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## Preliminary Application Note

# V850E/IF3, V850E/IG3

32-bit Single-Chip Microcontrollers

Sample Programs for A/D Converters 0 and 1

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**V850E/IF3:**

*μ*PD70F3451

*μ*PD70F3452

**V850E/IG3:**

*μ*PD70F3453

*μ*PD70F3454

[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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M5 02. 11-1

## 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:	$\overline{\text{xxx}}$ (overscore over pin or signal name)
Memory map address:	Higher addresses on the top and lower addresses on the bottom
<b>Note:</b>	Footnote for item marked with <b>Note</b> in the text
<b>Caution:</b>	Information requiring particular attention
<b>Remark:</b>	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

## 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 <sup>2</sup> C) 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	This manual
V850E/IF3, V850E/IG3 Sample Programs for A/D Converter 2 Application Note	To be prepared
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

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## CHAPTER 1 NORMAL OPERATION MODE

### 1.1 A/D Trigger Mode (1 Channel Conversion)

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to A/D trigger mode of the normal operation mode.
[Function name]	ad0_software_main
[Argument]	None
[Processing content]	Starts A/D conversion by setting the AD0SCM.AD0CE bit to 1. Stores the A/D conversion results to buf[ ] by performing A/D conversion to ANI00 pin. An A/D0 conversion end interrupt request signal (INTAD0) occurs upon every completion of A/D conversion. Performs A/D conversion for 10 times.
[SFR used]	AD0IC: 0x07 (Clears A/D0 conversion end interrupt request signal (INTAD0), releases mask, sets to priority level 7.)
[call function]	ad_port_set, ad_set, ad_start, ad_stop
[Variables]	unsigned short int buf [ ]: Conversion data storing buffer volatile unsigned char count: Conversion count variable unsigned int wait_co: WAIT variable
[Interrupt]	ad0_int
[Interrupt source]	INTAD0
[File name]	ad01_software_trigger.c
[Caution]	None

[Function name]	ad_set
[Processing content]	Sets A/D conversion control register.
[SFRs used]	AD0OCKS: 0x12 (Sets input clock as $f_{xx}/4$ .) AD0SCM: 0x0082 (Sets A/D trigger mode.) AD0CTC: 0x0C (Sets the number of conversion clocks to 32 (2 $\mu$ s).) OP0CTL0: 0x10 (Enables operational amplifier 0 operation.) OP1CTL0: 0x00 CMP0CTL0: 0x00 (Disables comparator 0 operation.) CMP1CTL0: 0x00
[call function]	None
[Variable]	unsigned int wait_co: WAIT variable
[File name]	ad01_software_trigger.c
[Caution]	A stabilization time of 10 $\mu$ s is required after operation of the operational amplifier is enabled.

[Function name]	ad_port_set
[Processing content]	Sets analog input pin.
[SFR used]	AD0CHEN: 0x0001 (Sets analog input pin to ANI00 pin.)
[call function]	None
[Variable]	None
[File name]	ad01_software_trigger.c
[Caution]	None

[Function name]	ad_start
[Processing content]	Start A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_software_trigger.c
[Caution]	None

[Function name]	ad_stop
[Processing content]	Stops A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 0 (Stops A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_software_trigger.c
[Caution]	None

### Interrupt function

[Function name]	ad0_int
[Servicing content]	Stores A/D conversion result data to buffer.
[SFR used]	AD0CR0                      A/D0 conversion result register 0
[call function]	None
[Variable]	unsigned short int buf [ ]:      Convert data storing buffer volatile unsigned char count:    Convert count variable
[File name]	ad01_software_trigger.c
[Caution]	None

Figure 1-1. A/D Trigger Mode (1 Channel Conversion) (1/2)

