M16C/26

Using the A-D Converter In Single Sweep Mode

1.0 Abstract

The following document outlines the steps necessary to setup, perform and read a single sweep conversion 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 Renesas M30262 is a 16-bit MCU based on the M16C/60 series CPU core. The MCU features up to 64K bytes of Flash ROM, 2K bytes of RAM and 4K bytes of Virtual EEPROM. The peripheral set includes UARTS, Timers, DMA, and GPIO. The M16C/26 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. Table 1 shows the performance of the ADC and Figure 1 shows a diagram of the ADC block.

Table 1 ADC Performance

Item	Performance
Method of A-D Conversion	Successive approximation (capacitive coupling amplifier)
Analog input voltage	0V to AVcc (Vcc)
Operating clock f_{AD}	f_{AD}, $f_{AD}2$, $f_{AD}3$, $f_{AD}4$, $f_{AD}6$, or $f_{AD}6$ or $f_{AD}12$ where f_{AD}=f(Xin)
Resolution	8-bit or 10-bit (selectable)
Operating modes	One-shot mode, repeat, single sweep mode, repeat mode, repeat sweep mode 0 and repeat sweep mode 1.
Analog input pins	8 pins AN_0 to AN_7
A-D conversion start condition	Software trigger: A-D conversion starts when the A-D conversion start flag changes to “1” External trigger (can be retriggered): A-D conversion starts when the A-D conversion start flag is “1” and the AD_{TRG}/P15 input (shared with INT3) changes from “H” to “L”
Conversion speed per pin	Without sample and hold function 8-bit resolution: 49 f_{AD} cycles, 10-bit resolution: 59 f_{AD} cycles. With sample and hold function 8-bit resolution: 28 f_{AD} cycles, 10-bit resolution:33 f_{AD} cycles.

