

Introduction

This module guide will enable you to effectively use a module in your own design. On completion of this guide, you will be able to add this module to your own design, configure it correctly for the target application and write code, using the included application project code as a reference and an efficient starting point. References to more detailed API descriptions and suggestions of other application projects that illustrate more advanced uses of the module are included in this document and should be valuable resources for creating more complex designs.

The Quad SPI (QSPI) HAL module is a high-level API for erasing and programming the contents of a QSPI flash device connected to the microcontroller, and is implemented on the `r_qspi` peripheral on the Synergy MCU. Unlike many other modules, there is no callback function for the QSPI.

Contents

1. QSPI HAL Module Features	2
2. QSPI HAL Module APIs Overview.....	2
3. QSPI HAL Module Operational Overview.....	3
3.1 QSPI HAL Module Important Operational Notes and Limitations	3
3.1.1 QSPI HAL Module Operational Notes	3
3.1.2 QSPI HAL Module Limitations	4
4. Including the QSPI HAL Module in an Application	4
5. Configuring the QSPI HAL Module.....	4
5.1 QSPI HAL Module Pin Configuration	5
6. Using the QSPI HAL Module in an Application.....	5
7. The QSPI HAL Module Application Project	6
8. Customizing the QSPI HAL Module for a Target Application	9
9. Running the QSPI HAL Module Application Project.....	9
10. QSPI HAL Module Conclusion	9
11. QSPI HAL Module Next Steps.....	9
12. QSPI HAL Module Reference Information.....	10

1. QSPI HAL Module Features

The QSPI HAL Module is used to initialize the QSPI peripheral that allows erasing and programming the contents of a QSPI flash device connected to the microcontroller over the Quad SPI interface. Key features include:

- Access Quad SPI flash devices using direct communication mode
- Read data from a QSPI flash device
- Program the page of a QSPI flash device
- Erase sectors of a QSPI flash device
- Select a bank to control access to a QSPI flash device

