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April 1st, 2010
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Preliminary Application Note

# V850E/IF3, V850E/IG3

## 32-bit Single-Chip Microcontrollers

## Sample Programs for A/D Converter 2

**V850E/IF3:**
- μPD70F3451
- μPD70F3452

**V850E/IG3:**
- μPD70F3453
- μPD70F3454

Document No. U18738EJ1V0AN00 (1st edition)
Date Published September 2007 N

**[MEMO]**

## NOTES FOR CMOS DEVICES

### ① VOLTAGE APPLICATION WAVEFORM AT INPUT PIN

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between $V_{IL}$ (MAX) and $V_{IH}$ (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between $V_{IL}$ (MAX) and $V_{IH}$ (MIN).

### ② HANDLING OF UNUSED INPUT PINS

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to $V_{DD}$ or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

### ③ PRECAUTION AGAINST ESD

A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

### ④ STATUS BEFORE INITIALIZATION

Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

### ⑤ POWER ON/OFF SEQUENCE

In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current.

The correct power on/off sequence must be judged separately for each device and according to related specifications governing the device.

### ⑥ INPUT OF SIGNAL DURING POWER OFF STATE

Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements.

Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

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# INTRODUCTION

**Cautions 1. This Application Note explains a case where the V850E/IG3 is used as a representative microcontroller. Use this Application Note for your reference when using the V850E/IF3.**

**2. Download the program used in this manual from the page of Programming Examples (http://www.necel.com/micro/en/designsupports/sampleprogram/index.html) in the NEC Electronics Website (http://www.necel.com/).**

**3. The sample programs are provided for reference purposes only and operations are therefore not subject to guarantee by NEC Electronics Corporation. When using sample programs, customers are advised to sufficiently evaluate this product based on their systems, before use.**

**4. When using sample programs, reference the following startup routine and link directive file and adjust them if necessary.**

- **Startup routine: ig3_start.s**
- **Link directive file: ig3_link.dir**

**Target Readers**

This Application Note is intended for users who understand the functions of the V850E/IF3 ($\mu$PD70F3451, 70F3452), and V850E/IG3 ($\mu$PD70F3453, 70F3454), and who design application systems that use these microcontrollers.

**Purpose**

This manual is intended to give users an understanding of the basic functions of the V850E/IF3 and V850E/IG3, using the application programs.

**How to Use This Manual**

It is assumed that the reader of this Application Note has general knowledge in the fields of electrical engineering, logic circuits, and microcontrollers.

For details of hardware functions (especially register functions, setting methods, etc.) and electrical specifications

→ See the **V850E/IF3, V850E/IG3 Hardware User's Manual**.

For details of instruction functions

→ See the **V850E1 Architecture User's Manual**.

**Conventions**

| | |
|---|---|
| Data significance: | Higher digits on the left and lower digits on the right |
| Active low representation: | $\overline{xxx}$ (overscore over pin or signal name) |
| Memory map address: | Higher addresses on the top and lower addresses on the bottom |
| **Note:** | Footnote for item marked with **Note** in the text |
| **Caution:** | Information requiring particular attention |
| **Remark:** | Supplementary information |
| Numeric representation: | Binary ... xxxx or xxxxB |
| | Decimal ... xxxx |
| | Hexadecimal ... xxxxH |
| Prefix indicating the power of 2 (address space, memory capacity): | |
| | K (kilo): $2^{10} = 1,024$ |
| | M (mega): $2^{20} = 1,024^2$ |
| | G (giga): $2^{30} = 1,024^3$ |

The function lists are structured as follows.

### Theme

| | |
|---|---|
| [Function] | Function description |
| [Function name] | Name of sample function |
| [Argument(s)] | Type and overview of argument(s) |
| [Processing content] | Processing content of sample function |
| [SFR(s) used] | Register name and setting content |
| [call function(s)] | Name and function of call function(s) |
| [Variable(s)] | Type, name, and overview of variable(s) used in sample function |
| [Interrupt(s)] | Name of function |
| [Interrupt source(s)] | Name |
| [File name] | Name of corresponding sample program file |
| [Caution(s)] | Caution(s) upon function usage |

### Interrupt function

| | |
|---|---|
| [Function name] | Name of interrupt function |
| [Servicing content] | Servicing content of interrupt function |
| [SFR(s) used] | Name of interrupt and conditions for occurrence |
| [call function(s)] | None |
| [Variable(s)] | Name of variable, function |
| [File name] | Name of corresponding sample program file |
| [Caution(s)] | None |

**Product Differences**

The differences between the V850E/IG3 and the V850E/IF3 related to the A/D converter 2 are shown below.

| Item | V850E/IG3 | V850E/IF3 |
|---|---|---|
| Analog input | 8 channels | 4 channels |

**Related Documents**

The related documents indicated in this publication may include preliminary versions. However, preliminary versions are not marked as such.

