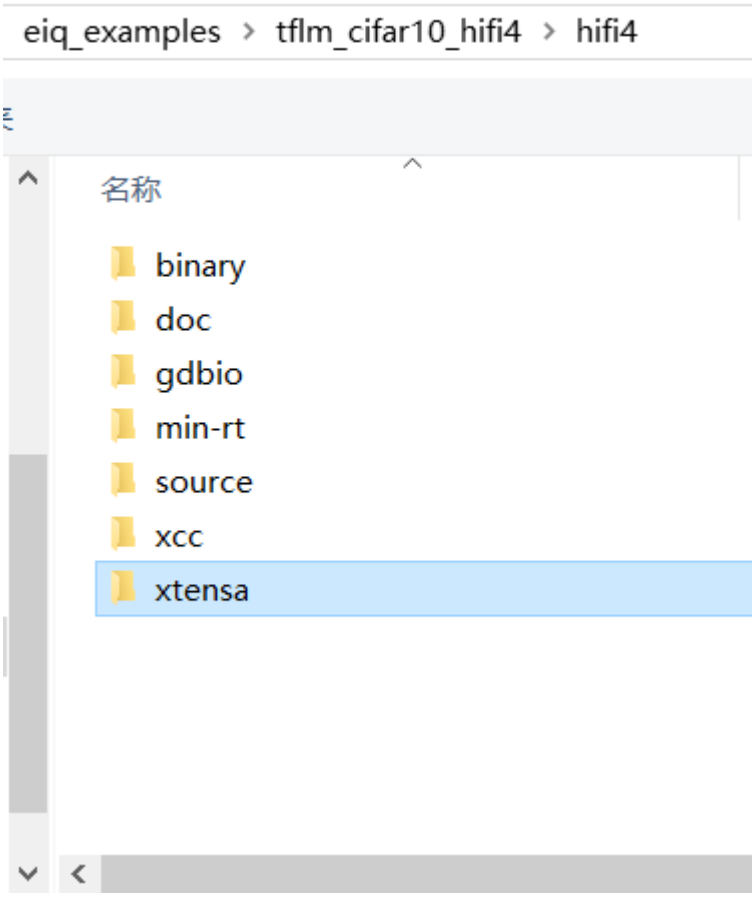
The projects for different supported toolchains are built. The “xcc” project builds on the command line and the “xtensa” directory is an Xplorer IDE project.

To run the tflm_cifar10_hifi4 example, import the SDK sources into the Xplorer IDE.

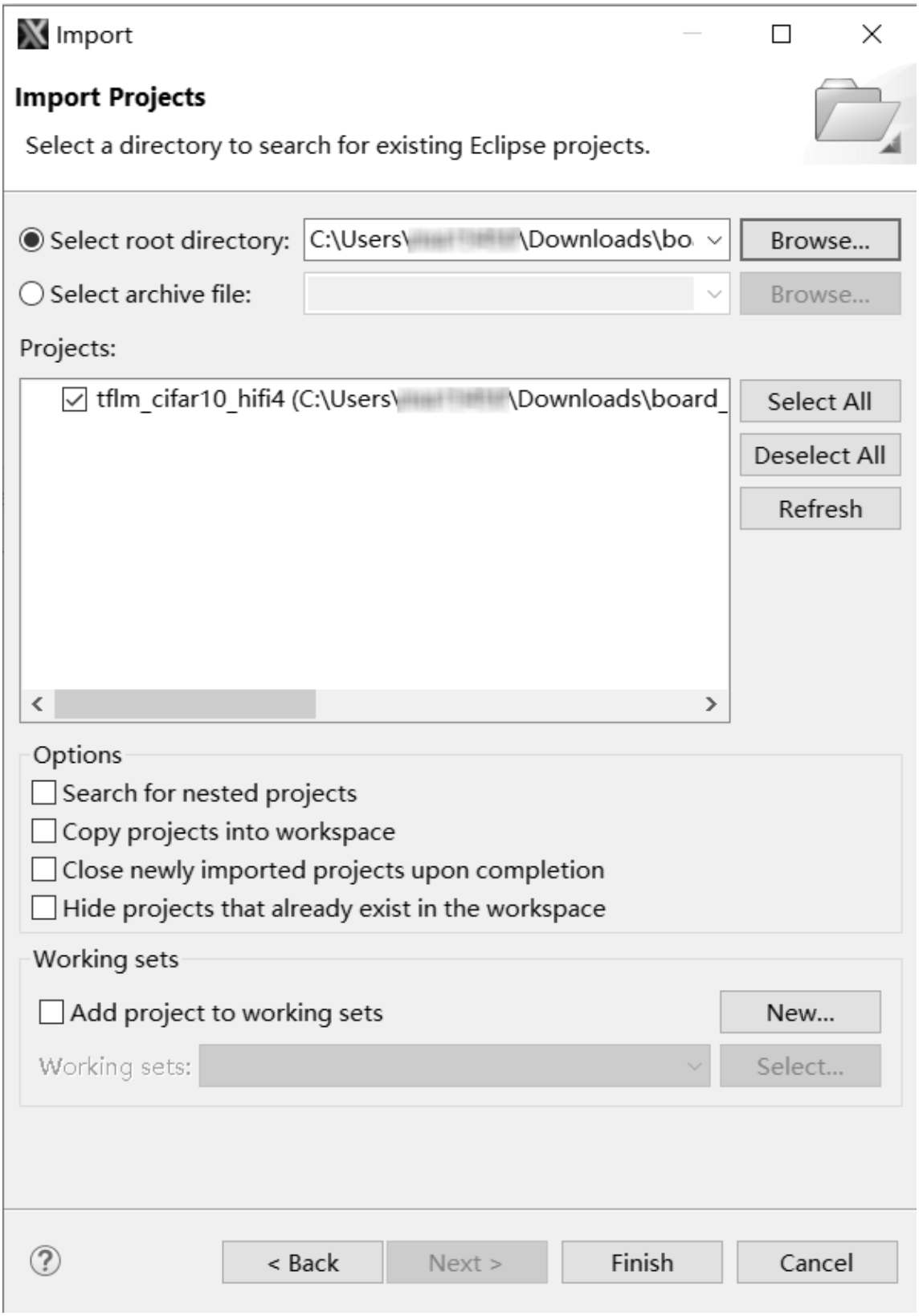
1. Select **File** > **Import** > **General** > **Existing Projects into Workspace**.



2. Click **Next**.
3. Select the SDK directory/boards/mimxrt700evk/eiq_examples/tflm_cifar10_hifi4/hifi4/xtensa as the root directory.

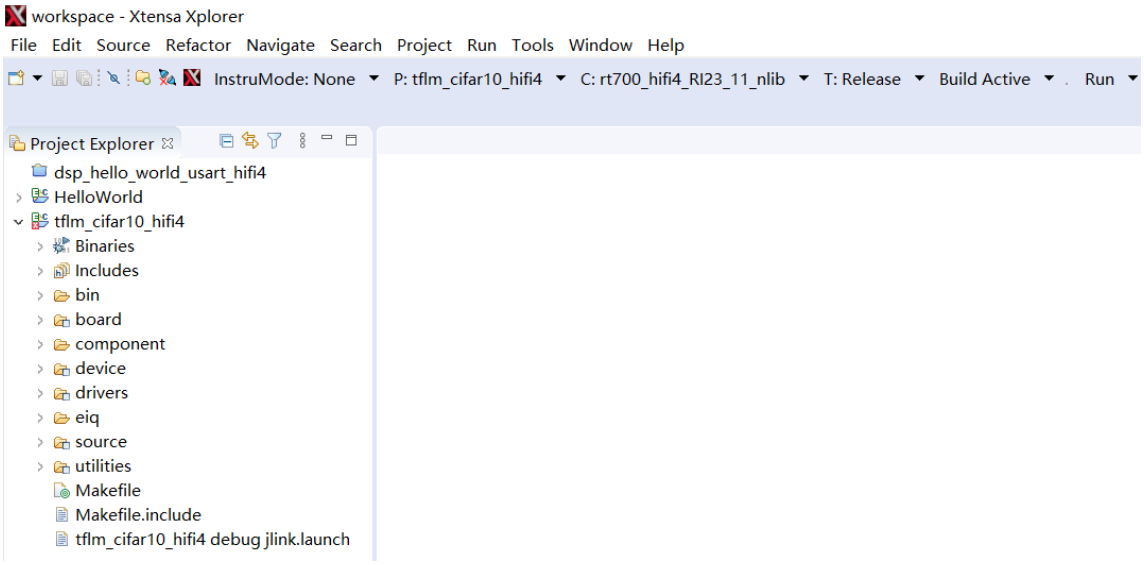


4. Click **Select Folder**.
5. Leave all the other options check boxes blank.

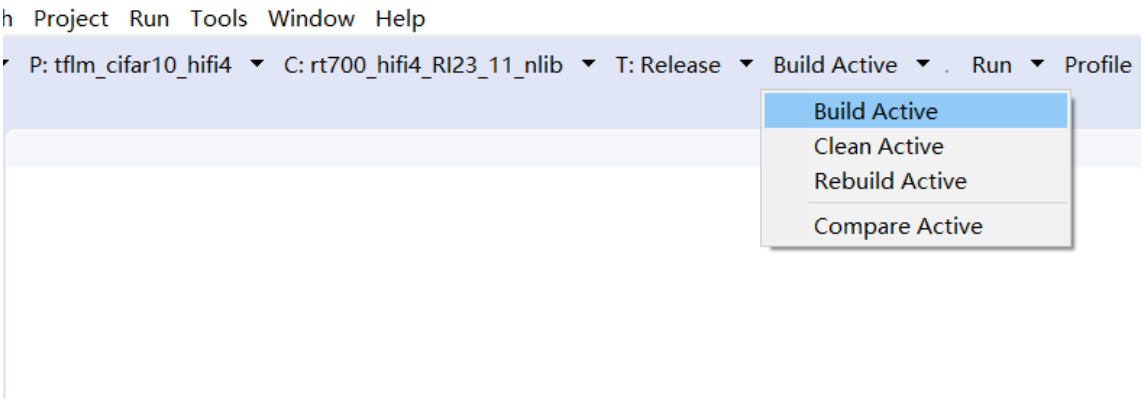


Once imported, the tflm_cifar10_hifi4 example appears in the **Project Explorer**.

6. To make a build selection for the project and hardware target configuration, use the drop-down buttons on the menu bar.



7. To build the DSP application image for the CM33 application, select the **Release target** option in the Xplorer IDE as below.



8. Three DSP binaries are generated and are loaded into different TCM or SRAM address segments:
   - <SDK_ROOT/>/boards/mimxrt700evk/eiq_examples/tflm_cifar10_hifi4/hifi4/binary/dsp_data_release.bin
   - <SDK_ROOT/>/boards/mimxrt700evk/eiq_examples/tflm_cifar10_hifi4/hifi4/binary/dsp_literal_release.bin
   - <SDK_ROOT/>/boards/mimxrt700evk/eiq_examples/tflm_cifar10_hifi4/hifi4/binary/dsp_text_release.bin

Parent topic:*Run and debug eIQ HiFi4 and HiFi1 DSP examples using Xplorer IDE*

Running an inference After converting the model to the TensorFlow Lite format, it is converted into a C language array to include it in the application source code. The *xxd* utility can be used for this purpose (distributed with the *Vim* editor for many platforms on https://www.vim.org/) as shown in *Converting a model to a C language header file*. The utility converts a TensorFlow Lite model into a C header file with an array definition containing the binary image of the model and a variable containing the data size.

Converting a model to a C language header file {#EXAMPLE_4 .section}

```
xxd -i mobilenet_v1_0.25_128_quant.tflite > mobilenet_v1_0.25_128_quant_model.h
```

After the header file is generated, the type of the array is changed from unsigned char to const char to match the library API input parameters and the default array name can be changed to a more convenient one. The user must align the buffer to at least 64-bit boundary (the size of a double-precision floating-point number) to avoid misaligned memory access. The alignment can be achieved by using the __ALIGNED(16) macro from the cmsis_compiler.h header file (available in the MCUXpresso SDK) in the array declaration before the data assignment.

The easiest way to create an application with the proper configuration is to copy and modify an existing example application. To learn where to find the example applications and how to build them, see the *Example applications*.

Running an inference using TensorFlow Lite for Microcontrollers involves several steps (shown for quantized model with signed 8-bit values as input and 32-floating point values as output):

1. Include the necessary eIQ TensorFlow Lite Micro library header files and the converted model.

   Including header files

   ```
   #include "tensorflow/lite/micro/micro_error_reporter.h"
   #include "tensorflow/lite/micro/micro_interpreter.h"
   #include "tensorflow/lite/micro/all_ops_resolver.h"
   #include "mobilenet_v1_0.25_128_quant_model.h"
   ```

2. Allocate a static memory buffer for input and output tensors and intermediate arrays. Load the FlatBuffer model image (assuming the mobilenet_v1_0.25_128_quant_model.h file generated in *Converting a model to a C language header file* defines an array named mobilenet_model and a size variable named mobilenet_model_len), build the interpreter object and allocate memory for tensors.

   Loading the FlatBuffer model

   ```
   constexpr int kTensorArenaSize = 1024 * 1024;
   static uint8_t tensorArena[kTensorArenaSize];
   const tflite::Model* model = tflite::GetModel(mobilenet_model);
   // TODO: Report an error if model->version() != TFLITE_SCHEMA_VERSION
   static tflite::AllOpsResolver microOpResolver;
   static tflite::MicroErrorReporter microErrorReporter;
   static tflite::MicroInterpreter interpreter(model,
     microOpResolver, tensorArena, kTensorArenaSize,
     microErrorReporter);
   interpreter->AllocateTensors();
   // TODO: Check return value for kTfLiteOk
   ```

3. Fillhe input data into the input tensor. For example, if a speech recognition model, image data from a camera or audio data from a microphone. The dimensions of the input data must be the same as the dimensions of the input tensor. These dimensions were specified when the model was created.

   Fill-in input data

   ```
   // Get access to the input tensor data
   TfLiteTensor* inputTensor = interpreter->input(0);
   // Copy the input tensor data from an application buffer
   for (int i = 0; i < inputTensor->bytes; i++)
     inputTensor->data.int8[i] = input_data[i];
   ```

4. Run the inference and read the output data from the output tensor. The dimensions of the output data must be the same as the dimensions of the output tensor. These dimensions were specified when the model was created.

   Running inference and reading output data

```
// Run the inference
interpreter->Invoke();
// TODO: Check the return value for TfLiteOk
// Get access to the output tensor data
TfLiteTensor* outputTensor = interpreter->output(0);
// Copy the output tensor data to an application buffer
for (int i = 0; i < outputTensor->bytes / sizeof(float32); i++)
  output_data[i] = outputTensor->data.f[i];
```

NPU inference {#npu_infer .section} Running an inference using a model converted for the NPU requires registration of a custom operator implementation. First the header file with the custom operator implementation interface must be included.

```
#include "tensorflow/lite/micro/kernels/micro_ops.h"
#include "tensorflow/lite/micro/all_ops_resolver.h"
#include "tensorflow/lite/micro/kernels/neutron/neutron.h"
```

Next, the specialized implemetation has to be registered in the operator resolver object.

```
static tflite::AllOpsResolver microOpResolver;
microOpResolver.AddCustom(tflite::GetString_NEUTRON_GRAPH(),
      tflite::Register_NEUTRON_GRAPH());
```

The specialized NPU nodes from the converted model are the executed using this newly registered implementation.

Adjusting the tensor arena size {#adjust_arena .section} The tensor arena is a static memory buffer used for intermediate tensor and scratch buffer allocation. The size of the tensor arena buffer is set by the kTensorArenaSize constant in the example above. The value depends on the tensor sizes used in the model and on the hardware-specific implementations of kernels, which may require various sizes of scratch buffers for intermediate computations. The value can be determined experimentally by running an inference with a small value, so the library fails with an insufficient tensor memory error and prints the missing amount. Continue adjusting the size until the error stops being reported. If the target hardware changes, readjust the value.

Code size optimization Typically, models do not use all the operators that are available in TensorFlow Lite. However, because of the default operator registration mechanism used in the library, the toolchain linker is not able to remove the code of unused operators. In order to reduce code size, it is possible to only register the specific operators used by a model. To determine which operators are used by a particular model, a model visualizer tool like Netron can be used. Then a mutable operator resolver object can be created that only registers the operators that are used by the model being inferenced.

Use the tflite::MicroMutableOpResolver object template, which is later passed to the tflite::MicroInterpreter object. Depending on the list of used operators, the result should be similar to the following code snippet. Make sure to update the MicroMutableOpResolver template parameter to reflect the number of operators that need to be registered.

Register only used operators in TensorFlow Lite Micro {#SECTION_SS1_DJQ_QPB .section}

```
#include "tensorflow/lite/micro/kernels/micro_ops.h"
      #include "tensorflow/lite/micro/micro_mutable_op_resolver.h"
      tflite::MicroMutableOpResolver<6> microOpResolver;
      microOpResolver.AddAveragePool2D();
      microOpResolver.AddConv2D();
      microOpResolver.AddDepthwiseConv2D();
```

(continues on next page)

(continued from previous page)

```
microOpResolver.AddDequantize();
microOpResolver.AddReshape();
microOpResolver.AddSoftmax();
static tflite::MicroInterpreter interpreter(
model, microOpResolver, tensorArena, kTensorArenaSize, microErrorReporter);
```

Note about the source code in the document Example code shown in this document has the following copyright and BSD-3-Clause license:

eIQ ExecuTorch Library User Guide

Overview ExecuTorch is an end-to-end solution for enabling on-device inference capabilities across mobile and edge devices including wearables, embedded devices and microcontrollers. It is part of the PyTorch Edge ecosystem and enables efficient deployment of PyTorch models to edge devices. For more information, see https://pytorch.org/executorch-overview.

The MCUXpresso Software Development Kit (MCUXpresso SDK) provides a comprehensive software package with a pre-integrated ExecuTorch based on version v0.5.0 with initial support for Neutron Backend. Neutron Backend enables acceleration of ML models on the eIQ® Neutron Neural Processing Unit (NPU).

This document describes the steps required to download and start using the ExecuTorch. Additionally, the document describes the steps required to create an application for running pretrained models.

Note: The document also assumes knowledge of machine learning frameworks for model training.

Supported platforms:

- i.MX RT700

Installation The ExecuTorch, with the Neutron Backend consists of:

- ExecuTorch with Neutron Backend for Ahead of Time ML Model Compilation
- Neutron Converter
- MCUXpresso SDK

Here we briefly describe each components purpose and steps to install them.

The **ExecuTorch AoT** and **Neutron Converter** are needed to convert a PyTorch model to ExecuTorch and Delegate it to eIQ Neutron NPU using the Neutron Backend. The **MCUXpresso SDK** provides project to build the ExecuTorch Runtime Library, the example application with simple CNN, toolchains and other middleware libraries to build and deploy the application on the target platform.

If you want run to prepared example application on the i.MX RT700 platform, and skip the model preparation phase continue with the *MCUXpresso SDK Part*.

ExecuTorch for Ahead of Time model preparation The ExecuTorch enables to deploy PyTorch models on edge devices. For this purpose the PyTorch model must be processed and converter by the ExecuTorch Ahead of Time (AoT) part. You can obtain the full ExecuTorch including the AoT part aligned with this version of MCUX SDK from the mcuxsdk-middleware-executorch release/mcux-full branch.

Installation Prerequisities:

- x86 Linux Machine with GLIBC-2.29 or higher (e.g. Ubuntu 20.04 or higher)
- Python 3.10, 3.11 or 3.12

To build and install the ExecuTorch follow these steps:

1. (Optional) Setup python virtual environment on desired location and activate it.

```
$ python3 -m venv venv
$ source venv/bin/activate
```

2. Clone the ExecuTorch from mcuxsdk-middleware-executorch

```
$ git clone --branch release/mcux-full https://github.com/nxp-mcuxpresso/mcuxsdk-middleware-executorch.git
$ cd mcuxsdk-middleware-executorch
$ git submodule update --init --recursive
```

3. Build and install the ExecuTorch and its dependencies:

```
$ ./install_requirements.sh
```

[!WARNING] The install_requirements.sh installs the CPU version of torch from https://download.pytorch.org/whl/cpu. If you are behind corporate proxy, it might have issues accessing it and you will see warnings like:

```
WARNING: Retrying (Retry(total=4, connect=None, read=None, redirect=None,␣
↪status=None)) after connection broken by 'SSLError(SSLCertVerificationError(1, '[SSL:␣
↪CERTIFICATE_VERIFY_FAILED] certificate verify failed: unable to get local issuer␣
↪certificate (_ssl.c:1006)'))': /whl/test/cpu/torch/
```

In this case the CUDA version of torch is installed and the install_requirements.sh script fails with:

```
PyTorch: CUDA cannot be found.  Depending on whether you are building
```

Make sure the pip can access the https://download.pytorch.org/whl/cpu PyPI.

Next continue with installation of the *Neutron Converter*

Neutron Converter The eIQ Neutron Backend uses the Neutron Converter to convert the ExecuTorch program to the eIQ Neutron NPU microcode.

Installation The Neutron Converter is available as a Python package and can be installed by the pip command from eiq.nxp.com/repository:

```
pip install --index-url https://eiq.nxp.com/repository neutron_converter_SDK_25_09==1.0.0
```

The Neutron Converter is used internally by the ExecuTorch, and it is tied to the particular BSP you are using - the suffix of the python package name. In the code snippet above the flavor is the SDK_25_09. In the *aot_neutron_convert.py* example script by the --neutron_converter_flavor parameter.

MCUXpresso SDK The MCUXpresso SDK is used to build, debug and deploy the application using the ExecuTorch on the target platform.

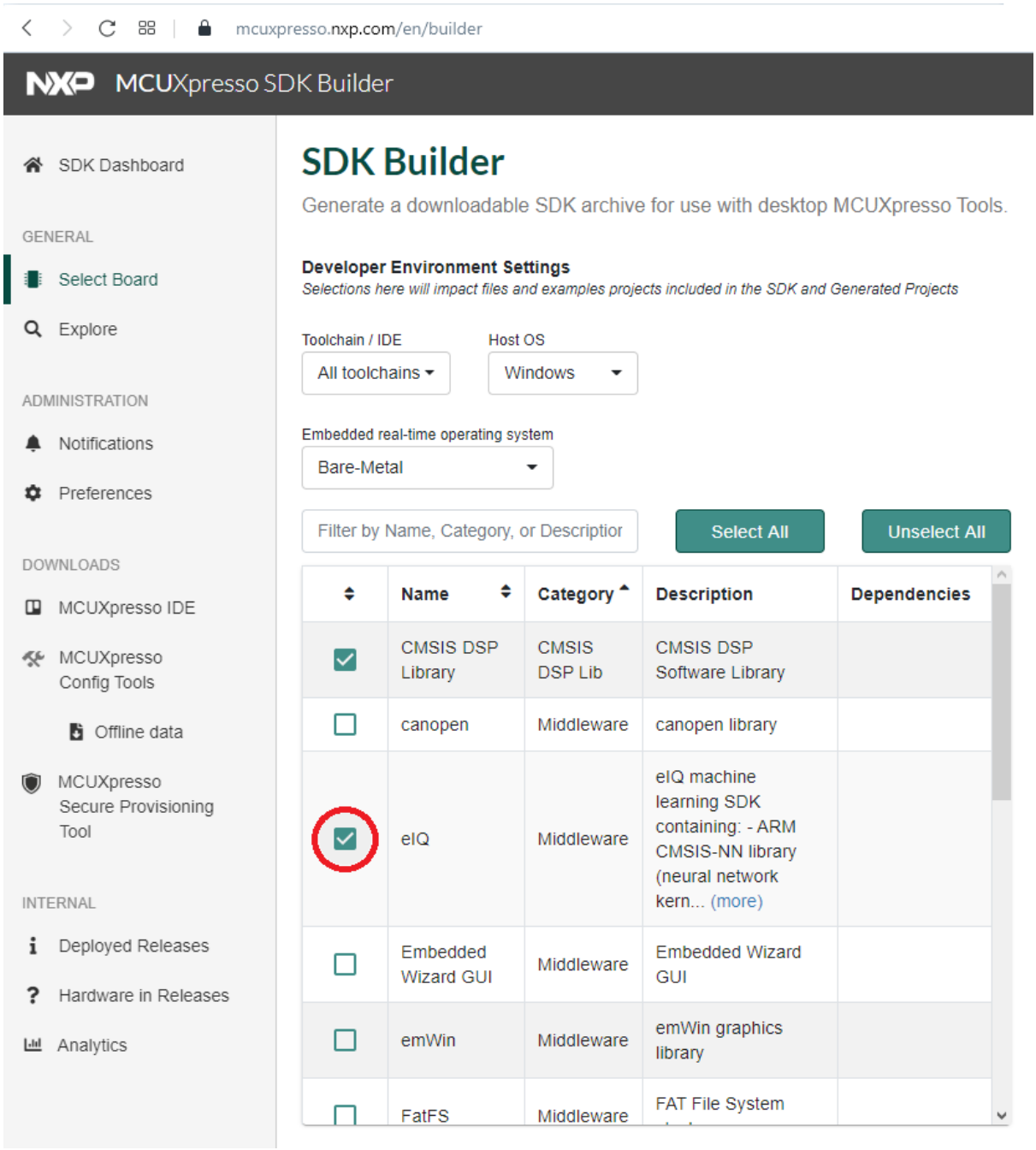
You can obtain the MCUXpresso SDK from MCUXpresso SDK Builder including the IDE. See the *getting_mcuxpress* for details.

In the MCUXpresso SDK, there are 2 projects available related to ExecuTorch:

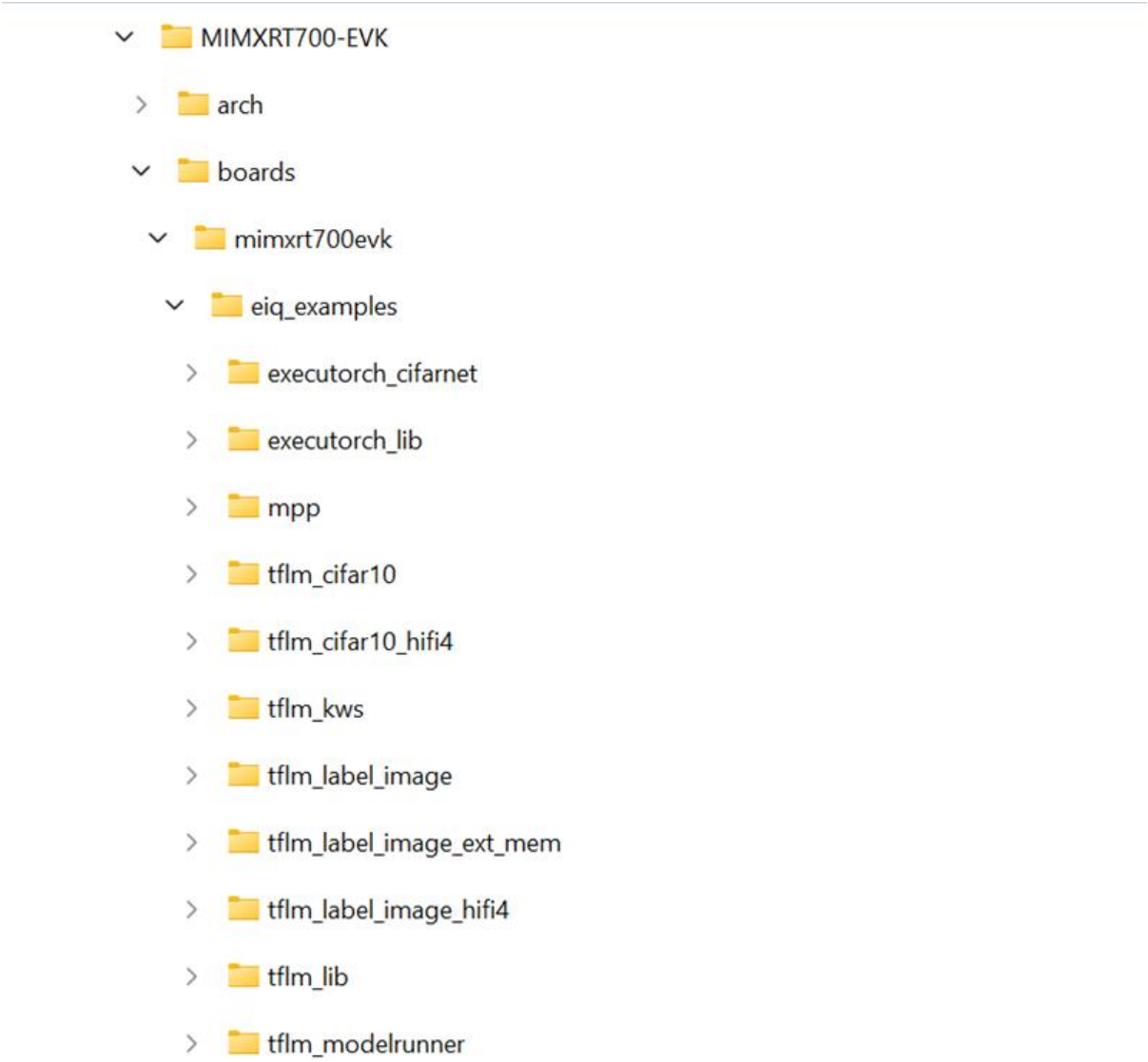
- executorch_lib
- executorch_cifarnet

For more details see *example_applications*. Here you will find the details to run build and run the demo applications.

Getting the MCUXpresso SDK with eIQ ExecuTorch The eIQ ExecuTorch library is part of the eIQ machine learning software package, which is an optional middleware component of MCUXpresso SDK. The eIQ component is integrated into the MCUXpresso SDK Builder delivery system available on mcuxpresso.nxp.com. To include eIQ machine learning into the MCUXpresso SDK package, the eIQ middleware component is selected in the software component selector on the SDK Builder page when building a new package. See *Figure 1*.



Once the MCUXpresso SDK package is downloaded, it can be extracted on a local machine or imported into the MCUXpresso IDE. For more information on the MCUXpresso SDK folder structure, see the Getting Started with MCUXpresso SDK User's Guide (document: MCUXSDKGSUG). The package directory structure is similar to *Figure 2*.



The *boards* directory contains example application projects for supported toolchains. For the list of supported toolchains, see the *MCUXpresso SDK Release Notes*. The *middleware* directory contains the eIQ library source code and example application source code and data.

PyTorch Model Conversion to ExecuTorch Format In this guideline we will show how to use the ExecuTorch AoT part to convert a PyTorch model to ExecuTorch format and delegate the model computation to eIQ Neutron NPU using the eIQ Neutron Backend.

First we will start with an example script converting the model. This example show the CifarNet model preparation. It is the same model which is part of the example_cifarnet

The steps are expected to be executed from the executorch root folder, in our case the mcuxsdk-middleware-executorch

1. After building the ExecuTorch you shall have the libquantized_ops_aot_lib.so located in the pip-out folder. We will need this library when generating the quantized cifarnet ExecuTorch model. So as first step we will find it:

```
$ find ./pip-out -name 'libquantized_ops_aot_lib.so'
./pip-out/temp.linux-x86_64-cpython-310/cmake-out/kernels/quantized/libquantized_ops_aot_lib.so
./pip-out/lib.linux-x86_64-cpython-310/executorch/kernels/quantized/libquantized_ops_aot_lib.so
```

2. Now run the aot_neutron_compile.py example with the cifar10 model

```
$ python examples/nxp/aot_neutron_compile.py \
  --quantize --so_library ./pip-out/lib.linux-x86_64-cpython-310/executorch/kernels/quantized/libquantized_
↪ops_aot_lib.so \
  --delegate --neutron_converter_flavor SDK_25_09 -m cifar10
```

3. It will generate you cifar10_nxp_delegate.pte file which can be used with the MXUXpresso SDK cifarnet_example project.

The generated PTE file is used in the executorch_cifarnet example application, see *example_application*.

MCUXpresso SDK Example applications The MCUXpresso SDK provides a set of projects and example application with the eIQ ExecuTorch. For details, see *Table 1*.

The eIQ ExecuTorch library is provided with a set of example applications. For details, see *Table 1*. The applications demonstrate the usage of the library in several use cases.

Name	Description	Availability
executorch_	This project contains the ExecuTorch Runtime Library source code and is used to build the ExecuTorch Runtime Library. The library is further used to build a full application using the leveraging ExecuTorch.	MIMXRT700-EVK (no camera and display support)
executorch_	Example application demonstrating the use of the ExecuTorch running a CifarNet classification model accelerated on the eIQ Neutron NPU. The Cifarnet is a small Convolutional Neural Network (CNN), trained on CIFAR-10 [1] dataset. The model clasifies the input images into 10 caterories.	MIMXRT700-EVK (no camera and display support)

For details on how to build and run the example applications with supported toolchains, see *Getting Started with MCUXpresso SDK User's Guide* (document: MCUXSDKGSUG).

How to build and run executorch_cifarnet example The example needs ExecuTorch Runtime Library and Neutron Libraries.

ExecuTorch Runtime Library:

- middleware/eiq/executorch/lib/cm33/armgcc/libexecutorch.a

Neutron Libraries:

- middleware/eiq/executorch/third-party/neutron/rt700/libNeutronDriver.a and
- middleware/eiq/executorch/third-party/neutron/rt700/libNeutronFirmware.a

In the example the model and the input image is already embedded into the program and ready to build and deploy to i.MX RT700, so you can continue right to the *building and deployment* section.

Convert the model and example input to C array In this section we describe where the model and example input is located in the example application sources, and how it was generated.

The **cifar10 model** ExecuTorch model is stored in boards/mimxrt700evk/eiq_examples/executorch_cifarnet/cm33_core0/model_pte.h. and was generated from the cifar10_nxp_delegate.pte (see *convert_model*).

We use the xxd command to get the C array containing the model data and array size:

```
$ xxd -i cifar10_nxp_delegate.pte > model_pte_data.h
```

then use the array data and size in the model_pte.h.

As **input image** we use the image from CIFAR-10 dataset [1]. After preprocessing and normalization it is converted to bytes and located here boards/mimxrt700evk/eiq_examples/executorch_cifarnet/cm33_core0/image_data.h. The preprocessing is performed as follows:

```
import torch
import torchvision
import numpy as np

batch_size = 1

transform = torchvision.transforms.Compose([
  torchvision.transforms.ToTensor(),
  torchvision.transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))
])

test_set = torchvision.datasets.CIFAR10(root='./data', train=False, download=True, transform=transform)
test_loader = torch.utils.data.DataLoader(test_set, batch_size=batch_size, shuffle=False, num_workers=0)

index = 0
num_images = 10
for data in test_loader:
  images, labels = data
  for image, label in zip(images,labels):
    arr = image.numpy().astype(np.float32)
    arr.tofile("img" + str(index) + "_" + str(int(label)) + ".bin")
    index = index + 1
    if index >= num_images:
      break
  if index >= num_images:
    break
```

This generates the num_images count of images from Cifar10 dataset, as input tensors for the cifar10 model and store them in corresponding .bin files. Then we use the xxd command to get the C array data and size:

```
$ xxd -i img0_3.bin > image_data_base.h
```

and again copy the array data and size in the image_data.h

Note, the img0 is the image picturing a cat, what is a class number 3.

Build, Deploy and Run

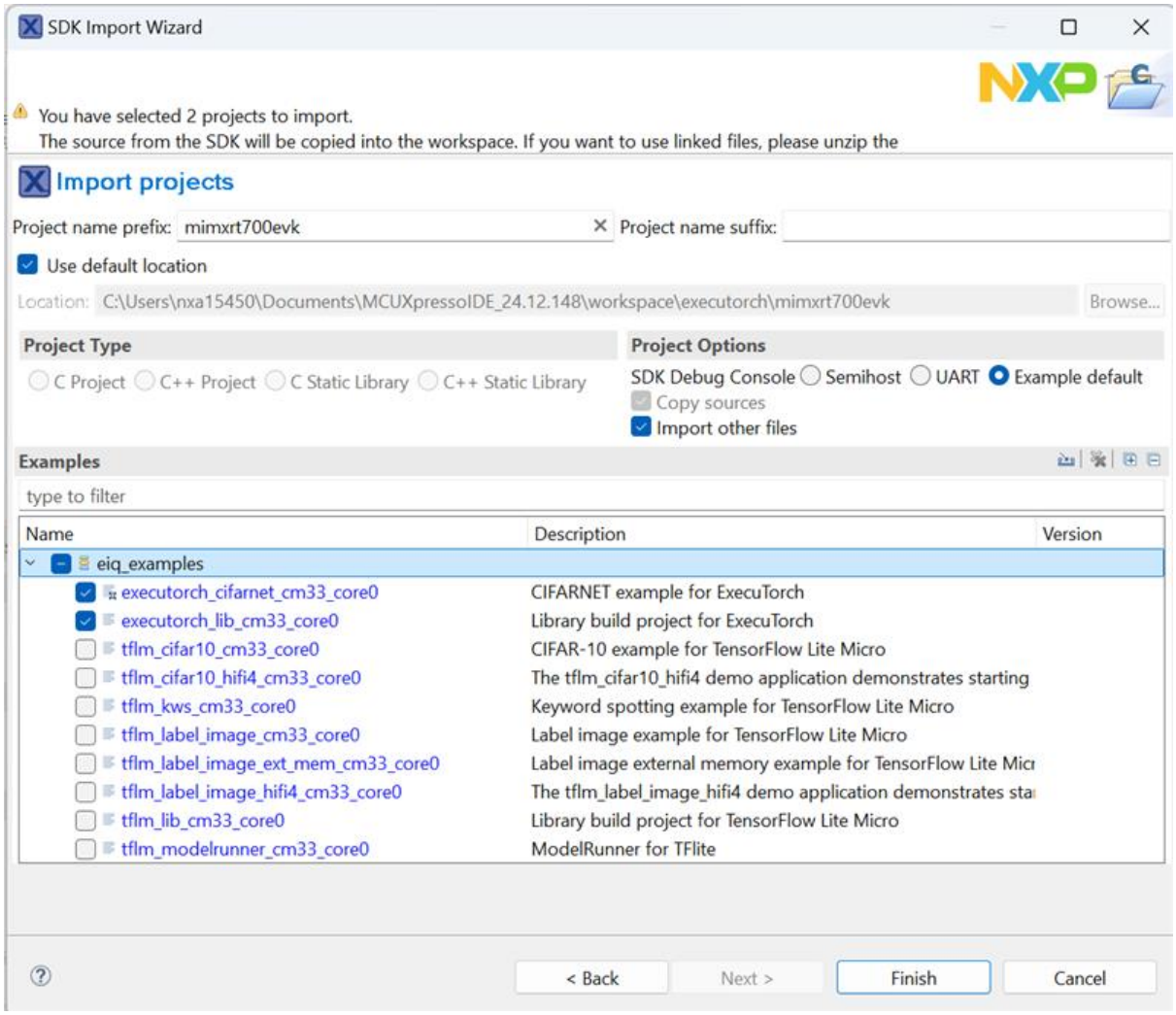
1. When using ARMGCC toolchain, the example application can be built as below. After building the example application, download it to the target with JLink as shown in *Figure 3*, an output message displays on the connected terminal as *Figure 4*.

```
$ boards/mimxrt700evk/eiq_examples/executorch_cifarnet/cm33_core0/armgcc$ ./build_flash_release.sh
```

```
J-Link>loadfile C:\rt700\executorch_cifarnet_cm33_core0.elf
'loadfile': Performing implicit reset & halt of MCU.
ResetTarget() start
-- JLINK ResetTarget --
Set CM33_SYSRESETREQ_EN
CPU0 CSW: 0x03000002
ResetTarget() end - Took 88.9ms
Downloading file [C:\rt700\executorch_cifarnet_cm33_core0.elf]...
J-Link: Flash download: Bank 0 @ 0x28000000: 1 range affected (315392 bytes)
J-Link: Flash download: Total: 20.220s (Prepare: 0.145s, Compare: 2.874s, Erase: 2.558s, Program: 13.212s, Verify: 1.392s, Restore: 0
.036s)
J-Link: Flash download: Program speed: 22 KB/s
O.K.
J-Link>reset
Reset delay: 0 ms
Reset type NORMAL: Resets core & peripherals via SYSRESETREQ & VECTRESET bit.
ResetTarget() start
-- JLINK ResetTarget --
Set CM33_SYSRESETREQ_EN
CPU0 CSW: 0x03000002
ResetTarget() end - Took 71.5ms
J-Link>go
Memory map 'after startup completion point' is active
```

```
Model PTE file loaded. Size: 99376 bytes.
Model buffer loaded, has 1 methods
Running method forward
Setting up planned buffer 0, size 53760.
Method loaded.
Preparing inputs...
Input prepared.
Starting the model execution...
Model executed successfully.
---------------------------------------
     Inference time: 11950 us
---------------------------------------
1 outputs:
Output[0][0]: 0
Output[0][1]: 0
Output[0][2]: 0
Output[0][3]: 0.996094
Output[0][4]: 0
Output[0][5]: 0
Output[0][6]: 0
Output[0][7]: 0
Output[0][8]: 0
Output[0][9]: 0
Program complete, exiting.
```

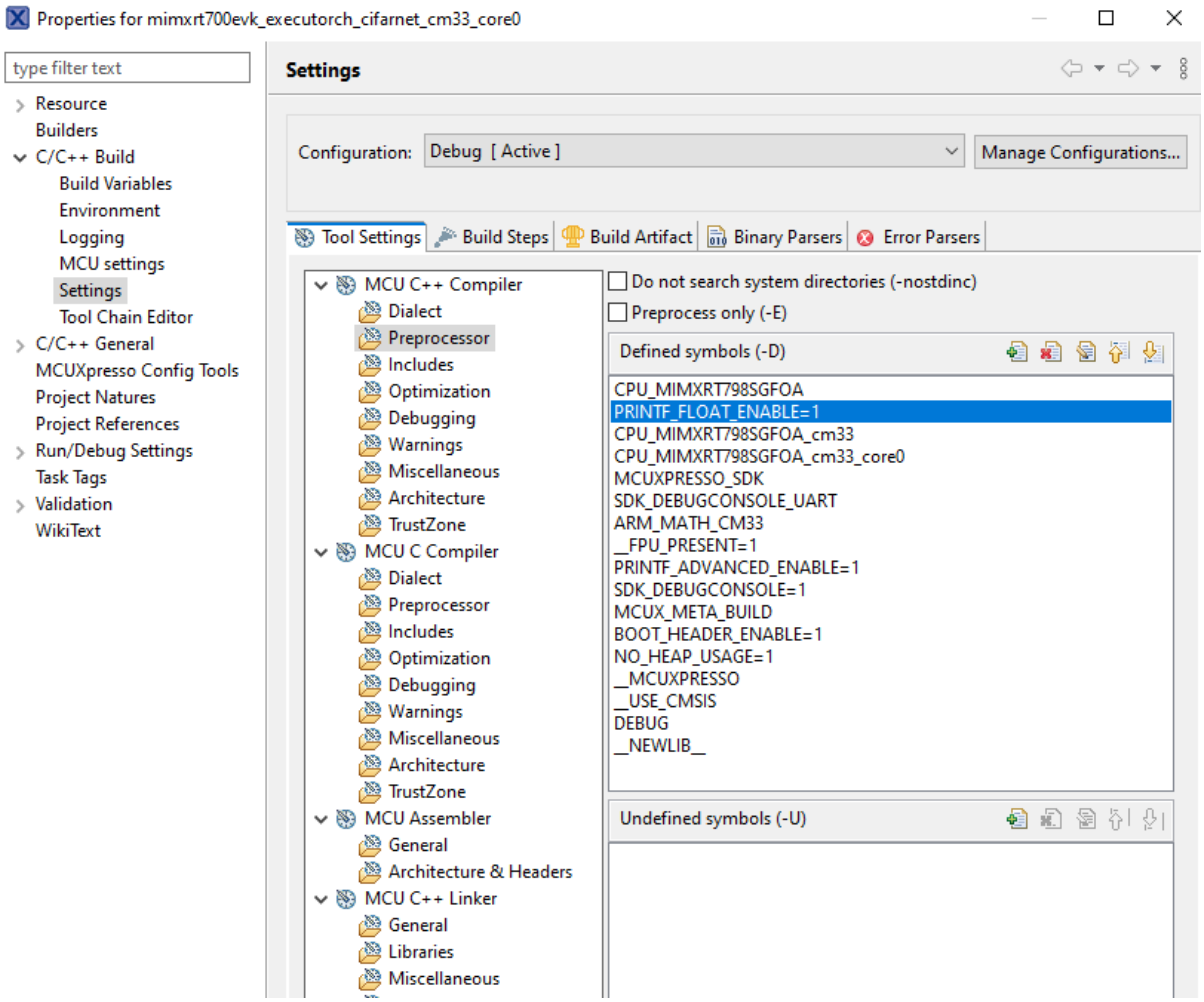
2. When using MCUXpresso IDE, the example applications can be imported through the SDK Import Wizard as shown in *Figure 5*.



After building the example application and downloading it to the target, the execution stops in the *main* function. When the execution resumes, an output message displays on the connected terminal. For example, *Figure 6* shows the output of the executorch_cifarnet example application.

```
Model PTE file loaded. Size: 99376 bytes.
Model buffer loaded, has 1 methods
Running method forward
Setting up planned buffer 0, size 53760.
Method loaded.
Preparing inputs...
Input prepared.
Starting the model execution...
Model executed successfully.
---------------------------------------
     Inference time: 14855 us
---------------------------------------
1 outputs:
Output[0][0]: 0
Output[0][1]: 0
Output[0][2]: 0
Output[0][3]: 0.996094
Output[0][4]: 0
Output[0][5]: 0
Output[0][6]: 0
Output[0][7]: 0
Output[0][8]: 0
Output[0][9]: 0
Program complete, exiting.
```

In case of missing probabilities in the printed output, add PRINTF_FLOAT_ENABLE=1 to the Preprocessor settings for C++ and C compiler:



How to build executorch_lib **example** If you want to build a new ExecuTorch Runtime Library, follow the commands as below and use the new library to replace the default Runtime library middleware/eiq/executorch/lib/cm33/armgcc/libexecutorch.a.

1. When using ARMGCC toolchain, the example application can be built as below.

```
$ boards/mimxrt700evk/eiq_examples/executorch_lib/cm33_core0/armgcc$ ./build_release.sh
$ boards/mimxrt700evk/eiq_examples/executorch_lib/cm33_core0/armgcc$ cp release/libexecutorch_lib_
↪cm33_core0.a.a ../../../../../../middleware/eiq/executorch/lib/cm33/armgcc/libexecutorch.a
```

2. When using MCUXpresso IDE, the example applications can be imported through the SDK Import Wizard as shown in the above *Figure 5*.

After building the example application, copy the new library mimxrt700evk_executorch_lib_cm33_core0\Debug\libmimxrt700evk_executorch_lib_cm33_core0.a to replace the default Runtime library mimxrt700evk_executorch_cifarnet_cm33_core0\eiq\executorch\lib\cm33\armgcc\libexecutorch.a.

[1] Learning Multiple Layers of Features from Tiny Images, Alex Krizhevsky, 2009

1.3 Motor Control

1.3.1 FreeMASTER

Communication Driver User Guide

Introduction

What is FreeMASTER? FreeMASTER is a PC-based application developed by NXP for NXP customers. It is a versatile tool usable as a real-time monitor, visualization tool, and a graphical control panel of embedded applications based on the NXP processing units.

This document describes the embedded-side software driver which implements an interface between the application and the host PC. The interface covers the following communication:

- **Serial** UART communication either over plain RS232 interface or more typically over a USB-to-Serial either external or built in a debugger probe.
- **USB** direct connection to target microcontroller
- **CAN bus**
- **TCP/IP network** wired or WiFi
- **Segger J-Link RTT**
- **JTAG** debug port communication
- ...and all of the above also using a **Zephyr** generic drivers.

The driver also supports so-called "packet-driven BDM" interface which enables a protocol-based communication over a debugging port. The BDM stands for Background Debugging Module and its physical implementation is different on each platform. Some platforms leverage a semi-standard JTAG interface, other platforms provide a custom implementation called BDM. Regardless of the name, this debugging interface enables non-intrusive access to the memory space while the target CPU is running. For basic memory read and write operations, there is no communication driver required on the target when communicating with the host PC. Use this driver to get more advanced FreeMASTER protocol features over the BDM interface. The driver must be configured for the packet-driven BDM mode, in which the host PC uses the debugging interface to write serial command frames directly to the target memory buffer. The same method is then used to read response frames from that memory buffer.

Similar to "packet-driven BDM", the FreeMASTER also supports a communication over [J-Link RTT]((https://www.segger.com/products/debug-probes/j-link/technology/about-real-time-transfer/) interface defined by SEGGER Microcontroller GmbH for ARM CortexM-based microcontrollers. This method also uses JTAG physical interface and enables high-speed real time communication to run over the same channel as used for application debugging.

Driver version 3 This document describes version 3 of the FreeMASTER Communication Driver. This version features the implementation of the new Serial Protocol, which significantly extends the features and security of its predecessor. The new protocol internal number is v4 and its specification is available in the documentation accompanying the driver code.

Driver V3 is deployed to modern 32-bit MCU platforms first, so the portfolio of supported platforms is smaller than for the previous V2 versions. It is recommended to keep using the V2 driver for legacy platforms, such as S08, S12, ColdFire, or Power Architecture. Reach out to FreeMASTER community or to the local NXP representative with requests for more information or to port the V3 driver to legacy MCU devices.

Thanks to a layered approach, the new driver simplifies the porting of the driver to new UART, CAN or networking communication interfaces significantly. Users are encouraged to port the driver to more NXP MCU platforms and contribute the code back to NXP for integration into future releases. Existing code and low-level driver layers may be used as an example when porting to new targets.

Note: Using the FreeMASTER tool and FreeMASTER Communication Driver is only allowed in systems based on NXP microcontroller or microprocessor unit. Use with non-NXP MCU platforms is **not permitted** by the license terms.

