arm CHINA

Application Note

Testing the QCU Driver of STAR

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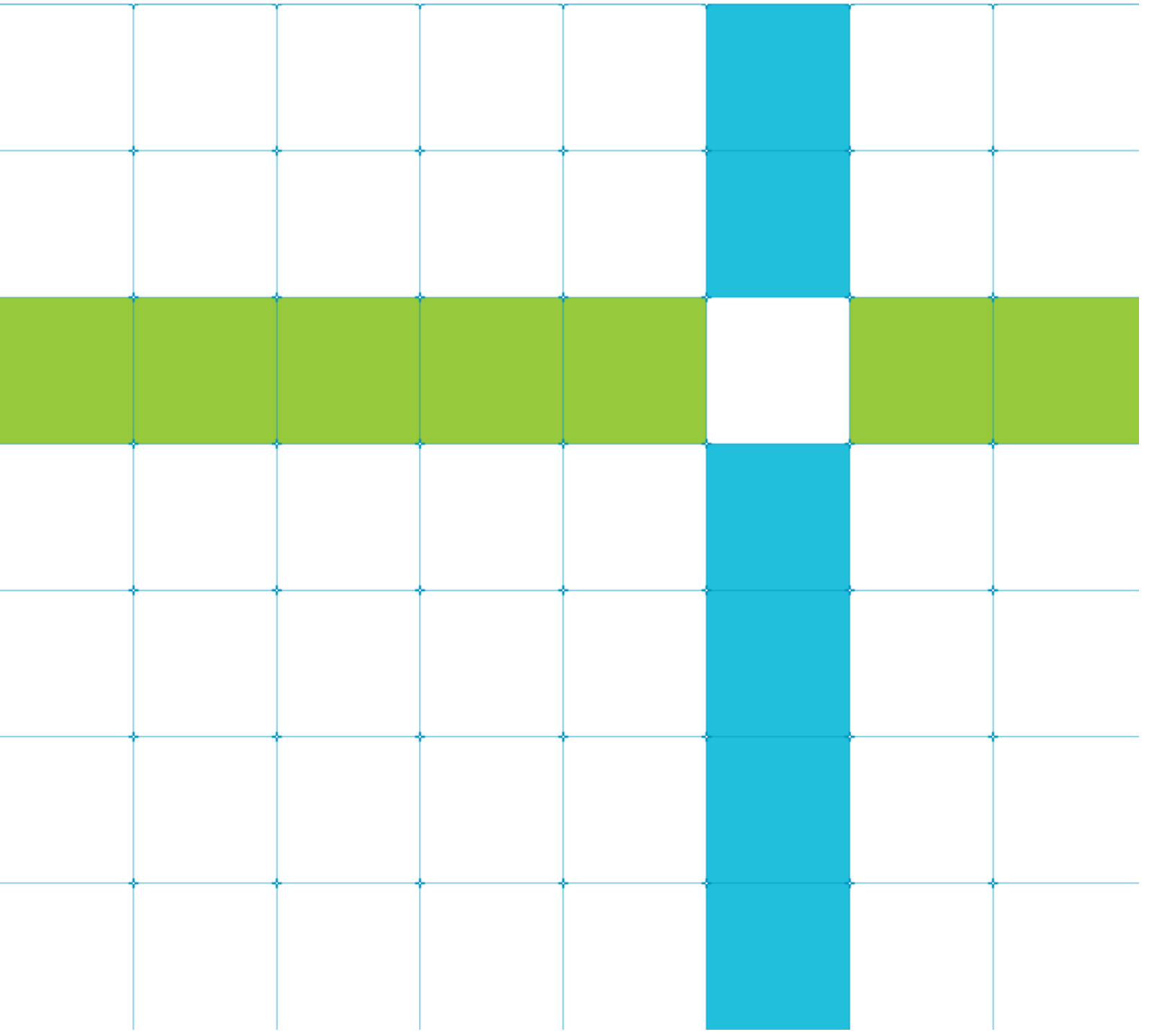
Non-Confidential



Non-Confidential Proprietary Notice

Release Information

Document History

Issue	Date	Confidentiality	Change
A	**25/02/2022**	**Non-Confidential**	**Initial release**

Contents

1 About this document

This Application Note is intended for developers, programmers, and users who use the Arm China STAR *Device Family Pack* (DFP). This Application Note gives you a basic understanding of the *QSPI Controller Unit* (QCU) driver in STAR and provides guidance on how to use the example project to test the functionality of QCU driver.

1.1 References

Reference	Document number	Title
[1]	00903001_0100_00	Arm China Star Processor Technical Reference Manual

1.2 Terms and abbreviations

This document uses the following terms and abbreviations.

Term	Meaning
CMSIS	Cortex Microcontroller Software Interface Standard
DFP	Device Family Pack
QCU	QSPI Controller Unit
QSPI	Quad Serial Peripheral Interface
MCC	Motherboard Configuration Controller

1.3 Conventions and feedback

The following describes the typographical conventions and how to give feedback:

Convention	Meaning
monospace	denotes text that can be entered at the keyboard, such as commands, file and program names, and source code.
monospace	denotes a permitted abbreviation for a command or option. The underlined text can be entered instead of the full command or option name.
monospace italic	denotes arguments to commands and functions where the argument is to be replaced by a specific value.
monospace bold	denotes language keywords when used outside example code.
italic	highlights important notes, introduces special terminology, denotes internal cross-references, and citations.
bold	highlights interface elements, such as menu names. Also used for emphasis in descriptive lists, where appropriate, and for Arm China processor signal names.

