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April 1st, 2010
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SH7137 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 an example of application of the A/D converter of the SH7137.

Target Device

SH7137

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	SH7137/SH7136
• Operating frequency	Internal clock: 80 MHz Bus clock: 40 MHz Peripheral clock: 40 MHz
• Compiler	SuperH RISC engine Family C/C++ Compiler Package Ver.9.01 Release01 from Renesas Technology
• Compiler options	-cpu = sh2a -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 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

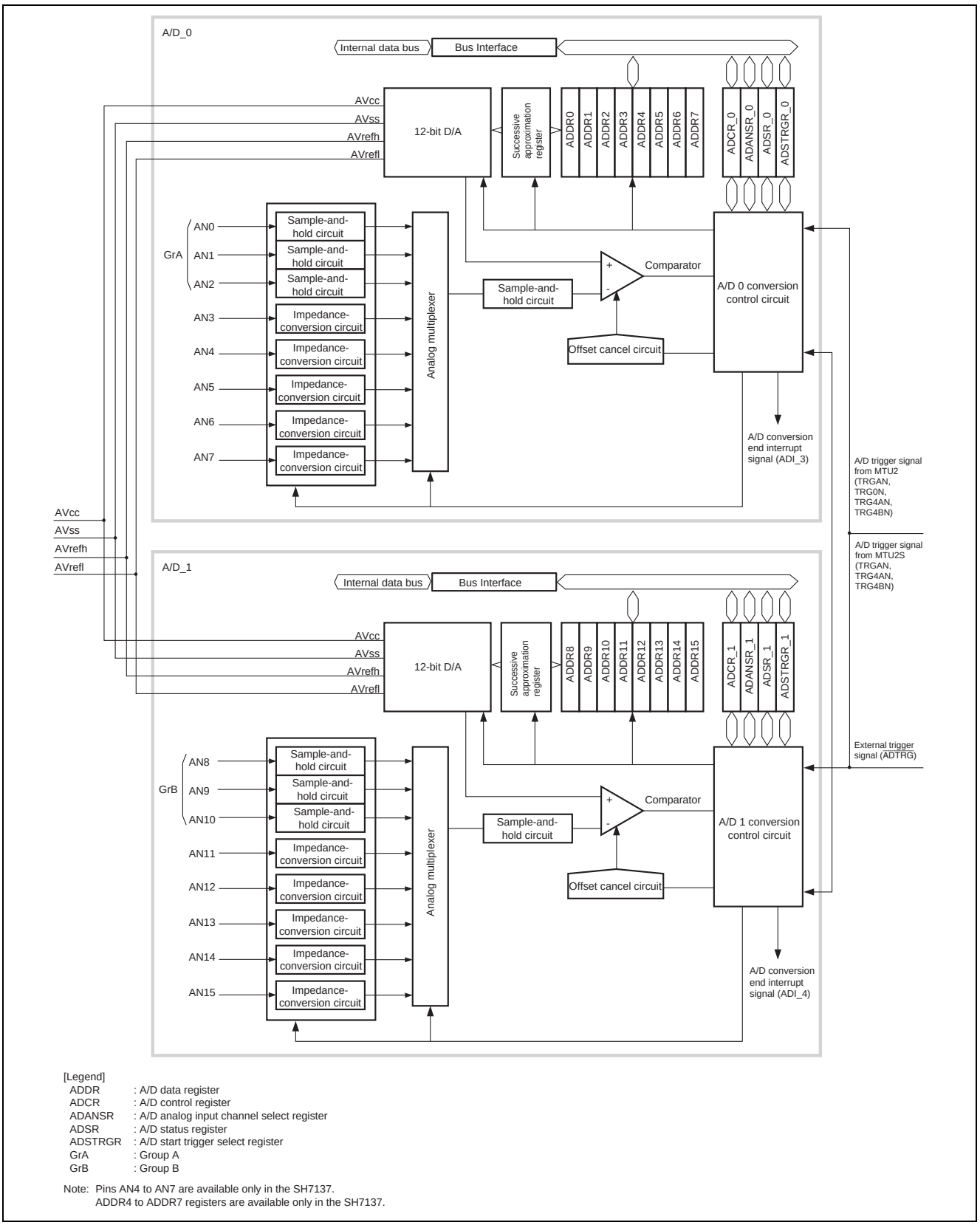
The operating modes of the 12-bit A/D converter are single-cycle scan mode and continuous scan mode. In single-cycle scan mode, A/D conversion is performed once on each of one or more specified channels and then ends. The ADST bit is automatically cleared to 0. In continuous scan mode, A/D conversion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

