Renesas Synergy™ Platform

SLCDC HAL Module Guide

R11AN0100EU0101
Rev.1.01
Sep 1, 2017

This module guide will enable you to effectively use a module in your own design. Upon 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 available in the Renesas Synergy Knowledge Base (as described in the References section at the end of this document), and should be valuable resources for creating more complex designs.

The Segment LCD Controller HAL module is a high-level API for Segment LCD applications and is implemented on r_slcdc. The Segment LCD Controller HAL module displays data on a Segment LCD and modifies the displayed data. The Segment LCD Controller HAL module uses the Segment LCD Controller module on a Synergy MCU.

Contents

1. SLCDC HAL Module Features

The SLCDC HAL module uses the Segment LCD Controller (SLCDC) to display data on a Segment LCD. The driver initializes the LCD for displaying data and configures the drive-voltage generator, the display waveform, the number of time slices, and the bias methods to drive the LCD. This module provides functions to display data to a specified set of segments, to update existing segment data, to enable and disable display, to set the display area, and to adjust the contrast.

This module supports the following features:

- Internal voltage-boosting for the LCD driver voltage generator: select the capacitor split method or the external resistance division.
- Display bias: select the 1/2 bias method, 1/3 bias method, or 1/4 bias method.
- Time slice of the display: select static, 2-time slice, 3-time slice, 4-time slice, or 8-time slice.
- Display waveform: select waveform A or waveform B.
- Display data area: select A-pattern, B-pattern, or blinking. You can switch the display data area.
- Use the RTC periodic interrupt (PRD) to generate a blinking display with A-pattern and B-pattern.
- Adjust the reference voltage (which is generated when operating the voltage boost circuit) in 16 steps (contrast adjustment.)