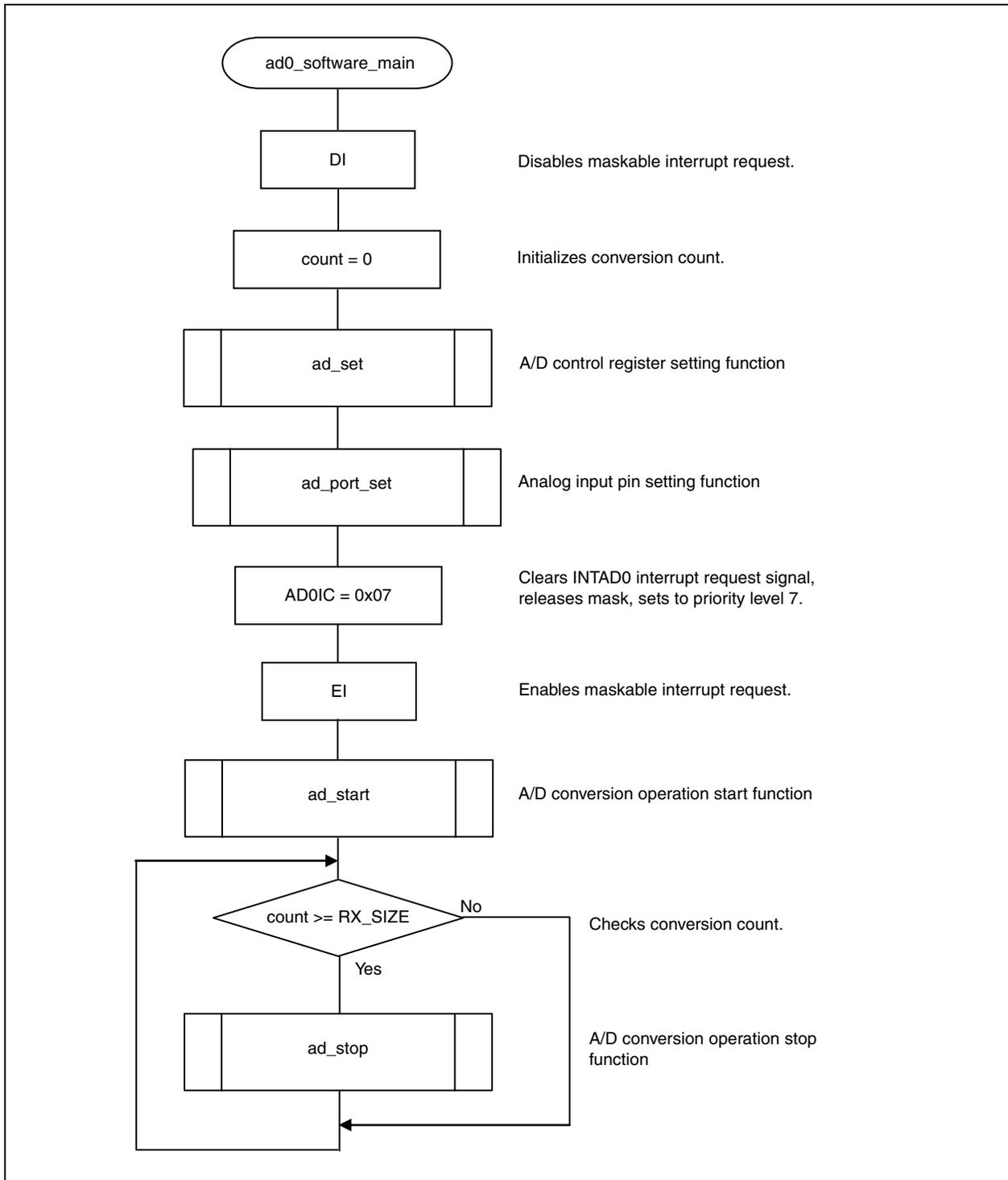
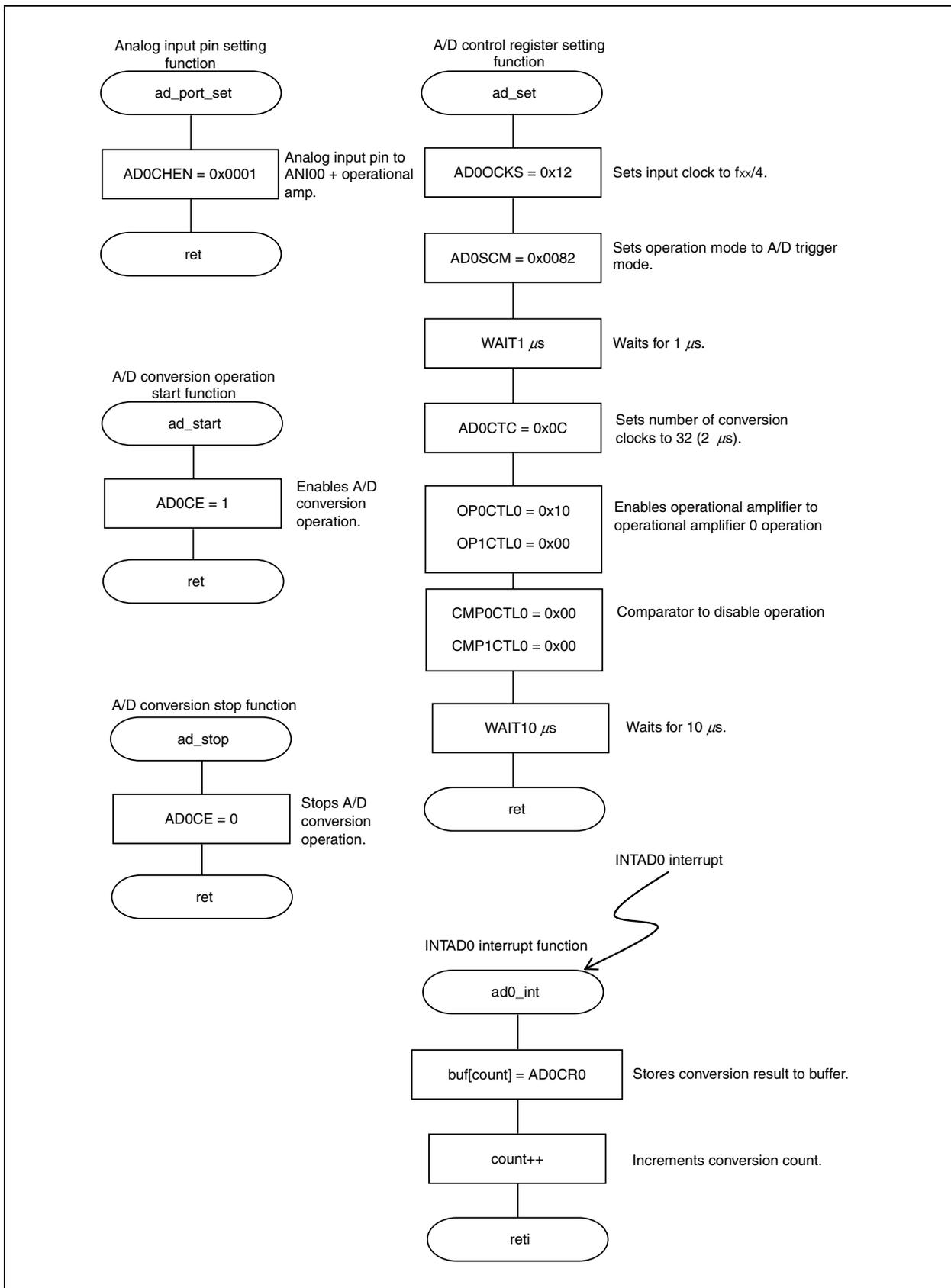


Figure 1-1. A/D Trigger Mode (1 Channel Conversion) (2/2)



## 1.2 A/D Trigger Mode (Multi-Channel Conversion)

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to A/D trigger mode of the normal operation mode.
[Function name]	ad0_software1_main
[Argument]	None
[Processing content]	<p>Starts A/D conversion by setting the AD0SCM.AD0CE bit to 1. 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 ANI00 pin, ANI01 pin, ANI02 pin, and ANI03 pin which have been specified by the ADOCHEN register, and continuously performing A/D conversion.</p> <p>An A/D0 conversion end interrupt request signal (INTAD0) occurs upon completion of conversion operation of the specified analog input pins.</p> <p>Performs A/D conversion for 10 times.</p>
[SFR used]	AD0IC: 0x07 (Clears A/D0 conversion end interrupt request signal (INTAD0), releases mask, sets to priority level 7.)
[call function]	ad_port_set, ad_set, ad_start, ad_stop
[Variables]	<p>unsigned short int buf[ ]: Conversion data storing buffer</p> <p>unsigned short int buf_1[ ]: Conversion data storing buffer</p> <p>unsigned short int buf_2[ ]: Conversion data storing buffer</p> <p>unsigned short int buf_3[ ]: Conversion data storing buffer</p> <p>volatile unsigned char count: Conversion count variable</p>
[Interrupt]	ad0_int
[Interrupt source]	INTAD0
[File name]	ad01_software1_trigger.c
[Caution]	None