Additionally, channels 0 to 2 and 8 to 10 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 12-bit A/D converter. For details on the 12-bit A/D converter, see the section on the A/D converter in the *SH7137 Group Hardware Manual*.

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 (Pϕ = 40 MHz)
Number of modules	2
Input channels	16 (SH7137), 12 (SH7136)
Operating modes	Single-cycle scan mode Continuous scan mode
Sample-and-hold function	Common to 0 to7 channels: 1 circuit Common to 8 to15 channels: 1 circuit Dedicated for individual channels: 1 circuit each for ch0 to 2 and 8 to 10 (6 in all)
Sources for activation of A/D conversion	Software: Setting of the ADST bit Timer: TRGAN, TRG0N, TRG4AN, and TRG4BN signals from the MTU2 module TRGAN, TRG4AN, and TRG4BN signals from the MTU2S module External trigger: ADTRG



[Legend]
ADDR : A/D data register
ADCR : A/D control register
ADANSR : A/D analog input channel select register
ADSR : A/D status register
ADSTRGR : A/D start trigger select register
GrA : Group A
GrB : Group B

Note: Pins AN4 to AN7 are available only in the SH7137.
ADDR4 to ADDR7 registers are available only in the SH7137.

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 *SH7137 Group Hardware Manual*.

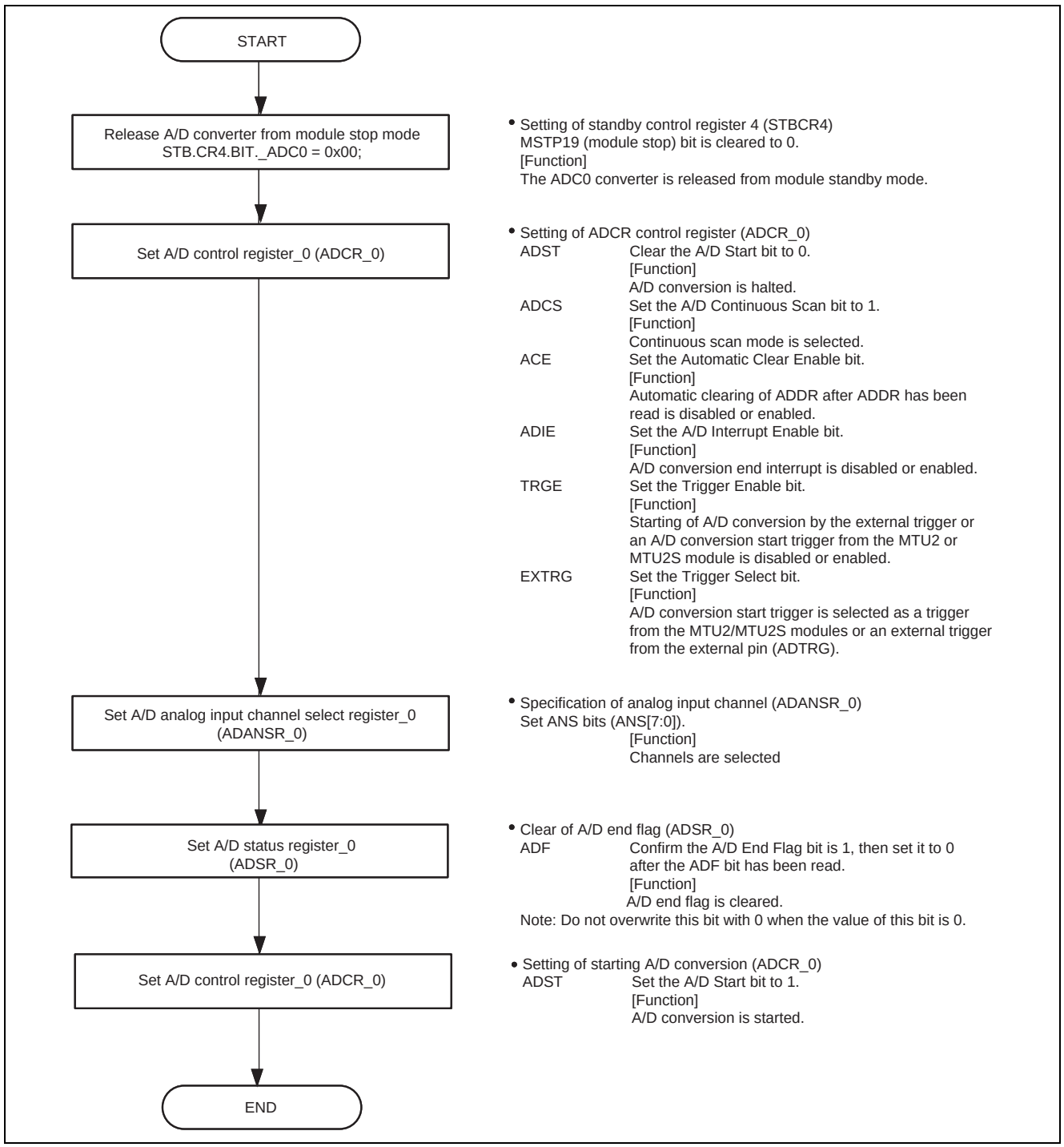


Figure 2 Initialization Sequence for 12-Bit A/D Conversion

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 Variables Used in the Sample Program

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

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_0 (ADCR_0)	H'FFFF D400	H'40	• ADST = 0: Halts A/D conversion • ADCS = 1: Continuous scan • ACE = 0: Disables automatic clearing 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
		H'C0	• ADST = 1: Starts A/D conversion

