

## 1. Abstract

This document describes the setting procedure to use the A/D converter in repeat mode.

## 2. Introduction

The application example described in this document applies to the following microcomputer (MCU):

- MCU: M16C/5L Group

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

### 3. Operation in Repeat Mode

This section describes operation when using the A/D converter in repeat mode with a software trigger.

- (1) When the ADST bit in the ADCON0 register is set to 1 (A/D conversion start), A/D conversion starts.
- (2) After completing A/D conversion, the value in the successive conversion register (conversion result) is transferred to the ADi register ( $i = 0$  to 7). The IR bit in the ADIC register does not become 1 (interrupt requested).
- (3) A/D conversion continues until the ADST bit in the ADCON0 register is set to 0 by a program. The conversion result is transferred to the ADi register every time A/D conversion is completed.

Figure 3.1 shows Operation Timing in Repeat Mode.

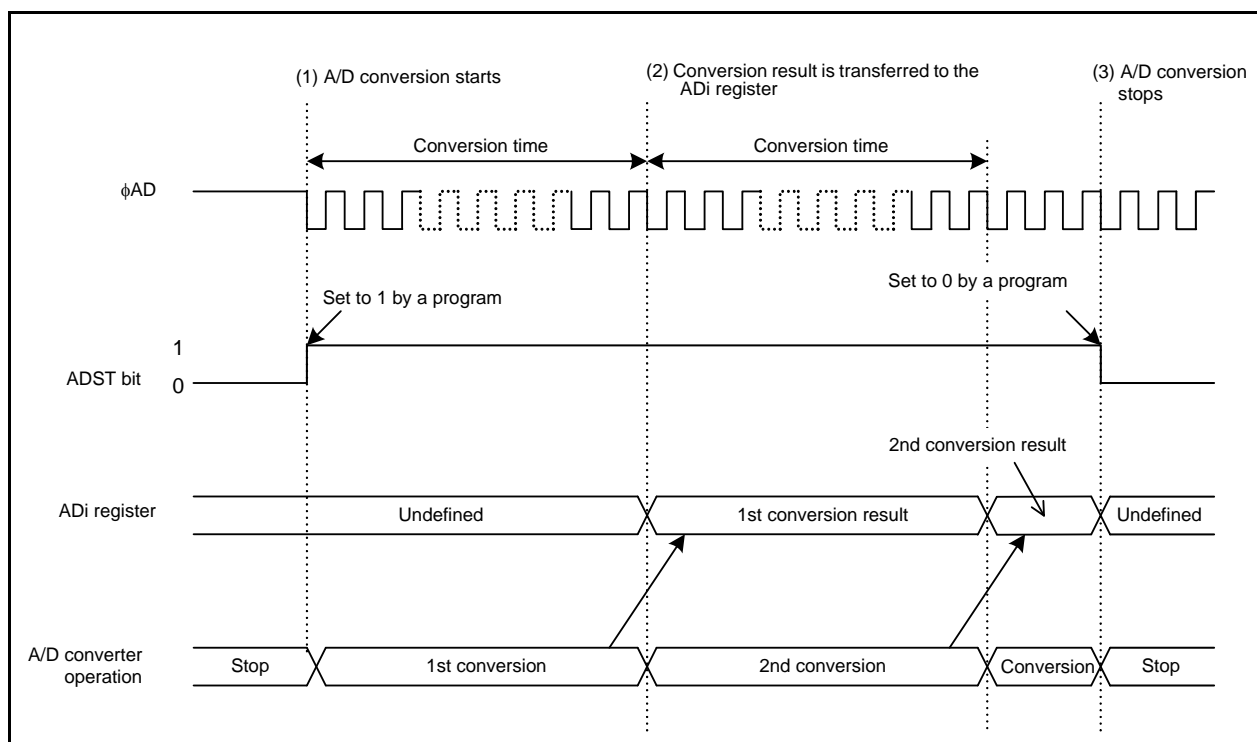


Figure 3.1 Operation Timing in Repeat Mode

## 4. A/D Conversion Time

This section describes how to calculate A/D conversion time.

### 4.1 A/D Conversion Cycle

Table 4.1 shows Cycles of A/D Conversion Item. A/D conversion time is described below.

Start processing time depends on which  $\phi_{AD}$  is selected.

A/D conversion starts after the start processing time elapses by setting the ADST bit in the ADCON0 register to 1 (A/D conversion start). When reading the ADST bit before starting A/D conversion, 0 (A/D conversion stop) is read.

In repeat mode, inter-execution processing time is inserted between A/D conversions.

- Repeat mode:

Start processing time + (A/D conversion execution time + inter-execution processing time + A/D conversion execution time + inter-execution processing time + ...)