1.3.1 Feedback on this product

If you have any comments and suggestions about this product, contact your supplier and give:

- Your name and company.
- The serial number of the product.
- Details of the release you are using.
- Details of the platform you are using, such as the hardware platform, operating system type and version.
- A small standalone sample of code that reproduces the problem.
- A clear explanation of what you expected to happen, and what actually happened.
- The commands you used, including any command-line options.
- Sample output illustrating the problem.
- The version string of the tools, including the version number and build numbers.

1.3.2 Feedback on documentation

If you have comments on the documentation, e-mail errata@armchina.com. Give:

- The title.
- The number, [Document ID Value], [Issue].
- If viewing online, the topic names to which your comments apply.
- If viewing a PDF version of a document, the page numbers to which your comments apply.
- A concise explanation of your comments.

Arm China also welcomes general suggestions for additions and improvements.

1.3.3 Other information

- Arm Glossary, http://infocenter.arm.com/help/topic/com.arm.doc.aeg0014-/index.html.

2 Introduction

2.1 CMSIS

The *Cortex Microcontroller Software Interface Standard* (CMSIS) is a vendor-independent hardware abstraction layer for microcontrollers.

The CMSIS defines generic tool interfaces and enables consistent device support.

The CMSIS provides:

- Simple software interfaces to processor and peripherals.
- A common approach to interface to peripherals, real-time operating systems, and middleware components.

2.2 STAR DFP

For CMSIS compliant toolchains such as Keil MDK and IAR EW, additional software components and support for microcontroller devices are provided by software packs.

A DFP is one of the CMSIS software packs. It indicates that a software pack contains support for microcontroller devices.

A DFP provides essential support for the software targets on a specific device, such as startup, system, linker scripts, and debug configuration.

The STAR processor is the first processor in the Arm China STAR series processor family.

STAR is a fully featured microcontroller class processor based on the Armv8-M mainline architecture with Arm TrustZone technology (depending on the actual core).

In STAR CMSIS DFP v1.3.0 and later, there are example projects of STAR application. These example projects can help you quickly build projects and run the application software and then get a better understanding of how to use STAR.

2.3 QCU

STAR QCU provides a mechanism to load executing programs directly from external Flash memory instead of boot-up from embedding Flash memory. It provides a low-cost and simple method to implement SoC integration.

QCU provides the necessary functionality to a host to communicate with a serial Flash device through the SPI. The unit supports most common serial Flash device instructions, such as read, program, erase and other custom instructions. The communication with Flash devices is used by commands, which includes five phases—Instruction, Address, Alternate byte, Dummy and Data. Any of these phases can be configured to be skipped, but at least one of them needs to be present.

QCU is highly flexible and can be configured to support a large number of SPI Flash memories. QCU also supports newer serial Flash devices with densities up to 256MB.

QCU is a specialized communication interface targeting single, dual or quad SPI Flash memories.

QCU can work in one of the following modes:

- **Direct Read Access mode**: The external Flash memory is mapped to the device address space and is seen by the system as if it was an internal memory. Direct Read Access mode can be used to both access and directly execute code from external Flash memory, and it supports Flash memory XIP mode. After power-on, QCU changes to default Direct Read Access mode to boot up. The operation mode is accessed through AHB-Bus. When in Direct Read mode, any other modes can be inserted at any time.
- **Indirect mode**: All the operations are performed using the registers. This mode allows software to access the internal TX FIFO and RX FIFO directly. The level of FIFO can be configurable. It is used to access the volatile and non-volatile configuration registers, the legacy SPI status registers, other status and protection registers and the Flash ROM content. It is recommended that this mode is used to erase and configure the serial Flash device. When a transaction request is from Q-AHB, the transaction will be waiting until exiting the current Indirect mode into Direct mode.
- **Inactive mode**: This mode is used to disable QSPI-Bus. It offers a *clean* state to set up the QSPI's related register, such as division clock index, command mode, and command type. When a transaction request is from Q-AHB, an error is returned.