[Function name]	ad_set
[Processing content]	Sets A/D conversion control register.
[SFRs used]	AD0OCKS: 0x12 (Sets input clock to f <sub>xx</sub> /4.) AD0SCM: 0x0082 (Sets A/D trigger mode.) AD0CTC: 0x0C (Sets the number of conversion clocks to 32 (2 $\mu$ s).) OP0CTL0: 0x00 (Enables operational amplifier 0 operation.) OP1CTL1: 0x00 CMP0CTL0: 0x00 (Disables comparator 0 operation.) CMP1CTL0: 0x00
[call function]	None
[Variable]	None
[File name]	ad01_software1_trigger.c
[Caution]	None

[Function name]	ad_port_set
[Processing content]	Sets analog input pin.
[SFRs used]	AD0CHEN: 0x000F (Sets analog input pin to ANI00 pin, ANI01 pin, ANI02 pin, and ANI03 pin.)
[call function]	None
[Variable]	None
[File name]	ad01_software1_trigger.c
[Caution]	None

[Function name]	ad_start
[Processing content]	Starts A/D convert operation.
[SFR used]	AD0SCM.AD0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_software1_trigger.c
[Caution]	None

[Function name]	ad_stop
[Processing content]	Stops A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 0 (Stops A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_software1_trigger.c
[Caution]	None

## Interrupt function

[Function name]	ad0_int
[Servicing content]	Stores A/D conversion result data to buffer.
[SFR used]	AD0CR0                      A/D0 conversion result register 0 AD0CR1                      A/D0 conversion result register 1 AD0CR2                      A/D0 conversion result register 2 AD0CR3                      A/D0 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]	ad01_software1_trigger.c
[Caution]	None

Figure 1-2. A/D Trigger Mode (Multi-Channel Conversion) (1/2)

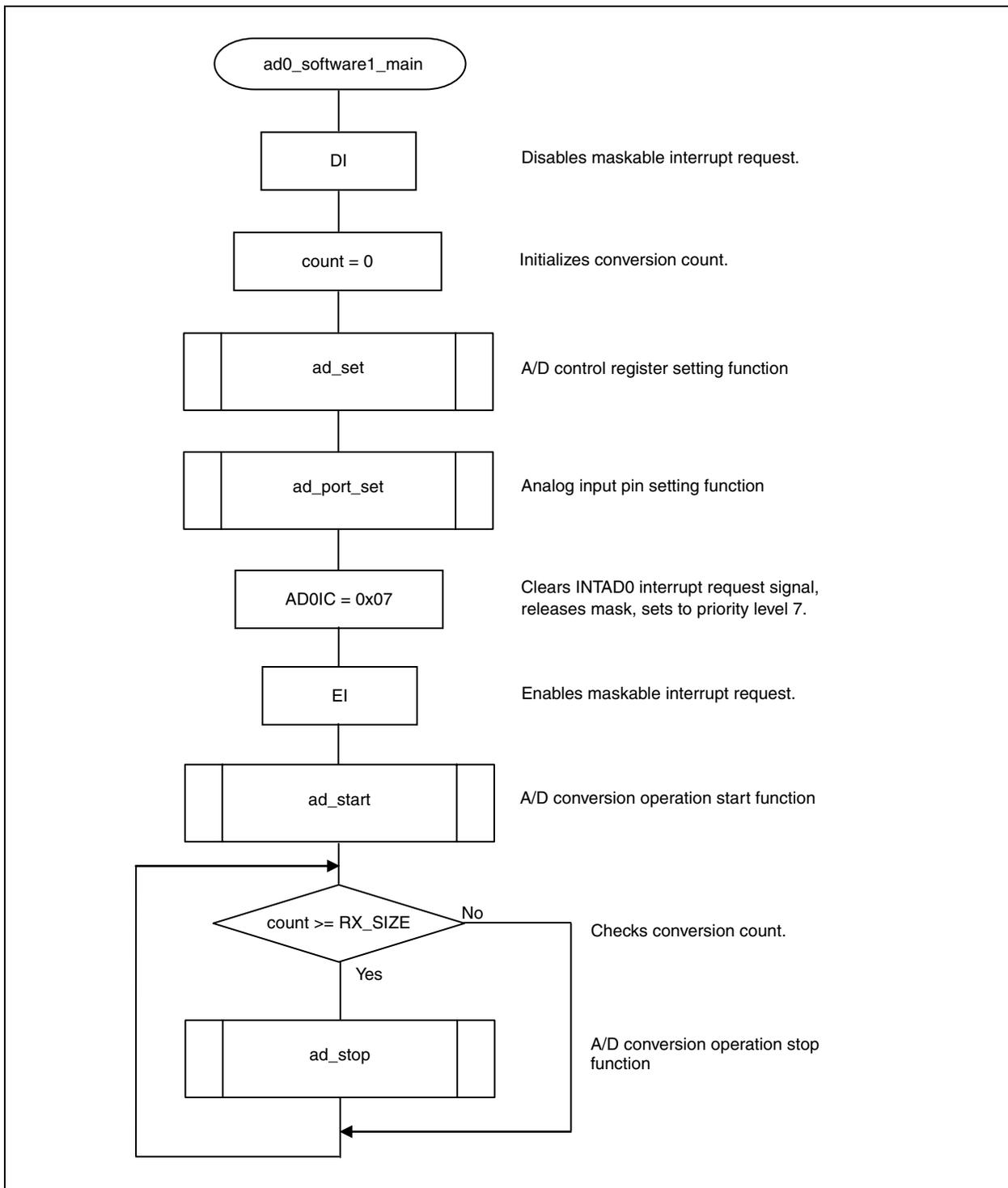
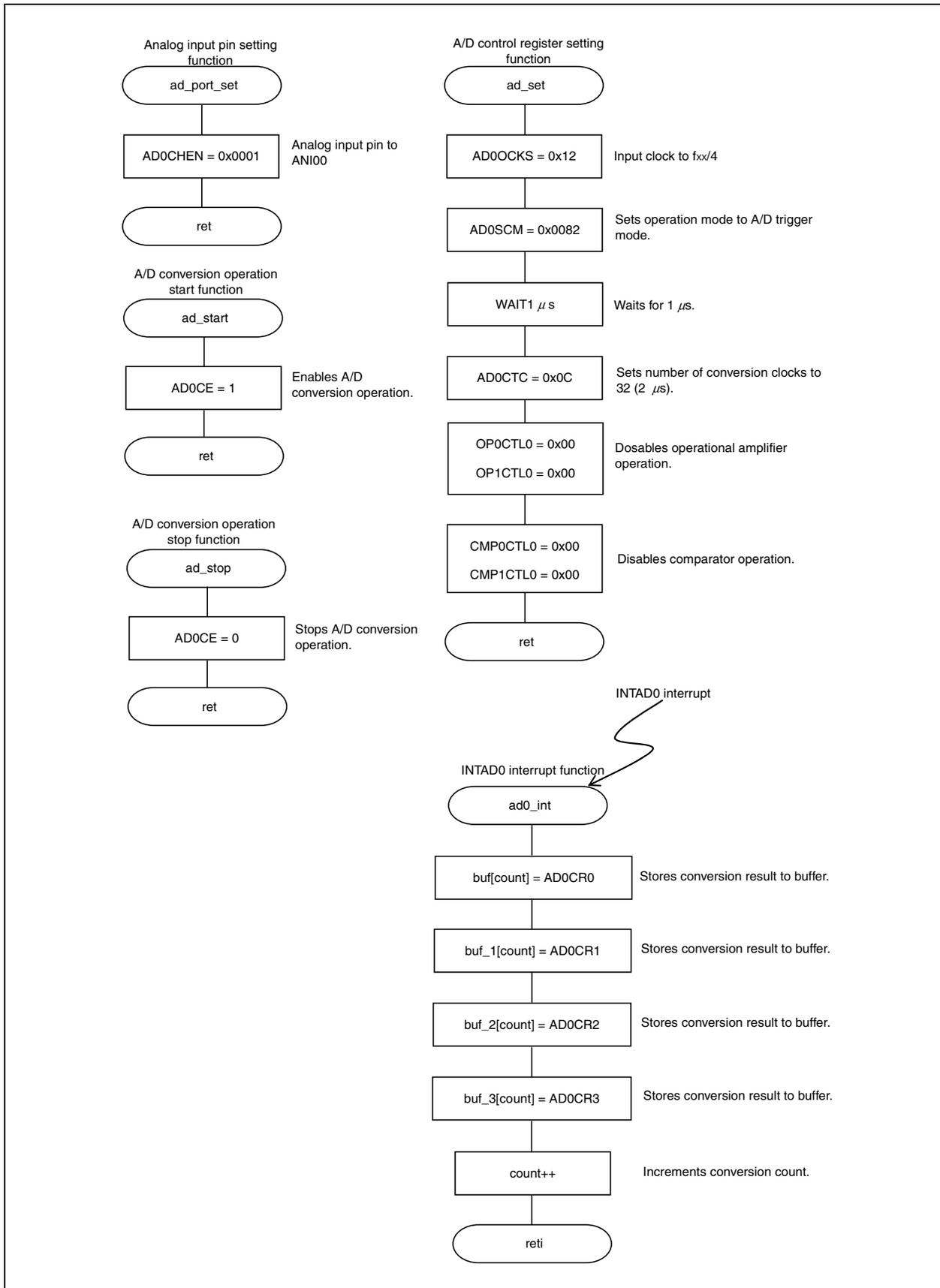