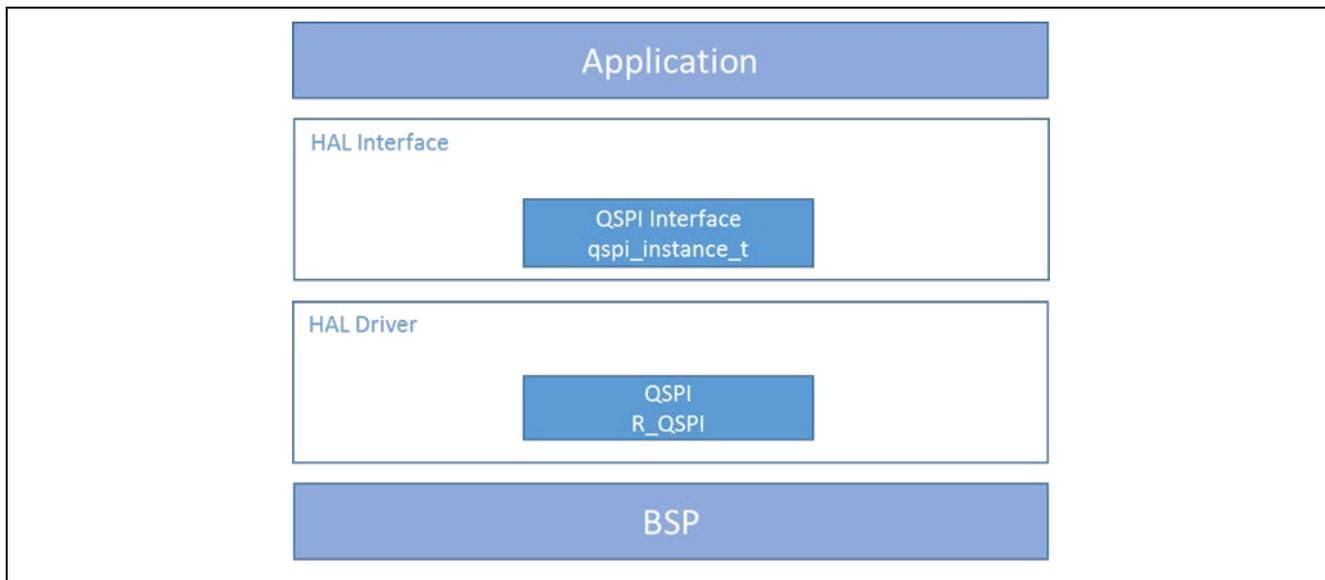


Figure 1 QSPI HAL Module Block Diagram

2. QSPI HAL Module APIs Overview

The QSPI interface defines APIs for opening, closing, reading, writing, erasing and device bank selection using the QSPI HAL module. A complete list of the available APIs, an example API call and a short description of each can be found in the following table. A table of status return values follows the API summary table.

Table 1 QSPI HAL Module API Summary

Function Name	Example API Call and Description
.open	<code>g_qspi0.p_api->open(g_qspi0.p_ctrl, g_qspi0.p_cfg);</code> Open the QSPI HAL module.
.close	<code>g_qspi0.p_api->close(g_qspi0.p_ctrl);</code> Close the QSPI HAL module.
.read	<code>g_qspi0.p_api->read(g_qspi0.p_ctrl, (uint8_t *) QSPI_DEVICE_ADDRESS, readBuffer, BUFFER_LENGTH);</code> Read data from the flash.
.pageProgram	<code>g_qspi0.p_api->pageProgram(g_qspi0.p_ctrl, (uint8_t *) QSPI_DEVICE_ADDRESS, writeBuffer, BUFFER_LENGTH);</code> Program a page of data to the flash.
.sectorErase	<code>g_qspi0.p_api->sectorErase(g_qspi0.p_ctrl, (uint8_t *) QSPI_DEVICE_ADDRESS);</code> Erase a sector on the flash.

Function Name	Example API Call and Description
.erase	<pre>g_qspi0.p_api->erase(g_qspi0.p_ctrl, (uint8_t *) QSPI_DEVICE_ADDRESS, BYTE_COUNT);</pre> <p>Erase a block of memory depending on the input argument "byte_count"</p>
.statusGet	<pre>g_qspi0.p_api->statusGet(g_qspi0.p_ctrl, &in_progress);</pre> <p>Get the write or erase status of the flash.</p>
.bankSelect	<pre>g_qspi0.p_api->bankSelect(0);</pre> <p>Select the bank to access.</p>
.infoGet	<pre>g_qspi0.p_api->infoGet(g_qspi0.p_ctrl, &qspi_info);</pre> <p>Provides information about the underlying QSPI flash, as specified in bsp_qspi.c</p>
.versionGet	<pre>g_qspi0.p_api->versionGet(& ssp_version);</pre> <p>Retrieve the API version with the version pointer.</p>

Note: For more complete descriptions of operation and definitions for the function data structures, typedefs, defines, API data, API structures and function variables, review the SSP User's Manual API References for the associated module.

Table 2 Status Return Values

Name	Description
SSP_SUCCESS	API Call Successful.
SSP_ERR_INVALID_ARGUMENT	Invalid parameter is passed.
SSP_ERR_ASSERTION	p_cfg was NULL.
SSP_ERR_NOT_OPEN	Driver is not opened.
SSP_ERR_UNSUPPORTED	Driver not able to query the following information from the flash manufacturer id, memory capacity and memory type.

Note: Lower-level drivers may return common error codes. Refer to the SSP User's Manual API References for the associated module for a definition of all relevant status return values.

3. QSPI HAL Module Operational Overview

The QSPI HAL module is used to initialize the QSPI peripheral so that the Synergy device can communicate (read, write, erase data) with a QSPI serial flash device.

The driver supports three operation modes: page program (write), read and erase.