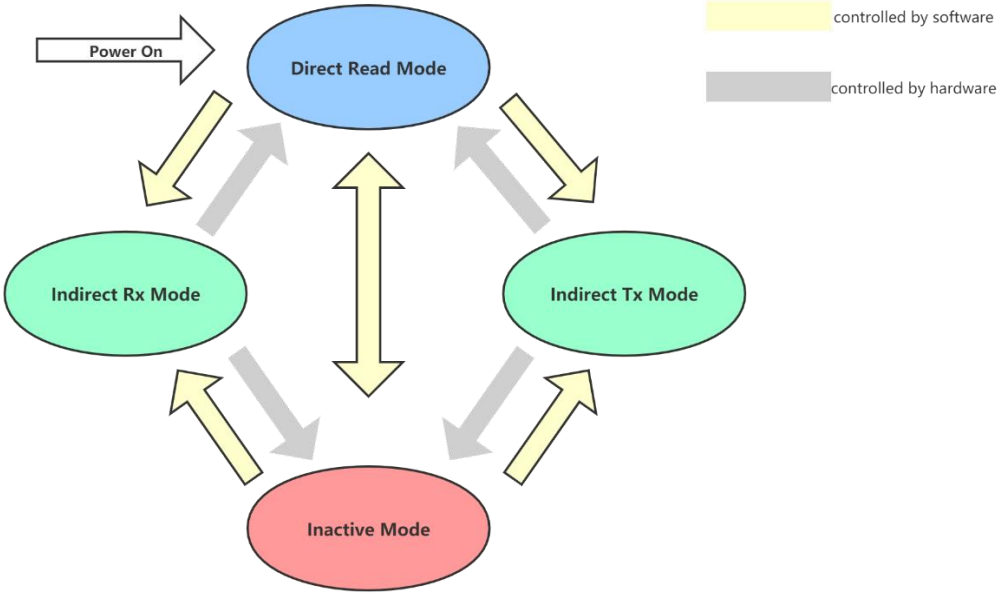


Figure 2-1 QCU modes

The initial state is Direct Read Mode after power-on or cold reset. You can configure QSPI to other states by setting the control register. Indirect Mode is a special state. When the transaction in Indirect Mode is done, hardware will be responsible for changing the state back to the previous one (Inactive or Direct Read, depending on the mode which it enters from). The status register is used to indicate whether the indirect transaction is done.

The Direct Read Mode and Indirect Mode use different sets of registers to construct respective SPI communication. These settings take effect only after the control register is configured, which means that you must confirm the target mode, Direct or Indirect mode, then write the corresponding registers. When the control register is configured, the QCU will load Mode-specific parameters according to the value of the control register.

3 Before you begin

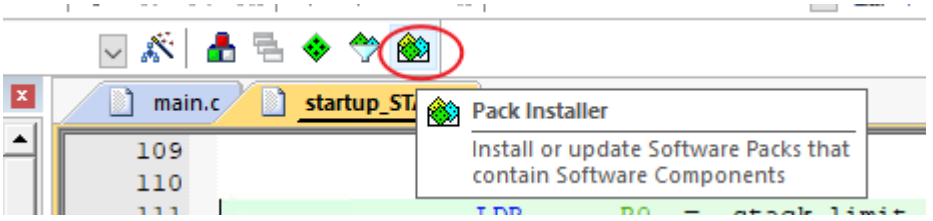
The example project of the application software will run on an MPS3 FPGA board.

Before using the example project, you must:

- Ensure that you have an MPS3 FPGA board and have a STAR-based device implemented with QCU on the board.
- Check the STAR CMSIS DFP version.

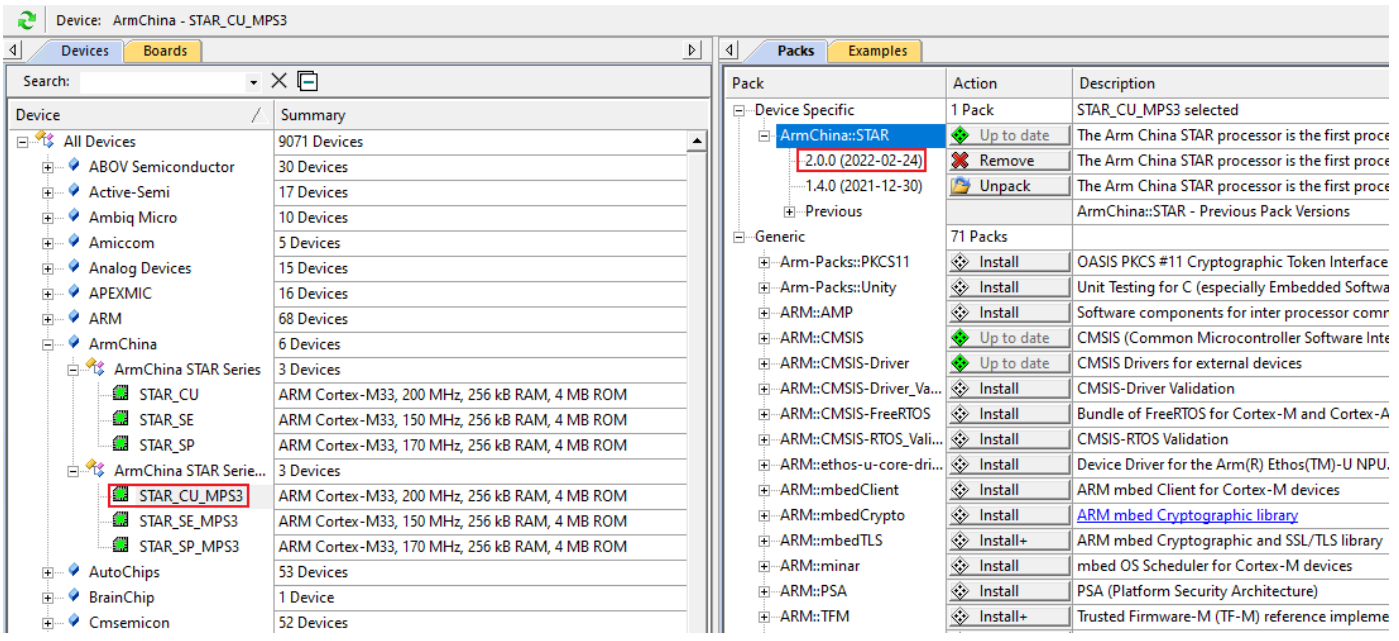
To check the STAR CMSIS DFP version:

1. Start MDK.
2. On the toolbar, click the **Pack Installer** icon.



3. On the **Devices** tab, select a device (for example, STAR_CU_MPS3) and check the version of the installed pack.

   As shown in the following figure, the version of the ArmChinaSTAR pack should be 2.0.0 or later.



4 QCU driver introduction

The QCU Driver is a set of functions in form of software snippets which can be used to drive STAR-internal (embedded) QSPI controller to access the STAR-external serial interface device typically such as serial Flash device. The following figure shows the software architecture with the QCU driver:

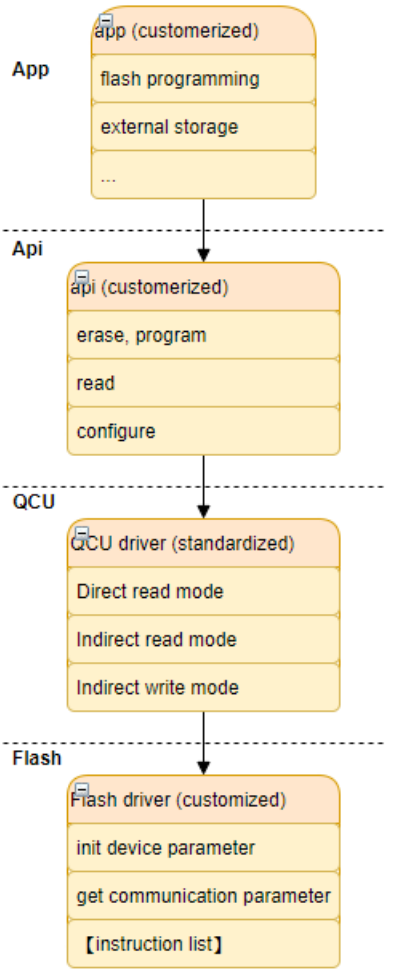


Figure 4-1 Software architecture with the QCU driver

The operations supported by the QCU driver are as follows:

- **Initiate**

  int32_t QCU_Init(GetInitParameter_t GetInitParameter)

  Initialize the control register of QCU according to the device, such as clock prescaler, Flash memory size, and SCK mode.

- **Indirect write**

  int32_t QCU_Write(uint8_t cmd, QCU_CommData_Typedef *comm_data, bool xip_mode, GetParameter_t GetParameter)

Send the data to the device or configure registers of the device in QCU indirect mode. In indirect write mode, all the operations are performed using the registers. Software is allowed to access serial Flash memory through the internal TX FIFO directly.

- **Indirect read**

  int32_t QCU_Read_Indirect(uint8_t cmd, QCU_CommData_Typedef *comm_data, GetParameter_t GetParameter)

  Read the memory data or status of the device using the QCU registers in indirect mode. In indirect read mode, software is allowed to access serial Flash memory through the internal RX FIFO directly.

- **Direct read**

  int32_t QCU_Read_Direct(uint8_t cmd, bool xip_mode, GetParameter_t GetParameter)

  This function configures the direct read mode registers of QCU. After calling the QCU_SetOPMode() function to change the OPMODE, the registers will be updated. The external Flash memory is mapped to the device address space and is seen by the system as if it was an internal memory.

- **Set OPMODE**

  int32_t QCU_SetOPMode(uint8_t op_mode, bool xip_mode)

  This function sets the operation mode of QCU. You need to ensure that parameters of registers such as *OMCR* and *RMCR* are configured correctly before calling this function.

- **Get OPMODE**

  uint8_t QCU_GetOPMode(void)

  This function gets the operation mode of QCU.

Before you proceed, ensure that the following preparations are completed:

- Familiar with QCU operation mode.
- Familiar with the command sequence and features of the serial Flash device that you are using.
- Coding Flash driver to provide the operation parameters for the QCU driver.

Then you can communicate with the Flash device.

5 Testing the QCU Driver by using the example project

An example project, which demonstrates how to test the QCU driver by using the example Flash API and Flash driver, is available in STAR DFP v2.0.0.

In this example, the hardware platform is MPS3, on which an MCU system with STAR-r1 inside is implemented.

Re-map the configuration files to enable the software to boot from BRAM. After that, the example software runs on BRAM and conducts Flash operations such as erase, program, and read memory by using the drivers. The logs are shown in the UART terminal window.

You can use this example project to test the software of the QCU driver if the software is modified. For example, when you change a new Flash device, you might need to modify the API and Flash driver. You can use this example project to help to test the software you modified.

