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32176 Group

Application of A/D Converter (Single A/D Conversion Mode)

1. Overview

This documentation presents a sample program, which uses the 32176 Group on-chip A/D converter in the single mode to perform A/D conversion.

The execution of A/D conversion in the single mode is called the single-A/D conversion mode in this Application Note.

2. Introduction

The sample task described here uses the following microcomputer, under the respective conditions.

- Microcomputer: 32176 Group (M32176FnVFP, M32176FnTFP)
- Operating frequency: 20 to 40 MHz (The sample program is compiled assuming a frequency of 40 MHz.)
- Operation Board: Starter kit for 32176 Group

3. Description of the Technology Applied

3.1 Outline of the A/D Converter

The 32176 have an internal A/D converter with 10-bit resolution using successive approximation comparison method. The A/D converter has 16 analog input pins (channels) from AD0IN0 to AD0IN15, and in addition to single conversion at each channel, successive A/D conversion is possible with N (N = 1 to 16) channels as one group.

Furthermore, A/D conversion value can be readout as 10-bit or 8-bit.

The following conversion modes and the operation modes can be used for A/D conversion.

(1) Conversion Modes

- A/D Conversion Mode: A/D conversion of standard analog voltage input.
- Comparator Mode (Note): The analog input voltage is compared with the set voltage for comparison to determine which is higher or lower (only in the single mode).

(2) Operation Modes

- Single Mode: Analog input voltage on one channel is converted from analog data to digital values, or "comparated". (Note)
- Scan Mode: Successive A/D conversion is performed of analog input voltage on selected multiple channels (N: Channel unit, N = 1 to 16).
  Single-Shot Scan Mode: Scan operation is performed for one cycle.
  Continuous Scan Mode: Scan operation is repeatedly performed until operation stops.

(3) Special Operation Modes

- Forcible single mode execution during scan: Conversion is forcibly executed in the single mode (in comparator mode) during scan operation.
- Starting the scan mode after execution in the single mode: Continues scan operation from the single mode.
- Conversion Re-start: Restarts A/D conversion during operation in the single mode or the scan mode.

Note: To discriminate between the comparison performed internally by the successive approximation type A/D converter and that performed in comparator mode using the same A/D converter as a comparator, the comparison in comparator mode is referred to here as "comparate."

For details on the A/D converter, refer to the 32176 Group User's Manual.

4. The Sample Program using Single A/D Conversion Mode

The single mode is the mode for one time A/D conversion of analog voltage input on a selected channel. At the point when the conversion is complete, an interrupt request or a DMA transfer request can be issued.

In this sample program, the channel number is specified by parameters, and undergoes A/D conversion.

4.1 Outline of the Sample Program

The value read from the toggle switch (port 13), is used for analog input channel number for A/D conversion. The 10-bit conversion result from the A/D conversion is converted to 8-bit and output to the LED (port 11); this processing is repeated. The conversion end interrupts and DMA transfer are not used.

The A/D conversion is performed in the slow mode, double speed, sample-and-hold enabled, fast sample-and-hold function, which is initiated by software trigger. In addition, disconnection detection assist function is enabled, and pre-charge method, which charges before conversion is selected as the disconnection detection assist method.

4.2 Processing Process

The basic processing flow when using the A/D converter is shown in figure 4.2.1.