**Documents related to V850E/IF3 and V850E/IG3**

| Document Name | Document No. |
|---|---|
| V850E1 Architecture User's Manual | U14559E |
| V850E/IF3, V850E/IG3 Hardware User's Manual | U18279E |
| V850E/IF3, V850E/IG3 Sample Programs for Serial Communication (UARTA) Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Serial Communication (UARTB) Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Serial Communication (CSIB) Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Serial Communication ($I^2C$) Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for DMA Function Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Timer M Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Watchdog Timer Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Timer AA Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Timer AB Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Timer T Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Port Function Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Clock Generator Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Standby Function Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for Interrupt Function Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for A/D Converters 0 and 1 Application Note | To be prepared |
| V850E/IF3, V850E/IG3 Sample Programs for A/D Converter 2 Application Note | This manual |
| V850E/IF3, V850E/IG3 Sample Programs for Low-Voltage Detector (LVI) Function Application Note | To be prepared |
| V850E/IF3, V850E/IG3 6-Phase PWM Output Control by Timer AB, Timer Q Option, Timer AA, A/D Converters 0 and 1 Application Note | U18717E |

## CONTENTS

# CHAPTER 1 SOFTWARE TRIGGER MODE (CONTINUOUS SELECT MODE)

| | |
|---|---|
| [Function] | Performs A/D conversion by setting the A/D conversion operation start timing to continuous select mode of software trigger mode. |
| [Function name] | ad2_main |
| [Argument] | None |
| [Processing content] | Starts A/D conversion by setting the AD2M0.AD2CE bit to 1. Stores the A/D conversion result to buf[] by A/D converting the ANI20 pin input.<br>An A/D2 conversion end interrupt request signal (INTAD2) occurs upon completion of every A/D conversion.<br>After A/D conversion, the conversion is performed repeatedly unless the AD2CE bit is set to 0.<br>Performs A/D conversion for 10 times. |
| [SFR used] | AD2IC: 0x07 (Clears A/D2 conversion end interrupt request signal (INTAD2), releases mask, sets to priority level 7.) |
| [call function] | ad2_port_set, ad2_analog_on, ad2_set, ad2_start, ad2_stop, ad2_analog_off |
| [Variables] | unsigned short int buf [ ]: Conversion data storing buffer<br>volatile unsigned char count: Conversion count variable<br>unsigned char wait: WAIT variable |
| [Interrupt] | ad2_int |
| [Interrupt source] | INTAD2 |
| [File name] | ad2.c |
| [Caution] | None |

| | |
|---|---|
| [Function name] | ad2_port_set |
| [Processing content] | Sets the alternate-function pin. |
| [SFR used] | PMC7: 0x01 (Specifies to ANI20 input pin.) |
| [call function] | None |
| [Variable] | None |
| [File name] | ad2.c |
| [Caution] | None |

| | |
|---|---|
| [Function name] | ad2_analog_on |
| [Processing content] | A/D power on. |
| [SFR used] | AD2M0.AD2PS: 1 (A/D power on) |
| [call function] | None |
| [Variable] | unsigned char wait: WAIT variable |
| [File name] | ad2.c |
| [Caution] | Set the AD2M0.AD2CE bit to 1, after the AD2PS bit is set to 1 and at least 2 $\mu$s have elapsed.<br>If the AD2CE bit is set to 1 before 2 $\mu$s have elapsed, the A/D conversion is performed but the accuracy of the first conversion result is not guaranteed. |

| | |
|---|---|
| [Function name] | ad2_set |
| [Processing content] | Sets A/D conversion control register. |
| [SFRs used] | AD2M0: 0x00 (Stops A/D conversion operation, sets continuous select mode.)<br>AD2M1: 0x03 (Sets conversion time to 124/$f_{AD2}$.)<br>AD2S: 0x00 (Sets analog input pin to ANI20 pin.) |
| [call function] | None |
| [Variable] | None |
| [File name] | ad2.c |
| [Caution] | None |

| | |
|---|---|
| [Function name] | ad2_start |
| [Processing content] | Starts A/D conversion operation. |
| [SFR used] | AD2M0.AD2CE: 1 (Enables A/D conversion operation.) |
| [call function] | None |
| [Variable] | None |
| [File name] | ad2.c |
| [Caution] | Set the AD2CE bit to 1, after the AD2M0.AD2PS bit is set to 1 and at least 2 $\mu$s have elapsed.<br>If the AD2CE bit is set to 1 before 2 $\mu$s have elapsed, the A/D conversion is performed but the accuracy of the first conversion result is not guaranteed. |

| | |
|---|---|
| [Function name] | ad2_stop |
| [Processing content] | Stops A/D conversion operation. |
| [SFR used] | AD2M0.AD2CE: 0 (Stops A/D conversion operation.) |
| [call function] | None |
| [Variable] | None |
| [File name] | ad2.c |
| [Caution] | None |

| | |
|---|---|
| [Function name] | ad2_analog_off |
| [Processing content] | A/D power off |
| [SFR used] | AD2M0.AD2PS: 0 (A/D power off) |
| [call function] | None |
| [Variable] | None |
| [File name] | ad2.c |
| [Caution] | None |