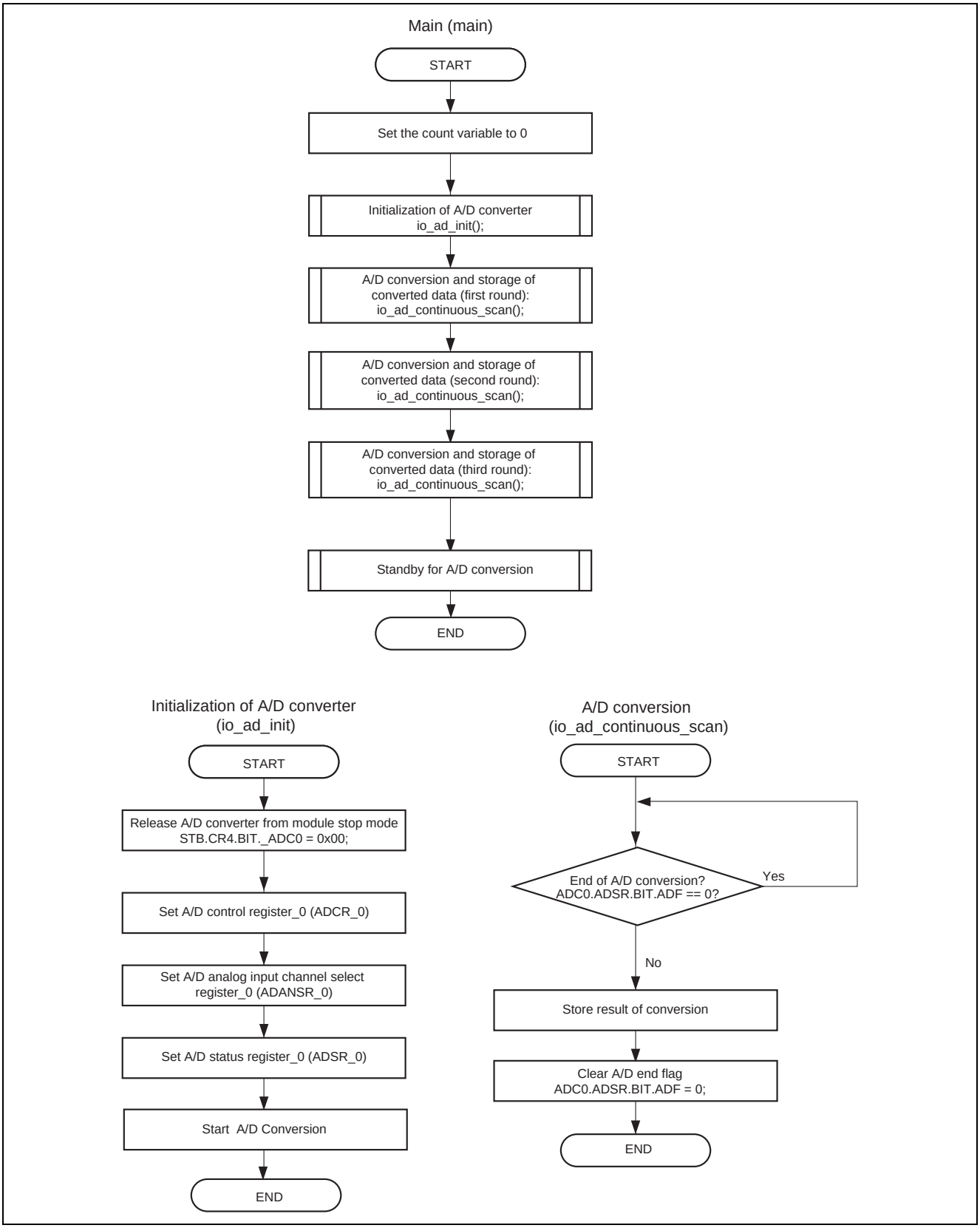


Figure 3 Flow of Handling the Sample Program

3. Listing of Sample Program

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

```
1  /*""FILE COMMENT""*******************************************************************
2  *
3  *       System Name    : SH7137 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-HS37
8  *       CPU            : SH7137
9  *       Compiler       : SHC9.1.1.0
10 *       note    : A/D conversion in continuous scan mode is performed by the A/D converter.
11 *                 Three rounds of A/D conversion on analog input channels 0 to 3
12 *                 (AN0 to AN3) proceed, and the converted data are stored in RAM.
13 *
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19 *       Copyright (C) 2008 Renesas Technology Corp. All Rights Reserved
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21 *
22 *       history        : 2008.02.26 ver.1.00.00
23 *""FILE COMMENT END""*******************************************************************/
24 #include <machine.h>
25 #include "iodefine.h"         /* SH7137 iodefine  */
26
27 /* ==== prototype declaration ==== */
28 void main(void);
29 void io_ad_init(void);
30 void io_ad_continuous_scan(unsigned short *ad_buf);
31
32 /* ==== symbol definition ==== */
33 #define AD 3
34 #define CH 4
35
36 /* ==== RAM allocation variable declaration ==== */
37 unsigned short Ad_data[AD][CH];
38
```

2. Sample Program Listing: "main.c" (2)

```
/*""FUNC COMMENT""*****************************************************************
* Outline      : main
*------------------------------------------------------------------------------
* Include      : #include "iodefine.h"
*------------------------------------------------------------------------------
* Declaration  : void main(void);
