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SH7211 Group

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

Introduction

This application note describes an example of settings for the 12-bit A/D converter in continuous scan mode as a sample application for the A/D converter of the SH7211.

Target Device

SH7211

Contents

1. Preface

1.1 Specifications

- A/D conversion in continuous scan mode by the 12-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

- 12-bit A/D converter (12-bit A/D)

1.3 Applicable Conditions

• MCU	SH7211 (R5F7211)	
• Clock operating mode	6	
• Operating frequency	Internal clock:	160 MHz
	Bus clock:	40 MHz
	Peripheral clock:	40 MHz
• C compiler	SuperH RISC Engine Family C/C++ Compiler Package Ver.9.0.3.0 from Renesas Technology	
• Compiler options	Default settings of the High-performance Embedded Workshop (-cpu = sh2a -debug -gbr = auto -global_volatile = 0 -opt_range = all -infinite_loop = 0 -del_vacant_loop = 0 -struct_alloc = 1)	

1.4 Related Application Note

None

2. Description of the Sample Application

The sample program employs the continuous scan mode of the 12-bit A/D converter to perform three rounds of 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 operating modes of the 12-bit A/D converter are single-cycle scan mode and continuous scan mode. In single-cycle scan mode, A/D conversion is performed once on each of one or more specified channels and then ends. The ADST bit is automatically cleared to 0. In continuous scan mode, A/D conversion is performed sequentially on one or more specified channels until the ADST bit is cleared to 0 by software.

A/D conversion is started by one of the following three methods.

1. Setting the ADST bit by software
2. A/D conversion triggers (TRGAN, TRG0N, TRG4AN, and TRG4BN from MTU2; TRGAN, TRG4AN, and TRG4BN from MTU2S)
3. Input of an external trigger: Falling edge on the $\overline{\text{ADTRG}}$ pin

Additionally, channels 0 to 2 have dedicated sample-and-hold circuits, so multiple channels are capable of simultaneous sampling.

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 12-bit A/D converter. For details on the 12-bit A/D converter, see the section on the A/D converter in the *SH7211 Group Hardware Manual* (REJ09B0344).

Table 1 Overview of the Module (A/D Converter) Used in the Sample Application

Item	Description
Resolution	12 bits
Minimum conversion time	1.25 µs per channel
Number of modules	1
Input channels	8
Operating modes	Single-cycle scan mode Continuous scan mode
Sample-and-hold function	Common to 0 to 2 channels: 1 circuit Dedicated for individual channels: 1 circuit each for ch0 to ch2 (3 in all)
Sources for activation of A/D conversion	Software: Setting of the ADST bit Timers: TRGAN, TRG0N, TRG4AN, and TRG4BN signals from the MTU2 module TRGAN, TRG4AN, and TRG4BN signals from the MTU2S module External trigger: $\overline{\text{ADTRG}}$