Target platforms The driver implementation uses the following abstraction mechanisms which simplify driver porting and supporting new communication modules:

- **General CPU Platform** (see source code in the src/platforms directory). The code in this layer is only specific to native data type sizes and CPU architectures (for example; alignment-aware memory copy routines). This driver version brings two generic implementations of 32-bit platforms supporting both little-endian and big-endian architectures. There are also implementations customized for the 56F800E family of digital signal controllers and S12Z MCUs. **Zephyr** is treated as a specific CPU platform as it brings unified user configuration (Kconfig) and generic hardware device drivers. With Zephyr, the transport layer and low-level communication layers described below are configured automatically using Kconfig and Device Tree technologies.
- **Transport Communication Layer** - The Serial, CAN, Networking, PD-BDM, and other methods of transport logic are implemented as a driver layer called FMSTR_TRANSPORT with a uniform API. A support of the Network transport also extends single-client modes of operation which are native for Serial, USB and CAN by a concept of multiple client sessions.
- **Low-level Communication Driver** - Each type of transport further defines a low-level API used to access the physical communication module. For example, the Serial transport defines a character-oriented API implemented by different serial communication modules like UART, LPUART, USART, and also USB-CDC. Similarly, the CAN transport defines a message-oriented API implemented by the FlexCAN or MCAN modules. Moreover, there are multiple different implementations for the same kind of communication peripherals. The difference between the implementation is in the way the low-level hardware registers are accessed. The *mcuxsdk* folder contains implementations which use MCUXpresso SDK drivers. These drivers should be used in applications based on the NXP MCUXpresso SDK. The “ampsdk” drivers target automotive-specific MCUs and their respective SDKs. The “dreg” implementations use a plain C-language access to hardware register addresses which makes it a universal and the most portable solution. In this case, users are encouraged to add more drivers for other communication modules or other respective SDKs and contribute the code back to NXP for integration.

  The low-level drivers defined for the Networking transport enable datagram-oriented UDP and stream TCP communication. This implementation is demonstrated using the lwIP software stack but shall be portable to other TCP/IP stacks. It may sound surprisingly, but also the Segger J-Link RTT communication driver is linked to the Networking transport (RTT is stream oriented communication handled similarly to TCP).

Replacing existing drivers For all supported platforms, the driver described in this document replaces the V2 implementation and also older driver implementations that were available separately for individual platforms (PC Master SCI drivers).

Clocks, pins, and peripheral initialization The FreeMASTER communication driver is only responsible for runtime processing of the communication and must be integrated with an user application code to function properly. The user application code is responsible for general initialization of clock sources, pin multiplexers, and peripheral registers related to the communication speed. Such initialization should be done before calling the FMSTR_Init function.

It is recommended to develop the user application using one of the Software Development Kits (SDKs) available from third parties or directly from NXP, such as MCUXpresso SDK, MCUXpresso IDE, and related tools. This approach simplifies the general configuration process significantly.

MCUXpresso SDK The MCUXpresso SDK is a software package provided by NXP which contains the device initialization code, linker files, and software drivers with example applications for the NXP family of MCUs. The MCUXpresso Config Tools may be used to generate the clock-setup and pin-multiplexer setup code suitable for the selected processor.

The MCUXpresso SDK also contains this FreeMASTER communication driver as a "middleware" component which may be downloaded along with the example applications from https://mcuxpresso.nxp.com/en/welcome.

MCUXpresso SDK on GitHub The FreeMASTER communication driver is also released as one of the middleware components of the MCUXpresso SDK on the GitHub. This release enables direct integration of the FreeMASTER source code Git repository into a target applications including Zephyr applications.

Related links:

- The official FreeMASTER middleware repository.
- Online version of this document

FreeMASTER in Zephyr The FreeMASTER middleware repository can be used with MCUXpresso SDK as well as a Zephyr module. Zephyr-specific samples which include examples of Kconfig and Device Tree configurations for Serial, USB and Network communications are available in separate repository. West manifest in this sample repository fetches the full Zephyr package including the FreeMASTER middleware repository used as a Zephyr module.

Example applications

MCUX SDK Example applications There are several example applications available for each supported MCU platform.

- **fmstr_uart** demonstrates a plain serial transmission, typically connecting to a computer's physical or virtual COM port. The typical transmission speed is 115200 bps.
- **fmstr_can** demonstrates CAN bus communication. This requires a suitable CAN interface connected to the computer and interconnected with the target MCU using a properly terminated CAN bus. The typical transmission speed is 500 kbps. A FreeMASTER-over-CAN communication plug-in must be used.
- **fmstr_usb_cdc** uses an on-chip USB controller to implement a CDC communication class. It is connected directly to a computer's USB port and creates a virtual COM port device. The typical transmission speed is above 1 Mbps.
- **fmstr_net** demonstrates the Network communication over UDP or TCP protocol. Existing examples use lwIP stack to implement the communication, but in general, it shall be possible to use any other TCP/IP stack to achieve the same functionality.
- **fmstr_wifi** is the fmstr_net application modified to use a WiFi network interface instead of a wired Ethernet connection.
- **fmstr_rtt** demonstrates the communication over SEGGER J-Link RTT interface. Both fmstr_net and fmstr_rtt examples require the FreeMASTER TCP/UDP communication plug-in to be used on the PC host side.
- **fmstr_eonce** uses the real-time data unit on the JTAG EOnCE module of the 56F800E family to implement pseudo-serial communication over the JTAG port. The typical transmission speed is around 10 kbps. This communication requires FreeMASTER JTAG/EOnCE communication plug-in.

- **fmstr_pdbdm** uses JTAG or BDM debugging interface to access the target RAM directly while the CPU is running. Note that such approach can be used with any MCU application, even without any special driver code. The computer reads from and writes into the RAM directly without CPU intervention. The Packet-Driven BDM (PD-BDM) communication uses the same memory access to exchange command and response frames. With PD-BDM, the FreeMASTER tool is able to go beyond basic memory read/write operations and accesses also advanced features like Recorder, TSA, or Pipes. The typical transmission speed is around 10 kbps. A PD-BDM communication plug-in must be used in FreeMASTER and configured properly for the selected debugging interface. Note that this communication cannot be used while a debugging interface is used by a debugger session.
- **fmstr_any** is a special example application which demonstrates how the NXP MCUXpresso Config Tools can be used to configure pins, clocks, peripherals, interrupts, and even the FreeMASTER "middleware" driver features in a graphical and user friendly way. The user can switch between the Serial, CAN, and other ways of communication and generate the required initialization code automatically.

Zephyr sample spplications Zephyr sample applications demonstrate Kconfig and Device Tree configuration which configure the FreeMASTER middleware module for a selected communication option (Serial, CAN, Network or RTT).

Refer to *readme.md* files in each sample directory for description of configuration options required to implement FreeMASTER connectivity.

Description

This section shows how to add the FreeMASTER Communication Driver into application and how to configure the connection to the FreeMASTER visualization tool.

Features The FreeMASTER driver implements the FreeMASTER protocol V4 and provides the following features which may be accessed using the FreeMASTER visualization tool:

- Read/write access to any memory location on the target.
- Optional password protection of the read, read/write, and read/write/flash access levels.
- Atomic bit manipulation on the target memory (bit-wise write access).
- Optimal size-aligned access to memory which is also suitable to access the peripheral register space.
- Oscilloscope access—real-time access to target variables. The sample rate may be limited by the communication speed.
- Recorder— access to the fast transient recorder running on the board as a part of the FreeMASTER driver. The sample rate is only limited by the MCU CPU speed. The length of the data recorded depends on the amount of available memory.
- Multiple instances of Oscilloscopes and Recorders without the limitation of maximum number of variables.
- Application commands—high-level message delivery from the PC to the application.
- TSA tables—describing the data types, variables, files, or hyperlinks exported by the target application. The TSA newly supports also non-memory mapped resources like external EEPROM or SD Card files.
- Pipes—enabling the buffered stream-oriented data exchange for a general-purpose terminal-like communication, diagnostic data streaming, or other data exchange.

The FreeMASTER driver features:

- Full FreeMASTER protocol V4 implementation with a new V4 style of CRC used.
- Layered approach supporting Serial, CAN, Network, PD-BDM, and other transports.
- Layered low-level Serial transport driver architecture enabling to select UART, LPUART, USART, and other physical implementations of serial interfaces, including USB-CDC.
- Layered low-level CAN transport driver architecture enabling to select FlexCAN, msCAN, MCAN, and other physical implementations of the CAN interface.
- Layered low-level Networking transport enabling to select TCP, UDP or J-Link RTT communication.
- TSA support to write-protect memory regions or individual variables and to deny the access to the unsafe memory.
- The pipe callback handlers are invoked whenever new data is available for reading from the pipe.
- Two Serial Single-Wire modes of operation are enabled. The “external” mode has the RX and TX shorted on-board. The “true” single-wire mode interconnects internally when the MCU or UART modules support it.

The following sections briefly describe all FreeMASTER features implemented by the driver. See the PC-based FreeMASTER User Manual for more details on how to use the features to monitor, tune, or control an embedded application.

Board Detection The FreeMASTER protocol V4 defines the standard set of configuration values which the host PC tool reads to identify the target and to access other target resources properly. The configuration includes the following parameters:

- Version of the driver and the version of the protocol implemented.
- MTU as the Maximum size of the Transmission Unit (for example; communication buffer size).
- Application name, description, and version strings.
- Application build date and time as a string.
- Target processor byte ordering (little/big endian).
- Protection level that requires password authentication.
- Number of the Recorder and Oscilloscope instances.
- RAM Base Address for optimized memory access commands.

Memory Read This basic feature enables the host PC to read any data memory location by specifying the address and size of the required memory area. The device response frame must be shorter than the MTU to fit into the outgoing communication buffer. To read a device memory of any size, the host uses the information retrieved during the Board Detection and splits the large-block request to multiple partial requests.

The driver uses size-aligned operations to read the target memory (for example; uses proper read-word instruction when an address is aligned to 4 bytes).

Memory Write Similarly to the Memory Read operation, the Memory Write feature enables to write to any RAM memory location on the target device. A single write command frame must be shorter than the MTU to fit into the target communication buffer. Larger requests must be split into smaller ones.

The driver uses size-aligned operations to write to the target memory (for example; uses proper write-word instruction when an address is aligned to 4 bytes).

Masked Memory Write To implement the write access to a single bit or a group of bits of target variables, the Masked Memory Write feature is available in the FreeMASTER protocol and it is supported by the driver using the Read-Modify-Write approach.

Be careful when writing to bit fields of volatile variables that are also modified in an application interrupt. The interrupt may be serviced in the middle of a read-modify-write operation and it may cause data corruption.

Oscilloscope The protocol and driver enables any number of variables to be read at once with a single request from the host. This feature is called Oscilloscope and the FreeMASTER tool uses it to display a real-time graph of variable values.

The driver can be configured to support any number of Oscilloscope instances and enable simultaneously running graphs to be displayed on the host computer screen.

Recorder The protocol enables the host to select target variables whose values are then periodically recorded into a dedicated on-board memory buffer. After such data sampling stops (either on a host request or by evaluating a threshold-crossing condition), the data buffer is downloaded to the host and displayed as a graph. The data sampling rate is not limited by the speed of the communication line, so it enables displaying the variable transitions in a very high resolution.

The driver can be configured to support multiple Recorder instances and enable multiple recorder graphs to be displayed on the host screen. Having multiple recorders also enables setting the recording point differently for each instance. For example; one instance may be recording data in a general timer interrupt while another instance may record at a specific control algorithm time in the PWM interrupt.

TSA With the TSA feature, data types and variables can be described directly in the application source code. Such information is later provided to the FreeMASTER tool which may use it instead of reading symbol data from the application ELF executable file.

The information is encoded as so-called TSA tables which become direct part of the application code. The TSA tables contain descriptors of variables that shall be visible to the host tool. The descriptors can describe the memory areas by specifying the address and size of the memory block or more conveniently using the C variable names directly. Different set of TSA descriptors can be used to encode information about the structure types, unions, enumerations, or arrays.

The driver also supports special types of TSA table entries to describe user resources like external EEPROM and SD Card files, memory-mapped files, virtual directories, web URL hyperlinks, and constant enumerations.

TSA Safety When the TSA is enabled in the application, the TSA Safety can be enabled and validate the memory accesses directly by the embedded-side driver. When the TSA Safety is turned on, any memory request received from the host is validated and accepted only if it belongs to a TSA-described object. The TSA entries can be declared as Read-Write or Read-Only so that the driver can actively deny the write access to the Read-Only objects.

Application commands The Application Commands are high-level messages that can be delivered from the PC Host to the embedded application for further processing. The embedded application can either poll the status, or be called back when a new Application Command arrives to be processed. After the embedded application acknowledges that the command is handled, the host receives the Result Code and reads the other return data from memory. Both the Application Commands and the Result Codes are specific to a given application and it is user's responsibility to define them. The FreeMASTER protocol and the FreeMASTER driver only implement the delivery channel and a set of API calls to enable the Application Command processing in general.

Pipes The Pipes enable buffered and stream-oriented data exchange between the PC Host and the target application. Any pipe can be written to and read from at both ends (either on the PC or the MCU). The data transmission is acknowledged using the special FreeMASTER protocol commands. It is guaranteed that the data bytes are delivered from the writer to the reader in a proper order and without losses.

Serial single-wire operation The MCU Serial Communication Driver natively supports normal dual-wire operation. Because the protocol is half-duplex only, the driver can also operate in two single-wire modes:

- "External" single-wire operation where the Receiver and Transmitter pins are shorted on the board. This mode is supported by default in the MCU driver because the Receiver and Transmitter units are enabled or disabled whenever needed. It is also easy to extend this operation for the RS485 communication.
- "True" single-wire mode which uses only a single pin and the direction switching is made by the UART module. This mode of operation must be enabled by defining the FMSTR_SERIAL_SINGLEWIRE configuration option.

Multi-session support With networking interface it is possible for multiple clients to access the target MCU simultaneously. Reading and writing of target memory is processed atomically so there is no risk of data corruption. The state-full resources such as Recorders or Oscilloscopes are locked to a client session upon first use and access is denied to other clients until lock is released..

Zephyr-specific

Dedicated communication task FreeMASTER communication may run isolated in a dedicated task. The task automates the FMSTR_Init and FMSTR_Poll calls together with periodic activities enabling the FreeMASTER UI to fetch information about tasks and CPU utilization. The task can be started automatically or manually, and it must be assigned a priority to be able to react on interrupts and other communication events. Refer to Zephyr FreeMASTER sample applications which all use this communication task.

Zephyr shell and logging over FreeMASTER pipe FreeMASTER implements a shell backend which may use FreeMASTER pipe as a I/O terminal and logging output. Refer to Zephyr FreeMASTER sample applications which all use this feature.

Automatic TSA tables TSA tables can be declared as "automatic" in Zephyr which make them automatically registered in the table list. This may be very useful when there are many TSA tables or when the tables are defined in different (often unrelated) libraries linked together. In this case user does not need to build a list of all tables manually.

Driver files The driver source files can be found in a top-level src folder, further divided into the sub-folders:

- ***src/platforms*** platform-specific folder—one folder exists for each supported processor platform (for example; 32-bit Little Endian platform). Each such folder contains a platform header file with data types and a code which implements the potentially platform-specific operations, such as aligned memory access.
- ***src/common*** folder—contains the common driver source files shared by the driver for all supported platforms. All the *.c* files must be added to the project, compiled, and linked together with the application.

- *freemaster.h* - master driver header file, which declares the common data types, macros, and prototypes of the FreeMASTER driver API functions.
- *freemaster_cfg.h.example* - this file can serve as an example of the FreeMASTER driver configuration file. Save this file into a project source code folder and rename it to *freemaster_cfg.h*. The FreeMASTER driver code includes this file to get the project-specific configuration options and to optimize the compilation of the driver.
- *freemaster_defcfg.h* - defines the default values for each FreeMASTER configuration option if the option is not set in the *freemaster_cfg.h* file.
- *freemaster_protocol.h* - defines the FreeMASTER protocol constants used internally by the driver.
- *freemaster_protocol.c* - implements the FreeMASTER protocol decoder and handles the basic Get Configuration Value, Memory Read, and Memory Write commands.
- *freemaster_rec.c* - handles the Recorder-specific commands and implements the Recorder sampling and triggering routines. When the Recorder is disabled by the FreeMASTER driver configuration file, this file only compiles to empty API functions.
- *freemaster_scope.c* - handles the Oscilloscope-specific commands. If the Oscilloscope is disabled by the FreeMASTER driver configuration file, this file compiles as void.
- *freemaster_pipes.c* - implements the Pipes functionality when the Pipes feature is enabled.
- *freemaster_appcmd.c* - handles the communication commands used to deliver and execute the Application Commands within the context of the embedded application. When the Application Commands are disabled by the FreeMASTER driver configuration file, this file only compiles to empty API functions.
- *freemaster_tsa.c* - handles the commands specific to the TSA feature. This feature enables the FreeMASTER host tool to obtain the TSA memory descriptors declared in the embedded application. If the TSA is disabled by the FreeMASTER driver configuration file, this file compiles as void.
- *freemaster_tsa.h* - contains the declaration of the macros used to define the TSA memory descriptors. This file is indirectly included into the user application code (via *freemaster.h*).
- *freemaster_sha.c* - implements the SHA-1 hash code used in the password authentication algorithm.
- *freemaster_private.h* - contains the declarations of functions and data types used internally in the driver. It also contains the C pre-processor statements to perform the compile-time verification of the user configuration provided in the *freemaster_cfg.h* file.
- *freemaster_serial.c* - implements the serial protocol logic including the CRC, FIFO queuing, and other communication-related operations. This code calls the functions of the low-level communication driver indirectly via a character-oriented API exported by the specific low-level driver.
- *freemaster_serial.h* - defines the low-level character-oriented Serial API.
- *freemaster_can.c* - implements the CAN protocol logic including the CAN message preparation, signalling using the first data byte in the CAN frame, and other communication-related operations. This code calls the functions of the low-level communication driver indirectly via a message-oriented API exported by the specific low-level driver.
- *freemaster_can.h* - defines the low-level message-oriented CAN API.
- *freemaster_net.c* - implements the Network protocol transport logic including multiple session management code.

  - *freemaster_net.h* - definitions related to the Network transport.
  - *freemaster_pdbdm.c* - implements the packet-driven BDM communication buffer and other communication-related operations.
  - *freemaster_utils.c* - aligned memory copy routines, circular buffer management and other utility functions
  - *freemaster_utils.h* - definitions related to utility code.
- ***src/drivers/[sdk]/serial*** - contains the code related to the serial communication implemented using one of the supported SDK frameworks.
  - *freemaster_serial_XXX.c* and *.h* - implement low-level access to the communication peripheral registers. Different files exist for the UART, LPUART, USART, and other kinds of Serial communication modules.
- ***src/drivers/[sdk]/can*** - contains the code related to the serial communication implemented using one of the supported SDK frameworks.
  - *freemaster_XXX.c* and *.h* - implement low-level access to the communication peripheral registers. Different files exist for the FlexCAN, msCAN, MCAN, and other kinds of CAN communication modules.
- ***src/drivers/[sdk]/network*** - contains low-level code adapting the FreeMASTER Network transport to an underlying TCP/IP or RTT stack.
  - *freemaster_net_lwip_tcp.c* and *_udp.c* - default networking implementation of TCP and UDP transports using lwIP stack.
  - *freemaster_net_segger_rtt.c* - implementation of network transport using Segger J-Link RTT interface

Driver configuration The driver is configured using a single header file (*freemaster_cfg.h*). Create this file and save it together with other project source files before compiling the driver code. All FreeMASTER driver source files include the *freemaster_cfg.h* file and use the macros defined here for the conditional and parameterized compilation. The C compiler must locate the configuration file when compiling the driver files. Typically, it can be achieved by putting this file into a folder where the other project-specific included files are stored.

As a starting point to create the configuration file, get the *freemaster_cfg.h.example* file, rename it to *freemaster_cfg.h*, and save it into the project area.

Note: It is NOT recommended to leave the *freemaster_cfg.h* file in the FreeMASTER driver source code folder. The configuration file must be placed at a project-specific location, so that it does not affect the other applications that use the same driver.

Configurable items This section describes the configuration options which can be defined in *freemaster_cfg.h*.

Interrupt modes

```
#define FMSTR_LONG_INTR   [0|1]
#define FMSTR_SHORT_INTR  [0|1]
#define FMSTR_POLL_DRIVEN [0|1]
```

Value Type boolean (0 or 1)

Description Exactly one of the three macros must be defined to non-zero. The others must be defined to zero or left undefined. The non-zero-defined constant selects the interrupt mode of the driver. See *Driver interrupt modes*.

- FMSTR_LONG_INTR — long interrupt mode
- FMSTR_SHORT_INTR — short interrupt mode
- FMSTR_POLL_DRIVEN — poll-driven mode

Note: Some options may not be supported by all communication interfaces. For example, the FMSTR_SHORT_INTR option is not supported by the USB_CDC interface.

Protocol transport

```
#define FMSTR_TRANSPORT [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER source code. Specify one of existing instances to make use of the protocol transport.

Description Use one of the pre-defined constants, as implemented by the FreeMASTER code. The current driver supports the following transports:

- **FMSTR_SERIAL** - serial communication protocol
- **FMSTR_CAN** - using CAN communication
- **FMSTR_PDBDM** - using packet-driven BDM communication
- **FMSTR_NET** - network communication using TCP or UDP protocol

Serial transport This section describes configuration parameters used when serial transport is used:

```
#define FMSTR_TRANSPORT FMSTR_SERIAL
```

FMSTR_SERIAL_DRV Select what low-level driver interface will be used when implementing the Serial communication.

```
#define FMSTR_SERIAL_DRV [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing serial driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/serial* implementation):

- **FMSTR_SERIAL_MCUX_UART** - UART driver
- **FMSTR_SERIAL_MCUX_LPUART** - LPUART driver
- **FMSTR_SERIAL_MCUX_USART** - USART driver
- **FMSTR_SERIAL_MCUX_MINIUSART** - miniUSART driver
- **FMSTR_SERIAL_MCUX_QSCI** - DSC QSCI driver
- **FMSTR_SERIAL_MCUX_USB** - USB/CDC class driver (also see code in the */support/mcuxsdk_usb* folder)

- **FMSTR_SERIAL_56F800E_EONCE** - DSC JTAG EOnCE driver

Other SDKs or BSPs may define custom low-level driver interface structure which may be used as FMSTR_SERIAL_DRV. For example:

- **FMSTR_SERIAL_DREG_UART** - demonstrates the low-level interface implemented without the MCUXpresso SDK and using direct access to peripheral registers.

FMSTR_SERIAL_BASE

```
#define FMSTR_SERIAL_BASE [address|symbol]
```

Value Type Optional address value (numeric or symbolic)

Description Specify the base address of the UART, LPUART, USART, or other serial peripheral module to be used for the communication. This value is not defined by default. User application should call FMSTR_SetSerialBaseAddress() to select the peripheral module.

FMSTR_COMM_BUFFER_SIZE

```
#define FMSTR_COMM_BUFFER_SIZE [number]
```

Value Type 0 or a value in range 32...255

Description Specify the size of the communication buffer to be allocated by the driver. Default value, which suits all driver features, is used when this option is defined as 0.

FMSTR_COMM_RQUEUE_SIZE

```
#define FMSTR_COMM_RQUEUE_SIZE [number]
```

Value Type Value in range 0...255

Description Specify the size of the FIFO receiver queue used to quickly receive and store characters in the FMSTR_SHORT_INTR interrupt mode.
The default value is 32 B.

FMSTR_SERIAL_SINGLEWIRE

```
#define FMSTR_SERIAL_SINGLEWIRE [0|1]
```

Value Type Boolean 0 or 1.

Description Set to non-zero to enable the “True” single-wire mode which uses a single MCU pin to communicate. The low-level driver enables the pin direction switching when the MCU peripheral supports it.

CAN Bus transport This section describes configuration parameters used when CAN transport is used:

```
#define FMSTR_TRANSPORT FMSTR_CAN
```

FMSTR_CAN_DRV Select what low-level driver interface will be used when implementing the CAN communication.

```
#define FMSTR_CAN_DRV [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing CAN driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/can implementation*):

- **FMSTR_CAN_MCUX_FLEXCAN** - FlexCAN driver
- **FMSTR_CAN_MCUX_MCAN** - MCAN driver
- **FMSTR_CAN_MCUX_MSCAN** - msCAN driver
- **FMSTR_CAN_MCUX_DSCFLEXCAN** - DSC FlexCAN driver
- **FMSTR_CAN_MCUX_DSCMSCAN** - DSC msCAN driver

Other SDKs or BSPs may define the custom low-level driver interface structure which may be used as FMSTR_CAN_DRV.

FMSTR_CAN_BASE

```
#define FMSTR_CAN_BASE [address|symbol]
```

Value Type Optional address value (numeric or symbolic)

Description Specify the base address of the FlexCAN, msCAN, or other CAN peripheral module to be used for the communication. This value is not defined by default. User application should call FMSTR_SetCanBaseAddress() to select the peripheral module.

FMSTR_CAN_CMDID

```
#define FMSTR_CAN_CMDID [number]
```

Value Type CAN identifier (11-bit or 29-bit number)

Description CAN message identifier used for FreeMASTER commands (direction from PC Host tool to target application). When declaring 29-bit identifier, combine the numeric value with FMSTR_CAN_EXTID bit. Default value is 0x7AA.

FMSTR_CAN_RSPID

```
#define FMSTR_CAN_RSPID [number]
```

Value Type CAN identifier (11-bit or 29-bit number)

Description CAN message identifier used for responding messages (direction from target application to PC Host tool). When declaring 29-bit identifier, combine the numeric value with FMSTR_CAN_EXTID bit. Note that both *CMDID* and *RSPID* values may be the same. Default value is 0x7AA.

FMSTR_FLEXCAN_TXMB

```
#define FMSTR_FLEXCAN_TXMB [number]
```

Value Type Number in range of 0..N where N is number of CAN message-buffers supported by HW module.

Description Only used when the FlexCAN low-level driver is used. Define the FlexCAN message buffer for CAN frame transmission. Default value is 0.

FMSTR_FLEXCAN_RXMB

```
#define FMSTR_FLEXCAN_RXMB [number]
```

Value Type Number in range of 0..N where N is number of CAN message-buffers supported by HW module.

Description Only used when the FlexCAN low-level driver is used. Define the FlexCAN message buffer for CAN frame reception. Note that the FreeMASTER driver may also operate with a common message buffer used by both TX and RX directions. Default value is 1.

Network transport This section describes configuration parameters used when Network transport is used:

```
#define FMSTR_TRANSPORT FMSTR_NET
```

FMSTR_NET_DRV Select network interface implementation.

```
#define FMSTR_NET_DRV [identifier]
```

Value Type Identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing NET driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/network implementation*):

- **FMSTR_NET_LWIP_TCP** - TCP communication using lwIP stack
- **FMSTR_NET_LWIP_UDP** - UDP communication using lwIP stack
- **FMSTR_NET_SEGGER_RTT** - Communication using SEGGER J-Link RTT interface

Other SDKs or BSPs may define the custom networking interface which may be used as FMSTR_CAN_DRV.

Add another row below:

FMSTR_NET_PORT

```
#define FMSTR_NET_PORT [number]
```

Value Type TCP or UDP port number (short integer)

Description Specifies the server port number used by TCP or UDP protocols.

FMSTR_NET_BLOCKING_TIMEOUT

```
#define FMSTR_NET_BLOCKING_TIMEOUT [number]
```

Value Type Timeout as number of milliseconds

Description This value specifies a timeout in milliseconds for which the network socket operations may block the execution inside *FMSTR_Poll*. This may be set high (e.g. 250) when a dedicated RTOS task is used to handle FreeMASTER protocol polling. Set to a lower value when the polling task is also responsible for other operations. Set to 0 to attempt to use non-blocking socket operations.

FMSTR_NET_AUTODISCOVERY

```
#define FMSTR_NET_AUTODISCOVERY [0|1]
```

Value Type Boolean 0 or 1.

Description This option enables the FreeMASTER driver to use a separate UDP socket to broadcast auto-discovery messages to network. This helps the FreeMASTER tool to discover the target device address, port and protocol options.

Debugging options

FMSTR_DISABLE

```
#define FMSTR_DISABLE [0|1]
```

Value Type boolean (0 or 1)

Description Define as non-zero to disable all FreeMASTER features, exclude the driver code from build, and compile all its API functions empty. This may be useful to remove FreeMASTER without modifying any application source code. Default value is 0 (false).

FMSTR_DEBUG_TX

```
#define FMSTR_DEBUG_TX [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to enable the driver to periodically transmit test frames out on the selected communication interface (SCI or CAN). With the debug transmission enabled, it is simpler to detect problems in the baudrate or other communication configuration settings.

The test frames are transmitted until the first valid command frame is received from the PC Host tool. The test frame is a valid error status frame, as defined by the protocol format. On the serial line, the test frame consists of three printable characters (+©W) which are easy to capture using the serial terminal tools.

This feature requires the FMSTR_Poll() function to be called periodically. Default value is 0 (false).

FMSTR_APPLICATION_STR

```
#define FMSTR_APPLICATION_STR
```

Value Type String.

Description Name of the application visible in FreeMASTER host application.

Memory access

FMSTR_USE_READMEM

```
#define FMSTR_USE_READMEM [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the Memory Read command and enable FreeMASTER to have read access to memory and variables. The access can be further restricted by using a TSA feature.
Default value is 1 (true).

FMSTR_USE_WRITEMEM

```
#define FMSTR_USE_WRITEMEM [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the Memory Write command.
The default value is 1 (true).

Oscilloscope options

FMSTR_USE_SCOPE

```
#define FMSTR_USE_SCOPE [number]
```

Value Type Integer number.

Description Number of Oscilloscope instances to be supported. Set to 0 to disable the Oscilloscope feature.
Default value is 0.

FMSTR_MAX_SCOPE_VARS

```
#define FMSTR_MAX_SCOPE_VARS [number]
```

Value Type Integer number larger than 2.

Description Number of variables to be supported by each Oscilloscope instance.
Default value is 8.

Recorder options

FMSTR_USE_RECORDER

```
#define FMSTR_USE_RECORDER [number]
```

Value Type Integer number.

Description Number of Recorder instances to be supported. Set to 0 to disable the Recorder feature.
Default value is 0.

FMSTR_REC_BUFF_SIZE

```
#define FMSTR_REC_BUFF_SIZE [number]
```

Value Type Integer number larger than 2.

Description Defines the size of the memory buffer used by the Recorder instance #0.
Default: not defined, user shall call ‘FMSTR_RecorderCreate()“ API function to specify this parameter in run time.

FMSTR_REC_TIMEBASE

```
#define FMSTR_REC_TIMEBASE [time specification]
```

Value Type Number (nanoseconds time).

Description Defines the base sampling rate in nanoseconds (sampling speed) Recorder instance #0.

Use one of the following macros:

- FMSTR_REC_BASE_SECONDS(x)
- FMSTR_REC_BASE_MILLISEC(x)
- FMSTR_REC_BASE_MICROSEC(x)
- FMSTR_REC_BASE_NANOSEC(x)

Default: not defined, user shall call 'FMSTR_RecorderCreate()" API function to specify this parameter in run time.

FMSTR_REC_FLOAT_TRIG

```
#define FMSTR_REC_FLOAT_TRIG [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the floating-point triggering. Be aware that floating-point triggering may grow the code size by linking the floating-point standard library.

Default value is 0 (false).

Application Commands options

FMSTR_USE_APPCMD

```
#define FMSTR_USE_APPCMD [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the Application Commands feature.
Default value is 0 (false).

FMSTR_APPCMD_BUFF_SIZE

```
#define FMSTR_APPCMD_BUFF_SIZE [size]
```

Value Type Numeric buffer size in range 1..255

Description The size of the Application Command data buffer allocated by the driver. The buffer stores the (optional) parameters of the Application Command which waits to be processed.

FMSTR_MAX_APPCMD_CALLS

```
#define FMSTR_MAX_APPCMD_CALLS [number]
```

Value Type Number in range 0..255

Description The number of different Application Commands that can be assigned a callback handler function using FMSTR_RegisterAppCmdCall(). Default value is 0.

TSA options

FMSTR_USE_TSA

```
#define FMSTR_USE_TSA [0|1]
```

Value Type Boolean 0 or 1.

Description Enable the FreeMASTER TSA feature to be used. With this option enabled, the TSA tables defined in the applications are made available to the FreeMASTER host tool.
Default value is 0 (false).

FMSTR_USE_TSA_SAFETY

```
#define FMSTR_USE_TSA_SAFETY [0|1]
```

Value Type Boolean 0 or 1.

Description Enable the memory access validation in the FreeMASTER driver. With this option, the host tool is not able to access the memory which is not described by at least one TSA descriptor. Also a write access is denied for objects defined as read-only in TSA tables.
Default value is 0 (false).

FMSTR_USE_TSA_INROM

```
#define FMSTR_USE_TSA_INROM [0|1]
```

Value Type Boolean 0 or 1.

Description Declare all TSA descriptors as *const*, which enables the linker to put the data into the flash memory. The actual result depends on linker settings or the linker commands used in the project.
Default value is 0 (false).

FMSTR_USE_TSA_DYNAMIC

```
#define FMSTR_USE_TSA_DYNAMIC [0|1]
```

Value Type Boolean 0 or 1.

Description Enable runtime-defined TSA entries to be added to the TSA table by the FMSTR_SetUpTsaBuff() and FMSTR_TsaAddVar() functions.
Default value is 0 (false).

Pipes options

FMSTR_USE_PIPES

```
#define FMSTR_USE_PIPES [0|1]
```

Value Type Boolean 0 or 1.

Description Enable the FreeMASTER Pipes feature to be used.
Default value is 0 (false).

FMSTR_MAX_PIPES_COUNT

```
#define FMSTR_MAX_PIPES_COUNT [number]
```

Value Type Number in range 1..63.

Description The number of simultaneous pipe connections to support.
The default value is 1.

Driver interrupt modes To implement the communication, the FreeMASTER driver handles the Serial or CAN module's receive and transmit requests. Use the *freemaster_cfg.h* configuration file to select whether the driver processes the communication automatically in the interrupt service routine handler or if it only polls the status of the module (typically during the application idle time).

This section describes each of the interrupt mode in more details.

Completely Interrupt-Driven operation Activated using:

```
#define FMSTR_LONG_INTR 1
```

In this mode, both the communication and the FreeMASTER protocol decoding is done in the *FMSTR_SerialIsr*, *FMSTR_CanIsr*, or other interrupt service routine. Because the protocol execution may be a lengthy task (especially with the TSA-Safety enabled) it is recommended to use this mode only if the interrupt prioritization scheme is possible in the application and the FreeMASTER interrupt is assigned to a lower (the lowest) priority.

In this mode, the application code must register its own interrupt handler for all interrupt vectors related to the selected communication interface and call the FMSTR_SerialIsr or FMSTR_CanIsr functions from that handler.

Mixed Interrupt and Polling Modes Activated using:

```
#define FMSTR_SHORT_INTR 1
```

In this mode, the communication processing time is split between the interrupt routine and the main application loop or task. The raw communication is handled by the *FMSTR_SerialIsr, FMSTR_CanIsr*, or other interrupt service routine, while the protocol decoding and execution is handled by the *FMSTR_Poll* routine. Call *FMSTR_Poll* during the idle time in the application main loop.

The interrupt processing in this mode is relatively fast and deterministic. Upon a serial-receive event, the received character is only placed into a FIFO-like queue and it is not further processed. Upon a CAN receive event, the received frame is stored into a receive buffer. When transmitting, the characters are fetched from the prepared transmit buffer.

In this mode, the application code must register its own interrupt handler for all interrupt vectors related to the selected communication interface and call the *FMSTR_SerialIsr* or *FMSTR_CanIsr* functions from that handler.

When the serial interface is used as the serial communication interface, ensure that the *FMSTR_Poll* function is called at least once per *N* character time periods. *N* is the length of the FreeMASTER FIFO queue (*FMSTR_COMM_RQUEUE_SIZE*) and the character time is the time needed to transmit or receive a single byte over the SCI line.

Completely Poll-driven

```
#define FMSTR_POLL_DRIVEN 1
```

In this mode, both the communication and the FreeMASTER protocol decoding are done in the *FMSTR_Poll* routine. No interrupts are needed and the *FMSTR_SerialIsr*, *FMSTR_CanIsr*, and similar handlers compile to an empty code.

When using this mode, ensure that the *FMSTR_Poll* function is called by the application at least once per the serial "character time" which is the time needed to transmit or receive a single character.

In the latter two modes (*FMSTR_SHORT_INTR* and *FMSTR_POLL_DRIVEN*), the protocol handling takes place in the FMSTR_Poll routine. An application interrupt can occur in the middle of the Read Memory or Write Memory commands' execution and corrupt the variable being accessed by the FreeMASTER driver. In these two modes, some issues or glitches may occur when using FreeMASTER to visualize or monitor volatile variables modified in interrupt servicing code.

The same issue may appear even in the full interrupt mode (FMSTR_LONG_INTR), if volatile variables are modified in the interrupt code with a priority higher than the priority of the communication interrupt.

Data types Simple portability was one of the main requirements when writing the FreeMASTER driver. This is why the driver code uses the privately-declared data types and the vast majority of the platform-dependent code is separated in the platform-dependent source files. The data types used in the driver API are all defined in the platform-specific header file.

To prevent name conflicts with the symbols used in the application, all data types, macros, and functions have the FMSTR_ prefix. The only global variables used in the driver are the transport and low-level API structures exported from the driver-implementation layer to upper layers. Other than that, all private variables are declared as static and named using the fmstr_ prefix.

Communication interface initialization The FreeMASTER driver does not perform neither the initialization nor the configuration of the peripheral module that it uses to communicate. It is the application startup code responsibility to configure the communication module before the FreeMASTER driver is initialized by the FMSTR_Init call.

When the Serial communication module is used as the FreeMASTER communication interface, configure the UART receive and transmit pins, the serial communication baud rate, parity (no-parity), the character length (eight bits), and the number of stop bits (one) before initializing the FreeMASTER driver. For either the long or the short interrupt modes of the driver (see *Driver interrupt modes*), configure the interrupt controller and register an application-specific interrupt handler for all interrupt sources related to the selected serial peripheral module. Call the FMSTR_SerialIsr function from the application handler.

When a CAN module is used as the FreeMASTER communication interface, configure the CAN receive and transmit pins and the CAN module bit rate before initializing the FreeMASTER driver. For either the long or the short interrupt modes of the driver (see *Driver interrupt modes*), configure the interrupt controller and register an application-specific interrupt handler for all interrupt sources related to the selected CAN peripheral module. Call the FMSTR_CanIsr function from the application handler.

Note: It is not necessary to enable or unmask the serial nor the CAN interrupts before initializing the FreeMASTER driver. The driver enables or disables the interrupts and communication lines, as required during runtime.

FreeMASTER Recorder calls When using the FreeMASTER Recorder in the application (FMSTR_USE_RECORDER > 0), call the FMSTR_RecorderCreate function early after FMSTR_Init to set up each recorder instance to be used in the application. Then call the FMSTR_Recorder function periodically in the code where the data recording should occur. A typical place to call the Recorder routine is at the timer or PWM interrupts, but it can be anywhere else. The example applications provided together with the driver code call the FMSTR_Recorder in the main application loop.

In applications where FMSTR_Recorder is called periodically with a constant period, specify the period in the Recorder configuration structure before calling FMSTR_RecorderCreate. This setting enables the PC Host FreeMASTER tool to display the X-axis of the Recorder graph properly scaled for the time domain.

Driver usage Start using or evaluating FreeMASTER by opening some of the example applications available in the driver setup package.

Follow these steps to enable the basic FreeMASTER connectivity in the application:

- Make sure that all **.c* files of the FreeMASTER driver from the *src/common/platforms/[your_platform]* folder are a part of the project. See *Driver files* for more details.
- Configure the FreeMASTER driver by creating or editing the *freemaster_cfg.h* file and by saving it into the application project directory. See *Driver configuration* for more details.
- Include the *freemaster.h* file into any application source file that makes the FreeMASTER API calls.
- Initialize the Serial or CAN modules. Set the baud rate, parity, and other parameters of the communication. Do not enable the communication interrupts in the interrupt mask registers.
- For the FMSTR_LONG_INTR and FMSTR_SHORT_INTR modes, install the application-specific interrupt routine and call the FMSTR_SerialIsr or FMSTR_CanIsr functions from this handler.
- Call the FMSTR_Init function early on in the application initialization code.
- Call the FMSTR_RecorderCreate functions for each Recorder instance to enable the Recorder feature.
- In the main application loop, call the FMSTR_Poll API function periodically when the application is idle.
- For the FMSTR_SHORT_INTR and FMSTR_LONG_INTR modes, enable the interrupts globally so that the interrupts can be handled by the CPU.

Communication troubleshooting The most common problem that causes communication issues is a wrong baud rate setting or a wrong pin multiplexer setting of the target MCU. When

a communication between the PC Host running FreeMASTER and the target MCU cannot be established, try enabling the FMSTR_DEBUG_TX option in the *freemaster_cfg.h* file and call the FMSTR_Poll function periodically in the main application task loop.

With this feature enabled, the FreeMASTER driver periodically transmits a test frame through the Serial or CAN lines. Use a logic analyzer or an oscilloscope to monitor the signals at the communication pins of the CPU device to examine whether the bit rate and signal polarity are configured properly.

Driver API

This section describes the driver Application Programmers' Interface (API) needed to initialize and use the FreeMASTER serial communication driver.

Control API There are three key functions to initialize and use the driver.

FMSTR_Init

Prototype

```
FMSTR_BOOL FMSTR_Init(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_protocol.c*

Description This function initializes the internal variables of the FreeMASTER driver and enables the communication interface. This function does not change the configuration of the selected communication module. The hardware module must be initialized before the *FMSTR_Init* function is called.

A call to this function must occur before calling any other FreeMASTER driver API functions.

FMSTR_Poll

Prototype

```
void FMSTR_Poll(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_protocol.c*

Description In the poll-driven or short interrupt modes, this function handles the protocol decoding and execution (see *Driver interrupt modes*). In the poll-driven mode, this function also handles the communication interface with the PC. Typically, the *FMSTR_Poll* function is called during the "idle" time in the main application task loop.

To prevent the receive data overflow (loss) on a serial interface, make sure that the FMSTR_Poll function is called at least once per the time calculated as:

*N * Tchar*

where:

- *N* is equal to the length of the receive FIFO queue (configured by the FMSTR_COMM_RQUEUE_SIZE macro). *N* is 1 for the poll-driven mode.
- *Tchar* is the character time, which is the time needed to transmit or receive a single byte over the SCI line.

Note: In the long interrupt mode, this function typically compiles as an empty function and can still be called. It is worthwhile to call this function regardless of the interrupt mode used in the application. This approach enables a convenient switching between the different interrupt modes only by changing the configuration macros in the *freemaster_cfg.h* file.

FMSTR_SerialIsr / FMSTR_CanIsr

Prototype

```
void FMSTR_SerialIsr(void);
void FMSTR_CanIsr(void);
```

- Declaration: *freemaster.h*
- Implementation: *hw-specific low-level driver C file*

Description This function contains the interrupt-processing code of the FreeMASTER driver. In long or short interrupt modes (see *Driver interrupt modes*), this function must be called from the application interrupt service routine registered for the communication interrupt vector. On platforms where the communication module uses multiple interrupt vectors, the application should register a handler for all vectors and call this function at each interrupt.

Note: In a poll-driven mode, this function is compiled as an empty function and does not have to be used.

Recorder API

FMSTR_RecorderCreate

Prototype

```
FMSTR_BOOL FMSTR_RecorderCreate(FMSTR_INDEX recIndex, FMSTR_REC_BUFF* buffCfg);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_rec.c*

Description This function registers a recorder instance and enables it to be used by the PC Host tool. Call this function for all recorder instances from 0 to the maximum number defined by the FMSTR_USE_RECORDER configuration option (minus one). An exception to this requirement is the recorder of instance *0* which may be automatically configured by FMSTR_Init when the *freemaster_cfg.h* configuration file defines the *FMSTR_REC_BUFF_SIZE* and *FMSTR_REC_TIMEBASE* options.

For more information, see *Configurable items*.

FMSTR_Recorder

Prototype

```
void FMSTR_Recorder(FMSTR_INDEX recIndex);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_rec.c*

Description This function takes a sample of the variables being recorded using the FreeMASTER Recorder instance *recIndex*. If the selected Recorder is not active when the *FMSTR_Recorder* function is being called, the function returns immediately. When the Recorder is active, the values of the variables being recorded are copied into the recorder buffer and the trigger conditions are evaluated.

If a trigger condition is satisfied, the Recorder enters the post-trigger mode, where it counts down the follow-up samples (number of *FMSTR_Recorder* function calls) and de-activates the Recorder when the required post-trigger samples are finished.

The *FMSTR_Recorder* function is typically called in the timer or PWM interrupt service routines. This function can also be called in the application main loop (for testing purposes).

FMSTR_RecorderTrigger

Prototype

```
void FMSTR_RecorderTrigger(FMSTR_INDEX recIndex);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_rec.c*

Description This function forces the Recorder trigger condition to happen, which causes the Recorder to be automatically deactivated after the post-trigger samples are sampled. Use this function in the application code for programmatic control over the Recorder triggering. This can be useful when a more complex triggering conditions need to be used.

Fast Recorder API The Fast Recorder feature is not available in the FreeMASTER driver version 3. This feature was heavily dependent on the target platform and it was only available for the 56F8xxxx DSCs.

TSA Tables When the TSA is enabled in the FreeMASTER driver configuration file (by setting the FMSTR_USE_TSA macro to a non-zero value), it defines the so-called TSA tables in the application. This section describes the macros that must to be used to define the TSA tables.

There can be any number of TSA tables spread across the application source files. There must be always exactly one TSA Table List defined, which informs the FreeMASTER driver about the active TSA tables.

When there is at least one TSA table and one TSA Table List defined in the application, the TSA information automatically appears in the FreeMASTER symbols list. The symbols can then be used to create FreeMASTER variables for visualization or control.

TSA table definition The TSA table describes the static or global variables together with their address, size, type, and access-protection information. If the TSA-described variables are of a structure type, the TSA table may also describe this type and provide an access to the individual structure members of the variable.

The TSA table definition begins with the FMSTR_TSA_TABLE_BEGIN macro with a *table_id* identifying the table. The *table_id* shall be a valid C-langiage symbol.

```
FMSTR_TSA_TABLE_BEGIN(table_id)
```

After this opening macro, the TSA descriptors are placed using these macros:

```
/* Adding variable descriptors */
FMSTR_TSA_RW_VAR(name, type)  /* read/write variable entry */
FMSTR_TSA_RO_VAR(name, type)  /* read-only variable entry */

/* Description of complex data types */
FMSTR_TSA_STRUCT(struct_name) /* structure or union type entry */
FMSTR_TSA_MEMBER(struct_name, member_name, type)  /* structure member entry */

/* Memory blocks */
FMSTR_TSA_RW_MEM(name, type, address, size) /* read/write memory block */
FMSTR_TSA_RO_MEM(name, type, address, size) /* read-only memory block */
```

The table is closed using the FMSTR_TSA_TABLE_END macro:

```
FMSTR_TSA_TABLE_END()
```

TSA descriptor parameters The TSA descriptor macros accept these parameters:

- *name* — variable name. The variable must be defined before the TSA descriptor references it.
- *type* — variable or member type. Only one of the pre-defined type constants may be used (see below).
- *struct_name* — structure type name. The type must be defined (typedef) before the TSA descriptor references it.
- *member_name* — structure member name.

Note: The structure member descriptors (FMSTR_TSA_MEMBER) must immediately follow the parent structure descriptor (FMSTR_TSA_STRUCT) in the table.

Note: To write-protect the variables in the FreeMASTER driver (FMSTR_TSA_RO_VAR), enable the TSA-Safety feature in the configuration file.

TSA variable types The table lists *type* identifiers which can be used in TSA descriptors:

Constant	Description
FMSTR_TSA_UINT*n*	Unsigned integer type of size *n* bits (n=8,16,32,64)
FMSTR_TSA_SINT*n*	Signed integer type of size *n* bits (n=8,16,32,64)
FMSTR_TSA_FRAC*n*	Fractional number of size *n* bits (n=16,32,64).
FMSTR_TSA_FRAC_Q(*m*,*n*)	Signed fractional number in general Q form (m+n+1 total bits)
FMSTR_TSA_FRAC_UQ(*m*,*n*)	Unsigned fractional number in general UQ form (m+n total bits)
FMSTR_TSA_FLOAT	4-byte standard IEEE floating-point type
FMSTR_TSA_DOUBLE	8-byte standard IEEE floating-point type
FMSTR_TSA_POINTER	Generic pointer type defined (platform-specific 16 or 32 bit)
FMSTR_TSA_USERTYPE(*name*)	Structure or union type declared with FMSTR_TSA_STRUCT record

TSA table list There shall be exactly one TSA Table List in the application. The list contains one entry for each TSA table defined anywhere in the application.

The TSA Table List begins with the FMSTR_TSA_TABLE_LIST_BEGIN macro and continues with the TSA table entries for each table.

