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April 1st, 2010
Renesas Electronics Corporation

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SH7263/SH7203 Groups

10-Bit A/D Converter: Example of Settings for Conversion in Scan Mode

Introduction

This application note describes an example of settings for the 10-bit A/D converter in scan mode as an example of application of the A/D converter of the SH7263 and SH7203 Groups.

Target Devices

SH7263/SH7203

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1. Preface

1.1 Specifications

- A/D conversion in scan mode by the 10-bit A/D converter
- Three rounds of A/D conversion are performed on analog input channels 0 to 3 (AN0 to AN3), and the converted data are stored in RAM.

1.2 Module Used

- 10-bit A/D converter (10-bit A/D)

1.3 Applicable Conditions

- MCU: SH7263/SH7203
- Operating frequency:
  - Internal clock: 200 MHz
  - Bus clock: 66.67 MHz
  - Peripheral clock: 33.3 MHz
- C compiler: SuperH RISC Engine Family C/C++ Compiler Package Ver.9.01 from Renesas Technology
- Compiler options:
  - -cpu = sh2afpu -fpu = single -include = "$(WORKSPDIR)/inc"
  - -object = "$(CONFIGDIR)/$(FILELEAF).obj" -debug -gbr = auto -chgincpath
  - -errorpath -global_volatile = 0 -opt_range = all -infinite_loop = 0
  - -del_vacant_loop = 0 -struct_alloc = 1 -nologo

1.4 Related Application Note

None
2. Description of the Sample Application

The sample program employs the scan mode of the 10-bit A/D converter to perform three rounds A/D conversion on input channels 0 to 3 (AN0 to AN3), and then stores converted data in RAM.

2.1 Operational Overview of Module Used

The 10-bit A/D converter has three operating modes: single mode, multi mode, and scan mode. Scan mode is useful for monitoring analog inputs in a group of one or more channels at all times. In scan mode, A/D conversion is performed sequentially for a maximum of eight specified analog input channels.

Table 1 gives an overview of the module used in this sample application (i.e. the A/D converter) and figure 1 is a block diagram of the 10-bit A/D converter. For details on the 10-bit A/D converter, see the section on A/D converter in the SH7263/SH7203 Group Hardware Manual.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>10 bits</td>
</tr>
<tr>
<td>Minimum conversion time</td>
<td>3.9 μs per channel (Pφ = 33 MHz operation)</td>
</tr>
<tr>
<td>Number of modules</td>
<td>1</td>
</tr>
<tr>
<td>Input channels</td>
<td>8</td>
</tr>
<tr>
<td>Operating modes</td>
<td>Single mode, Multi mode, Scan mode</td>
</tr>
<tr>
<td>Sample-and-hold function</td>
<td>Common to all channels: 1 circuit</td>
</tr>
<tr>
<td>Sources for activation of A/D conversion</td>
<td>Software: Settings of the ADST bit, Timer: TRGAN, TRG0N, TRG4AN, and TRG4BN signals from the MTU2 module, External trigger: ADTRG</td>
</tr>
</tbody>
</table>
Figure 1 Block Diagram of the 10-Bit A/D Converter
2.2 Procedure for Setting Module Used

Figure 2 shows an example of the initialization sequence for A/D conversion in scan mode. For details on the settings of individual registers, see the SH7263/SH7203 Group Hardware Manual.

START

Release A/D converter from module stop mode

Set A/D control status register (ADCSR)

END

- Setting of standby control register 3 (STBCR3)
  MSTP32 (module stop) bit is cleared to 0.
  [Function]
  The A/D converter is released from module standby mode.

- Setting of A/D control status register (ADCSR)
  ADF Clear the A/D End Flag bit to 0.
  [Function]
  The flag indicates end of A/D conversion.
  ADIE Clear the A/D Interrupt Enable bit to 0.
  [Function]
  A/D conversion end interrupt is disabled.
  ADST Clear the A/D Start bit to 0.
  [Function]
  A/D conversion is halted.
  TRGS[3:0] Set the Timer Trigger Select bit to B'0000.
  [Function]
  A/D conversion by external trigger input is disabled.
  CKS[1:0] Set the Clock Select bit to B'00.
  [Function]
  Conversion time is selected.
  Conversion time = 138 clock cycles (maximum), clock = P/4
  MDS[2:0] Set the Multi-scan Mode bit to B'110.
  [Function]
  Scan mode (A/D conversion on 1 to 4 channels) is selected.
  CH[2:0] Set the Channel Select bit to B'011.
  [Function]
  Channels for A/D conversion are selected.
  Multi mode = AN0 to AN3

Figure 2 Initialization Sequence for 10-Bit A/D Conversion

General input pin functions, analog-input pin functions for the A/D converter, analog-output pin functions for the D/A converter (pins PA6 and PA7 only) are multiplexed on the general input pins for port A. These pin functions are changed automatically, so the pin function controller (PFC) does not have a register for settings to control them.