- *Page program* programs a single page of data to the flash device. Page size is specific to flash memory and may vary from vendor to vendor. Typical page sizes of flash are 128,256 and 512 bytes. Use the infoGet API to get the supported page size for the underlying flash device.
- *Read* operation will read the data from the flash and store it to the user-provided buffer.
- *Erase* operation will erase the block of data from the flash. Use infoGet API to get the supported erase size for the underlying flash device.

Note: After any erase/write operation and before starting the next operation, it is advisable to use the statusGet API to poll the status of operation; not doing this may corrupt user data.

3.1 QSPI HAL Module Important Operational Notes and Limitations

3.1.1 QSPI HAL Module Operational Notes

In the case of using a board supported by the SSP, a BSP-based project (SK-S7G2 and DK-S7G2) and the board having a QSPI memory device pre-installed, the BSP initializes and places the QSPI peripheral in ROM access mode with XIP

(execute in place) enabled. This process enables the memory to be read like standard memory, meaning the QSPI HAL module is only be needed when erasing and programming the QSPI flash device.

The typical QSPI application programs or erases data on the QSPI flash device. When this driver is not open, the QSPI flash device contents get mapped to 0x60000000 and can be read as if ordinary memory.

This driver has been tested on the S7G2 and S3A7 Synergy microcontroller groups using the QSPI peripheral block and the Micron N25Q256A QSPI flash device.

3.1.2 QSPI HAL Module Limitations

Refer to the latest SSP Release Notes for any additional operational limitations for this module.

4. Including the QSPI HAL Module in an Application

This section describes how to include the QSPI HAL module in an application using the SSP configurator.

Note: The process assumes you are familiar with creating a project, adding threads adding a stack to a thread and configuring a block within the stack. If you are unfamiliar with any of these items, refer to the first few chapters of the SSP User’s Manual to learn how to manage each of these important steps in creating SSP-based applications.

To add the QSPI Driver to an application, add it to a thread using the stacks selection sequence given in the following table. (The default name for the QSPI Driver g_qspi0. This name can be changed in the associated Properties window).

Table 3 QSPI HAL Module Selection Sequence

Resource	ISDE Tab	Stacks Selection Sequence
g_qspi0	Threads	Select HAL/Common and select New > Driver > Storage > QSPI HAL on QSPI

When the QSPI HAL module on r_qspi is added to the thread stack as shown in the following figure, the configurator automatically adds any needed lower-level modules. Modules with a **Gray** band are individual modules that stand alone.



Figure 2 QSPI HAL Module Stack

5. Configuring the QSPI HAL Module

No component options of the QSPI HAL module need to be changed. The driver does not use the QSPI interrupt, so it is not enabled. Consider changing only the name of the driver instance for easier source code development.

The SSP configuration window automatically highlights any selections, such as interrupts or operating modes, requiring configuration for lower-level modules to achieve successful operation. In most applications, the default values for modules in the lower layers of the stack can be accepted. The following tables detail the available options that can be specified in the Properties window.

Note: You may want to open your ISDE, create the module and explore the property settings in parallel with looking over the configuration settings in the following table. This helps to orient you and provides a useful ‘hands-on’ approach to learning the ins and outs of developing with SSP.

Table 4 Configuration Settings for the QSPI HAL Module on r_qspi

ISDE Property	Value	Description
Parameter Checking	Default (BSP)	Parameter checking level.
Name	g_qspi0	Name of the QSPI HAL instance. This may be edited to an application specific name if required.

Note: The example values and defaults given for settings come from a project using the Synergy S7G2 MCU. Other MCUs may have different default values and available configuration settings.

5.1 QSPI HAL Module Pin Configuration

The QSPI peripheral module uses pins on the MCU to communicate to external devices. I/O pins must be selected and configured as required by the external device. The following table indicates the method for selecting pins within the SSP configuration window. The subsequent table lists an example selection sequence for the QSPI pins.

Table 5 Pin Selection Sequence for the QSPI HAL Module

Resource	ISDE Tab	Pin selection Sequence
QSPI	Pins	Select Peripherals > Storage:QSPI > QSPI0

Note: The selection sequence assumes the QSPI0 is the desired hardware target for the driver.