Figure 1-2. A/D Trigger Mode (Multi-Channel Conversion) (2/2)



### 1.3 Hardware Trigger Mode (ITRG1)

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to hardware trigger mode of the normal operation mode.
[Function name]	ad0_external_main
[Argument]	None
[Processing content]	<p>Starts A/D conversion when the trigger is input from the ADTRG0 pin. 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 ANI00 pin, ANI01 pin, ANI02 pin, and ANI03 pin which have been specified by the AD0CHEN register, and continuously performing A/D conversion.</p> <p>An A/D0 conversion end interrupt request signal (INTAD0) occurs upon completion of conversion operation of the specified analog input pins.</p> <p>Performs A/D conversion for 10 times.</p>
[SFRs used]	AD0IC: 0x07 (Clears A/D0 conversion end interrupt request signal (INTAD0), releases mask, sets to priority level 7.)
[call function]	ad_trgger_port_set, ad_port_set, ad_set, ad_start, ad_stop
[Variables]	<p>unsigned short int buf[ ]: Conversion data storing buffer</p> <p>unsigned short int buf_1[ ]: Conversion data storing buffer</p> <p>unsigned short int buf_2[ ]: Conversion data storing buffer</p> <p>unsigned short int buf_3[ ]: Conversion data storing buffer</p> <p>volatile unsigned char count: Conversion count variable</p>
[Interrupt]	ad0_int
[Interrupt source]	INTAD0
[File name]	ad01_external_trigger.c
[Caution]	None

[Function name]	ad_set
[Processing content]	Sets A/D conversion control register.
[SFRs used]	AD0OCKS: 0x12 (Sets input clock to f <sub>xx</sub> /4.) AD0SCM: 0x0182 (Sets hardware trigger mode.) ADTR: 0x00 (Sets to falling edge.) ADTF: 0x01 (Sets to falling edge.) AD0CTC: 0x0C (Sets the number of conversion clocks to 32 (2 μs).) OP0CTL0: 0x00 (Enables operational amplifier 0 operation.) OP1CTL0: 0x00 CMP0CTL0: 0x00 (Disables comparator 0 operation.) CMP1CTL0: 0x00
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c
[Caution]	None

[Function name]	ad_trigger_port_set
[Processing content]	Sets alternate-function pin.
[SFRs used]	PFC1: 0x40 (Specifies to ADTRG0 input pin.) PFCE1: 0x00 (Specifies to ADTRG0 input pin.) PMC1: 0x40 (Specifies to ADTRG0 input pin.)
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c
[Caution]	None

[Function name]	ad_port_set
[Processing content]	Sets analog input pin.
[SFR used]	AD0CHEN: 0x000F (Sets analog input pin to ANI00 pin, ANI01 pin, ANI02 pin, and ANI03 pin.)
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c
[Caution]	None

[Function name]	ad_start
[Processing content]	Enables A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c
[Caution]	None

[Function name]	ad_stop
[Processing content]	Stops A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 0 (Stop A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c
[Caution]	None

