M16C/26

Using the A-D 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 on-chip analog to digital converter (ADC) of the M16C/26. 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 include 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 on-chip 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 shows the internal circuitry of the ADC block and Table 1 shows the performance of the ADC.

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.

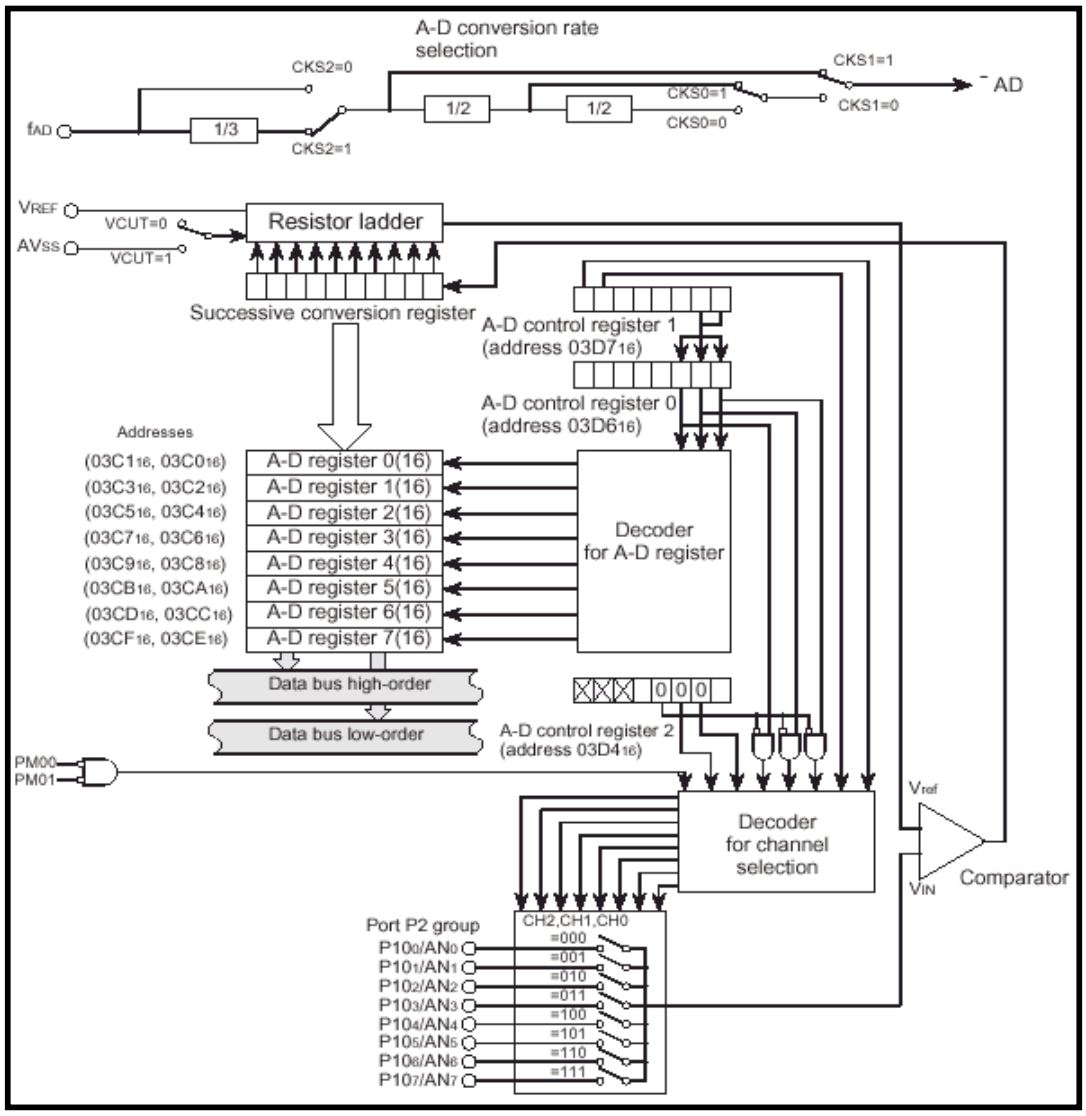
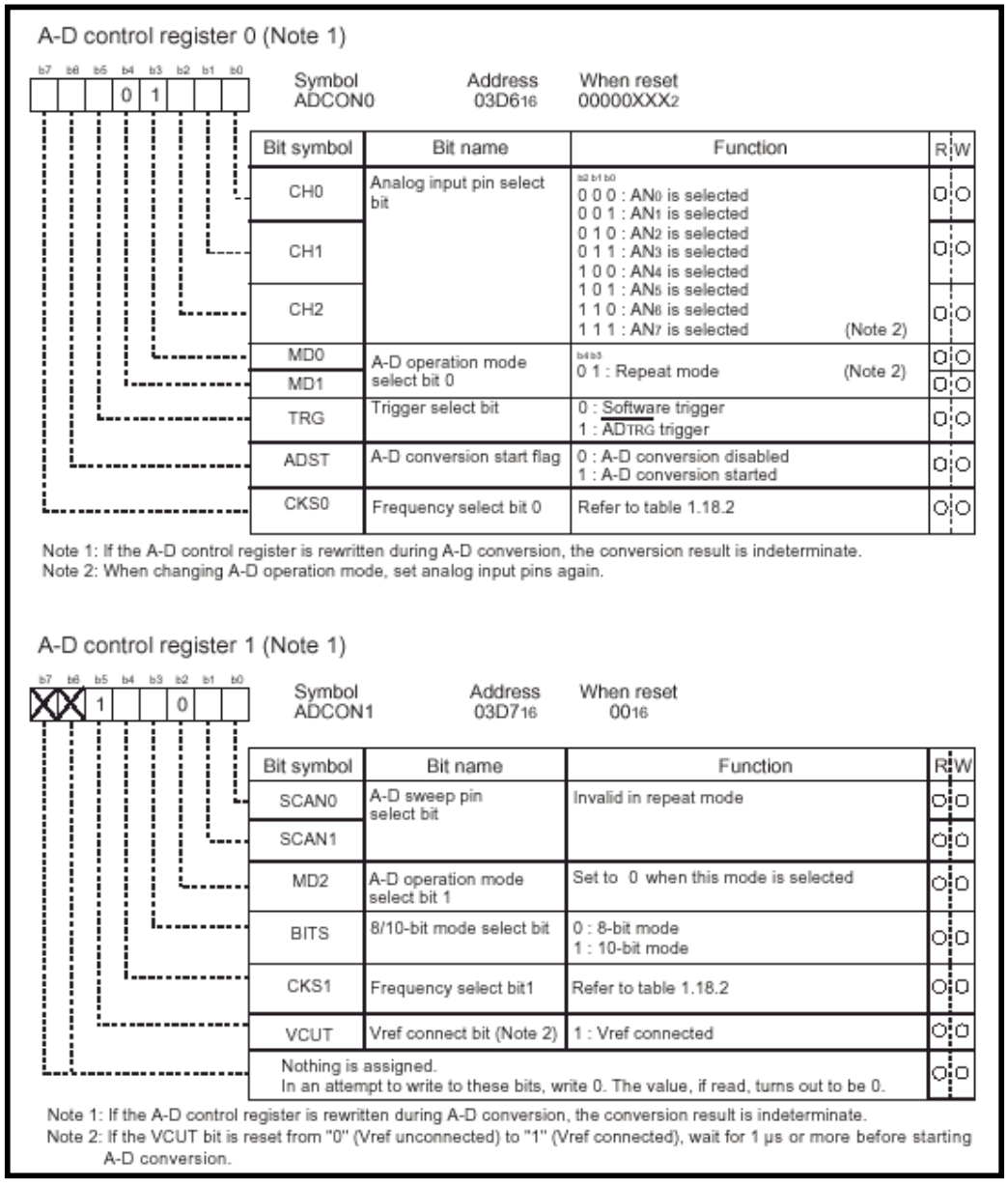