The general input function of the PA7 to PA0 pins is only enabled while the A/D and D/A converters are halted.

When port A data register L (PADRL) is read during operation of the A/D or D/A converter, values of bits corresponding to pins that are in use for conversion become undefined.
2.3 Operation of the Sample Program

In this sample program, A/D conversion in scan mode is performed on channels 0 to 3 (AN0 to AN3). The A/D converter is activated by software and converted data are stored in RAM. This processing is repeated three times.

Table 2 gives a description of RAM in this sample program.

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Area</th>
<th>Name of Employing Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>unsigned short AD_data[AD][CH]</td>
<td>Array for storing A/D-converted data (2 bytes/datum)</td>
<td>On-chip RAM</td>
<td>io_ad_scan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(unsigned short*ad_buf)</td>
</tr>
</tbody>
</table>

2.4 Sequence of Processing by the Sample Program

Table 3 gives settings for a register used in the sample program and figure 3 shows the flow of handling the sample program.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Address</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/D control status register (ADCSR)</td>
<td>H'FFFE5820</td>
<td>H'0033</td>
<td>ADIE = 0: Disables A/D conversion end interrupt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ADST = 0: Halts A/D conversion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TRGS[3:0] = B'0000: Disables starting of A/D conversion by external trigger</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CKS[1:0] = B'00: Operating clock = Pφ/4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDS[2:0] = B'110: Scan mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CH[2:0] = B'011: AN0 to AN3</td>
</tr>
<tr>
<td></td>
<td>H'2033</td>
<td></td>
<td>ADST = 1: Starts A/D conversion</td>
</tr>
</tbody>
</table>
Main (main)

START

Set the count variable to 0

Initialization of A/D converter
io_ad_init();

A/D conversion and storage
of converted data (first round)
io_ad_scan();

A/D conversion and storage
of converted data (second round)
io_ad_scan();

A/D conversion and storage
of converted data (third round)
io_ad_scan();

Stop A/D conversion
ADC.DCSR.BIT.ADF = 0;

END

Initialization of A/D converter (io_ad_init)

START

Release A/D converter from module stop mode
CPG.STBCR3.BIT.MSTP32 = 0x00;

Set A/D control status register (ADCSR)

Start A/D conversion
ADC.ADCSR.BIT.ADST = 1;

END

A/D conversion (io_ad_scan)

START

End of A/D conversion?
ADC.ADCSR.BIT.ADF = 0?

Yes

No

Store converted data (AN0 to AN3)
Read A/D data register A (ADDRA)
Read A/D data register B (ADDRB)
Read A/D data register C (ADDRC)
Read A/D data register D (ADDRD)

Clear A/D end flag
ADC.ADCSR.BIT.ADF = 0;

