

To our customers,

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April 1<sup>st</sup>, 2010  
Renesas Electronics Corporation

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## M16C/26

### Using the A-D Converter in Single Shot Mode

#### 1.0 Abstract

The following document outlines the steps necessary to setup, perform and read a single conversion using the onboard 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 10-bit A/D, 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 $f_{AD}$	$f_{AD}$ , $f_{AD2}$ , $f_{AD3}$ , $f_{AD4}$ , $f_{AD6}$ , or $f_{AD12}$ 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 <sub>0</sub> to AN <sub>7</sub>
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 <sub>TRG</sub> /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.

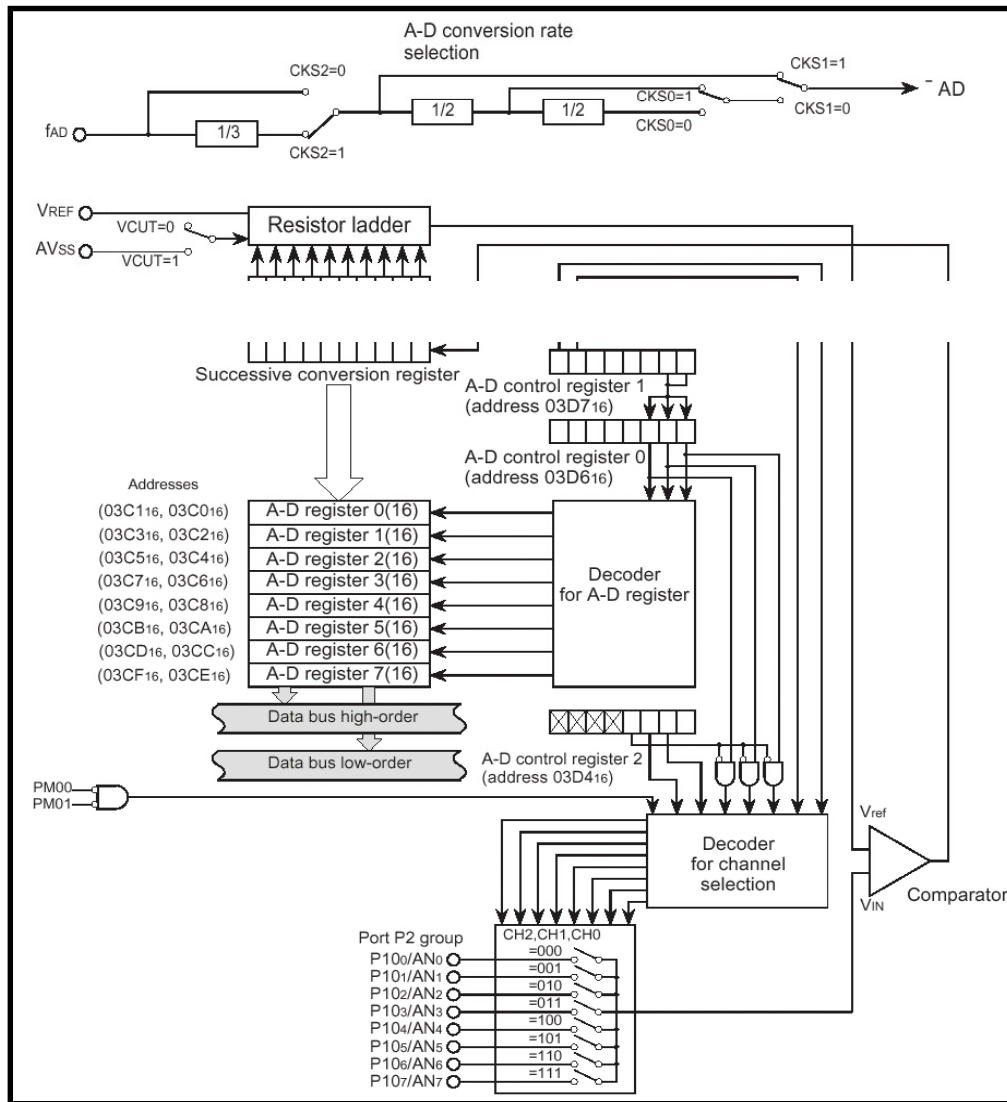


Figure 1 ADC Block Diagram

### 3.0 One-Shot Mode Description

In one shot-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. An interrupt signifies the completion of a conversion. 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 specification for the device in question. Figure 2 and Figure 3 show the control registers for the ADC in One-Shot Mode.