```
FMSTR_TSA_TABLE_LIST_BEGIN()

FMSTR_TSA_TABLE(table_id)
FMSTR_TSA_TABLE(table_id2)
FMSTR_TSA_TABLE(table_id3)
...
```

The list is closed with the FMSTR_TSA_TABLE_LIST_END macro:

```
FMSTR_TSA_TABLE_LIST_END()
```

TSA Active Content entries FreeMASTER v2.0 and higher supports TSA Active Content, enabling the TSA tables to describe the memory-mapped files, virtual directories, and URL hyperlinks. FreeMASTER can access such objects similarly to accessing the files and folders on the local hard drive.

With this set of TSA entries, the FreeMASTER pages can be embedded directly into the target MCU flash and accessed by FreeMASTER directly over the communication line. The HTML-coded pages rendered inside the FreeMASTER window can access the TSA Active Content resources using a special URL referencing the *fmstr:* protocol.

This example provides an overview of the supported TSA Active Content entries:

```
FMSTR_TSA_TABLE_BEGIN(files_and_links)

/* Directory entry applies to all subsequent MEMFILE entries */
FMSTR_TSA_DIRECTORY("/text_files")     /* entering a new virtual directory */

/* The readme.txt file will be accessible at the fmstr://text_files/readme.txt URL */
FMSTR_TSA_MEMFILE("readme.txt", readme_txt, sizeof(readme_txt)) /* memory-mapped file */

/* Files can also be specified with a full path so the DIRECTORY entry does not apply */
FMSTR_TSA_MEMFILE("/index.htm", index, sizeof(index))          /* memory-mapped file */
FMSTR_TSA_MEMFILE("/prj/demo.pmp", demo_pmp, sizeof(demo_pmp)) /* memory-mapped file */

/* Hyperlinks can point to a local MEMFILE object or to the Internet */
FMSTR_TSA_HREF("Board's Built-in Welcome Page", "/index.htm")
FMSTR_TSA_HREF("FreeMASTER Home Page", "http://www.nxp.com/freemaster")
```

(continues on next page)

(continued from previous page)

```
/* Project file links simplify opening the projects from any URLs */
FMSTR_TSA_PROJECT("Demonstration Project (embedded)", "/prj/demo.pmp")
FMSTR_TSA_PROJECT("Full Project (online)", "http://mycompany.com/prj/demo.pmp")

FMSTR_TSA_TABLE_END()
```

TSA API

FMSTR_SetUpTsaBuff

Prototype

```
FMSTR_BOOL FMSTR_SetUpTsaBuff(FMSTR_ADDR buffAddr, FMSTR_SIZE buffSize);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_tsa.c*

Arguments

- *buffAddr* [in] - address of the memory buffer for the dynamic TSA table
- *buffSize* [in] - size of the memory buffer which determines the maximum number of TSA entries to be added in the runtime

Description This function must be used to assign the RAM memory buffer to the TSA subsystem when FMSTR_USE_TSA_DYNAMIC is enabled. The memory buffer is then used to store the TSA entries added dynamically to the runtime TSA table using the FMSTR_TsaAddVar function call. The runtime TSA table is processed by the FreeMASTER PC Host tool along with all static tables as soon as the communication port is open.

The size of the memory buffer determines the number of TSA entries that can be added dynamically. Depending on the MCU platform, one TSA entry takes either 8 or 16 bytes.

FMSTR_TsaAddVar

Prototype

```
FMSTR_BOOL FMSTR_TsaAddVar(FMSTR_TSATBL_STRPTR tsaName, FMSTR_TSATBL_STRPTR␣
↪tsaType,
    FMSTR_TSATBL_VOIDPTR varAddr, FMSTR_SIZE32 varSize,
    FMSTR_SIZE flags);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_tsa.c*

Arguments

- *tsaName* [in] - name of the object
- *tsaType* [in] - name of the object type
- *varAddr* [in] - address of the object

- *varSize* [in] - size of the object
- *flags* [in] - access flags; a combination of these values:
  - *FMSTR_TSA_INFO_RO_VAR* — read-only memory-mapped object (typically a variable)
  - *FMSTR_TSA_INFO_RW_VAR* — read/write memory-mapped object
  - *FMSTR_TSA_INFO_NON_VAR* — other entry, describing structure types, structure members, enumerations, and other types

Description This function can be called only when the dynamic TSA table is enabled by the FMSTR_USE_TSA_DYNAMIC configuration option and when the FMSTR_SetUpTsaBuff function call is made to assign the dynamic TSA table memory. This function adds an entry into the dynamic TSA table. It can be used to register a read-only or read/write memory object or describe an item of the user-defined type.

See *TSA table definition* for more details about the TSA table entries.

Application Commands API

FMSTR_GetAppCmd

Prototype

```
FMSTR_APPCMD_CODE FMSTR_GetAppCmd(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Description This function can be used to detect if there is an Application Command waiting to be processed by the application. If no command is pending, this function returns the FMSTR_APPCMDRESULT_NOCMD constant. Otherwise, this function returns the code of the Application Command that must be processed. Use the FMSTR_AppCmdAck call to acknowledge the Application Command after it is processed and to return the appropriate result code to the host.

The FMSTR_GetAppCmd function does not report the commands for which a callback handler function exists. If the FMSTR_GetAppCmd function is called when a callback-registered command is pending (and before it is actually processed by the callback function), this function returns FMSTR_APPCMDRESULT_NOCMD.

FMSTR_GetAppCmdData

Prototype

```
FMSTR_APPCMD_PDATA FMSTR_GetAppCmdData(FMSTR_SIZE* dataLen);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *dataLen* [out] - pointer to the variable that receives the length of the data available in the buffer. It can be NULL when this information is not needed.

Description This function can be used to retrieve the Application Command data when the application determines that an Application Command is pending (see *FMSTR_GetAppCmd*).

There is just a single buffer to hold the Application Command data (the buffer length is FMSTR_APPCMD_BUFF_SIZE bytes). If the data are to be used in the application after the command is processed by the FMSTR_AppCmdAck call, copy the data out to a private buffer.

FMSTR_AppCmdAck

Prototype

```
void FMSTR_AppCmdAck(FMSTR_APPCMD_RESULT resultCode);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *resultCode* [in] - the result code which is to be returned to FreeMASTER

Description This function is used when the Application Command processing finishes in the application. The resultCode passed to this function is returned back to the host and the driver is re-initialized to expect the next Application Command.

After this function is called and before the next Application Command arrives, the return value of the FMSTR_GetAppCmd function is FMSTR_APPCMDRESULT_NOCMD.

FMSTR_AppCmdSetResponseData

Prototype

```
void FMSTR_AppCmdSetResponseData(FMSTR_ADDR resultDataAddr, FMSTR_SIZE resultDataLen);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *resultDataAddr* [in] - pointer to the data buffer that is to be copied to the Application Command data buffer
- *resultDataLen* [in] - length of the data to be copied. It must not exceed the FMSTR_APPCMD_BUFF_SIZE value.

Description This function can be used before the Application Command processing finishes, when there are data to be returned back to the PC.

The response data buffer is copied into the Application Command data buffer, from where it is accessed when the host requires it. Do not use FMSTR_GetAppCmdData and the data buffer after FMSTR_AppCmdSetResponseData is called.

Note: The current version of FreeMASTER does not support the Application Command response data.

FMSTR_RegisterAppCmdCall

Prototype

```
FMSTR_BOOL FMSTR_RegisterAppCmdCall(FMSTR_APPCMD_CODE appCmdCode, FMSTR_
↪PAPPCMDFUNC callbackFunc);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *appCmdCode* [in] - the Application Command code for which the callback is to be registered
- *callbackFunc* [in] - pointer to the callback function that is to be registered. Use NULL to unregister a callback registered previously with this Application Command.

Return value This function returns a non-zero value when the callback function was successfully registered or unregistered. It can return zero when trying to register a callback function for more than FMSTR_MAX_APPCMD_CALLS different Application Commands.

Description This function can be used to register the given function as a callback handler for the Application Command. The Application Command is identified using single-byte code. The callback function is invoked automatically by the FreeMASTER driver when the protocol decoder obtains a request to get the application command result code.

The prototype of the callback function is

```
FMSTR_APPCMD_RESULT HandlerFunction(FMSTR_APPCMD_CODE nAppcmd,
    FMSTR_APPCMD_PDATA pData, FMSTR_SIZE nDataLen);
```

Where:

- *nAppcmd* -Application Command code
- *pData* —points to the Application Command data received (if any)
- *nDataLen* —information about the Application Command data length

The return value of the callback function is used as the Application Command Result Code and returned to FreeMASTER.

Note: The FMSTR_MAX_APPCMD_CALLS configuration macro defines how many different Application Commands may be handled by a callback function. When FMSTR_MAX_APPCMD_CALLS is undefined or defined as zero, the FMSTR_RegisterAppCmdCall function always fails.

Pipes API

FMSTR_PipeOpen

Prototype

```
FMSTR_HPIPE FMSTR_PipeOpen(FMSTR_PIPE_PORT pipePort, FMSTR_PPIPEFUNC pipeCallback,
↪
    FMSTR_ADDR pipeRxBuff, FMSTR_PIPE_SIZE pipeRxSize,
    FMSTR_ADDR pipeTxBuff, FMSTR_PIPE_SIZE pipeTxSize,
    FMSTR_U8 type, const FMSTR_CHAR *name);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipePort* [in] - port number that identifies the pipe for the client
- *pipeCallback* [in] - pointer to the callback function that is called whenever a pipe data status changes
- *pipeRxBuff* [in] - address of the receive memory buffer
- *pipeRxSize* [in] - size of the receive memory buffer
- *pipeTxBuff* [in] - address of the transmit memory buffer
- *pipeTxSize* [in] - size of the transmit memory buffer
- *type* [in] - a combination of FMSTR_PIPE_MODE_xxx and FMSTR_PIPE_SIZE_xxx constants describing primary pipe data format and usage. This type helps FreeMASTER decide how to access the pipe by default. Optional, use 0 when undetermined.
- *name* [in] - user name of the pipe port. This name is visible to the FreeMASTER user when creating the graphical pipe interface.

Description This function initializes a new pipe and makes it ready to accept or send the data to the PC Host client. The receive memory buffer is used to store the received data before they are read out by the FMSTR_PipeRead call. When this buffer gets full, the PC Host client denies the data transmission into this pipe until there is enough free space again. The transmit memory buffer is used to store the data transmitted by the application to the PC Host client using the FMSTR_PipeWrite call. The transmit buffer can get full when the PC Host is disconnected or when it is slow in receiving and reading out the pipe data.

The function returns the pipe handle which must be stored and used in the subsequent calls to manage the pipe object.

The callback function (if specified) is called whenever new data are received through the pipe and available for reading. This callback is also called when the data waiting in the transmit buffer are successfully pushed to the PC Host and the transmit buffer free space increases. The prototype of the callback function provided by the user application must be as follows. The *PipeHandler* name is only a placeholder and must be defined by the application.

```
void PipeHandler(FMSTR_HPIPE pipeHandle);
```

FMSTR_PipeClose

Prototype

```
void FMSTR_PipeClose(FMSTR_HPIPE pipeHandle);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call

Description This function de-initializes the pipe object. No data can be received or sent on the pipe after this call.

FMSTR_PipeWrite

Prototype

```
FMSTR_PIPE_SIZE FMSTR_PipeWrite(FMSTR_HPIPE pipeHandle, FMSTR_ADDR pipeData,
    FMSTR_PIPE_SIZE pipeDataLen, FMSTR_PIPE_SIZE writeGranularity);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call
- *pipeData* [in] - address of the data to be written
- *pipeDataLen* [in] - length of the data to be written
- *writeGranularity* [in] - size of the minimum unit of data which is to be written

Description This function puts the user-specified data into the pipe's transmit memory buffer and schedules it for transmission. This function returns the number of bytes that were successfully written into the buffer. This number may be smaller than the number of the requested bytes if there is not enough free space in the transmit buffer.

The *writeGranularity* argument can be used to split the data into smaller chunks, each of the size given by the *writeGranularity* value. The FMSTR_PipeWrite function writes as many data chunks as possible into the transmit buffer and does not attempt to write an incomplete chunk. This feature can prove to be useful to avoid the intermediate caching when writing an array of integer values or other multi-byte data items. When making the nGranularity value equal to the nLength value, all data are considered as one chunk which is either written successfully as a whole or not at all. The nGranularity value of 0 or 1 disables the data-chunk approach.

FMSTR_PipeRead

Prototype

```
FMSTR_PIPE_SIZE FMSTR_PipeRead(FMSTR_HPIPE pipeHandle, FMSTR_ADDR pipeData,
    FMSTR_PIPE_SIZE pipeDataLen, FMSTR_PIPE_SIZE readGranularity);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call
- *pipeData* [in] - address of the data buffer to be filled with the received data
- *pipeDataLen* [in] - length of the data to be read
- *readGranularity* [in] - size of the minimum unit of data which is to be read

Description This function copies the data received from the pipe from its receive buffer to the user buffer for further processing. The function returns the number of bytes that were successfully copied to the buffer. This number may be smaller than the number of the requested bytes if there is not enough data bytes available in the receive buffer.

The readGranularity argument can be used to copy the data in larger chunks in the same way as described in the FMSTR_PipeWrite function.

API data types This section describes the data types used in the FreeMASTER driver. The information provided here can be useful when modifying or porting the FreeMASTER Communication Driver to new NXP platforms.

Note: The licensing conditions prohibit use of FreeMASTER and the FreeMASTER Communication Driver with non-NXP MPU or MCU products.

Public common types The table below describes the public data types used in the FreeMASTER driver API calls. The data types are declared in the *freemaster.h* header file.

Type name	Description
FMSTR_ADDR	Data type used to hold the memory address. On most platforms, this is normally a C-pointer, but it may also be a pure integer type.
For example, this type is defined as long integer on the 56F8xxx platform where the 24-bit addresses must be supported, but the C-pointer may be only 16 bits wide in some compiler configurations.	
FMSTR_SIZE	Data type used to hold the memory block size.
It is required that this type is unsigned and at least 16 bits wide integer.	
FMSTR_BOOL	Data type used as a general boolean type.
This type is used only in zero/non-zero conditions in the driver code.	
FMSTR_APPCM	Data type used to hold the Application Command code.
Generally, this is an unsigned 8-bit value.	
FMSTR_APPCM	Data type used to create the Application Command data buffer.
Generally, this is an unsigned 8-bit value.	
FMSTR_APPCM	Data type used to hold the Application Command result code.
Generally, this is an unsigned 8-bit value.	

Public TSA types The table describes the TSA-specific public data types. These types are declared in the *freemaster_tsa.h* header file, which is included in the user application indirectly by the *freemaster.h* file.

FMSTR_TSA_TI	Data type used to hold a descriptor index in the TSA table or a table index in the list of TSA tables.
By default, this is defined as FMSTR_SIZE.	
FMSTR_TSA_TS	Data type used to hold a memory block size, as used in the TSA descriptors.
By default, this is defined as FMSTR_SIZE.	

Public Pipes types The table describes the data types used by the FreeMASTER Pipes API:

FMSTR_HPIPE	Pipe handle that identifies the open-pipe object.
Generally, this is a pointer to a void type.	
FMSTR_PIPE_P	Integer type required to hold at least 7 bits of data.
Generally, this is an unsigned 8-bit or 16-bit type.	
FMSTR_PIPE_SI	Integer type required to hold at least 16 bits of data.
This is used to store the data buffer sizes.	
FMSTR_PPIPEF	Pointer to the pipe handler function.
See *FMSTR_PipeOpen* for more details.	

Internal types The table describes the data types used internally by the FreeMASTER driver. The data types are declared in the platform-specific header file and they are not available in the application code.

FMSTR_U8	The smallest memory entity. On the vast majority of platforms, this is an unsigned 8-bit integer. On the 56F8xx DSP platform, this is defined as an unsigned 16-bit integer.
FMSTR_U16	Unsigned 16-bit integer.
FMSTR_U32	Unsigned 32-bit integer.
FMSTR_S8	Signed 8-bit integer.
FMSTR_S16	Signed 16-bit integer.
FMSTR_S32	Signed 32-bit integer.
FMSTR_FLOAT	4-byte standard IEEE floating-point type.
FMSTR_FLAGS	Data type forming a union with a structure of flag bit-fields.
FMSTR_SIZE8	Data type holding a general size value, at least 8 bits wide.
FMSTR_INDEX	General for-loop index. Must be signed, at least 16 bits wide.
FMSTR_BCHR	A single character in the communication buffer. Typically, this is an 8-bit unsigned integer, except for the DSP platforms where it is a 16-bit integer.
FMSTR_BPTR	A pointer to the communication buffer (an array of FMSTR_BCHR).

Document references

Links

- This document online: https://mcuxpresso.nxp.com/mcuxsdk/latest/html/middleware/freemaster/doc/index.html

- FreeMASTER tool home: www.nxp.com/freemaster
- FreeMASTER community area: community.nxp.com/community/freemaster
- FreeMASTER GitHub code repo: https://github.com/nxp-mcuxpresso/mcux-freemaster
- MCUXpresso SDK home: www.nxp.com/mcuxpresso
- MCUXpresso SDK builder: mcuxpresso.nxp.com/en

Documents

- *FreeMASTER Usage Serial Driver Implementation* (document AN4752)
- *Integrating FreeMASTER Time Debugging Tool With CodeWarrior For Microcontrollers v10.X Project* (document AN4771)
- *Flash Driver Library For MC56F847xx And MC56F827xx DSC Family* (document AN4860)

Revision history This Table summarizes the changes done to this document since the initial release.

Revision	Date	Description
1.0	03/2006	Limited initial release
2.0	09/2007	Updated for FreeMASTER version. New Freescale document template used.
2.1	12/2007	Added description of the new Fast Recorder feature and its API.
2.2	04/2010	Added support for MPC56xx platform, Added new API for use CAN interface.
2.3	04/2011	Added support for Kxx Kinetis platform and MQX operating system.
2.4	06/2011	Serial driver update, adds support for USB CDC interface.
2.5	08/2011	Added Packet Driven BDM interface.
2.7	12/2013	Added FLEXCAN32 interface, byte access and isr callback configuration option.
2.8	06/2014	Removed obsolete license text, see the software package content for up-to-date license.
2.9	03/2015	Update for driver version 1.8.2 and 1.9: FreeMASTER Pipes, TSA Active Content, LIN Transport Layer support, DEBUG-TX communication troubleshooting, Kinetis SDK support.
3.0	08/2016	Update for driver version 2.0: Added support for MPC56xx, MPC57xx, KEAxx and S32Kxx platforms. New NXP document template as well as new license agreement used. added MCAN interface. Folders structure at the installation destination was rearranged.
4.0	04/2019	Update for driver released as part of FreeMASTER v3.0 and MCUXpresso SDK 2.6. Updated to match new V4 serial communication protocol and new configuration options. This version of the document removes substantial portion of outdated information related to S08, S12, ColdFire, Power and other legacy platforms.
4.1	04/2020	Minor update for FreeMASTER driver included in MCUXpresso SDK 2.8.
4.2	09/2020	Added example applications description and information about the MCUXpresso Config Tools. Fixed the pipe-related API description.
4.3	10/2024	Added description of Network and Segger J-Link RTT interface configuration. Accompanying the MCUXpresso SDK version 24.12.00.
4.4	04/2025	Added Zephyr-specific information. Accompanying the MCUXpresso SDK version 25.06.00.

1.4 Multimedia

1.4.1 Xtensa Audio Framework (XAF)

Xtensa Audio Framework (XAF) Examples

Overview The Xtensa Audio Framework (XAF) is designed to accelerate the development of audio processing applications for the HiFi family of DSP cores. The multicore version of XAF described in these examples is designed to work with subsystems having single or multiple DSPs, enabling sophisticated audio processing capabilities in embedded systems.

Each demo showcases a dual-core architecture:

- cm33/ - The ARM application for the Cortex-M33 core, which provides the user interface and system control
- dsp/ - The DSP application that performs audio processing using the XAF middleware library

When an application is started, a shell interface is displayed on the terminal that executes from the ARM core. Users can control the application through shell commands, which are relayed via RPMsg-Lite IPC to the DSP core where they are processed and responses are returned. This architecture demonstrates efficient partitioning of workloads - with user interface and control tasks handled by the ARM core while computationally intensive audio processing is offloaded to the specialized DSP core.

For more information about XAF and detailed documentation on the API and available components, please refer to the Cadence XAF documentation (/middleware/cadence/multicore-xaf/xa_af_hostless/doc).

Availability Note **Important**: These XAF examples are not included in the standard MCUXpresso SDK repository. They are available as part of the MCUXpresso SDK Builder package on the NXP website. To access these examples, please visit MCUXpresso SDK Builder and create a customized SDK package that includes the XAF examples for your target platform.

Included Examples

XAF Playback Example The dsp_xaf_playback application demonstrates audio file decoding and playback capabilities using the DSP core and Xtensa Audio Framework, supporting various audio codecs while handling operations through a shell interface on the ARM core that communicates with DSP processing.

XAF Record Example The dsp_xaf_record example captures audio from digital microphones (DMIC), processes it on the DSP core using voice enhancement algorithms, performs voice recognition (VIT), and outputs the detected wake words and voice commands to the console, enabling hands-free voice control applications.

XAF USB Example The XAF USB example demonstrates DSP-powered USB audio processing in two configurations: USB speaker and USB microphone. The application uses shell commands to switch between modes, with the ARM core handling USB communication while the DSP processes audio.

XAF Playback Example

Table of Content

- *Known Issues*

Overview The dsp_xaf_playback application demonstrates audio processing using the DSP core, the Xtensa Audio Framework (XAF) middleware library, and selected Xtensa audio codecs.

As shown in the table below, the application is supported on several development boards and each development board may have certain limitations, some development boards may also require hardware modifications or allow the use of an audio expansion board. Therefore, please check the supported features and *Hardware modifications* or *Example configuration* sections before running the demo.

Limitations:

- **MP3 encoder, G.711, G.722, BSAC, DAB+, DAB/MP2, DRM:** Provided only as linked libraries but are not enabled in the example.

Functionality The application includes the following main components:

1. **ARM Core (CM33)** - Handles user interface, SD card operations, and communicates with the DSP core
2. **DSP Core** - Processes audio data using the Xtensa Audio Framework (XAF)

The typical audio processing pipeline includes:

- File source component (reads from SD card)
- Decoder component (decodes compressed audio)
- Renderer component (outputs to audio hardware)

When the file playback command is issued, the ARM core reads the file from SD card and sends data to the DSP, which processes it and outputs to the audio hardware.

Hardware Requirements

- Development board (one of the following):
  - EVK-MIMXRT595 board
  - EVK-MIMXRT685 board
  - MIMXRT685-AUD-EVK board
  - MIMXRT700-EVK board
- Micro USB cable
- JTAG/SWD debugger
- Headphones with 3.5 mm stereo jack
- Personal Computer
- SD card with audio files (for file playback feature)

Hardware Modifications Some development boards need some hardware modifications to run the application.

- *EVK-MIMXRT595:*

  To enable the example audio using WM8904 codec, connect pins as follows:

  - JP7-1 <–> JP8-2

Note: The I3C Pin configuration in pin_mux.c is verified for default 1.8V, for 3.3V, need to manually configure slew rate to slow mode for I3C-SCL/SDA.

- *EVK-MIMXRT685:*

  To enable the example audio using WM8904 codec, connect pins as follows:

  – JP7-1 <–> JP8-2

- *MIMXRT685-AUD-EVK:*

  – Set the hardware jumpers (Tower system/base module) to default settings.

  – Set hardware jumpers JP2 2<–>3, JP44 1<–>2 and JP45 1<–>2.

- *MIMXRT700-EVK:*

  Set the hardware jumpers to default settings.

Preparation

1. Connect headphones to Audio HP / Line-Out connector (J4).
   - EVK-MIMXRT595 - J4
   - EVK-MIMXRT685 - J4
   - MIMXRT685-AUD-EVK - J4, J50, J51, J52
   - MIMXRT700-EVK - J29
2. Connect a micro USB cable between the PC host and the debug USB port on the development board.
   - EVK-MIMXRT595 - J40
   - EVK-MIMXRT685 - J5
   - MIMXRT685-AUD-EVK - J5
   - MIMXRT700-EVK - J54
3. Open a serial terminal with the following settings:
   - 115200 baud rate
   - 8 data bits
   - No parity
   - One stop bit
   - No flow control
4. Download the program for CM33 core to the target board.
5. Launch the debugger in your IDE to begin running the demo.
6. If building release configuration, start the xt-ocd daemon and download the program for DSP core to the target board. If building debug configuration, launch the Xtensa IDE or xt-gdb debugger to begin running the demo.

Notes:

- DSP image can only be debugged using J-Link debugger. See the document 'Getting Started with Xplorer' for your particular board for more information.

Example Configuration The example can be configured by user. Before configuration, please check the *table* to see if the feature is supported on the development board.

- **MIMXRT700-EVK Decoder Configuration:**

  RT700 has limited RAM on Cortex-M33 core 1 which limits the available decoders. Only SBC decoder is enabled by default. In order to enable a different decoder/encoder, it is necessary to define the appropriate define on project level. Use one of the following define from the list of the supported decoders on the HiFi1 core:

  - XA_AAC_DECODER
  - XA_MP3_DECODER
  - XA_SBC_DECODER
  - XA_VORBIS_DECODER
  - XA_OPUS_DECODER

Running the Demo The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application. The DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Application for Cortex-M33 can be built by the other toolchains listed in MCUXpresso SDK Release Notes.

The release configurations of the demo will combine both applications into one ARM image. With this, the ARM core will load and start the DSP application on startup. Pre-compiled DSP binary images are provided under dsp/binary/ directory. If you make changes to the DSP application in release configuration, rebuild ARM application after building the DSP application. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol DSP_IMAGE_COPY_TO_RAM, found in IDE project settings, is defined to the value 1 when building release configuration.

The debug configurations will build two separate applications that need to be loaded independently. DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Required tool versions can be found in MCUXpresso SDK Release Notes for the board. Application for cm33 can be built by the other toolchains listed there. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol DSP_IMAGE_COPY_TO_RAM, found in IDE project settings, is defined to the value 0 when building debug configuration. The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application.

In order to debug both the Cortex-M33 and DSP side of the application, please follow the instructions:

1. It is necessary to run the Cortex-M33 side first and stop the application before the DSP_Start function
2. Run the xt-ocd daemon with proper settings
3. Download and debug the DSP application

In order to get TRACE debug output from the XAF it is necessary to define XF_TRACE 1 in the project settings. It is possible to save the TRACE output into RAM using DUMP_TRACE_TO_BUF 1 define on project level. Please see the initialization of the TRACE function in the xaf_main_dsp.c file. For more details see XAF documentation.

When the demo runs successfully, the terminal will display the following output (example from MIMXRT700-EVK):

```
*****************************
DSP audio framework demo start
*****************************
```

(continues on next page)

(continued from previous page)

```
[CM33 Main] Configure codec

[DSP_Main] Cadence Xtensa Audio Framework
[DSP_Main] Library Name    : Audio Framework (Hostless)
[DSP_Main] Library Version : 3.5
[DSP_Main] API Version     : 3.2

[DSP_Main] start
[DSP_Main] established RPMsg link
[CM33_Main] DSP image copied to DSP TCM
[CM33_Main][APP_SDCARD_Task] start
[CM33_Main][APP_DSP_IPC_Task] start
[CM33_Main][APP_Shell_Task] start

Copyright  2024  NXP
```

Type help to see the command list. Similar description will be displayed on serial console (*If multi-channel playback mode is enabled, the description is slightly different. Available encoders/decoders may differ - refer to the* table.):

```
"help": List all the registered commands

"exit": Exit program

"version": Query DSP for component versions

"file": Perform audio file decode and playback from SD card
  USAGE: file [list|stop|<audio_file>]
    list          List audio files on SD card available for playback
    <audio_file>  Select file from SD card and start playback

"decoder": Perform decode on DSP and play to speaker.
  USAGE: decoder [aac|mp3|opus|sbc|vorbis_ogg|vorbis_raw]
    aac:        Decode aac data
    mp3:        Decode mp3 data
    opus:       Decode opus data
    sbc:        Decode sbc data
    vorbis_ogg: Decode OGG VORBIS data
    vorbis_raw: Decode raw VORBIS data

"encoder": Encode PCM data on DSP and compare with reference data.
  USAGE: encoder [opus|sbc]
    opus: Encode pcm data using opus encoder
    sbc:  Encode pcm data using sbc encoder

"src" Perform sample rate conversion on DSP

"gain": Perform PCM gain adjustment on DSP
```

Xtensa IDE log when command is playing a file (mp3/aac/vorbis/...):

```
    File playback start, initial buffer size: 16384
    [DSP Codec] Audio Device Ready
    [DSP Codec] Decoder component started
    [DSP Codec] Setting decode playback format:
      Decoder     : mp3_dec
      Sample rate: 16000
      Bit Width   : 16
      Channels    : 2
    [DSP Codec] Renderer component started
```

(continues on next page)

(continued from previous page)

```
[DSP Codec] Connected XA_DECODER ->  XA_RENDERER
[DSP_ProcessThread] start
[DSP_BufferThread] start
```

Xtensa IDE log when decoder command starts playback successfully:

```
[DSP_Main] Input buffer addr: 0x20020000, buffer size: 94276
[DSP Codec] Audio Device Ready
[DSP Codec] Decoder created
[DSP Codec] Decoder component started
[DSP Codec] Renderer component created
[DSP Codec] Connected XA_DECODER -> XA_RENDERER
[DSP_ProcessThread] start
[DSP_ProcessThread] Execution complete - exiting
[DSP_ProcessThread] exiting
[DSP Codec] Audio device closed

[CM33 CMD] [APP_DSP_IPC_Task] response from DSP, cmd: 0, error: 0
[CM33 CMD] Decode complete
```

MIMXRT685-AUD-EVK Multi-channel Support: The MIMXRT685-AUD-EVK board supports multi-channel audio. When selecting audio files for playback, you can specify the number of channels:

```
file [list|stop|<audio_file> [<nchannel>]]
<nchannel>    Select the number of channels (2 or 8 can be selected).
NOTE: Selected audio file must meet the following parameters:
          - Sample rate: 96 kHz
          - Width:       32 bit
```

Xtensa IDE log when command is playing a PCM file:

```
[DSP_FILE_REN] Audio Device Ready
[DSP_FILE_REN] post-proc/pcm_gain component started
[DSP_FILE_REN] post-proc/client_proxy component started
[DSP_FILE_REN] Connected post-proc/pcm_gain -> post-proc/client_proxy
[DSP_FILE_REN] renderer component started
[DSP_FILE_REN] Connected post-proc/client_proxy -> renderer
[DSP_BufferThread] start
[DSP_ProcessThread] start
[DSP_CleanupThread] start3
```

Known Issues

1. The “file stop” command doesn’t stop the playback for some small files (with low sample rate).
2. MIMXRT700-EVK: Has limited RAM on Cortex-M33 core 1 which limits the available decoders.

XAF Record Example

Table of Content

Overview The dsp_xaf_record application demonstrates audio processing using the DSP core, the Xtensa Audio Framework (XAF) middleware library, with a focus on audio recording, processing and voice recognition (VIT - Voice Intelligent Technology).

As shown in the table below, the application is supported on several development boards and each development board may have certain limitations, some development boards may also require hardware modifications or allow to use of an audio expansion board. Therefore, please check the supported features and *Hardware modifications* or *Example configuration* sections before running the demo.

Functionality The application includes the following main components:

1. **ARM Core (CM33)** - Handles user interface and communicates with the DSP core
2. **DSP Core** - Processes audio data using the Xtensa Audio Framework (XAF)

The typical audio processing pipeline includes:

- Audio source component - DMIC audio
- VIT component (perform voice recognition)
- Renderer component (playback on codec)

The application demonstrates recording from digital microphones (DMIC), processing the audio with voice enhancement algorithms, performing voice recognition, and prints back in console detected WakeWord and list of commands.

Hardware Requirements

- Development board (one of the following):
  - EVK-MIMXRT595 board
  - EVK-MIMXRT685 board
  - MIMXRT685-AUD-EVK board (optionally with 8CH-DMIC expansion board - rev B required)
  - MIMXRT700-EVK board
- Micro USB cable
- JTAG/SWD debugger
- Headphones with 3.5 mm stereo jack
- Personal Computer

Hardware Modifications Some development boards need some hardware modifications to run the application.

- *EVK-MIMXRT595:*

  To enable the example audio using WM8904 codec, connect pins as follows:

  – JP7-1 <–> JP8-2

  Note: The I3C Pin configuration in pin_mux.c is verified for default 1.8V, for 3.3V, need to manually configure slew rate to slow mode for I3C-SCL/SDA.

- *EVK-MIMXRT685:*

  To enable the example audio using WM8904 codec, connect pins as follows:

  – JP7-1 <–> JP8-2

- *MIMXRT685-AUD-EVK*

  1. Set the hardware jumpers (Tower system/base module) to default settings.
  2. Set hardware jumpers JP2 2<–>3, JP44 1<–>2 and JP45 1<–>2.

  For 8CH-DMIC expansion board (optional):

  1. Connect the 8CH-DMIC expansion board to the MIMXRT685-AUD-EVK board to the DMIC connector (J31). For safety reasons, the expansion board must be connected when the power supply is disconnected.
  2. Set the hardware jumpers on the 8-DMIC expansion board to 2MIC, 3MICA, 3MICC config (Short: J6, J9, J10).
  3. Set the hardware jumpers JP44 2<–>3 and JP45 2<–>3 on the MIMXRT685-AUD-EVK board for on-board DMIC bypass.

- *MIMXRT700-EVK:*

  Set the hardware jumpers to default settings.

Preparation

1. Connect headphones to Audio HP / Line-Out connector.
   - EVK-MIMXRT595 - J4
   - EVK-MIMXRT685 - J4
   - MIMXRT685-AUD-EVK - J4, J50 for third channel when using 3 microphones
   - MIMXRT700-EVK - J29
2. Connect a micro USB cable between the PC host and the debug USB port on the development board.
   - EVK-MIMXRT595 - J40
   - EVK-MIMXRT685 - J5
   - MIMXRT685-AUD-EVK - J5
   - MIMXRT700-EVK - J54
3. Open a serial terminal with the following settings:
   - 115200 baud rate
   - 8 data bits
   - No parity
   - One stop bit

- No flow control

4. Download the program for CM33 core to the target board.
5. Launch the debugger in your IDE to begin running the demo.
6. If building release configuration, start the xt-ocd daemon and download the program for DSP core to the target board. If building debug configuration, launch the Xtensa IDE or xt-gdb debugger to begin running the demo.

Notes:

- DSP image can only be debugged using J-Link debugger. See the document 'Getting Started with Xplorer' for your particular board for more information.

Example Configuration The example can be configured by user. Before configuration, please check the *table* to see if the feature is supported on the development board.

- **MIMXRT685-AUD-EVK 8CH-DMIC expansion board settings:**

  Select how many microphones should be used

  - Set the BOARD_DMIC_NUM preprocessor macro to 1,2, 3 (default) or 4 in the project for the CM33 core.
  - When the 8CH-DMIC expansion board is used, the DMIC_BOARD_CONNECTED macro must be set to 1 (default) in the project for the DSP core.
  - Important: When you set the value to 2, 3 or 4 you have to connect the 8CH-DMIC expansion board and set the DMIC_BOARD_CONNECTED macro to 1. Don't forget set the hardware jumpers JP44 2-3 and JP45 2-3.

Running the Demo The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application. The DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Application for Cortex-M33 can be built by the other toolchains listed in MCUXpresso SDK Release Notes.

The release configurations of the demo will combine both applications into one ARM image. With this, the ARM core will load and start the DSP application on startup. Pre-compiled DSP binary images are provided under dsp/binary/ directory. If you make changes to the DSP application in release configuration, rebuild ARM application after building the DSP application. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol DSP_IMAGE_COPY_TO_RAM, found in IDE project settings, is defined to the value 1 when building release configuration.

The debug configurations will build two separate applications that need to be loaded independently. DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Required tool versions can be found in MCUXpresso SDK Release Notes for the board. Application for cm33 can be built by the other toolchains listed there. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol DSP_IMAGE_COPY_TO_RAM, found in IDE project settings, is defined to the value 0 when building debug configuration. The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application.

In order to debug both the Cortex-M33 and DSP side of the application, please follow the instructions:

1. It is necessary to run the Cortex-M33 side first and stop the application before the DSP_Start function
2. Run the xt-ocd daemon with proper settings
3. Download and debug the DSP application

In order to get TRACE debug output from the XAF it is necessary to define XF_TRACE 1 in the project settings. It is possible to save the TRACE output into RAM using DUMP_TRACE_TO_BUF 1 define on project level. Please see the initialization of the TRACE function in the xaf_main_dsp.c file. For more details see XAF documentation.

Running on CM33 When the demo runs successfully, the CM33 terminal will display the following output (example from MIMXRT700-EVK):

```
******************************
DSP audio framework demo start
******************************

[CM33 Main] Configure codec

[DSP_Main] Cadence Xtensa Audio Framework
[DSP_Main] Library Name    : Audio Framework (Hostless)
[DSP_Main] Library Version : 3.5
[DSP_Main] API Version     : 3.2

[DSP_Main] start
[DSP_Main] established RPMsg link
[CM33 Main] DSP image copied to DSP TCM
[CM33 Main][APP_DSP_IPC_Task] start
[CM33 Main][APP_Shell_Task] start

Copyright  2024  NXP

>>
```

Type help to see the command list. Similar description will be displayed on serial console (example from MIMXRT700-EVK):

```
"help": List all the registered commands

"exit": Exit program

"version": Query DSP for component versions

"record_dmic": Record DMIC audio , perform voice recognition (VIT) and playback on codec
USAGE: record_dmic [language]
For voice recognition say supported WakeWord and in 3s frame supported command.
If selected model contains strings, then WakeWord and list of commands will be printed in console.
NOTE: this command does not return to the shell
```

After running the "record_dmic en" command, similar output will be printed

```
[CM33 CMD] Setting VIT language to en
[DSP_Main] Number of channels 1, sampling rate 16000, PCM width 32
[CM33 CMD] [APP_DSP_IPC_Task] response from DSP, cmd: 13, error: 0
[DSP Record] Audio Device Ready
[CM33 CMD] DSP DMIC Recording started
[CM33 CMD] To see VIT functionality say wakeword and command
[DSP VIT] VIT Model info
[DSP VIT]   VIT Model Release = 0x40a00
[DSP VIT]   Language supported : English
[DSP VIT]   Number of WakeWords supported : 2
[DSP VIT]   Number of Commands supported : 12
[DSP VIT]   VIT_Model integrating WakeWord and Voice Commands strings : YES
[DSP VIT]   WakeWords supported :
[DSP VIT]    'HEY NXP'
[DSP VIT]    'HEY TV'
```

(continues on next page)

(continued from previous page)

```
[DSP VIT]   Voice commands supported :
[DSP VIT]    'MUTE'
[DSP VIT]    'NEXT'
[DSP VIT]    'SKIP'
[DSP VIT]    'PAIR DEVICE'
[DSP VIT]    'PAUSE'
[DSP VIT]    'STOP'
[DSP VIT]    'POWER OFF'
[DSP VIT]    'POWER ON'
[DSP VIT]    'PLAY MUSIC'
[DSP VIT]    'PLAY GAME'
[DSP VIT]    'WATCH CARTOON'
[DSP VIT]    'WATCH MOVIE'
[DSP Record] connected CAPTURER -> GAIN_0
[DSP Record] connected XA_GAIN_0 -> XA_VIT_PRE_PROC_0
[DSP Record] connected XA_VIT_PRE_PROC_0 -> XA_RENDERER_0
[DSP VIT]  - WakeWord detected 1 HEY NXP
[DSP VIT]  - Voice Command detected 6 STOP
```

Xtensa IDE log of successful start of command:

```
Number of channels 2, sampling rate 16000, PCM width 16
Audio Device Ready
connected CAPTURER -> GAIN_0
connected CAPTURER -> XA_VIT_PRE_PROC_0
connected XA_VIT_PRE_PROC_0 -> XA_RENDERER_0
```

Running on DSP Debug configuration: When the demo runs successfully, the terminal will display the following:

```
Cadence Xtensa Audio Framework
  Library Name    : Audio Framework (Hostless)
  Library Version : 3.2
  API Version     : 3.0

[DSP_Main] start
[DSP_Main] established RPMsg link
Number of channels 2, sampling rate 16000, PCM width 16

connected CAPTURER -> GAIN_0
connected XA_GAIN_0 -> XA_VIT_PRE_PROC_0
connected XA_VIT_PRE_PROC_0 -> XA_RENDERER_0
```

Known Issues There are limited features in release SRAM target because of memory limitations. To enable/disable components, set appropriate preprocessor define in project settings to 0/1 (e.g. XA_VIT_PRE_PROC etc.). Debug and flash targets have full functionality enabled.

XAF USB Example

Table of Content

Overview The dsp_xaf_usb_demo application demonstrates audio processing using the DSP core, the Xtensa Audio Framework (XAF) middleware library.

As shown in the table below, the application is supported on several development boards and each development board may have certain limitations, some development boards may also require hardware modifications or allow to use of an audio expansion board. Therefore, please check the supported features and *Hardware modifications* section before running the demo.

Functionality The application includes the following main components:

1. **ARM Core (CM33)** - Handles user interface, and communicates with the DSP core
2. **DSP Core** - Processes audio data using the Xtensa Audio Framework (XAF)

The XAF USB example demonstrates DSP-powered USB audio processing in two configurations: USB speaker and USB microphone. The application uses shell commands to switch between modes, with the ARM core handling USB communication while the DSP processes audio.

- USB Speaker Mode (USB2.0 □ Line out): Receives audio from a USB host, processes it on the DSP, and outputs through the headphone jack, making the device function as a USB speaker for your computer.
- USB Microphone Mode (DMIC □ USB2.0): Captures audio from the onboard digital microphones, processes it on the DSP, and streams it to a USB host as a standard audio input device.

Hardware Requirements

- Development board (one of the following):
  - EVK-MIMXRT595 board
  - EVK-MIMXRT685 board
  - MIMXRT685-AUD-EVK board
  - MIMXRT700-EVK board
- 2x Micro USB cable
- JTAG/SWD debugger
- Headphones with 3.5 mm stereo jack
- Personal Computer

Hardware Modifications Some development boards need some hardware modifications to run the application.

- *EVK-MIMXRT595:*

  To enable the example audio using WM8904 codec, connect pins as follows:

  - JP7-1 <–> JP8-2

  Note: The I3C Pin configuration in pin_mux.c is verified for default 1.8V, for 3.3V, need to manually configure slew rate to slow mode for I3C-SCL/SDA.

- *EVK-MIMXRT685:*

  To enable the example audio using WM8904 codec, connect pins as follows:

  - JP7-1 <–> JP8-2

- *MIMXRT685-AUD-EVK*
  - Set the hardware jumpers (Tower system/base module) to default settings.
  - Set hardware jumpers JP2 2<–>3, JP44 1<–>2 and JP45 1<–>2.
- *MIMXRT700-EVK:*

  Set the hardware jumpers to default settings.

Preparation

1. Connect headphones to Audio HP / Line-Out connector.
   - EVK-MIMXRT595 - J4
   - EVK-MIMXRT685 - J4
   - MIMXRT685-AUD-EVK - J4
   - MIMXRT700-EVK - J29
2. Connect the first micro USB cable between the PC host and the debug USB port on the development board.
   - EVK-MIMXRT595 - J40
   - EVK-MIMXRT685 - J5
   - MIMXRT685-AUD-EVK - J5
   - MIMXRT700-EVK - J54
3. Connect the second micro USB cable between the PC host and the USB port on the development board.
   - EVK-MIMXRT595 - J38
   - EVK-MIMXRT685 - J7
   - MIMXRT685-AUD-EVK - J7
   - MIMXRT700-EVK - J40
4. Open a serial terminal with the following settings:
   - 115200 baud rate
   - 8 data bits
   - No parity
   - One stop bit
   - No flow control
5. Download the program for CM33 core to the target board.
6. Launch the debugger in your IDE to begin running the demo.
7. If building release configuration, start the xt-ocd daemon and download the program for DSP core to the target board. If building debug configuration, launch the Xtensa IDE or xt-gdb debugger to begin running the demo.

Notes:

- DSP image can only be debugged using J-Link debugger. See the document 'Getting Started with Xplorer' for your particular board for more information.

Running the Demo The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application. The DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Application for Cortex-M33 can be built by the other toolchains listed in MCUXpresso SDK Release Notes.

The release configurations of the demo will combine both applications into one ARM image. With this, the ARM core will load and start the DSP application on startup. Pre-compiled DSP binary images are provided under dsp/binary/ directory. If you make changes to the DSP application in release configuration, rebuild ARM application after building the DSP application. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol DSP_IMAGE_COPY_TO_RAM, found in IDE project settings, is defined to the value 1 when building release configuration.

The debug configurations will build two separate applications that need to be loaded independently. DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Required tool versions can be found in MCUXpresso SDK Release Notes for the board. Application for cm33 can be built by the other toolchains listed there. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol DSP_IMAGE_COPY_TO_RAM, found in IDE project settings, is defined to the value 0 when building debug configuration. The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application.

In order to debug both the Cortex-M33 and DSP side of the application, please follow the instructions:

1. It is necessary to run the Cortex-M33 side first and stop the application before the DSP_Start function
2. Run the xt-ocd daemon with proper settings
3. Download and debug the DSP application

In order to get TRACE debug output from the XAF it is necessary to define XF_TRACE 1 in the project settings. It is possible to save the TRACE output into RAM using DUMP_TRACE_TO_BUF 1 define on project level. Please see the initialization of the TRACE function in the xaf_main_dsp.c file. For more details see XAF documentation.

Running on CM33 When the demo runs successfully, the CM33 terminal will display the following output (example from MIMXRT700-EVK):

```
******************************
DSP audio framework demo start
******************************

[CM33 Main] Configure codec

[DSP_Main] Cadence Xtensa Audio Framework
[DSP_Main] Library Name    : Audio Framework (Hostless)
[DSP_Main] Library Version : 3.5
[DSP_Main] API Version     : 3.2

[DSP_Main] start
[DSP_Main] established RPMsg link
[CM33 Main] DSP image copied to DSP TCM
[CM33 Main][APP_DSP_IPC_Task] start
[CM33 Main][APP_Shell_Task] start

Copyright 2024 NXP

>>
```

Type help to see the command list. Similar description will be displayed on serial console (example from MIMXRT700-EVK):

```
  "help": List all the registered commands

  "exit": Exit program

  "version": Query DSP for component versions

  "usb_speaker": Perform usb speaker device and playback on DSP
    USAGE: usb_speaker [start|stop]
    start          Start usb speaker device and playback on DSP
    stop           Stop usb speaker device and playback on DSP

  "usb_mic": Record DMIC audio and playback on usb microphone audio device
    USAGE: usb_mic [start|stop]
    start          Start record and playback on usb microphone audio device
    stop           Stop record and playback on usb microphone audio device
```

When usb_speaker command starts playback successfully, the terminal will display following output:

```
[APP_DSP_IPC_Task] response from DSP, cmd: 21, error: 0
DSP USB playback start
>>
```

Xtensa IDE log when command is playing a file:

```
USB speaker start, initial buffer size: 960
[DSP_USB_SPEAKER] Audio Device Ready
[DSP_USB_SPEAKER] post-proc/pcm_gain component started
[DSP_USB_SPEAKER] post-proc/client_proxy component started
[DSP_USB_SPEAKER] Connected post-proc/pcm_gain -> post-proc/client_proxy
[DSP_USB_SPEAKER] renderer component started
[DSP_USB_SPEAKER] Connected post-proc/client_proxy -> renderer
[DSP_ProcessThread] start
[DSP_BufferThread] start
[DSP_CleanupThread] start
```

The USB device on your host will be enumerated as XAF USB DEMO.

Xtensa IDE will not show any additional log entry.

Running the demo DSP Debug configuration: When the demo runs successfully, the terminal will display the following:

```
Cadence Xtensa Audio Framework
  Library Name    : Audio Framework (Hostless)
  Library Version : 2.6p1
  API Version     : 2.0

[DSP_Main] start
[DSP_Main] established RPMsg link
```

Known Issues

- When starting the "usb_speaker" after the "usb_mic" command, the sound output may be distorted. Please power cycle the board.

1.5 Wireless

1.5.1 NXP Wireless Framework and Stacks

1.5.2 EdgeFast Bluetooth

Currently we provide pdf version of those documentation, later release may convert the pdf documentation to markdown for better review and aligned format.

- EdgeFast BT PAL API Reference Manual pdf.

MCUXpressoSDK EdgeFast Bluetooth Protocol Abstraction

Introduction This document provides an overview of the EdgeFast Bluetooth Protocol Abstraction Layer stack software based on FreeRTOS OS on the NXP board with variant wireless module chipsets. This document covers hardware setup, build, and usage of the provided demo applications.

Stack API Reference EdgeFast Bluetooth Protocol Abstraction Layer is a wrapper layer on top of the bluetooth host stack. Zephyr Bluetooth host stack API is used as the basis of the EdgeFast Bluetooth Protocol Abstraction Layer with some enhancement on A2DP/SPP/HFP.

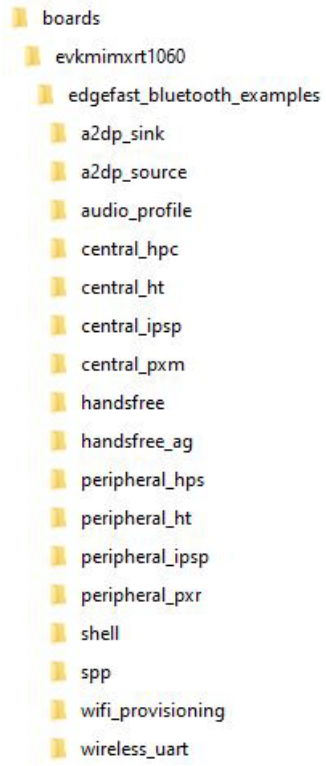
The APIs of the EdgeFast Bluetooth Protocol Abstraction Layer host stack are described in the EdgeFast Bluetooth Protocol Abstraction Layer RM document.

Note: The online document of the Zephyr Bluetooth Host stack is available here: https://docs.zephyrproject.org/latest/reference/bluetooth/index.html.

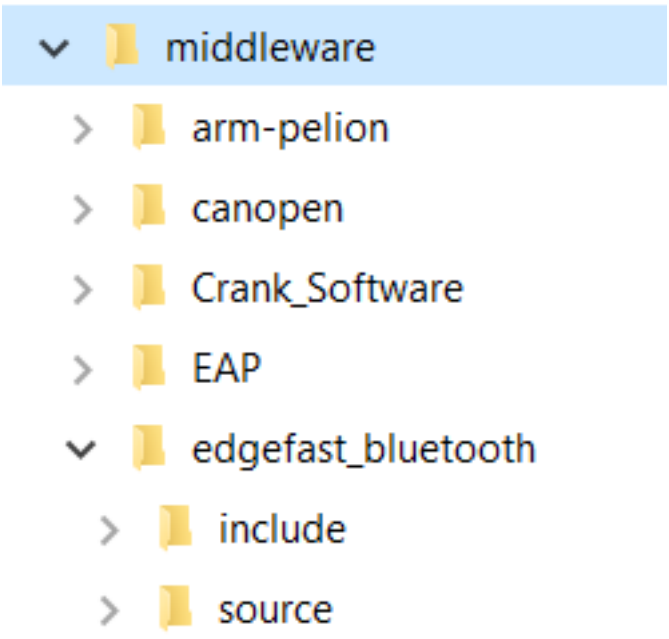
Parent topic:*Introduction*

Overview The EdgeFast Bluetooth Protocol Abstraction Layer host stack software is built based on MCUXpresso SDK. The following chapter uses RT1060 as an example, other boards have similar folder structure and corresponding document.