## Interrupt function

| | |
|---|---|
| [Function name] | ad2_int |
| [Servicing content] | Stores A/D conversion result data to buffer. |
| [SFR used] | AD2CR0 A/D2 conversion result register 0 |
| [call function] | None |
| [Variables] | unsigned short int buf [ ]: Conversion data storing buffer<br>volatile unsigned char count: Convert count variable |
| [File name] | ad2.c |
| [Caution] | None |

**Figure 1-1. Software Trigger Mode (Continuous Select Mode) (1/3)**

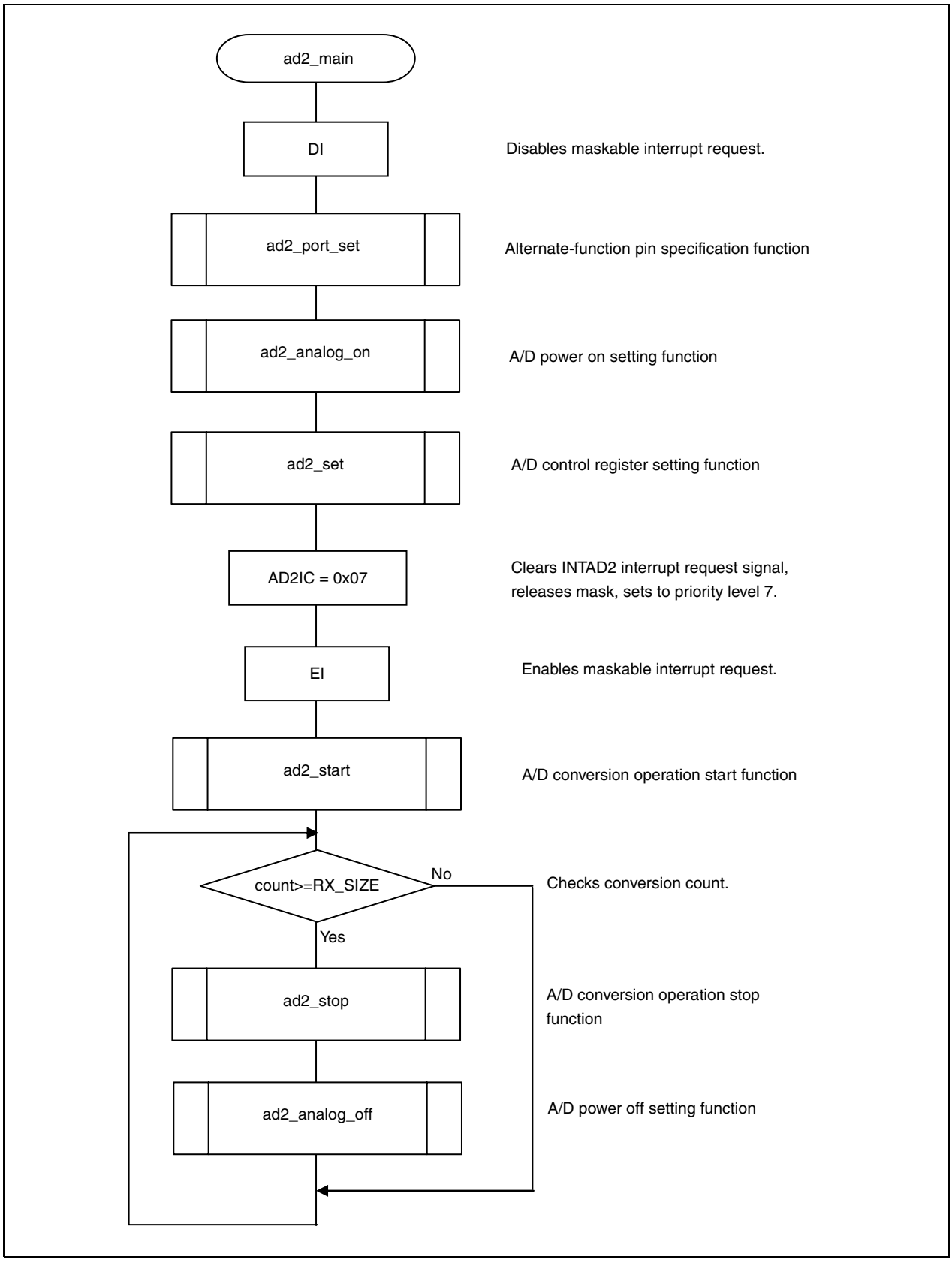


**Figure 1-1. Software Trigger Mode (Continuous Select Mode) (2/3)**

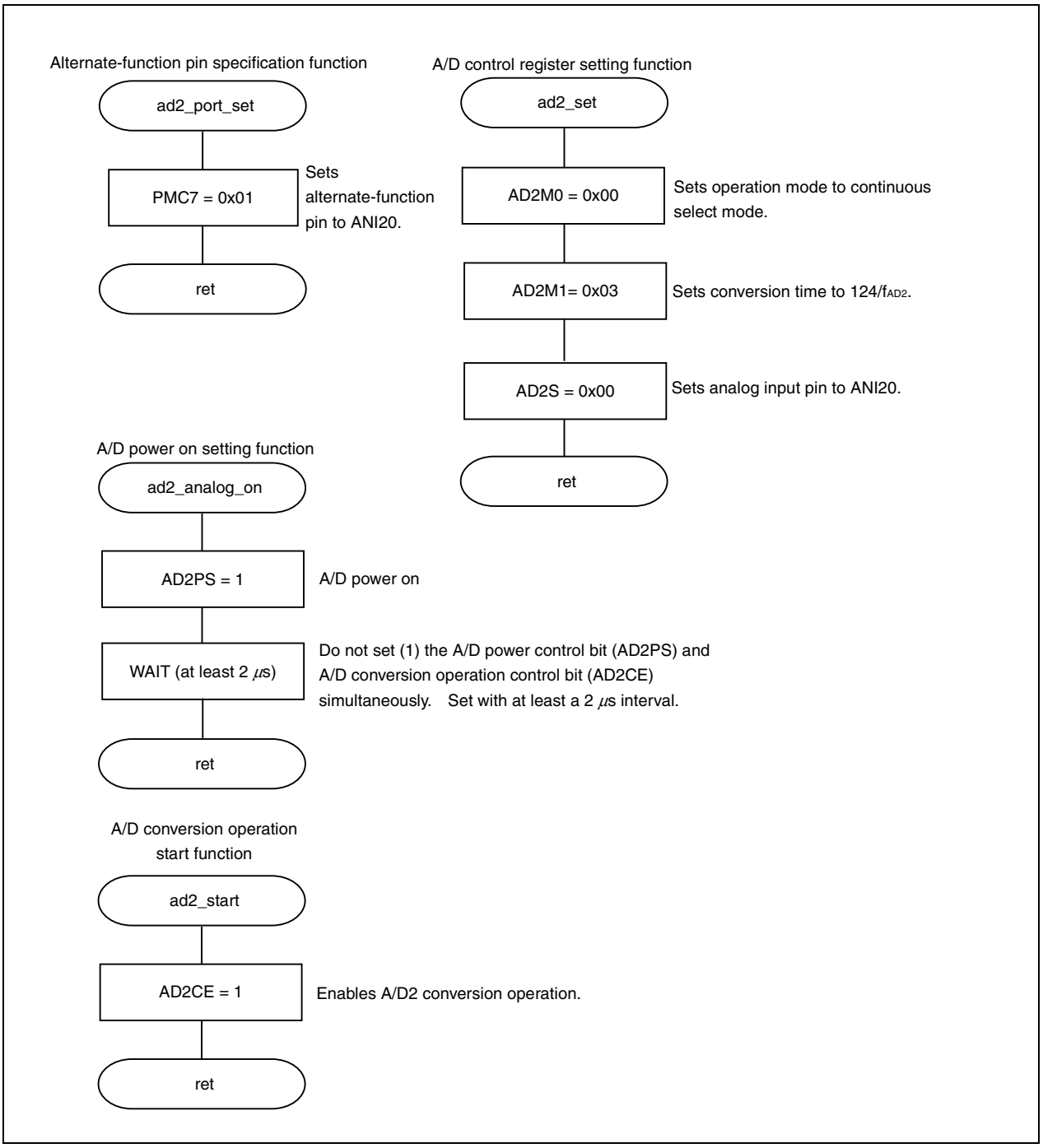
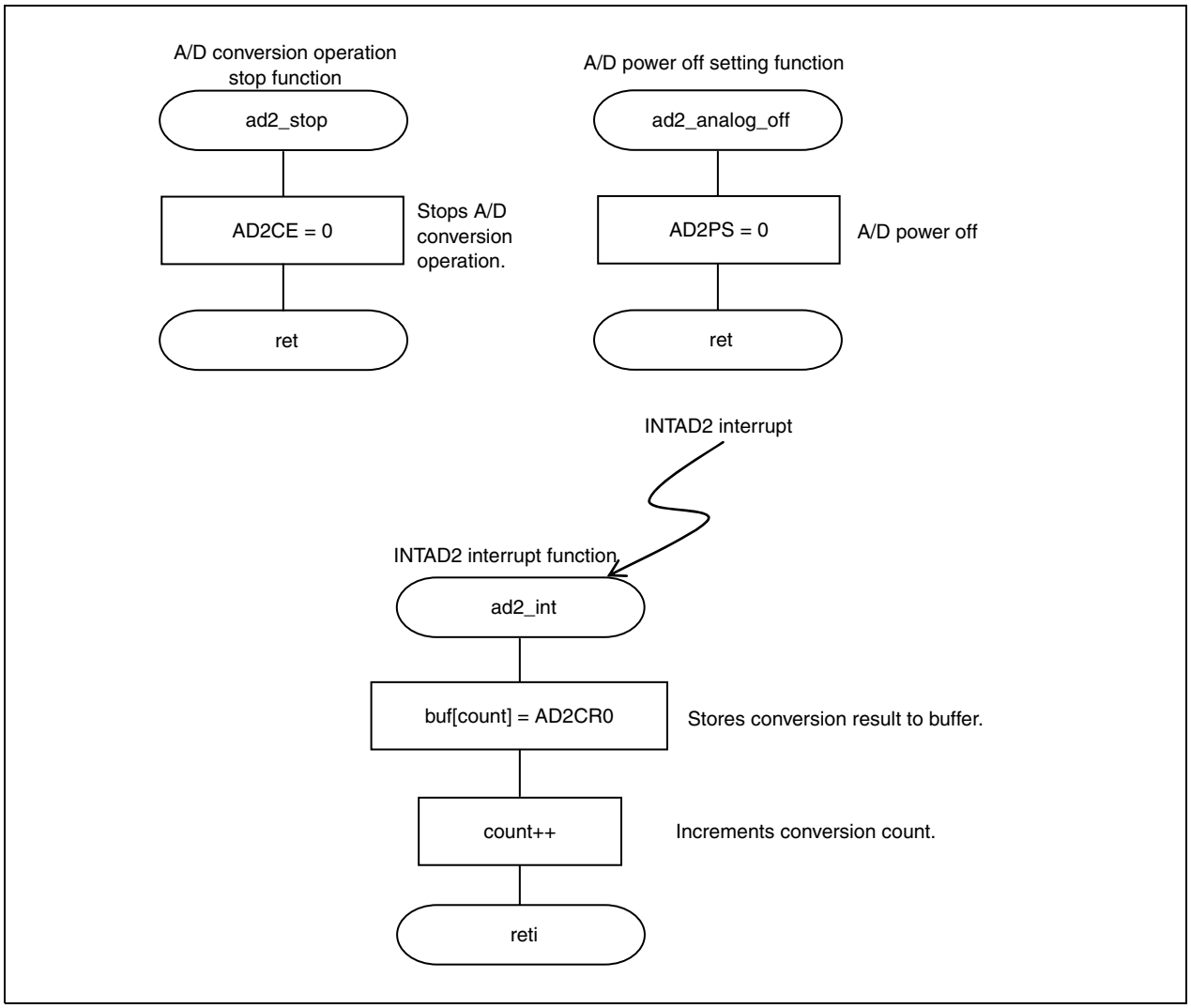