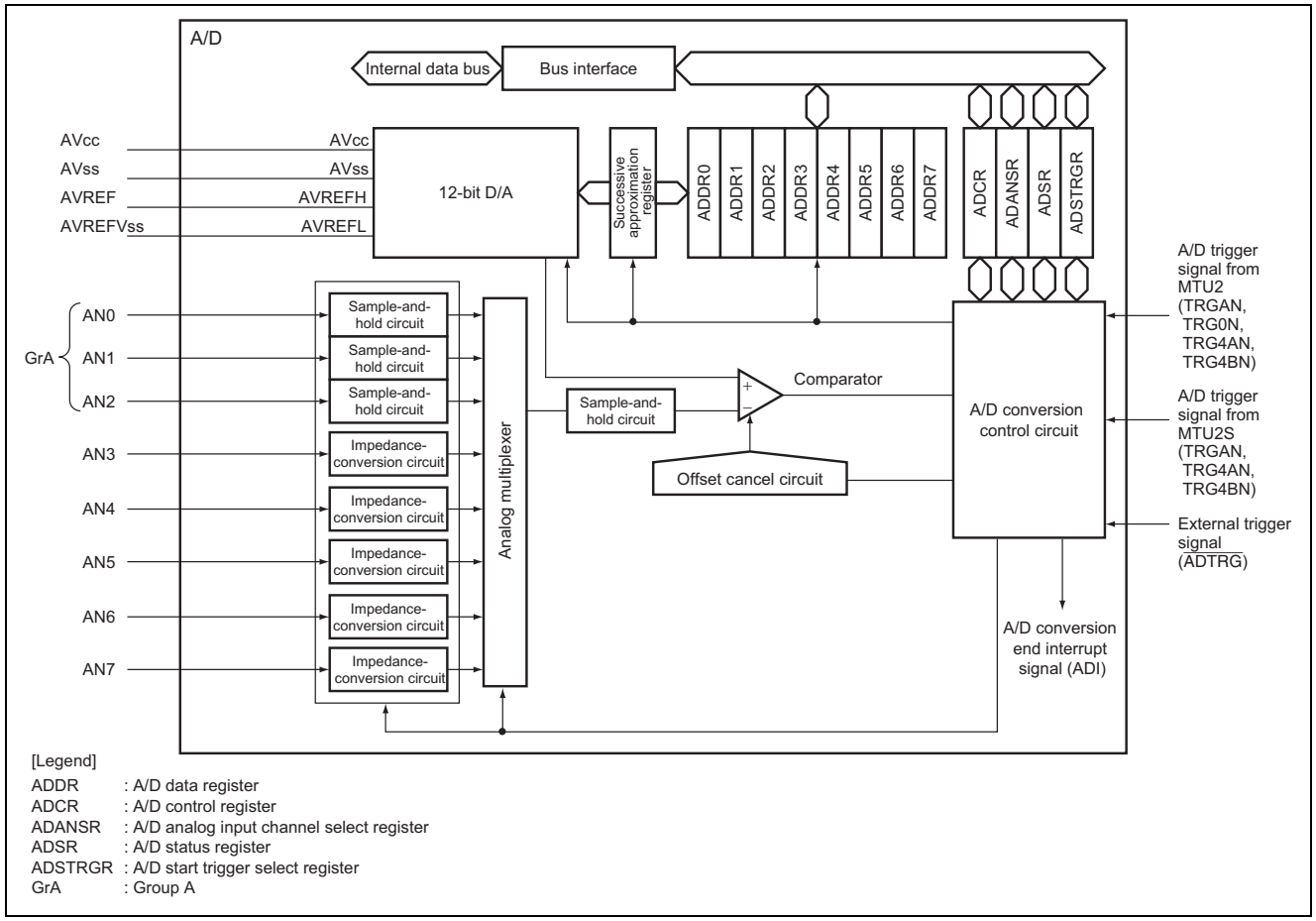

Figure 1 Block Diagram of the 12-Bit A/D Converter

2.2 Procedure for Setting Module Used

Figure 2 shows an example of the initialization sequence for A/D conversion in continuous scan mode. For details on the settings of individual registers, see the *SH7211 Group Hardware Manual* (REJ09B0344).