Note: for more information of changing Flash, refer to chapter 6 of the document "Application_Note_Using_the_QCU_Driver_of_STAR_v1.0_en"

Running this project might also help you to quickly understand the STAR QCU and the driver, as you can observe the behavior and result of the QCU driver (and the QCU hardware itself). For example, you can use the debug tool to run and debug multiple functions such as Direct Read, Indirect Read, Programing, and Erase. Figure 5-1 shows the overview of the testing project:

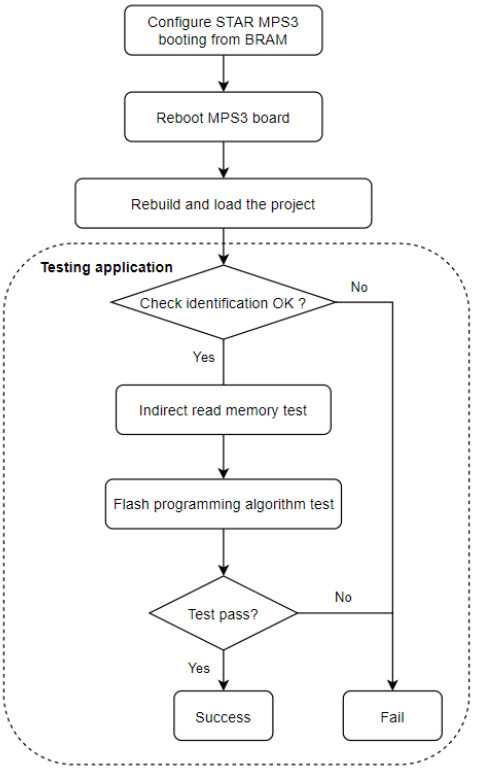


Figure 5-1 Testing project overview

The following figure shows the workflow of Flash identification check:

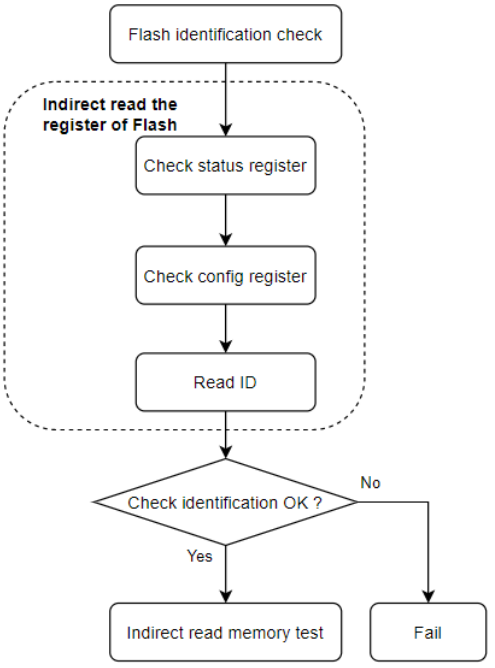


Figure 5-2 Workflow of Flash identification check

The following figure shows the workflow of indirect read memory test:

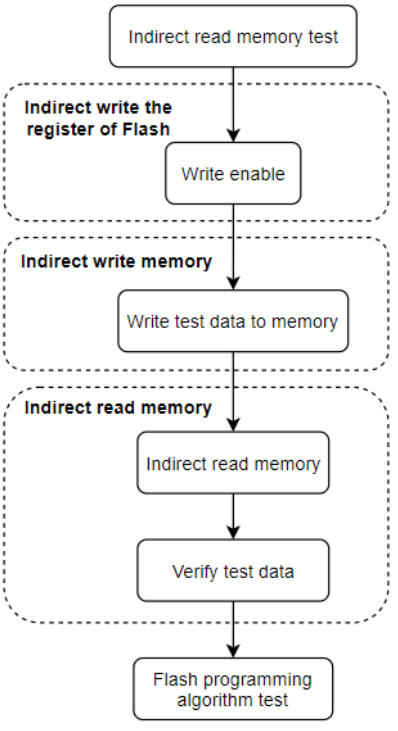


Figure 5-3 Workflow of indirect read memory test

The following figure shows the workflow of Flash programming algorithm test:

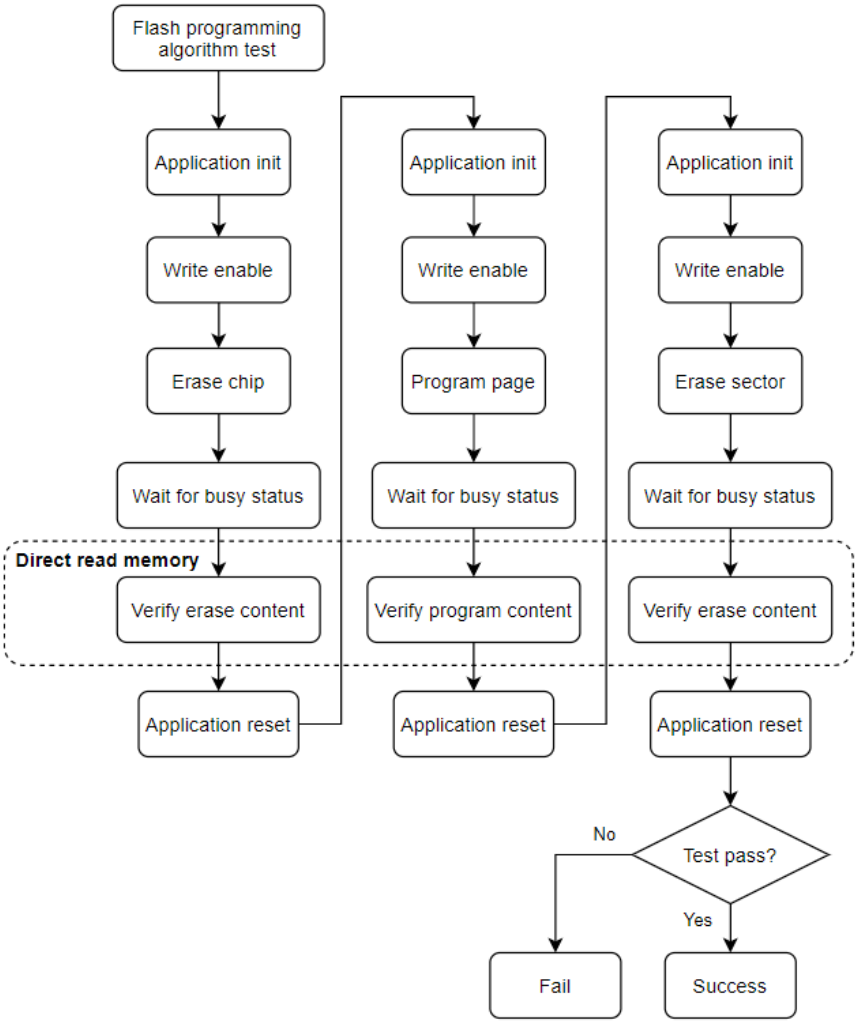
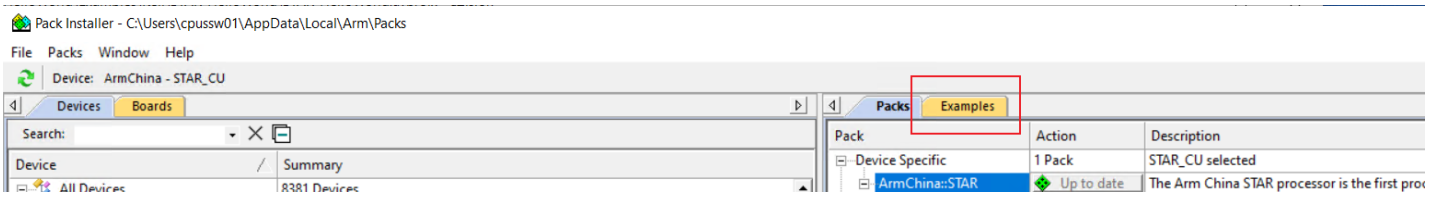


Figure 5-4 Workflow of Flash programming algorithm test

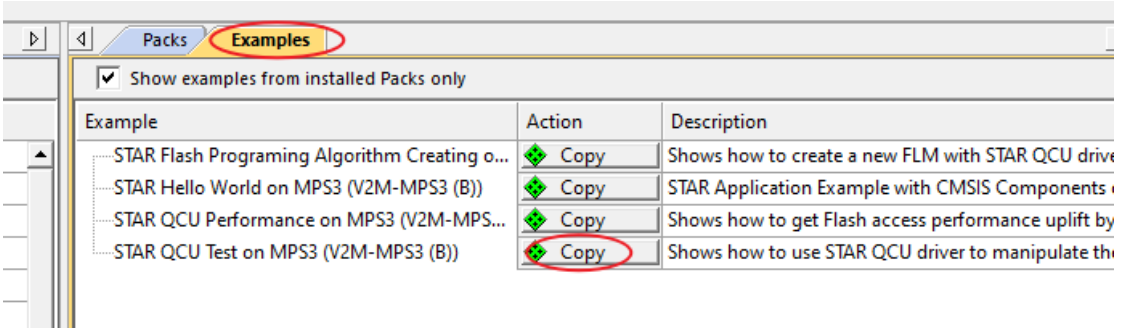
To use the example project, take the following steps:

1. In the Pack Installer, click the **Examples** tab.



2. On the **Examples** tab, select the example that you want to use and click **Copy**.

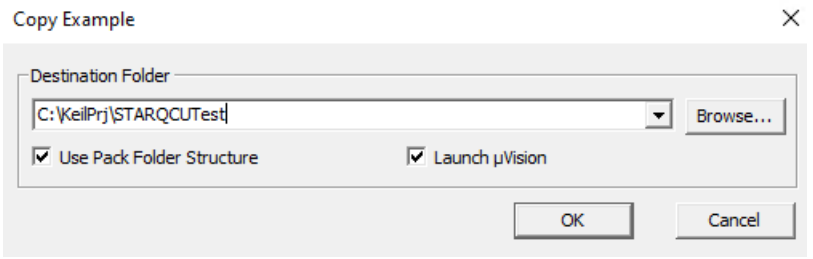
An example named **STAR QCU Test on MPS3** is available in STAR CMSIS DFP v2.0.0. This example project will show how to use the QCU driver to communicate with the Flash device on the STAR MPS3 board.