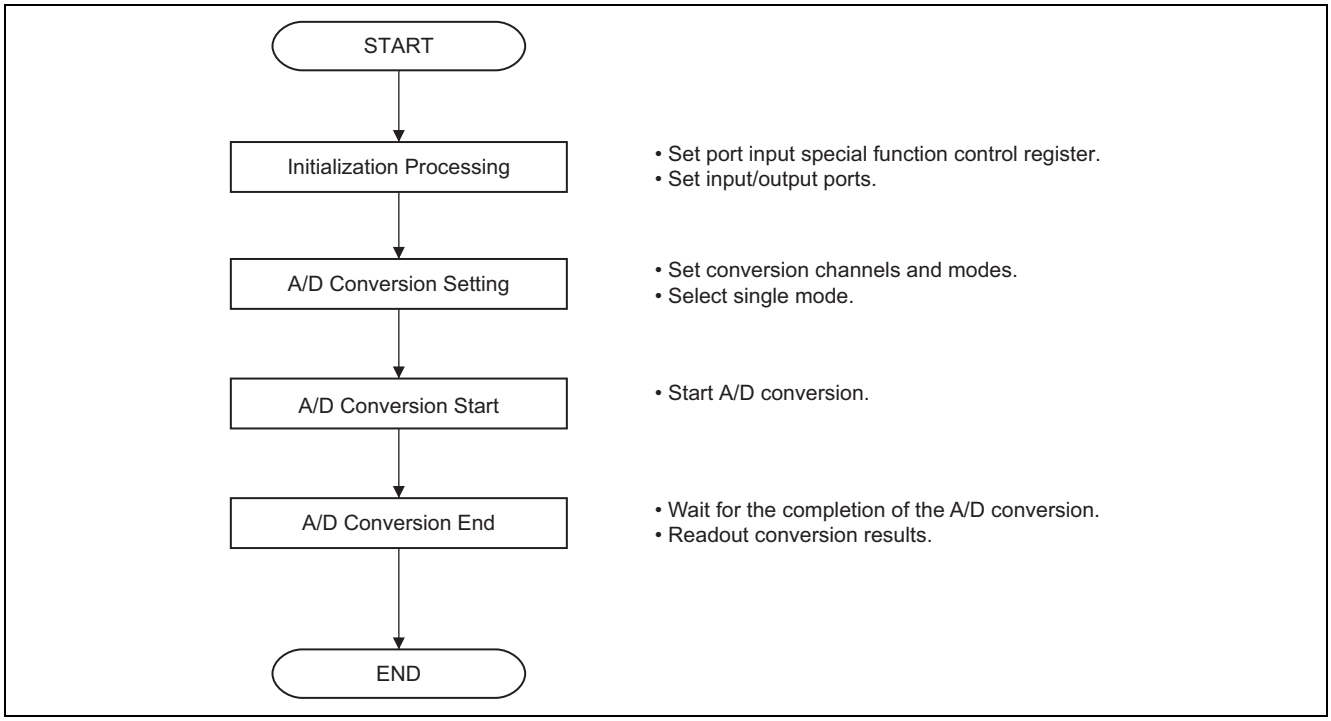

Figure 4.2.1 Basic Process Flow for the A/D Converter

4.3 Description of Sample Program

Note: The registers used are indicated as (register name: bit name).

4.3.1 Various Initialization Function (init_func ())

(1) Call the port initialization function.

4.3.2 Port Initialization Function (port_init ())

(1) Set the output port
- Set the input enable bit of the port input special function control register to input enabled. (PICNT: PIEN0)
- Initialize the P11 data register. (P11DATA)
- Set the P11 direction register to the output mode. (P11DIR)
- Set the P11 operation mode register to input/output port. (P11MOD)

(2) Set the input port
- Set the P13 direction register to input mode. (P13DIR)
- Set the P13 operation mode register to input/output port. (P13MOD)

Note: If a Direction Register is set as output before setting up a Data Register, an unfixed value is outputted until writing will be performed to a Data Register.

4.3.3 Main Function (main ())

(1) Call the various initialization function.
(2) Readout the P13 data register.
- Use the analog input channel for A/D conversion.

(3) Call the function for A/D conversion execution.
- Provide the number of analog input channels to undergo A/D conversion.

(4) Change the A/D conversion results from 10 bits to 8bits and output the results to the P11 data register.

4.3.4 A/D0 Conversion Execution Function (AD0exe ())

(1) Setting the A/D converter.
- Enable only the lower 4 bits to be used within the channels of the A/D analog input pins.
- Enable A/D disconnection detection assist function. (AD0DDACR: ADDDAEN)
- Set the A/D0 disconnection detection assist method select register. (AD0DDASEL)
- Set the A/D0 single mode register 1. (AD0SIM1: ADSMSL, ADSSPD, ADSSHSL, ADSSHSPD, ANSEL)
  A/D conversion mode, normal conversion speed, sample-and-hold enabled, high-speed sample-and-hold, analog input pins selected.

