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April 1st, 2010
Renesas Electronics Corporation

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M16C/Tiny Series

Operation of A/D Converter (One-Shot Mode, External Trigger)

1. Abstract

In one-shot mode of A/D converter, choose functions from those listed in Table 1. Operations of the checked items are described below.

Table 1. Choosed Functions

Item	Set-up		Item	Set-up	
Operating Clock ϕ_{AD}	Yes	fAD, divided-by-2 of fAD, divided-by-3 of fAD, divided-by-4 of fAD, divided-by-6 of fAD, divided-by-12 of fAD	A/D Conversion Start Condition		Software trigger
				Yes	$\overline{AD_{TRG}}$ trigger
Resolution		8-bit	Sample and hold function		Without sample and hold
	Yes	10-bit		Yes	With sample and hold
Analog Input Pins	Yes	Select one pin from AN_0 to AN_7 (Note 1)			

Note 1: Conditions for the M16C/26

For the M16C/26A, the 48-pin version permits one of AN_0–AN_7, AN_{30}–AN_{32}, and AN_{24} to be selected, and the 42-pin version permits one of AN_0–AN_7 and AN_{30}–AN_{31} to be selected.

For the M16C/28, the 80-pin version permits one of AN_0–AN_7, AN_{00}–AN_{07}, and AN_{20}–AN_{27} to be selected, and the 64-pin version permits one of AN_0–AN_7, AN_{00}–AN_{03}, and AN_{24} to be selected.

For the M16C/29, the 80-pin version permits one of AN_0–AN_7, AN_{00}–AN_{07}, AN_{20}–AN_{27}, and AN_{30}–AN_{32} to be selected, and the 64-pin version permits one of AN_0–AN_7, AN_{00}–AN_{03}, AN_{24}, and AN_{30}–AN_{32} to be selected.

2. Introduction

The explanation of this issue is applied to the following condition:
Applicable MCU: M16C/26, M16C/26A, M16C/28, M16C/29 Group

This program can be used for the other M16C Families which have the same SFR (Special Function Register) as the one in the M16C/26, M16C/26A, M16C/28, M16C/29 However, since some functions may be modified such as added functions, check it in a manual. Execute sufficient evaluation when using this application note.

