To our customers,

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: http://www.renesas.com

April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (http://www.renesas.com)

Send any inquiries to http://www.renesas.com/inquiry.

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: "Standard", "High Quality", and "Specific". The recommended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as "Specific" without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as "Specific" or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is "Standard" unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.

   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.

   "Specific": Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.
8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

M16C/62

Using the M16C/62 Analog to Digital Converter in Repeat Sweep Mode 1

1.0 Abstract

The following article outlines the steps necessary to set up, perform, and read multiple conversions on multiple channels 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.

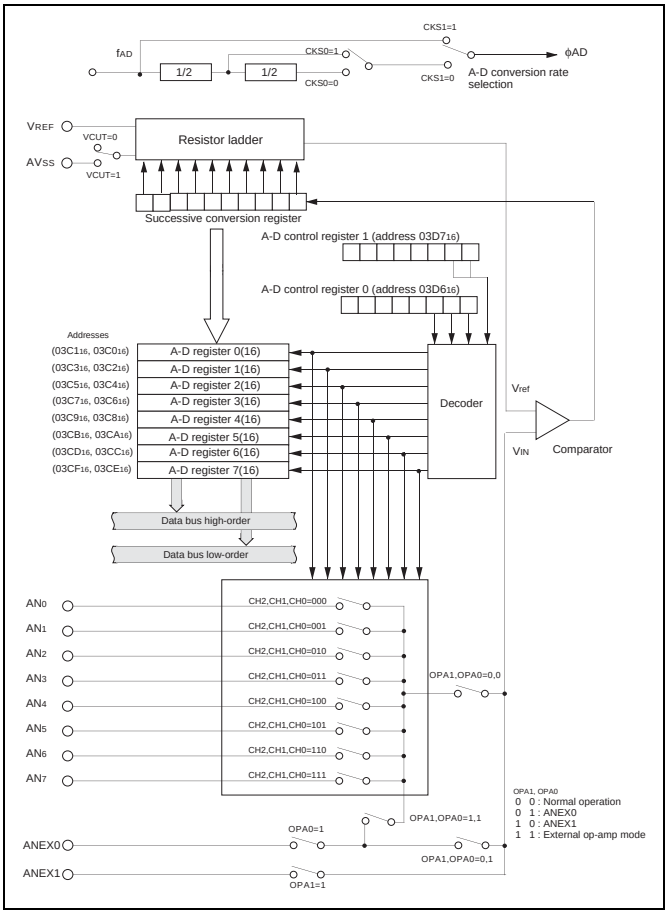

Figure 1 Internal Circuitry for ADC Block—Overview

3.0 Repeat Sweep Mode 1 Description

In repeat sweep mode 1, groups of pins of the ADC can be selected as input sources. Once triggered, a conversion takes place on the selected pins and the results are stored in the ADC result registers corresponding to the selected channels. This is repeated until the ADC conversion start flag is disabled. No interrupt is generated on the completed conversions, but rather the ADC output registers are read to determine the converted values. 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.

A-D control register 0 (Note 1)

b7 b6 b5 b4 b3 b2 b1 b0

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 0 : One-shot mode 0 1 : Repeat mode 1 0 : Single sweep mode 1 1 : Repeat sweep mode 0 Repeat sweep mode 1 (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	0 : fAD/4 is selected 1 : fAD/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: 03D7₁₆ | When reset: 00₁₆

Bit symbol	Bit name	Function	R	W
SCAN0	A-D sweep pin select bit	When single sweep and repeat sweep mode 0 are 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		When repeat sweep mode 1 is selected b1 b0 0 0 : AN0 (1 pin) 0 1 : AN0, AN1 (2 pins) 1 0 : AN0 to AN2 (3 pins) 1 1 : AN0 to AN3 (4 pins)	○	○
MD2	A-D operation mode select bit 1	0 : Any mode other than repeat sweep mode 1 1 : Repeat sweep mode 1	○	○
BITS	8/10-bit mode select bit	0 : 8-bit mode 1 : 10-bit mode	○	○
CKS1	Frequency select bit 1	0 : fAD/2 or fAD/4 is selected 1 : fAD is selected	○	○
VCUT	Vref connect bit	0 : Vref not connected 1 : Vref connected	○	○
OPA0	External op-amp connection mode bit	b7 b6 0 0 : ANEX0 and ANEX1 are not used 0 1 : ANEX0 input is A-D converted 1 0 : ANEX1 input is A-D converted 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