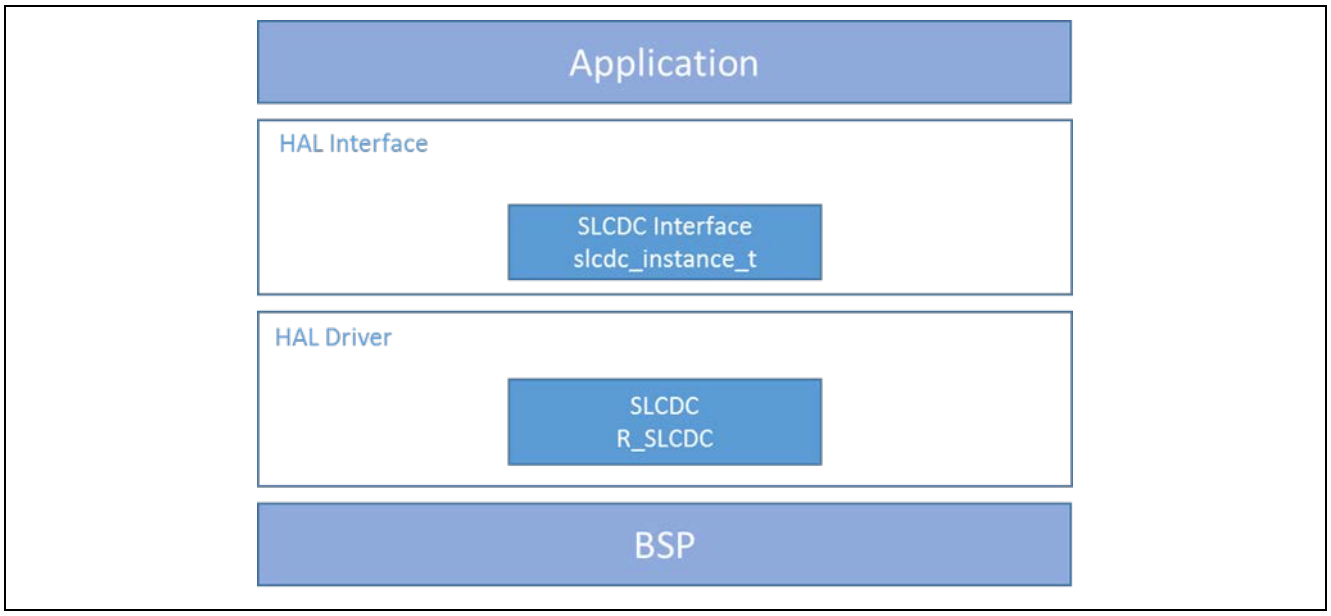

Figure 1 SLCD HAL Module Block Diagram

2. SLCDC HAL Module APIs Overview

The Segment LCD Controller HAL module defines APIs for functions such as opening, writing, starting, modifying and closing. 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 SLCDC HAL Module API Summary

Function Name	Example API Call and Description
.open	`g_slcdc.p_api->open(g_slcdc.p_ctrl, g_slcdc.p_cfg);` Open SLCD device.
.write	`g_slcdc.p_api->write(g_slcdc.p_ctrl, start_segment, &data, segment_count);` Write data to SLCD segments. Specifies the initial display data. The data parameter is a pointer to an array of bytes consisting at least segment_count items, in which each byte is associated with one segment data register. When the number of time slices is static, 2, 3 or 4, the lower 4 bits of the data become an A-pattern area and the upper 4 bits become a B-pattern area. See .setdisplayArea for setting a display area.
.modify	`g_slcdc.p_api->modify(g_slcdc.p_ctrl, segment, data_mask, data);` Rewrite data in the SLCD segment. Rewrites the LCD display data in 1-bit units. If a bit is not specified for rewriting, the value stored in the bit is held as it is. Specifies the data to rewrite.
.start	`g_slcdc.p_api->start(g_slcdc.p_ctrl);` Enable display on the SLCD. Displays the specified data on the LCD. Before that data should be written to the segments.
.stop	`g_slcdc.p_api->stop(g_slcdc.p_ctrl);` Disable display on the SLCD. Stops displaying data on the SLCD.
.contrastIncrease	`g_slcdc.p_api->contrastIncrease(g_slcdc.p_ctrl);` Increase the display contrast. Increase by 1 unit. This function can be selected when the internal voltage boosting method is used for the drive voltage generator.
.contrastDecrease	`g_slcdc.p_api->contrastDecrease(g_slcdc.p_ctrl);` Decrease the display contrast. Decrease by 1 unit. This function can be selected when the internal voltage boosting method is used for the drive voltage generator.