*------------------------------------------------------------------------------
* Function     : A/D conversion with continuous scan mode
*------------------------------------------------------------------------------
* Argument     : void
*------------------------------------------------------------------------------
* Return Value : none
*------------------------------------------------------------------------------
* Notice       :
*""FUNC COMMENT END""*************************************************************/
void main(void)
{
    unsigned char count;
    count = 0;

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

    /* ==== A/D convert ==== */
    io_ad_continuous_scan(&Ad_data[count][0]);
    count++;
    io_ad_continuous_scan(&Ad_data[count][0]);
    count++;
    io_ad_continuous_scan(&Ad_data[count][0]);

    ADCO.ADCR.BIT.ADST = 0;           /* A/D conversion stop */

    while(1){
        /* loop */
    }
}

/*""FUNC COMMENT""*****************************************************************
* Outline      : Initial setting of ADC
*------------------------------------------------------------------------------
* Include      : #include "iodefine.h"
*------------------------------------------------------------------------------
* Declaration  : void io_ad_init(void);
*------------------------------------------------------------------------------
* Function     : Initial setting of ADC
*------------------------------------------------------------------------------
* Argument     : void
*------------------------------------------------------------------------------
* Return Value : none
*------------------------------------------------------------------------------
* Notice       :
*""FUNC COMMENT END""*************************************************************/
```