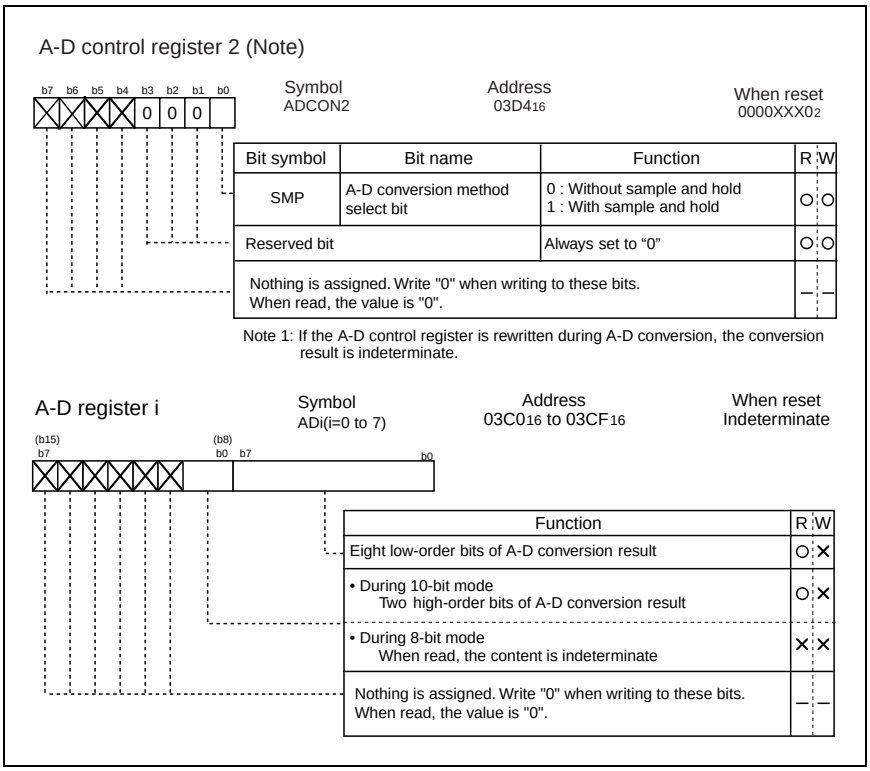

Figure 3 A-D Converter Related Register

4.0 Example Program

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

Environment Setup

- Repeat sweep mode 1 conversions
- 10-bit mode
- Analog inputs 0–1 used
- Sample and hold enabled
- Vref connected
- Conversion clock used will be f_{AD} /2 (when f(Xin) is greater than 10 MHz, f_{AD} must be divided)
- Software conversion start

ADC Software Setup

- Set the ADCON0 register for f_{AD} /2 and repeat sweep mode 1 operation (0x98)
- Set the ADCON1 register for 10-bit mode, f_{AD}divided, AN0-1 sweep, and connect Vref (0x2d)
- 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 channel values in the variables ‘TempStore(x)’

5.0 Reference

Renesas Technology Corporation Semiconductor Home Page

http://www.renesas.com

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
- 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_sweep_mode_1.c
 *
 *    AUTHOR: Renesas Technology Corporation, Inc. (June 2003)
 *
 *
 *    PURPOSE: Outlines how to use the M16C/62 ADC in repeat sweep
 *             mode 1. On reset, program repeatedly stores the results
 *             of the conversions in variables that can be examined
 *             using KD30 and the MSV1632-62 Starter Kit

 *
 *****************************************************************/

#include "sfr62.h"

int TempStore0 = 0x0000;          // Location where AN0 result is stored
int TempStore1 = 0x0000;          // Location where AN1 result is stored
```

```
/*
 ** main
 *
 *  PARAMETERS: None
 *
 *  DESCRIPTION: Main function. Where program execution starts. Sets
 *                           up the ADC then reads conversion results.
 *
 *  RETURNS: Nothing
 *
 */

void main (void){

       adcon0 = 0x98;  /*10011000   Repeat Sweep mode1, 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 */

       adcon1 = 0x2d; /*00101101 10 bit mode, fADdivided, Vref connected, AN0 & AN1
converted
                         |||||||______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){
       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

           }
}
```

Keep safety first in your circuit designs!

- Renesas Technology Corporation puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage.
  Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of nonflammable material or (iii) prevention against any malfunction or mishap.

Notes regarding these materials

- These materials are intended as a reference to assist our customers in the selection of the Renesas Technology Corporation product best suited to the customer's application; they do not convey any license under any intellectual property rights, or any other rights, belonging to Renesas Technology Corporation or a third party.
- Renesas Technology Corporation assumes no responsibility for any damage, or infringement of any third-party's rights, originating in the use of any product data, diagrams, charts, programs, algorithms, or circuit application examples contained in these materials.
- All information contained in these materials, including product data, diagrams, charts, programs and algorithms represents information on products at the time of publication of these materials, and are subject to change by Renesas Technology Corporation without notice due to product improvements or other reasons. It is therefore recommended that customers contact Renesas Technology Corporation or an authorized Renesas Technology Corporation product distributor for the latest product information before purchasing a product listed herein.
  The information described here may contain technical inaccuracies or typographical errors.
  Renesas Technology Corporation assumes no responsibility for any damage, liability, or other loss rising from these inaccuracies or errors.
  Please also pay attention to information published by Renesas Technology Corporation by various means, including the Renesas Technology Corporation Semiconductor home page (http://www.renesas.com).
- When using any or all of the information contained in these materials, including product data, diagrams, charts, programs, and algorithms, please be sure to evaluate all information as a total system before making a final decision on the applicability of the information and products. Renesas Technology Corporation assumes no responsibility for any damage, liability or other loss resulting from the information contained herein.
- Renesas Technology Corporation semiconductors are not designed or manufactured for use in a device or system that is used under circumstances in which human life is potentially at stake. Please contact Renesas Technology Corporation or an authorized Renesas Technology Corporation product distributor when considering the use of a product contained herein for any specific purposes, such as apparatus or systems for transportation, vehicular, medical, aerospace, nuclear, or undersea repeater use.
- The prior written approval of Renesas Technology Corporation is necessary to reprint or reproduce in whole or in part these materials.
- If these products or technologies are subject to the Japanese export control restrictions, they must be exported under a license from the Japanese government and cannot be imported into a country other than the approved destination.
  Any diversion or reexport contrary to the export control laws and regulations of Japan and/or the country of destination is prohibited.
- Please contact Renesas Technology Corporation for further details on these materials or the products contained therein.