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Renesas Electronics Corporation

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## M32C/84, 85, 86, 87, 88 Group

### A/D Converter Operation in One-Shot Mode and External Op-Amp Connection Mode

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#### 1. Abstract

In external operating amplifier (op-amp) connection mode, multiple analog inputs can be amplified by one external op-amp using extended analog input pins ANEX0 and ANEX1.

#### 2. Introduction

The application example described in this document is applied to the following MCUs and parameter(s):

MCUs: M32C/84 Group  
M32C/85 Group  
M32C/86 Group  
M32C/87 Group  
M32C/88 Group

This program can be used with other M16C Family MCUs which have the same special function registers (SFRs) as the above MCUs. Check the manual for any additions and modifications to functions. Careful evaluation is recommended before using this application note.

### 3. Application Example

This section describes how to amplify the input voltage of the AN<sub>i</sub> (i = 0 to 7) pin by an external op-amp and how to A/D convert in one-shot mode.

Other configurations are as follows:

- Operating clock ( $\phi$ AD) : fAD divided by 2
- Resolution : 10 bits
- A/D conversion start parameters : Software trigger
- Sample & hold function : Enabled
- DMAC operation mode : Disabled

#### 3.1 Example Description

- (1) Setting the ADST bit in the AD0CON0 register to 1 (A/D conversion started) causes the input voltage of the AN<sub>i</sub> pin to be output from the ANEX0 pin. A/D conversion takes place on the input voltage of the ANEX1 pin. (Connect an op-amp between the ANEX0 and ANEX1 pins).
- (2) After the A/D conversion is completed on the AN<sub>i</sub> pin, the content of the successive approximation register (conversion result) is transferred to the AD0<sub>i</sub> register (i = 0 to 7).  
At the same time, the IR bit in the AD0IC register is set to 1 (interrupt requested).  
Also, the ADST bit in the AD0CON0 register is set to 0 (A/D conversion stopped) and the A/D converter stops operating.

Figure 1 shows the Wiring and One-Shot Mode Operation When External Op-Amp Selected.