**Figure 1-1. Software Trigger Mode (Continuous Select Mode) (3/3)**



## CHAPTER 2 SOFTWARE TRIGGER MODE (CONTINUOUS SCAN MODE)

| | |
|---|---|
| [Function] | Performs A/D conversion by setting the A/D conversion operation start timing to continuous scan mode of the software trigger mode. |
| [Function name] | ad2_1_main |
| [Argument] | None |
| [Processing content] | Starts A/D conversion by setting the AD2M0.AD2CE bit to 1.<br>Stores the A/D conversion results to buf[], buf_1[], buf_2[], and buf_3[] which correspond to the analog input pins, by selecting pins in the order of ANI20 pin, ANI21 pin, ANI22 pin, and ANI23 pin which have been specified by the AD2S register.<br>An A/D2 conversion end interrupt request signal (INTAD2) is generated upon completion of A/D conversion of the specified analog input.<br>After A/D conversion, the conversion is performed repeatedly unless the AD2CE bit is set to 0.<br>Performs A/D conversion for 10 times. |
| [SFR used] | AD2IC: 0x07 (Clears A/D2 conversion end interrupt request signal (INTAD2), releases mask, sets to priority level 7.) |
| [call function] | ad2_port_set, ad2_analog_on, ad2_set, ad2_start, ad2_stop, ad2_analog_off |
| [Variables] | unsigned short int buf[ ]: Conversion data storing buffer<br>unsigned short int buf_1[ ]: Conversion data storing buffer<br>unsigned short int buf_2[ ]: Conversion data storing buffer<br>unsigned short int buf_3[ ]: Conversion data storing buffer<br>volatile unsigned char count: Conversion count variable<br>unsigned char wait: WAIT variable |
| [Interrupt] | ad2_int |
| [Interrupt source] | INTAD2 |
| [File name] | ad2_1.c |
| [Caution] | None |

| | | |
|---|---|---|
| [Function name] | ad2_port_set | |
| [Processing content] | Sets the alternate-function pin. | |
| [SFRs used] | PMC7: | 0x0F (Specifies ANI20 to ANI23 input pins) |
| [call function] | None | |
| [Variable] | None | |
| [File name] | ad2_1.c | |
| [Caution] | None | |

| | | |
|---|---|---|
| [Function name] | ad2_analog_on | |
| [Processing content] | A/D power on. | |
| [SFR used] | AD2M0.AD2PS: | 1 (A/D power on) |
| [call function] | None | |
| [Variable] | unsigned char wait: | WAIT variable |
| [File name] | ad2_1.c | |
| [Caution] | Set the AD2M0.AD2CE bit to 1, after the AD2PS bit is set to 1 and at least 2 $\mu$s have elapsed.<br>If the AD2CE bit is set to 1 before 2 $\mu$s have elapsed, the A/D conversion is performed but the accuracy of the first conversion result is not guaranteed. | |