.setdisplayArea	`g_slcdc.p_api->setdisplayArea(g_slcdc.p_ctrl, display_area);` Set LCD display area. This function sets a specified display area, A-pattern or B-pattern. This function can be used to set blink on where A-pattern and B-pattern area data will be alternately displayed. When using blinking, the RTC is required to operate before this function is executed. To configure the RTC, follow the steps below. 1) Open RTC 2) Set Periodic interrupt request, ½ second 3) Start RTC counter 4) Enable IRQ, RTC_EVENT_PERIODIC_IRQ Refer to the User's Manual: Microcontrollers for the detailed procedure.
.close	`g_slcdc.p_api->close(g_slcdc.p_ctrl);` Close display device.
.versionGet	`g_slcdc.p_api->versionGet(&version);` Retrieve the API version using the version pointer.

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	Function successful
SSP_ERR_ASSERTION	Assertion error
SSP_ERR_INVALID_ARGUMENT	Invalid Argument
SSP_ERR_HW_LOCKED	SLCDC resource is locked
SSP_ERR_NOT_OPEN	Device is not opened or initialized
SSP_ERR_UNSUPPORTED	Unsupported operation
SSP_ERR_NOT_ENABLED	RTC not enabled for blink operation

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. SLCDC HAL Module Operational Overview

This module uses the Segment LCD controller (SLCDC) to display data on a Segment LCD. The driver initializes the LCD for displaying data and configures the drive-voltage generator, the display waveform, the number of time slices, and the bias methods to drive the LCD. This module provides functions to display data to a specified set of segments, to modify existing segment data, to enable and disable display, to set the display area, and to adjust the contrast. The information displayed on the LCD can be modified by changing the contents of the LCD display data registers.