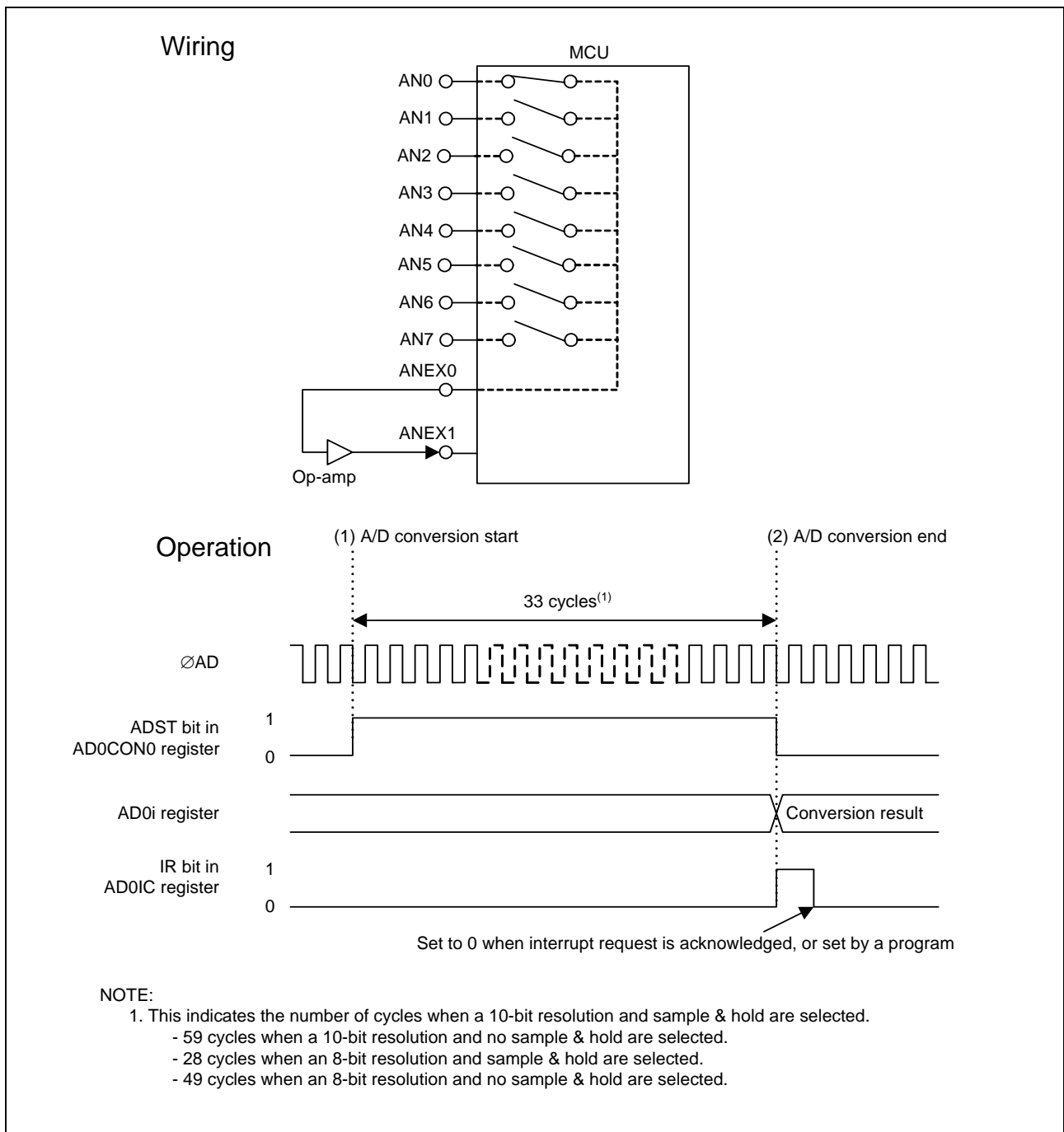


Figure 1 Wiring and One-Shot Mode Operation When External Op-Amp Selected

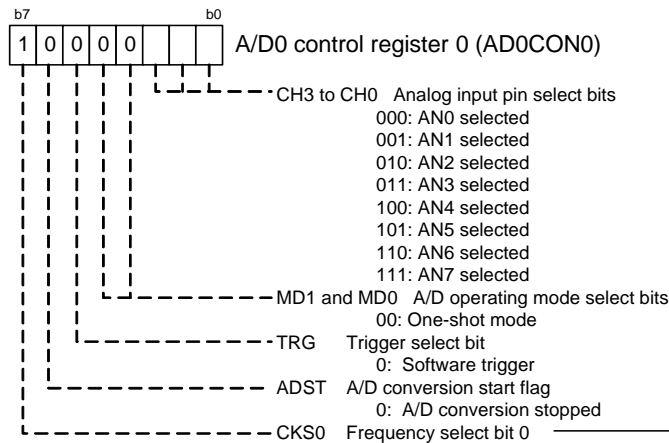
### 3.2 Setup

This section shows the setup sequence and values to perform the application example described in

#### 3.1 Example Description.

Refer to the MCUs Hardware Manual for details of individual registers.

(1) Set A/D0 control register 0

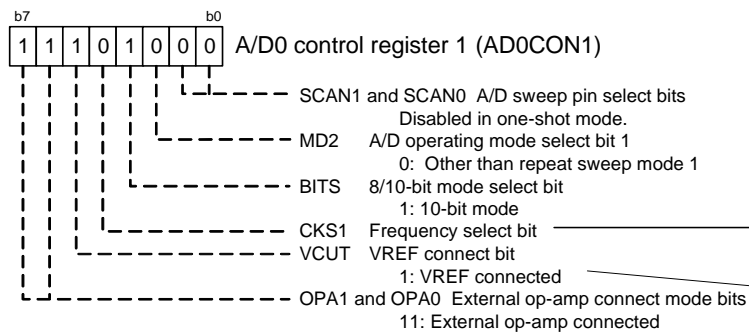


The A/D converter operating clock (∅AD) can be selected by:  
 the CKS0 bit in the AD0CON0 register,  
 the CKS1 bit in the AD0CON1 register,  
 or the CKS2 bit in the AD0CON3 register.

CKS2	CKS1	CKS0	∅AD
0	0	0	: fAD divided by 4
0	0	1	: fAD divided by 2
0	1	0	: fAD divided by 3
0	1	1	: fAD
1	0	0	: fAD divided by 8
1	1	0	: fAD divided by 6

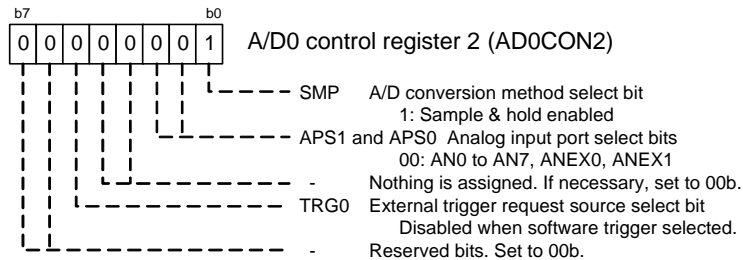
Make sure the settings are set as shown above.  
 When VCC1 = 4.2 V to 5.5 V,  
 set ∅AD frequency to 16 MHz or below.  
 When VCC1 = 3.0 V to 5.5 V,  
 set ∅AD frequency to 10 MHz or below.