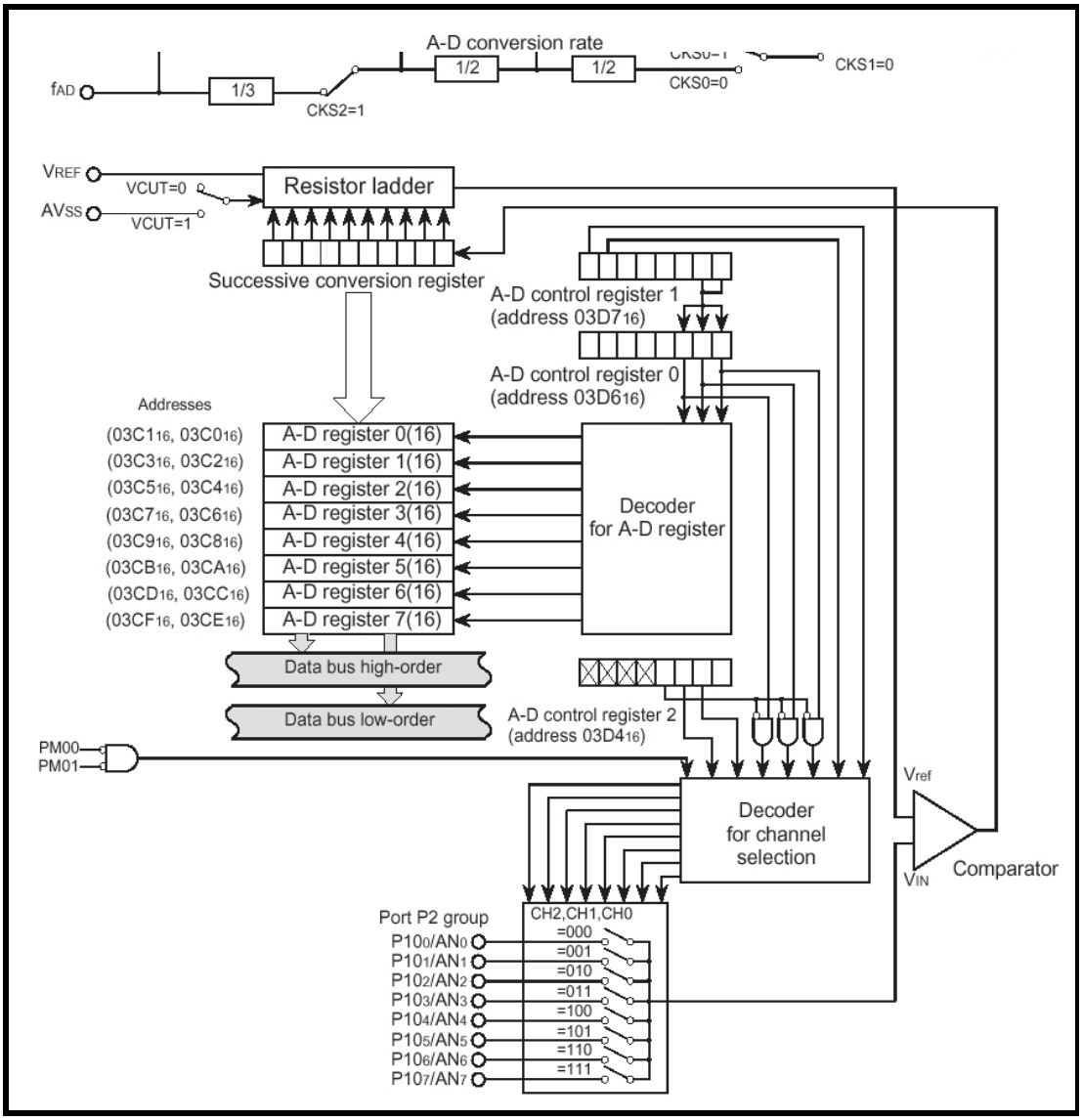
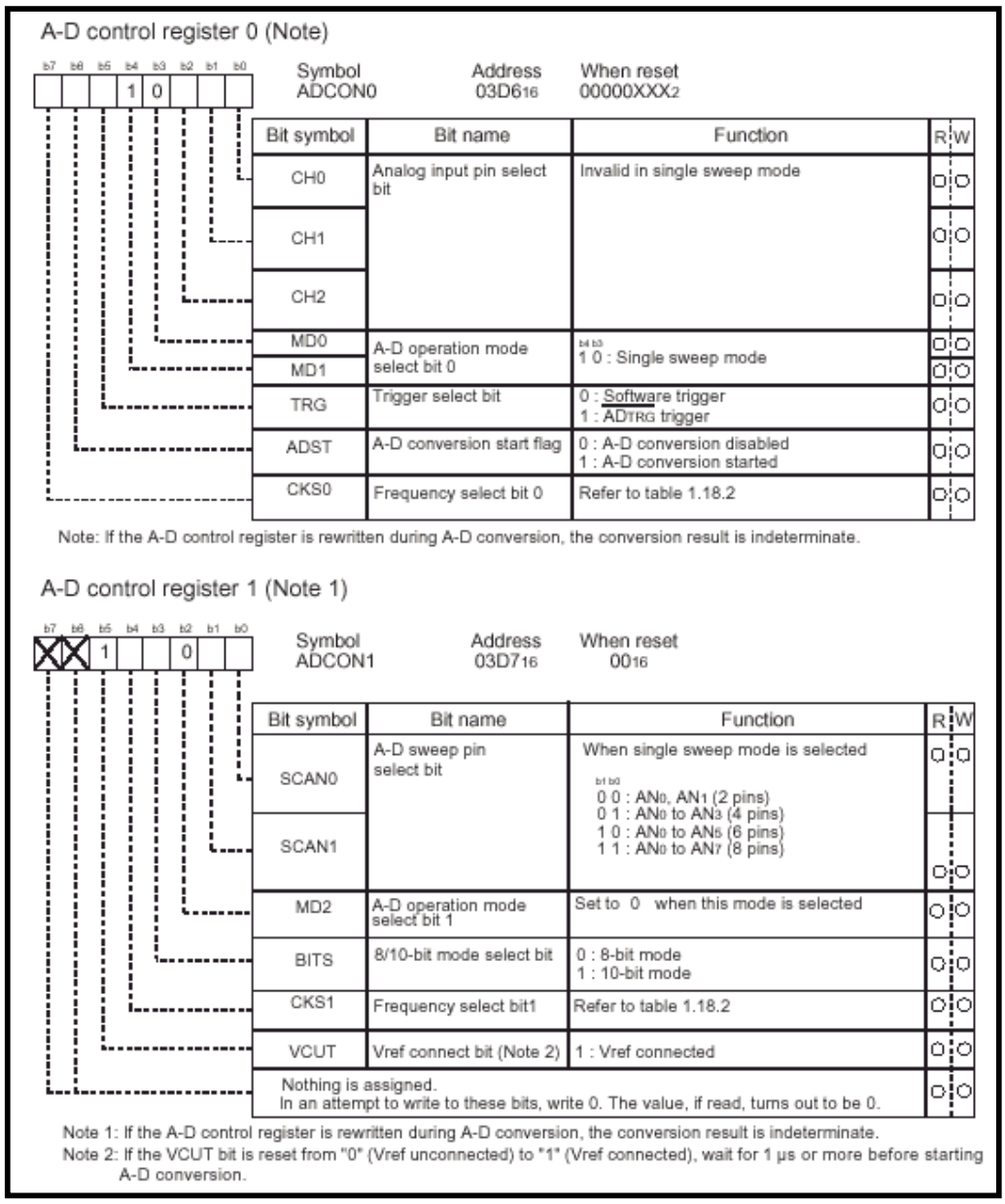


