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# M16C/62

## Using the M16C/62 Analog to Digital Converter in Repeat Mode

### 1.0 Abstract

The following article outlines the steps necessary to set up, perform, and read multiple conversions on a single channel using the onboard analog to digital converter (ADC) of the M16C. The ADC is useful in measuring output voltages of sensors such as accelerometers or other analog instrumentation and converting them to digital values.

### 2.0 Introduction

The M16C line of devices features an onboard analog to digital converter (ADC). The ADC consists of one 10-bit successive approximation circuit with a capacitive coupled amplifier. There are eight analog input pins, selectable conversion clock speeds, sample and hold function, and several conversion modes. Figure 1 is an overview of the internal circuitry for the ADC block.

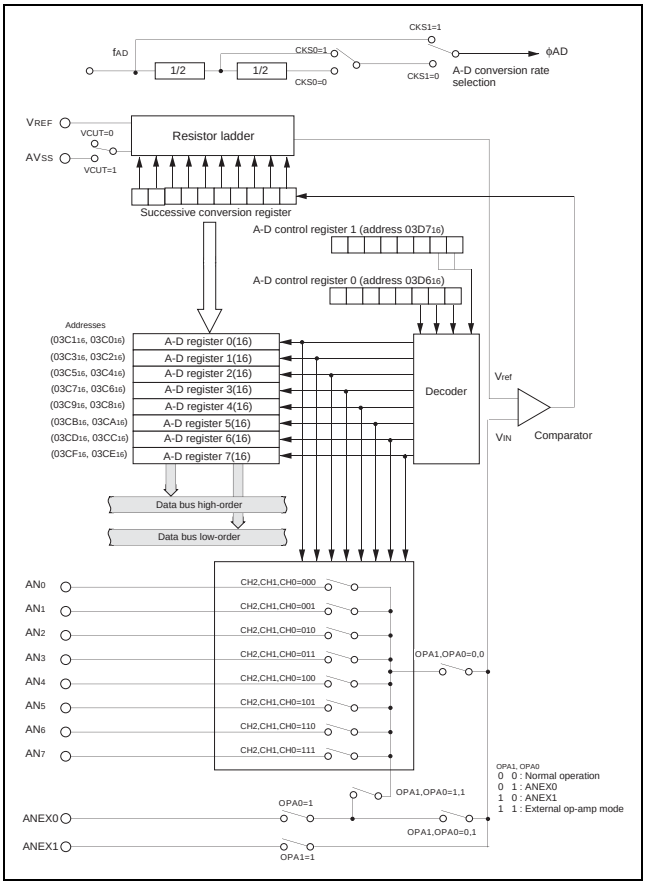


**Figure 1 Internal Circuitry for ADC Block—Overview**

## 3.0 Repeat Mode Description

In repeat mode, one pin of the ADC is selected as the input source. Once triggered, a conversion takes place on the selected pin and the result is stored in the ADC result register corresponding to the selected channel. This is repeated until the ADC conversion start flag is disabled. No interrupt is generated on the completed conversion, but rather the ADC output register can be read anytime to determine the converted value. Figure 2 and Figure 3 are overviews of the registers that will be used in this example. These registers are detailed in the included sample code. For specific details, consult the MCU specification for the device in question.

A-D control register 0 (Note 1)

b7 b6 b5 b4 b3 b2 b1 b0

Symbol: ADCON0 | Address: 03D6$_{16}$ | When reset: 00000XXX$_2$

| Bit symbol | Bit name | F unction | R | W |
|---|---|---|---|---|
| CH0 | Analog input pin select bit | b2 b1 b0<br>0 0 0 : AN$_0$ is selected<br>0 0 1 : AN$_1$ is selected<br>0 1 0 : AN$_2$ is selected<br>0 1 1 : AN$_3$ is selected<br>1 0 0 : AN$_4$ is selected<br>1 0 1 : AN$_5$ is selected<br>1 1 0 : AN$_6$ is selected<br>1 1 1 : AN$_7$ is selected (Note 2) | ○ | ○ |
| CH1 | | | ○ | ○ |
| CH2 | | | ○ | ○ |
| MD0 | A-D operation mode select bit 0 | b4 b3<br>0 0 : One-shot mode<br>0 1 : Repeat mode<br>1 0 : Single sweep mode<br>1 1 : Repeat sweep mode 0<br>Repeat sweep mode 1 (Note 2) | ○ | ○ |
| MD1 | | | ○ | ○ |
| TRG | Trigger select bit | 0 : Software trigger<br>1 : ADTRG trigger | ○ | ○ |
| ADST | A-D conversion start flag | 0 : A-D conversion disabled<br>1 : A-D conversion started | ○ | ○ |
| CKS0 | Frequency select bit 0 | 0 : f$_{AD}$/4 is selected<br>1 : f$_{AD}$/2 is selected | ○ | ○ |

Note 1: If the A-D control register is rewritten during A-D conversion, the conversion result is indeterminate.
Note 2: When changing A-D operation mode, set analog input pin again.