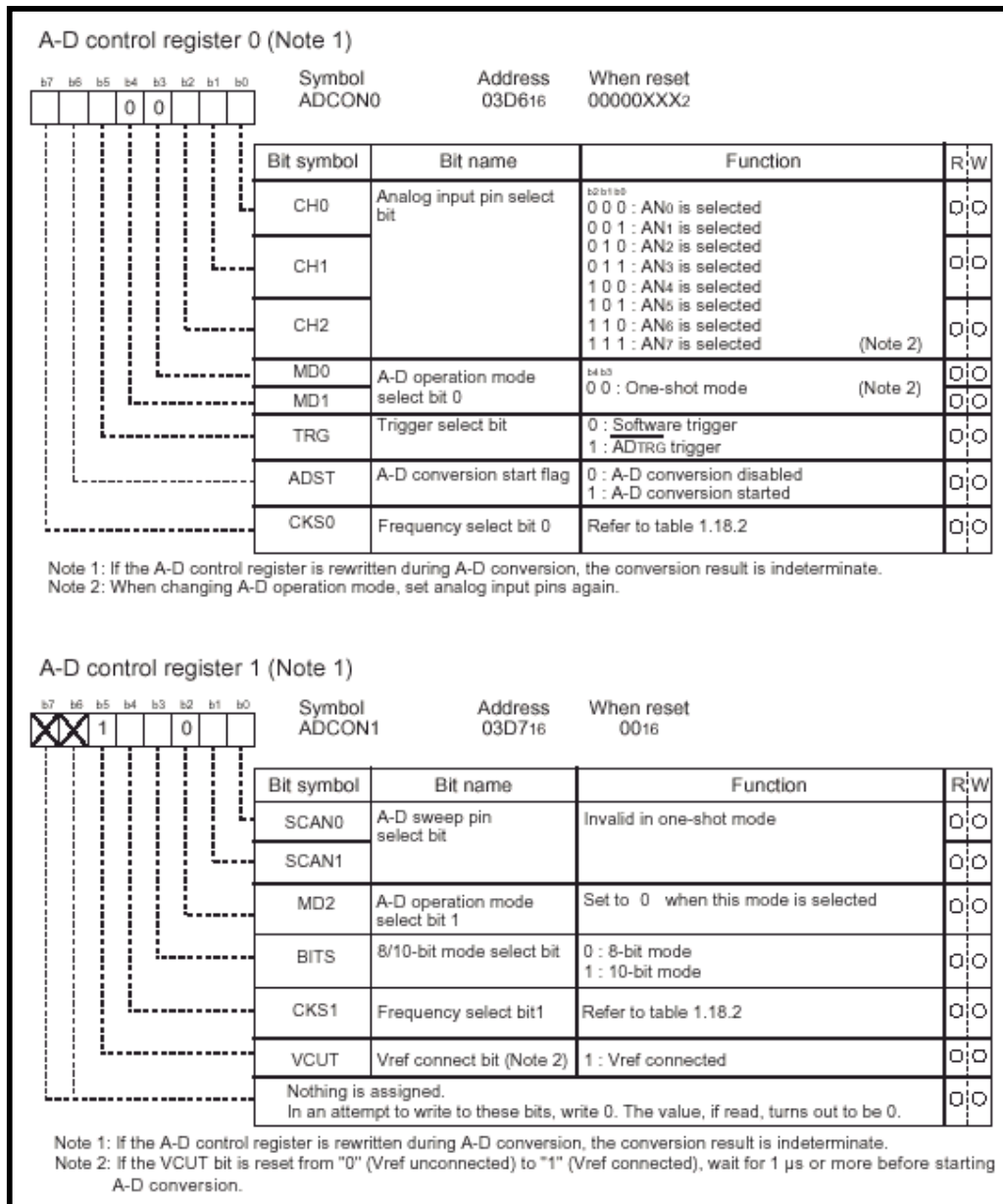


Figure 2 ADC Control Registers in One-Shot Mode

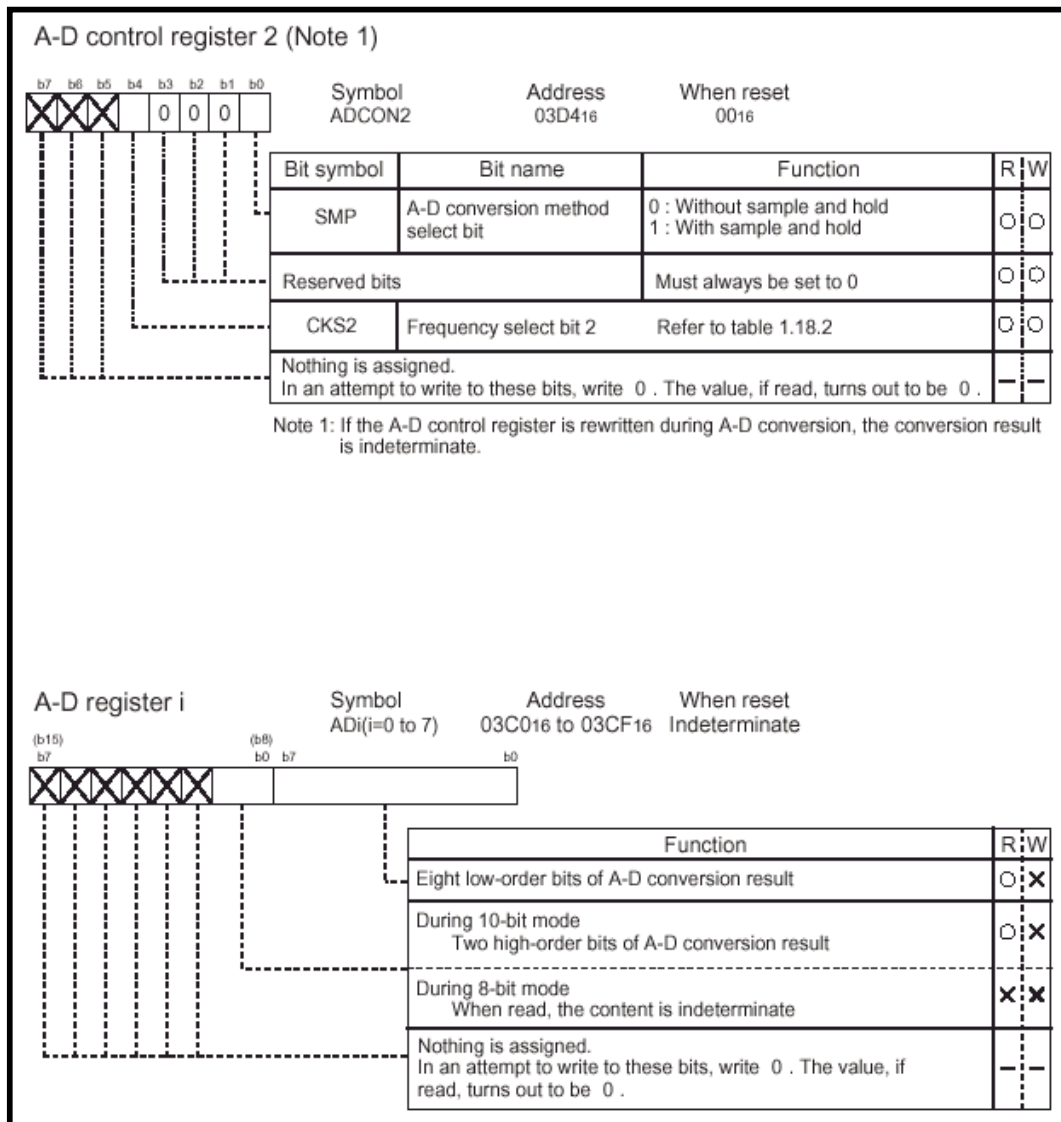


Figure 3 ADC Control Registers

#### **4.0 Example Program**

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

- Single shot conversion
- 10-bit mode
- Analog input 0 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](mailto: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 written in C and compiled using the KNC30 compiler. The program performs one conversion on reset. This code could be simply 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 implement in a user application.

```

/*****

*   DESCRIPTION: single_shot.c
*
*   PURPOSE: Outlines how to use the M16C/262 ADC in single shot mode.
*   On reset, program stores the result of the conversion in a variable that
*   can be examined using
*   KD30 or similar tool.
*****/
#include "sfr26.h"
int TempStore = 0x0000;           // Location where ADC 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 = 0;                   /*
    /* 00000000;                 /* AN0, 1 shot 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 1
        ||_____ Trigger select bit
        |_____ A/D conversion start flag
        |_____ Frequency select bit 0*/

    adcon1 = 0x38;
        /*
        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 connect bit
        |_____ Reserved
        |_____ Reserved */

```





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)
.glob  _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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