Folder structure The following figure shows the EdgeFast Bluetooth examples folder structure.



The following figure shows the EdgeFast Bluetooth Protocol Abstraction Layer host stack folder structure.



The following table provides information regarding the structure and description.

|**Folder**

|**Description**

| |————|————| |*boards/*

CMSIS/

devices/

docs/

middleware/

rtos/

tools/

|MCUXpresso SDK directory. Refer to Chapter 5

Release contents of MCUXpresso SDK Release Notes at *root/docs/ MCUXpresso SDK Release Notes for EVK-MIMXRT1060.pdf* to *know the details*

| |*boards/<board>/wireless/edgefast_bluetooth_examples*

|EdgeFast Bluetooth Protocol Abstraction Layer host stack example projects| |*middleware/wireless/edgefast_bluetooth*

|EdgeFast Bluetooth Protocol Abstraction Layer host stack source code

|

The EdgeFast Bluetooth folder includes two subfolders:

- **include**: This subfolder includes EdgeFast Bluetooth Protocol Abstraction Layer host stack headers.
- **source**: This subfolder includes EdgeFast Bluetooth Protocol Abstraction Layer host stack source code based on the Ethermind Bluetooth host stack APIs.

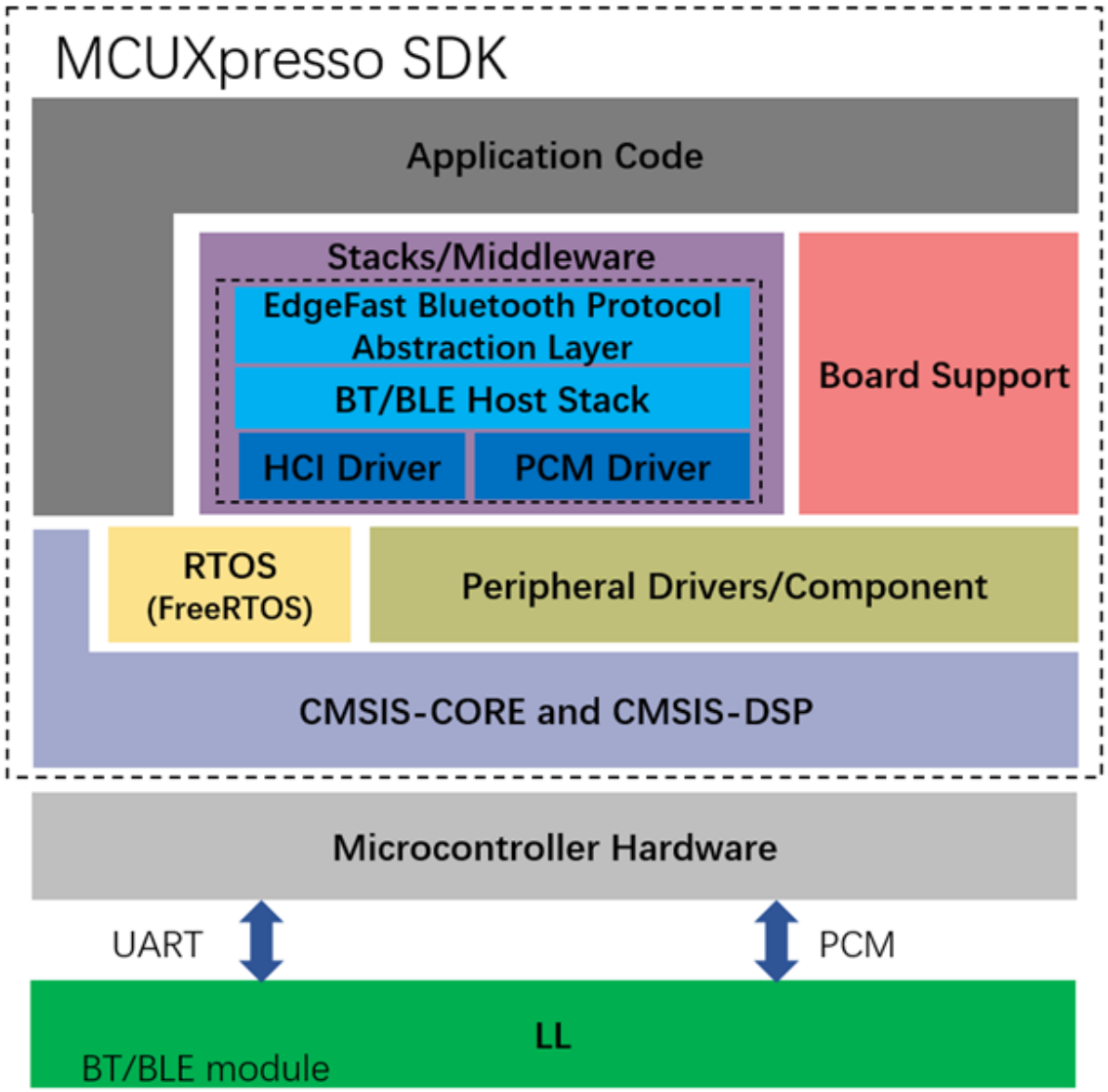
Parent topic:*Overview*

Architecture The figure Architecture of EdgeFast Bluetooth Protocol Abstraction Layer demo in MCUXpresso SDK below shows that the EdgeFast Bluetooth Protocol Abstraction Layer host stack is integrated into the MCUXpresso SDK as a middleware component. It leverages the RTOS, the board support, the peripheral driver/component, and other components in the MCUXpresso SDK. The Bluetooth application is built on top of the EdgeFast Bluetooth Protocol Abstraction Layer host stack and supports different peripheral features, Bluetooth features, and different RTOSes required by the user.

MCUXpresso SDK has the dual-chip architecture defined by EdgeFast Bluetooth Protocol Abstraction Layer project, the Bluetooth application code, and the EdgeFast Bluetooth Protocol Abstraction Layer host stack running on the reference board. For example, MIMXRT1060-EVK and the Linker Layer (LL) run on the Bluetooth modules like AW-AM457-USD, Murata Type 1XK, and Murata Type 1ZM and has single-chip architecture. Bluetooth Host stack and LL runs on the same chip, and communicate with Internal Communication Unit (IMU).

The communication between the host stack and the LL is implemented via the standard HCI UART interface and PCM interface for voice, or the IMU interface.

For details about the different components in MCUXpresso SDK, see *Getting Started with MCUXpresso SDK User's Guide* (document MCUXSDKGSUG) at *root/docs/Getting Started with MCUXpresso SDK.pdf*. For details on possible hardware rework requirements, see the hardware rework guide document of the relative board. For example, Hardware Rework Guide for EdgeFast BT



PAL.

Parent topic:*Overview*

Features This section provides an overview of Bluetooth features, toolchain support, and RTOS support.

Bluetooth features

- Bluetooth 5.0 compliant
- Protocol support
  - L2CAP, GAP, GATT, RFCOMM, SDP, and SM

    Note: The Enhanced Attribute (EATT) protocol is not supported in the current version. However, the support will be available in a future version.
- Classic profile
  - SPP, A2DP, and HFP
- LE profile
  - HTP, PXP, IPSP, HPS

- Integrated the Fatfs based on USB Host MSD in SDK
- Digital Audio Interface including PCM interface for HFP

Parent topic: Features

Toolchain support

- IAR Embedded Workbench for ARM®
- MCUXpresso IDE
- Keil® MDK/µVision
- Makefiles support with GCC from Arm Embedded

Note: For details on IDE Development tools version details, see Section 3, Development tools in MCUXpresso SDK Release Notes (document MCUXSDKMIMXRT106XRN). The Release Notes document is available at *root/docs/ MCUXpresso SDK Release Notes for EVK-MIMXRT1060.pdf*.

Parent topic: Features

RTOS support

- FreeRTOSTMOS

Note: The FreeRTOS static allocation feature is required by Edgefast Bluetooth. The macro configSUPPORT_STATIC_ALLOCATION needs to be set to enable this feature.

Parent topic: Features

Parent topic:*Overview*

Examples list

- The following examples are provided. Not all the examples are implemented on all the boards. See the board package for a list of the implemented examples.
  - **central_hpc (central http proxy service client)**: Demonstrates a basic Bluetooth Low Energy Central role functionality. The application scans for other Bluetooth Low Energy devices and establishes a connection to the peripheral with the strongest signal. The application specifically looks for HPS Server and programs a set of characteristics that configures a Hyper Text Transfer Protocol (HTTP) request, initiates request, and reads the response once connected.
  - **central_ht (central health thermometer)**: Demonstrates a basic Bluetooth Low Energy Central role functionality. The application scans for other Bluetooth Low Energy devices and establishes a connection to the peripheral with the strongest signal. The application specifically looks for health thermometer sensor and reports the die temperature readings once connected.
  - **central_ipsp (central Internet protocol support profile)**: Demonstrates a basic Bluetooth Low Energy Central role functionality. The application scans for other Bluetooth Low Energy devices and establishes connection to the peripheral with the strongest signal. The application specifically looks for IPSP Service and communicates between the devices that support IPSP. Once connected, the communication is done using IPv6 packets over the Bluetooth Low Energy transport.
  - **central_pxm (central proximity monitor)**: Demonstrates a basic Bluetooth Low Energy Central role functionality. The application scans for other Bluetooth Low Energy devices and establishes a connection to the peripheral with the strongest signal. The application specifically looks for Proximity Reporter.

- **peripheral beacon**: Demonstrates the Bluetooth Low Energy Peripheral role, This application implements types of beacon applications.
  - **beacon**: Demonstrates the Bluetooth Low Energy Broadcaster role functionality by advertising Company Identifier, Beacon Identifier, UUID, A, B, C, RSSI.
  - **Eddystone**: The Eddystone Configuration Service runs as a GATT service on the beacon while it is connectable and allows configuration of the advertised data, the broadcast power levels, and the advertising intervals.
  - **iBeacon**: Demonstrates the Bluetooth Low Energy Broadcaster role functionality by advertising an Apple iBeacon.
- **peripheral_hps (peripheral http proxy service)**: Demonstrates the Bluetooth Low Energy Peripheral role. The application specifically exposes the HTTP Proxy GATT Service.
- **peripheral_ht (peripheral health thermometer)**: Demonstrates the Bluetooth Low Energy Peripheral role. The application specifically exposes the HT (Health Thermometer) GATT Service. Once a device connects, it generates dummy temperature values.
- **peripheral_ipsp (peripheral Internet protocol support profile)**: Demonstrates the Bluetooth Low Energy Peripheral role. The application specifically exposes the Internet Protocol Support GATT Service.
- **peripheral_pxr (peripheral proximity reporter)**: Demonstrates the Bluetooth Low Energy Peripheral role. The application specifically exposes the Proximity Reporter (including LLS, IAS, and TPS) GATT Service.
- **wireless uart**: The application automatically starts advertising the wireless uart service and connects to the wireless uart service after the role switch. The wireless UART service is a custom service that implements a custom writable ASCII Char characteristic (UUID: 01ff0101-ba5e-f4ee-5ca1-eb1e5e4b1ce0) that holds the character written by the peer device.
- **spp (serial prot profile)**: Application demonstrates the use of the SPP feature.
- **handsfree**: Application demonstrating usage of the Hands-free Profile (HFP) feature.
- **handsfree_ag**: Application demonstrating usage of the Hands-free Profile Audio Gateway (HFP-AG) feature.
- **a2dp_sink**: Application demonstrating how to use the a2dp sink feature.
- **a2dp_source**: Application demonstrating how to use the a2dp source feature.
- **audio_profile**: Demonstrates the following functions.
  - There are five parts working in the demo: AWS cloud, Android app, audio demo (running on RT1060), U-disk, and Bluetooth headset.
  - With an app running on the smartphone (Android phone), the end user connects to the AWS cloud and controls the audio demo running on the RT1060 EVK board through AWS cloud. Some operations like play, play next, and pause are used to control the media play functionalities.
  - Audio demo running on the RT1060 EVK board connects to the AWS through WiFi. A connection establishes between the RT1060 EVK board and a Bluetooth headset. To get the media resource (mp3 files) from the U-disk, an HS USB host is enabled, and a U-disk with mp3 files is connected to RT1060 EVK board via the USB port. The audio demo searches the root directory of the U-disk for the music files (only mp3 files are supported) and uploads the song file list to AWS. The song list is shown in the app running on the smartphone. The music can then be played out via the Bluetooth headset once end user controls the app to play the mp3 file.

  - **wifi_provisioning**: Demonstrates the WiFi provisioning service that safely sends credential from phone to device over Bluetooth low energy. By default, AWS Wi-Fi provisioning demo starts advertising if the Wi-Fi access point (AP) is not configured and waits for the Wi-Fi AP configuration. After connecting to the Android APK, the demo executes the request from cellphone and sends the response. When the Wi-Fi AP is configured, the Shadow demo connects to the AWS via Wi-Fi and publishes the configured Wi-Fi AP information.
  - **shell**: Shell application demonstrating the shell mode of the simplified Adapter APIs.

Parent topic:*Overview*

Hardware For dual-chip implementation, the Bluetooth demo runs on a (reference board) along with the ported EdgeFast Bluetooth Protocol Abstraction Layer API host stack. The Linker Layer (LL) runs on a wireless module. A standard UART HCI and PCM is used to communicate between the two boards, the IMU is used to communicate in between. The Bluetooth host and controller stack run on different boards. The demo hardware requires two different boards; a development board for host stack and application and a wireless module adapter board for controller running. For example, the evkmimxrt1060 and uSD-15x15 Adapter Board for AW-AM457-uSD board, or any of the supported Murata modules with the Murata uSD-M.2 adapter. For details on the board hardware requirement and board setting, see the following documents. For one-chip implementation, the Bluetooth demo, EdgeFast Bluetooth Protocol Abstraction Layer API host stack, and LL run on one chip and they communicate with IMU.

- Hardware rework guide document of the relative board, Hardware Rework Guide for MIMXRT1060-EVK and AW-AM457-uSD, or Hardware Interconnection Guide for i.MX RT EVKs and Murata M.2 modules.
- Readme file of the examples.

Reference boards list

- MIMXRT1170: For details, see the quick start guide of this reference board (MIMXRT1170).
- MIMXRT685-EVK: For details, see the quick start guide of this reference board (MIMXRT685-EVK).
- MIMXRT595-EVK: For details, see the quick start guide of this reference board. (MIMXRT595-EVK).
- MIMXRT1050-EVKB: For details, see the quick start guide of this reference board (MIMXRT1050-EVKB).

Parent topic:*Hardware*

Dual-chip wireless module list

Module	HCI
uSD-15x15 Adapter Board for AW-AM457-uSD	UART
uSD-15x15 Adapter Board for AW-CM358-uSD	UART
uSD-15x15 Adapter Board for AW-AM510-uSD	UART
AW-CM358MA	UART
AW-CM510MA	UART
K32W061	UART
Murata uSD-M.2 Adapter (LBEE0ZZ1WE-uSD-M2) and Embedded Artists 1ZM M.2 Module (EAR00364)	UART
Murata uSD-M.2 Adapter (LBEE0ZZ1WE-uSD-M2) and Embedded Artists 1XK M.2 Module (EAR00385)	UART

For details on AzureWave module, see the quick start guide of this reference board AW-AM457-uSD, AW-CM358-uSD, AW-CM358MA, AW-AM510-uSD, AW-CM510MA, and K32W061.

For Murata documentation, refer to the Quick Start Guide and User Guide here.

Note: The boards and wireless module lists are not random combination. For the wireless module support list of specific board, see the readme.txt of each example.

Parent topic:*Hardware*

Demo This topic lists the steps to run a demo application using IAR, steps to run a demo application using MCUXpresso IDE, and steps to download LL firmware from the reference board. The following chapter uses RT1060 and peripheral_ht as an example.

Before you run the example, see the readme.txt in current the peripheral_ht directory and the Hardware Rework Guide for EdgeFast BT PAL document to set the jumper and connect the wireless module with development board.

The uSD type wireless module is similar to the Development board connector in the Run an IAR example section. If the module is M2 type, connect the module to the onboard M2 interface.

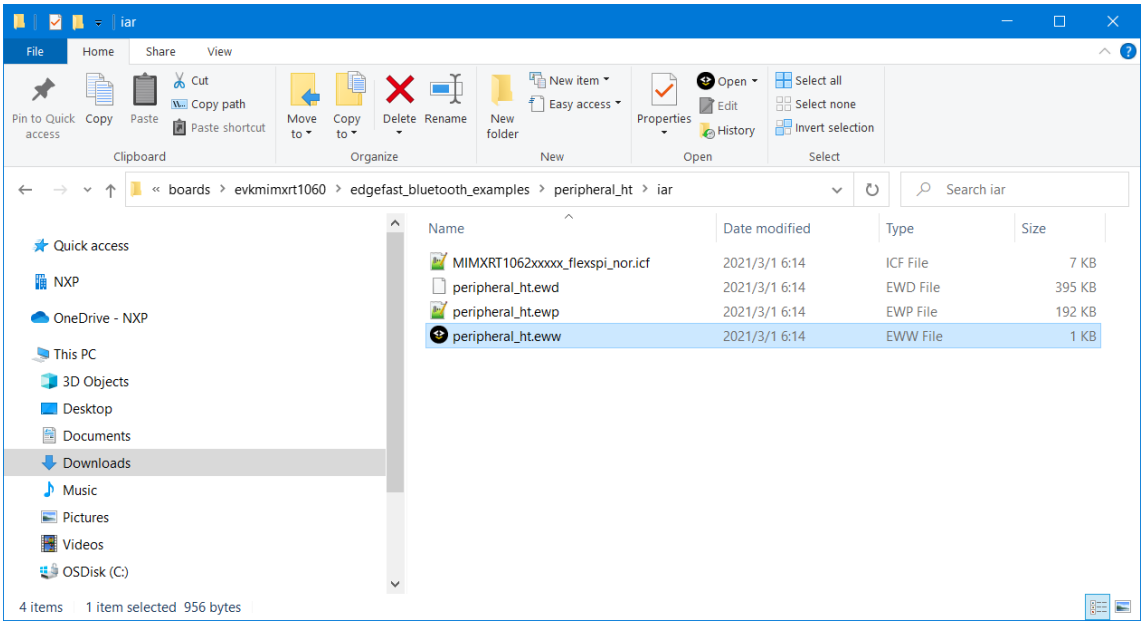
Run a demo application using IAR This document uses EVKRT1060 EdgeFast Bluetooth Protocol Abstraction Layer API example to describe the steps to open a project, build an example, and run a project. For details, see Section 3 in *Getting Started with MCUXpresso SDK User's Guide*(document MCUXSDKGSUG) at*root/docs/Getting Started with MCUXpresso SDK.pdf*.

Open an IAR example For the IAR Embedded Workbench, unpack the contents of the archive to a folder on a local drive.

1. The example projects are available at:

   <root>/boards/evkmimxrt1060/edgefast_bluetooth_examples/peripheral_ht/iar

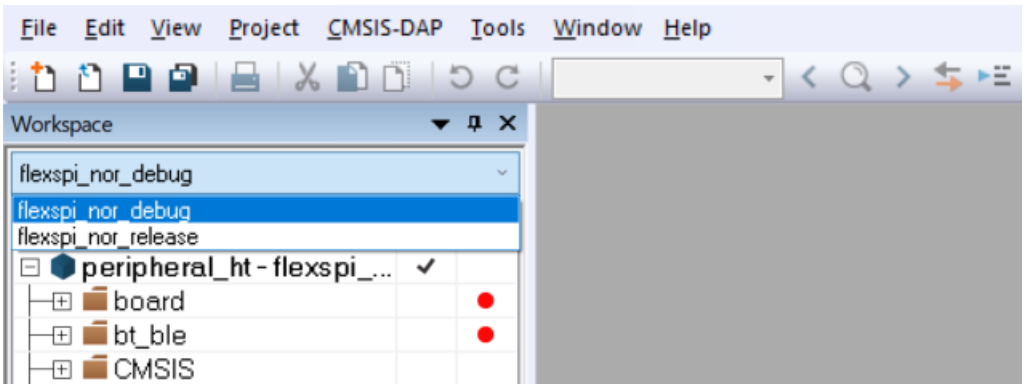
2. Open the IAR workspace file. For example, the highlighted *.eww format file



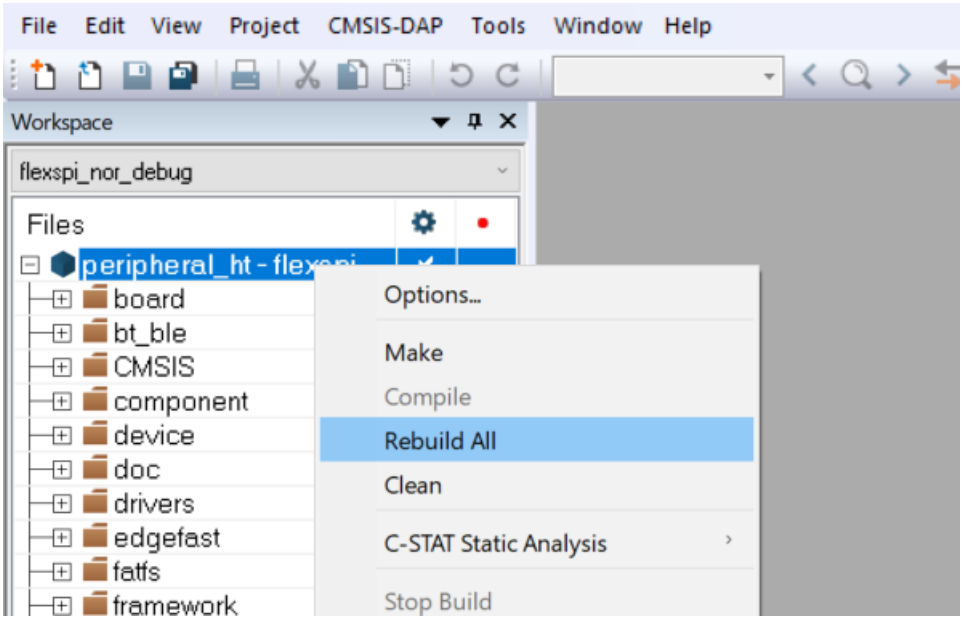
Parent topic: Run a demo application using IAR

Build an IAR example

1. Select flexspi_nor_debug or flexspi_nor_release configurations from the drop-down selector above the project tree in the workspace.



2. Build the EdgeFast Bluetooth Protocol Abstraction Layer project.

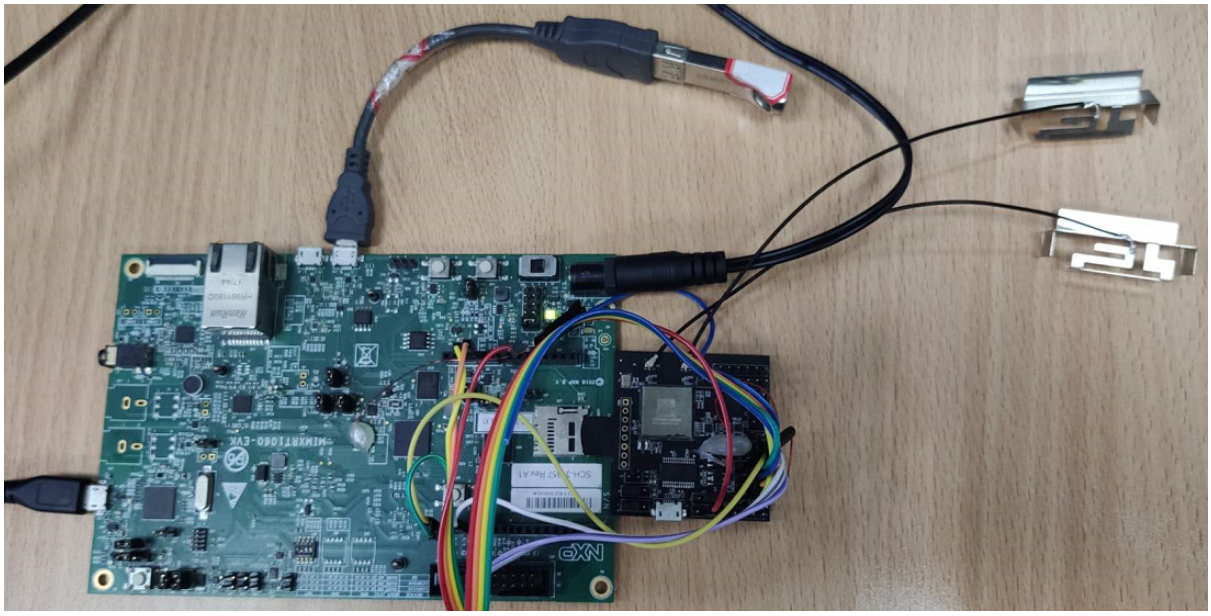


Note: Wireless module does not have flash hardware and requires 512 KB image loaded from board (such as RT1060) on system startup. The 512 KB image is kept on RT1060 side and only flexspi_nor target is supported for Bluetooth examples. Other targets are not supported because memory size limit.

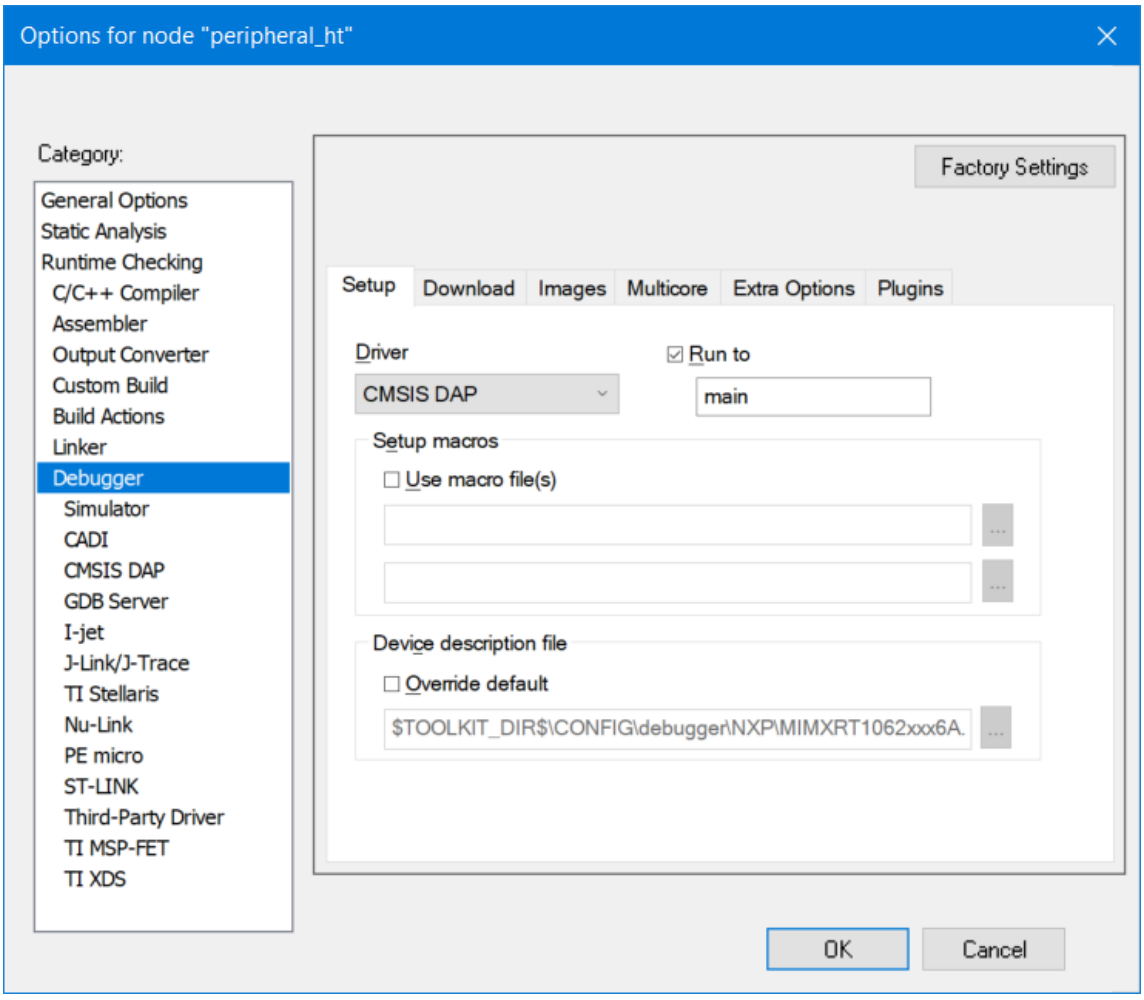
Parent topic: Run a demo application using IAR

Run an IAR example This document uses the peripheral_ht as an example to describe the steps to run an example. For details on other projects and compilers, see the readme file in the corresponding example directory.

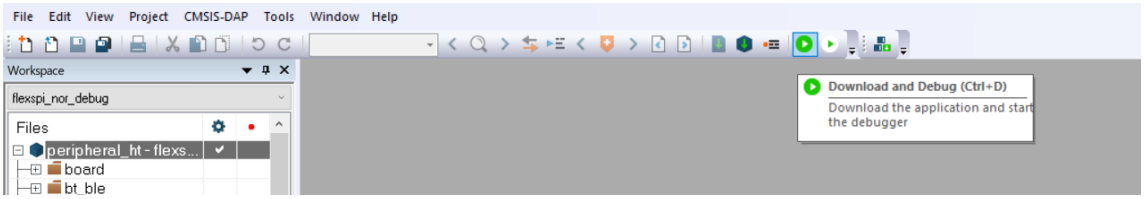
The following figure shows the connection of RT1060 and the uSD wireless module.



1. Connect the USB debug console port to PC. For example, connect J14 of EVKRT1060 to the PC.
2. Connect a 5 V power source to the J1 jack in the Wireless module board.
3. Make the appropriate debugger settings in the project options window, as shown in the figure below.



4. Click the **Download and Debug** button to flash the executable onto the board, as shown in the following figure. After the download is complete, if you must test the function of HFP, stop IAR debugging, and then connect the PCM interface. Reset the target board by manually.



5. Linker layer (LL) Firmware running in wireless module loads from EVKRT1060 by SDIO interface, so need take a bit time to download the LL firmware, “Initialize AW-AM457-uSD Driver” prints in the debug console. For example, it depends on the firmware. For details, see readme.txt.

Note: The projects are configured to use “CMSIS DAP” as the default debugger. Ensure that the OpenSDA chip of the board contains a CMSIS. DAP firmware or that the debugger selection corresponds to the physical interface used to interface to the board.

Parent topic: Run a demo application using IAR

Parent topic:*Demo*

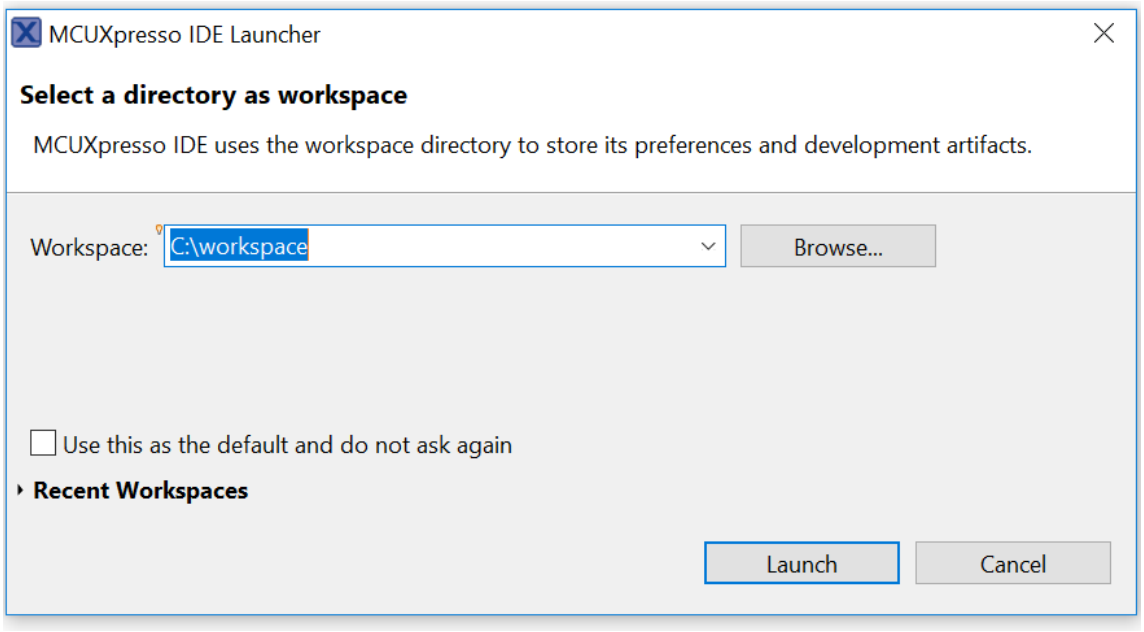
Run a demo application using MCUXpresso IDE

This document uses peripheral_ht example to describe the steps to open a project, build an example, and run a project on MCUXpresso IDE.

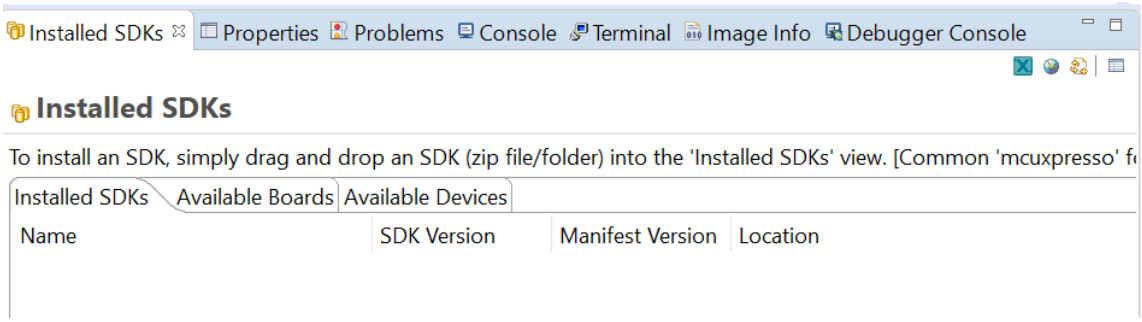
For details, see Section 3 in *Getting Started with MCUXpresso SDK User's Guide* (document MCUXSDKGSUG) at *root/docs/Getting Started with MCUXpresso SDK.pdf* and refer to the readme file in the corresponding demo's directory.

Open an MCUXpresso IDE example

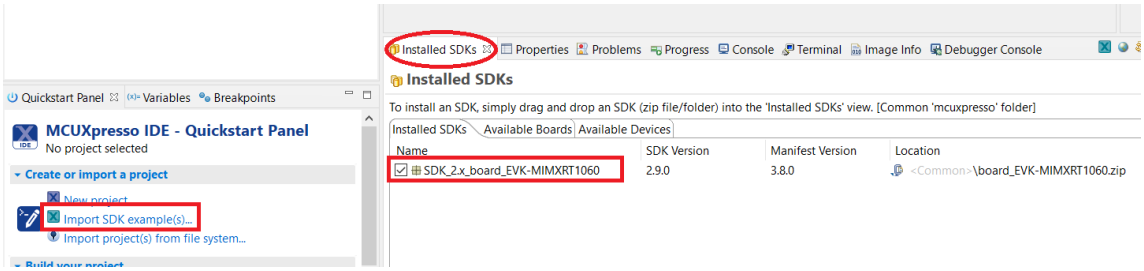
1. Open MCUXpresso IDE and open an existing or a new workspace location.



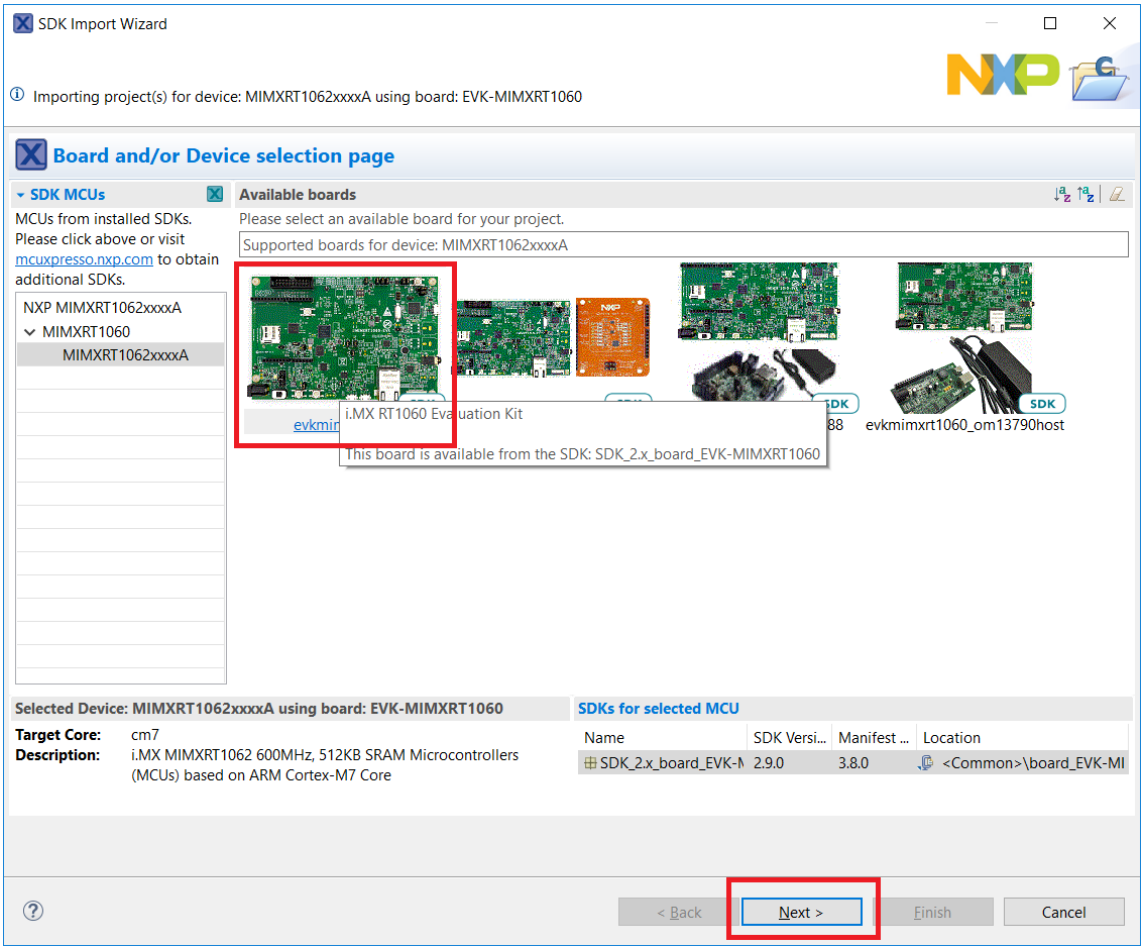
2. Drag and drop the package archive into the MCUXpresso Installed SDKs area in the lower right of the main window.



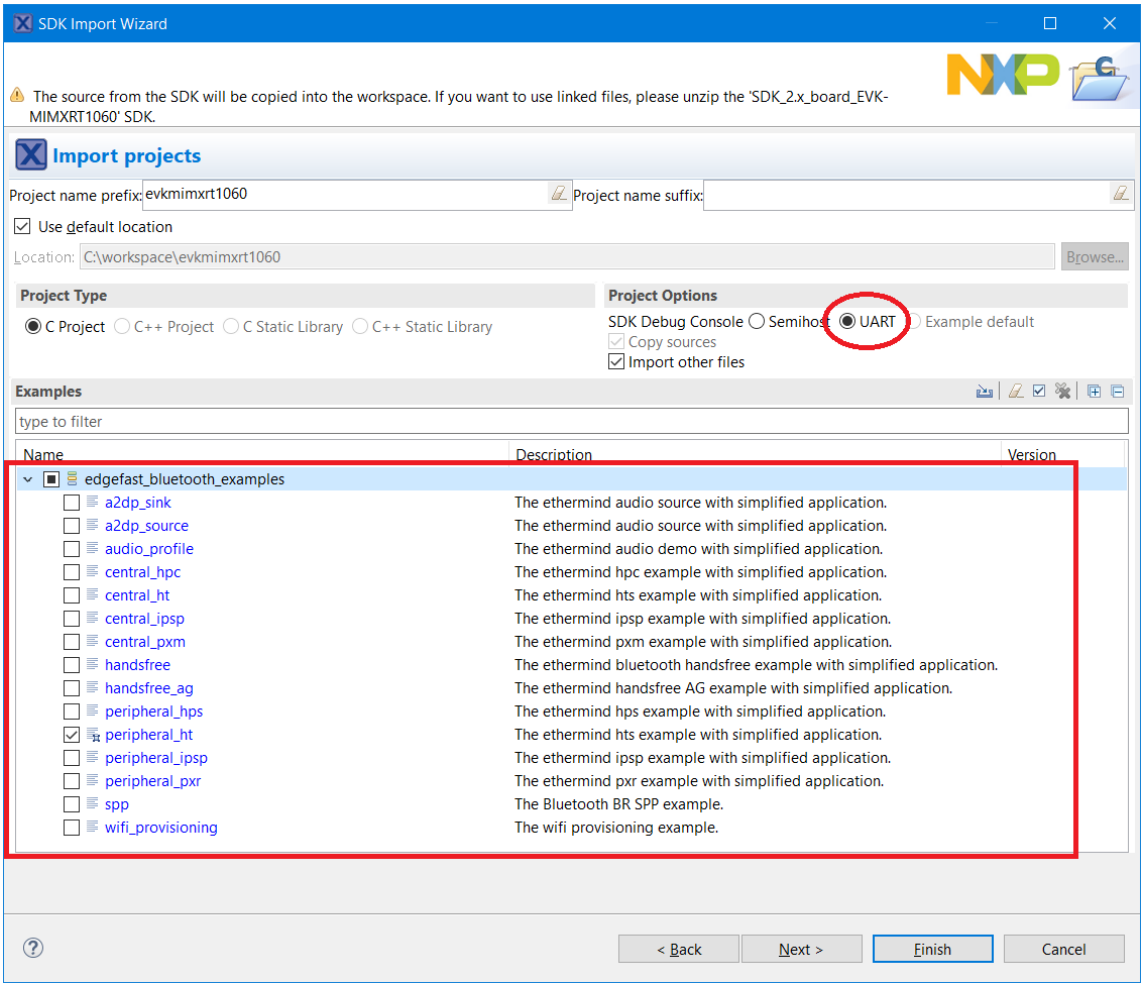
3. After the SDK is loaded successfully, select the **Import the SDK examples(s)...** to add examples to your workspace.



4. Select the evkmimxrt1060 board and click the **Next** button to select the desired example(s).



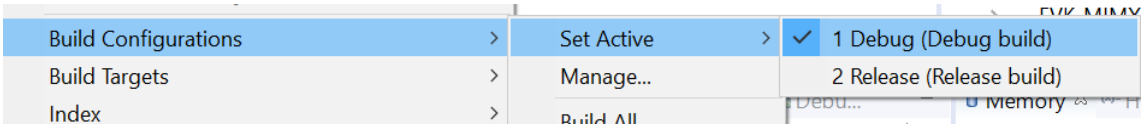
5. Select the evkmimxrt1060 board EdgeFast Bluetooth example. For example, peripheral_ht.
6. Ensure to change SDK debug console from **Semihost** to **UART**.
7. Click **Finish**.



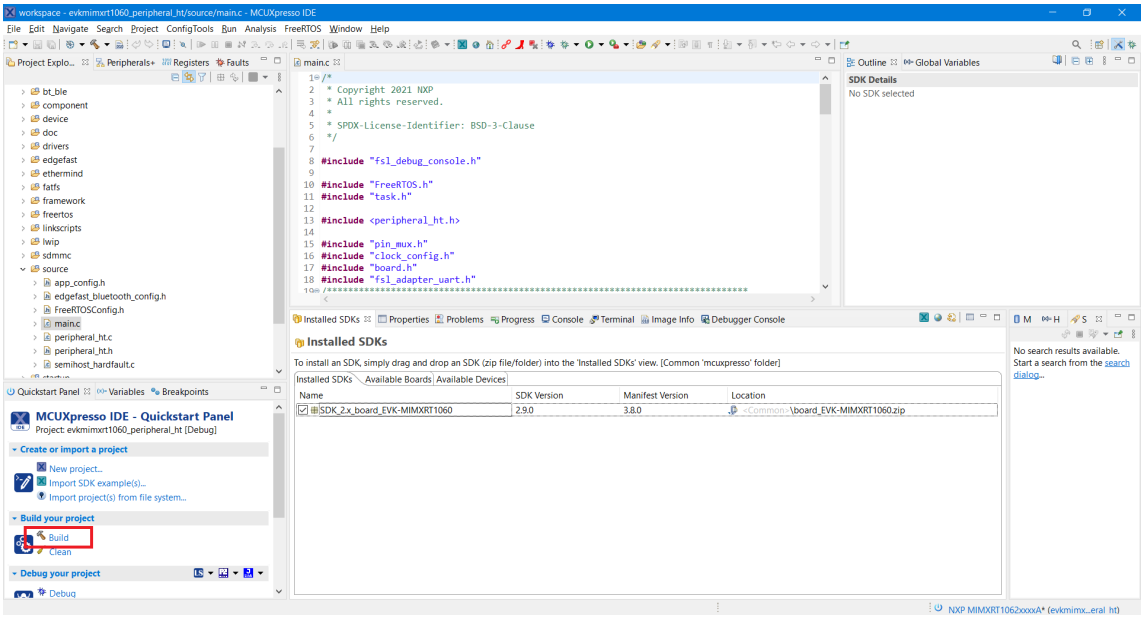
Parent topic: Run a demo application using MCUXpresso IDE

Build an MCUXpresso IDE example

1. Select desired target for your project.



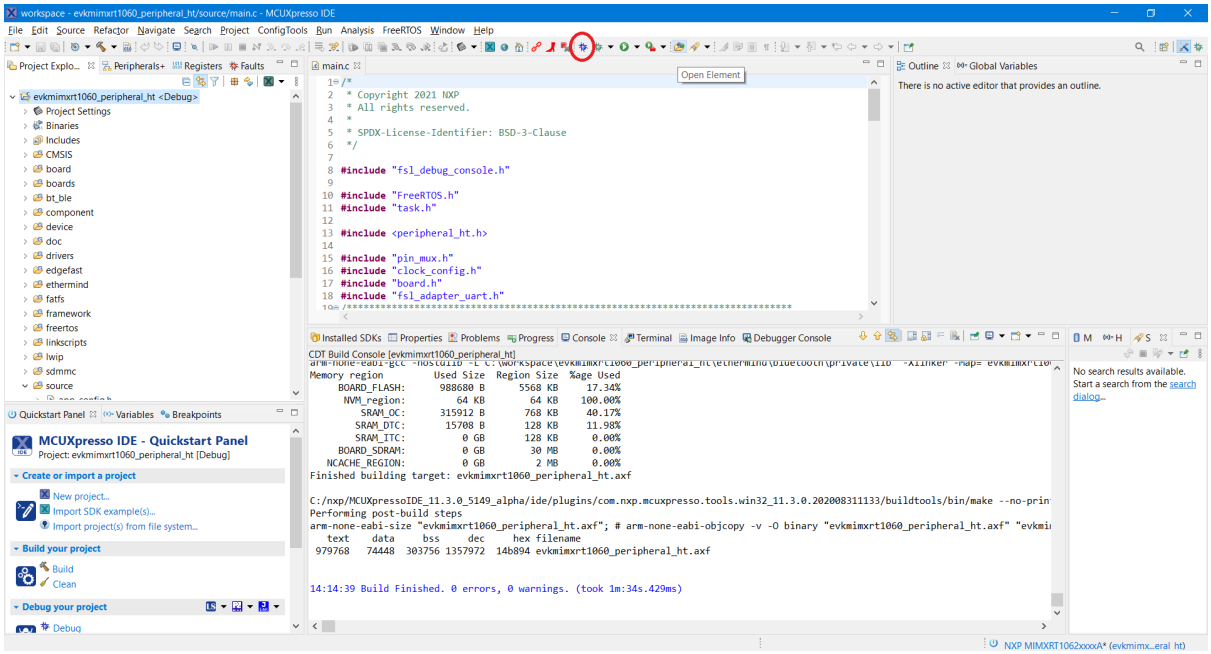
2. Build MCUXpresso IDE EdgeFast Bluetooth Protocol Abstraction Layer project.



Parent topic: Run a demo application using MCUXpresso IDE

Run an MCUXpresso IDE example For MCUXpresso IDE project running, all steps are similar to Run an IAR example except the steps of downloading image from compiler.

To download MCUXpresso IDE image to board, click the **Debug** button to download the executable file onto the board.



Parent topic: Run a demo application using MCUXpresso IDE

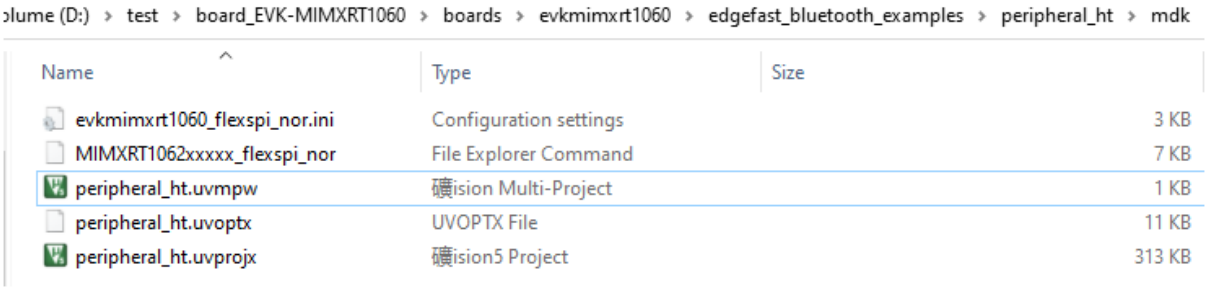
Parent topic:*Demo*

Run a demo application using MDK This document uses peripheral_ht example to describe the steps to open a project, build an example, and run a project on MDK.