## Interrupt function

[Function name]	ad0_int
[Servicing content]	Stores A/D conversion result data to buffer.
[SFRs used]	AD0CR0            A/D0 conversion result register 0 AD0CR1            A/D0 conversion result register 1 AD0CR2            A/D0 conversion result register 2 AD0CR3            A/D0 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]	ad01_external_trigger.c
[Caution]	None

Figure 1-3. Hardware Trigger Mode (ITRG1) (1/2)

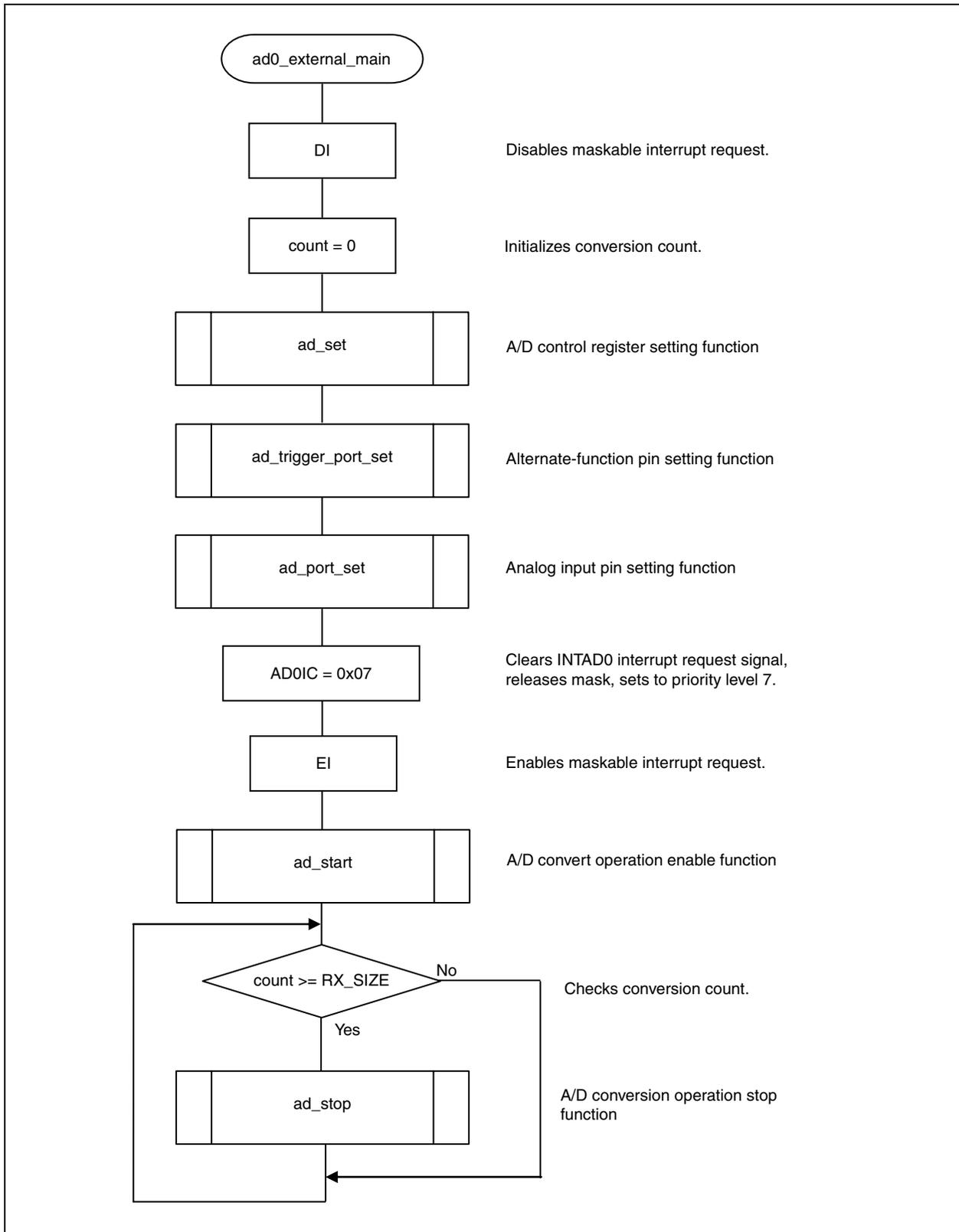
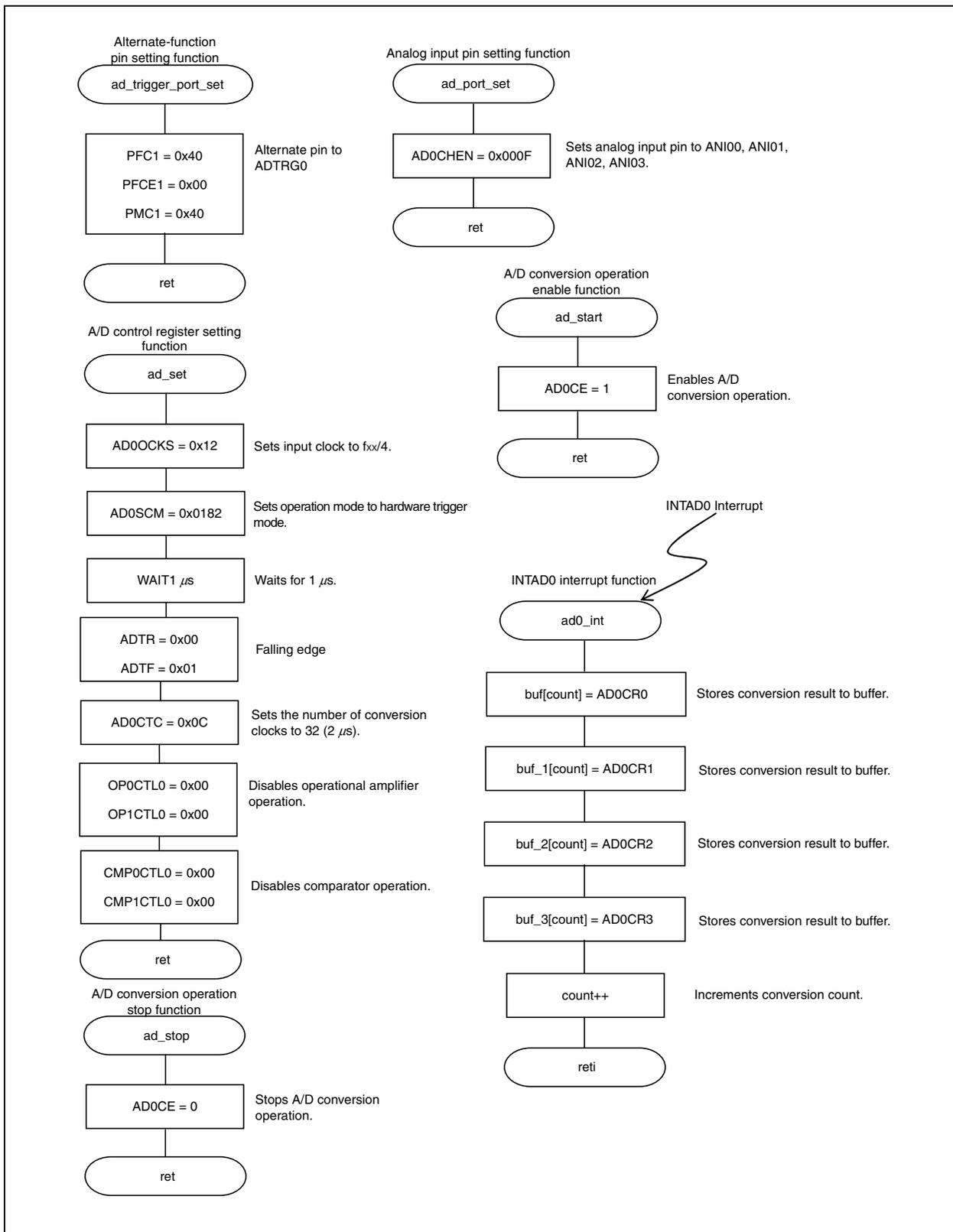