| | | |
|---|---|---|
| [Function name] | ad2_set | |
| [Processing content] | Sets the A/D conversion control register. | |
| [SFRs used] | AD2M0:<br>AD2M1:<br>AD2S: | 0x50 (Stops A/D conversion operation, sets to continuous scan mode.)<br>0x03 (Sets conversion time to 124/$f_{AD2}$.)<br>0x03 (Sets analog input pin to ANI20 to ANI23.) |
| [call function] | None | |
| [Variable] | None | |
| [File name] | ad2_1.c | |
| [Caution] | None | |

| | |
|---|---|
| [Function name] | ad2_start |
| [Processing content] | Enables A/D conversion operation. |
| [SFR used] | AD2M0.AD2CE: 1 (Enables A/D conversion operation.) |
| [call function] | None |
| [Variable] | None |
| [File name] | ad2_1.c |
| [Cautions] | Set the AD2CE bit to 1, after the AD2M0.AD2PS bit is set to 1 and at least 2 $\mu$s have elapsed.<br>If the AD2CE bit is set to 1 before 2 $\mu$s have elapsed, the A/D conversion is performed but the accuracy of the first conversion result is not guaranteed. |

| | |
|---|---|
| [Function name] | ad2_stop |
| [Processing content] | Stops A/D conversion operation. |
| [SFR used] | AD2M0.AD2CE: 0 (Stops A/D conversion operation.) |
| [call function] | None |
| [Variable] | None |
| [File name] | ad2_1.c |
| [Caution] | None |

| | |
|---|---|
| [Function name] | ad2_analog_off |
| [Processing content] | A/D power off. |
| [SFR used] | AD2M0.AD2PS: 0 (A/D power off) |
| [call function] | None |
| [Variable] | None |
| [File name] | ad2_1.c |
| [Caution] | None |

## Interrupt function

| | | |
|---|---|---|
| [Function name] | ad2_int | |
| [Servicing content] | Stores A/D conversion result data to buffer. | |
| [SFRs used] | AD2CR0 | A/D2 conversion result register 0 |
| | AD2CR1 | A/D2 conversion result register 1 |
| | AD2CR2 | A/D2 conversion result register 2 |
| | AD2CR3 | A/D2 conversion result register 3 |
| [call function] | None | |
| [Variables] | unsigned short int buf[ ]: | Conversion data storing buffer |
| | unsigned short int buf_1[ ]: | Conversion data storing buffer |
| | unsigned short int buf_2[ ]: | Conversion data storing buffer |
| | unsigned short int buf_3[ ]: | Conversion data storing buffer |
| | volatile unsigned char count: | Conversion count variable |
| [File name] | ad2_1.c | |
| [Caution] | None | |