3.1 SLCDC HAL Module Operational Notes

- This driver is a HAL driver and has no dependencies with the ThreadX RTOS. You can add the Segment LCD HAL module to a thread in the ThreadX RTOS if it is desirable.
- To write to a sequence of segments, give start segment number and number of segments to be written in the `write` API.

3.2 SLCDC HAL Module Limitations

- There are no known limitations in the SLCDC HAL module.
- Refer to the most recent *SSP Release Notes* for any additional operational limitations for this module.

4. Including the SLCDC HAL Module in an Application

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

Note: This section 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 *Getting Started Guide for SSP* listed in the References section at the end of this document to learn how to manage each of these important steps in creating SSP-based applications.

To add the Segment LCD Controller Driver to an application, simply add it to a thread using the stacks selection sequence given in the following table. (The default name for the Segment LCD HAL module is g_slcdc0. This name can be changed in the associated Properties window.)

Table 3 SLCD HAL Module Selection Sequence

Resource	ISDE Tab	Stacks Selection Sequence
g_slcdc0 Segment LCD Driver on r_slcdc	Threads	New Stack> Driver> Graphics> Segment LCD Driver on r_slcdc

When the Segment LCD Controller HAL Module on r_slcdc is added to the Thread Stack as shown in the figure below, the configurator automatically adds the needed lower-level modules. Any drivers that need additional configuration information will be highlighted in Red. Modules with a Gray band are individual modules that stand alone.

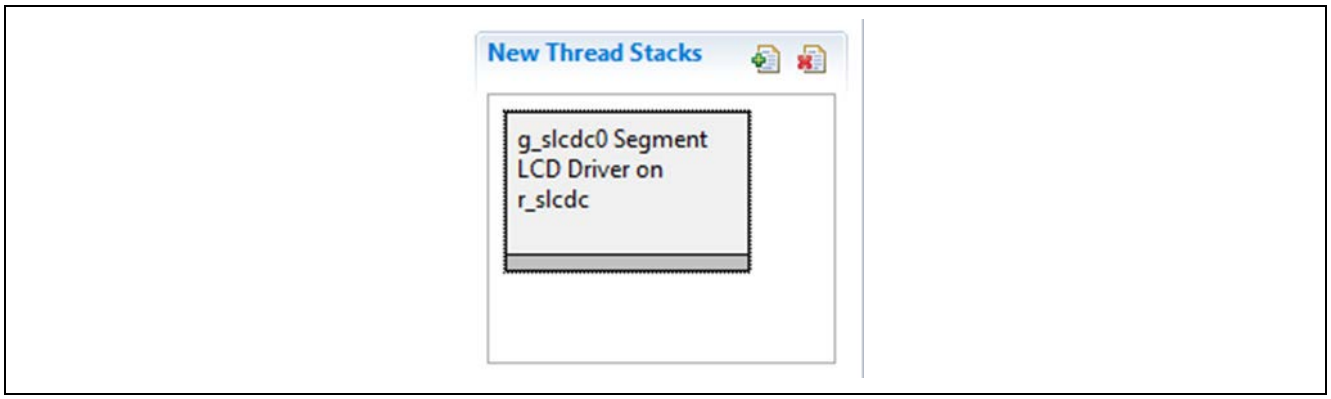

Figure 2 SLCD HAL Module Stack

5. Configuring the SLCDC HAL Module

The SLCD Controller HAL module must be configured by the user for the desired operation. The SSP configuration window will automatically identify (by highlighting the block in red) any required configuration selections, such as interrupts or operating modes, which must be configured for lower-level modules for successful operation. Furthermore, only those properties that can be changed without causing conflicts are available for modification. Other properties are 'locked' and not available for changes and are identified with a lock icon for the 'locked' property in the Properties window in the ISDE. This approach simplifies the configuration process and makes it much less error prone than previous manualapproaches to configuration. The available configuration settings and defaults for all the user-accessible properties are given in the Properties tab within the SSP Configurator, and are shown in the following tables for easy reference.