For details, see the related section in the Getting Started with MCUXpresso SDK User's Guide (document: MCUXSDKGSUG) in the directory *root/docs/* and the readme file in the corresponding demo's directory.

Open an MDK project For the IAR Embedded Workbench, unpack the contents of the archive to a folder on a local drive.

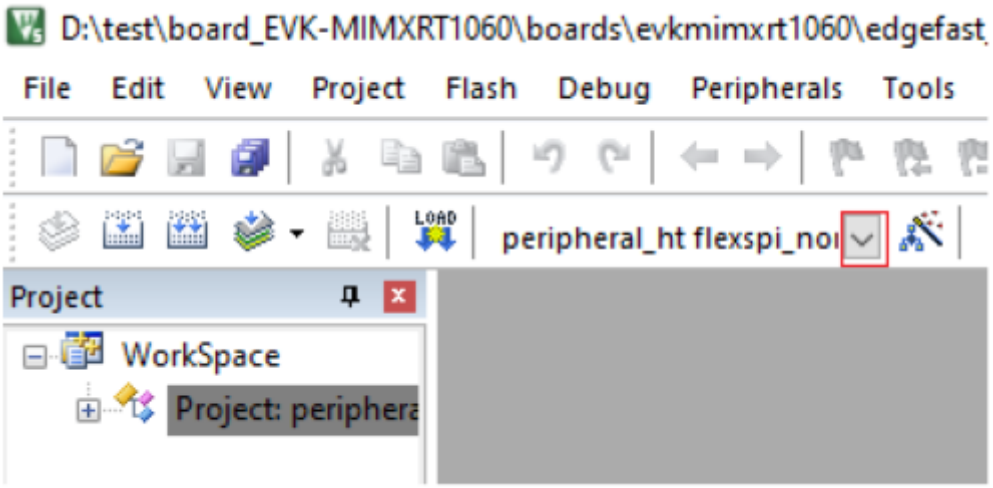
1. The example projects are available at: <root>/boards/evkmimxrt1060/edgefast_bluetooth_examples/peripheral_ht/mdk.
2. Open the mdk workspace file. For example, the highlighted *.uvmpw format file.



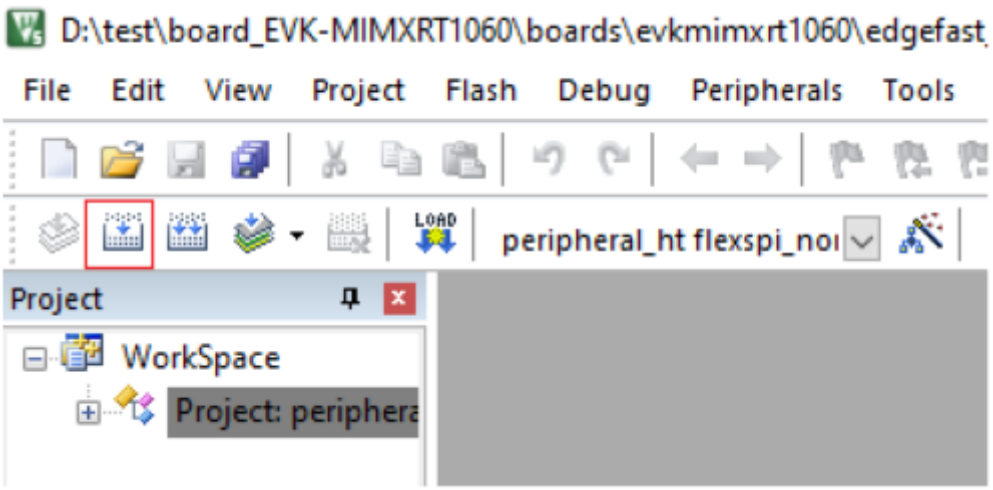
Parent topic: Run a demo application using MDK

Build an MDK example To build an MDK example:

1. Select *flexspi_nor_debug* or *flexspi_nor_release* configurations from the drop-down selector above the project tree in the workspace.



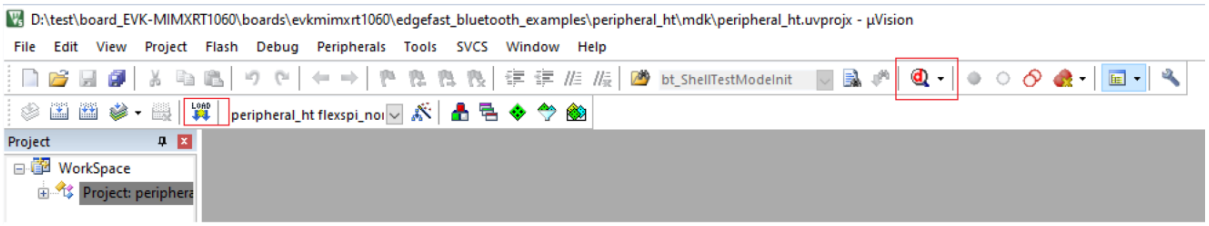
2. Click the highlighted icon to build the EdgeFast Bluetooth Protocol Abstraction Layer project.



Parent topic: Run a demo application using MDK

Run an MDK example For MDK project running, all steps are similar to Run an IAR example except the steps of downloading image from compiler.

To download the MDK image to the board, click the **Debug** button. The executable file downloads to the board.



Parent topic: Run a demo application using MDK

Parent topic:*Demo*

Run a demo application using Arm GCC This document uses peripheral_ht example to describe the steps to open a project, build an example, and run a project on MDK.

For details, see the related section in *Getting Started with MCUXpresso SDK User's Guide* (document: MCUXSDKGSUG) at *root/docs/* and the readme file in the corresponding demo's directory.

Setup tool chains See the section "Run a demo using Arm GCC" of getting start document. For example, *Getting Started with MCUXpresso SDK for MIMXRT1160-EVK*.

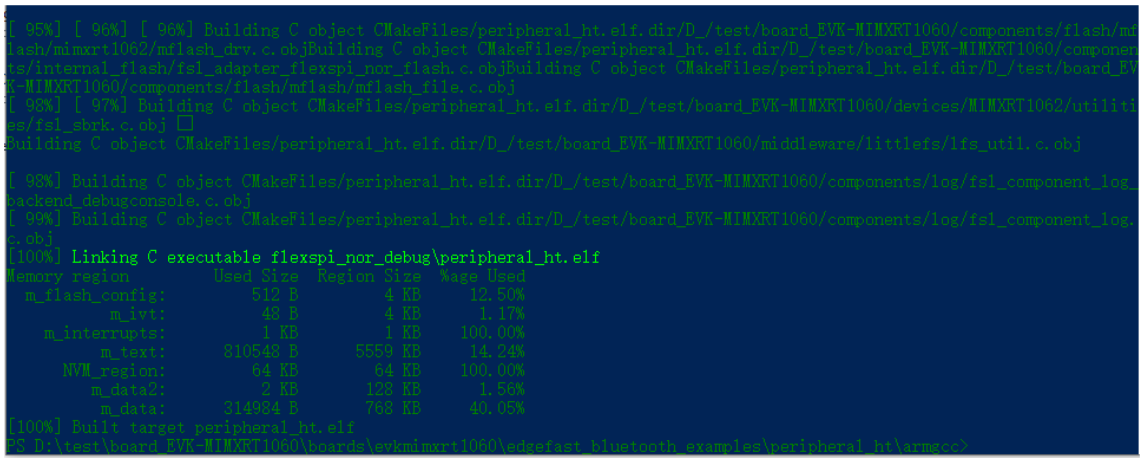
Parent topic: Run a demo application using Arm GCC

Build a GCC example To build a GCC example:

1. Change the directory to the project directory: <install_dir>\boards\evkmimxrt1060\edgefast_bluetooth_examples\peripheral_ht\armgcc.
2. Run the build script.

   For windows, the script is build_flexspi_nor_debug.bat/ build_flexspi_nor_release.bat.

   The build output is shown in the following figure.



Parent topic: Run a demo application using Arm GCC

Run a GCC example Refer to the section "Run a demo using Arm GCC" of the getting start document. For example, see Getting Started with MCUXpresso SDK for MIMXRT1060-EVK. The peripheral_ht.elf is the target to download.

Parent topic: Run a demo application using Arm GCC

Parent topic:*Demo*

Download Linker Layer firmware from the reference board Download the Linker Layer (LL) Firmware from Reference board EVKRT1060 by SDIO interface before running the Bluetooth Controller stack. The LL download is necessary because wireless module does not support flash.

Parent topic:*Demo*

Change board-specific parameters There are some board-specific parameters that can be changed in the application layer for EdgeFast BT PAL.

Change HCI UART parameters Since the controller can support different baud rates, the demo provides an interface with configurable baud rates. The function*controller_hci_uart_get_configuration* is used to get HCI UART parameters, including the instance, default baud rate, which depends on the controller, running baud rate which defined by macro BOARD_BT_UART_BAUDRATE and so on. If this function returns '0' and the running baud rate is inconsistent with the default baud rate, EdgeFast BT PAL switches the baud rate of the controller to the running baud rate.

Parent topic: Change board-specific parameters

Change USB Host stack parameters Since the board supports multiple USB ports, the demo provides a configurable interface for USB Host stack. The function*USB_HostGetConfiguration* received the instance of USB for EdgeFast BT PAL. For the case where there is a USBPHY, the demo configures the properties of the PHY through*USB_HostPhyGetConfiguration*.

Note: There are series of hex bytes printed on the console after the wireless module resets. However, it does not impact the EdgeFast BT PAL application running.

Parent topic: Change board-specific parameters

Parent topic:*Demo*

Known issues This section provides a list of known issues in the release package.

Notes This section provides a list of notes to use EdgeFast Bluetooth stack

- the follow configuration items related to resource needs more attention
  - CONFIG_BT_MAX_CONN The max connections that can be created.
  - CONFIG_BT_MAX_PAIRED The max supported paired devices.
  - CONFIG_BT_BUF_EVT_RX_COUNT The max received hci events and acl data packets at one time if the sys work queue task is blocked. One example is: when LE connection is created and HCI_LE_Enhanced_Connection_Complete is received, the sys work queue task is busy with processing the HCI_LE_Enhanced_Connection_Complete. If the received hci events exceed CONFIG_BT_BUF_EVT_RX_COUNT, it may leads potential issue, please increase value of the macro.
- All the EdgeFast Bluetooth API should be called only after EdgeFast Bluetooth is initialized.
- Don't send HCI cmd from the sys work queue task or any stack's callbacks.

EdgeFast BT PAL configuration documentation **CONFIG_BT_BUF_RESERVE**

Buffer reserved length, suggested value is 8.

CONFIG_BT_SNOOP

Whether enable bt snoop feature, 0 - disable, 1 - enable.

CONFIG_BT_HCI_CMD_COUNT

Number of HCI command buffers, ranging from 2 to 64. Number of buffers available for HCI commands Range 2 to 64 is valid.

CONFIG_BT_RX_BUF_COUNT

Number of HCI RX buffers, ranging from 2 to 255. Number of buffers available for incoming ACL packets or HCI events from the controller Range 2 to 255 is valid.

CONFIG_BT_RX_BUF_LEN

Maximum supported HCI RX buffer length, ranging from 73 to 2000. Maximum data size for each HCI RX buffer. This size includes everything starting with the ACL or HCI event headers. Note that buffer sizes are always rounded up to the nearest multiple of 4, so if this Kconfig value is something else then there is some wasted space. The minimum of 73 has been taken for LE SC which has an L2CAP MTU of 65 bytes. On top of this, The L2CAP header (4 bytes) and the ACL header (also 4 bytes) which yields 73 bytes. Range is 73 to 2000.

CONFIG_BT_HCI_RESERVE

Reserve buffer size for user. Headroom that the driver needs for sending and receiving buffers. Add a new 'default' entry for each new driver.

CONFIG_BT_DISCARDABLE_BUF_COUNT

Number of discardable event buffers, if the macro is set to 0, disable this feature, if greater than 0, this feature is enabled. Number of buffers in a separate buffer pool for events which the HCI driver considers discardable. Examples of such events could be , for example, Advertising Reports. The benefit of having such a pool means that if there is a heavy inflow of such events it does not cause the allocation for other critical events to block and may even eliminate deadlocks in some cases.

CONFIG_BT_DISCARDABLE_BUF_SIZE

Size of discardable event buffers, ranging from 45 to 257. Size of buffers in the separate discardable event buffer pool. The minimum size is set based on the Advertising Report. Setting the buffer can save memory if with size set differently from that of the CONFIG_BT_RX_BUF_LEN. range is 45 to 257.

CONFIG_BT_HCI_TX_STACK_SIZE

HCI TX task stack size needed for executing bt_send with specified driver, should be no less than 512.

CONFIG_BT_HCI_TX_PRIO

HCI TX task priority.

CONFIG_BT_RX_STACK_SIZE

Size of the receiving thread stack. This is the context from which all event callbacks to the application occur. The default value is sufficient for basic operation, but if the application needs to do advanced things in its callbacks that require extra stack space, this value can be increased to accommodate for that.

CONFIG_BT_RX_PRIO

RX task priority.

CONFIG_BT_PERIPHERAL

Peripheral Role support, if the macro is set to 0, feature is disabled, if 1, feature is enabled. Select this for LE Peripheral role support.

CONFIG_BT_BROADCASTER

Broadcaster Role support, if the macro is set to 0, feature is disabled, if 1, feature is enabled. Select this for LE Broadcaster role support.

CONFIG_BT_EXT_ADV

Extended Advertising and Scanning support [EXPERIMENTAL], if the macro is set to 0, feature is disabled, if 1, feature is enabled. Select this to enable Extended Advertising API support. This enables support for advertising with multiple advertising sets, extended advertising data, and advertising on LE Coded PHY. It enables support for receiving extended advertising data as a scanner, including support for advertising data over the LE coded PHY. It enables establishing connections over LE Coded PHY.

CONFIG_BT_CENTRAL

Central Role support, if the macro is set to 0, feature is disabled, if 1, feature is enabled. Select this for LE Central role support.

CONFIG_BT_WHITELIST

Enable whitelist support. This option enables the whitelist API. This takes advantage of the whitelisting feature of a Bluetooth LE controller. The whitelist is a global list and the same whitelist is used by both scanner and advertiser. The whitelist cannot be modified while it is in use. An Advertiser can whitelist which peers can connect or request scan response data. A scanner can whitelist advertiser for which it generates advertising reports. Connections can be established automatically for whitelisted peers.

This option deprecates the bt_le_set_auto_conn API in favor of the bt_conn_create_aute_le API.

CONFIG_BT_DEVICE_NAME

Bluetooth device name. Name can be up to 248 bytes long (excluding NULL termination). Can be empty string.

CONFIG_BT_DEVICE_APPEARANCE

Bluetooth device appearance. For the list of possible values, see the link: www.bluetooth.com/specifications/assigned-numbers.

CONFIG_BT_DEVICE_NAME_DYNAMIC

Allow to set Bluetooth device name on runtime. Enabling this option allows for runtime configuration of Bluetooth device name.

CONFIG_BT_ID_MAX

Maximum number of local identities, range 1 to 10 is valid. Maximum number of supported local identity addresses. For most products, this is safe to leave as the default value (1). Range 1 to 10 is valid.

CONFIG_BT_CONN

Connection enablement, if the macro is set to 0, feature is disabled, if 1, feature is enabled.

CONFIG_BT_MAX_CONN

it is the max connection supported by host stack. Maximum number of simultaneous Bluetooth connections supported.

CONFIG_BT_HCI_ACL_FLOW_CONTROL

Controller to host ACL flow control support. Enable support for throttling ACL buffers from the controller to the host. This is useful when the host and controller are on separate cores, since it ensures that we do not run out of incoming ACL buffers.

CONFIG_BT_PHY_UPDATE

PHY Update, if the macro is set to 0, feature is disabled, if 1, feature is enabled. Enable support for Bluetooth 5.0 PHY Update Procedure.

CONFIG_BT_DATA_LEN_UPDATE

Data Length Update. If the macro is set to 0, feature is disabled, if 1, feature is enabled. Enable support for Bluetooth v4.2 LE Data Length Update procedure.

CONFIG_BT_CREATE_CONN_TIMEOUT

Timeout for pending LE Create Connection command in seconds.

CONFIG_BT_CONN_PARAM_UPDATE_TIMEOUT

Peripheral connection parameter update timeout in milliseconds, range 1 to 65535 is valid. The value is a timeout used by peripheral device to wait until it starts the connection parameters update procedure to change default connection parameters. The default value is set to 5s, to comply with BT protocol specification: Core 4.2 Vol 3, Part C, 9.3.12.2 Range 1 to 65535 is valid.

CONFIG_BT_CONN_TX_MAX

Maximum number of pending TX buffers. Maximum number of pending TX buffers that have not yet been acknowledged by the controller.

CONFIG_BT_REMOTE_INFO

Enable application access to remote information. Enable application access to the remote information available in the stack. The remote information is retrieved once a connection has been established and the application is notified when this information is available through the remote_version_available connection callback.

CONFIG_BT_REMOTE_VERSION

Enable fetching of remote version. Enable this to get access to the remote version in the Controller and in the host through bt_conn_get_info(). The fields in question can be then found in the bt_conn_info struct.

CONFIG_BT_SMP_SC_ONLY

Secure Connections Only Mode. This option enables support for Secure Connection Only Mode. In this mode device shall only use Security Mode 1 Level 4 with exception for services that only require Security Mode 1 Level 1 (no security). Security Mode 1 Level 4 stands for authenticated LE Secure Connections pairing with encryption. Enabling this option disables legacy pairing.

CONFIG_BT_SMP_OOB_LEGACY_PAIR_ONLY

Force Out of Band Legacy pairing. This option disables Legacy and LE SC pairing and forces legacy OOB.

CONFIG_BT_SMP_DISABLE_LEGACY_JW_PASSKEY

Forbid usage of insecure legacy pairing methods. This option disables Just Works and Passkey legacy pairing methods to increase security.

CONFIG_BT_PRIVACY

Privacy Feature, if the macro is set to 0, feature is disabled, if 1, feature is enabled. Enable local Privacy Feature support. This makes it possible to use Resolvable Private Addresses (RPAs).

CONFIG_BT_ECC

Enable ECDH key generation support. This option adds support for ECDH HCI commands.

CONFIG_BT_TINYCRYPT_ECC

Use TinyCrypt library for ECDH. If this option is used to set TinyCrypt library which is used for emulating the ECDH HCI commands and events needed by e.g. LE Secure Connections. In builds including the Bluetooth LE host, if don't set the controller crypto which is used for ECDH and if the controller doesn't support the required HCI commands the LE Secure Connections support will be disabled. In builds including the HCI Raw interface and the Bluetooth LE controller, this

option injects support for the 2 HCI commands required for LE Secure Connections so that hosts can make use of those. The option defaults to enabled for a combined build with Zephyr's own controller, since it does not have any special ECC support itself (at least not currently).

CONFIG_BT_TINYCRYPT_ECC_PRIORITY

Thread priority of ECC Task.

CONFIG_BT_HCI_ECC_STACK_SIZE

Thread stack size of ECC Task.

CONFIG_BT_RPA

Bluetooth Resolvable Private Address (RPA)

CONFIG_BT_RPA_TIMEOUT

Resolvable Private Address timeout, defaults to 900 seconds. This option defines how often resolvable private address is rotated. Value is provided in seconds and defaults to 900 seconds (15 minutes).

CONFIG_BT_SIGNING

Data signing support, if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables data signing which is used for transferring authenticated data in an unencrypted connection.

CONFIG_BT_SMP_APP_PAIRING_ACCEPT

Accept or reject pairing initiative. When receiving pairing request or pairing response queries, the application shall either accept proceeding with pairing or not. This is for pairing over SMP and does not affect SSP, which will continue pairing without querying the application. The application can return an error code, which is translated into an SMP return value if the pairing is not allowed.

CONFIG_BT_SMP_ALLOW_UNAUTH_OVERWRITE

Allow unauthenticated pairing for paired device. This option allows all unauthenticated pairing attempts made by the peer where an unauthenticated bond already exists. This would enable cases where an attacker could copy the peer device address to connect and start an unauthenticated pairing procedure to replace the existing bond. When this option is disabled in order to create a new bond the old bond must be explicitly deleted with bt_unpair.

CONFIG_BT_FIXED_PASSKEY

Use a fixed passkey for pairing, set passkey to fixed or not. With this option enabled, the application will be able to call the bt_passkey_set() API to set a fixed passkey. If set, the pairing_confim() callback will be called for all incoming pairings.

CONFIG_BT_BONDABLE

Bondable Mode, if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables support for Bondable Mode. In this mode, Bonding flag in AuthReq of SMP Pairing Request/Response is set indicating the support for this mode.

CONFIG_BT_BONDING_REQUIRED

Always require bonding. When this option is enabled remote devices are required to always set the bondable flag in their pairing request. Any other kind of requests will be rejected.

CONFIG_BT_SMP_ENFORCE_MITM

Enforce MITM protection, if the macro is set to 0, feature is disabled, if 1, feature is enabled. With this option enabled, the Security Manager is set MITM option in the Authentication Requirements Flags whenever local IO Capabilities allow the generated key to be authenticated.

CONFIG_BT_OOB_DATA_FIXED

Use a fixed random number for LESC OOB pairing. With this option enabled, the application will be able to perform LESC pairing with OOB data that consists of fixed random number and confirm value. This option should only be enabled for debugging and should never be used in production.

CONFIG_BT_KEYS_OVERWRITE_OLDEST

Overwrite oldest keys with new ones if key storage is full. With this option enabled, if a pairing attempt occurs and the key storage is full, then the oldest keys in storage will be removed to free space for the new pairing keys.

CONFIG_BT_HOST_CCM

Enable host side AES-CCM module. Enables the software-based AES-CCM engine in the host. Will use the controller's AES encryption functions if available, or BT_HOST_CRYPTO otherwise.

CONFIG_BT_L2CAP_RX_MTU

Maximum supported L2CAP MTU for incoming data, if CONFIG_BT_SMP is set, range is 65 to 1300, otherwise range is 23 to 1300. Maximum size of each incoming L2CAP PDU. Range is 23 to 1300 range is 65 to 1300 for CONFIG_BT_SMP.

CONFIG_BT_L2CAP_TX_BUF_COUNT

Number of buffers available for outgoing L2CAP packets, ranging from 2 to 255. Range is 2 to 255.

CONFIG_BT_L2CAP_TX_FRAG_COUNT

Number of L2CAP TX fragment buffers, ranging from 0 to 255. Number of buffers available for fragments of TX buffers.

Warning: Setting this to 0 means that the application must ensure that queued TX buffers never need to be fragmented, that is the controller's buffer size is large enough. If this is not ensured, and there are no dedicated fragment buffers, a deadlock may occur. In most cases the default value of 2 is a safe bet. Range is 0 to 255.

CONFIG_BT_L2CAP_TX_MTU

Maximum supported L2CAP MTU for L2CAP TX buffers, if CONFIG_BT_SMP is set, the range is 65 to 2000. Otherwise, range is 23 to 2000. Range is 23 to 2000. Range is 65 to 2000 for CONFIG_BT_SMP.

CONFIG_BT_L2CAP_DYNAMIC_CHANNEL

L2CAP Dynamic Channel support. This option enables support for LE Connection oriented Channels, allowing the creation of dynamic L2CAP Channels.

CONFIG_BT_L2CAP_DYNAMIC_CHANNEL

L2CAP Dynamic Channel support. This option enables support for LE Connection oriented Channels, allowing the creation of dynamic L2CAP Channels.

Bluetooth BR/EDR support [EXPERIMENTAL] This option enables Bluetooth BR/EDR support.

CONFIG_BT_ATT_PREPARE_COUNT

Number of ATT prepares write buffers, if the macro is set to 0, feature is disabled, if greater than 1, feature is enabled. Number of buffers available for ATT prepares write, setting this to 0 disables GATT long/reliable writes.

CONFIG_BT_ATT_TX_MAX

Maximum number of queued outgoing ATT PDUs. Number of ATT PDUs that can be at a single moment queued for transmission. If the application tries to send more than this amount the calls blocks until an existing queued PDU gets sent. Range is 1 to CONFIG_BT_L2CAP_TX_BUF_COUNT.

CONFIG_BT_GATT_SERVICE_CHANGED

GATT Service Changed support, if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables support for the service changed characteristic.

CONFIG_BT_GATT_DYNAMIC_DB

GATT dynamic database support, if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables registering/unregistering services at runtime.

CONFIG_BT_GATT_CACHING

GATT Caching support, if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables support for GATT Caching. When enabled the stack registers Client Supported Features and Database Hash characteristics which is used by clients to detect if anything has changed on the GATT database.

CONFIG_BT_GATT_CLIENT

GATT client support, if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables support for the GATT Client role.

CONFIG_BT_GATT_READ_MULTIPLE

GATT Read Multiple Characteristic. Values support, if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables support for the GATT Read Multiple Characteristic Values procedure.

CONFIG_BT_GAP_AUTO_UPDATE_CONN_PARAMS

Automatic Update of Connection Parameters, if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option, if enabled, allows automatically sending request for connection parameters update after GAP recommended 5 seconds of connection as peripheral.

CONFIG_BT_GAP_PERIPHERAL_PREF_PARAMS

Configure peripheral preferred connection parameters. This configures peripheral preferred connection parameters. Enabling this option results in adding PPCP characteristic in GAP. If disabled it is up to application to set expected connection parameters.

CONFIG_BT_MAX_PAIRED

Maximum number of paired devices. Maximum number of paired Bluetooth devices. The minimum (and default) number is 1.

CONFIG_BT_MAX_SCO_CONN

Maximum number of simultaneous SCO connections. Maximum number of simultaneous Bluetooth synchronous connections supported. The minimum (and default) number is 1. Range 1 to 3 is valid.

CONFIG_BT_RFCOMM

Bluetooth RFCOMM protocol support [EXPERIMENTAL], if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables Bluetooth RFCOMM support.

CONFIG_BT_RFCOMM_L2CAP_MTU

L2CAP MTU for RFCOMM frames. Maximum size of L2CAP PDU for RFCOMM frames.

CONFIG_BT_HFP_HF

Bluetooth Handsfree profile HF Role support [EXPERIMENTAL], if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables Bluetooth HF support.

CONFIG_BT_AVDTP

Bluetooth AVDTP protocol support [EXPERIMENTAL], if the macro is set to 0, feature is disabled, if 1, feature is enabled. This option enables Bluetooth AVDTP support.

CONFIG_BT_A2DP

Bluetooth A2DP Profile [EXPERIMENTAL]. This option enables the A2DP profile.

CONFIG_BT_A2DP_SOURCE

Bluetooth A2DP profile source function. This option enables the A2DP profile Source function.

CONFIG_BT_A2DP_SINK

Bluetooth A2DP profile sink function. This option enables the A2DP profile Sink function.

CONFIG_BT_A2DP_TASK_PRIORITY

Bluetooth A2DP profile task priority. This option sets the task priority. The task is used to process the streamer data and retry command.

CONFIG_BT_A2DP_TASK_STACK_SIZE

Bluetooth A2DP profile task stack size. This option sets the task stack size.

CONFIG_BT_PAGE_TIMEOUT

Bluetooth Page Timeout. This option sets the page timeout value. Value is selected as (N * 0.625) ms.

CONFIG_BT_DIS_MODEL

Model name. The device model inside Device Information Service.

CONFIG_BT_DIS_MANUF

Manufacturer name. The device manufacturer inside Device Information Service.

CONFIG_BT_DIS_PNP

Enable PnP_ID characteristic. Enable PnP_ID characteristic in Device Information Service.

CONFIG_BT_DIS_PNP_VID_SRC

Vendor ID source, range 1 - 2. The Vendor ID Source field designates which organization assigned the value used in the Vendor ID field value. The possible values are:

- 1 Bluetooth SIG, the Vendor ID was assigned by the Bluetooth SIG
- 2 USB IF, the Vendor ID was assigned by the USB IF

CONFIG_BT_DIS_PNP_VID

Vendor ID, range 0 - 0xFFFF. The Vendor ID field is intended to uniquely identify the vendor of the device. This field is used in conjunction with Vendor ID Source field, which determines which organization assigned the Vendor ID field value. Note: The Bluetooth Special Interest Group assigns Device ID Vendor ID, and the USB Implementers Forum assigns Vendor IDs, either of which can be used for the Vendor ID field value. Device providers should procure the Vendor ID from the USB Implementers Forum or the Company Identifier from the Bluetooth SIG.

CONFIG_BT_DIS_PNP_PID

Product ID, range 0 - 0xFFFF. The Product ID field is intended to distinguish between different products made by the vendor identified with the Vendor ID field. The vendors themselves manage Product ID field values.

CONFIG_BT_DIS_PNP_VER

Product Version, range 0 - 0xFFFF. The Product Version field is a numeric expression identifying the device release number in Binary-Coded Decimal. This is a vendor-assigned value, which defines the version of the product identified by the Vendor ID and Product ID fields. This field is intended to differentiate between versions of products with identical Vendor IDs and Product IDs. The value of the field value is 0xJJMN for version JJ.M.N (JJ - major version number, M - minor version number, N - subminor version number); For example, version 2.1.3 is represented with value 0x0213 and version 2.0.0 is represented with a value of 0x0200. When upward-compatible changes are made to the device, it is recommended that the minor version number be incremented. If incompatible changes are made to the device. It is recommended that the major version number is incremented. The subminor version is incremented for bug fixes.

CONFIG_BT_DIS_SERIAL_NUMBER

Enable DIS Serial number characteristic, 1 - enable, 0 - disable. Enable Serial Number characteristic in Device Information Service.

CONFIG_BT_DIS_SERIAL_NUMBER_STR

Serial Number. Serial Number characteristic string in Device Information Service.

CONFIG_BT_DIS_FW_REV

Enable DIS Firmware Revision characteristic, 1 - enable, 0 - disable. Enable Firmware Revision characteristic in Device Information Service.

CONFIG_BT_DIS_FW_REV_STR

Firmware revision. Firmware Revision characteristic String in Device Information Service.

CONFIG_BT_DIS_HW_REV

Enable DIS Hardware Revision characteristic, 1 - enable, 0 - disable. Enable Hardware Revision characteristic in Device Information Service.

CONFIG_BT_DIS_HW_REV_STR

Hardware revision. Hardware Revision characteristic String in Device Information Service.

CONFIG_BT_DIS_SW_REV

Enable DIS Software Revision characteristic, 1 - enable, 0 - disable. Enable Software Revision characteristic in Device Information Service.

CONFIG_BT_DIS_SW_REV_STR

Software revision Software revision characteristic String in Device Information Service.

CONFIG_SYSTEM_WORKQUEUE_STACK_SIZE

System work queue stack size.

CONFIG_SYSTEM_WORKQUEUE_PRIORITY

System work queue priority.

CONFIG_BT_HCI_TRANSPORT_INTERFACE_TYPE

HCI transport interface type.

CONFIG_BT_HCI_TRANSPORT_INTERFACE_INSTANCE

HCI transport interface instance number.

CONFIG_BT_HCI_TRANSPORT_INTERFACE_SPEED

HCI transport interface rate. Configures the interface speed, for example, the default interface is h4, the speed to 115200

CONFIG_BT_HCI_TRANSPORT_TX_THREAD

Whether enable HCI transport TX thread.

CONFIG_BT_HCI_TRANSPORT_RX_THREAD

Whether enable HCI transport RX thread.

CONFIG_BT_HCI_TRANSPORT_RX_STACK_SIZE

HCI transport RX thread stack size.

CONFIG_BT_HCI_TRANSPORT_TX_STACK_SIZE

HCI transport TX thread stack size.

CONFIG_BT_HCI_TRANSPORT_TX_PRIO

HCI transport TX thread priority.

CONFIG_BT_HCI_TRANSPORT_RX_PRIO

HCI transport RX thread priority.

CONFIG_BT_MSG_QUEUE_COUNT

Message number in message queue.

Rework Guide for EdgeFast Bluetooth Protocol Abstraction Layer

Hardware Rework Guide for MIMXRT1170-EVKB and Murata M.2 Module This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT1170-EVKB and the Murata's 1XK, 1ZM, 2EL or 2LL solution - direct M.2 connection to Embedded Artists EAR00385 (1XK), EAR00364 (1ZM), Rev-A1 (2EL) or EAR00500 (2LL) M.2 modules.

The hardware rework has two parts:

- HCI UART rework
- PCM interface rework

Hardware rework

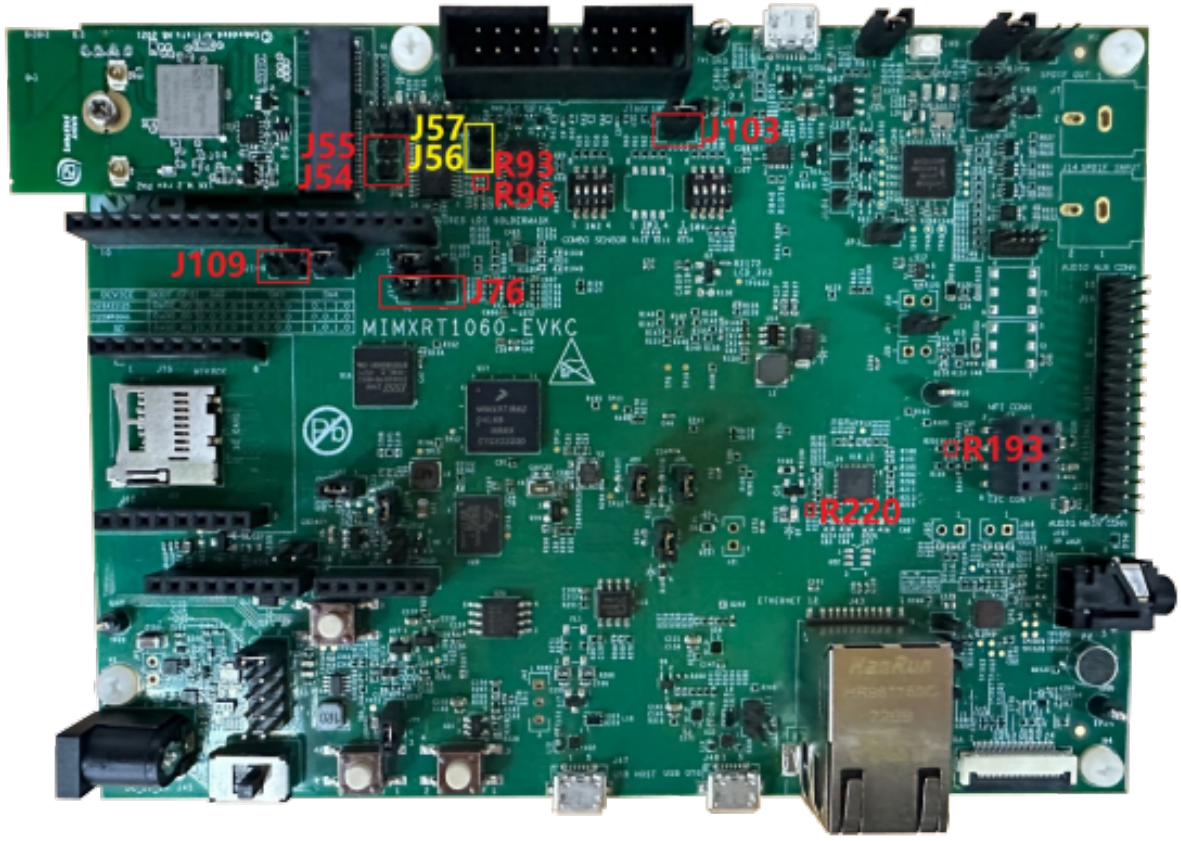
- **HCI UART rework**

1. Mount R93, R96.
2. Remove R193.
3. Connect J109, connect J76 2-3.

- **PCM interface rework**

1. Remove J54 and J55, connect J56 and J57.
2. Remove R220.
3. Connect J103.

Note: When J103 is connected, flash cannot be downloaded. So, remove the connection when downloading flash and reconnect it after downloading.



Parent topic:*Hardware Rework Guide for MIMXRT1060-EVKC and Murata M.2 Module*

Hardware Rework Guide for MIMXRT1170-EVKB and Murata 2EL M.2 Module Hardware Rework Guide for MIMXRT1170-EVKB and Murata

2EL M.2 Module

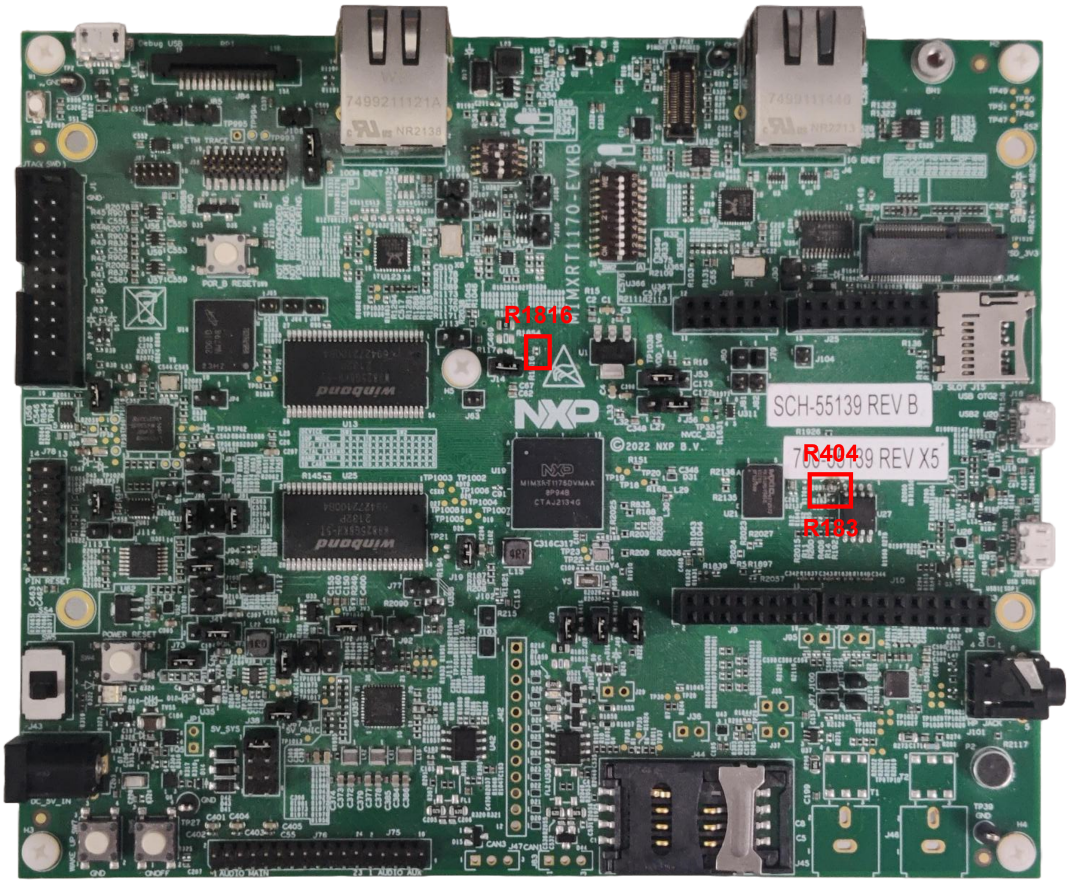
This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT1170-EVKB and the Murata 2EL M.2 solution - direct M.2 connection to Embedded Artists' Rev-A1 (2EL) M.2 modules.

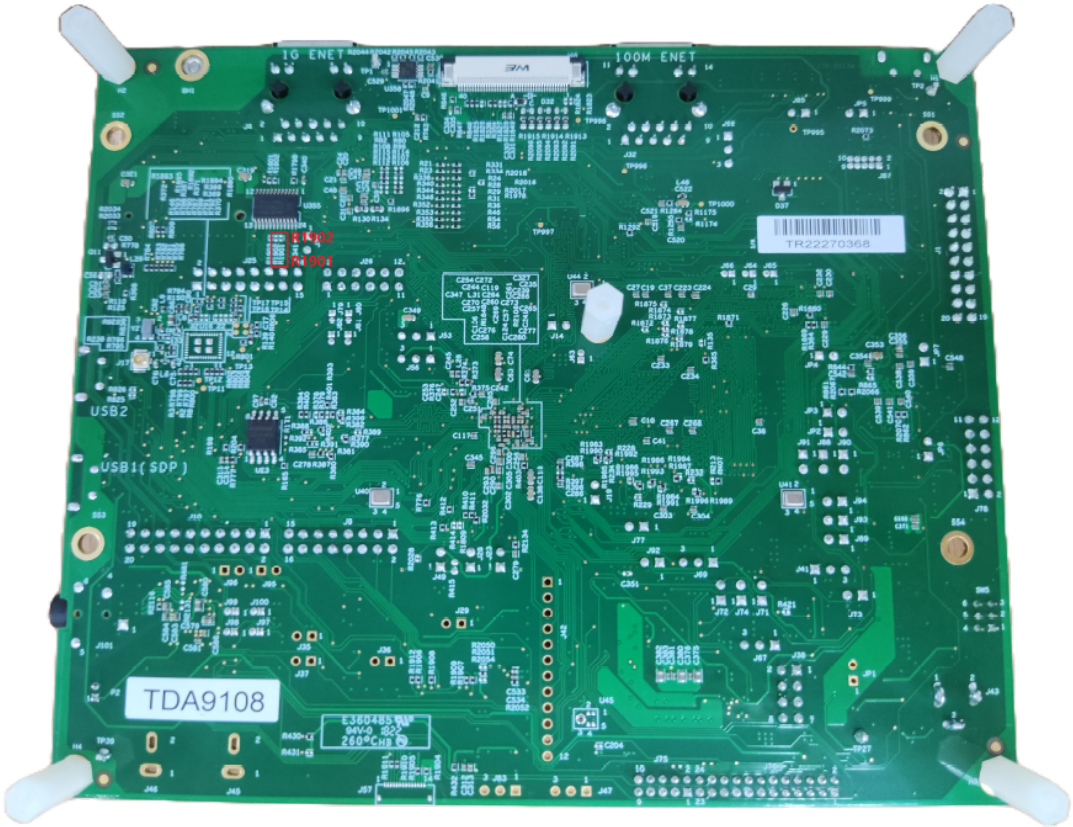
The hardware rework has three parts:

- HCI UART rework
- PCM interface rework
- LE Audio Synchronization interface rework (only used on sink side)

Hardware rework

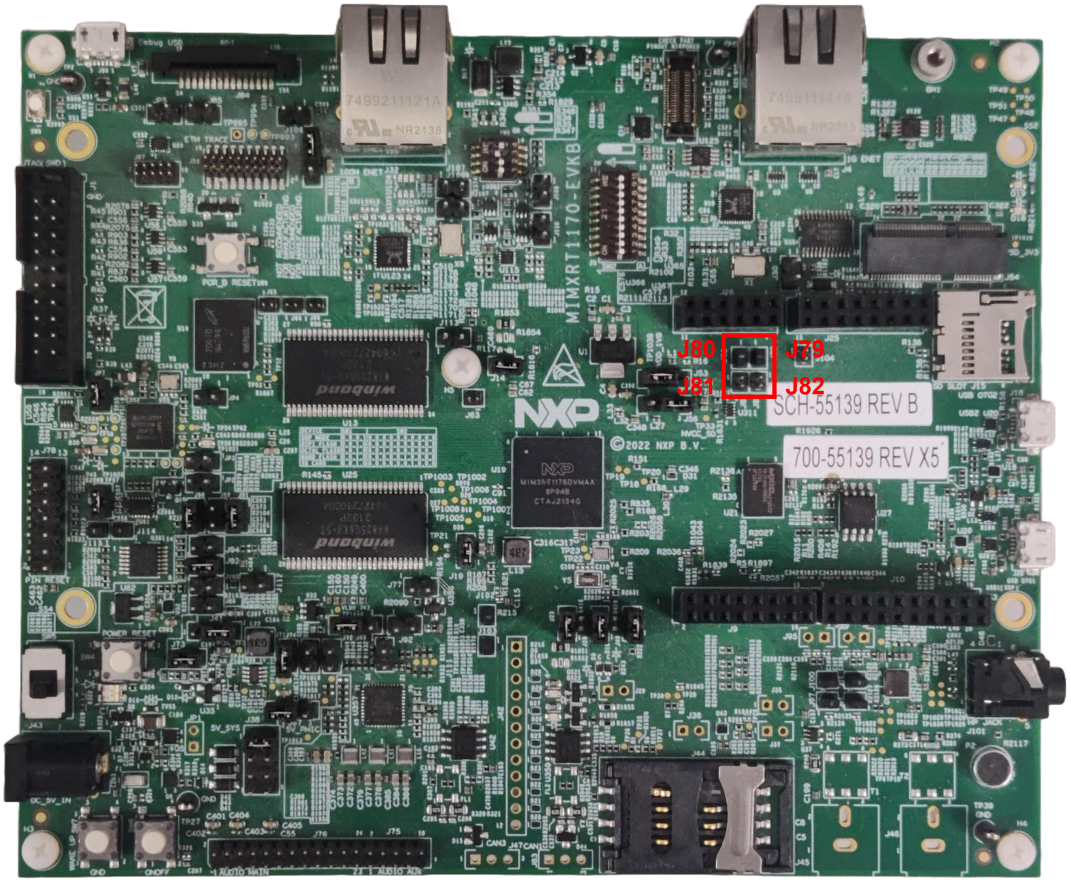
- **HCI UART rework**
  1. Remove resistors R183 and R1816.
  2. Solder 0 ohm resistor to R404, R1901, and R1902.

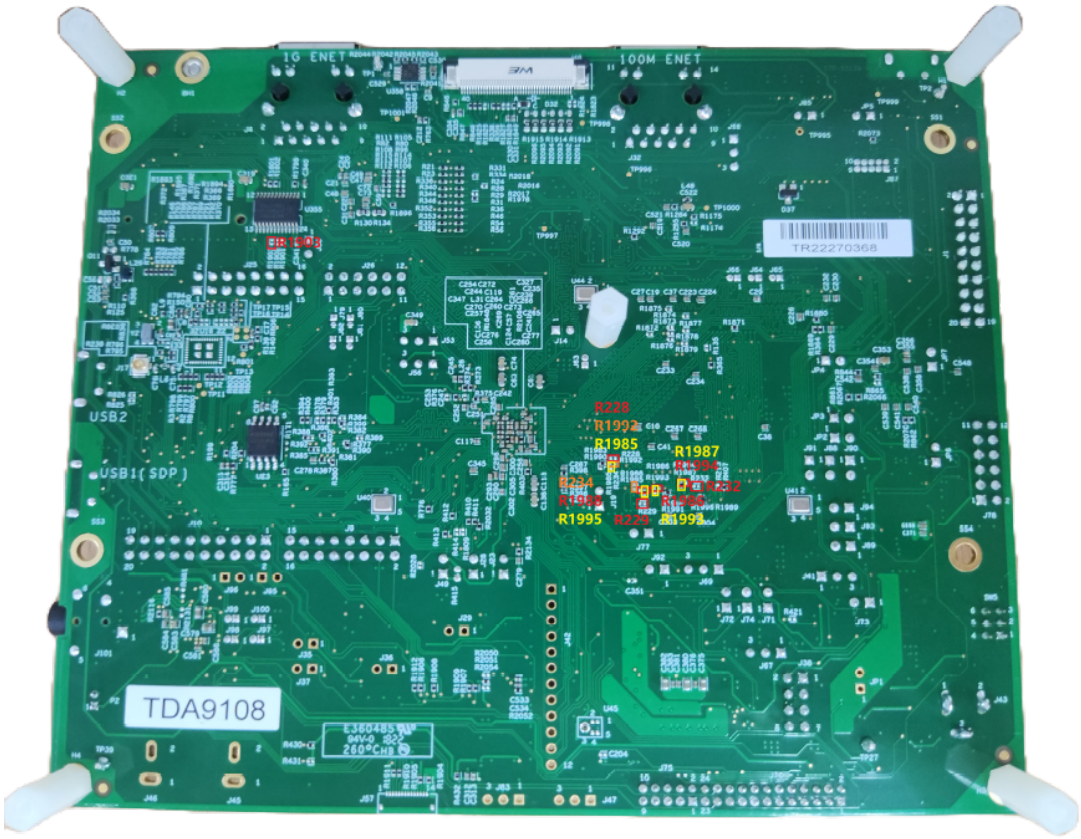




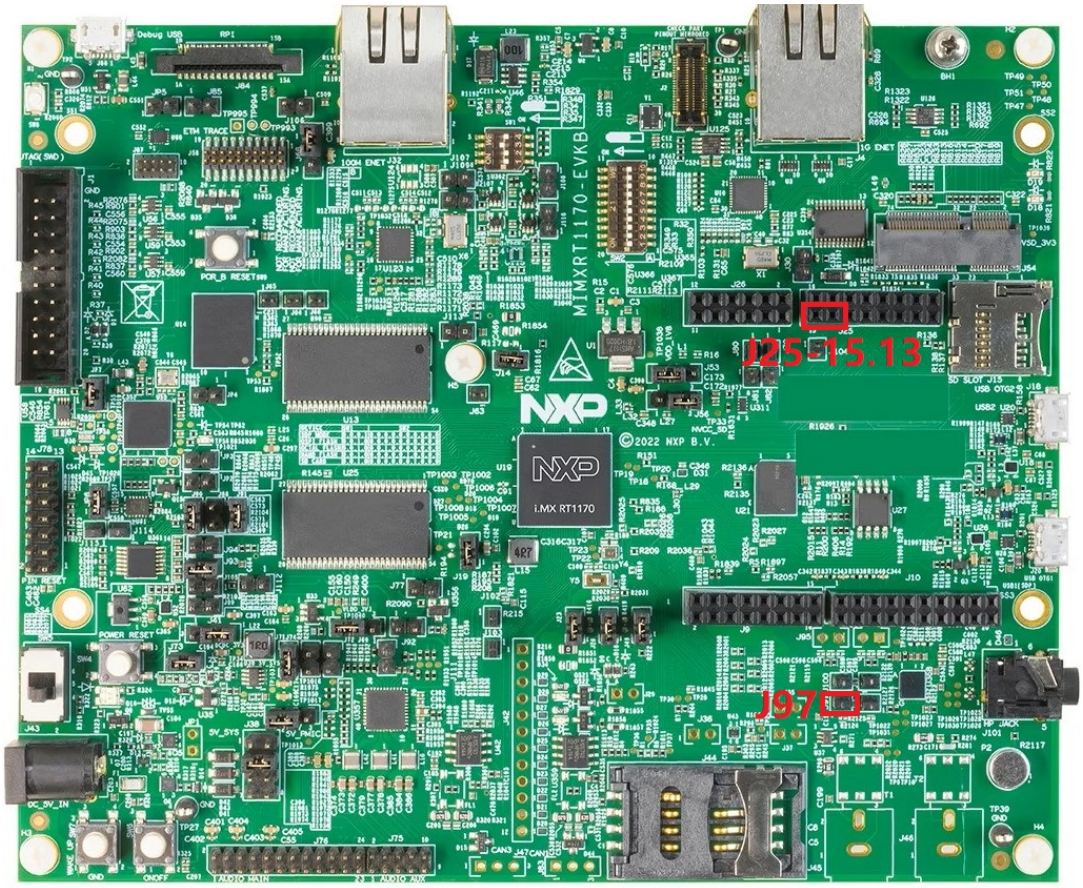
- **PCM interface rework**
  1. Disconnect header J79 and J80.