Figure 1-3. Hardware Trigger Mode (ITRG1) (2/2)



## 1.4 Hardware Trigger Mode (ITRG2 to ITRG4)

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to hardware trigger mode of the normal operation mode.
[Function name]	ad0_timer_main
[Argument]	None
[Processing content]	Starts A/D conversion when the A/D conversion start trigger signal of a timer (motor control function) is input. Stores the A/D conversion results to buf[ ] by performing A/D conversion of ANI00 pin. An A/D0 conversion end interrupt request signal (INTAD0) occurs upon every completion of A/D conversion. Performs A/D conversion for 10 times.
[SFR used]	AD0IC: 0x07 (Clears A/D0 conversion end interrupt request signal (INTAD0), releases mask, sets to priority level 7.)
[call function]	ad_port_set, ad_set, ad_start, ad_timer_trigger, ad_stop
[Variables]	unsigned short int buf [ ]: Conversion data storing buffer volatile unsigned char count: Conversion count variable unsigned int wait_co: WAIT variable
[Interrupt]	ad01_int
[Interrupt source]	INTAD0
[File name]	ad01_timer_trigger.c
[Caution]	None

[Function name]	ad_set
[Processing content]	Sets A/D conversion control register.
[SFRs used]	AD0OCKS: 0x12 (Sets input clock to f <sub>xx</sub> /4.) AD0SCM: 0x0182 (Sets hardware trigger mode.) AD0CTC: 0x0C (Sets the number of conversion clocks to 32 (2 $\mu$ s).) OP0CTL0: 0x10 (Enables operational amplifier 0 operation.) OP1CTL0: 0x00 CMP0CTL0: 0x10 (Enables comparator 0 (full-range) operation) CMP1CTL0: 0x00
[call function]	None
[Variable]	unsigned int wait_co: WAIT variable
[File name]	ad01_timer_trigger.c
[Caution]	A stabilization time of 10 $\mu$ s is required after operation of the operational amplifier or comparator is enabled.

[Function name]	ad_port_set
[Processing content]	Sets analog input pin.
[SFR used]	AD0CHEN: 0x0001 (Sets analog input pin to ANI00 pin.)
[call function]	None
[Variable]	None
[File name]	ad01_timer_trigger.c
[Caution]	None

[Function name]	ad_start
[Processing content]	Enables A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_timer_trigger.c
[Caution]	None

[Function name]	ad_timer_trigger
[Processing content]	Sets the timer trigger of the A/D conversion.
[SFRs used]	TAA0CTL0.TAA0CE: 1 (Starts TAA0 operation.) TAB0CTL0.TAB0CE: 1 (Starts TAB0 operation.)
[call function]	None
[Variable]	None
[File name]	ad01_timer_trigger.c
[Cautions]	Omitted due to the same settings as the int_taa_init, int_tab_init, int_tmq_op_init functions in interrupt.c. For details of interrupt.c, refer to <b>V850E/IF3, V850E/IG3 Sample Programs for Interrupt Function Application Note (U18736E)</b> .

[Function name]	ad_stop
[Processing content]	Stops A/D convert operation.
[SFR used]	AD0SCM.AD0CE: 0 (Stops A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_timer_trigger.c
[Caution]	None

## Interrupt function

[Function name]	ad0_int
[Processing content]	Stores A/D conversion result data to buffer.
[SFR used]	AD0CR0                      A/D0 conversion result register 0
[call function]	None
[Variables]	unsigned short int buf [ ]:      Conversion data storing buffer volatile unsigned char count:    Conversion count variable
[File name]	ad01_timer_trigger.c
[Caution]	None

Figure 1-4. Hardware Trigger Mode (ITRG2 to ITRG4) (1/3)