(2) Starting A/D conversion.
- Set the A/D0 single mode register. (AD0SIM0: ADSSEL, ADSREQ)
- Set the conversion start trigger to software trigger, without using DMA transfer request.
- Start A/D conversion. (AD0SIM0: ADSSTT)

(3) A/D conversion completed .
- Wait for the completion of the A/D conversion. (AD0SIM0: AD0SCMP)
- Readout conversion results. (AD0DTn)

4.4 Sample Program

The following shows a single A/D conversion mode sample program.

Note that the sample program below requires the SFR definition file. The latest SFR definition file can be downloaded from Renesas Technology website. When using the SFR definitions file, adjust the path setting to match the operating computer environment.

4.4.1 ad_main.c

```
/*""FILE COMMENT""*****************************************************
 *      M32R C Programming              Rev. 1.11
 *              < Sample Program for 32176 >
 *              < AD converter (main routine) >
 *
 *      Copyright (c) 2004 Renesas Technology Corporation
 *                         All Rights Reserved
 ***********************************************************************/

/***********************************************************************/
/*              Include file                                           */
/***********************************************************************/

#include                "..\inc\sfr32176_pragma.h"

/***********************************************************************/
/*              Function prototype declaration                         */
/***********************************************************************/

        void            main(void);                             /* Main function */
        void            init_func(void);                        /* Initial setup function */
        void            port_init(void);                        /* Initialize port */

/***********************************************************************/
/*              Definition of external reference                       */
/***********************************************************************/

extern  USHORT  AD0exe( UCHAR);                 /* Execute AD conversion */

/*""FUNC COMMENT""*****************************************************
 * Function name: init_func()
 *---------------------------------------------------------------------
 * Description  : Call various initialization functions
 *---------------------------------------------------------------------
 * Argument     : -
 *---------------------------------------------------------------------
 * Returns      : -
 *---------------------------------------------------------------------
 * Notes        :
 *""FUNC COMMENT END""************************************************/
void init_func(void)
{
        port_init();                                            /* Initialize port */
}

/*""FUNC COMMENT""*****************************************************
 * Function name: port_init()
 *---------------------------------------------------------------------
 * Description  : Initialize port
 *---------------------------------------------------------------------
 * Argument     : -
 *---------------------------------------------------------------------
 * Returns      : -
 *---------------------------------------------------------------------
 * Notes        :
 *""FUNC COMMENT END""************************************************/
void port_init(void)
{
        PICNT = PIEN0;                                          /* Enable port input */

/*** LED output port ***/

        P11DATA = 0x00;                                         /* Output data (must be set
prior to mode) */
        P11DIR = 0xff;                                          /* P110-P117 : Output mode */
```

```
65          P11MOD = 0x00;                                      /* P110-P117 : Input/output
port */
66
67  /*** Switch input port ***/
68
69          P13DIR = 0x00;                                      /* P130-P137 : Input mode */
70          P13MOD = 0x00;                                      /* P130-P137 : Input/output
port */
71  }
72
73  /*""FUNC COMMENT""*****************************************************
74   * Function name: main()
75   *-----------------------------------------------------------------------
76   * Description  : A-D converts signals read in from PORT13 on AD0 channel
77   *              : and outputs conversion result (8 bits) to LED (PORT11)
78   *-----------------------------------------------------------------------
79   * Argument     : -
80   *-----------------------------------------------------------------------
81   * Returns      : -
82   *-----------------------------------------------------------------------
83   * Notes        : -
84   *""FUNC COMMENT END""*************************************************/
85  void main(void)
86  {
87          USHORT  ad_result;                                  /* AD conversion result */
88          UCHAR   channel;                                    /* Selected AD conversion
channel */
89
90          init_func();                                        /* Initialize microcomputer */
91
92          while(1) {
93                  channel = P13DATA;                          /* Read specified conversion
channel */
94                  ad_result = AD0exe( channel);               /* Execute AD conversion */
95
96                  P11DATA = (ad_result >> 2u);                /* Output conversion result */
97          }
98  }
```