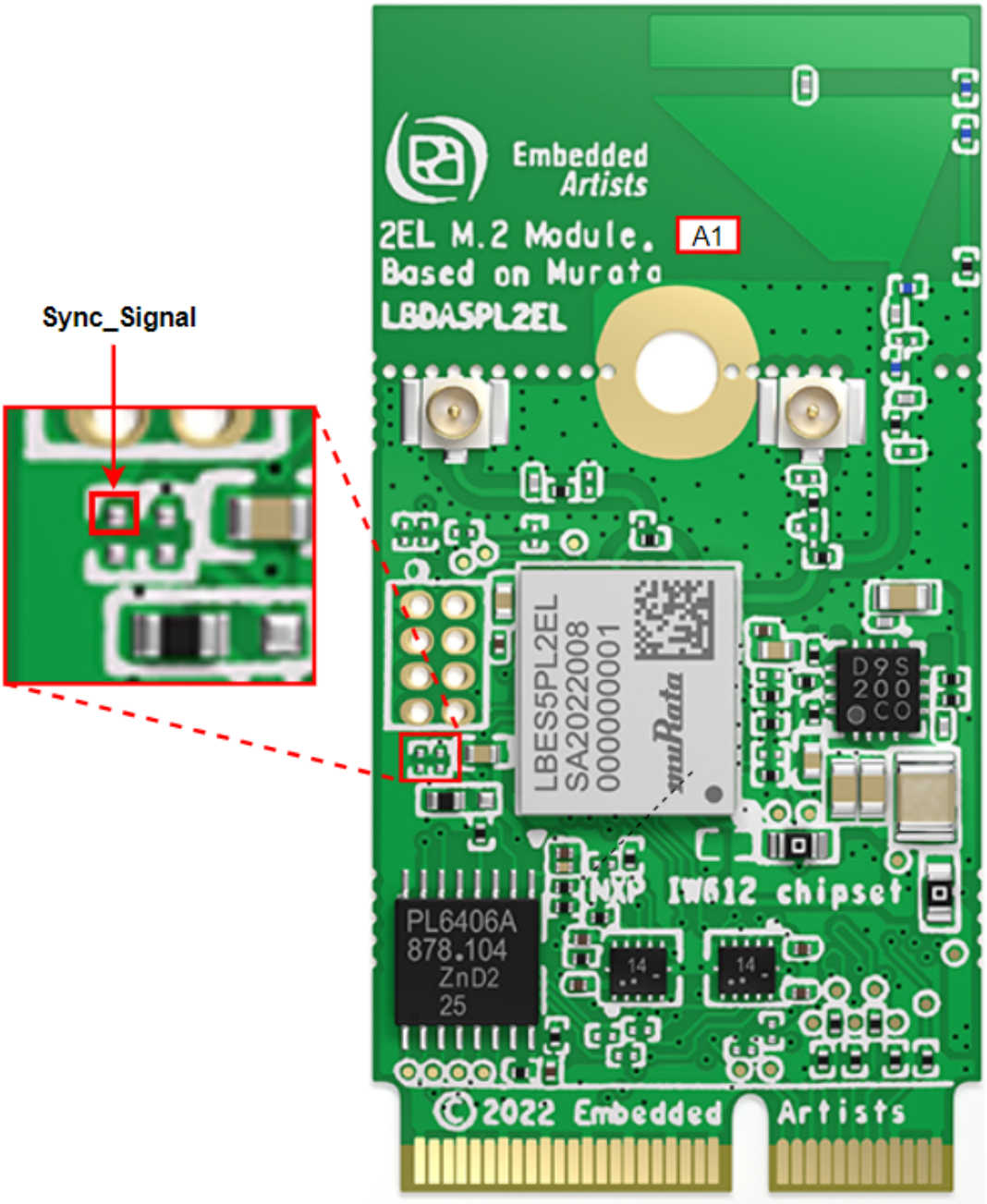
2. Connect header J81 and J82.
3. Remove resistors R1985, R1986, R1987, R1988, R1992, R1993, R1994, and R1995.
4. Solder 0 ohm resistor to R228, R229, R232, R234, and R1903.





- LE Audio Synchronization interface rework (only used on sink side)
  1. Connect J25-15 with J97.
  2. Connect J25-13 with 2EL's GPIO_27


J25 1-3
J97



Parent topic:*Hardware Rework Guide for MIMXRT1170-EVKB and Murata 2EL M.2 Adapter*

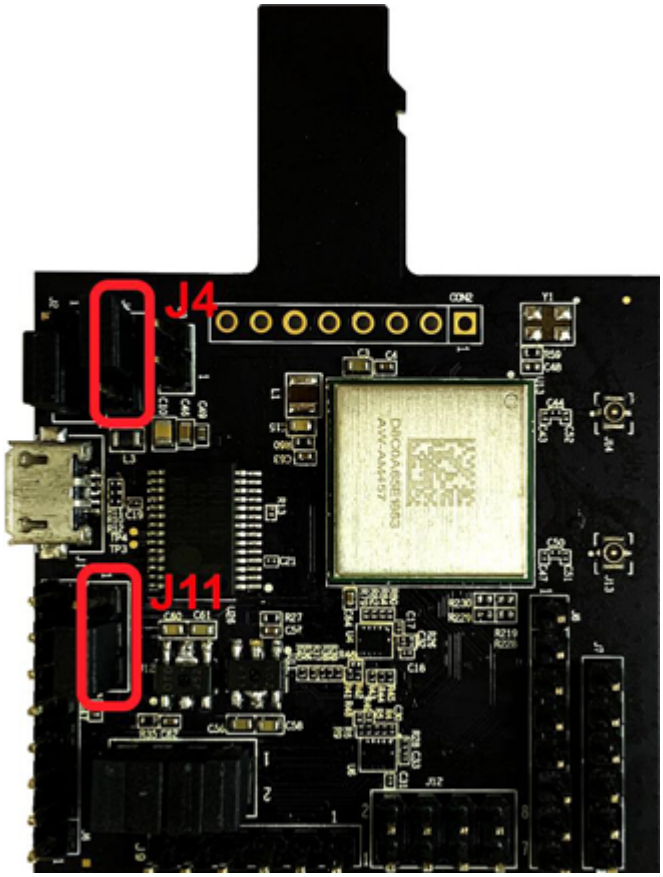
Hardware Rework Guide for MIMXRT685-EVK and AW-AM457-uSD This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT685-EVK board and AW-AM457-uSD. The AW-AM457-uSD user guide is available here.The hardware rework has one part:

- HCI UART rework

Hardware rework **HCI UART rework**

- R398 move from 1-2 to 2-3
- JP12 2-3
- Connect the pins of two boards as the following table.

Pin Name	AW-AM457-uSD	i.MX RT685	PIN NAME	GPIONAME of i.MX RT685
UART_TXD	J10 (pin 4)	J27 (pin 1)	US-ART4_RXD	FC4_RXD_SDA_MOSI_DATA
UART_RXD	J10 (pin 2)	J27 (pin 2)	USART4_TXD	FC4_TXD_SCL_MISO_WS
UART_RTS	J10 (pin 6)	J47 (pin 9)	USART4_CTS	FC4_CTS_SDA_SSEL0
UART_CTS	J10 (pin 8)	J27 (pin 5)	USART4_RTS	FC4_RTS_SCL_SSEL1
GND	J6 (pin 7)	J29 (pin 6)	GND	GND



Jumper Settings:

- Connect J4[2-3] for VIO 3.3 V supply
- Connect J11[2-3] for VIO_SD 3.3 V supply

PCM interface rework

Connect the pins of two boards as the following table.

Pin Name	AW-AM457-uSD	i.MX RT685	PIN NAME of I.MX RT685	GPIONAME of I.MX RT685
PCM_IN	J9 (pin 1)	J47 (pin 7)	I2S2_TXD	FC2_RXD_SDA_MOSI_DATA
PCM_OUT	J9 (pin 2)	J28 (pin 4)	I2S5_RXD	FC5_RXD_SDA_MOSI_DATA
PCM_SYNC	J9 (pin 3)	J28 (pin 5)	I2S5_WS	FC5_TXD_SCL_MISO_WS
PCM_CLK	J9 (pin 4)	J28 (pin 6)	I2S5_SCK	FC5_SCK
GND	J9 (pin 6)	J29 (pin 7)	GND	GND

Parent topic:*Hardware Rework Guide for MIMXRT685-EVK and AW-AM457-uSD*

Hardware Rework Guide for MIMXRT685-EVK and AW-CM358-uSD This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT685-EVK board and AW-CM358-uSD. The AW-CM358-uSD user guide is available here. The hardware rework has one part:

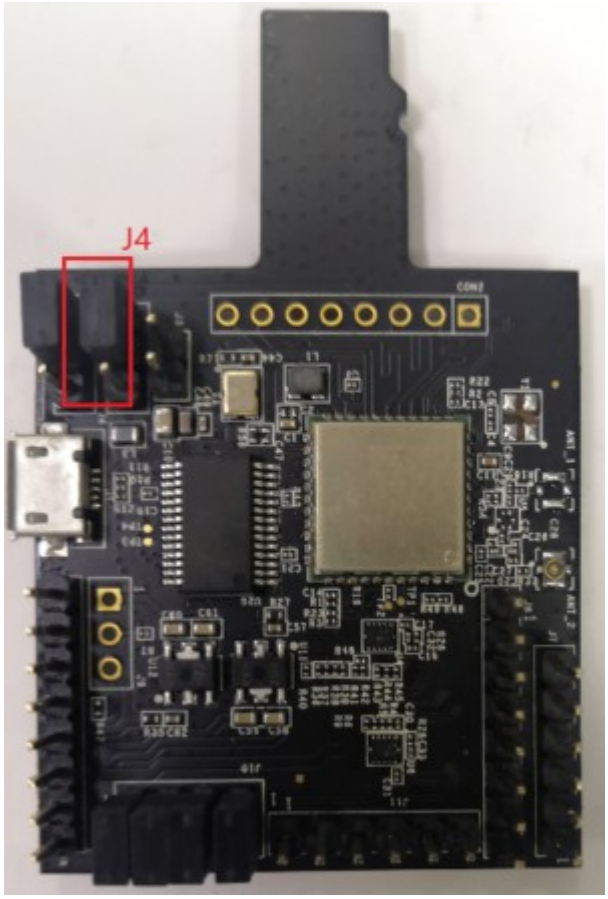
- HCI UART rework

Hardware rework **HCI UART rework**

R398 move from 1-2 to 2-3.

Connect the pins of two boards as the following table.

Pin Name	AW-CM358-USD	i.MXRT685	PIN NAME	GPIONAME of RT685
UART_TXD	J10 (pin 4)	J27 (pin 1)	USART4_RXD	FC4_RXD_SDA_MOSI_DATA
UART_RXD	J10 (pin 2)	J27 (pin 2)	USART4_TXD	FC4_TXD_SCL_MISO_WS
UART_RTS	J10 (pin 6)	J47 (pin 9)	USART4_CTS	FC4_CTS_SDA_SSEL0
UART_CTS	J10 (pin 8)	J27 (pin 5)	USART4_RTS	FC4_RTS_SCL_SSEL1
GND	J6 (pin 7)	J29 (pin 6)	GND	GND



Jumper Setting:

Connect J4[1-2] for VIO 1.8 V supply.

PCM interface rework

Connect the pins of two boards as the following table.

Pin Name	AW-CM358-USD	i.MX RT685	PIN NAME of RT685	GPIONAME of RT685
PCM_IN	J11 (pin 1)	J47 (pin 7)	I2S2_TXD	FC2_RXD_SDA_MOSI_DATA
PCM_OUT	J11 (pin 2)	J28 (pin 4)	I2S5_RXD	FC5_RXD_SDA_MOSI_DATA
PCM_SYNC	J11 (pin 3)	J28 (pin 5)	I2S5_WS	FC5_TXD_SCL_MISO_WS
PCM_CLK	J11 (pin 4)	J28 (pin 6)	I2S5_SCK	FC5_SCK
GND	J11 (pin 5)	J29 (pin 7)	GND	GND

Parent topic:*Hardware Rework Guide for MIMXRT685-EVK and AW-CM358-uSD*

Hardware Rework Guide for MIMXRT685-EVK and AW-AM510-uSD This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT685-EVK board and AW-AM510-uSD. The AW-AM510-uSD user guide is available here. The hardware rework has one part:

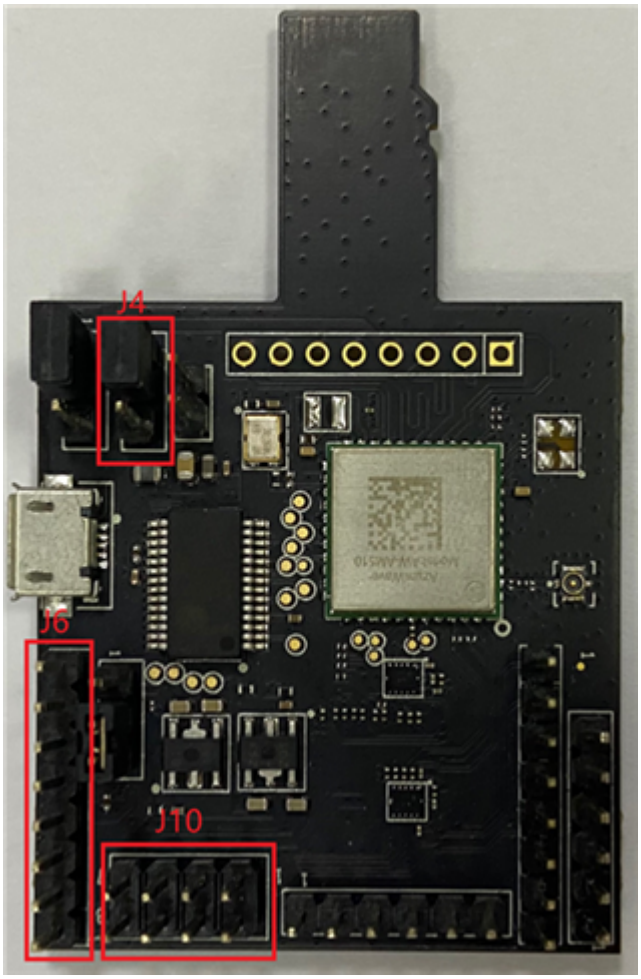
- HCI UART rework

Hardware rework

- **HCI UART rework**

Connect the pins of two boards as the following table.

Pin Name	AW-AM510-uSD	i.MXRT685	PIN NAME	GPIO NAME of RT685
UART_TXD	J10 (pin 4)	J27 (pin 1)	USART4_RXD	FC4_RXD_SDA_MOSI_DATA
UART_RXD	J10 (pin 2)	J27 (pin 2)	USART4_TXD	FC4_TXD_SCL_MISO_WS
UART_RTS	J10 (pin 6)	J47 (pin 9)	USART4_CTS	FC4_CTS_SDA_SSEL0
UART_CTS	J10 (pin 8)	J27 (pin 5)	USART4_RTS	FC4_RTS_SCL_SSEL1
GND	J6 (pin 7)	J29 (pin 6)	GND	GND



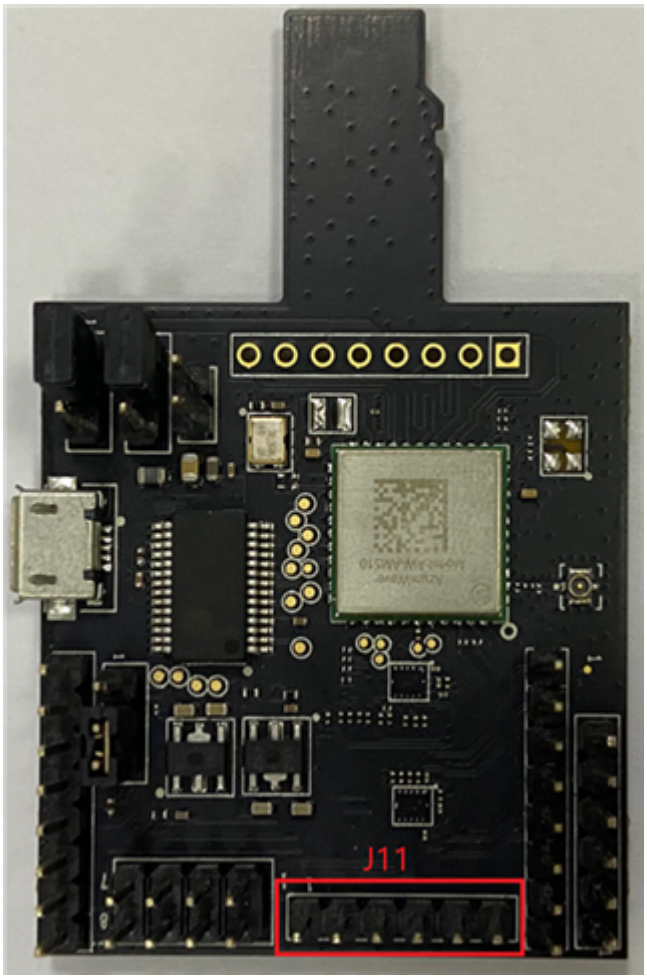
Jumper Setting:

– Connect J4[2-3] for VIO 3.3 V supply

- **PCM interface rework**

Connect the pins of two boards as the following table.

PIN NAME	AW-AM510-USD	i.MX RT685	PIN NAME of RT685	GPIONAME of RT685
PCM_IN	J11 (pin 1)	J47 (pin 7)	I2S2_TXD	FC2_RXD_SDA_MOSI_DATA
PCM_OUT	J11 (pin 2)	J28 (pin 4)	I2S5_RXD	FC5_RXD_SDA_MOSI_DATA
PCM_SYNC	J11 (pin 3)	J28 (pin 5)	I2S5_WS	FC5_TXD_SCL_MISO_WS
PCM_CLK	J11 (pin 4)	J28 (pin 6)	I2S5_SCK	FC5_SCK
GND	J11 (pin 6)	J29 (pin 7)	GND	GND



Parent topic:*Hardware Rework Guide for MIMXRT685-EVK and AW-AM510-uSD*

Hardware Rework Guide for MIMXRT685-EVK and Murata uSD-M.2 Adapter This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT685-EVK board and the Murata uSD-M.2 adapter. For details on the Murata uSD-M.2 Adapter, see Murata's uSD-M.2 webpage.

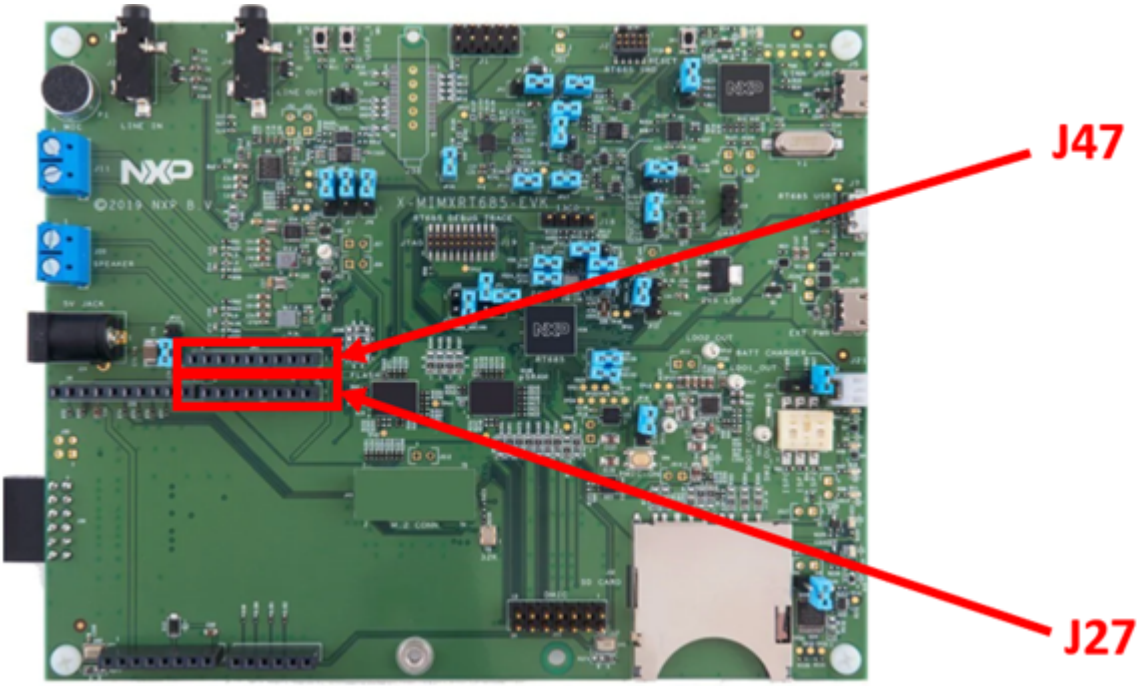
The hardware rework has one part:

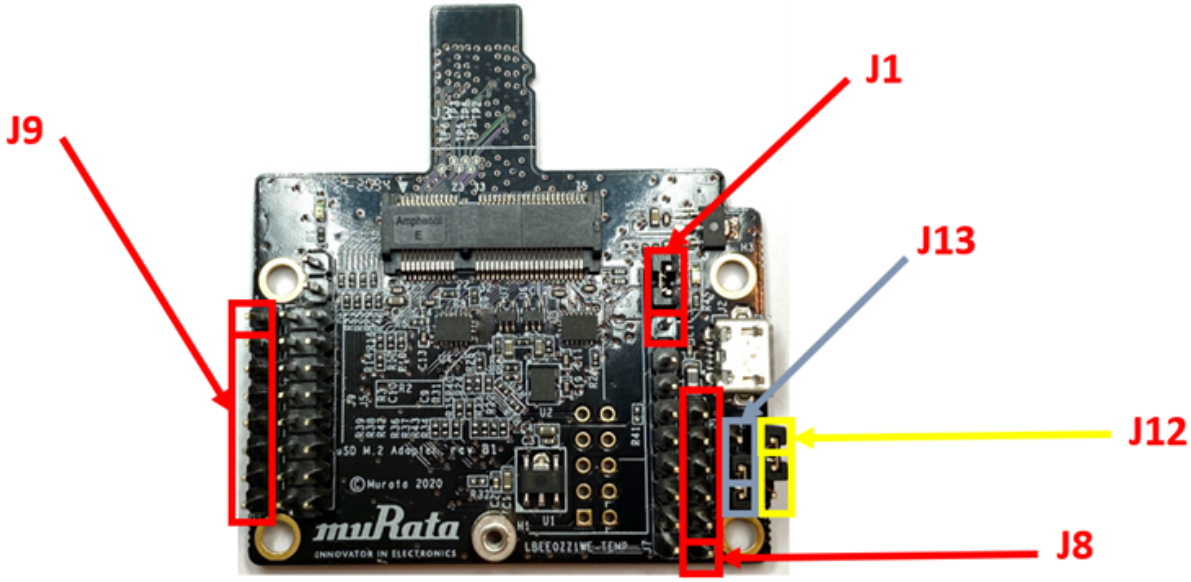
- HCI UART rework

Hardware rework **HCI UART rework :**

- JP12 2-3
- Connect the pins of two boards as the following table using jumper cables included in Murata's uSD-M.2 Adapter kit.

Pin name	uSD-M.2 adapter pin	i.MX RT685 pin	Pin name of RT685	GPIO name of RT685
BT_UART_TXD_HO	J9 (pin 1)	J27 (pin 1)	USART4_RXD	FC4_RXD_SDA_MOSI_DATA
BT_UART_RXD_HO	J9 (pin 2)	J27 (pin 2)	USART4_TXD	FC4_TXD_SCL_MISO_WS
BT_UART_RTS_HO	J8 (pin 3)	J47 (pin 9)	USART4_CTS	FC4_CTS_SDA_SSEL0
BT_UART_CTS_HO	J8 (pin 4)	J27 (pin 5)	USART4_RTS	FC4_RTS_SCL_SSEL1





Murata uSD-M.2 jumper settings:

- Both J12 and J13 = 1-2 (WLAN-SDIO = 1.8 V; and BT-UART and WLAN/BT-CTRL = 3.3 V)
- J1 = 2-3 (3.3 V from uSD connector)

Parent topic:*Hardware Rework Guide for MIMXRT685-EVK and Murata uSD-M.2 Adapter*

Hardware Rework Guide for MIMXRT685-AUD-EVK and Murata M.2 Module This section is a brief hardware rework guidance of the Edgefast Bluetooth PAL on the NXP i.MX MIMXRT685-AUD-EVK board and the Murata's 1XK, 1ZM, 2EL or 2LL solution - direct M.2 connection to Embedded Artists EAR00385 (1XK), EAR00364 (1ZM), Rev-A1 (2EL) or EAR00500 (2LL) M.2 modules.

The hardware rework has one part:

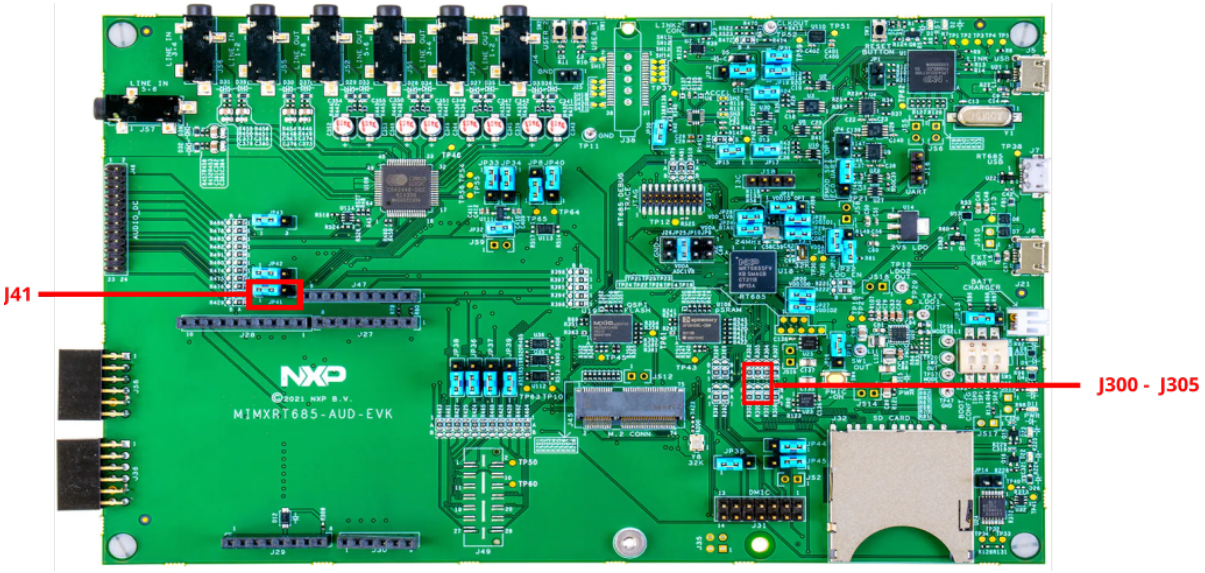
- HCI UART rework

Hardware rework **HCI UART rework:**

Mount R300~R305 A-B

Jumper Setting:

- Connect JP41[2-3]



Parent topic:*Hardware Rework Guide for MIMXRT685-AUD-EVK and Murata M.2 Module*

Hardware Rework Guide for Low Power Feature on MIMXRT595-EVK and Murata 2EL M.2 Module This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL for low power feature on the NXP i.MX MIMXRT595-EVK board and the Murata's 2EL - direct M.2 connection to Embedded Artists' Rev-A1 (2EL) M.2 modules.

The hardware rework has three parts:

- Debug console serial rework
- Host wake-up controller pin rework (H2C)
- Controller wake-up host pin rework (C2H)

Hardware rework

- **Debug console serial rework**

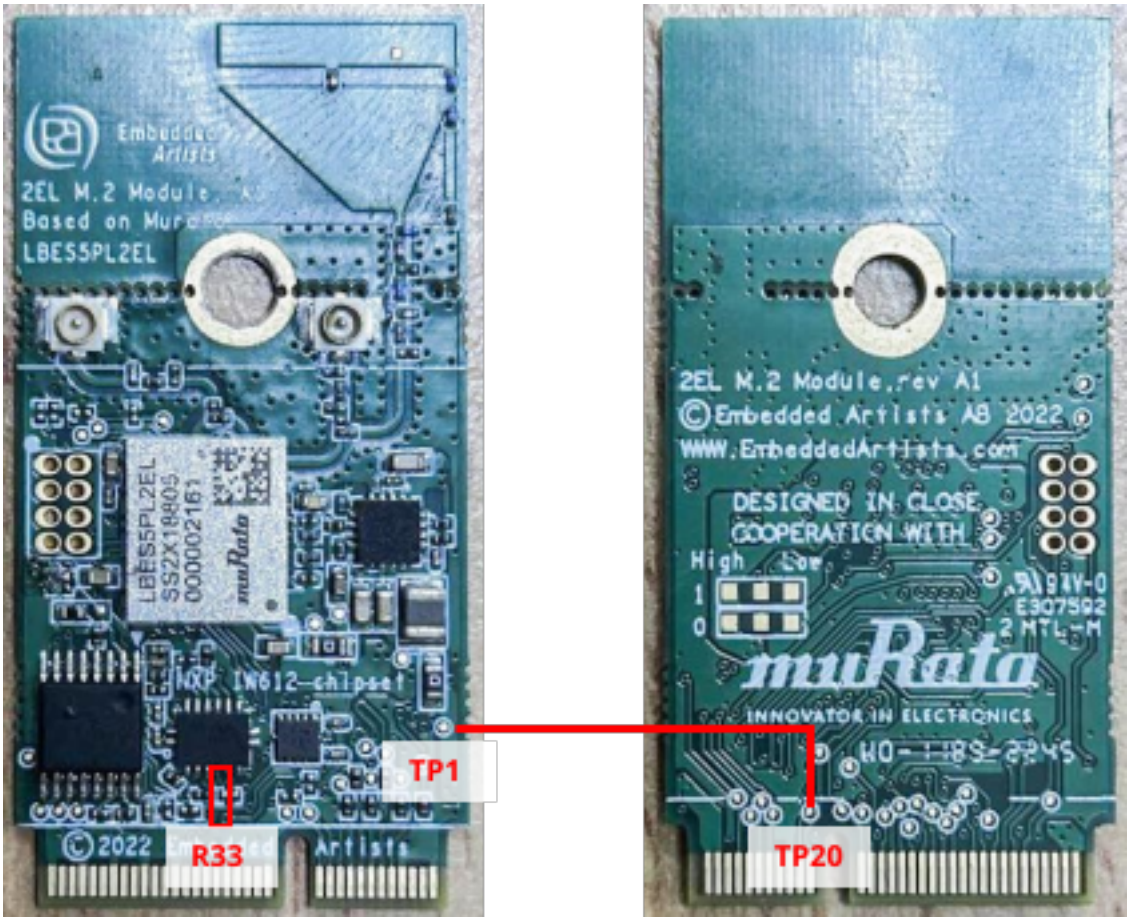
  For details, refer *Hardware Rework Guide for MIMXRT595-EVK and Murata M.2 Module*.

- **Host wake-up controller pin rework**:

  For details, refer Hardware Rework Guide for Low Power Feature on MIMXRT595-EVK and Murata 1XK M.2 Module.

- **Controller wake-up host pin rework:**

1. Remove resistors R709 on MIMXRT595-EVK,
2. Solder 0K ohm resistor on R33 of Murata 2EL M.2 Module
3. Solder 10K ohm resistor on the Murata 2EL M.2 Module between TP1 and TP20.



Parent topic:*Hardware Rework Guide for Low Power Feature on MIMXRT595-EVK and Murata 2EL M.2 Module*

Hardware Rework Guide for MIMXRT595-EVK and Murata M.2 Module This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT595-EVK board and the Murata's 1XK, 1ZM, 2EL or 2LL solution - direct M.2 connection to Embedded Artists EAR00385 (1XK), EAR00364 (1ZM), Rev-A1 (2EL) or EAR00500 (2LL) M.2 modules.

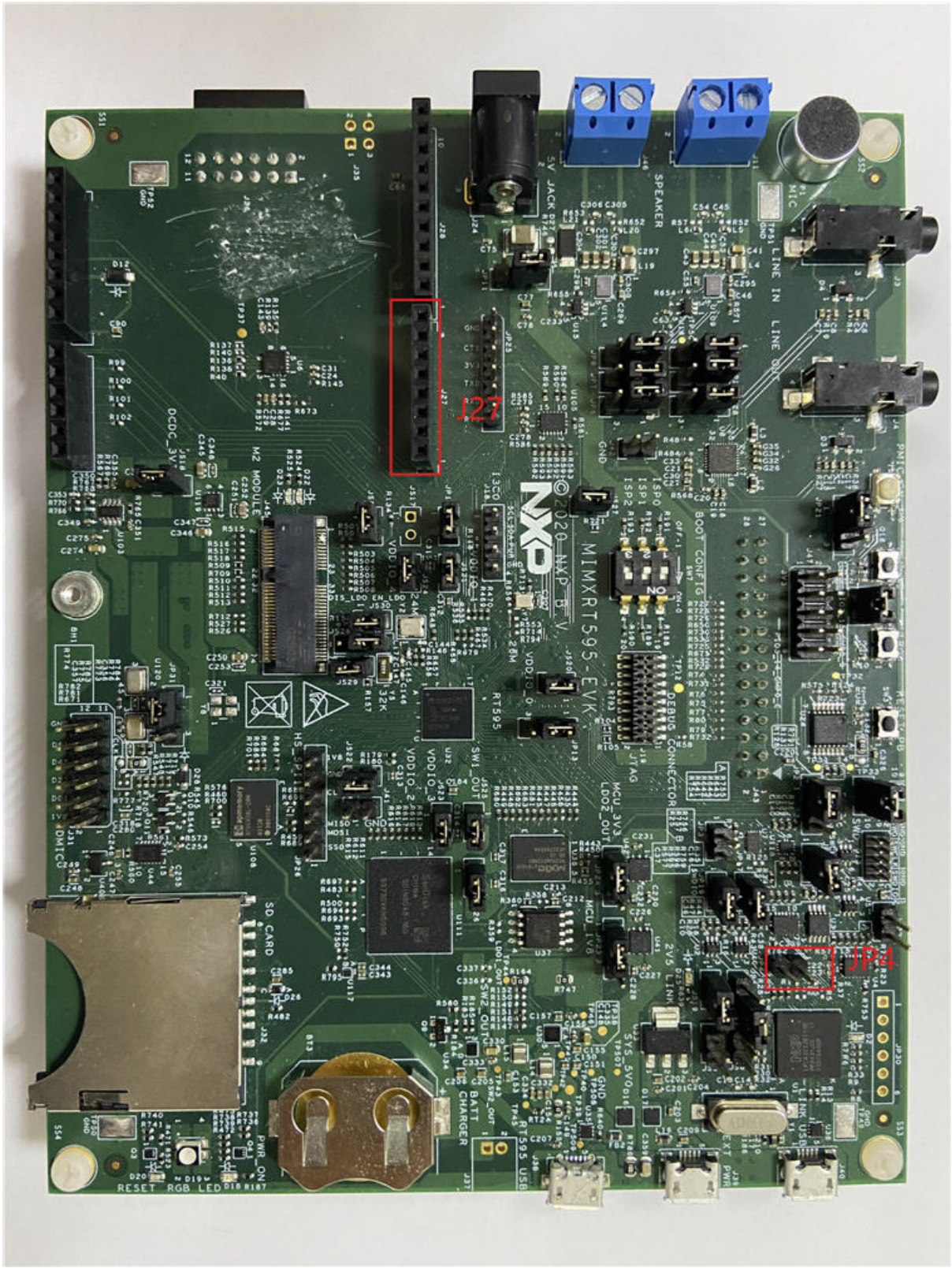
The hardware rework has one part:

- Debug console serial rework

Hardware rework **Debug console serial rework:**

No special rework is required, except the following to enable the debug port.

- JP4 1-2.
- J27 1 - TX of USB to serial converter
- J27 2 - RX of USB to serial converter



Parent topic:*Hardware Rework Guide for MIMXRT595-EVK and Murata M.2 Module*

Hardware Rework Guide for Low Power Feature on MIMXRT595-EVK and Murata 1XK M.2 Module This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL for low power feature on the NXP i.MX MIMXRT595-EVK board and the Murata's 1XK - direct M.2 connection to Embedded Artists EAR00385 (1XK) M.2 modules.

The hardware rework has three parts:

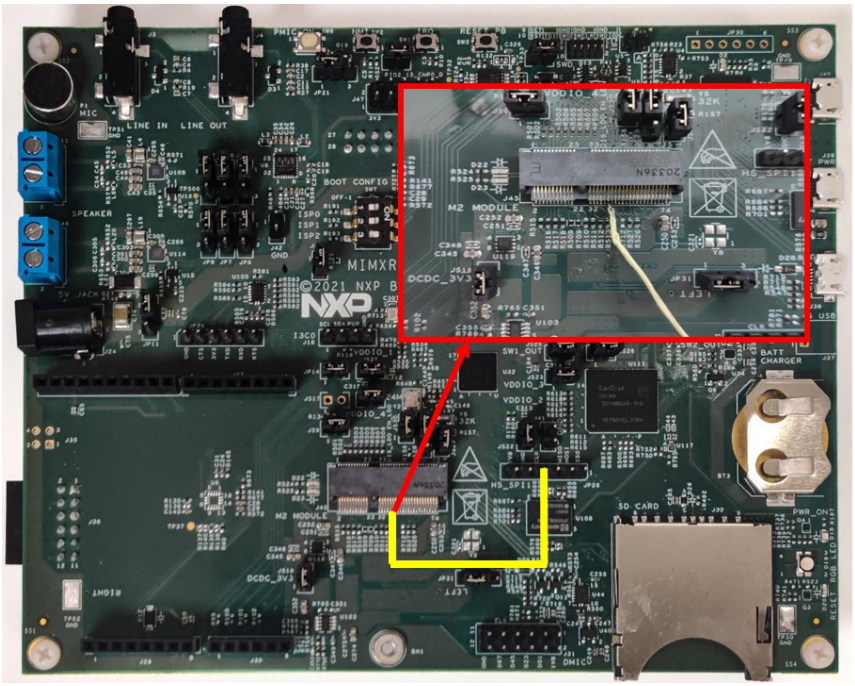
- Debug console serial rework
- Host wake-up controller pin rework (H2C)
- Controller wake-up host pin rework (C2H)

Hardware rework **Debug console serial rework:**

For details, refer *Hardware Rework Guide for MIMXRT595-EVK and Murata M.2 Module*.

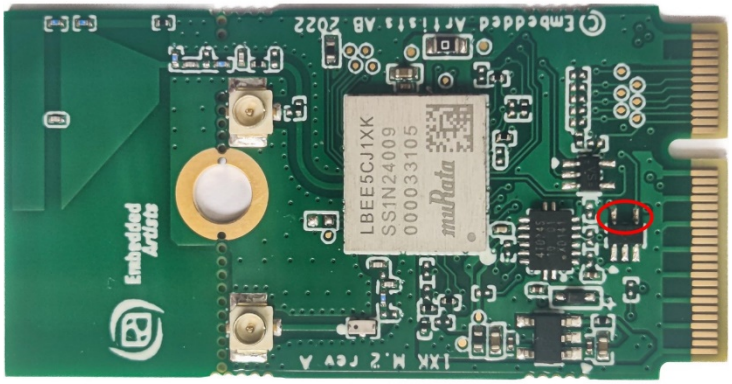
Host wake-up controller pin rework:

Connect M.2 (pin 42) to JP26 (pin 4) with a wire.



Controller wake-up host pin rework:

1. Remove resistors R709 on MIMXRT595-EVK.
2. Solder 10K ohm resistor on the Murata 1XK M.2 Module at the location shown in the following figure.



Parent topic:*Hardware Rework Guide for Low Power Feature on MIMXRT595-EVK and Murata 1XK M.2 Module*

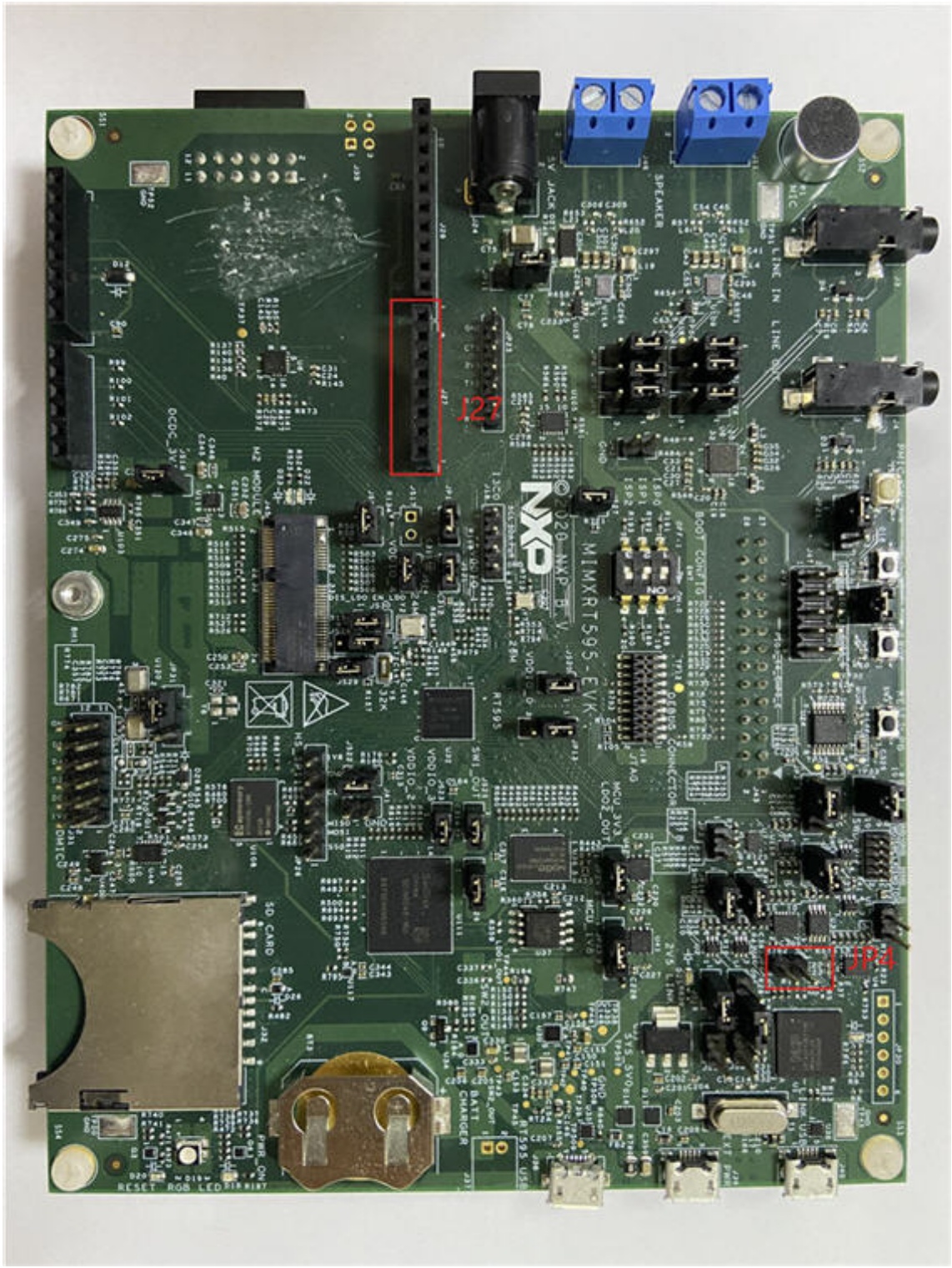
Hardware Rework Guide for MIMXRT595-EVK and AW-AM510MA This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT595-EVK board and AW-AM510MA. The AW-AM510MA user guide is available here. The hardware rework has one part:

- Debug console serial rework

Hardware rework **Debug console serial rework:**

No special rework is required, except the following to enable the debug port.

- Connect J39 with external power.
- Connect JP4 1-2.
- J27 1 — TX of USB to serial converter.
- J27 2 — RX of USB to serial converter.



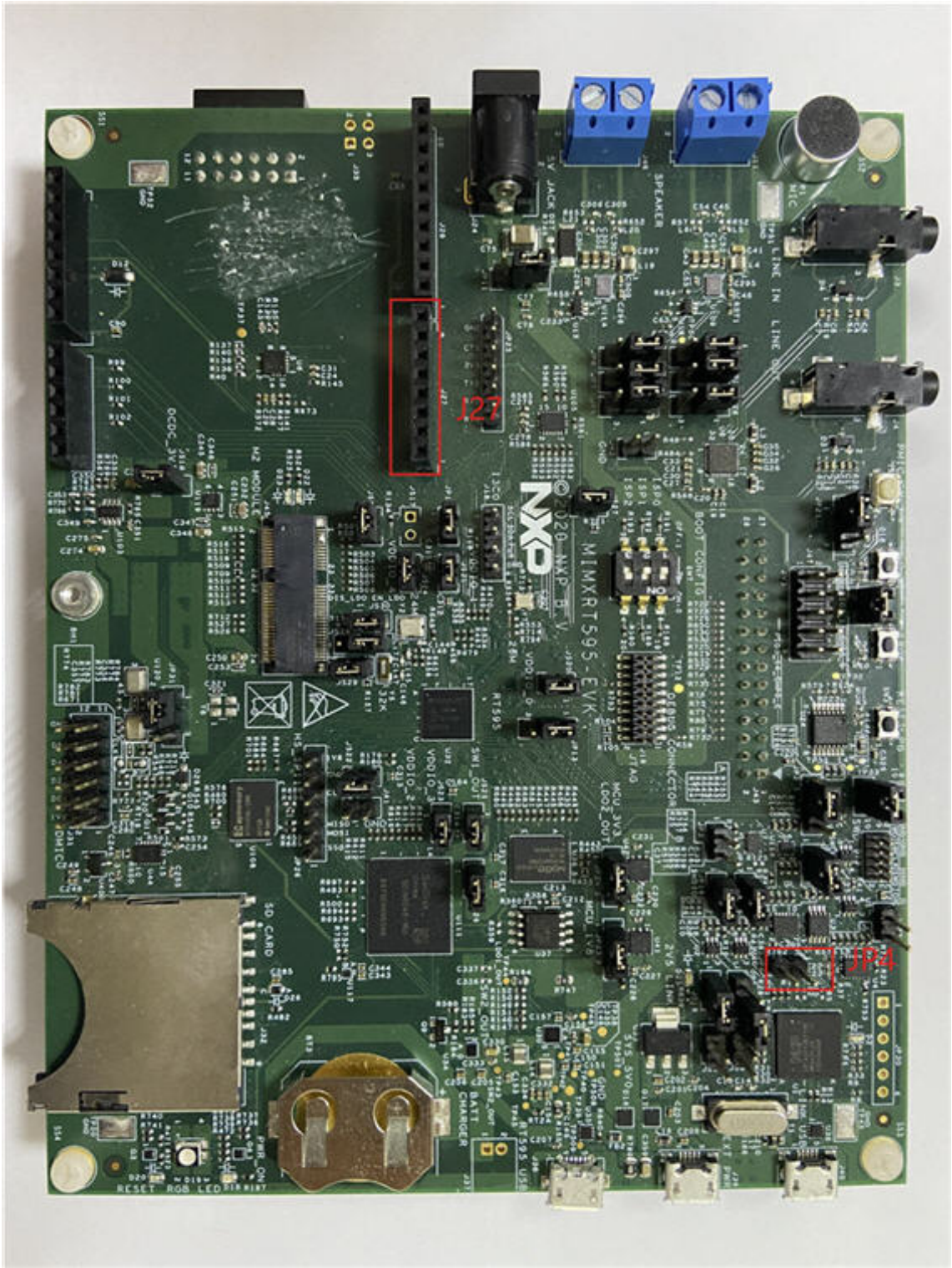
Parent topic:*Hardware Rework Guide for MIMXRT595-EVK and AW-AM510MA*

Hardware Rework Guide for MIMXRT595-EVK and AW-CM358MA This section is a brief hardware rework guidance of the Ethermind Bluetooth stack on the NXP i.MX MIMXRT595-EVK board and AW-CM358MA. The AW-CM358MA user guide is available here. The hardware rework has one part:

- Debug console serial rework

Hardware rework **Debug console serial rework:**

- Connect J39 with external power.
- JP4 1-2
- J27 1 - TX of USB to serial converter
- J27 2 - RX of USB to serial converter



Parent topic:*Hardware Rework Guide for MIMXRT595-EVK and AW-CM358MA*

Hardware Rework Guide for MIMXRT1040-EVK and Murata M.2 Module This section is a brief hardware rework guidance of the Edgefast Bluetooth PAL on the NXP i.MX MIMXRT1040-EVK board and the Murata's 1XK, 1ZM or 2LL solution - direct M.2 connection to Embedded Artists EAR00385 (1XK), EAR00364 (1ZM) or EAR00500 (2LL) M.2 modules.