Note: You may want to open your ISDE and create the Segment LCD Controller HAL module and explore the property settings in parallel with looking over the following configuration table settings. This will help orient you and can be a useful hands-on approach to learning the ins and outs of developing with SSP.

Table 4 Configuration Settings for the SLCDC HAL Module on r_slcdc

ISDE Property	Value	Description
Parameter Checking	BSP, Enabled, Disabled (Default: BSP)	Select if extra code will be added to check parameter values
Name	g_slcdc0	Module Name
Slcdc Clock	Clock LOCO, Clock SOSC, Clock Mosc, Clock HOCO (Default: Clock HOCO)	SLCD clock source (LCDSCKSEL).
Slcdc Clock Divisor	Clk Divisor LOCO 4/8/16/32/64/128/256/512/1024 Clk Divisor HOCO 256/1,024/2,048/4,096/8,192/16,384/32,768/65,536/131,072/262,144/524,288 (Default: Clk Divisor HOCO16,384)	LCD clock setting (LCDC0), clock divisor
Bias Method	Bias 2, Bias 3, Bias 4 (Default: Bias 2)	LCD display bias method select (LBAS bit)
Time Slice	Static, Slice 2, Slice 3, Slice 4 (Default: Static)	Time slice of LCD display select (LDTY bit)
Wave Form	Wave A, Wave B (Default: Wave A)	LCD display waveform select (LWAVE bit).
Slcdc Drive Voltage Generator	External resistance division, Internal voltage boosting, Capacitor Split (Default: External resistance division)	LCD Drive Voltage Generator Select (MDSTET bit)

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

5.1 SLCDC HAL Module Clock Configuration

The SLCDC clock cannot be configured from the Clocks Tab. Configure the clock in the Properties window of the g_slcdc driver. The operating clock of the Segment LCD HAL Module is specified by the SLCDC Clock and SLCDC Clock Divisor settings in the **Properties** window. The Segment LCD HAL module-source clock can be configured as the Main (MOSC), HOCO (High-speed Clock Oscillator), LOCO (Low-speed Clock Oscillator), or Sub-clock (SOSC) using the ISDE configurator. For HOCO and LOCO settings, several clock divisors are available.

5.2 SLCDC HAL Module Pin Configuration

The SLCDC 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 illustrates the method for selecting the pins within the SSP configuration window and the subsequent table illustrates an example selection for the pins.

Note: For some peripherals, the operation mode selection determines what peripheral signals are available and thus what MCU pins are required.

Table 5 Pin Selection Sequence for the SLCDC HAL Module

Resource	ISDE Tab	Pin selection Sequence
SLCDC	Pins	Select **Peripherals > Graphics: SLCDC > SLCDC0**

Note: The selection sequence assumes SLCDC0 is the desired hardware target for the driver.

Table 6 Pin Configuration Settings for the SLCDC HAL Module

Pin Configuration Property	Value	Description
Operation Mode	Disabled, Custom, Static, 2x Slice, 3x Slice, 4x Slice, 8x Slice (Default: Custom)	Select operation mode enable or disable
CAPH	None, P111 (Default: None)	Capacitor connection pin
CAPL	None, P112 (Default: P112)	Capacitor connection pin
COM0:3	None, Pn (Default: P104:107)	Common pins
COM4:7	None, Pn (Default: None)	Common pins
VL1:4	None, Pn (Default: P100:103)	Power supply pins
SEG00:02, SEG06:07, SEG16:17, SEG21:25, SEG46:51	None, Pn (Default: None)	Segment pins
SEG03	None, P303 (Default: P303)	Segment pin
SEG04:05	None, Pn (Default: P314:315)	Segment pins
SEG08	None, P902 (Default: P902)	Segment pin
SEG09:15	None, Pn (Default: P312:306)	Segment pins
SEG18:19	None, Pn (Default: P808:809)	Segment pins
SEG20	None, P313 (Default: P313)	Segment pin
SEG26:27	None, Pn (Default: P806:807)	Segment pins
SEG28:34	None, Pn (Default: P608:614)	Segment pins
SEG35:41	None, Pn (Default: P606:600)	Segment pins
SEG42:43	None, Pn (Default: P805:804)	Segment pins
SEG44:45	None, Pn (Default: P800:801)	Segment pins

Note: The example values are for a project using the Synergy S3A7 MCU Group and the DK-S3A7 Kit. Other Synergy Kits and other Synergy MCUs may have different available pin configuration settings.