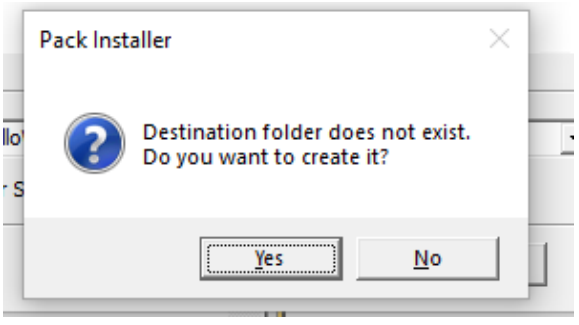
Note:

Sometimes the Copy button is disabled in gray because updates are needed for certain packs. You can check the progress bar to confirm this situation. When the progress reaches 100%, the Copy button will be enabled.

3. In the **Copy Example** dialog box that appears, specify the destination folder path to save the project, and then click **OK**.



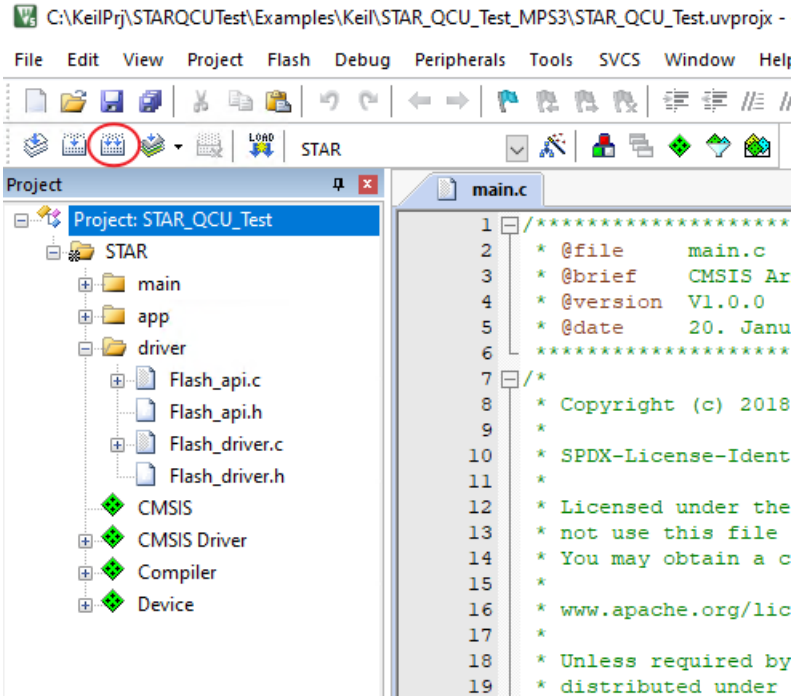
If the destination folder does not exist, click **Yes** to create it.



A project is created in the destination folder.

The µVision will start automatically and open the created project. In the Project pane, you can see all the required files.

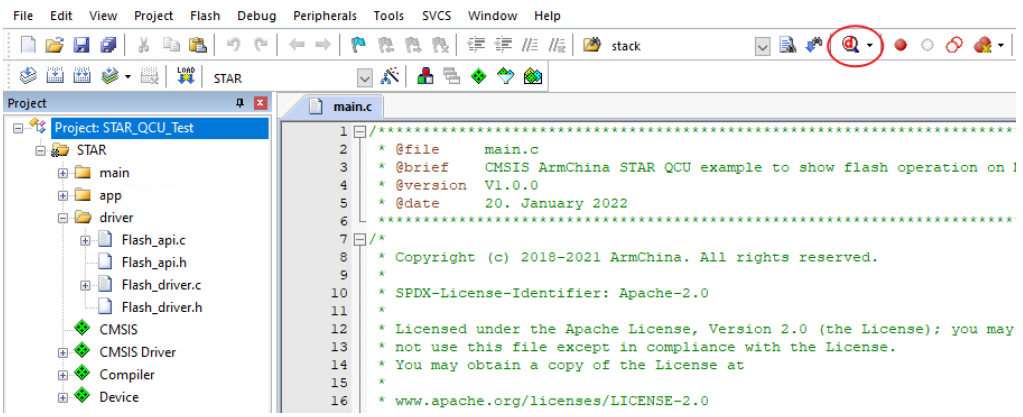
4. Click the **Rebuild** icon to recompile and build the project.