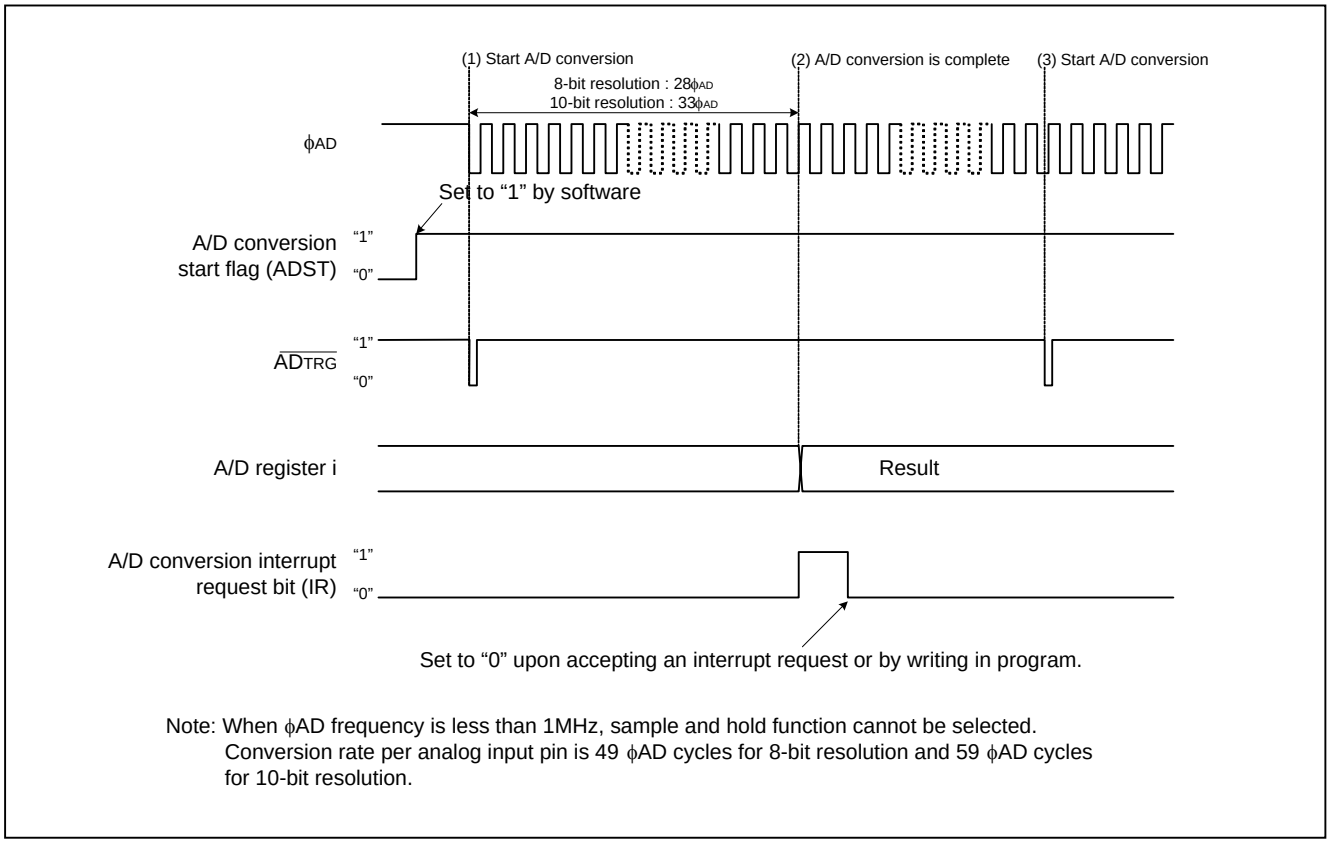
3. Operation of A/D Converter

(1) If the level of the $\overline{\text{ADTRG}}$ changes from "H" to "L" with the A-D conversion start flag set to "1", the A/D converter begins operating.

(2) After A/D conversion is completed, the content of the successive comparison register (conversion result) is transmitted to A/D register i. At this time, the A/D conversion interrupt request bit goes to "1". Also the A/D converter stops operating.

(3) If the level of the $\overline{\text{ADTRG}}$ pin changes from "H" to "L", the A/D converter carries out conversion from step (1) again. If the level of the $\overline{\text{ADTRG}}$ pin changes from "H" to "L" while conversion is in progress, the A/D converter stops the A/D conversion in process, and carries out conversion from step (1) again.

Figure 1 shows the operation timing



Note: When ϕAD frequency is less than 1MHz, sample and hold function cannot be selected.
Conversion rate per analog input pin is 49 ϕAD cycles for 8-bit resolution and 59 ϕAD cycles for 10-bit resolution.

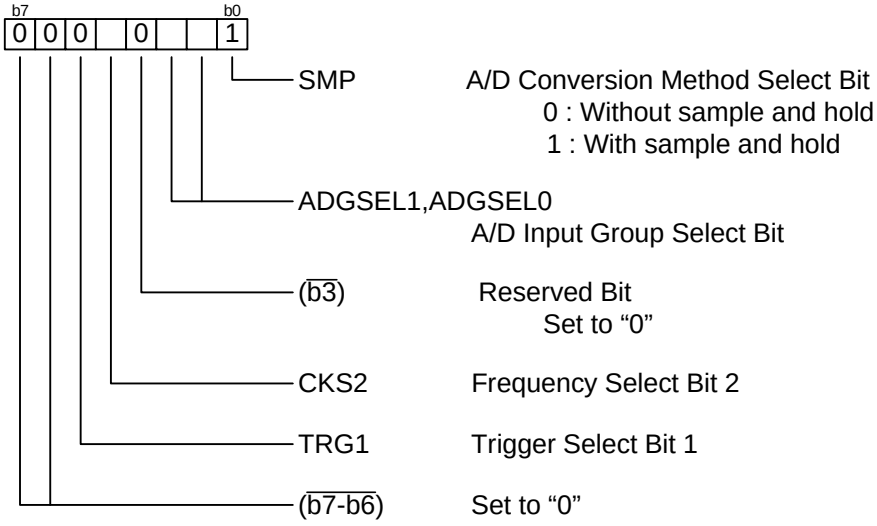
Figure 1. Operation Timing of One-Shot Mode, External Trigger is selected