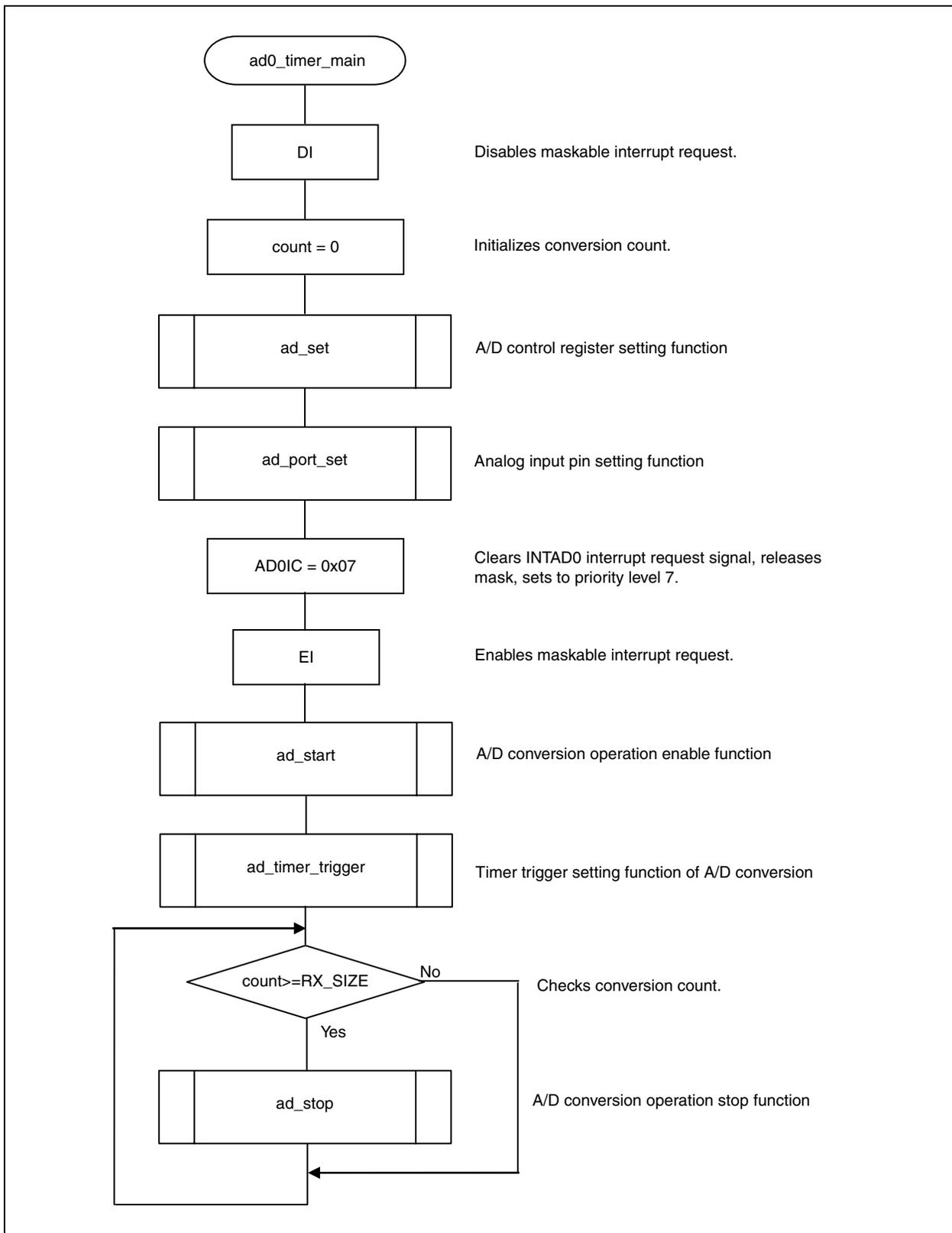


Figure 1-4. Hardware Trigger Mode (ITRG2 to ITRG4) (2/3)

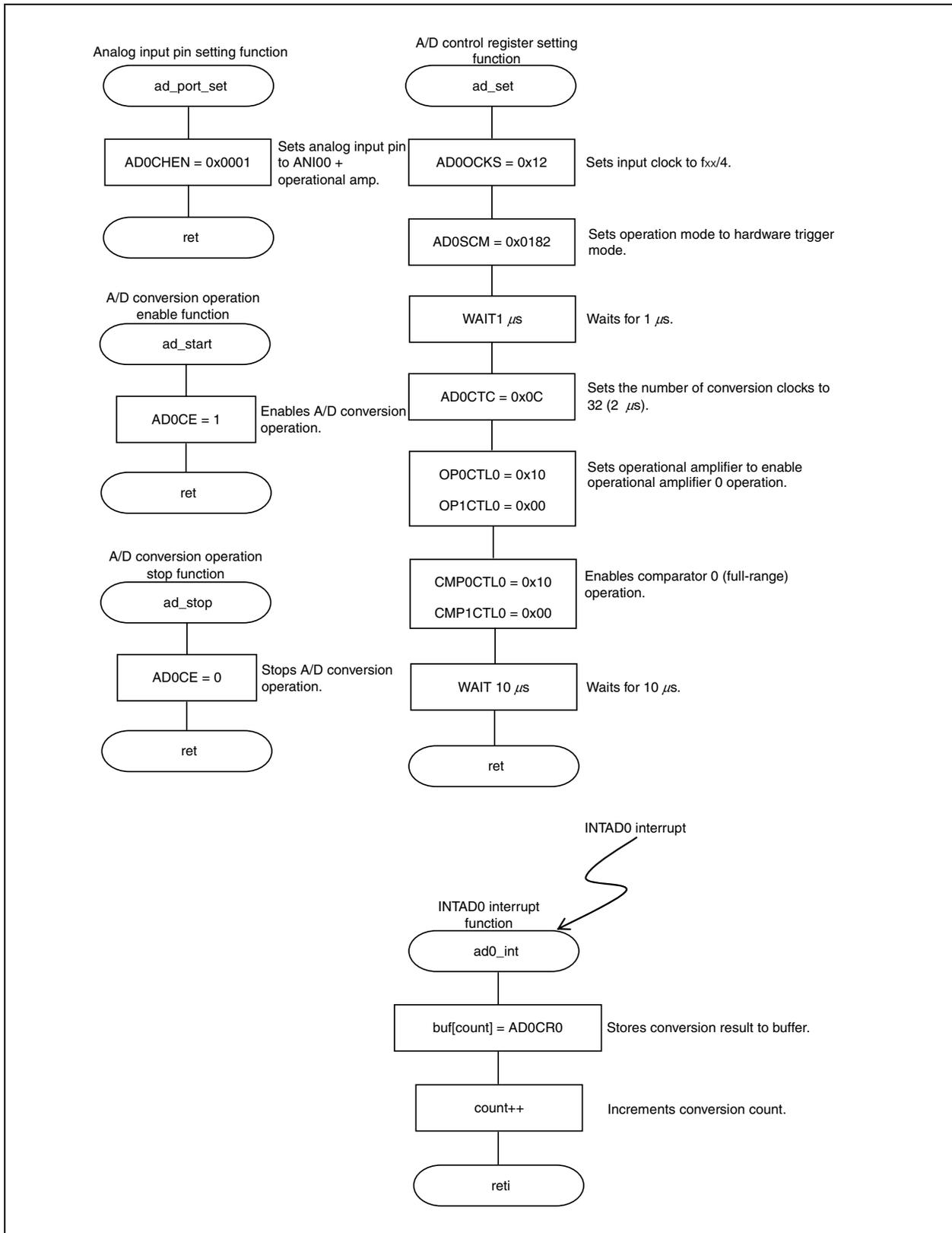
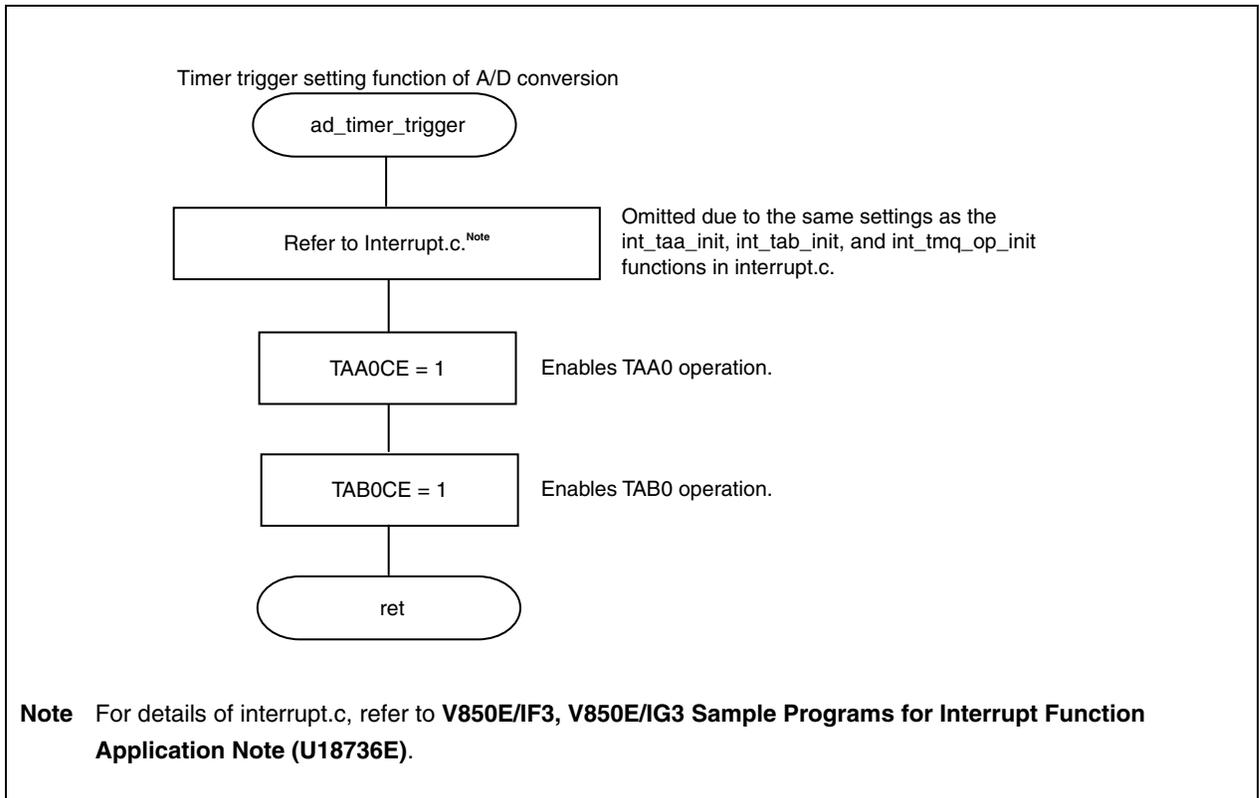