3. Sample Program Listing: "main.c" (3)

```
91  void io_ad_init(void)
92  {
93      /* ==== Release of module standby (ADC0) ==== */
94      STB.CR4.BIT._ADC0 = 0x00;
95
96      /* ==== Setting of ADC ==== */
97      /* ---- A/D Control Register (ADCR) ---- */
98      ADC0.ADCR.BYTE = 0x40;
99          /* 7    = b'0      : A/D conversion start flag                    */
100         /* 6    = b'1      : Continuous scan                              */
101         /* 5    = b'0      : Automatic clearing of ADDR by its readout
102                                 is disabled                                */
103         /* 4    = b'0      : Generation of A/D conversion end interrupt
104                                 is disabled                                */
105         /* 3-2  = b'0      : Reserve                                      */
106         /* 1    = b'0      : A/D conversion start by the external trigger
107                                 or an A/D conversion start trigger from
108                                 the MTU2 or MTU2S is disabled              */
109         /* 0    = b'0      : A/D converter is started by the A/D conversion
110                                 start trigger from the MTU2 or MTU2S       */
111
112     /* ---- A/D Analog Input Channel Select Register (ADANSR) ---- */
113     ADC0.ADANSR.BYTE = 0x0f;          /* AN0-AN3 */
114
115     /* ---- A/D Status Register (ADSR) ---- */
116     if(ADC0.ADSR.BIT.ADF == 0x01){
117         ADC0.ADSR.BIT.ADF = 0x00;     /* ADF clear */
118     }
119     ADC0.ADCR.BIT.ADST = 1;           /* A/D conversion start */
120 }
121
122 /*""FUNC COMMENT""*****************************************************************
123 * Outline      : A/D conversion
124 *-------------------------------------------------------------------------------
125 * Include      : #include "iodefine.h"
126 *-------------------------------------------------------------------------------
127 * Declaration  : void io_ad_continuous_scan(unsigned short *ad_buf);
128 *-------------------------------------------------------------------------------
129 * Function     : Clearing of A/D end flag (ADF), and storing of conversion data
130 *-------------------------------------------------------------------------------
131 * Argument     : unsigned short *ad_buf ; Buffer which A/D conversion data are stored
132 *-------------------------------------------------------------------------------
133 * Return Value : none
134 *-------------------------------------------------------------------------------
135 * Notice       :
136 *""FUNC COMMENT END""*************************************************************/
137 void io_ad_continuous_scan(unsigned short *ad_buf)
138 {
139     while(ADC0.ADSR.BIT.ADF == 0){
140         /* A/D conversion completion waiting */
141     }
142     *ad_buf++ = ADC0.ADDR0;       /* AN0 */
143     *ad_buf++ = ADC0.ADDR1;       /* AN1 */
144     *ad_buf++ = ADC0.ADDR2;       /* AN2 */
145     *ad_buf++ = ADC0.ADDR3;       /* AN3 */
146     ADC0.ADSR.BIT.ADF = 0;        /* ADF clear */
147 }
148
149 /* End of File */
```

4. Documents for Reference

- Software Manual
  SH-1/SH2/SH-DSP Software Manual
  The most up-to-date version of this document is available on the Renesas Technology Website.
- Hardware Manual
  SH7137 Group Hardware Manual
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Revision Record

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Jun.18.08	—	First edition issued
1.01	Dec.12.08	8 to 10	Listing of Sample Program modified

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