Figure 1 ADC Block Diagram

3.0 Single Sweep Mode Description

In single sweep mode, multiple pins of the ADC can be selected as the input source. Once triggered, a single conversion takes place on the selected pins and the results are stored in the ADC result registers corresponding to the selected channels. An interrupt is generated signifying the completion of the conversions. An overview of the registers that will be used in this example is shown below. These registers are detailed in the included sample code. For specific details, consult the MCU datasheet. Figure 2 and Figure 3 show the control registers for the ADC in Single Sweep Mode.



A-D control register 0 (Note)

b7	b6	b5	b4	b3	b2	b1	b0
			1	0			

Symbol ADCON0 — Address 03D6₁₆ — When reset 00000XXX₂

Bit symbol	Bit name	Function	R	W
CH0	Analog input pin select bit	Invalid in single sweep mode	○	○
CH1			○	○
CH2			○	○
MD0	A-D operation mode select bit 0	b4 b3 1 0 : Single sweep mode	○	○
MD1			○	○
TRG	Trigger select bit	0 : Software trigger 1 : ADTRG trigger	○	○
ADST	A-D conversion start flag	0 : A-D conversion disabled 1 : A-D conversion started	○	○
CKS0	Frequency select bit 0	Refer to table 1.18.2	○	○

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

A-D control register 1 (Note 1)

b7	b6	b5	b4	b3	b2	b1	b0
X	X	1			0		

Symbol ADCON1 — Address 03D7₁₆ — When reset 00₁₆

Bit symbol	Bit name	Function	R	W
SCAN0	A-D sweep pin select bit	When single sweep mode is selected b1 b0 0 0 : AN0, AN1 (2 pins) 0 1 : AN0 to AN3 (4 pins) 1 0 : AN0 to AN5 (6 pins) 1 1 : AN0 to AN7 (8 pins)	○	○
SCAN1			○	○
MD2	A-D operation mode select bit 1	Set to 0 when this mode is selected	○	○
BITS	8/10-bit mode select bit	0 : 8-bit mode 1 : 10-bit mode	○	○
CKS1	Frequency select bit1	Refer to table 1.18.2	○	○
VCUT	Vref connect bit (Note 2)	1 : Vref connected	○	○
Nothing is assigned. In an attempt to write to these bits, write 0. The value, if read, turns out to be 0.			○	○

Note 1: If the A-D control register is rewritten during A-D conversion, the conversion result is indeterminate.
Note 2: If the VCUT bit is reset from "0" (Vref unconnected) to "1" (Vref connected), wait for 1 µs or more before starting A-D conversion.