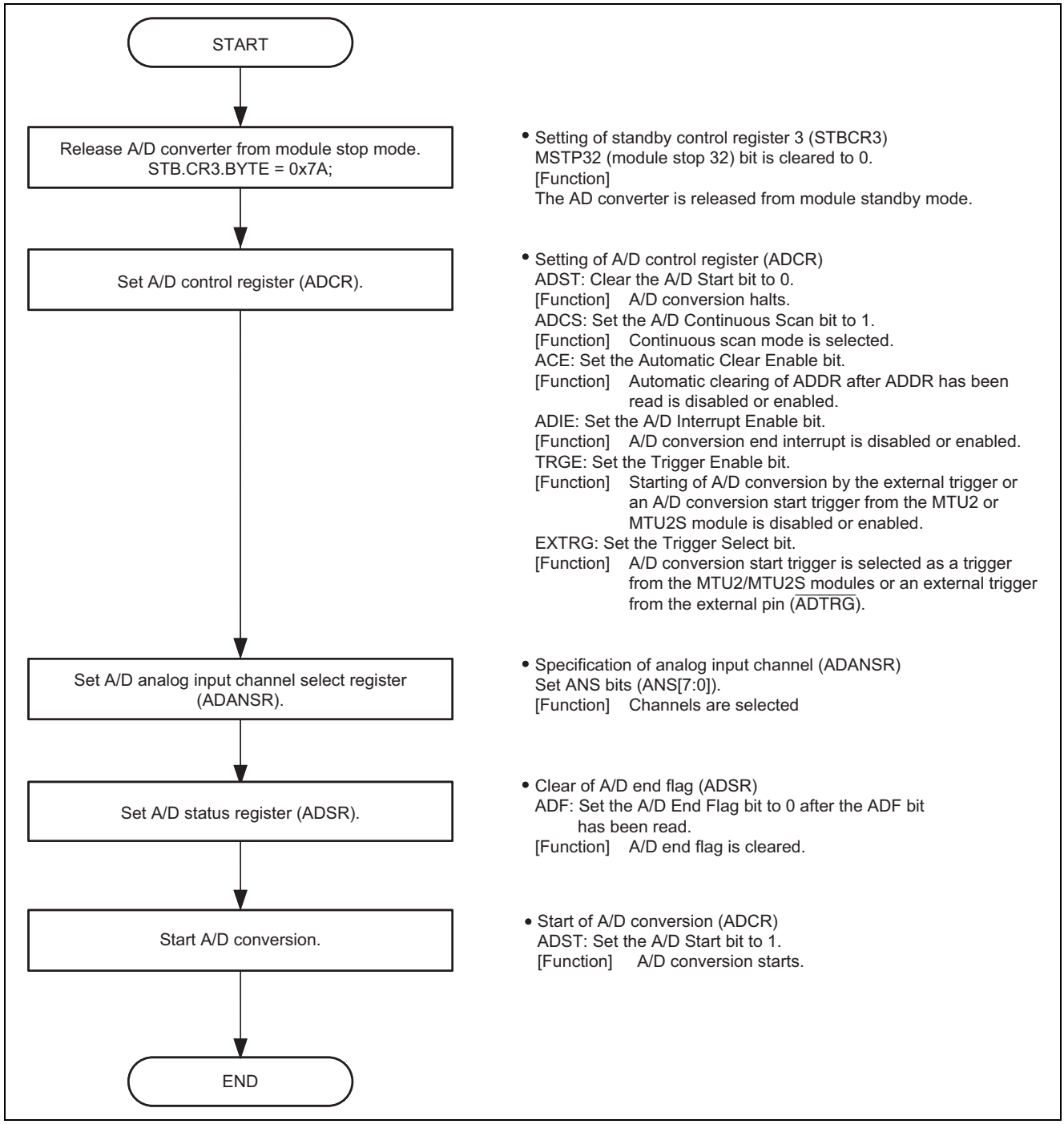

Figure 2 Initialization Sequence for 12-Bit A/D Conversion

2.3 Operation of the Sample Program

In this sample program, A/D conversion in continuous 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 usage in this sample program.

Table 2 Variable Used in the Sample Program

Variable Name	Description	Area	Name of Employing Module
Ad_data[AD][CH]	Array for storing A/D-converted data (2 bytes/datum)	On-chip RAM	io_ad_conv (void)

2.4 Sequence of Processing by the Sample Program

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

Table 3 Register Settings Used in Sample Program

Register Name	Address	Setting	Description
A/D control register (ADCR)	H'FFFF E800	H'00	• ADCS = 1: Continuous scan • ACE = 0: Disables automatic clearing of ADDR after reading of ADDR. • ADIE = 0: Disables A/D conversion end interrupt. • TRGE = 0: Disables starting of A/D conversion by an external trigger or by the MTU2 and MTU2S modules.
A/D analog input channel select register (ADANSR)	H'FFFF E820	H'0F	• Selects AN0 to AN3.

