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---

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April 1\textsuperscript{st}, 2010
Renesas Electronics Corporation

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Introduction

This application note describes transmission and reception of serial data by using the clock-synchronous transfer function of the serial communications interface (SCI). This application note is a summary for quick reference of information required in the design of user software.

Target Device

SH7137

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1. Preface

1.1 Specifications

This sample application employs the clock-synchronous serial transfer function of the serial communications interface (SCI) to perform data transmission and reception. Figure 1 shows an example of connection for transmission and reception by the SCI in clock-synchronous mode.

- SCI_0 is used.
- The communications format has a fixed 8-bit data length.
- Interrupts for transmission and reception are used to conduct full-duplex communications on SCI_0. That is, the data-transfer controller (DTC) is activated by the transmit-data-empty interrupt on the transmitting side and the receive-data-full interrupt on the receiving side.
- Once 256 bytes of data have been transmitted and received, each operation for transmission and reception is halted.

![Figure 1 Connection Example for Transmission and Reception by the SCI in Clock-Synchronous Mode](image)

1.2 Module Used

Serial communications interface (SCI_0)

1.3 Applicable Conditions

MCU: SH7137  
Operating frequency: Internal clock 80 MHz  
Bus clock 40 MHz  
Peripheral clock 40 MHz  
C compiler: SuperH RISC Engine Family C/C++ Compiler Package Ver.9.11  
(from Renesas Technology Corp.)
2. Description of the Sample Application

This sample application employs interrupt source of the serial communications interface (SCI), a transmit-data-empty interrupt (TXI) and a receive-data-full interrupt (RXI) to transmit and receive serial data in clock-synchronous mode. In clock-synchronous mode, the SCI transmits and receives serial data in synchronization with clock pulses.

2.1 Summary of MCU Module Used

In clock-synchronous mode, the SCI transmits and receives data in synchronization with clock pulses. This mode is suitable for high-speed serial communications. An internal clock or an external clock from the SCK pin can be selected as the SCI clock source. When an internal clock has been selected, a synchronizing clock is output from the SCK pin. When an external clock has been selected, a synchronizing clock is input into the SCK pin.

The transmitting and receiving sections of the SCI are independent, so full-duplex communications is possible while sharing the same clock. Both the transmitter and receiver have a double buffered structure so that data can be read or written during transmission and reception, which enables continuous data transfer.

For details on the SCI, please refer to the section on serial communication interface in the SH7137 Group Hardware Manual.

Table 1 gives an overview of serial communications interface in clock-synchronous mode. Figure 2 shows a block diagram of the SCI.

### Table 1 Overview of Serial Data Communications in Clock-Synchronous Mode

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of interfaces</td>
<td>3 (SCI_0, SCI_1, SCI_2)</td>
</tr>
<tr>
<td>Clock sources</td>
<td>For internal clock: Pφ, Pφ/4, Pφ/16, Pφ/64 (Pφ: peripheral clock)</td>
</tr>
<tr>
<td></td>
<td>For external clock: input clock on the SCK pin</td>
</tr>
<tr>
<td>Data format</td>
<td>Transfer data length: Fixed at 8 bits</td>
</tr>
<tr>
<td></td>
<td>Order: LSB first and MSB first are selectable</td>
</tr>
<tr>
<td>Baud rate</td>
<td>For internal clock: 250 bps to 5,000,000 bps (Pφ = 40 MHz)</td>
</tr>
<tr>
<td></td>
<td>For external clock: up to 6,666,666.7 bps (Pφ = 40 MHz, external input clock of 6.6667 MHz)</td>
</tr>
<tr>
<td>Error detection</td>
<td>Overrun error</td>
</tr>
<tr>
<td>Interrupt requests</td>
<td>Transmit-data-empty interrupt (TXI)</td>
</tr>
<tr>
<td></td>
<td>Receive-data-full interrupt (RXI)</td>
</tr>
<tr>
<td>Clock sources</td>
<td>Internal and external clocks are selectable</td>
</tr>
<tr>
<td></td>
<td>• Internal clock</td>
</tr>
<tr>
<td></td>
<td>When the internal clock has been selected, the SCI operates using the clock from the baud-rate</td>
</tr>
<tr>
<td></td>
<td>generator and outputs this clock to external devices as the synchronizing clock.</td>
</tr>
<tr>
<td></td>
<td>• External clock</td>
</tr>
<tr>
<td></td>
<td>When the external clock has been selected, the SCI operates on the input synchronizing clock, not</td>
</tr>
<tr>
<td></td>
<td>using the on-chip baud rate generator.</td>
</tr>
</tbody>
</table>
SH7137 Group
Transmission and Reception of Serial Data by the SCI in Clock-Synchronous Mode (Full-Duplex Communications)

Figure 2  Block Diagram of the SCI
2.2 Description of the Sample Program

Table 2 gives the settings for SCI communications function of this sample program, and figure 3 shows the operations in data transmission and reception.