6. Using the SLCDC HAL Module in an Application

The typical steps in using the Segment LCD Controller HAL module in an application are:

1. Initialize the SLCDC HAL module using the `open` API
2. Write a sequence of segments using the `write` API
3. Change the display area or blinking display using the `setdisplayArea` API
4. Enable the display by using the `start` API
5. Adjust contrast using the `contrastIncrease` or `contrastDecrease` APIs
6. Disable the display by using the `stop` API
7. Close the driver using the `close` API.

These common steps are illustrated in a typical operational flow diagram in the figure below:

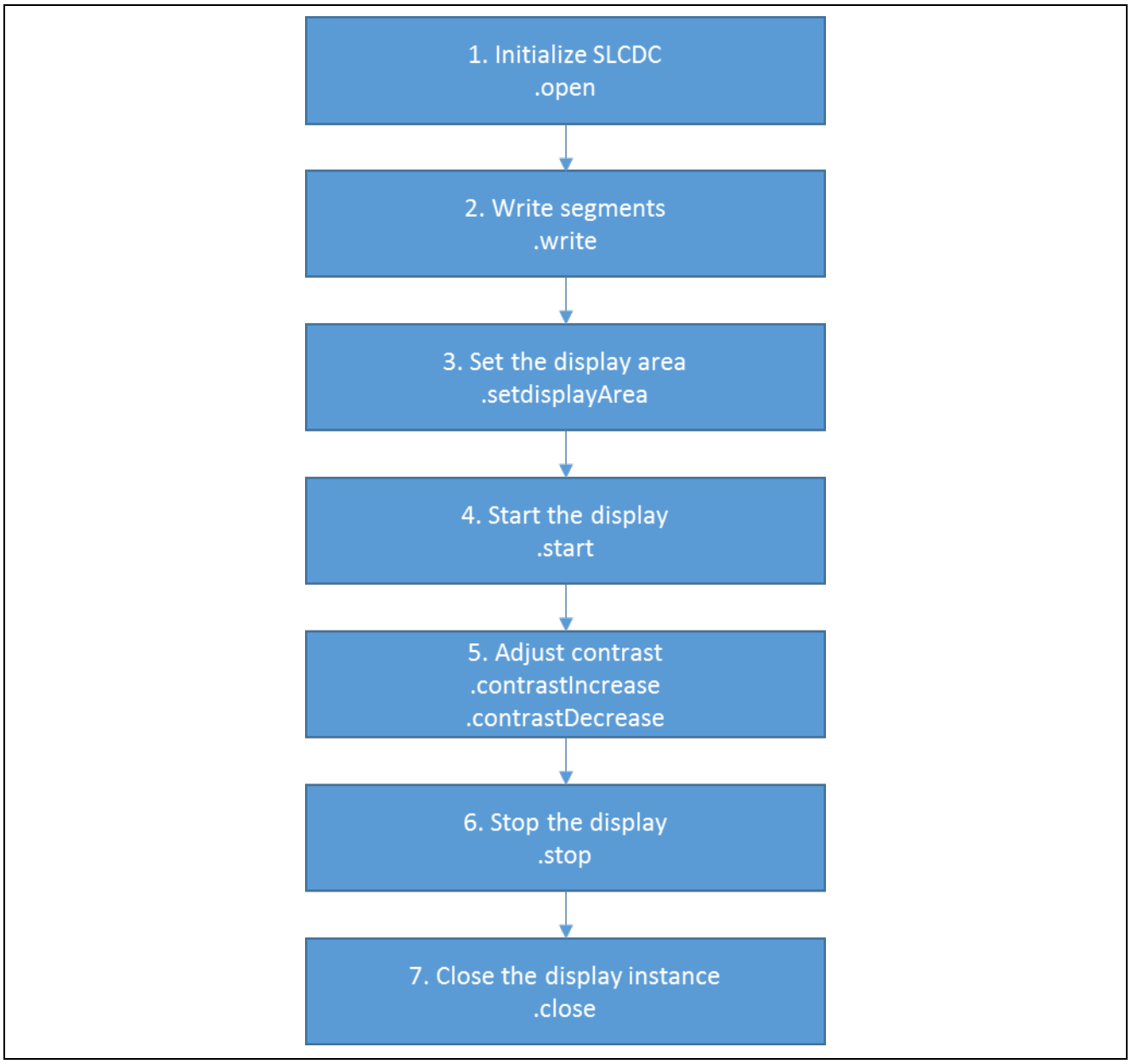

Figure 3 Flow Diagram of a Typical Segment LCDC HAL Module Application

7. SLCD HAL Module Application Project

The application project associated with this module guide demonstrates the aforementioned steps in a full design. The project can be found using the link provided in the References section at the end of this document. You may want to import and open the application project within the ISDE and view the configuration settings for the Segment LCD HAL module. You can also read over the code (in `slcdc_thread_entry.c`) which is used to illustrate the Segment LCD APIs in a complete design.

The application project demonstrates the typical use of the Segment LCD APIs. The application project main thread entry initializes the Segment LCD HAL module. The counter counts up and down and its current value is displayed on the screen. Counting up starts with decreased contrast and the countdown runs with increased contrast. The following table identifies the target versions for the associated software and hardware used by the application project:

Table 7 Software and Hardware Resources Used by the Application Project

Resource	Revision	Description
e² 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
DK-S3A7	v2.0	Development Kit

A simple flow diagram of the application project is given in the following figure:

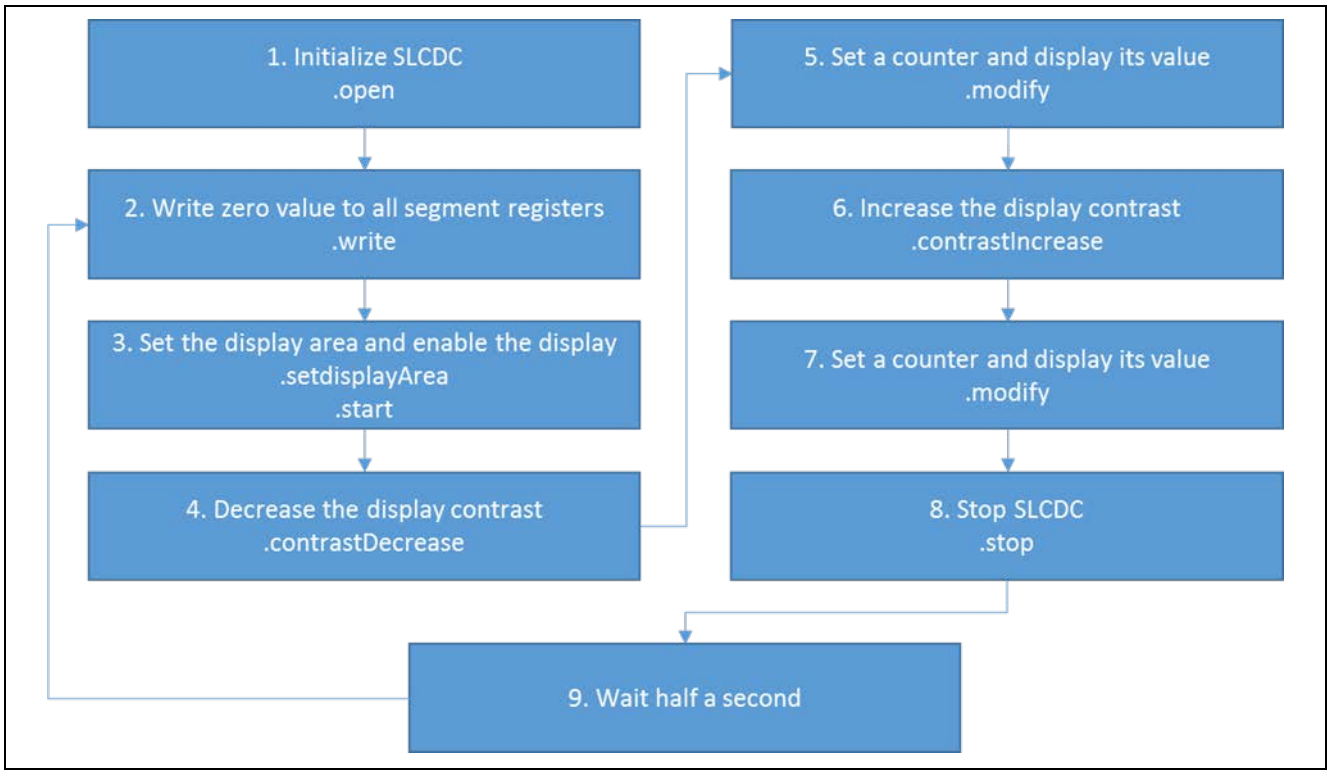

Figure 4 SLCD HAL Module Application Project Flow Diagram

The complete application project can be found as described in the References section at the end of this document. The `slcdc_thread_entry.c` file is located in the project once it has been imported into the ISDE. You can open this file within the ISDE and follow along with the description provided to help identify key uses of APIs.

The first section of `slcdc_thread_entry.c` has the header file which references the SLCDC instance structure and a code section where the segment buffer and some constants are defined. The next section contains function prototypes; these include SLCD helper functions used in the thread-entry function. After all declarations, their definitions follow. The first one initializes SLCDC using the `open` API. The next function sets the display area and starts the display using the `setdisplayArea` and the `start` APIs. When the display should be disabled, the relevant function calls the `stop` API.

The following functions switch on/off all segments using the `write` API. For contrast adjustment, there are another two routines; they increase or decrease the display contrast by a specified number using the `contrastIncrease` or `constrastDecrease` APIs. The next two functions are used for displaying a number on the largest group of segments. Each digit is displayed on the relevant 7-segment group; internally it calls the `modify` API. The next function displays a counter counting up from 0 to the given number, and the following one works similarly, except that it counts down.

The last section is the thread-entry function. At the beginning, it initializes the display and enters the infinite loop. In the loop, all segments are turned off, then the display is enabled and the display area is set. After the display contrast decreases, the counter is started and displayed on the screen. If it is finished, the display contrast is increased and the countdown starts. After these operations, the display is disabled, the function waits half a second, and the loop's body runs again.

A few key properties are configured in this application project to support the required operations and the physical properties of the target board and MCU. The following table lists the properties with the values set for this specific project. You can also open the application project and view these settings in the Properties window as a hands-on exercise.

Table 8 SLCD HAL Module Configuration Settings for the Application Project

ISDE Property	Value Set
Parameter Checking	Default (BSP)
Name	g_slcdc
Slcdc Clock	Clock Loco
Slcdc Clock Divisor	Clk Divisor Loco 128
Bias Method	Bias 3
Time Slice	Slice 4
Wave Form	Wave A
Slcdc Drive Voltage Generator	Internal voltage boosting

8. Customizing the SLCD HAL Module for a Target Application

Some configuration settings will normally be changed by the developer from those shown in the application project. For example, the user can easily change the configuration settings for the SLCDC clock source and the clock divisor. The user can also change the bias method, time slice, waveform, and drive-voltage generator. This can be done using the Properties tab in the configurator when the Segment LCD HAL module block is selected on the Threads tab. Moreover, segment data lines can be changed using the Pins tab.

9. Running the SLCD HAL Module Application Project

To run the Segment LCD HAL module application project and to see it executed on a target kit, you can simply import it into your ISDE, compile and run debug.