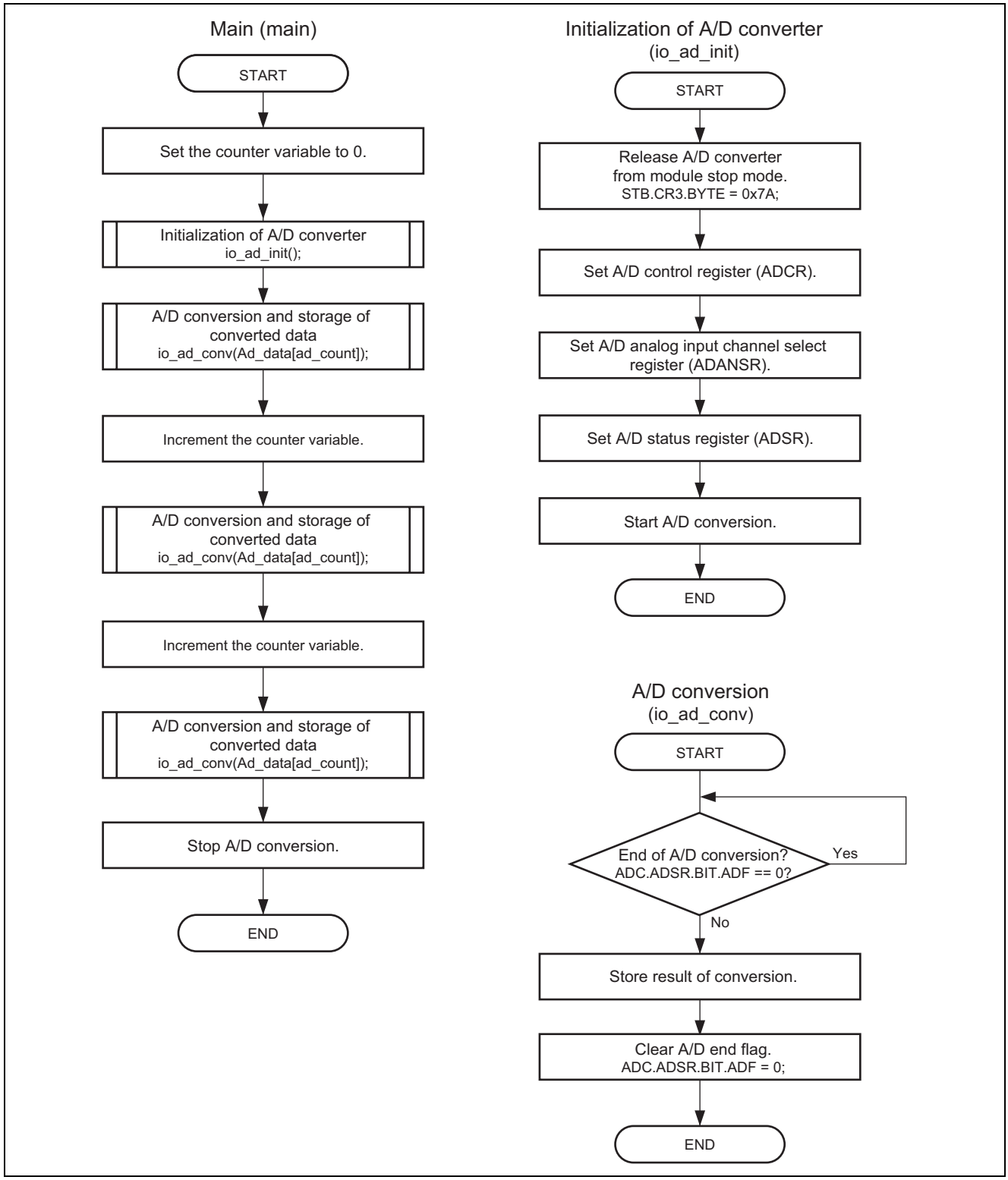

Figure 3 Flow of Handling the Sample Program

3. Listing of Sample Program

1. Sample program listing: "main.c" (1)

```
1       /*""FILE COMMENT""*****************************************************************
2       *
3       * System Name  : SH7211 Sample Program
4       * File Name    : main.c
5       * Contents     : Sample program for A/D conversion in continuous scan mode
6       * Version      : 1.00.00
7       * Model        : M3A-HS11
8       * CPU          : SH7211
9       * Compiler     : SHC9.0.3.0
10      * note         : A/D conversion in continuous scan mode is performed by the A/D
11      *                converter. Three rounds of A/D conversion on analog input channels
12      *                0 to 3 (AN0 to AN3) proceed, and the converted data are stored in RAM.
13      *
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21      *
22      * History : 2007.09.04 ver.1.00.00
23      *""FILE COMMENT END""*************************************************************/
24      #include <machine.h>
25      #include "iodefine.h"     /* SH7211 iodefine */
26
27
28      /* ==== prototype declaration ==== */
29      void main(void);
30      void io_ad_init(void);
31      void io_ad_conv(unsigned short *ad_buf);
32
33      /* ==== symbol definition ==== */
34      #define AD 3
35      #define CH 4
36
37      /* ==== RAM allocation variable declaration ==== */
38      unsigned short Ad_data[AD][CH];
39      unsigned char ad_count;
40
41
```