**Figure 2-1. Software Trigger Mode (Continuous Scan Mode) (1/3)**

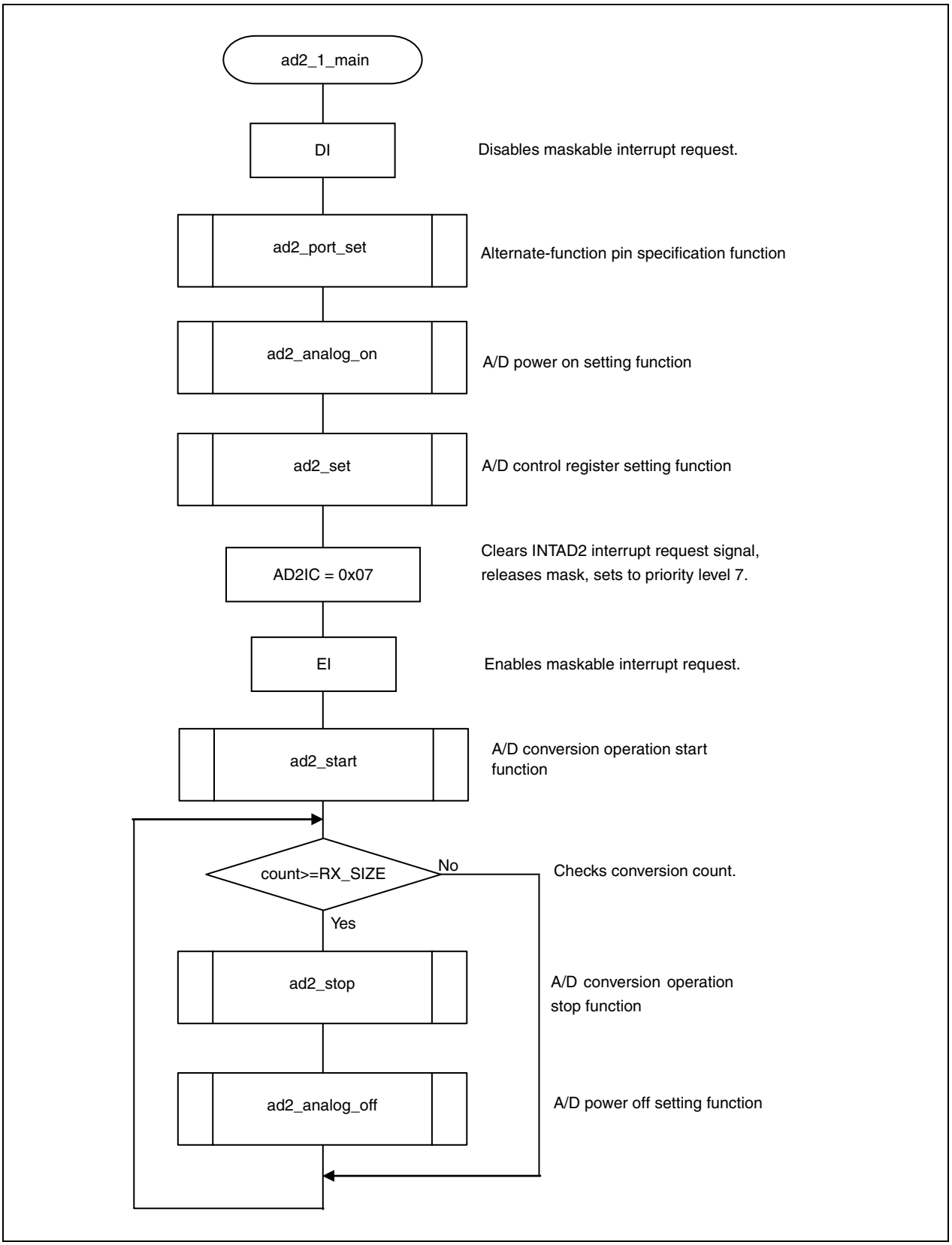


**Figure 2-1. Software Trigger Mode (Continuous Scan Mode) (2/3)**

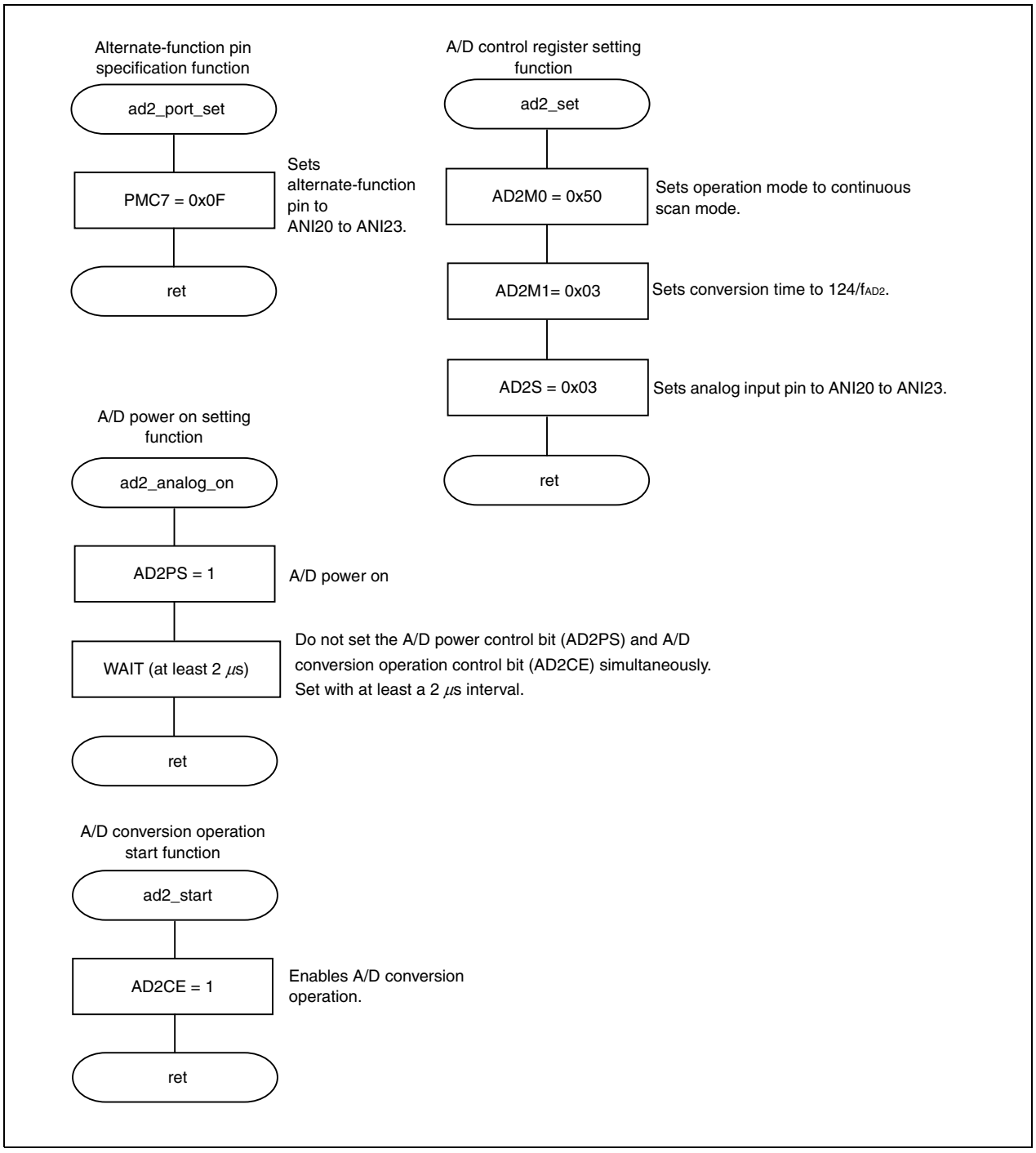