Figure 1 ADC Block Diagram

3.0 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. Below is an overview 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 datasheet. Figure 2 and Figure 3 show the control registers for the ADC setup in the Repeat Mode.



A-D control register 0 (Note 1)

b7	b6	b5	b4	b3	b2	b1	b0
			0	1			

Symbol: ADCON0 — Address: 03D6₁₆ — When reset: 00000XXX₂

Bit symbol	Bit name	Function	R	W
CH0	Analog input pin select bit	b2 b1 b0 0 0 0 : AN0 is selected 0 0 1 : AN1 is selected 0 1 0 : AN2 is selected 0 1 1 : AN3 is selected 1 0 0 : AN4 is selected 1 0 1 : AN5 is selected 1 1 0 : AN6 is selected 1 1 1 : AN7 is selected (Note 2)	○	○
CH1			○	○
CH2			○	○
MD0	A-D operation mode select bit 0	b4 b3 0 1 : Repeat mode (Note 2)	○	○
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 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 pins again.

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	Invalid in repeat mode	○	○
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 Repeat Mode

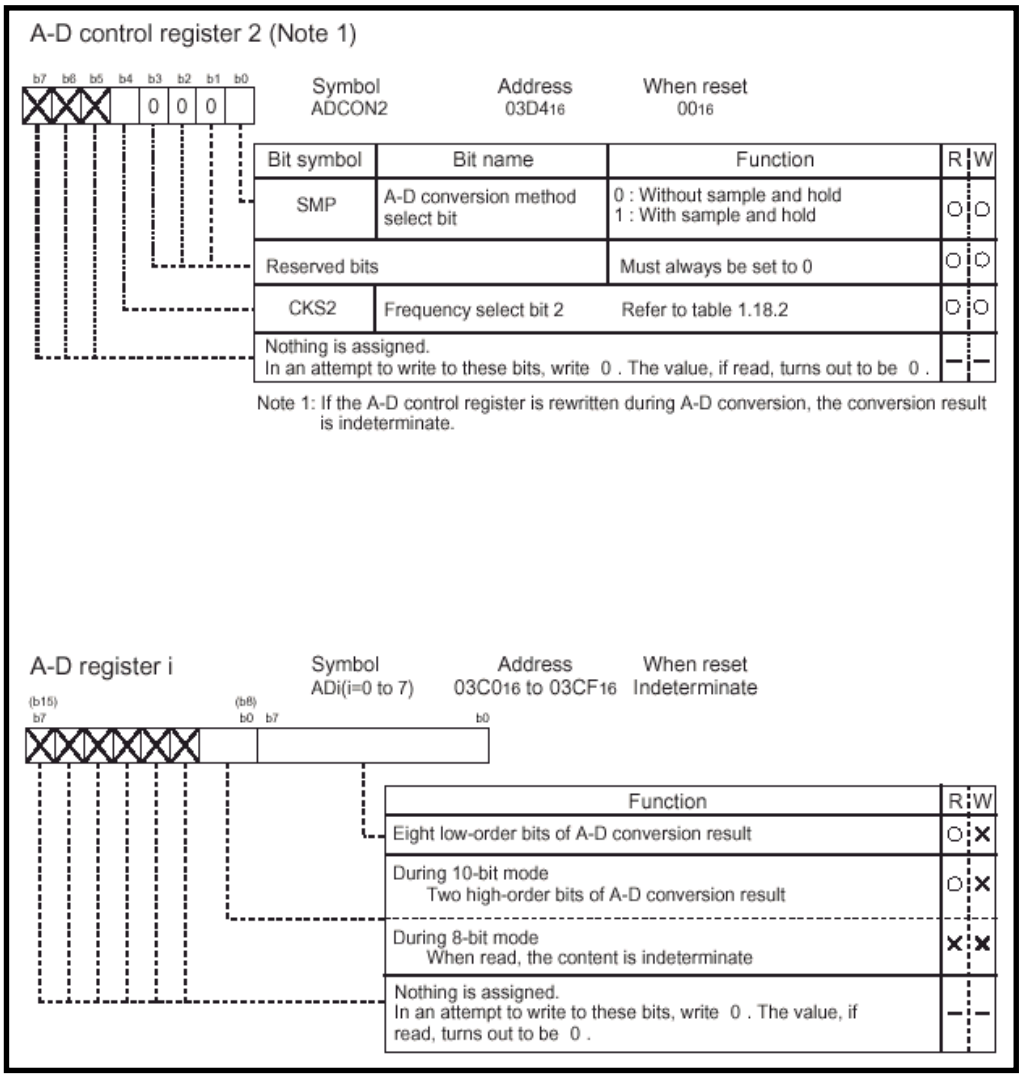


Figure 3 ADC Control Register

4.0 Example Program

The following example program demonstrates how to perform a conversion using the ADC with the following environment:

- Repeat mode conversion
- 10-bit mode
- Analog input 0 used
- Sample and hold enabled
- Vref connected
- 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
- 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 compiled using the KNC30 compiler. The program starts the conversion process on reset. This code was written to run on the MSV30262 Starter Kit and can be modified for a user application.

```
/***********************************************************************
*    DESCRIPTION: repeat_mode.c                                        *
*                                                                      *
*    PURPOSE: Outlines how to use the M16C/26 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 MSV30262-Starter Kit or similar tool. *
*                                                                      *
***********************************************************************/

#include "sfr26.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 = 0x08;

                      /*              AD control register 1
                       00001000;  /* AN0, repeat 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 = 0x28;

                      /*              AD control register 1
                       00101000;  /* 10 bit mode, fAD/4, 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 connected
                       ||____________Reserved
                       |_____________Reserved    */



       adcon2 = 0x01;

                      /*            AD control register 2
                      00000001;    /* Sample and hold enabled, fAD/4
                      ||||||||______Sample and hold select bit
                      |||||||_______Reserved
                      ||||||________Reserved
                      |||||_________Reserved
                      ||||__________Frequency select bit 2
                      |||___________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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