### Table 2  Settings for Communications Function of the Sample Program

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module</td>
<td>SCI_0</td>
</tr>
<tr>
<td>Communications mode</td>
<td>Clock-synchronous mode</td>
</tr>
<tr>
<td>Interrupts</td>
<td>Transmit-data-empty interrupt (TXI)</td>
</tr>
<tr>
<td></td>
<td>Receive-data-full interrupt (RXI)</td>
</tr>
<tr>
<td>Transfer rate</td>
<td>100 kbps</td>
</tr>
<tr>
<td>Rounds of transmission</td>
<td>256 (256 bytes)</td>
</tr>
<tr>
<td>Rounds of reception</td>
<td>256 (256 bytes)</td>
</tr>
<tr>
<td>Data length</td>
<td>8-bit data (fixed)</td>
</tr>
<tr>
<td>Bit order</td>
<td>LSB-first</td>
</tr>
<tr>
<td>Synchronizing clock</td>
<td>Internal clock/synchronizing clock on the SCK pin</td>
</tr>
</tbody>
</table>

![Figure 3  Operations for Data Transmission and Reception](image-url)
2.3 Procedure for Setting Module Used

This section describes the procedure for setting up SCI_0 for clock-synchronous mode operation.

Figure 4 shows the flow of processing by the sample program, figure 5 shows the flow of settings for release from module-standby mode, figure 6 shows the flow for setting up the pin function controller, and figure 7 shows the flow for initialization of data transmission and reception in clock-synchronous mode. Furthermore, figure 8 shows the flow for handling transmit interrupts in clock-synchronous mode, and figure 9 shows the flow for handling receive interrupts in clock-synchronous mode.

For details on the settings of individual registers, see the SH7137 Group Hardware Manual.

---

**Figure 4 Flow of Processing by the Sample Program**

```
main

Release from power-down mode
    stbcr_init()

[1] Clock is supplied to SCI_0.

Initialization of SCI_0
    sci_init()

[2] Initialization of the serial communications interface SCI_0 is set.

Initialization of PFC
    pfc_init()

[3] Initialization of the pin function controller
Input and output pins of the SCI are set.

Setting of the interrupt level
    INTC.IPRL.BIT._SCI_0 = 0xF

[4] Setting of the SCI interrupt level
Interrupt level of the SCI_0 is set to D'15.

NO

Initialization of the storage buffer completed?

YES

Enabling transmission/reception of data
    SCI_0.SCSCR.BYTE |= 0xFC

Enable transmitting operation and transmit interrupts
Enable receiving operation and receive interrupts

Change of interrupt mask level
    set_imask(0)

[7] The interrupt mask level is set to D'0.

[8] Loop processing
```
stbcr_init()

Set standby control register 3 (STBCR3)

[1] Enabling clock supply to SCI_0
   SCI_0: Bit MSTP11 is set to B'0.

END

Figure 5  Flow of Settings for Release from Module-Standby Mode

pfc_init()

Set port E control register L1 (PECRL1)

[1] Setting of multiplexed pins as SCI input and output pins
   Bit PE1MD (RXD0) is set to B'110.
   Bit PE2MD (TXD0) is set to B'110.
   Bit PE3MD (SCK0) is set to B'110.

END

Figure 6  Flow for Setting up the Pin Function Controller

sci_init()

Set serial control register (SCSCR_0)

[1] Initialization of flags of the SCSCR
   Bit TIE (Transmit interrupt enable) is set to B'0.
   Bit RIE (Receive interrupt enable) is set to B'0.
   Bit TE (Transmit enable) is set to B'0.
   Bit RE (Receive enable) is set to B'0.

Set serial control register (SCSCR_0)

[2] Selection of clock source and setting of clock output
   Bit CKE (clock enable) is set to B'10.

Set serial mode register (SCSMR_0)

[3] Setting of serial communications format
   Bit C/A (communication mode) is set to B'1.
   Bit CKS (clock select) is set.

Set bit-rate register (SCBRR_0)

[4] Setting of bit rate
   Bit rate is set to 100 kbps.

Set serial control register (SCSCR_0)

[5] Transmission/reception of data
   Bit TIE (Transmit interrupt enable) is set to B'1.
   Bit RIE (Receive interrupt enable) is set to B'1.
   Bit TE (Transmit enable) is set to B'1.
   Bit RE (Receive enable) is set to B'1.

END

Figure 7  Flow for Initialization of Data Transmission and Reception in Clock-Synchronous Mode
int_sci_txi()

Write the transmit data to the transmit data register (SCTDR_0)

Increment the data-buffer pointer

Transmission of 256-byte data completed?