The hardware rework has two parts:

- HCI UART rework
- PCM interface rework
- Wake pin rework

Hardware rework

1. HCI UART rework
    - Solder R93 and R96
2. PCM interface rework
    - Solder R70 and R79; remove R76 and R86; Connect J80.
3. Wake pin rework
    - When using 2LL M.2 module, remove R456 and R457 to avoid the module has an impact on boot configuration.

Note: Make sure to disconnect J80 when debugging. Otherwise, the debugger downloading fails.

Parent topic:*Hardware Rework Guide for MIMXRT1040-EVK and Murata M.2 Module*

Hardware Rework Guide for MIMXRT1060-EVKC and Murata M.2 Module This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT1060-EVKC and the Murata's 1XK, 1ZM, 2EL or 2LL solution - direct M.2 connection to Embedded Artists EAR00385 (1XK), EAR00364 (1ZM), Rev-A1 (2EL) or EAR00500 (2LL) M.2 modules.

The hardware rework has two parts:

- HCI UART rework
- PCM interface rework

Hardware rework

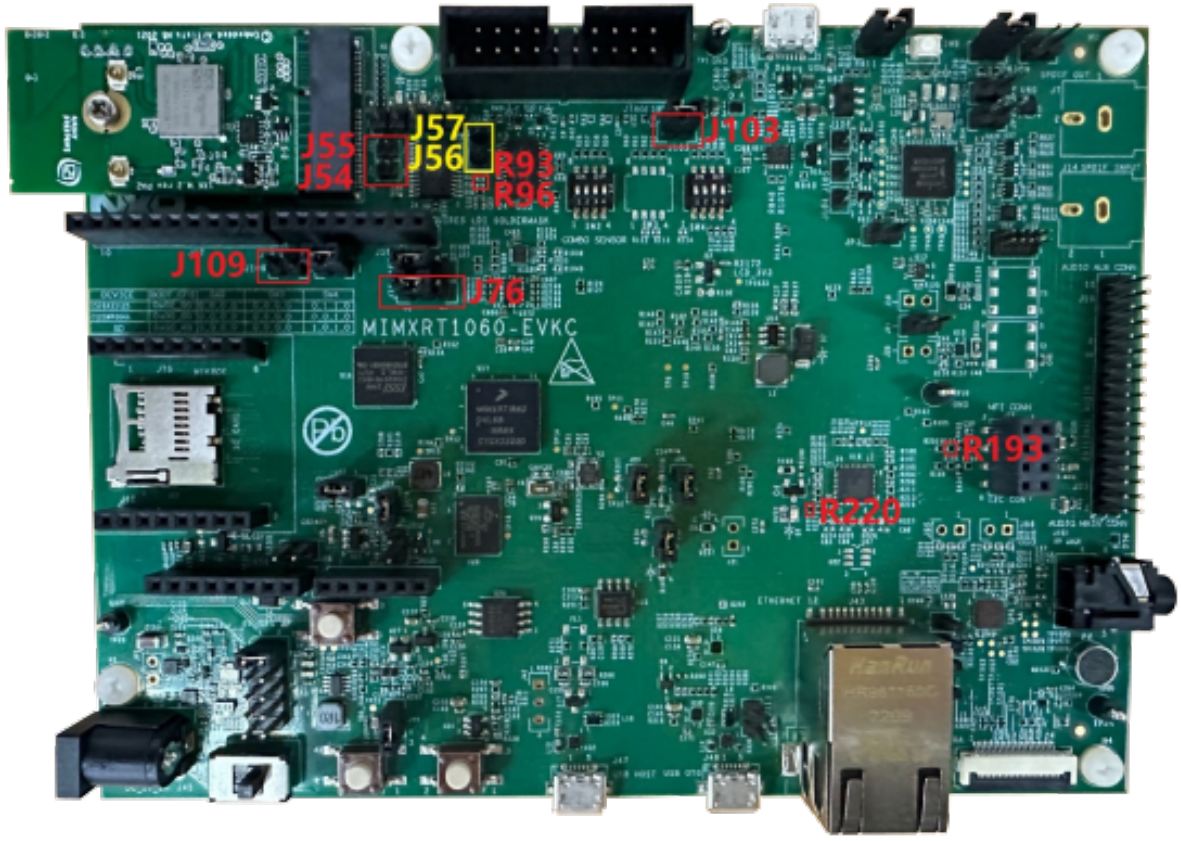
- **HCI UART rework**

1. Mount R93, R96.
2. Remove R193.
3. Connect J109, connect J76 2-3.

- **PCM interface rework**

1. Remove J54 and J55, connect J56 and J57.
2. Remove R220.
3. Connect J103.

Note: When J103 is connected, flash cannot be downloaded. So, remove the connection when downloading flash and reconnect it after downloading.



Parent topic:*Hardware Rework Guide for MIMXRT1060-EVKC and Murata M.2 Module*

Hardware Rework Guide for MIMXRT1060-EVKC and Murata 2EL M.2 Adapter This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP i.MX MIMXRT1060-EVKC and the Murata 2EL M.2 solution - direct M.2 connection to Embedded Artists' Rev-A1 (2EL) M.2 modules.

The hardware rework has three parts:

- HCI UART rework
- PCM interface rework
- LE Audio Synchronization interface rework (only used on sink side)

Hardware rework

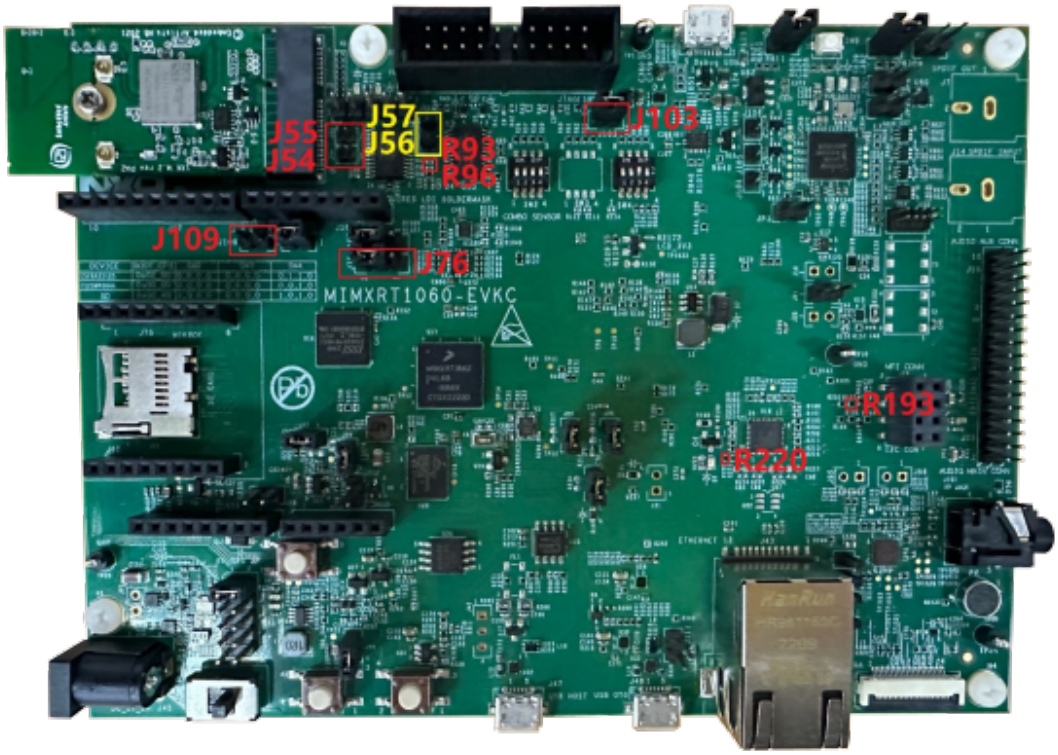
- HCI UART rework

1. Mount R93, R96.
2. Remove R193.
3. Connect J109, connect J76 2-3.

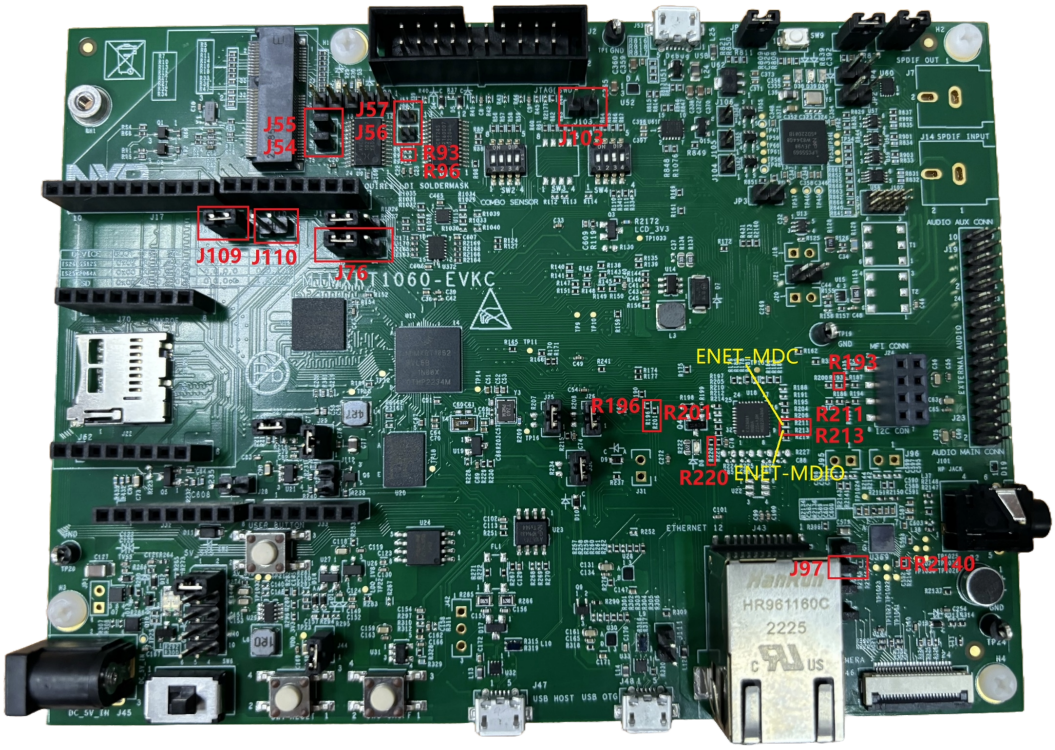
- PCM interface rework

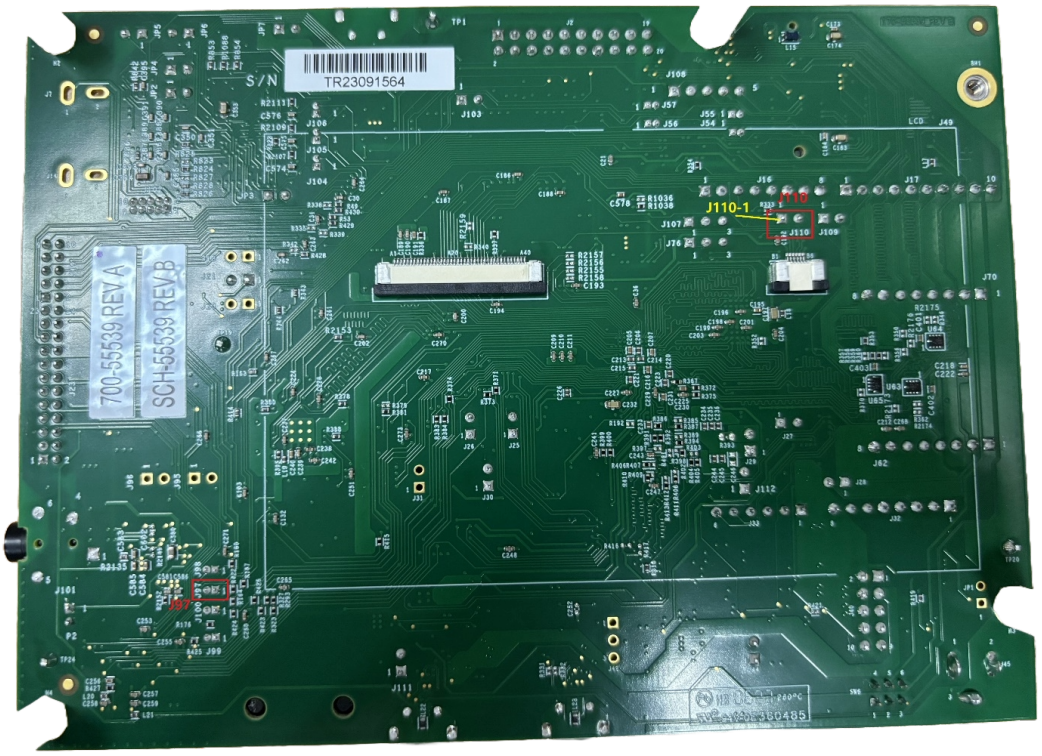
1. Remove J54 and J55, connect J56, and J57.
2. Remove R220.
3. Connect J103.

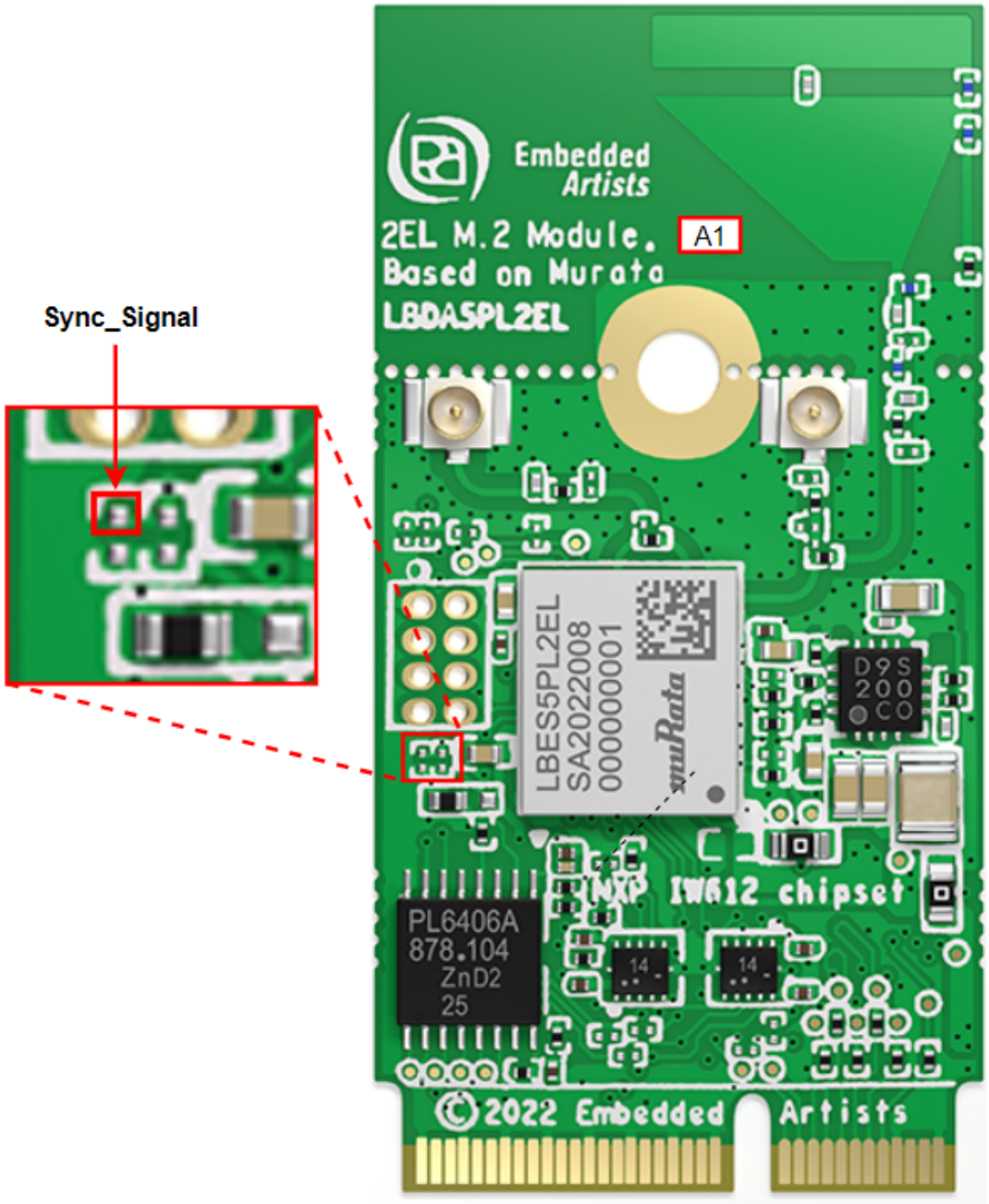
   Note: When J103 is connected, flash cannot be downloaded. So, remove the connection when downloading flash and reconnect it after downloading.



- LE Audio Synchronization interface rework (only used on sink side)
  1. Remove J110 jumper cap.
  2. Remove R196, R201, R213, and R211.
  3. Connect J110-1 (GPT2_CLK) to R2140 (SAI_MCLK).
  4. Connect ENET_MDIO (GPT2_CAP1) with J97 (SAI_SW).
  5. Connect ENET_MDC (GPT2_CAP2) with 2EL's GPIO_27 (Sync Signal).




S/N
TR23091564
700-55539 REV.A
SCH-55539 REV.B
J110-1
J110



Parent topic:*Hardware Rework Guide for MIMXRT1060-EVKC and Murata 2EL M.2 Adapter*

Hardware Rework Guide for MCXN547-EVK and Murata M.2 Module This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP MCXN547-EVK board and the Murata's 1XK, 1ZM or 2LL solution - direct M.2 connection to Embedded Artists EAR00385 (1XK), EAR00364 (1ZM) or EAR00500 (2LL) M.2 modules.

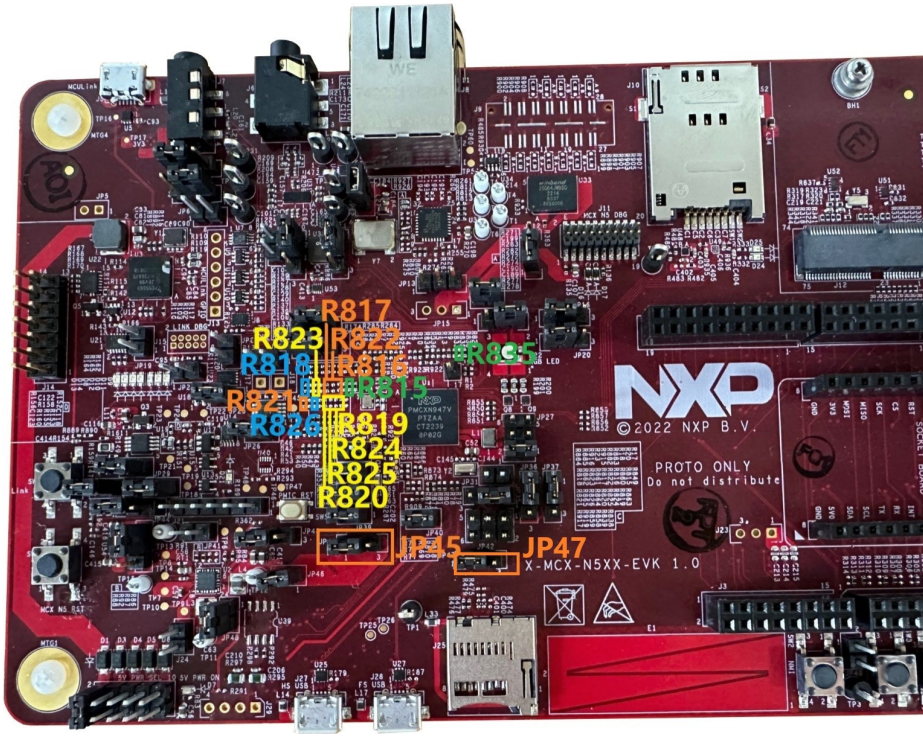
The hardware rework consists of two parts:

- M.2 UART interface
- M.2 SDIO interface

Hardware rework

- M.2 UART interface rework

  - Mount R835
  - Connect JP45 2-3 to supply 1.8V for GPIO4
- M.2 SDIO interface rework
  - Connect JP47 2-3 to supply 1.8V for GPIO2
  - Remove R818, connect R823
  - Remove R819, connect R824
  - Remove R817, connect R822
  - Remove R815, connect R816
  - Remove R820, connect R825
  - Remove R821, connect R826



Hardware Rework Guide for MCXN947-EVK and Murata M.2 Module This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP MCXN947-EVK board and the Murata's 1XK, 1ZM or 2LL solution - direct M.2 connection to Embedded Artists EAR00385 (1XK), EAR00364 (1ZM) or EAR00500 (2LL) M.2 modules.

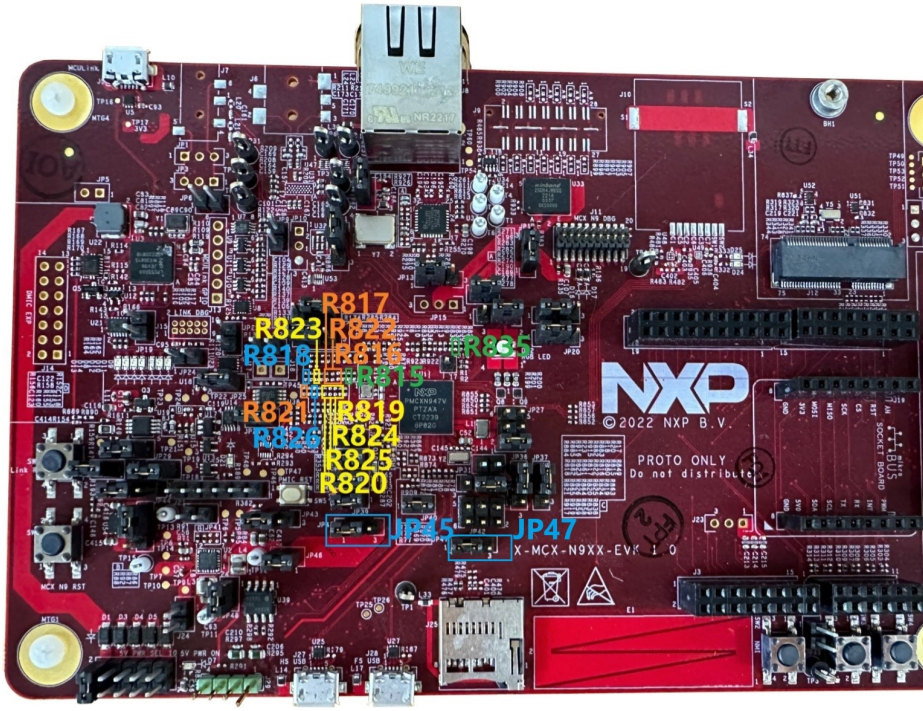
The hardware rework consists of two parts:

- M.2 UART interface
- M.2 SDIO interface

Hardware rework

- M.2 UART interface rework
  - Mount R835
  - Connect JP45 2-3 to supply 1.8V for GPIO4
- M.2 SDIO interface rework
  - Connect JP47 2-3 to supply 1.8V for GPIO2

- Remove R818, connect R823
- Remove R819, connect R824
- Remove R817, connect R822
- Remove R815, connect R816
- Remove R820, connect R825



- Remove R821, connect R826

Hardware Rework Guide for IMXRT1050-EVKB and Murata M.2 Module This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP IMXRT1050-EVKB board and the Murata 1XK,1ZM and 2EL solution - direct M.2 connection to Embedded Artists' EAR00385 (1XK) , EAR00364 (1ZM) or EAR00409 (2EL)M.2 modules. The hardware rework consists of three parts:

- Murata uSDM
- HCI UART rework

Hardware rework

- Murata uSD-M.2 jumper settings
  - J12 = 1-2: WLAN-SDIO & BT-PCM = 1.8 V
  - J13 = 1-2: BT-UART & WLAN/BT-CTRL = 3.3 V
  - J1 = 2-3: 3.3 V from uSD connector
- HCI UART interface rework

  Connect the TX/RX/RTS/CTS pins of the two boards as show in Table 1 using the jumper cables included in the Murata's uSD-M.2 Adapter kit as shown in the following table.

Pin name	uSD-M.2 adapter pin	i.MX RT1050-EVKB pin	Pin name of RT1050-EVKB	GPIO name of RT1050-EVKB
BT_UART_TXD_	J9 (pin 1)	J22 (pin 1)	LPUART3_RXD	GPIO_AD_B1_07
BT_UART_RXD_	J9 (pin 2)	J22 (pin 2)	LPUART3_TXD	GPIO_AD_B1_06
BT_UART_RTS_]	J8 (pin 3)	J23 (pin 3)	LPUART3_CTS	GPIO_AD_B1_04
BT_UART_CTS_]	J8 (pin 4)	J23 (pin 4)	LPUART3_RTS	GPIO_AD_B1_05
GND	J7 (pin 7)	J25 (pin 7)	GND	GND

Parent topic:*Hardware Rework Guide for IMXRT1050-EVKB and Murata M.2 Module*

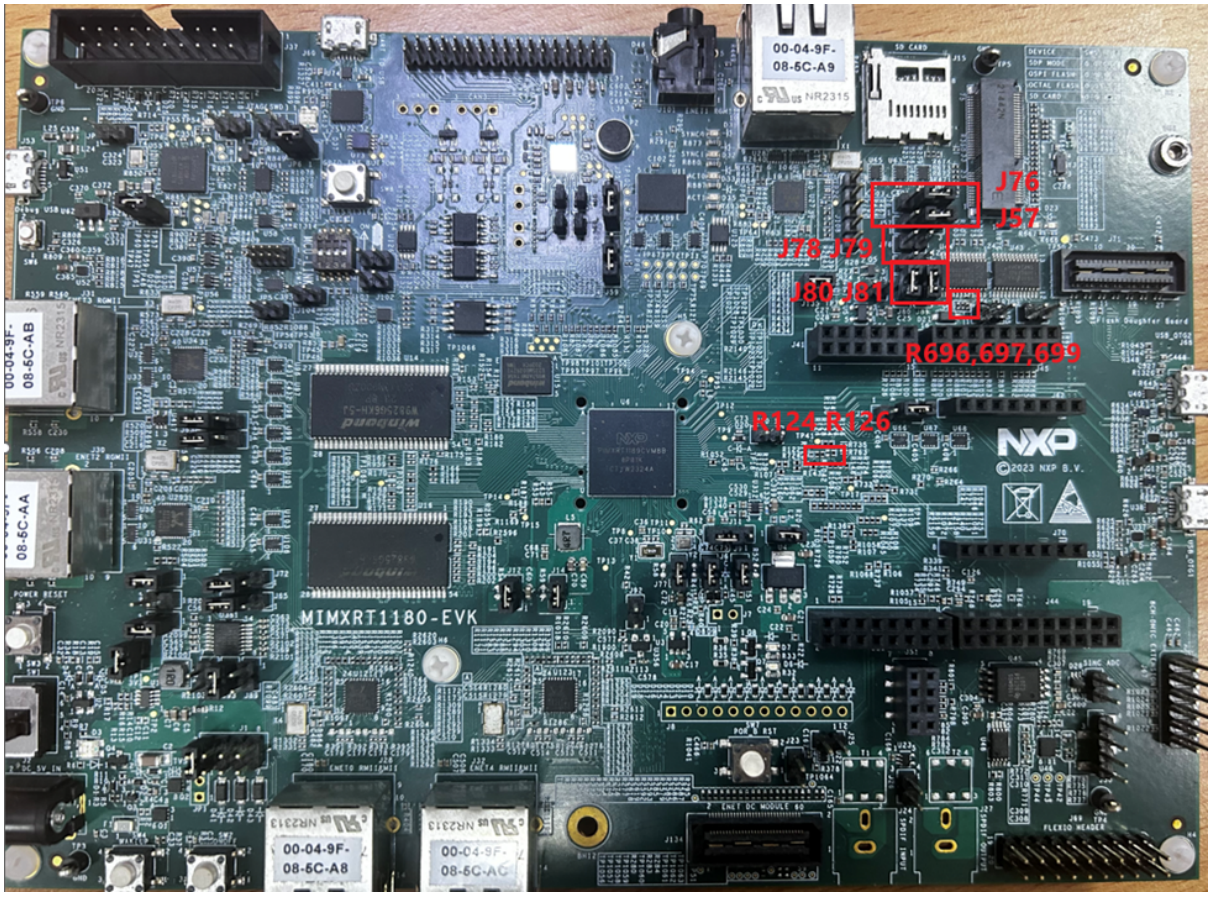
Hardware Rework Guide for MIMXRT1180 and Murata M.2 Module This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP MIMXRT1180 board and the Murata's 1XK, 1ZM, 2EL or 2LL solution - direct M.2 connection to Embedded Artists EAR00385 (1XK), EAR00364 (1ZM), Rev-A1 (2EL) or EAR00500 (2LL) M.2 modules.

The hardware rework consists of two parts:

- HCI UART rework
- PCM interface rework

Hardware rework

- HCI UART rework:
  - Remove: R124,R126
  - Mount R696, R697
  - Connect J57 [2-3], J76 [2-3]
- PCM interface rework
  - Mount R699
  - Disconnect J78 J79
  - Connect J80 J81



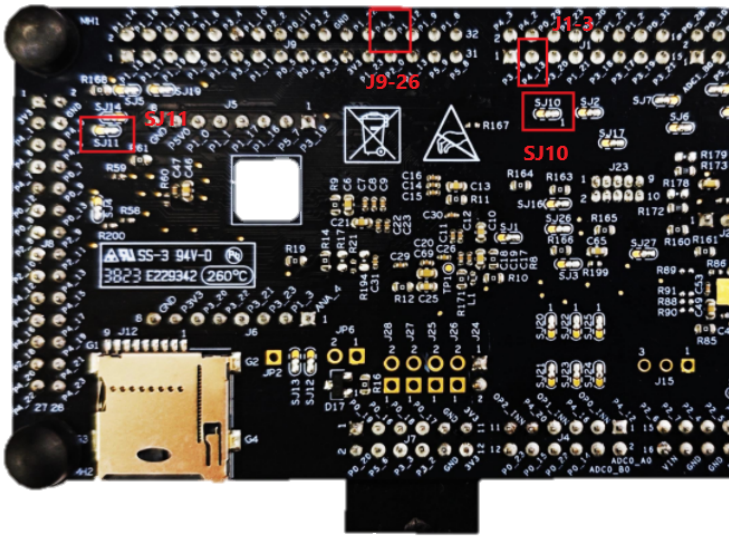
Hardware Rework Guide for FRDM-MCXN947 and X-FRDM-WIFI-M.2 Adapter This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP FRDM-MCXN947 board and X-FRDM-WIFI-M.2 or the Murata's 2LL EAR00500 (2LL) M.2 modules solution.

The hardware rework consists of one part:

- UART interface rework

Hardware rework

- UART interface rework
  - Remove SJ11 1-2, connect SJ11 2-3
  - Remove SJ10 1-2, connect J1-3 to J9-26
- X-FRDM-WIFI-M.2 jumper setting
  - Connect J8(On X-FRDM-WIFI-M.2) for 1.8V
  - Connect J24(On X-FRDM-WIFI-M.2) for 3.3V
  - Connect J19(On X-FRDM-WIFI-M.2) for 1.8V
  - Connect J25(On X-FRDM-WIFI-M.2) for 3.3V
  - Connect J15(On X-FRDM-WIFI-M.2) for 1.8V
  - Connect J16(On X-FRDM-WIFI-M.2) for 3.3V
  - Connect J17(On X-FRDM-WIFI-M.2) for 1.8V



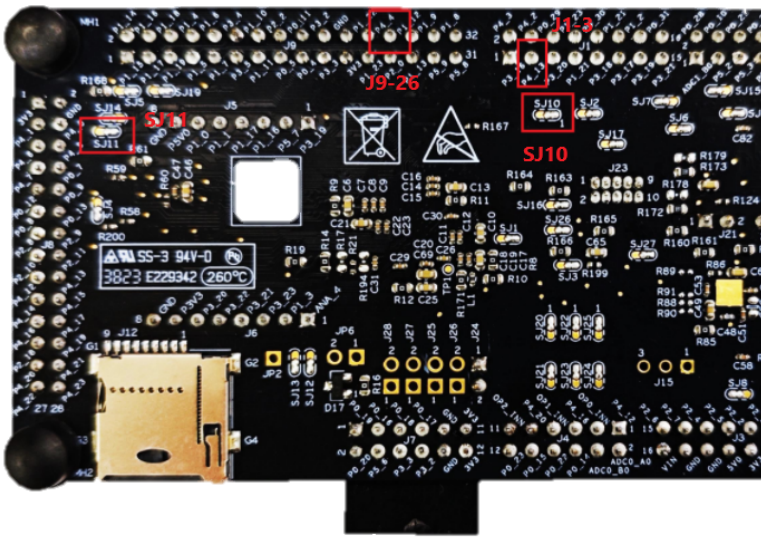
– Connect J18(On X-FRDM-WIFI-M.2) for 3.3V

Hardware Rework Guide for FRDM-MCXN947 and FRDM-IW416-AW-AM510 This section is a brief hardware rework guidance of the EdgeFast Bluetooth PAL on the NXP FRDM-MCXN947 board and FRDM-IW416-AW-AM510 board. The hardware rework consists of two parts:

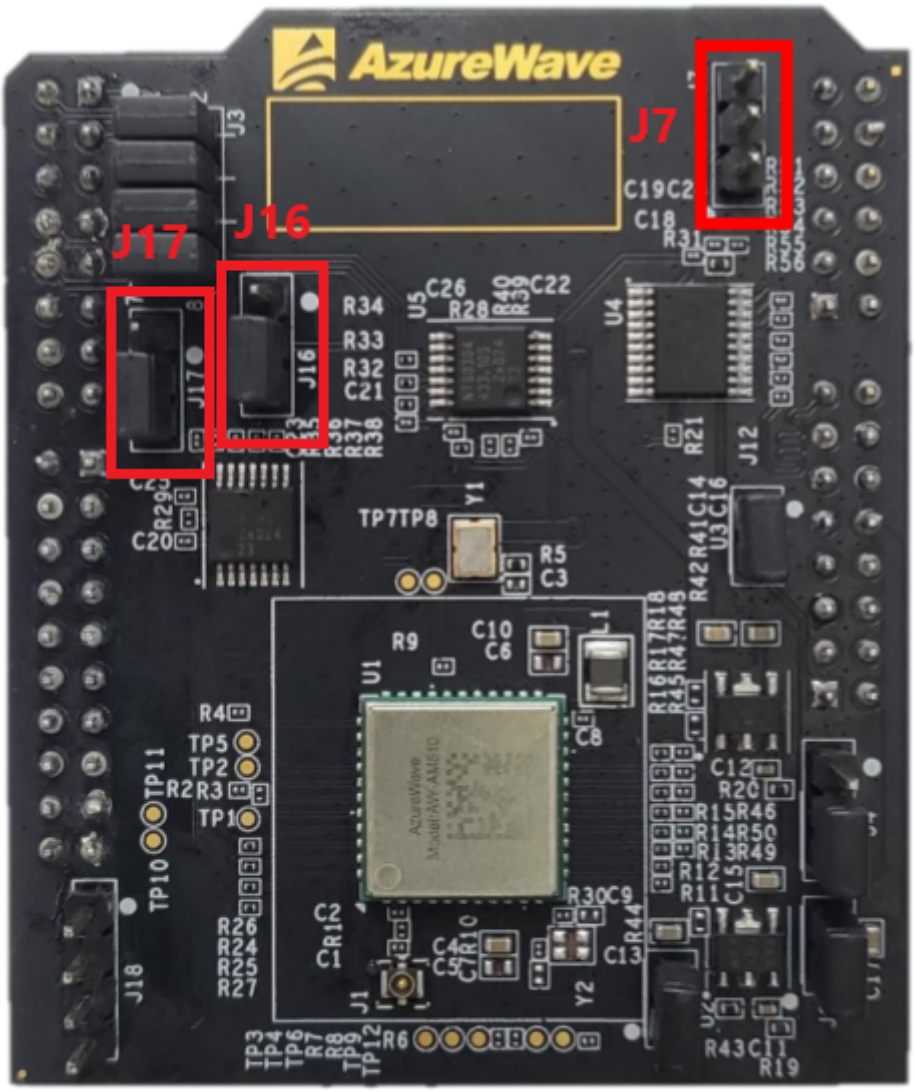
- UART interface rework
- FRDM-IW416-AW-AM510

Hardware rework

- UART interface rework
  - Remove SJ11 1-2, connect SJ11 2-3
  - Remove SJ10 1-2, connect J1-3 to J9-26
- FRDM-IW416-AW-AM510 jumper setting
  - Connect J16 2-3 for 3.3V supply
  - Connect J17 2-3 for 3.3V UART voltage level



– Connect J7 2-3 for 3.3V SDIO voltage level



Enabling Additional EdgeFast Bluetooth Protocol Abstraction Layer Examples on RT1064

Introduction NXP supports Bluetooth/Bluetooth Low Energy on RT1060EVK and RT1060EVKC. RT1064 has the same MCU die with RT1060EVK and RT1060EVKC and therefore it is possible to migrate the examples.

This document takes *peripheral_ht* as an example and describes the steps to migrate EdgeFast examples from RT1060EVK to RT1064 (based on SDK 2.13.0) and from RT1060EVKC to RT1064 (based on SDK 2.14.0) with different toolchains including IAR, Arm GCC, and MDK.

Migrate examples from RT1060EVK to RT1064 This topic describes the Common steps and the steps to migrate with the IAR, Arm GCC, and MDKtoolchains.

Common steps

1. Download *SDK_2.13.0_EVK-MIMXRT1060* and *SDK_2.13.0_EVK-MIMXRT1064*.
2. Copy the following folders from RT1060EVK package to RT1064 package: <install_dir>/components/internal_flash/ <install_dir>/middleware/edgefast_bluetooth/ <install_dir>/middleware/wireless/.

3. Create a folder named edgefast_bluetooth_examples/ under <rt1064_install_dir>/boards/evkmimxrt1064/.
4. Copy the entire folder from <rt1060evk_install_dir>/boards/evkmimxrt1060/edgefast_bluetooth_examples/peripheral_ht/ to < rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/.
5. Copy *clock_config.[c/h]* and *board.c* from <rt1064_install_dir>/boards/evkmimxrt1064/demo_apps/hello_world/ to <rt1064_installed>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/ to replace the previous files.
6. Add #define EDGEFAST_BT_LITTLEFS_MFLASH 1 in <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht /app_config.c.
7. Make the following changes in <rt1064_installed>/boards/evkmimxrt1064/edgefast_bluetooth/peripheral_ht/board.h.

```
73 #define BOARD_FLASH_SIZE (0x800000U)
```

```
73 #define BOARD_FLASH_SIZE (0x400000U)
```

Parent topic:*Migrate examples from RT1060EVK to RT1064*

IAR

1. Navigate to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/iar/.
2. Make the following changes.

File name	Previous item	New item
peripheral_ht.ewp	1060 1062	1064 1064

3. Rename MIMXRT1062xxxxx_flexspi_nor.icf as MIMXRT1064xxxxx_flexspi_nor.icf and make the following changes.

```
47 define symbol m_interrupts_start       = 0x60002000;
48 define symbol m_interrupts_end         = 0x600023FF;
49
50 define symbol m_text_start             = 0x60002400;
51 define symbol _ROM_END_                = 0x6057FFFF;
66 define exported symbol m_boot_hdr_conf_start = 0x60000000;
67 define symbol m_boot_hdr_ivt_start           = 0x60001000;
68 define symbol m_boot_hdr_boot_data_start     = 0x60001020;
69 define symbol m_boot_hdr_dcd_data_start      = 0x60001030;
95 BT_LITTLEFS_STORAGE_SECTOR_SIZE = 0x1000;  /* 4k flash secto
96 BT_LITTLEFS_STORAGE_MAX_SECTORS = (0x60800000 - EDGEFAST_BT_
97 ***/
```

```
47 define symbol m_interrupts_start       = 0x70002000;
48 define symbol m_interrupts_end         = 0x700023FF;
49
50 define symbol m_text_start             = 0x70002400;
51 define symbol _ROM_END_                = 0x7017FFFF;
66 define exported symbol m_boot_hdr_conf_start = 0x70000000;
67 define symbol m_boot_hdr_ivt_start           = 0x70001000;
68 define symbol m_boot_hdr_boot_data_start     = 0x70001020;
69 define symbol m_boot_hdr_dcd_data_start      = 0x70001030;
95 BT_LITTLEFS_STORAGE_SECTOR_SIZE = 0x1000;  /* 4k flash sect
96 BT_LITTLEFS_STORAGE_MAX_SECTORS = (0x70400000 - EDGEFAST_BT
97 ***/
```

Parent topic:*Migrate examples from RT1060EVK to RT1064*

Arm GCC

1. Navigate to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/armgcc/.
2. Rename the following files.

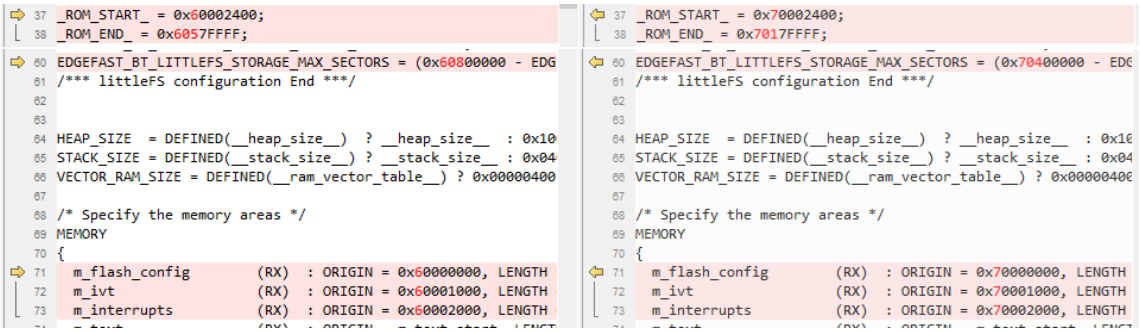
Path	Previous name	**New name**
<rt1064_install_dir>/middleware/wireless/ethermind/	middleware_edgefast_bluetooth_cmake	middleware_edgefast_bluetooth_k32w061_contro cmake

3. Make following changes.

File name	Previous item	New item
config.cmake	1060	1064
	1062	1064
flags.cmake	1062	1064
CMakeLists.txt	1060	1064
	1062	1064

4. *mflash* is used in RT1064 instead of flash_adapter,therefore, comment include(component_flexspi_nor_flash_adapter_rt1064_MIMXRT1064) in *CMakeLists.txt*.

5. Rename MIMXRT1062xxxxx_flexspi_nor.ld as MIMXRT1064xxxxx_flexspi_nor.ld and make the following changes.



Parent topic:*Migrate examples from RT1060EVK to RT1064*

MDK

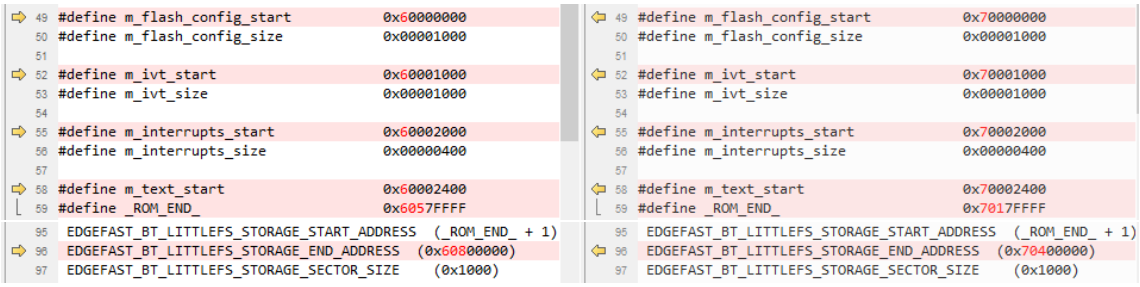
1. Navigate to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/mdk/.

2. Make following changes.

File name	Previous item	New item
peripheral_ht.uvprojx	1060	1064
	1062	1064

3. Copy evkmimxrt1064_flexspi_nor.ini from <rt1064_install_dir>/boards/evkmimxrt1064/demo_apps/hello_world/mdk/ to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/mdk/.

4. Rename MIMXRT1062xxxxx_flexspi_nor as MIMXRT1064xxxxx_flexspi_nor and make the following changes.



Parent topic:*Migrate examples from RT1060EVK to RT1064*

Migrate examples from RT1060EVKC to RT1064 This topic describes the Common steps and the steps to migrate with the IAR, Arm GCC, and MDK toolchains.

Common steps

1. Download SDK_2.14.0_EVKC-MIMXRT1060 and SDK_2.14.0_EVK-MIMXRT1064.
2. Copy the following folders from the RT1060EVKC package to the RT1064 package: <install_dir>/middleware/edgefast_bluetooth/ <install_dir>/middleware/wireless/ethermind.
3. Create a new folder named edgefast_bluetooth_examples/ under <rt1064_install_dir>/boards/evkmimxrt1064/.
4. Copy the entire folder from <rt1060evkc_install_dir>/boards/evkcmimxrt1060/edgefast_bluetooth_examples/peripheral_ht/ to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/.
5. Copy clock_config.[c/h] and board.c from <rt1064_install_dir>/boards/evkmimxrt1064/demo_apps/hello_world/ to <rt1064_installed>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/ to replace the previous files.

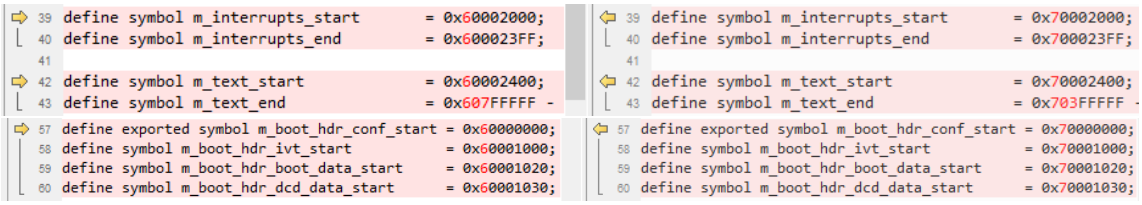
Parent topic:*Migrate examples from RT1060EVKC to RT1064*

IAR

1. Navigate to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/iar/.
2. Make the following changes in the listed order.

File name	Previous item	New item
peripheral_ht.ewp	1062	1064
mflash/evkcmimxrt1060	mflash/mimxrt1064	
evkcmimxrt1060	evkmimxrt1064	
6B	6A	

3. Rename MIMXRT1062xxxxx_flexspi_nor.icf as MIMXRT1064xxxxx_flexspi_nor.icf and make the following changes.



Parent topic:*Migrate examples from RT1060EVKC to RT1064*

Arm GCC

1. Navigate to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/armgcc/.

2. Copy folder from <rt1060evkc_install_dir>/boards/evkcmimxrt1060/edgefast_bluetooth_examples/template/ to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/ and rename the files.

Path	Previous name	New name
<rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/	middleware_edgefast_bluetooth_mcux_linker_template_evkcmimxrt1060.cmake	middleware_edgefast_bluetooth_mcux_linker_template_evkmimxrt1064.cmake
	middleware_edgefast_bluetooth_sdio_template_evkcmimxrt1060.cmake	middleware_edgefast_bluetooth_sdio_template_evkmimxrt1064.cmake

3. Add the following content to<rt1064_install_dir>/devices/MIMXRT1064/all_lib_device.cmake at appropriate location.

```
...
  ${CMAKE_CURRENT_LIST_DIR}/../../boards
  ${CMAKE_CURRENT_LIST_DIR}/../../boards/evkmimxrt1064/edgefast_bluetooth_examples/
↪template
  ${CMAKE_CURRENT_LIST_DIR}/../../middleware/edgefast_bluetooth
  ${CMAKE_CURRENT_LIST_DIR}/../../middleware/wireless/ethermind
...
include_if_use(middleware_edgefast_bluetooth_ble_ethermind_cm7f)
include_if_use(middleware_edgefast_bluetooth_ble_ethermind_lib_cm7f)
include_if_use(middleware_edgefast_bluetooth_br_ethermind_cm7f)
include_if_use(middleware_edgefast_bluetooth_br_ethermind_lib_cm7f)
include_if_use(middleware_edgefast_bluetooth_btble_ethermind_cm7f)
include_if_use(middleware_edgefast_bluetooth_btble_ethermind_lib_cm7f)
include_if_use(middleware_edgefast_bluetooth_common_ethermind)
include_if_use(middleware_edgefast_bluetooth_common_ethermind_hci)
include_if_use(middleware_edgefast_bluetooth_common_ethermind_hci_uart)
include_if_use(middleware_edgefast_bluetooth_config_ethermind)
include_if_use(middleware_edgefast_bluetooth_config_template)
include_if_use(middleware_edgefast_bluetooth_extension_common_ethermind)
include_if_use(middleware_edgefast_bluetooth_k32w061_controller)
include_if_use(middleware_edgefast_bluetooth_mcux_linker_template_ evkmimxrt1064)
include_if_use(middleware_edgefast_bluetooth_pal)
include_if_use(middleware_edgefast_bluetooth_pal_db_gen_ethermind)
include_if_use(middleware_edgefast_bluetooth_pal_host_msd_fatfs_ethermind)
include_if_use(middleware_edgefast_bluetooth_pal_platform_ethermind)
include_if_use(middleware_edgefast_bluetooth_porting)
include_if_use(middleware_edgefast_bluetooth_porting_atomic)
include_if_use(middleware_edgefast_bluetooth_porting_list)
include_if_use(middleware_edgefast_bluetooth_porting_net)
include_if_use(middleware_edgefast_bluetooth_porting_toolchain)
include_if_use(middleware_edgefast_bluetooth_porting_work_queue)
include_if_use(middleware_edgefast_bluetooth_profile_bas)
include_if_use(middleware_edgefast_bluetooth_profile_dis)
include_if_use(middleware_edgefast_bluetooth_profile_fmp)
include_if_use(middleware_edgefast_bluetooth_profile_hps)
include_if_use(middleware_edgefast_bluetooth_profile_hrs)
include_if_use(middleware_edgefast_bluetooth_profile_hts)
include_if_use(middleware_edgefast_bluetooth_profile_ipsp)
include_if_use(middleware_edgefast_bluetooth_profile_pxr)
include_if_use(middleware_edgefast_bluetooth_profile_tip)
include_if_use(middleware_edgefast_bluetooth_profile_wu)
include_if_use(middleware_edgefast_bluetooth_sdio_template_evkmimxrt1064)
include_if_use(middleware_edgefast_bluetooth_shell)
include_if_use(middleware_edgefast_bluetooth_shell_ble)
include_if_use(middleware_edgefast_bluetooth_template)
include_if_use(middleware_edgefast_bluetooth_wifi_nxp_controller_base)...
```

4. Make the following changes in the listed order.

File name	Previous item	New item
config.cmake	MIMXRT1	MIMXRT1064xxxxA
mflash_evkcmimxrt1060	mflash_rt	
1062	1064	
evkcmimxrt1060	evk-mimxrt10	
flags.cmake	1062	1064
6B	6A	
CMakeLists.txt	1062	1064
<rt1064_install_dir>/middleware/edgefast_bluetooth/middleware_edgefast_bluetooth_template.cmake	evkcmimx	evk-mimxrt1064
<rt1064_install_dir>/middleware/wireless/ethermind/middleware_edgefast_bluetooth_common_ethermind_hci_uart.cmake	1062	1064
<rt1064_install_dir>/middleware/wireless/ethermind/middleware_edgefast_bluetooth_k32w061_controller.cmake	1062	1064
<rt1064_install_dir>/middleware/wireless/ethermind/middleware_edgefast_bluetooth_wifi_nxp_controller_base.cmake	evkcmimx	evk-mimxrt1064
<rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/middleware_edgefast_bluetooth_mcux_cmake	1062	1064 mxrt1064.
<rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/middleware_edgefast_bluetooth_sdio_t cmake	1062	1064 1.