**Table 4.1 Cycles of A/D Conversion Item**

A/D Conversion Item		Number of Cycles
Start processing time	$\phi_{AD} = f_{AD}$	1 to 2 cycles of $f_{AD}$
	$\phi_{AD} = f_{AD}$ divided by 2	2 to 3 cycles of $f_{AD}$
	$\phi_{AD} = f_{AD}$ divided by 3	3 to 4 cycles of $f_{AD}$
	$\phi_{AD} = f_{AD}$ divided by 4	3 to 4 cycles of $f_{AD}$
	$\phi_{AD} = f_{AD}$ divided by 6	4 to 5 cycles of $f_{AD}$
	$\phi_{AD} = f_{AD}$ divided by 12	7 to 8 cycles of $f_{AD}$
A/D conversion execution time	Open-circuit detection disabled	40 cycles of $\phi_{AD}$
	Open-circuit detection enabled	42 cycles of $\phi_{AD}$
Inter-execution processing time		1 cycle of $\phi_{AD}$
End processing time		2 to 3 cycles of $f_{AD}$

### 4.2 A/D Operation Clock Frequencies

Table 4.2 lists the A/D Operation Clock Frequencies.

**Table 4.2 A/D Operation Clock Frequencies (1)**

$V_{CC} = AV_{CC} = V_{REF} = 3.0$  to  $5.5$  V,  $V_{SS} = AV_{SS} = 0$  V at  $T_{opr} = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  (for J version) /  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (for K version) unless otherwise specified.

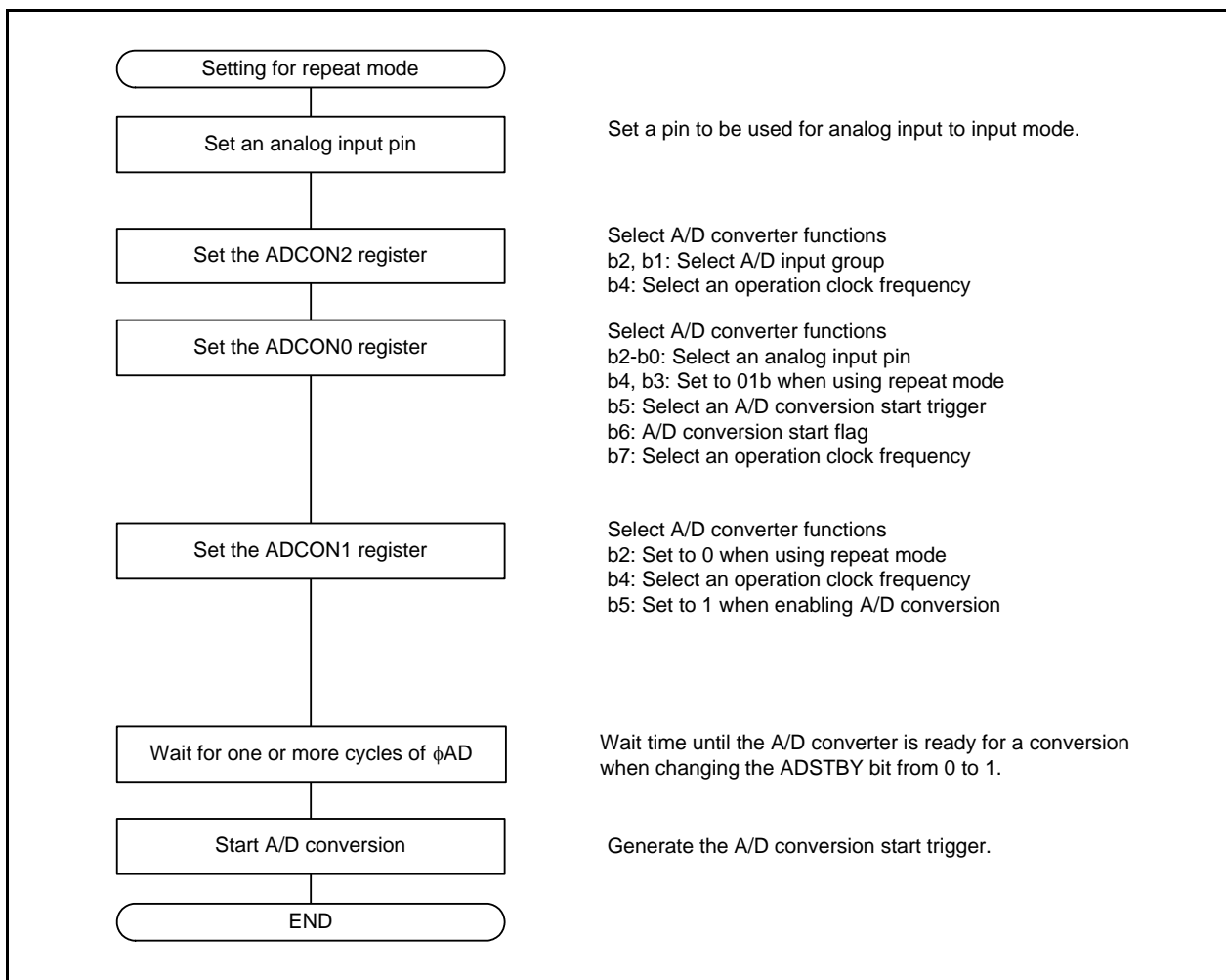
Symbol	Parameter	Measuring Condition	Standard			Unit
			Min.	Typ.	Max.	
$\phi_{AD}$	A/D operating clock frequency	$4.0\text{ V} \leq V_{CC} \leq 5.5\text{ V}$	2		25	MHz
		$3.2\text{ V} \leq V_{CC} \leq 4.0\text{ V}$	2		16	MHz
		$3.0\text{ V} \leq V_{CC} \leq 3.2\text{ V}$	2		10	MHz