NO

YES

Disable transmit interrupts

Clear the TDRE bit in the serial status register (SCSSR_0) to 0

END

Figure 8  Flow for Handling Transmit Interrupts in Clock-Synchronous Mode
**Figure 9** Flow for Handling Receive Interrupts in Clock-Synchronous Mode

- **int_sci_rx()**
- **Overrun error?**
  - **NO**
  - **YES**
  - Clear the ORER flag in the serial status register (SCSSR_0)
- Read the received data into the receive data register (SCRDR_0)
- Increment the data-buffer pointer
- **NO**
  - Reception of 256-byte data completed?
  - **YES**
  - Disable receive interrupts
  - Clear the RDRF bit in the serial status register (SCSSR_0)
- **END**
2.4 Procedure for Processing by the Sample Program

In this sample program, character strings are transmitted and received after initialization of SCI_0.

2.4.1 Clock Pulse Generator (CPG)

Table 3 gives settings for the register of the clock pulse generator in the sample program.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Address</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency control register</td>
<td>H'FFFF E800</td>
<td>H'0241</td>
<td>IFC [2:0] = B'000: × 1 (Iφ)</td>
</tr>
<tr>
<td>(FRQCR)</td>
<td></td>
<td></td>
<td>BFC [2:0] = B'001: × 1/2 (Bφ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PFC [2:0] = B'001: × 1/2 (Pφ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MIFC [2:0] = B'000: × 1 (MIφ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MPFC [2:0] = B'001: × 1/2 (MPφ)</td>
</tr>
</tbody>
</table>

2.4.2 Standby Control Register

Table 4 gives settings for the standby control register in the sample program.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Address</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standby control register 3</td>
<td>H'FFFF E806</td>
<td>H'F7</td>
<td>MSTP11 = B'0: SCI_0 operates</td>
</tr>
<tr>
<td>(STBCR3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.4.3 Interrupt Controller (INTC)

Table 5 gives settings for the register of the interrupt controller in the sample program.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Address</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt priority register L</td>
<td>H'FFFF E992</td>
<td>H'F000</td>
<td>IPR [15:12] = H'F: SCI_0 is at a level 15</td>
</tr>
<tr>
<td>(IPRL)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The interrupt priorities for RXI_0 and TXI_0 are in the same order as the offset addresses of the interrupt vectors. For details on interrupt priority, see the “Interrupt Exception Handling Vector Table” in the section on the interrupt controller of the SH7137 Group Hardware Manual.

2.4.4 Pin Function Controller (PFC)

Table 6 gives settings for the register of the pin function controller in the sample program.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Address</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port E control register L1</td>
<td>H'FFFF D316</td>
<td>H'1110</td>
<td>PE3MD [2:0] = B'110: SCK0 input/output</td>
</tr>
<tr>
<td>(PECRL1)</td>
<td></td>
<td></td>
<td>PE2MD [2:0] = B'110: TXD0 output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PE1MD [2:0] = B'110: RXD0 input</td>
</tr>
</tbody>
</table>
2.4.5 Serial Communications Interface

Table 7 gives settings for the registers of the SCI in the sample program.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Address</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial mode register</td>
<td>H'FFFF C000</td>
<td>H'80</td>
<td>C/A = B'1: Clock-synchronous mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CHR = B'0: 8-bit data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CKS [1:0] = B'00: Pφ clock</td>
</tr>
<tr>
<td>Bit-rate register</td>
<td>H'FFFF C002</td>
<td>D'99</td>
<td>Clock-synchronous mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bit rate: 100k (bit/s) *1</td>
</tr>
<tr>
<td>Serial control register</td>
<td>H'FFFF C004</td>
<td>H'00</td>
<td>Initialization</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TIE = B'0: Disables transmit-data-empty-interrupt (TXI) request</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RIE = B'0: Disables receive-data-full-interrupt (RXI) and receive-error-interrupt (ERI) requests</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TE = B'0: Disables transmission of data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RE = B'0: Disables reception of data</td>
</tr>
<tr>
<td>Serial status register</td>
<td>H'FFFF C008</td>
<td>H'84</td>
<td>Initial value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TDRE = B'1: Transmit data register empty flag</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TEND = B'1: Transmit end flag</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>H'04 At the time of setting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The TDRE flag is cleared to 0.</td>
</tr>
</tbody>
</table>

Note: 1. For details on bit rate settings, see the table of bit rates and SCBRR settings in the section on the serial communication interface in the *SH7137 Group Hardware Manual*. 
3. Documents for Reference

- Software Manual
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  SH7137 Group Hardware Manual
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<thead>
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<th>Rev.</th>
<th>Date</th>
<th>Description</th>
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11. In case Renesas products listed in this document are detached from the products to which the Renesas products are attached or affixed, the risk of accident such as swallowing by infants and small children is very high. You should implement safety measures so that Renesas products may not be easily detached from your products. Renesas shall have no liability for damages arising out of such detachment.

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