3.1 Register Setting

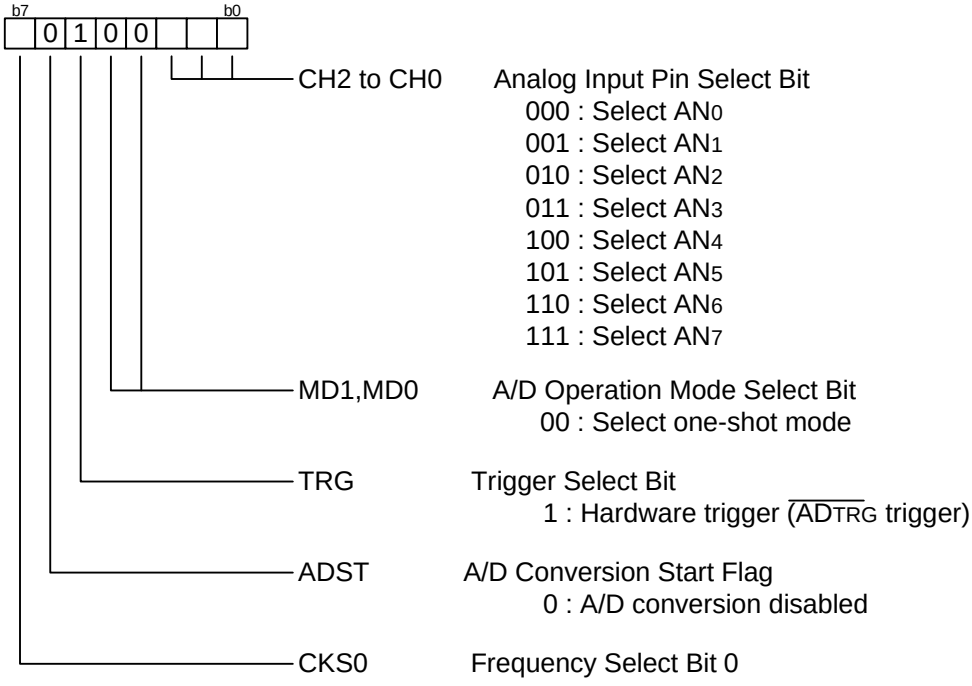
To enable the operation defined in “Section 3. Operation of A/D Converter”, the following register settings must be taken place step by step. For detail configuration of each register, please refer to M16C/26 Group hardware manual, M16C/26A Group hardware manual, M16C/28 Group hardware manual, M16C/29 Group hardware manual.

3.1.1 M16C/26A, M16C/28, M16C/29

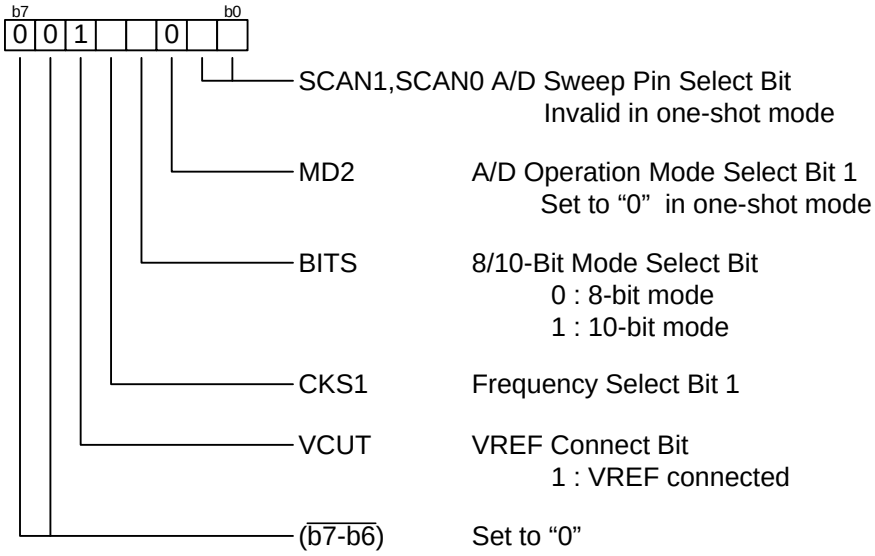
(1) Setting A/D control register 2



(2) Setting A/D control register 0



(3) Setting A/D control register 1

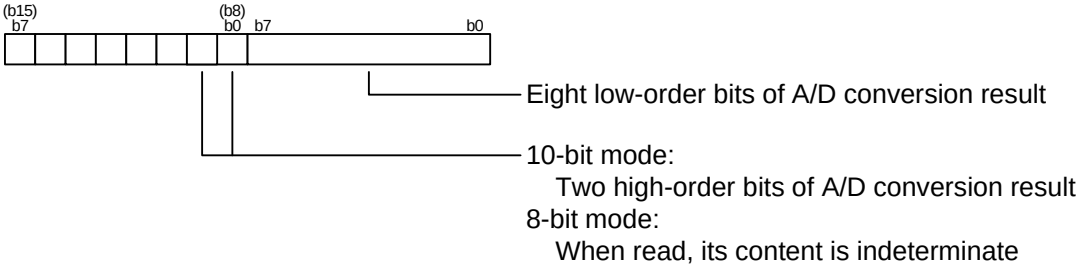


(4) A/D conversion start (setting A/D control register 0)

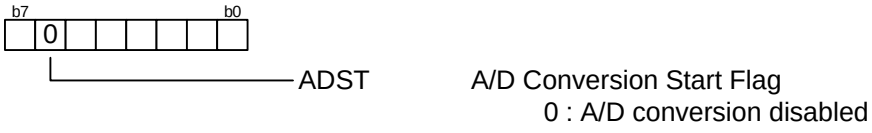
(5) A/D conversion starts when ADTRG changes state from high to low.