END

Figure 3 Flow of Handling the Sample Program
# Listing of Sample Program

1. Sample Program Listing: "main.c" (1)

```c
/*FILE COMMENT*********************************************************************
  * System Name  : SH7203 Sample Program
  * File Name    : main.c
  * Contents     : Sample program for A/D conversion in scan mode
  * Version      : 1.00.00
  * Model        : M3A-HS30
  * CPU          : SH7203
  * Compiler     : SHC9.1.1.0
  * note         : A/D conversion in scan mode is performed by the A/D converter.
  *                Three rounds of A/D conversion on channels 0 to 3 (AN0 to AN3)
  *                proceed, and the converted data are stored in RAM.
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  *                history    : 2008.01.09 ver.1.00.00
**FILE COMMENT END******************************************************************/
#include <machine.h>
#include "iodefine.h"       /* SH7203 iodefine */

/* ==== prototype declaration ==== */
void main(void);
void io_ad_init(void);
void io_ad_scan(unsigned short *ad_buf);

/* ==== symbol definition ==== */
#define AD 3
#define CH 4

/* ==== RAM allocation variable declaration ==== */
unsigned short Ad_data[AD][CH];
```
2. Sample Program Listing: "main.c" (2)

```c
/*"FUNC COMMENT"*******************************************************
* Outline   : main
*-----------------------------------------------------------------------
* Include   : #include "iodefine.h"
*     : #include <machine.h>
*-----------------------------------------------------------------------
* Declaration  : void main(void);
*-----------------------------------------------------------------------
* Function   : A/D conversion with scan mode
*-----------------------------------------------------------------------
* Argument   : void
*-----------------------------------------------------------------------
* Return Value  : void
*-----------------------------------------------------------------------
* Notice   : non
"FUNC COMMENT END"***************************************************/
void main(void)
{
  unsigned char count;
  count = 0;

  /* ==== Initial setting of ADC ==== */
  io_ad_init();

  /* ==== A/D conversion ==== */
  io_ad_scan(&Ad_data[count][0]);
  count++;
  io_ad_scan(&Ad_data[count][0]);
  count++;
  io_ad_scan(&Ad_data[count][0]);

  ADC.ADCSR.BIT.ADST = 0;  /* A/D conversion stop */

  while(1){
    /* loop */
  }
}
```
3. Sample Program Listing: "main.c" (3)

```c
/*""FUNC COMMENT""***************************************************************************
* Outline : Initial setting of ADC
*------------------------------------------------------------------------------
* Include  : #include "iodefine.h"
*------------------------------------------------------------------------------
* Function  : Initial setting of ADC
* Argument  : void
* Return Value : void
*------------------------------------------------------------------------------
* Notice  : non
*""FUNC COMMENT END""**************************************************************************/

void io_ad_init(void)
{
  /* ==== Setting of power down mode(ADC) ==== */
  CPG.STBCR3.BIT.MSTP32 = 0x00;
  /* ==== Setting of ADC ==== */
  /* ---- A/D Control/Status Register(ADCSR) ---- */
  ADC.ADCSR.WORD = 0x0033;
  /* 15 = b'0  : A/D End Flag                                */
  /* 14 = b'0  : A/D end interrupt request (ADI) is disabled */
  /* 13 = b'0  : A/D conversion is stopped                   */
  /* 12 = b'0  : reserve                                     */
  /* 11-8 = b'000 : Start of A/D conversion by external trigger input is disabled */
  /* 7-6 = b'00  : clock = Pφ/4                                */
  /* 5-3 = b'110 : Scan mode                                  */
  /* 2-0 = b'011 : Channel Select AN0-AN3                      */
  /* ---- A/D Status Register(ADSR) ---- */
  ADC.ADCSR.BIT.ADF = 0; /* ADF clear */

  while(ADC.ADCSR.BIT.ADF == 0){ /* A/D conversion completion waiting */
/* A/D conversion completion waiting */
*ad_buf++ = ADC.ADDRA.WORD; /* AN0 */
*ad_buf++ = ADC.ADDRB.WORD; /* AN1 */
*ad_buf++ = ADC.ADDRC.WORD; /* AN2 */
*ad_buf++ = ADC.ADDRD.WORD; /* AN3 */
  }
  ADC.ADCSR.BIT.AST = 1; /* A/D conversion start */

} /*""FUNC COMMENT""***************************************************************************
* Outline : A/D conversion
*------------------------------------------------------------------------------
* Include  : #include "iodefine.h"
*------------------------------------------------------------------------------
* Declaration : void io_ad_scan(unsigned short *ad_buf);
*------------------------------------------------------------------------------
* Function  : Clearing of A/D end flag (ADF), and storing of conversion data
*------------------------------------------------------------------------------
* Argument  : unsigned short *ad_buf ; Buffer
*------------------------------------------------------------------------------
* Return Value : none
*------------------------------------------------------------------------------
* Notice  :
*""FUNC COMMENT END""**************************************************************************/

void io_ad_scan(unsigned short *ad_buf)
{
  while(ADC.ADCSR.BIT.ADF == 0){ /* A/D conversion completion waiting */
/* A/D conversion completion waiting */
*ad_buf++ = ADC.ADDRA.WORD; /* AN0 */
*ad_buf++ = ADC.ADDRB.WORD; /* AN1 */
*ad_buf++ = ADC.ADDRC.WORD; /* AN2 */
*ad_buf++ = ADC.ADDRD.WORD; /* AN3 */
  }

ADC.ADCSR.BIT.ADF = 0; /* ADF clear */

/* End of File */
```
4. Documents for Reference

- Software Manual
  The most up-to-date version of this document is available on the Renesas Technology Website.

- Hardware Manual
  SH7203 Group Hardware Manual
  SH7263 Group Hardware Manual
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