EPSON
EXCEED YOUR VISION

S1C31 Family Application Note

S1C31 Family
Self-Testing
Sample Software Manual

arm

SEIKO EPSON CORPORATION

Rev.1.00

Evaluation board/kit and Development tool important notice

1. This evaluation board/kit or development tool is designed for use for engineering evaluation, demonstration, or development purposes only. Do not use it for other purposes. It is not intended to meet the requirements of design for finished products.
2. This evaluation board/kit or development tool is intended for use by an electronics engineer and is not a consumer product. The user should use it properly and in a safe manner. Seiko Epson dose not assume any responsibility or liability of any kind of damage and/or fire coursed by the use of it. The user should cease to use it when any abnormal issue occurs even during proper and safe use.
3. The part used for this evaluation board/kit or development tool may be changed without any notice.

NOTICE

Table of Contents

1. Overview

This S1C31 self-testing sample software (IEC60730SELF) provides examples of self-diagnosis tests based on the IEC60730 standard.

This library and sample software are included in the S1C31xxx peripheral circuit sample software package. The S1C31xxx peripheral circuit sample software package is available on Seiko Epson's website.

In addition to this manual, please also refer to the "S1C31xxx Technical Manual".

1.1. Working Environment

The following is required when writing and debugging the sample software.

- Evaluation Board
  - S5U1C31xxxTx evaluation board with S1C31 series.
- Debug Probes *1*2
  - IAR Systems I-jet or SEGGER J-Link
- Integrated Development Environment
  - IAR Embedded Workbench for ARM® (IAR EWARM) or MDK-ARM® (uVision)
- S1C31SetupTool package
  - Includes Flash loader and Configuration files (.svd etc).
- S1C31xxx Peripheral circuit sample software package

*1: Debug probes are not required for library function calls from the sample software.

*2: I-jet is available only with IAR EWARM. J-Link is available for both IAR EWARM and MDK-ARM.

For details on the above, refer to the attached manual.

1.2 Precautions for Usage

This sample software is for reference only. Our company will not take any responsibility for any problems caused by this library. Please thoroughly verify the operation when using this library for your product.

2. About IEC 60730 standard

The International Electrotechnical Commission (IEC) has issued the IEC 60730 standard for development of household appliances. Consumer electronics sold and used in Europe are required by law to comply with this safety standard. The purpose of this standard is to protect consumers from hazards arising from malfunctions and defects in final products by discovering them in a timely manner through periodic self-testing.

Software control for microcontrollers is categorized according to the following standards.

Class A: Control functions not intended to be relied upon for the safety of the equipment (e.g., lighting fixtures)
Class B: Control functions intended to prevent unsafe operation of the controlled equipment (e.g., washing machines, refrigerators, freezers, dishwashers)
Class C: Control functions intended to prevent special hazards (e.g., combustion appliances)

The majority of control software for household appliances falls under Class B, and the following self-testing is recommended for final products.

- Diagnosis of microcontroller and program counter stack failure
- Diagnosis of interrupt cycle abnormalities
- Diagnosis of abnormalities in the operating clock frequency of the microcontroller
- Diagnosis of abnormalities in the ROM/RAM memory
- Diagnosis of communication errors with external interfaces

For more detailed information, refer to Annex H of IEC 60730.

3. Self-testing sample software

The contents of the self-diagnosis of this sample software are as follows.

- Memory failure test (read/write test, March-C test)
- Integrity testing of data in the memory (generates checksum and CRC)
- Interrupt test (interrupt cycle and interrupt count check)
- Main clock stability test (operating frequency check)

The read/write test and March-C test perform a read and write test in ranges specified for the memory, register, stack pointer, and status register.

For generating a checksum and CRC, an error detection code is requested and returned for data in the memory in the specified range.

The interrupt test counts how many interrupts occur in a certain period of time and returns that as a value.

The main clock stability test uses the sub-clock (32KHz) to check that the main clock is operating at a normal operating frequency.