Table 6 Pin Configuration Settings for the QSPI HAL Module

Property	Value	Description
Pin Group Selection	<ul style="list-style-type: none"> • Mixed • _A only 	Pin group selection.
Operation Mode	<ul style="list-style-type: none"> • Disabled • Custom • Single or Dual • Quad 	Operation mode.
QSPCLK	None, P500	QSPI clock output pin.
QSSL	None, P501	QSPI slave select pin.
QIO0	None, P502	Data 0 input/output.
QIO1	None, P503	Data 1 input/output.
QIO2	None, P504	Data 2 input/output.
QIO3	None, P505	Data 3 input/output.

Note: The example values come from a project using the Synergy S7G2 and the SK-S7G2 Kit. Other Synergy Kits and other Synergy MCUs may have different available pin configuration settings.

6. Using the QSPI HAL Module in an Application

Once the module has been configured and the files generated, the QSPI is ready to be used in an application.

The typical steps in using the QSPI HAL module in an application are:

1. Initialize the QSPI HAL module using the `open` API call.
2. Read a block of data using the `read` API call.
3. Erase a sector of data using the `sectorErase` API call.
4. Erase `n` bytes of data using the `erase` API call.
 - a. `infoGet` can be used to get the supported erase sizes by the underlying flash.
 - b. `statusGet` API can be used to poll the status of erase operation applicable for `sectorErase` API also.

5. Program a page of data using the `pageProgram` API call.
 - a. Use `infoGet` API to get the page size supported by the underlying flash.
 - b. `statusGet` API can be used to poll the status of write operation.
6. Close the QSPI HAL module using the `close` API call.

Note: It is advisable to use the `erase` API instead of `sectorErase` API as the Sector is not a standard size for flash device and it varies with different vendors.