To implement the Segment LCD HAL module application in a new project, follow the steps below for defining, configuring, auto-generating files, adding code, compiling and debugging on the target kit. Following these steps is a hands-on approach that can help make the development process with SSP more practical, while just reading over this guide will tend to be more theoretical.

Note: The following steps are described 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 listed in the Reference Section at the end of this document.

To create and run the Segment LCD HAL module application project, simply follow these steps:

1. Create a new Renesas Synergy project for the DK-S3A7 board, called SLCDC_HAL_MG_AP.
2. Select the **Threads** tab.
3. Add a new thread called
   a. Symbol: slcdc_thread
   b. Name: Segment LCD Controller Thread
4. Add the Segment LCD HAL module to Segment LCD Controller Thread.
5. Configure the Segment LCD HAL Module.
6. Click on the **Generate Project Content** button.
7. Add the code from the supplied project file `slcdc_thread_entry.c` or copy over the generated `slcdc_thread_entry.c` file.
8. Connect to the host PC via a micro USB cable to J15 on DK-S3A7 board.
9. Start to debug the application.
10. The output can be viewed on the screen.

Figure 5 Example Output from Segment LCD HAL Module Application Project

10. SLCD 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 incorrect selection of lower-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. SLCD HAL Module Next Steps

After you have mastered a simple SLCDC HAL module project, you may want to review a more complex example. You may find that the Real-Time Clock (RTC) is needed or communication with sensor using the SPI might be useful. All these components are described in documents available as described in the References section at the end of this document.

Other application projects and application notes that demonstrate SLCDC HAL module functionality are available as described in the References section at the end of this document.

12. SLCD 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_slcd 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_SLCD_Module_Guide_Resources.

Website and Support

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

Technical Contact Details:

- America: https://www.renesas.com/en-us/support/contact.html
- Europe: https://www.renesas.com/en-eu/support/contact.html
- Japan: https://www.renesas.com/ja-jp/support/contact.html

Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	May 15, 2017		Initial Release
1.01	Sep 1, 2017		Update to Hardware and Software Resources Table

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other disputes involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawing, chart, program, algorithm, application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copy or otherwise misappropriation of Renesas Electronics products.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots etc.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Renesas Electronics products are neither intended nor authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems, surgical implantations etc.), or may cause serious property damages (space and undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for which the product is not intended by Renesas Electronics.
6. When using the Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat radiation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions or failure or accident arising out of the use of Renesas Electronics products beyond such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please ensure to implement safety measures to guard them against the possibility of bodily injury, injury or damage caused by fire, and social damage in the event of failure or malfunction of Renesas Electronics products, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures by your own responsibility as warranty for your products/system. Because the evaluation of microcomputer software alone is very difficult and not practical, please evaluate the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please investigate applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive carefully and sufficiently and use Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall not use Renesas Electronics products or technologies for (1) any purpose relating to the development, design, manufacture, use, stockpiling, etc., of weapons of mass destruction, such as nuclear weapons, chemical weapons, or biological weapons, or missiles (including unmanned aerial vehicles (UAVs)) for delivering such weapons, (2) any purpose relating to the development, design, manufacture, or use of conventional weapons, or (3) any other purpose of disturbing international peace and security, and you shall not sell, export, lease, transfer, or release Renesas Electronics products or technologies to any third party whether directly or indirectly with knowledge or reason to know that the third party or any other party will engage in the activities described above. When exporting, selling, transferring, etc., Renesas Electronics products or technologies, you shall comply with any applicable export control laws and regulations promulgated and administered by the governments of the countries asserting jurisdiction over the parties or transactions.
10. Please acknowledge and agree that you shall bear all the losses and damages which are incurred from the misuse or violation of the terms and conditions described in this document, including this notice, and hold Renesas Electronics harmless, if such misuse or violation results from your resale or making Renesas Electronics products available any third party.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.3.0-1 November 2016)

RENESAS

SALES OFFICES

Renesas Electronics Corporation

http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL II Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

Colophon 6.0