Figure 2 ADC Control Registers in Single Sweep Mode

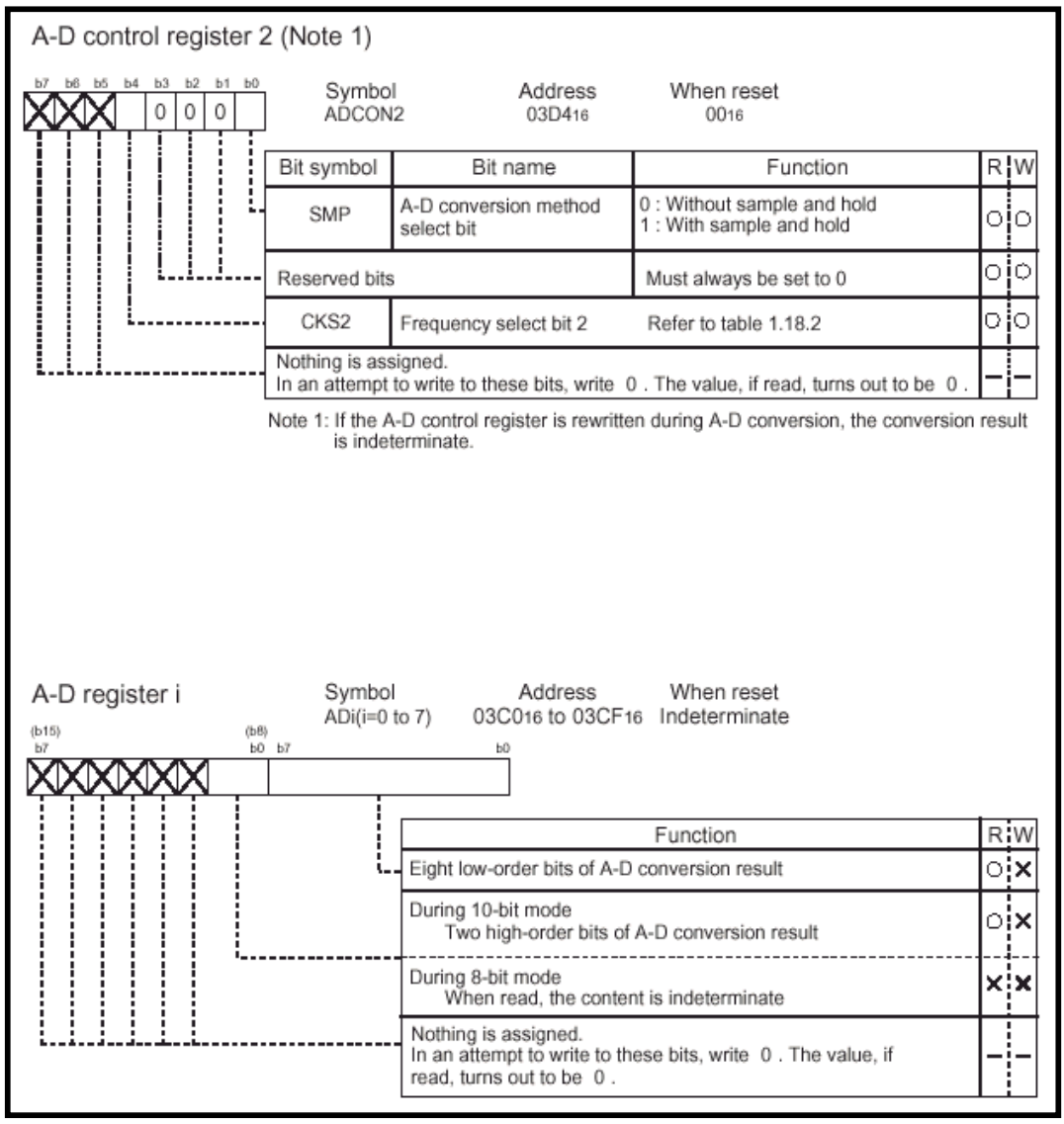


Figure 3 ADC Control Registers

4.0 Example Program

The following example program demonstrates how to perform a conversion using the ADC with the following configuration.

- Single sweep conversion
- 10 bit mode
- Analog inputs 0-3 used
- Sample and hold enabled
- Internal Vref
- Conversion clock used will be $f_{AD}/4$ (When f(Xin) is greater than 10 MHz, f_{AD} must be divided)
- Software conversion start

5.0 Reference

Renesas Technology Corporation Semiconductor Home Page

http://www.renesas.com

E-mail Support

support_apl@renesas.com

Data Sheets

- M16C/26 datasheets, M30262eds.pdf

User's Manual

- M16C/20/60 C Language Programming Manual, 6020c.pdf
- M16C/20/60 Software Manual, 6020software.pdf
- Writing interrupt handlers in C for the M16C Application Note
- MSV30262-SKP or MSV-Mini26-SKP Quick start guide
- MSV30262-SKP or MSV-Mini26-SKP Users Manual
- MDECE30262 or MSV-Mini26-SKP Schematic