Note:

1. Use when  $AV_{CC} = V_{CC}$ .

## 5. Settings

Figure 5.1 shows the Setting Procedure When Using Repeat Mode. Refer to the User's Manual: Hardware for details on registers.



**Figure 5.1 Setting Procedure When Using Repeat Mode**

## 6. Sample Code

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

### 6.1 Sample Code Operation

In repeat mode, functions listed in Table 6.1 can be selected. The settings used in the sample code are marked with “✓” in the table. The sample code operation is as follows; set the CPU clock as the main clock with no division by executing functions for CPU initialization, transition from 125 kHz on-chip oscillator mode to high-speed mode, then execute the function for A/D conversion in repeat mode. Refer to 6.2 Function Tables for details on functions.

**Table 6.1 Sample Code Settings**

Functions	Settings	
Operating clock $\phi$ AD	✓	f1
		f1 divided by 2
		f1 divided by 3
		f1 divided by 4
		f1 divided by 6
		f1 divided by 12
		fOCO40M divided by 2
		fOCO40M divided by 3
		fOCO40M divided by 4
		fOCO40M divided by 6
		fOCO40M divided by 12
A/D conversion start conditions	✓	Software trigger
		Trigger by $\overline{\text{ADTRG}}$
Analog input pins <sup>(1)</sup>	✓	1 pin from AN0 to AN7
		1 pin from AN0_0 to AN0_7
		1 pin from AN2_0 to AN2_7
A/D open-circuit detection assist function	✓	Not used

Note:

1. The number of usable analog input pins varies depending on pin numbers of the package used. Refer to the “A/D Converter” in the User’s Manual: Hardware for details.

## 6.2 Function Tables

### Function Tables for This Document

Declaration	void ad_repeat(void)
Outline	A/D conversion in repeat mode
Argument	None
Variable	None
Returned value	None
Function	Set the A/D converter to repeat mode and set the functions as marked in Table 6.1. Set an analog input pin to AN0, and set P10 to input mode. Generate a software trigger and start A/D conversion of the input voltage at the AN0 pin.

Declaration	unsigned short read_ad_register(unsigned char ch)
Outline	Read A/D register
Argument	unsigned char ch    Select the A/D register to be read
Variable	None
Returned value	unsigned short read_ad_data    Value read from the A/D register
Function	Read the A/D register selected with the unsigned char ch argument. Then return the read value as a returned value.

### Other Function Tables

Declaration	void mcu_init(void)
Outline	CPU initialization
Argument	None
Variable	None
Returned value	None
Function	Set to single-chip mode. Switch the CPU clock from 125 kHz on-chip oscillator mode divided-by-8 to 125 kHz on-chip oscillator mode divided-by-1.

Declaration	void highspeed_from_foco125k(void)
Outline	Transition from 125 kHz on-chip oscillator mode to high-speed mode
Argument	None
Variable	None
Returned value	None
Function	Switch the CPU clock from 125 kHz on-chip oscillator mode (fOCO-S divided by 1) to high-speed mode.

## 7. Reference Documents

M16C/5L Group User's Manual: Hardware Rev.1.00

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

Technical Update/Technical News

The latest information can be downloaded from the Renesas Electronics website.

M16C Series/R8C Family C Compiler Package V.5.45 C Compiler User's Manual Rev.3.00

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Rev.	Date	Description	
		Page	Summary
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## General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

### 1. Handling of Unused Pins

Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.

- The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

### 2. Processing at Power-on

The state of the product is undefined at the moment when power is supplied.

- The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.

In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.

In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

### 3. Prohibition of Access to Reserved Addresses

Access to reserved addresses is prohibited.

- The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

### 4. Clock Signals

After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.

- When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

### 5. Differences between Products

Before changing from one product to another, i.e. to one with a different part number, confirm that the change will not lead to problems.

- The characteristics of MPU/MCU in the same group but having different part numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different part numbers, implement a system-evaluation test for each of the products.

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