3.1. Folder configuration

The configuration of the S1C31xxx peripheral circuit sample software package is as follows.

```
S1C31xxxSamplePKG_very_yy.zip
[S1C31xxxSamplePKG_very_yy]
        |- [Licenses] : License group
        |- [Drivers] : Driver group
        |       |- [board] : Drivers related to the evaluation board
        |       |       |- [S5U1C31xxxTx]
        |       |       |       |- [ARM]
        |       |       |       |- [IAR]
        |       |       |       |- board.c/.h : Evaluation board setting program
        |       |       |       |- settings.h : Definition file for setting the function of the evaluation board
        |       |       |       |- …
        |       |- [CMSIS] : CMSIS driver
        |       |       |- [Device]
        |       |       |       |- [S1C31xxx]
        |       |       |               |- [Include]
        |       |       |               |       |-S1C31xxx.h : CMSIS peripheral circuit access layer header file
        |       |       |               |       |- …
        |       |       |               |- [Source]
        |       |       |                       |- [ARM]
        |       |       |                       |- [IAR]
        |       |       |                       |       |- startup_S1C31xxx.s : CMSIS startup program
        |       |       |                       |- system_S1C31xxx.c : CMSIS peripheral circuit access layer program
        |       |       |- …
        |       |- [sePeripheralLibrary] : Peripheral circuit library
        |               |- se_clg.c/.h
        |               |- se_i2c.c/.h
        |               |- …
        |- [Projects] : Sample software group
        |       |- [Applications] : Various application software
        |       |       |- [IEC60730SELF] : Sample software for self-testing
        |       |       |- …
        |       |- …
        |- …
        README_e.txt
        README_j.txt
```

Figure 3.1.1 Configuration of the S1C31xxx peripheral circuit sample software package

3.2. File configuration

The source code for this self-testing sample software is included in the folder of "IEC60730 compliant" sample software package Table 3.2.1. shows the list of sample files for self-testing.

Table 3.2.1 List of sample files for Self-testing

File name	Content
main.c	Calls the test function
s1c31TestRam16.c	RAM R/W test (for 16-bit devices)
s1c31TestRam8.c	RAM R/W test (for 8-bit devices)
s1c31TestRegister.c	General purpose register, stack pointer R/W test
s1c31TestRegister.s	General purpose register, stack pointer R/W test
s1c31TestPsr.c	Status register R/W test
s1c31RwPsr.s	Software exception for causing the status register R/W test to be performed
s1c31TestRamMarchc.c	RAM March-C test
s1c31TestChksum.c	Calculates checksum
s1c31TestCrc.c	Calculates CRC (calculation)
s1c31TestCrcTbl.c	Calculates CRC (table lookup)
s1c31TestInterupt.c	Interrupt test
s1c31TestClk.c	Main clock stability test
s1c31SelfTest.h	Header file used by the self-testing sample program

3.3. Operation

1. Run RAM Read/Write test (for 16bit device)
2. Run RAM Read/Write test (for 8bit device)
3. Run Register Read/Write test
4. Run PSR Read/Write test
5. Run RAM Read/Write test by March-C
6. Run to calculate checksum
7. Run to calculate CRC
8. Run interrupt test (port interrupt test depending on the number if presses by SW7)
9. Run clock test