Wait until the A/D converter stops.

(6) Reading conversion result (read ADi register)

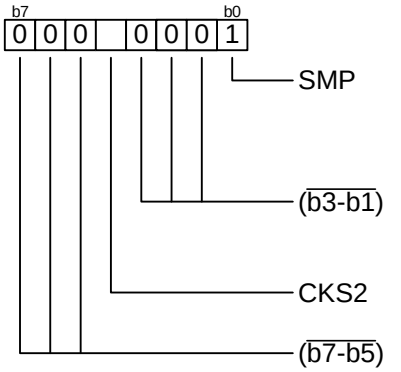


(7) A/D conversion disable (setting A/D control register 0)



3.1.2 M16C/26

(1) Setting A/D control register 2



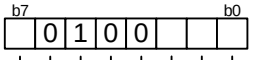
SMP — A/D Conversion Method Select Bit
0 : Without sample and hold
1 : With sample and hold

($\overline{b3}$-$\overline{b1}$) — Reserved Bit
Set to “0”

CKS2 — Frequency Select Bit 2

($\overline{b7}$-$\overline{b5}$) — Set to “0”

(2) Setting A/D control register 0



CH2 to CH0 — Analog Input Pin Select Bit
000 : Select AN0
001 : Select AN1
010 : Select AN2
011 : Select AN3
100 : Select AN4
101 : Select AN5
110 : Select AN6
111 : Select AN7

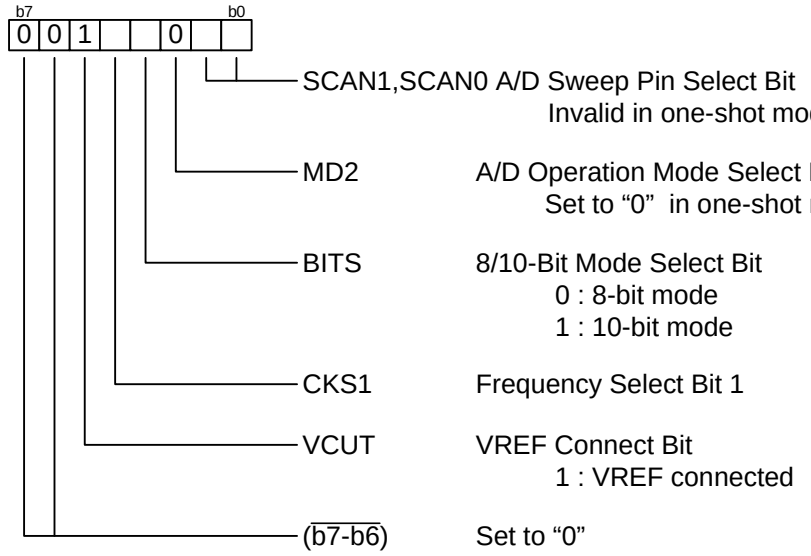
MD1,MD0 — A/D Operation Mode Select Bit
00 : Select one-shot mode

TRG — Trigger Select Bit
1 : Hardware trigger ($\overline{\text{ADTRG}}$ trigger)

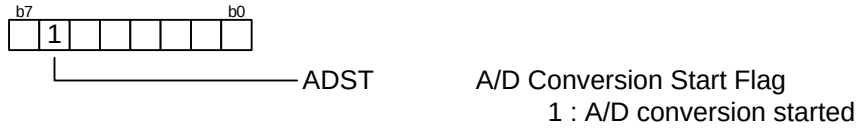
ADST — A/D Conversion Start Flag
0 : A/D conversion disabled