6.0 Software Code

The sample software provided was written in C and compiled using the KNC30 compiler. The program performs one conversion on reset. This code could be modified to use a timer for the trigger of the ADC to provide multiple conversions at specific intervals. The example program was written to run on the MSV30262 Starter Kit but could be modified to a user application.

```
/*****************************************************************
* DESCRIPTION: single_sweep.c                                    *
*
* PURPOSE: Outlines how to use the M16C/26 ADC in single sweep *
* mode. On reset, program stores the results of the conversions*
* in variables that can be examined using KD30 or similar tool.*
*****************************************************************/
#include "sfr26.h"
int TempStore0 = 0x0000; // Location where ADC0 result is stored
int TempStore1 = 0x0000; // Location where ADC1 result is stored

int TempStore2 = 0x0000; // Location where ADC2 result is stored
int TempStore3 = 0x0000; // Location where ADC3 result is stored

#pragma INTERRUPT ADCInt // compiler directive telling where
                         // the ADC interrupt is located
 void ADCInt(void);
/*
 ** main
 *  PARAMETERS: None
 * DESCRIPTION: Main function. Where program execution starts.
 * Sets up the ADC then waits for interrupt to occur.
 *  RETURNS: Nothing
 */
void main (void){
```

```
        adcon0 = 0X10;
                  /*
                  00010000;  /* AN0, single sweep mode, software trigger, fAD/4
                  ||||||||______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 0
                  |||___________Trigger select bit
                  ||____________A/D conversion start flag
                  |_____________Frequency select bit 0 */

        adcon1 = 0X39;
                  /*
                  00111001;  /* 10 bit mode, fAD/1, Vref connected, AN0-3
                  ||||||||______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
                  ||____________Reserved
                  |_____________Reserved */

adcon2 = 0X01;
                  /*
                  00000001;  /* Sample and hold enabled, fAD/4
                  ||||||||______Sample and hold select bit
                  |||||||_______Reserved
                  ||||||________Reserved
                  |||||_________Reserved
                  ||||__________Frequency select bit 2
                  |||___________Reserved
                  ||____________Reserved
                  |_____________Reserved */


adic = 0X01;
                  /*
                  00000001;  /* Enable the ADC interrupt
                  ||||||||______interrupt priority select bit 0
                  |||||||_______interrupt priority select bit 1
                  ||||||________interrupt priority select bit 2
                  |||||_________interrupt request bit
                  ||||__________reserved
                  |||___________reserved
                  ||____________reserved
                  |_____________reserved */

    _asm ("   fset i") ;    // globally enable interrupts
    adst = 1;               // Start a conversion here
    while (1){}             // Program waits here forever
}
```

```
/*
 ** ADCInt
 *  PARAMETERS: None
 *  DESCRIPTION: Interrupt routine of the ADC. Here the converted value is
 *                 loaded into a variable and masked off to show the result.
 *  RETURNS: Nothing
 */
void ADCInt(void){

       TempStore0= ad0 & 0x03ff;   // Mask off the upper 6 bits of the
                                   // variable leaving only the result
                                   // in the variable itself

       TempStore1= ad1 & 0x03ff;   // Mask off the upper 6 bits of the
                                   // variable leaving only the result
                                   // in the variable itself

       TempStore2= ad2 & 0x03ff;   // Mask off the upper 6 bits of the
                                   // variable leaving only the result
                                   // in the variable itself

       TempStore3= ad3 & 0x03ff;   // Mask off the upper 6 bits of the
                                   // variable leaving only the result
                                   // in the variable itself
}
```

In order for this program to run properly, ADC interrupt vector needs to point to the interrupt function, ADCInt. The ADC interrupt vector in “sect30.inc” must be modified as shown below.

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;       File Name:  sect30.inc
;       Content:    Section include file for MSV30262-SKP.
;       Copyright 2003 Renesas Technology America, Inc.
;       All rights reserved
;===========================================================================
;       $Log:$
;===========================================================================
                        :
                        :
       .lword dummy_int     ; DMA1(for user)(vector 12)
       .lword dummy_int     ; Key input interrupt(for user)(vect 14)
       .glb   _ADCInt
       .lword _ADCInt       ; A-D(for user)(vector 14)
       .lword dummy_int     ; uart2 transmit(for user)(vector 15)
       .lword dummy_int     ; uart2 receive(for user)(vector 16)

                        :
                        :
```

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