5. Rename MIMXRT1062xxxxx_flexspi_nor.ld as MIMXRT1064xxxxx_flexspi_nor.ld and make the following changes.

```
m_text_start        = 0x60002400;
m_text_size         = 0x007FDC00 - LITTLEFS_REGION_SIZE;

HEAP_SIZE  = DEFINED(__heap_size__)  ? __heap_size__  : 0x1000;
STACK_SIZE = DEFINED(__stack_size__) ? __stack_size__ : 0x0400;
VECTOR_RAM_SIZE = DEFINED(__ram_vector_table__) ? 0x00000400 : 0;

/* Specify the memory areas */
MEMORY
{
  m_flash_config       (RX)  : ORIGIN = 0x60000000, LENGTH = 0x00001000
  m_ivt                (RX)  : ORIGIN = 0x60001000, LENGTH = 0x00001000
  m_interrupts         (RX)  : ORIGIN = 0x60002000, LENGTH = 0x00000400
```

```
m_text_start        = 0x70002400;
m_text_size         = 0x003FDC00 - LITTLEFS_REGION_SIZE;

HEAP_SIZE  = DEFINED(__heap_size__)  ? __heap_size__  : 0x1000;
STACK_SIZE = DEFINED(__stack_size__) ? __stack_size__ : 0x0400;
VECTOR_RAM_SIZE = DEFINED(__ram_vector_table__) ? 0x00000400 : 0;

/* Specify the memory areas */
MEMORY
{
  m_flash_config       (RX)  : ORIGIN = 0x70000000, LENGTH = 0x00001000
  m_ivt                (RX)  : ORIGIN = 0x70001000, LENGTH = 0x00001000
  m_interrupts         (RX)  : ORIGIN = 0x70002000, LENGTH = 0x00000400
```

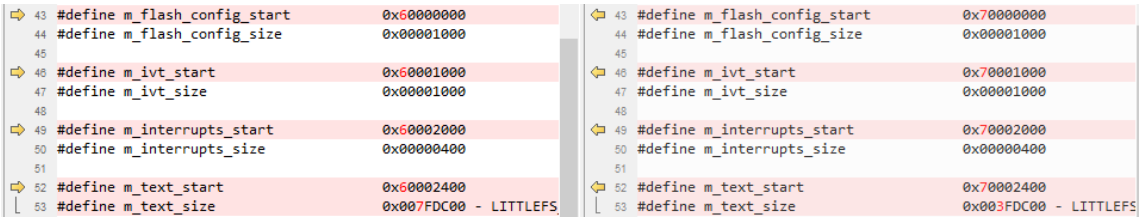
Parent topic:*Migrate examples from RT1060EVKC to RT1064*

MDK

1. Navigate to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/mdk/.
2. Make the following changes in the listed order.

File name	Previous item	New item
peripheral_ht.uvprojx	1062	1064
	mflash/evkcmimxrt1060	mflash/mimxrt1064
	evkcmimxrt1060	evkcmimxrt1064
	6B	6A

3. Copy evkmimxrt1064_flexspi_nor.ini from <rt1064_install_dir>/boards/evkmimxrt1064/demo_apps/hello_world/mdk/ to <rt1064_install_dir>/boards/evkmimxrt1064/edgefast_bluetooth_examples/peripheral_ht/mdk/.
4. Rename MIMXRT1062xxxxx_flexspi_nor as MIMXRT1064xxxxx_flexspi_nor and make the following changes.



Parent topic:*Migrate examples from RT1060EVKC to RT1064*

Note about the source code in the document Example code shown in this document has the following copyright and BSD-3-Clause license:

Enabling Additional Edgefast BT PAL Examples on M4 core for RT1170

Introduction RT1170 works with two cores: M7 and M4, on which both all EdgeFast examples can run. However, all the EdgeFast examples in the release package are enabled on M7. Only the A2DP source example is enabled on M4.

EdgeFast projects for both the cores share the demo source files but with different project settings. Therefore, the examples can be migrated.

This document describes the steps to migrate EdgeFast examples from M7 to M4 with different toolchains. There are four main steps required. Additionally, you can also delete the function.

1. Create an M4 project
2. Rearrange source files
3. Rearrange project files

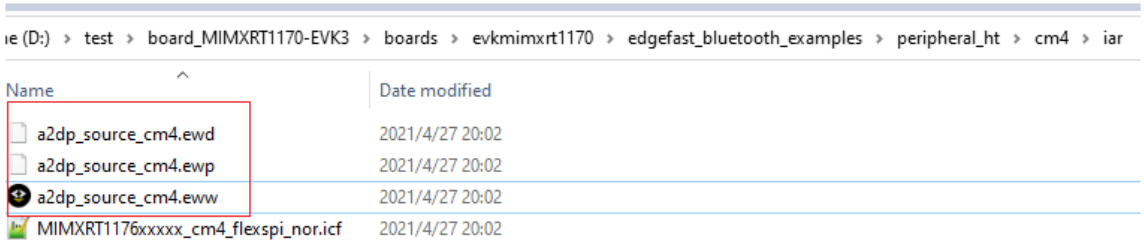
4. Adjust project settings
5. Delete function

In this document, the peripheral_ht example is used to demonstrate how to enable EdgeFast examples on M4 core with IAR and ARMGCC.

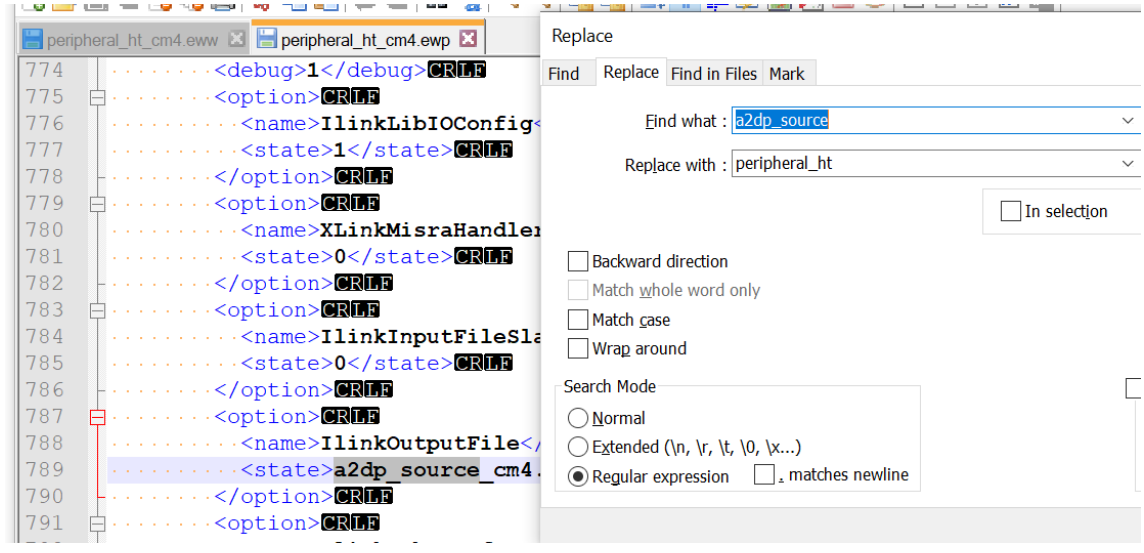
IAR This section describes the steps to create an M4 project with IAR, rearrange source and project files, adjust project settings, and delete function.

Create an M4 project To create an M4 project, perform the following steps:

1. Copy the folder *cm4* in the directory <*install_dir*>*boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*a2dp_* into the folder in which the example should be enabled. In this case, copy the folder *cm4* into the directory <*install_dir*>|*boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht*.
2. Open the folder *iar* in the directory <*install_dir*>*boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*periph*
3. Rename the files. Change the file name name *a2dp_source_cm4* to *peripheral_ht_cm4* in all the respective files.



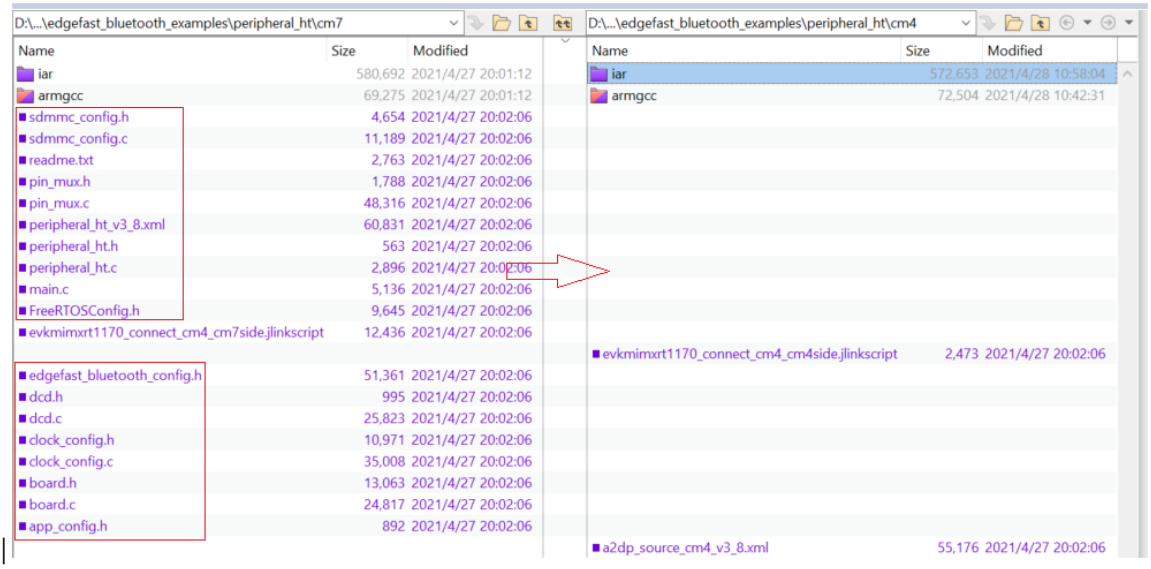
4. Open the files *peripheral_ht_cm4.eww* and *peripheral_ht_cm4.ewp* with a text editor, such as Notepad, Notepad++, Sublime, or Visual Studio Code.
5. Search and replace all *a2dp_source_cm4* with *peripheral_ht _cm4*, and then save the files.



Parent topic:*IAR*

Rearrange source files To rearrange source files, perform the following steps:

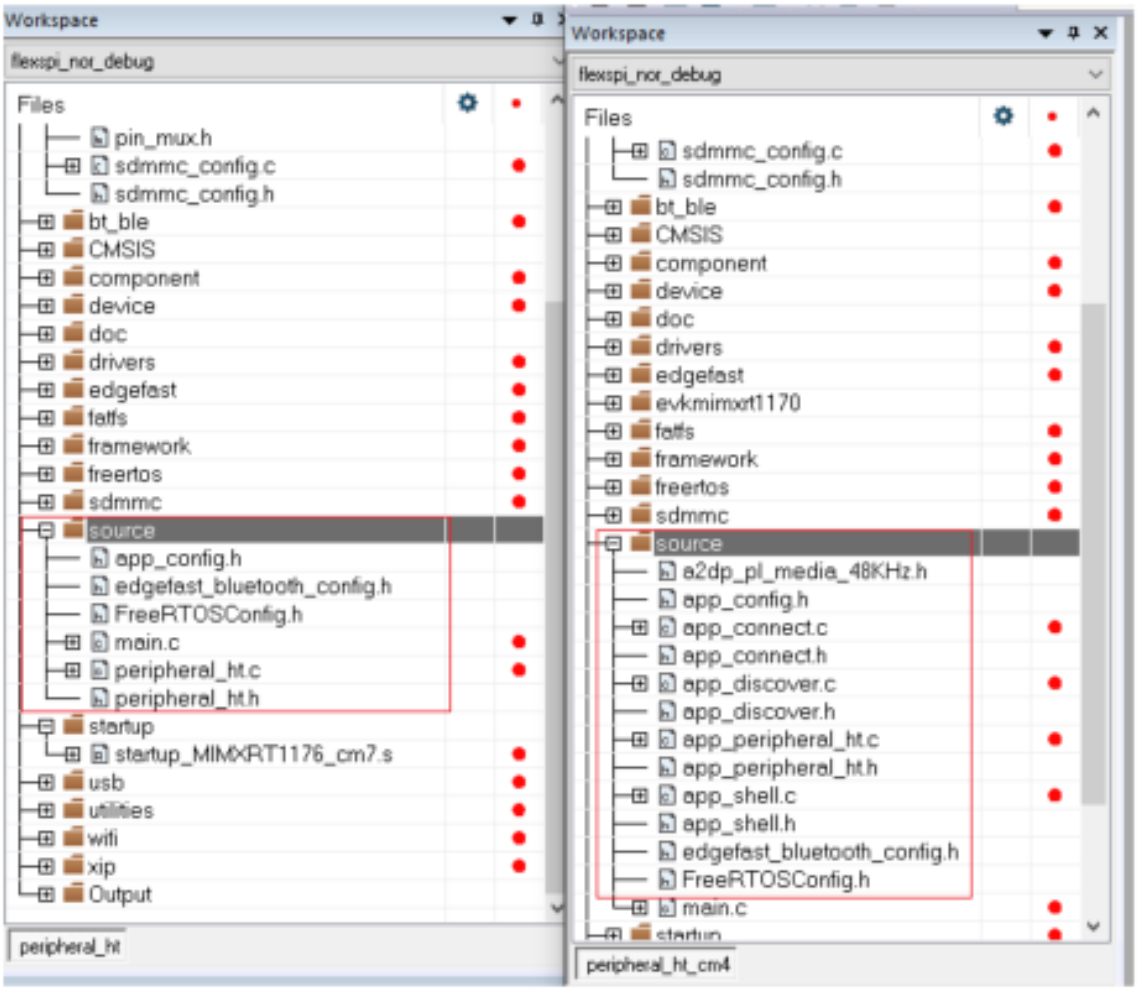
1. Open the folder *cm4* in the directory <*install_dir*> *boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peri* and delete all files with the extensions *.c and *.h.
2. Copy the files with the extensions *.c and *.h from the folder *boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht*|*cm7*| to the folder <*install_dir*> *boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht*|*cm4*.



Parent topic:*IAR*

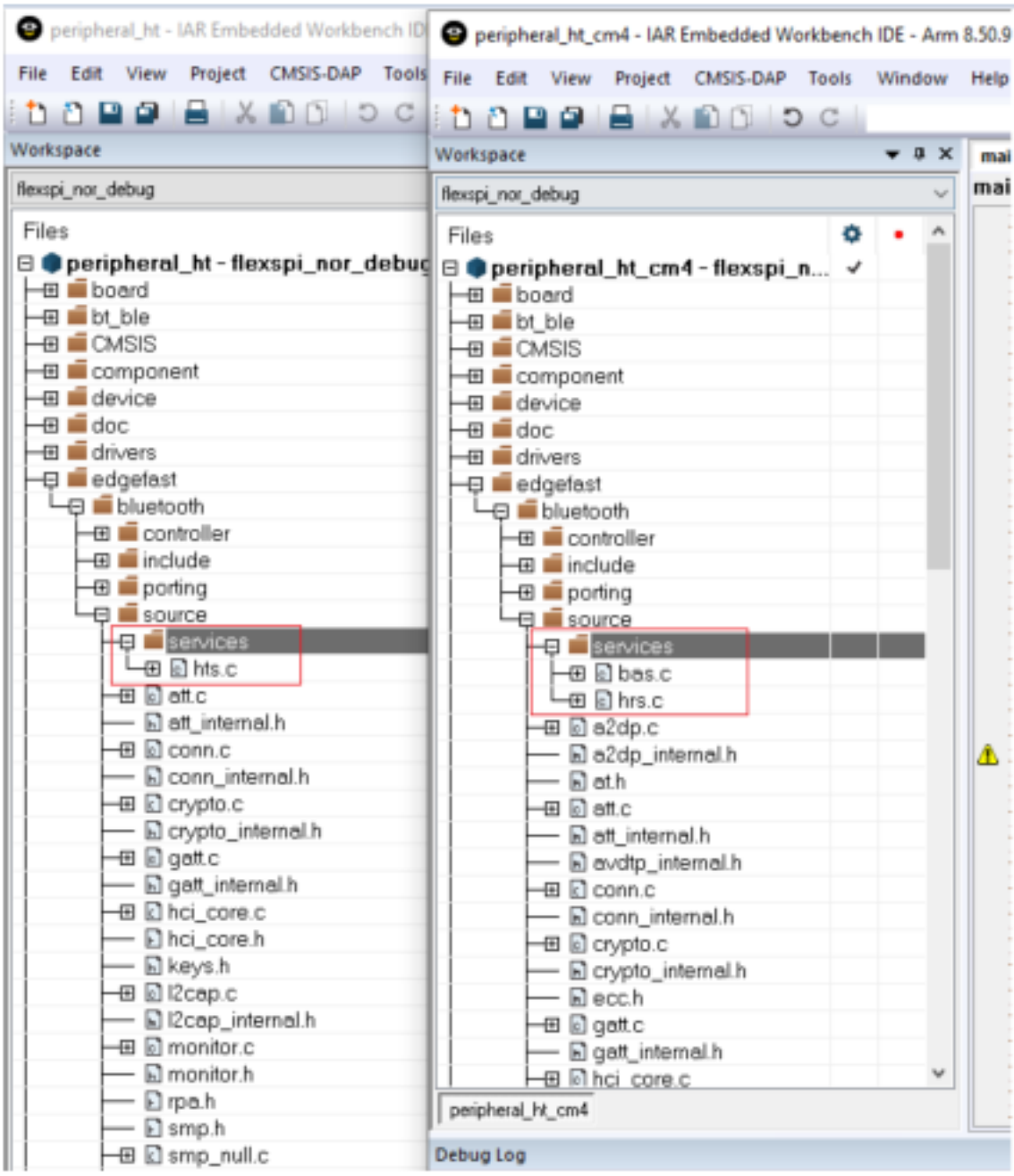
Rearrange project files To rearrange project files, perform the following steps:

1. Open the *peripheral_ht _cm7*and *peripheral_ht _cm4* IAR projects in the directories <*install_dir*> *boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht* |*cm7*|*iar* and <*install_dir*> *boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht* |*cm4*|*iar*.
    1. Compare the whole project directory, find file groups that the cm7 project has but are missing in the cm4 project. Add the missing file groups from the cm7 project into the cm4 project.
    2. Compare the difference between the two groups with the same name. Remove files that do not exist in the cm7 project but exist in the cm4 project. Find files that are available in the cm7 project but are missing in the cm4 project. Add the missing files from the cm7 project into the cm4 project.
2. For example, in the following figure, the files in the source group in the cm4 project must be removed, and the files in the path: <*install_dir*>|*boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht* with the same name as the files in the cm7 project must be added into the *source* group.



3. Compare the *services* group.

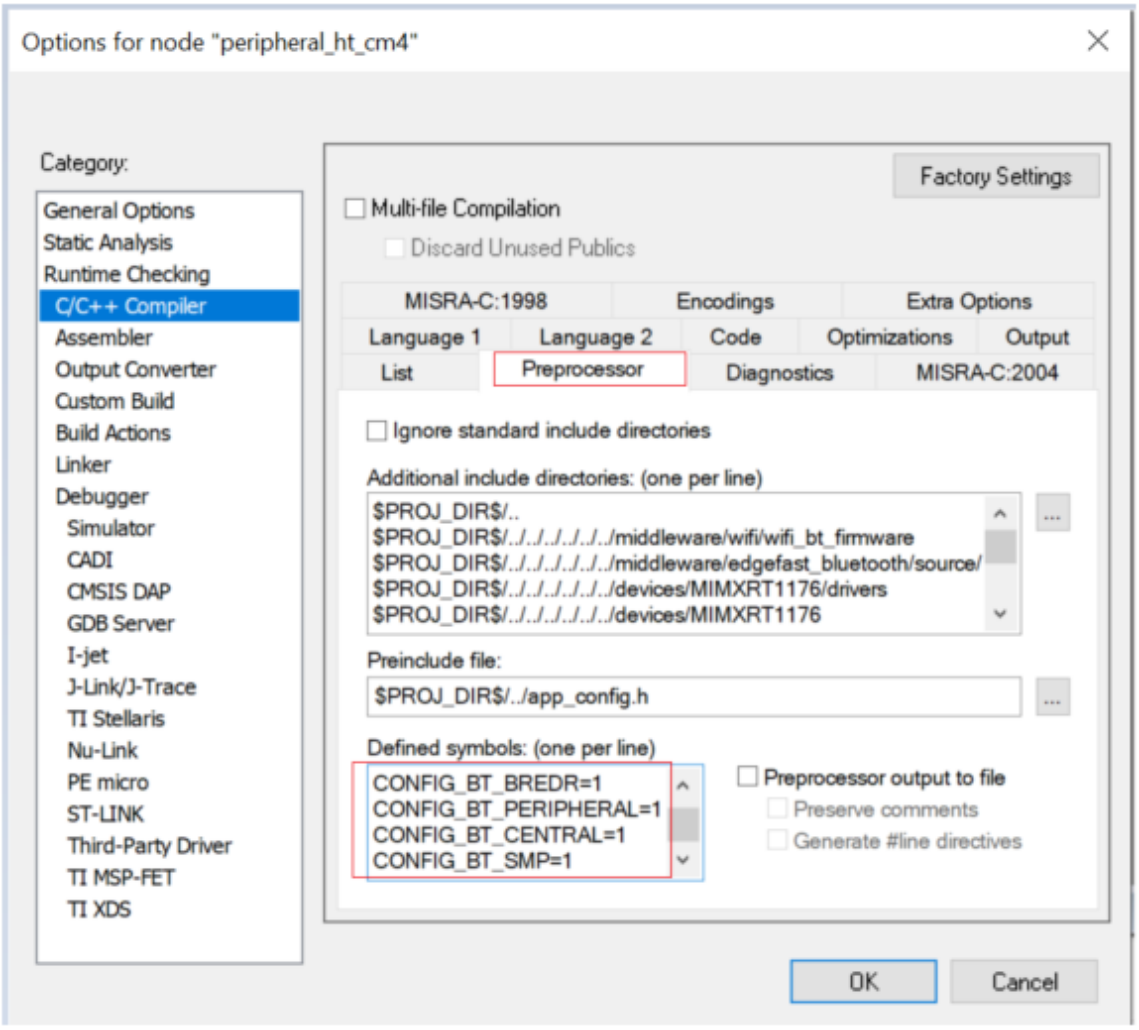
   The peripheral hts profile is in the *services* folder. Add the hts.c file to the *services* group of the *cm4* folder.



Parent topic:*IAR*

Adjust project settings To adjust the project settings, perform the following steps:

1. Compare the macro in the project settings: **Option** > **C/C++ compiler** > **Preprocessor**.
2. Find the macros that do not exist in the **cm4** project but are available in the **cm7** project. Delete these macro. The rule is that **m7** macro setting should be same with **m4**.



|

|

The macros are in the**peripheral_ht_cm4.ewp** file.

|

|

Parent topic:*IAR*

Delete function As a final step, remove the function *"SCB_DisableDCache()*; in main.c.

On the completion of the above steps, the M7 project successfully migrates to an M4 project. You can now download and debug the M4 example project.

Parent topic:*IAR*

Arm GCC This section describes the steps to create an M4 project with Arm GCC, rearrange source and project files, adjust project settings, and delete function.

Create an M4 project To create an M4 project, perform the following steps:

1. Copy the folder <*install_dir*> *boards|evkmimxrt1170|edgefast_bluetooth_examples|a2dp_source|cm4* into another folder in which the example should be enabled. In this case, copy the folder <*install_dir*>

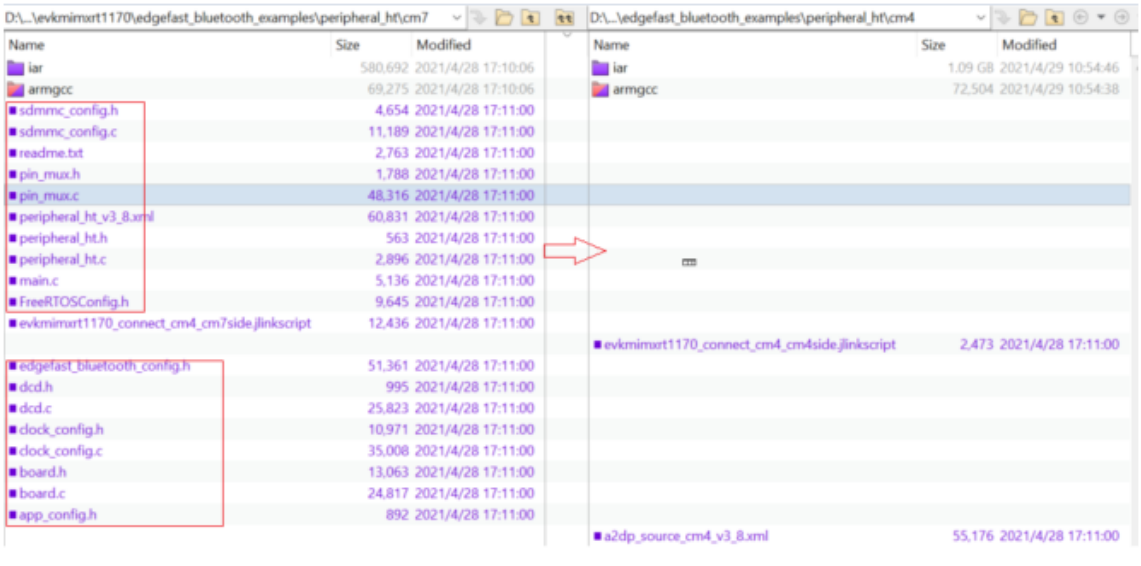
boards\evkmimxrt1170\edgefast_bluetooth_examples\a2dp_source \cm4 into*<install_dir>boards\evkmimxrt1170\edgefast_bluetooth_examples\peripheral_ht\cm4*.

2. Open the file *CMakeLists.txt* located in the path: *<install_dir>boards\evkmimxrt1170\edgefast_bluetooth_examples\peripheral_ht\cm4\ armgcc*.
3. Search and replace all *a2dp_source_cm4* with *peripheral_ht_cm4*, and then save the files.

Parent topic:*Arm GCC*

Rearrange source files To rearrange source files, perform the following steps:

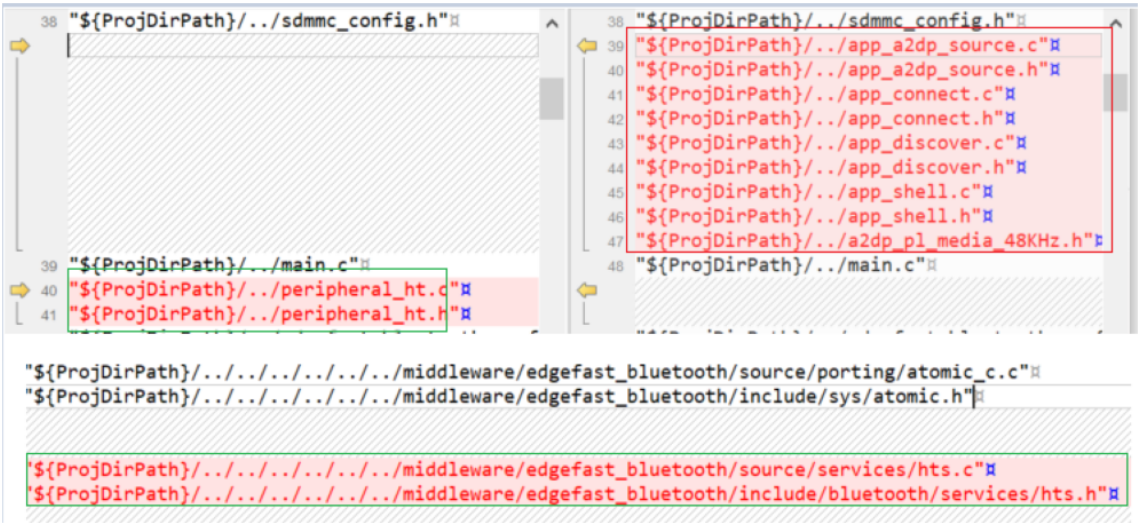
1. Open the folder *<install_dir>boards\evkmimxrt1170\edgefast_bluetooth_examples\peripheral_ht\cm4* and delete all files with the extensions *.c and *.h.
2. Copy the files with the extensions *.c and *.h in the folder *<install_dir>boards\evkmimxrt1170\edgefast_bluetooth_examples\peripheral_ht\cm7* to the folder *<install_dir>boards\evkmimxrt1170\edgefast_bluetooth_examples\peripheral_ht\cm4*.



Parent topic:*Arm GCC*

Rearrange project files To rearrange project files, perform the following steps:

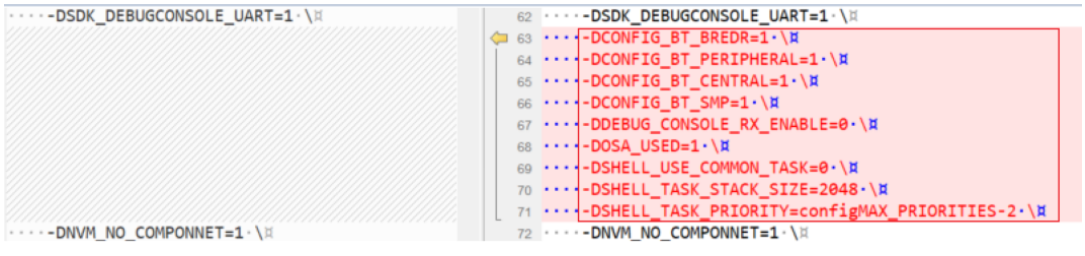
1. Open the *CMakeLists.txt* of the two examples respectively. The two files are in the *<install_dir>boards\evkmimxrt1170\edgefast_bluetooth_examples\peripheral_ht\cm7\armgcc* and *<install_dir>boards\evkmimxrt1170\edgefast_bluetooth_examples\peripheral_ht\cm4\armgcc* folders respectively.
2. Search the section *add_executable*. Compare the difference between the two sections. Remove files that do not exist in the *cm7* project but are available in the *cm4* project. Add the files that exist in the *cm7* project but are not available in the *cm4* project into the *cm4* project. For example, in the following figure, the files in the red box should be removed and the files in the green box must be added into the *cm4* project.



Parent topic:*Arm GCC*

Adjust project setting To adjust the project settings, perform the following steps:

1. Open the *flags.cmake* of the two examples respectively. The two files are in the <*install_dir*>*boards**evkmimxrt1170**edgefast_bluetooth_examples**peripheral_ht**cm7**armgcc* and <*install_dir*>*boards**evkmimxrt1170**edgefast_bluetooth_examples**peripheral_ht**cm4**armgcc* folders respectively.
2. Search the ***CMAKE_C_FLAGS_DEBUG*** section.
    1. Compare the macro between the two sections.
    2. Add the macros that do not exist in the **cm4** project but are available in the **cm7** project into the cm4 project. The rule is that macro setting should be same.
    3. Delete the macros highlighted in the red rectangle.



Parent topic:*Arm GCC*

Delete function As a final step, remove the function *"SCB_DisableDCache()* in main.c.

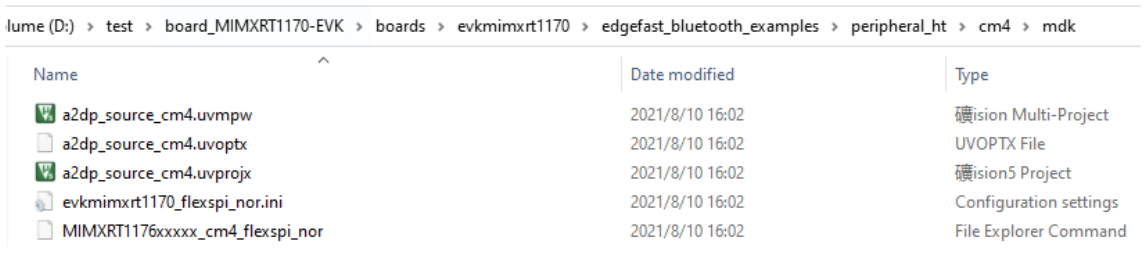
On the completion of the above steps, the M7 project successfully migrates to an M4 project. You can now download and debug the M4 example project.

Parent topic:*Arm GCC*

MDK This section describes the steps to create an M4 project with MDK, rearrange source and project files, adjust project settings, and delete function.

Create an M4 project

1. Copy folder *cm4* from <*install_dir*>*boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*a2dp_source*|*cm4* into the folder in where the example must be enabled. In this case, copy folder *cm4* into directory <*install_dir*>|*boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht*.
2. Open folder mdk from <*install_dir*>*boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht*|*cm4*

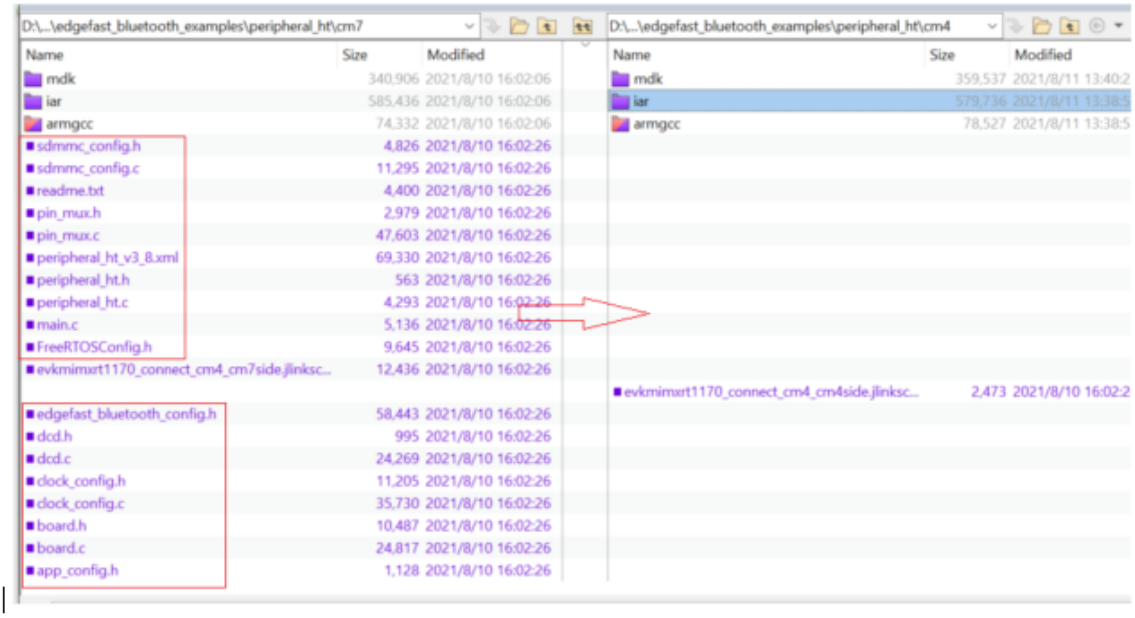


3. Change the filename *a2dp_source_cm4* to *peripheral_ht_cm4* respectively.
4. Open the files *peripheral_ht_cm4.**uvmpw* and *peripheral_ht_cm4.* *uvoptx*, *peripheral_ht_cm4.uvprojx*with a text editor, such as Notepad, Notepad++, Sublime, or Visual Studio code.
5. Search and replace *a2dp_source_cm4* with *peripheral_ht _cm4*, and then save the files.

Parent topic:*MDK*

Rearrange source files

1. Open folder *cm4* in *<install_dir>**boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht*|*cm4*, and delete all files with the .c and .h file name extension.
2. Copy files with the .c and .h filename extension in folder *cm7* with directory <*install_dir*> *boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht*|*cm7*to folder *cm4* with directory <*install_dir*> *boards*|*evkmimxrt1170*|*edgefast_bluetooth_examples*|*peripheral_ht*|*cm4*.

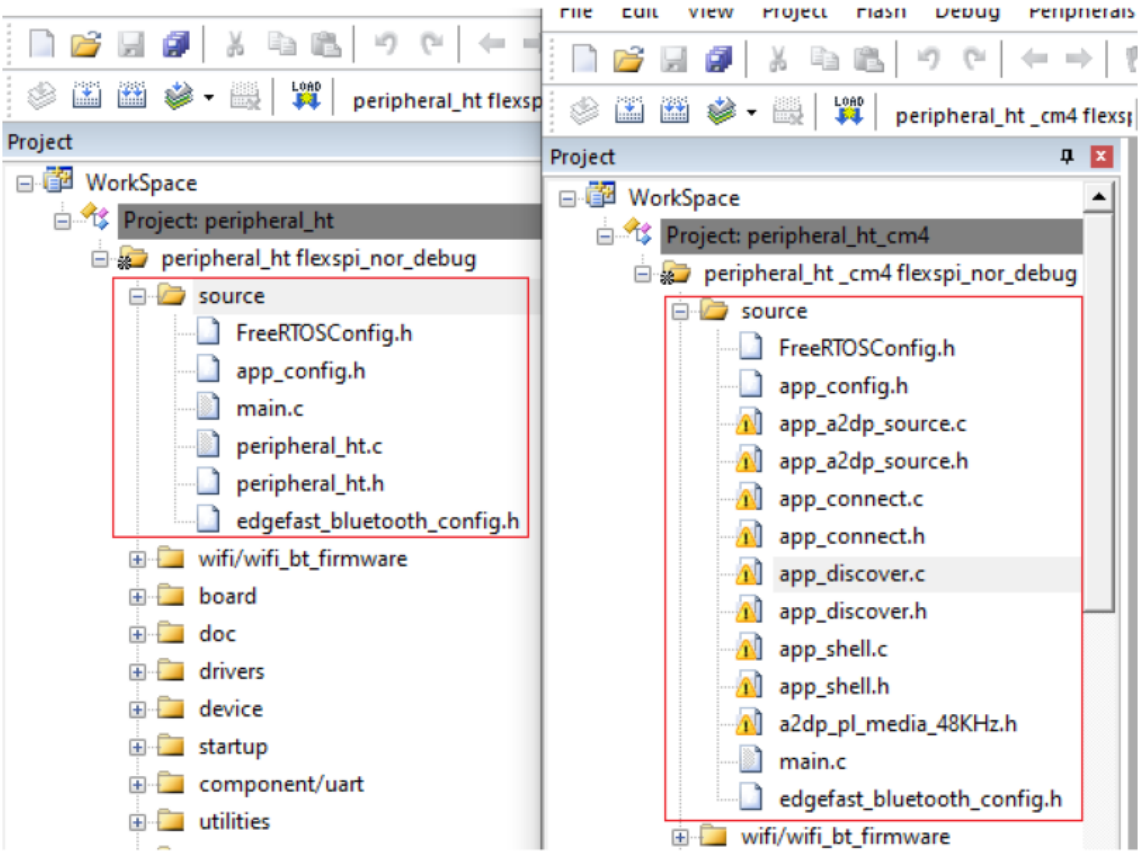


.

Parent topic:*MDK*

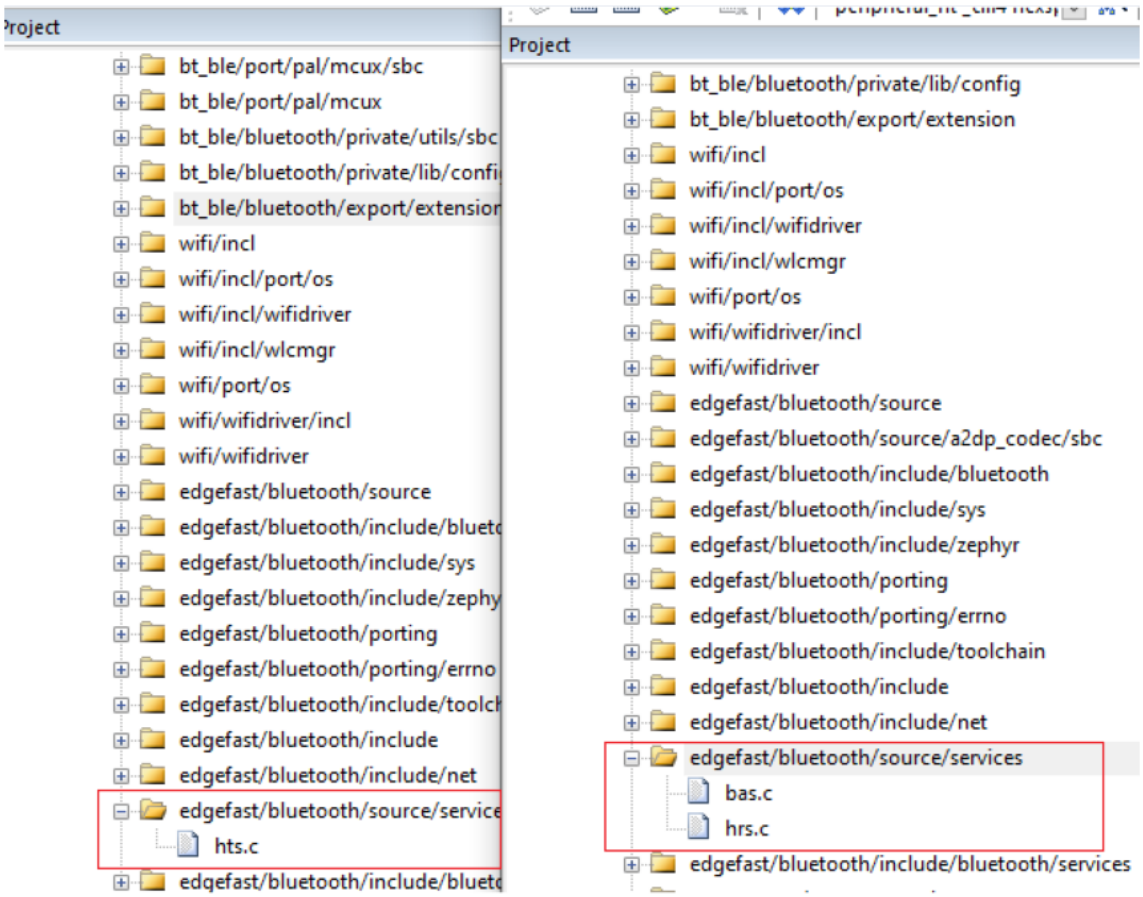
Rearrange project files

1. Open the *peripheral_ht _cm7* and *peripheral_ht _cm4* IAR projects. The two workspaces are located in *<install_dir>**boards**evkmimxrt1170**edgefast_bluetooth_examples**peripheral_ht* *cm7**mdk* and *<install_dir>**boards**evkmimxrt1170**edgefast_bluetooth_examples**peripheral_ht* *cm4**mdk* respectively.
   - Compare the whole project directory, find file groups that the cm7 project has but the cm4 project not and then add these groups into the cm4 project.
   - Compare the difference between the two groups with the same name, remove files that do not exist in the cm7 project but exist in the cm4 project; find files that the cm7 project has but the cm4 project not and then add these files into the cm4 project.
2. For the *source* group, in this case, the files in the source group in the cm4 project must be removed, and the files in the path *<install_dir>**boards**evkmimxrt1170*\ *boards**evkmimxrt1170**edgefast_bluetooth_examples**peripheral_ht**cm4* with the same name as the files in the cm7 project must be added into the *source* group.



3. Compare the **service: group**.

   Peripheral hts profile is located in "**service**" folder. Add the hts.c file to the services group of the cm4 folder.

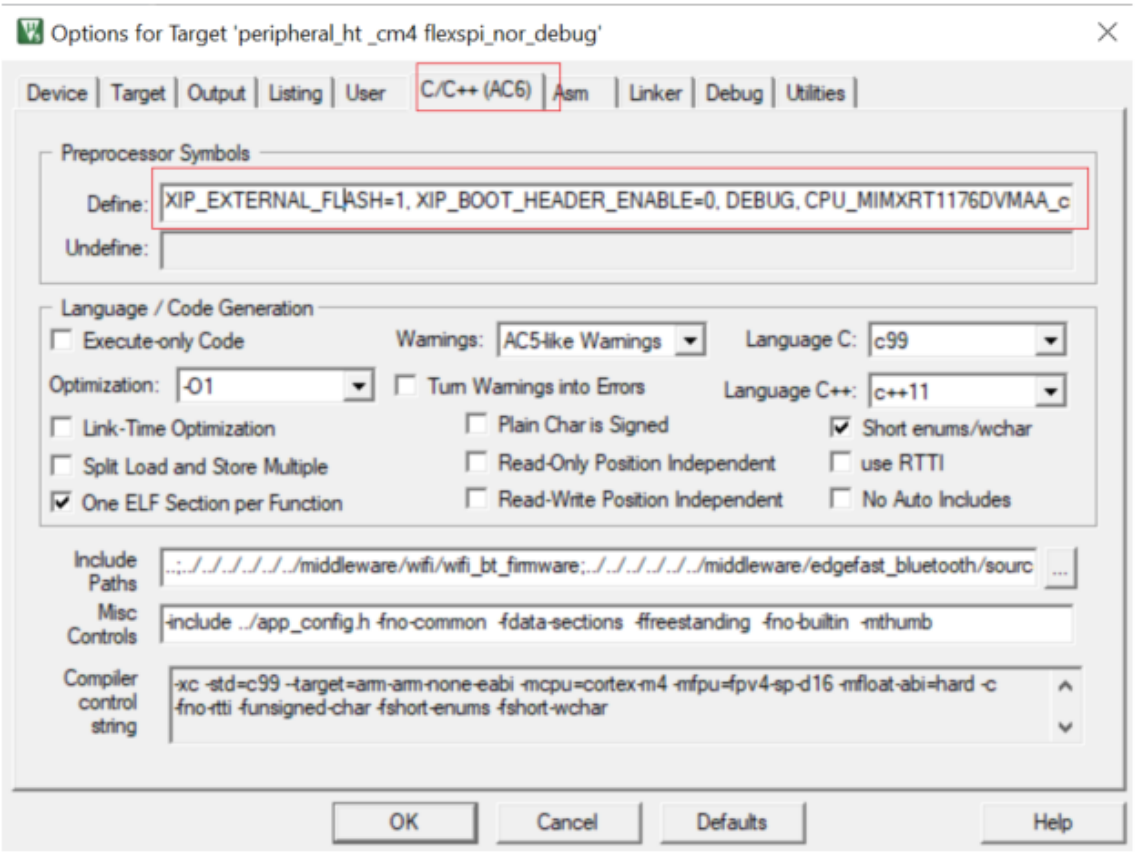


.

Parent topic:*MDK*

Adjust project settings

1. Compare the macro in the project settings: *preprocessor symbols*.
2. Compare the macro that does exist in the cm4 project but exists in the cm7 project.
3. Delete the following macro. The rule is that m7 macro setting should be same as m4 .
   The macro could also be found in be eripheral_ht_cm4.uvprojx.



|

|

|

Parent topic:*MDK*

Delete function Remove function *SCB_DisableDCache();* in *main.c*.

On successful completion of the above steps, the M7 project is changed to the M4 project. You can now download and debug the M4 example project.

Parent topic:*MDK*

Note The above steps are based on the **a2dp_source** example and help enable the **peripheral_ht** example on the **m4** core. You can use the same steps for other examples and migrate them from an **m7** project to an **m4** project.

Chapter 2

RTOS

2.1 FreeRTOS

2.1.1 FreeRTOS kernel

Open source RTOS kernel for small devices.

FreeRTOS kernel for MCUXpresso SDK Readme

FreeRTOS kernel for MCUXpresso SDK ChangeLog

FreeRTOS kernel Readme

2.1.2 FreeRTOS drivers

This is set of NXP provided FreeRTOS reentrant bus drivers.

2.1.3 backoffalgorithm

Algorithm for calculating exponential backoff with jitter for network retry attempts.

Readme

2.1.4 corehttp

C language HTTP client library designed for embedded platforms.

2.1.5 corejson

JSON parser.

Readme

2.1.6 coremqtt

MQTT publish/subscribe messaging library.

2.1.7 corepkcs11

PKCS #11 key management library.

Readme

2.1.8 freertos-plus-tcp

Open source RTOS FreeRTOS Plus TCP.

Readme