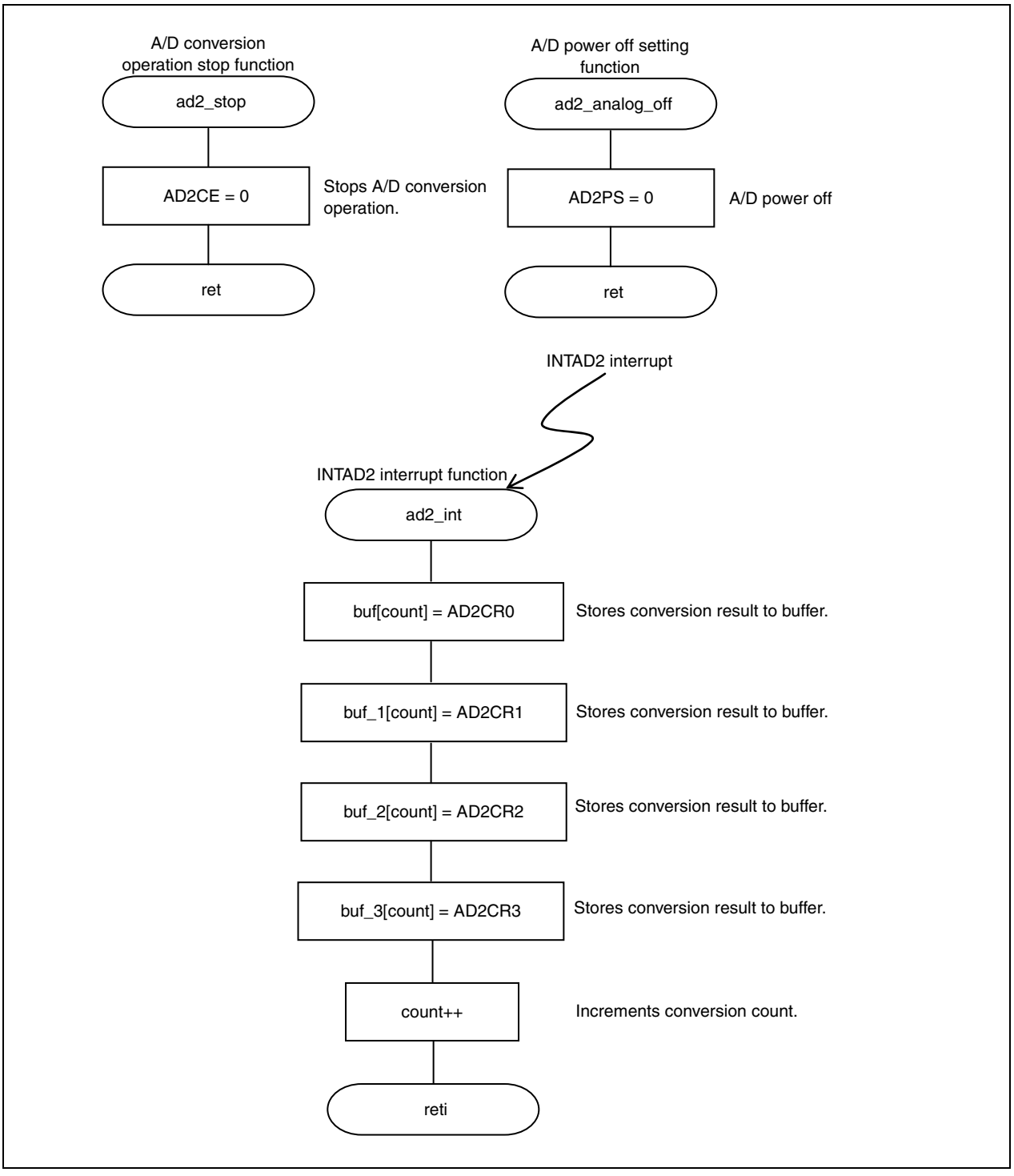


**Figure 2-1. Software Trigger Mode (Continuous Scan Mode) (3/3)**



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