(2) Set A/D0 control register 1

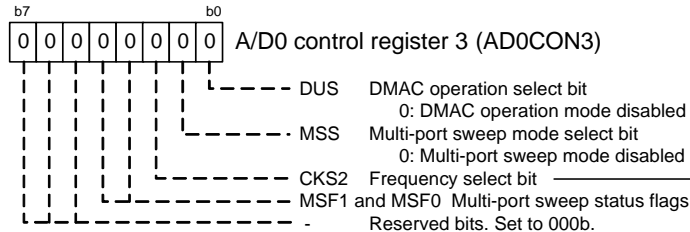


When changing the VCUT bit from 0 to 1, wait for 1 μs or more before starting A/D conversion.

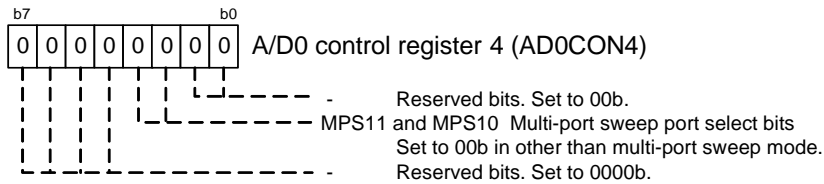
(3) Set A/D0 control register 2



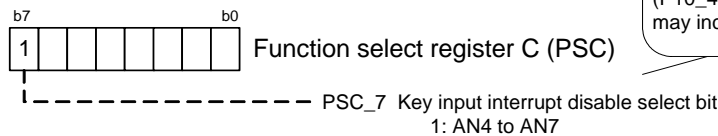
(4) Set A/D0 control register 3



(5) Set A/D0 control register 4

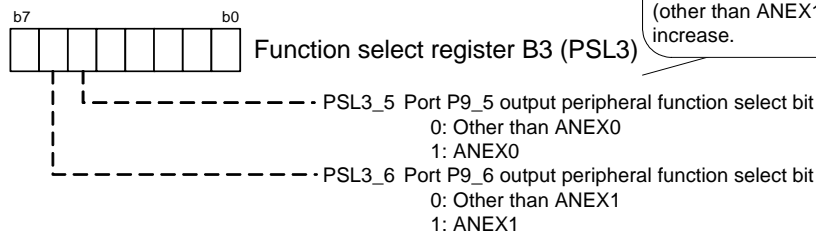


(6) Set the function select registers  
(When pins P10\_4 to P10\_7 are used as analog input pins.)



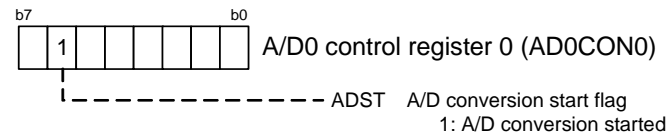
AN4 to AN7 can be used when the PSC\_7 bit is set to 0 (P10\_4 to P10\_7, or KI0 to KI3), but power consumption may increase.

(When pins P9\_5 and P9\_6 are used as analog input pins.)



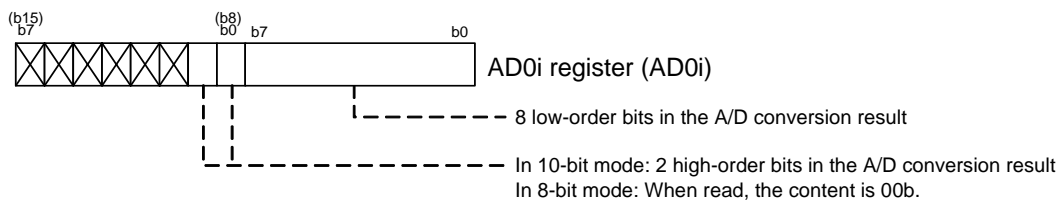
ANEX0 and ANEX1 can be used when the PSL3\_5 bit is set to 0 (other than ANEX0) and the PSL3\_6 bit is set to 0 (other than ANEX1), but power consumption may increase.

(7) Start A/D Conversion (Set A/D0 control register 0)



(8) Wait until A/D conversion is completed

(9) Read the A/D conversion result (read the AD0i register)



#### 4. Sample Programming Code

A sample program can be downloaded from the Renesas Technology website.  
For download, click “Application Notes” in the left-hand side menu of the M16C Family page.

#### 5. Reference Documents

Hardware Manuals

M32C/84 Group Hardware Manual

M32C/85 Group Hardware Manual

M32C/86 Group Hardware Manual

M32C/87 Group Hardware Manual

M32C/88 Group Hardware Manual

The latest version can be downloaded from the Renesas Technology website.

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REVISION HISTORY	M32C/84, 85, 86, 87, 88 Group A/D Converter Operation in One-Shot Mode and External Op-Amp Connection Mode
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		Page	Summary
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