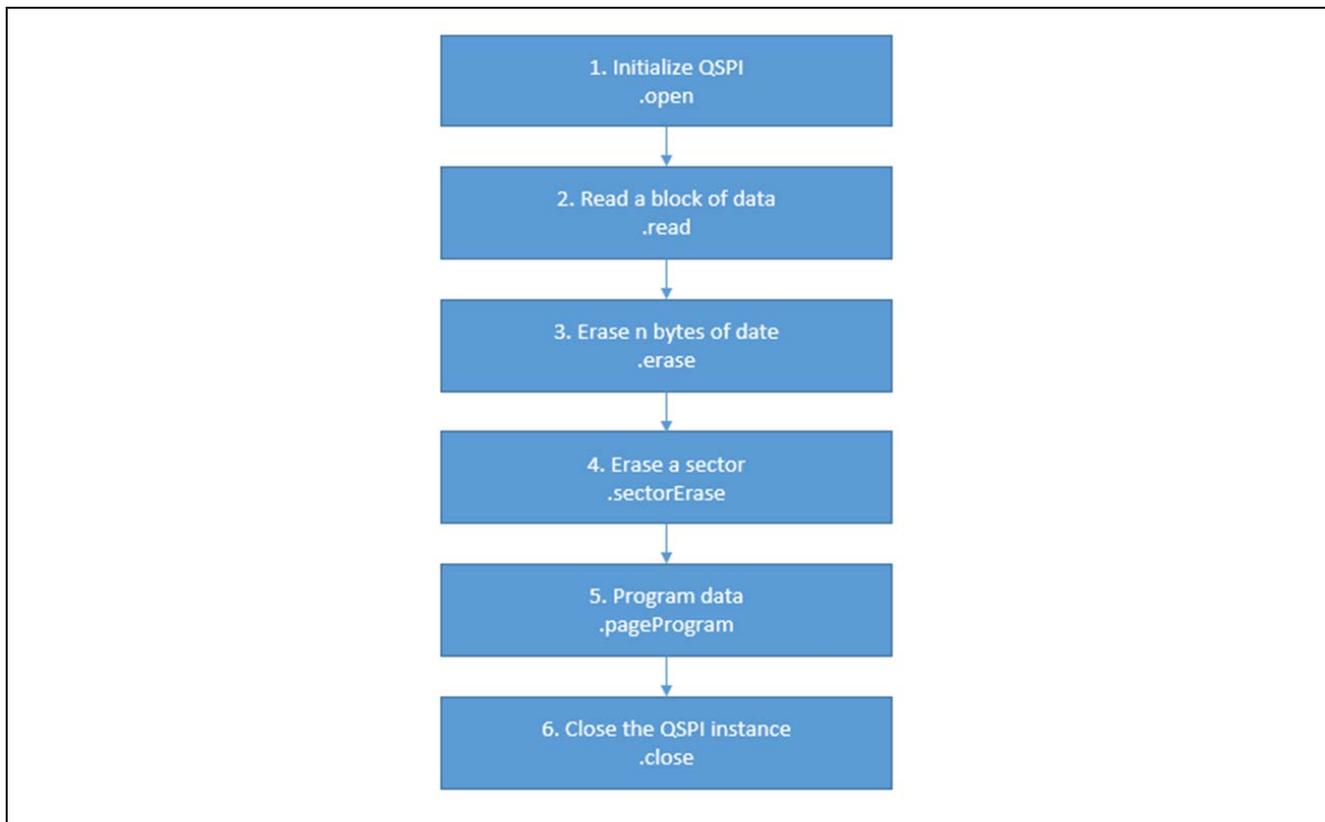


Figure 3 Flow Diagram of a Typical QSPI HAL Module Application

7. The QSPI HAL Module Application Project

The application project associated with this module guide demonstrates the steps used in a full design. The project can be found using the link in the References section at the end of this document. You can read over the code in `hal_entry.c` file.

The application project demonstrates the typical use of the QSPI HAL module APIs. The application project includes the following steps:

1. Turns off the three user LEDs of SK-S7G2: LED1, LED2 & LED3
2. Initializes and opens the QSPI HAL module.
3. Erases the first sector of QSPI flash device.
4. Waits until the erase process completes.
5. Writes a test pattern to the QSPI flash device.
6. Waits until the write process completes.
7. Reads data from the flash device using the QSPI HAL module.
8. Closes the QSPI HAL module.
9. Compares the write and read buffers.
10. If write and read buffers are equal LED1 (green LED) toggles. If the buffers are unequal, indicating an error condition, LED2 (red LED) toggles.
11. Waits for the push button (SW4) to be pressed by the user.
12. LED3 illuminates to indicate the next stage of the application.
13. Reads data from the flash device, via ROM access mode.
14. Compares write and read buffers.
15. If buffers are equal LED1 (green LED) toggles. If the buffers are unequal, indicating an error condition, LED2 (red LED) toggles.

Table 7 Software and Hardware Resources Used by the Application Project

Resource	Revision	Description
e ² studio	5.3.1 or later	Integrated Solution Development Environment
SSP	1.2.0 or later	Synergy Software Platform
IAR EW for Renesas Synergy	7.71.2 or later	IAR Embedded Workbench for Renesas Synergy
SSC	5.3.1 or later	Synergy Standalone Configurator
SK-S7G2	v3.0 to v3.1	Starter Kit

The following figure shows the QSPI HAL Application project flow diagram:

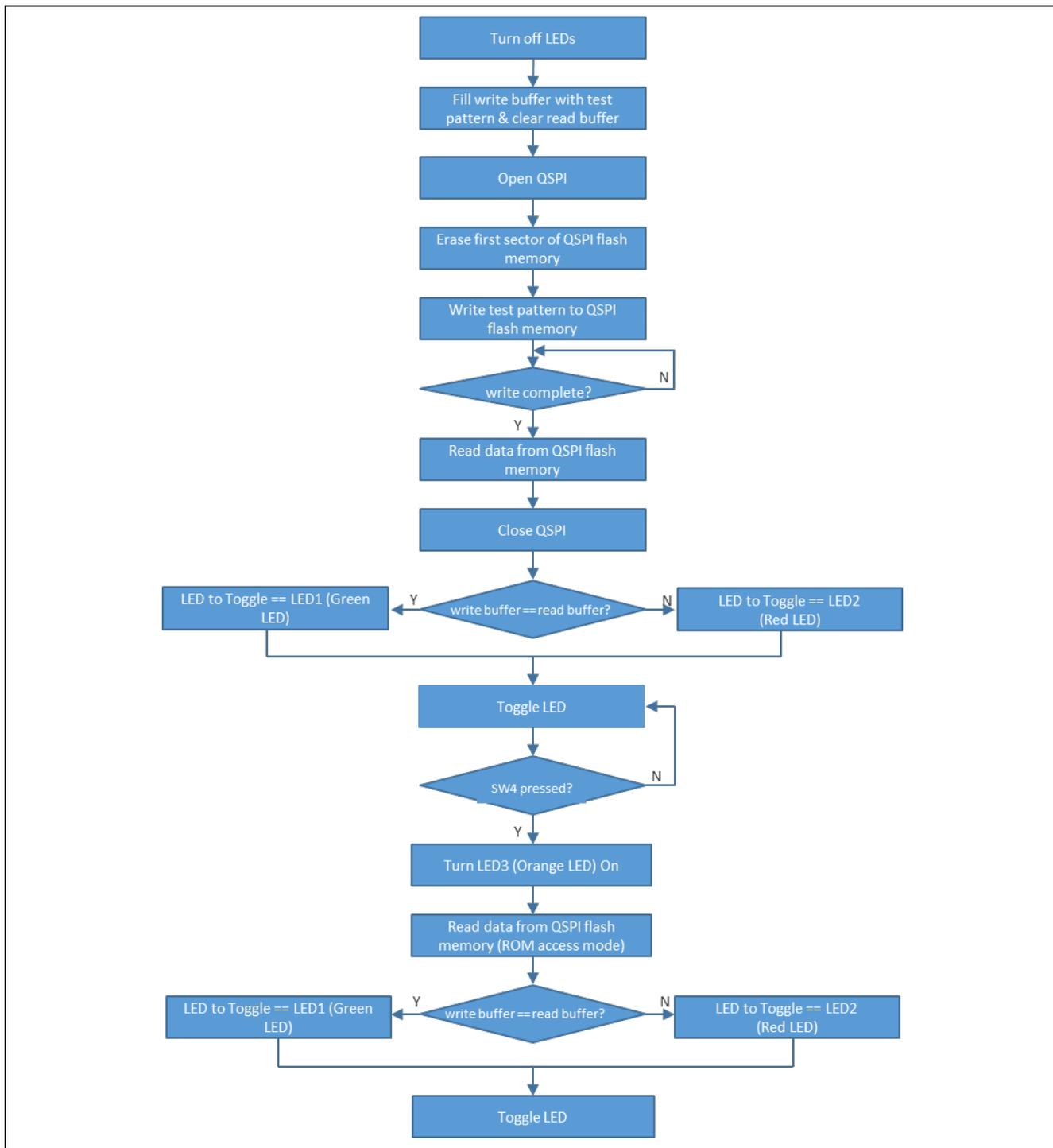


Figure 4 QSPI HAL Module Application Project Flow Diagram

The first section of `hal_entry.c` includes the auto-generated header file that references the QSPI instance structure. The next section has the definitions for LEDs and the pushbutton switch I/O ports. This section also includes the default buffer size for the read and write data buffers and the physical address location where the QSPI is mapped. Within the function `hal_entry.c`, the variables are declared.