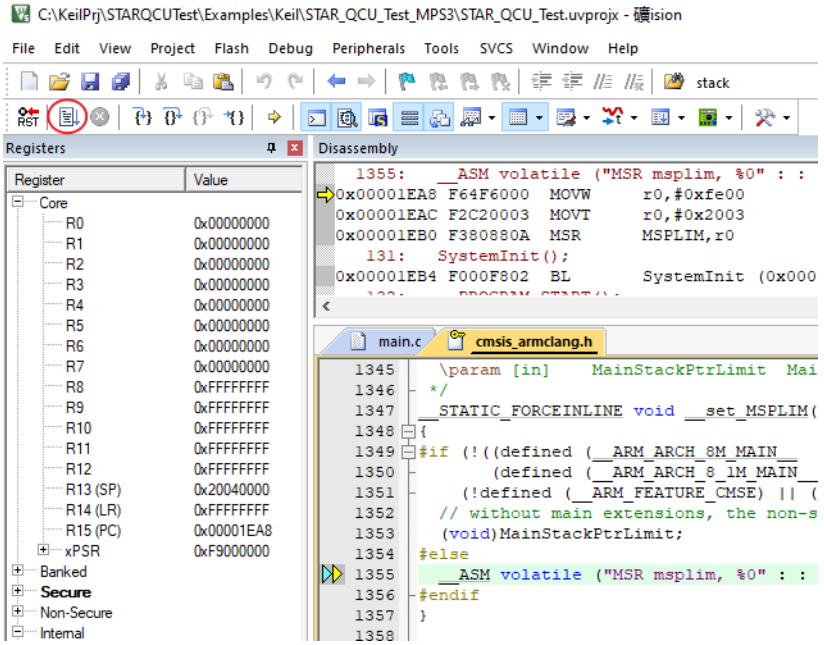
5. Configure the text file $F:\MB\HBI0309C\AN524\an524_v2.txt and reboot the MPS3 board.

```
REMAP: BRAM
REMAPVAL: 0
XIPMODE: SPI
TOTALSYSCONS: 4
SYSCON: 0x000 0x00000001
SYSCON: 0x008 0x00000000
SYSCON: 0x018 0x00000002
SYSCON: 0x01c 0x00000003
```

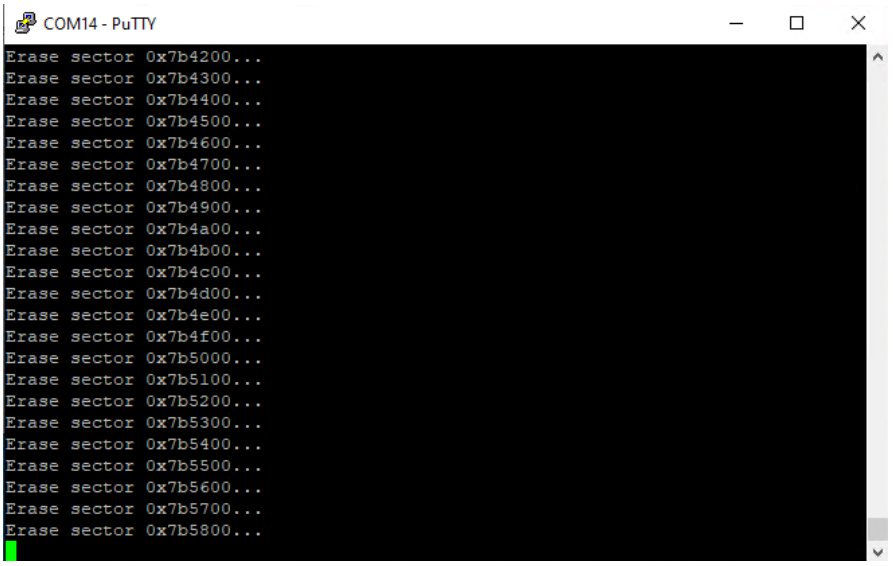
6. Load this example to the STAR MPS3 board directly with Keil MDK Debug Session.

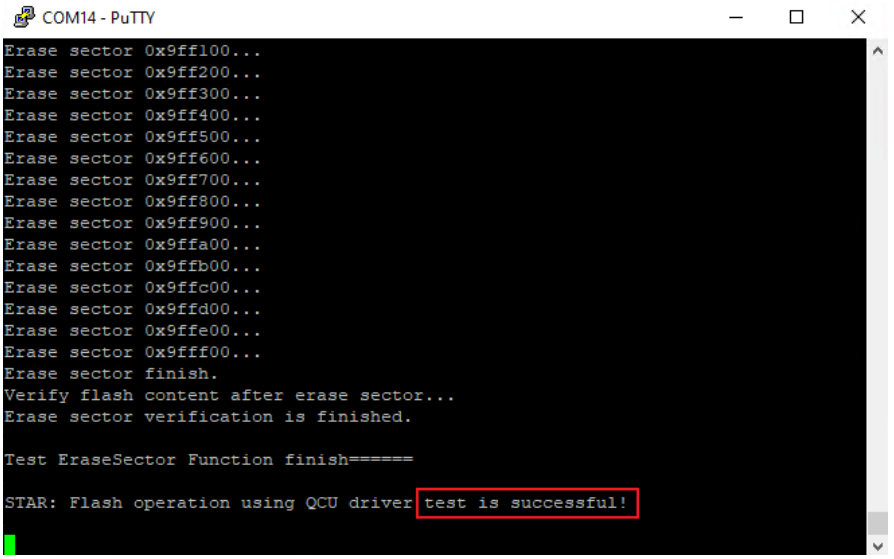


7. Run the built software.



You can see the running log in the UART terminal window and observe the process of the Flash operation using the QCU driver.





Based on this project, you can start to use the QCU driver and explore more Flash operations in your STAR-based application software.