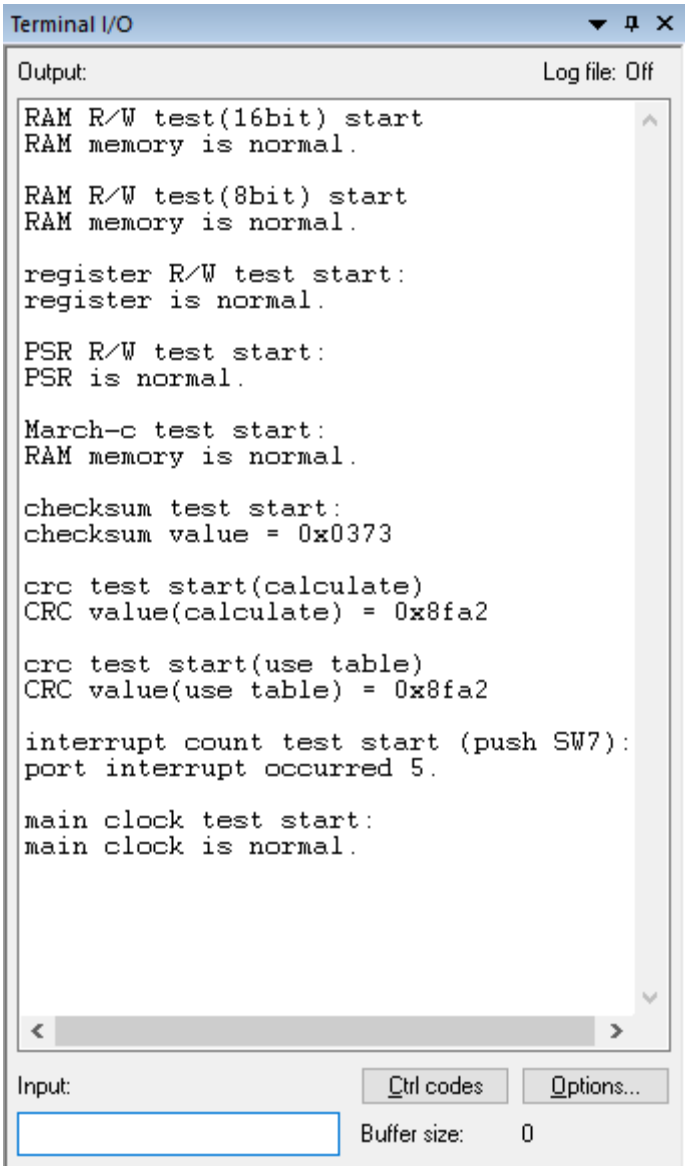

Figure 3.3.1 Example output

3.4. Function specification

s1c31TestRam16

Syntax	Short s1c31TestRam16 (unsigned short *chkAddr, unsigned short chkNum)
Arguments	*chkAddr Start address of RAM to be tested. chkNum RAM data size to be tested.
Return Value	Result of RAM R/W 0x0000 (E_OK): No difference from the written value 0x0001 (E_MEMORY): There is a difference with the written value
Explanation	This function writes 0xaa55 (0x55aa) to the memory for the number of chkNum from the address pointed to by chkAddr. After that, it reads and compares it with the written value, and returns E_OK if there is no difference and E_MEMORY if there is a difference.
Caution	The least significant bit of chkAddr is always treated as 0. The operation is not guaranteed when the specified memory area overlaps the stack area. S1c31TestRam16 checks the memory for chkNum x 2 bytes.

s1c31TestRam8

Syntax	Short s1c31TestRam8 (unsigned short *chkAddr, unsigned short chkNum)
Arguments	*chkAddr Start address of RAM to be tested. chkNum RAM data size to be tested.
Return Value	Result of RAM R/W 0x0000 (E_OK): No difference from the written value 0x0001 (E_MEMORY): There is a difference with the written value
Explanation	This function writes 0xa5 (0x5a) to the memory for the number of chkNum from the address pointed to by chkAddr. After that, it reads and compares it with the written value, and returns E_OK if there is no difference and E_MEMORY if there is a difference.
Caution	The least significant bit of chkAddr is always treated as 0. The operation is not guaranteed when the specified memory area overlaps the stack area. S1c31TestRam8 checks the memory for chkNum x 1 bytes.

s1c31TestRegister

Syntax	Short s1c31TestRegister (void)
Arguments	void
Return Value	Result of Register Read/Write 0x0000 (E_OK): No difference from the written value 0x0002 (E_REGISTER): There is a difference with the written value
Explanation	This function writes 0x555555 (0xaaaaaa) to registers in Arm core. After that, it reads and compares it with the written value, and returns E_OK if there is no difference and E_REGISTER if there is a difference.

s1c31TestPsr

Syntax	Short s1c31TestPsr (void)
Arguments	void
Return Value	Result of Register Read/Write 0x0000 (E_OK): No difference from the written value 0x0002 (E_REGISTER): There is a difference with the written value
Explanation	This function writes 0x555555 (0xaaaaaa) to status registers in Arm core. After that, it reads and compares it with the written value, and returns E_OK if there is no difference and E_REGISTER if there is a difference.

s1c31TestRamMarchc

Syntax	Short s1c31TestRamMarchc (unsigned short *chkAddr, unsigned short chkNum)
Arguments	*chkAddr Start address of RAM to be tested. chkNum RAM data size to be tested.
Return Value	Result of RAM R/W 0x0000 (E_OK): No difference from the written value 0x0001 (E_MEMORY): There is a difference with the written value
Explanation	This function runs March-C tests for the number of chkNum from the address pointed by chkAddr. And returns E_OK if there is no difference and E_MEMORY if there is a difference.
Caution	The operation is not guaranteed when the specified memory area overlaps the stack area. The memory in the test range will be rewritten to 0x00.