Once the LEDs and data buffers initialize, the QSPI HAL module initializes with the `open` API call. The application code then makes API calls to sector erase, status get, page program, status get and read and close. Once the instance is closed, read data is compared to the write data. If the data matches, then the Green LED toggles while checking the state of the pushbutton switch, SW4. If there is a data mismatch, the Red LED toggles. When pressed, the orange LED illuminates and the application again read the flash device contents. As the QSPI driver is closed, the QSPI peripheral accesses the QSPI flash via ROM access mode. The read data is compared with write data. If the data matches, then the Green LED toggles. If there is a data mismatch, the Red LED toggles.

8. Customizing the QSPI HAL Module for a Target Application

This module guide detailed a QSPI HAL module that is generic in its support of QSPI flash devices. A given board's BSP is written to support a specific QSPI device. For example, DK-S7G2 and SK-S7G2 boards use a Micron N25Q256A QSPI flash device.

No customization of the QSPI is possible using the Synergy Configuration IDSE. To target a different QSPI device, a new BSP and a new `bsp_qspi.c` file must be created. The `bsp_qspi.c` file contains code for device-specific QSPI commands; for example, taking the QSPI device in and out of ROM access mode. During operation, the QSPI HAL module uses generic QSPI commands to do QSPI operations.

9. Running the QSPI HAL Module Application Project

To run the QSPI HAL module Application project and to see it executed on a target kit, simply import it into your ISDE, compile and run debug. Refer to the Synergy Project Import Guide ([r11an0023eu0116-synergy-ssp-import-guide.pdf](#)) file included in this package) for instructions on importing the project into e² studio or IAR Embedded Workbench for Renesas Synergy, as well as building/running the application.

To implement the QSPI HAL module application in a new project, follow the steps given in this section to define, configure, auto-generate files, add code, compile and debug the application on the target kit. Following these steps gives you a hand-on approach that helps make the development process with SSP more practical, while just reading over this guide tends to be more theoretical.

Note: The steps are in sufficient detail for someone experienced with the basic flow through the Synergy development process. If these steps are not familiar, refer to the first few chapters of the SSP User's Manual for a description of how to accomplish these steps.

1. Create a new Renesas Synergy C project for the SK-S7G2 board called "S7_SK_QSPI".
2. Select the S7G2-SK BSP project template and create project.
3. Open Configuration.xml from generated project and select the Thread tab.
4. Add the QSPI HAL Module to HAL/Common thread from New Stack > Driver > Storage > QSPI HAL on QSPI
5. Click the **Generate Project Content** button.
6. Add code from the supplied project file, `hal_entry.c`, or copy the file over the generated `hal_entry.c` file.
7. Connect to the host PC via a micro USB cable to J19 on SK-S7G2.
8. Start to debug the application.
9. The green LED should start blinking.

10. QSPI HAL Module Conclusion

This module guide has provided all the background information needed to select, add, configure and use the module in an example project. Many of these steps were time consuming and error-prone activities in previous generations of embedded systems. The Renesas Synergy Platform makes these steps much less time consuming and removes the common errors, like conflicting configuration settings or the incorrect selection of low level drivers. The use of high level APIs (as demonstrated in the application project) illustrates additional development time savings by allowing work to begin at a high level and avoiding the time required in older development environments to use or, in some cases, create, lower-level drivers.

11. QSPI HAL Module Next Steps

After you have mastered a simple QSPI HAL project, you may want to review a more complex example. Other application projects and application notes that demonstrate QSPI HAL use can be found in the References section at the end of this document.

12. QSPI HAL Module Reference Information

SSP User Manual: Available in html format in the SSP distribution package and as a pdf from the Synergy Gallery.

Links to all the most up-to-date r_qspi module reference materials and resources are available on the Synergy Knowledge Base:

https://en-us.knowledgebase.renesas.com/English_Content/Renesas_Synergy%E2%84%A2_Platform/Renesas_Synergy_Knowledge_Base/r_qspi_Module_Guide_Resources

Website and Support

Support: <https://synergygallery.renesas.com/support>

Technical Contact Details:

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	May 25, 2017		Initial version
1.01	Aug 23, 2017		Update to Hardware and Software Resources Table

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