2. Sample program listing: "main.c" (2)

```
42      /*""FUNC COMMENT""*************************************************************
43      * Outline      : main
44      *-------------------------------------------------------------------------
45      * Include      : #include "iodefine.h"
46      *              : #include <machine.h>
47      *-------------------------------------------------------------------------
48      * Declaration  : void main(void);
49      *-------------------------------------------------------------------------
50      * Function     : AD conversion with continuous scan mode
51      *-------------------------------------------------------------------------
52      * Argument     : none
53      *-------------------------------------------------------------------------
54      * Return Value : none
55      *-------------------------------------------------------------------------
56      * Note         : none
57      *""FUNC COMMENT END""*********************************************************/
58      void main(void)
59      {
60
61          ad_count = 0;
62
63          /* ==== Initial setting of ADC ==== */
64          io_ad_init();
65
66          /* ==== A/D convert ==== */
67          io_ad_conv(Ad_data[ad_count]);
68          ad_count++;
69          io_ad_conv(Ad_data[ad_count]);
70          ad_count++;
71          io_ad_conv(Ad_data[ad_count]);
72
73          ADC.ADCR.BIT.ADST = 0;        /* A/D conversion stop */
74
75          while(1){
76                  /* loop */
77          }
78
79      }
80
```

3. Sample program listing: "main.c" (3)

```
/*""FUNC COMMENT""*************************************************************
* Outline      : Initial setting of ADC
*------------------------------------------------------------------------------
* Include      : #include "iodefine.h"
*------------------------------------------------------------------------------
* Declaration  : void ad_init(void);
*------------------------------------------------------------------------------
* Function     : Initial setting of ADC
*------------------------------------------------------------------------------
* Argument     : none
*------------------------------------------------------------------------------
* Return Value : none
*------------------------------------------------------------------------------
* Note         : none
*""FUNC COMMENT END""*********************************************************/
void io_ad_init(void)
{
    /* ==== Release of module standby(ADC) ==== */
    STB.CR3.BYTE = 0x7A;

    /* ==== Setting of ADC ==== */
    /* ---- A/D Control Register(ADCR) ---- */
    ADC.ADCR.BYTE = 0x40;
           /* 7 = b'0     : A/D End Flag                                  */
           /* 6 = b'1     : Continuous scan                               */
           /* 5 = b'0     : Automatic clearing of ADDR
                             after being read is disabled                  */
           /* 4 = b'0     : Generation of A/D conversion end
                             interrupt is disabled                         */
           /* 3-2 = b'0   : reserve                                       */
           /* 1 = b'0     : A/D conversion start by the external trigger
                             or an A/D conversion start trigger from
                             the MTU or MTU2S is disabled                  */
           /* 0 = b'0     : A/D converter is started by the A/D conversion
                             start trigger from the MTU2 or MTU2S          */

    /* ---- A/D Analog Input Channel Select Register(ADANSR) ---- */
    ADC.ADANSR.BYTE = 0x0F;    /* AN0-AN3 */

    /* ---- A/D Status Register(ADSR) ---- */
    ADC.ADSR.BIT.ADF &= 0;     /* ADF clear */

    ADC.ADCR.BIT.ADST = 1;     /* A/D conversion start */

}
```

4. Sample program listing: "main.c" (4)

```
127     /*""FUNC COMMENT""*****************************************************
128     * Outline      : A/D convert
129     *-------------------------------------------------------------------------
130     * Include      : #include "iodefine.h"
131     *-------------------------------------------------------------------------
132     * Declaration  : void ad_conv(unsigned short *ad_buf);
133     *-------------------------------------------------------------------------
134     * Function     : Clearing the ADF flag, storing converted data
135     *-------------------------------------------------------------------------
136     * Argument     : none
137     *-------------------------------------------------------------------------
138     * Return Value : none
139     *-------------------------------------------------------------------------
140     * Note         : none
141     *""FUNC COMMENT END""*************************************************/
142     void io_ad_conv(unsigned short *ad_buf)
143     {
144
145         while(ADC.ADSR.BIT.ADF == 0){
146                /* A/D conversion completion waiting */
147         }
148
149         *ad_buf++ = ADC.ADDR0;        /* AN0 */
150         *ad_buf++ = ADC.ADDR1;        /* AN1 */
151         *ad_buf++ = ADC.ADDR2;        /* AN2 */
152         *ad_buf++ = ADC.ADDR3;        /* AN3 */
153         ADC.ADSR.BIT.ADF = 0;         /* ADF clear */
154
155     }
156
157     /* End of File */
158
```

4. Documents for Reference

- Software Manual (REJ09B0051)
  SH-2A, SH2A-FPU Software Manual
  The most up-to-date version of this document is available on the Renesas Technology Website.
- Hardware Manual
  SH7211 Group Hardware Manual (REJ09B0344)
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