A-D control register 1 (Note)

b7 b6 b5 b4 b3 b2 b1 b0

Symbol: ADCON1 | Address: 03D7$_{16}$ | When reset: 00$_{16}$

| Bit symbol | Bit name | Function | R | W |
|---|---|---|---|---|
| SCAN0 | A-D sweep pin select bit | When single sweep and repeat sweep mode 0 are selected<br>b1 b0<br>0 0 : AN$_0$, AN$_1$ (2 pins)<br>0 1 : AN$_0$ to AN$_3$ (4 pins)<br>1 0 : AN$_0$ to AN$_5$ (6 pins)<br>1 1 : AN$_0$ to AN$_7$ (8 pins) | ○ | ○ |
| SCAN1 | | When repeat sweep mode 1 is selected<br>b1 b0<br>0 0 : AN$_0$ (1 pin)<br>0 1 : AN$_0$, AN$_1$ (2 pins)<br>1 0 : AN$_0$ to AN$_2$ (3 pins)<br>1 1 : AN$_0$ to AN$_3$ (4 pins) | ○ | ○ |
| MD2 | A-D operation mode select bit 1 | 0 : Any mode other than repeat sweep mode 1<br>1 : Repeat sweep mode 1 | ○ | ○ |
| BITS | 8/10-bit mode select bit | 0 : 8-bit mode<br>1 : 10-bit mode | ○ | ○ |
| CKS1 | Frequency select bit 1 | 0 : f$_{AD}$/2 or f$_{AD}$/4 is selected<br>1 : f$_{AD}$ is selected | ○ | ○ |
| VCUT | Vref connect bit | 0 : Vref not connected<br>1 : Vref connected | ○ | ○ |
| OPA0 | External op-amp connection mode bit | b7 b6<br>0 0 : ANEX0 and ANEX1 are not used<br>0 1 : ANEX0 input is A-D converted<br>1 0 : ANEX1 input is A-D converted<br>1 1 : External op-amp connection mode | ○ | ○ |
| OPA1 | | | ○ | ○ |

Note: If the A-D control register is rewritten during A-D conversion, the conversion result is indeterminate.