CKS0 — Frequency Select Bit 0

(3) Setting A/D control register 1



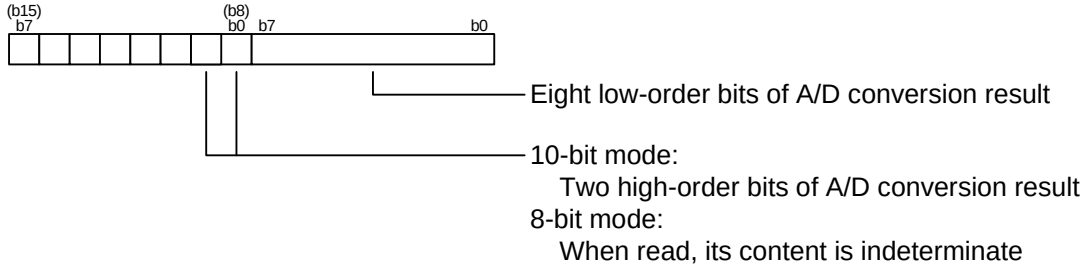
(4) A/D conversion start (setting A/D control register 0)



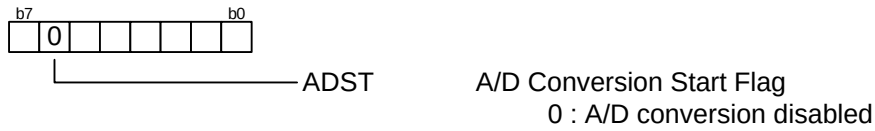
(5) A/D conversion starts when ADTRG changes state from high to low.

Wait until the A/D converter stops.

(6) Reading conversion result (read ADi register)



(7) A/D conversion disable (setting A/D control register 0)



4. Sample Program

4.1 M16C/26A, M16C/28, M16C/29

```
/************************************************************
 *                                                          *
 *   FILE NAME :                                            *
 *   CPU       : M16C/Tiny series                           *
 *   Function  : Operation of A/D Converter                 *
 *               (one-shot mode, an external trigger)       *
 *   Version   : 1.00                                       *
 *                                                          *
 *   Copyright (C)2004, Renesas Technology Corp.            *
 *   Copyright (C)2004, Renesas Solutions Corp.             *
 *                                                          *
 ************************************************************/
/***************************
 *   include file          *
 ***************************/
#include "sfr28.h"

/***************************
 *   Function Definition   *
 ***************************/

/***************************
 *   main                  *
 ***************************/
    unsigned short  ad_data;

void main(void) {

    adic = 0;

    adcon2 = 0x01;   /*  Setting A/D control register 2
                         Enabled sample and hold
                         Port 10 group selected
                         Frequency is selected to fAD/4
                     */

    adcon0 = 0x20;   /*  Setting A/D control register 0
                         AN0 is selected
                         One-shot mode is selected
                         Hardware trigger (ADtrg trigger) is selected
                     */

    adcon1 = 0x28;   /*  Setting A/D control register 1
                         10-bit mode is selected
                         Vref is connected
                     */

    adst = 1;        /*   A/D convert start */

    while (1) {

        while (!ir_adic) {       /* Check & wait until complete of A/D convert */
        }
        ir_adic = 0;

        ad_data = 0x03ff & ad0;  /* Read conversion result */

    }
}
```

4.2 M16C/26

```
/************************************************************
 *                                                          *
 *   FILE NAME :                                            *
 *   CPU       : M16C/Tiny series                           *
 *   Function  : Operation of A/D Converter                 *
 *               (one-shot mode, an external trigger)       *
 *   Version   : 1.00                                       *
 *                                                          *
 *   Copyright (C)2004, Renesas Technology Corp.            *
 *   Copyright (C)2004, Renesas Solutions Corp.             *
 *                                                          *
 ************************************************************/
/***************************
 *   include file          *
 ***************************/
#include "sfr262.h"

/***************************
 *   Function Definition   *
 ***************************/

/***************************
 *   main                  *
 ***************************/
    unsigned short  ad_data;

void main(void) {

    adic = 0;

    adcon2 = 0x01;   /*  Setting A/D control register 2
                         Enabled sample and hold
                         Frequency is selected to fAD/4
                     */

    adcon0 = 0x20;   /*  Setting A/D control register 0
                         AN0 is selected
                         One-shot mode is selected
                         ADtrg trigger is selected
                     */

    adcon1 = 0x28;   /*  Setting A/D control register 1
                         10-bit mode is selected
                         Vref is connected
                     */

    adst = 1;        /*  A/D convert start */

    while (1) {

        while (!ir_adic) {       /* Check & wait until complete of A/D convert */
        }
        ir_adic = 0;

        ad_data = 0x03ff & ad0;  /* Read conversion result */

    }
}
```

5. Reference

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Hardware Manual

M16C/26, M16C/26A, M16C/28, M16C/29 Group Hardware Manual
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TECHNICAL UPDATE/TECHNICAL NEWS

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