4.4.2 ad.c

```
/*""FILE COMMENT""*****************************************************
 *      M32R C Programming              Rev. 1.11
 *              < Sample Program for 32176 >
 *              < AD converter >
 *
 *      Copyright (c) 2004 Renesas Technology Corporation
 *                         All Rights Reserved
 **********************************************************************/

/************************************************************************/
/*              Include file                                            */
/************************************************************************/

#include                "..\inc\sfr32176_pragma.h"

/************************************************************************/
/*              Function prototype declaration                          */
/************************************************************************/

        USHORT  AD0exe( UCHAR AD0ch );          /* Execute AD conversion */

/************************************************************************/
/*              Define macro                                            */
/************************************************************************/

                                        /* 0123 4567
*/
#define ADSIM0_ini      0x01            /* 0000 0001B
*/
                                        /* |||| |||+---- AD conversion start
*/
                                        /* |||| ||+----- No operation
*/
                                        /* |||| |+------ A-D conversion/comparate completed
bit */
                                        /* |||| +------- No DMA transfer request
*/
                                        /* |||+--------- Software trigger
*/
                                        /* ||+---------- hardware trigger select 0 bit
*/
                                        /* |+----------- don't care
*/
                                        /* +------------ hardware trigger select 1 bit
*/

                                        /* 0123 4567
*/
#define ADSIM1_ini      0x40            /* 0111 0000B
*/
                                        /* |||| ++++---- AD0 selected
*/
                                        /* |||+--------- Fast sample-and-hold
*/
                                        /* ||+---------- Enable sample-and-hold
*/
                                        /* |+----------- Double speed
*/
                                        /* +------------ AD conversion mode
*/

#define ADDASEL_ini     0xffu           /* Precharge before conversion
*/

/*""FUNC COMMENT""*****************************************************
 * Function name: AD0exe()
 *----------------------------------------------------------------------
 * Description  : AD conversion using AD0
 *              : - Executes AD conversion on the channel specified with
 *              :   the argument and returns the conversion result
 *----------------------------------------------------------------------
 * Argument     : unsigned char AD0ch   AD0 converter channel number on which to convert
 *----------------------------------------------------------------------
 * Returns      : 10-bit AD conversion result
 *----------------------------------------------------------------------
```

```
58    * Notes         : - Only the 4 low-order bits of the channel number are used
59    *               : - More than 1 cycle of wait time (dummy wait cycles) is
60    *               :   required when starting AD conversion and reading out
61    *               :   the AD conversion-finished bit
62    *               : - Wait until AD conversion finishes
63    *""FUNC COMMENT END""***************************************************/
64   USHORT  AD0exe( UCHAR AD0ch)
65   {
66           ULONG   j;
67           USHORT  *AdDtPtr;
68
69           AD0ch &= 0x0fu;                          /* Use only the 4 low-order bits of channel
number */
70
71           AdDtPtr = (USHORT *)&AD0DT0;             /* Start address of AD0 conversion result
register */
72
73           AD0DDACR |= AD0DDAEN;                    /* Enable A-D disconnection detection assist
function */
74           AD0DDASEL = ADDASEL_ini;                 /* Precharge before conversion */
75
76           AD0SIM1 = ADSIM1_ini;
77           AD0SIM1 |= AD0ch;
78
79           AD0SIM0 = ADSIM0_ini;                    /* Start AD conversion */
80
81           for( j = 0ul; j < 1ul; j++){             /* Dummy wait cycle until reading out the AD
conversion-finished bit */
82                   ;
83           }
84           while( AD0SCMP != ( AD0SIM0 & AD0SCMP)){/* Wait until AD conversion finishes */
85                   ;
86           }
87
88           return( AdDtPtr[AD0ch]);                 /* Read out conversion result */
89   }
```

5. Reference Documents

- 32176 Group User's Manual (Rev.1.01)
- M32R Family Software Manual (Rev.1.20)
- M3T-CC32R V.4.30 User's Manual (Compiler)
- M3T-CC32R V.4.30 User's Manual (Assembler)

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- Renesas Technology Corp. website.

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Rev.	Date	Description	
		Page	Summary
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