**Figure 2 A-D Converter Related Registers**

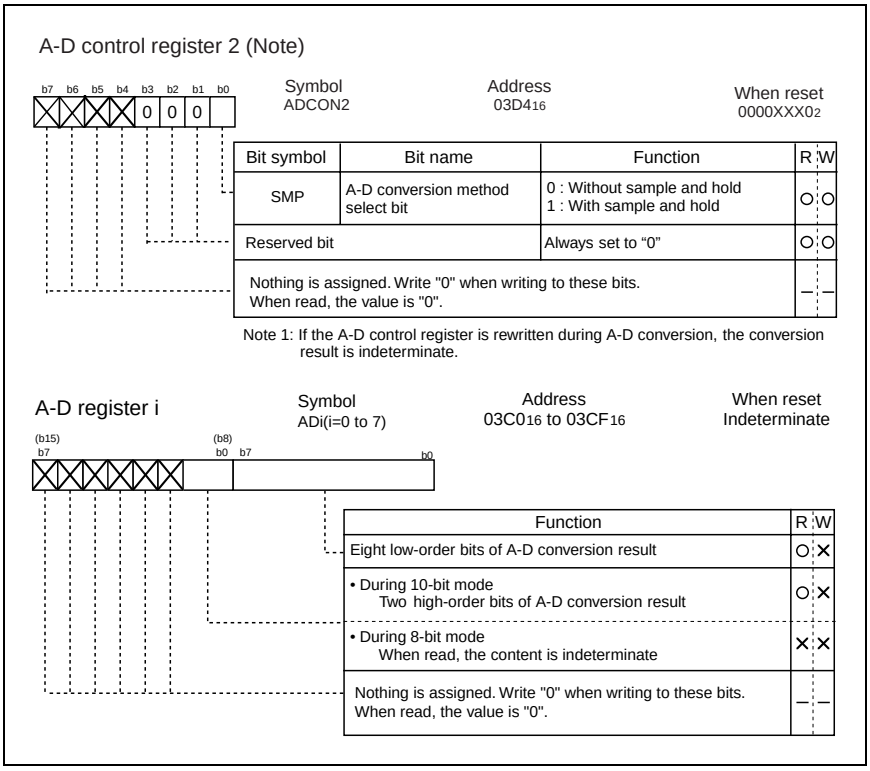


**Figure 3 A-D Converter Related Register**

## 4.0 Example Program

This example program demonstrates how to perform a conversion using the ADC in the following environment:

### Environment Setup

- Repeat mode conversion
- 10-bit mode
- Analog input 0 used
- Sample and hold enabled
- Vref connected
- Conversion clock used will be fAD/2 (if f(Xin) is greater than 10 MHz, fAD must be divided )
- Software conversion start

### ADC Software Setup

- Set the ADCON0 register for AN0 input, fAD/2 and repeat mode operation (0x08)
- Set the ADCON1 register for 10-bit mode, fAD divided, and connect Vref (0x38)
- Set the ADCON2 register for sample and hold (0x01)
- Enable the A/D converter by setting the ADST bit to 1
- Read current A/D value in variable ‘TempStore’

## 5.0 Reference

**Renesas Technology Corporation Semiconductor Home Page**

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**E-mail Support**

support_apl@renesas.com

**Data Sheets**

- M16C/62 datasheets, 62aeds.pdf

**User's Manual**

- M16C/62 User's Manual, 62eum.pdf
- M16C/60 and M16C/20 C Language Programming Manual, 6020EC.pdf
- Application Note: Writing Interrupt Handlers in C for the M16C
- NC30 Ver. 4.0 User's Manual, NC30UE.pdf

## 6.0 Software Code

The sample software provided was written using the NC30 compiler. The program starts the conversion process on reset.

```
/***********************************************************************
 *
 *    DESCRIPTION: repeat_mode.c
 *
 *    AUTHOR: Renesas Technology Corporation (June 2003)
 *
 *
 *    PURPOSE: Outlines how to use the M16C/62 ADC in repeat
 *             mode. On reset, program repeatedly stores the result
 *             of the conversion in a variable that can be examined
 *             using KD30 and the MSV1632-62 Starter Kit or similar tool.
 *
 ***********************************************************************/

#include "sfr62.h"

unsigned int TempStore = 0x0000;          // Location where ADC result is stored

/*
 ** main
 *
 *  PARAMETERS: None
 *
```

```
 *  DESCRIPTION: Main function. Where program execution starts. Sets
 *                           up the ADC then begins conversions.
 *
 *  RETURNS: Nothing
 *
 */

 void main (void){

       adcon0 = 0x88;       /*10001000;  /* AN0 input, repeat mode, software
 trigger,fAD/2
                              ||||||||______analog input select bit 0
                              |||||||_______analog input select bit 1
                              ||||||________analog input select bit 2
                              |||||_________A/D operation mode select bit 0
                              ||||__________A/D operation mode select bit 1
                              |||___________trigger select bit
                              ||____________A/D conversion start flag
                              |_____________frequency select bit (divide by 2) */

       adcon1 = 0x28;       /*00101000 10 bit mode, fAD2, Vref connected
                              ||||||||______A/D sweep pin select bit 0
                              |||||||_______A/D sweep pin select bit 1
                              ||||||________A/D operation mode select bit 1
                              |||||_________8/10 bit mode select bit
                              ||||__________frequency select bit 1
                              |||___________Vref connect bit
                              ||____________external op-amp connection bit 0
                              |_____________external op-amp connection bit 1 */

       adcon2 = 0x01;       /*00000001    Sample and hold enabled
                             ||||||||______sample and hold select bit
                             |||||||_______reserved
                             ||||||________reserved
                             |||||_________reserved
                             ||||__________reserved
                             |||___________reserved
                             ||____________reserved
                             |_____________reserved */

    adst = 1;                        // Start a conversion here

    while (1){
       TempStore = ad0 & 0x03ff;   // Mask off the upper 6 bits of the
                                          // variable leaving only the result
                                          // in the variable itself
           }
}
```

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