s1c31TestChksum

Syntax	Short s1c31TestChksum (unsigned short *chkAddr, unsigned short chkNum)
Arguments	*chkAddr Start address of RAM to be tested. chkNum RAM data size to be tested.
Return Value	Result of checksum calculation.
Explanation	This function reads the value of memory for the number of chkNum from the address pointed by chkAddr and returns the result of checksum.

s1c31TestCrc

Syntax	Short s1c31TestCrc (unsigned short *chkAddr, unsigned short chkNum)
Arguments	*chkAddr Start address of RAM to be tested. chkNum RAM data size to be tested.
Return Value	Result of CRC calculation.
Explanation	This function reads the value of memory for the number of chkNum from the address pointed by chkAddr and returns the result of CRC calculation.

s1c31TestCrcTbl

Syntax	Short s1c31TestCrcTbl (unsigned short *chkAddr, unsigned short chkNum)
Arguments	*chkAddr Start address of RAM to be tested. chkNum RAM data size to be tested.
Return Value	Result of CRC calculation.
Explanation	This function reads the value of memory for the number of chkNum from the address pointed by chkAddr. After that, refer to the table (CRC-CCITT table) to calculate the CRC and return the result.

s1c31TestInterupt

Syntax	Short s1c31TestInterrupt (unsigned short numInt)
Arguments	numInt Number of interrupts specified by CLG 16 bit timer.
Return Value	Number of interrupts occurred
Explanation	This function counts generated interrupts (P13 (SW7) interrupt is used) before the number of interrupts specified by numInt (CLG 16 bit timer is used) are generated.

s1c31TestClk

Syntax	int s1c31TestClk (unsigned long baseFreq, unsigned short range)
Arguments	baseFreq The ideal main clock used (Hz) Range Allowable error (%)
Return Value	Result of Clock Test 0x0000 (E_OK): Within tolerance 0x0003 (E_CLOCK): Outside tolerance
Explanation	This function checks whether the ideal frequency of the main clock specified by baseFreq operates within the tolerance (%) range specified by range. If the result is within the specified tolerance, it returns E_OK, and if it is out of the range, it returns E_CLOCK.

Revision History

Attachment-1

Rev. No.	Date	Page	Category	Contents
Rev.1.00	01/15/2021	All	New	New create

EPSON

International Sales Operations

America

Epson America, Inc.

Headquarter:
3131 Katella Ave., Los Alamitos, CA 90720, USA
Phone: +1-562-290-4677

San Jose Office:
214 Devcon Drive
San Jose, CA 95112 USA
Phone: +1-800-228-3964 or +1-408-922-0200

Europe

Epson Europe Electronics GmbH
Riesstrasse 15, 80992 Munich,
Germany
Phone: +49-89-14005-0 FAX: +49-89-14005-110

Asia

Epson (China) Co., Ltd.
4th Floor, Tower 1 of China Central Place, 81 Jianguo Road, Chaoyang District, Beijing 100025 China
Phone: +86-10-8522-1199 FAX: +86-10-8522-1120

Shanghai Branch
Room 1701 & 1704, 17 Floor, Greenland Center II,
562 Dong An Road, Xu Hui District, Shanghai, China
Phone: +86-21-5330-4888 FAX: +86-21-5423-4677

Shenzhen Branch
Room 804-805, 8 Floor, Tower 2, Ali Center,No.3331
Keyuan South RD(Shenzhen bay), Nanshan District, Shenzhen 518054, China
Phone: +86-10-3299-0588 FAX: +86-10-3299-0560

Epson Taiwan Technology & Trading Ltd.
15F, No.100, Songren Rd, Sinyi Dist, Taipei City 110. Taiwan
Phone: +886-2-8786-6688

Epson Singapore Pte., Ltd.
438B Alexandra Road,
Block B Alexandra TechnoPark, #04-01/04, Singapore 119968
Phone: +65-6586-5500 FAX: +65-6271-7066

Epson Korea Co.,Ltd
10F Posco Tower Yeoksam, Teheranro 134 Gangnam-gu,
Seoul, 06235, Korea
Phone: +82-2-3420-6695

Seiko Epson Corp.
Sales & Marketing Division

Device Sales & Marketing Department
29th Floor, JR Shinjuku Miraina Tower, 4-1-6 Shinjuku,
Shinjuku-ku, Tokyo 160-8801, Japan

Document Code: 414142700
First Issue January 2021 in Japan