Figure 1-4. Hardware Trigger Mode (ITRG2 to ITRG4) (3/3)



## CHAPTER 2 EXTENDED OPERATION MODE

### 2.1 Conversion Channel Specification Mode

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to conversion channel specification mode of the extended operation mode.
[Function name]	ad0_change_channel_main
[Argument]	None
[Processing content]	Starts the A/D conversion when the ITRG1 signal is generated by setting the AD0CE bit to 1 and entering into the trigger wait status. Performs the A/D conversion of ANI01 pin for four times and stores the A/D conversion results to buf[ ], buf_1[ ], buf_2[ ], and buf_3[ ]. An A/D0 conversion end interrupt request signal (INTAD0) occurs upon every completion of A/D conversion. Performs A/D conversion for 10 times.
[SFR used]	AD0IC: 0x07 (Clears A/D0 conversion end interrupt request signal (INTAD0), releases mask, sets to priority level 7.)
[call function]	ad_port_set, ad_set, ad_start, ad_stop
[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
[Interrupt]	ad0_int
[Interrupt source]	INTAD0
[File name]	ad01_change_channel.c
[Caution]	None

[Function name]	ad_set
[Processing content]	Sets A/D conversion control register.
[SFRs used]	AD0OCLKS: 0x12 (Sets input clock to f <sub>xx</sub> /4.) AD0SCM: 0x0182 (Sets hardware trigger mode.) AD0TSEL: 0x00 (Specifies ITRG1 as trigger.) AD0CTL0: 0x02 (Sets to conversion channel specification mode.) AD0CTC: 0x0C (Sets the number of conversion clocks to 32 (2 μs).) OP0CTL0: 0x00 (Disables operational amplifier 0 operation.) OP1CTL0: 0x00 CMP0CTL0: 0x00 (Disables comparator 0 operation.) CMP1CTL0: 0x00
[call function]	None
[Variable]	None
[File name]	ad01_change_channel.c
[Caution]	None

[Function name]	ad_port_set
[Processing content]	Sets analog input pin.
[SFRs used]	AD0CHEN: 0x000F (Sets the number of conversions to 4 times.) AD0CH1: 0x11 (Sets analog input pin to ANI01 pin.)
[call function]	None
[Variable]	None
[File name]	ad01_change_channel.c
[Caution]	None

[Function name]	ad_start
[Processing content]	Enables A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_change_channel.c
[Caution]	None

[Function name]	ad_stop
[Processing content]	Stops A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 0 (Stops A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_change_channel.c
[Caution]	None

## Interrupt function

[Function name]	ad0_int
[Processing content]	Stores A/D conversion result data to buffer.
[SFRs used]	AD0CR0: A/D0 conversion result register 0 AD0CR1: A/D0 conversion result register 1 AD0CR2: A/D0 conversion result register 2 AD0CR3: A/D0 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]	ad01_change_channel.c
[Caution]	None

Figure 2-1. Conversion Channel Specification Mode (1/2)

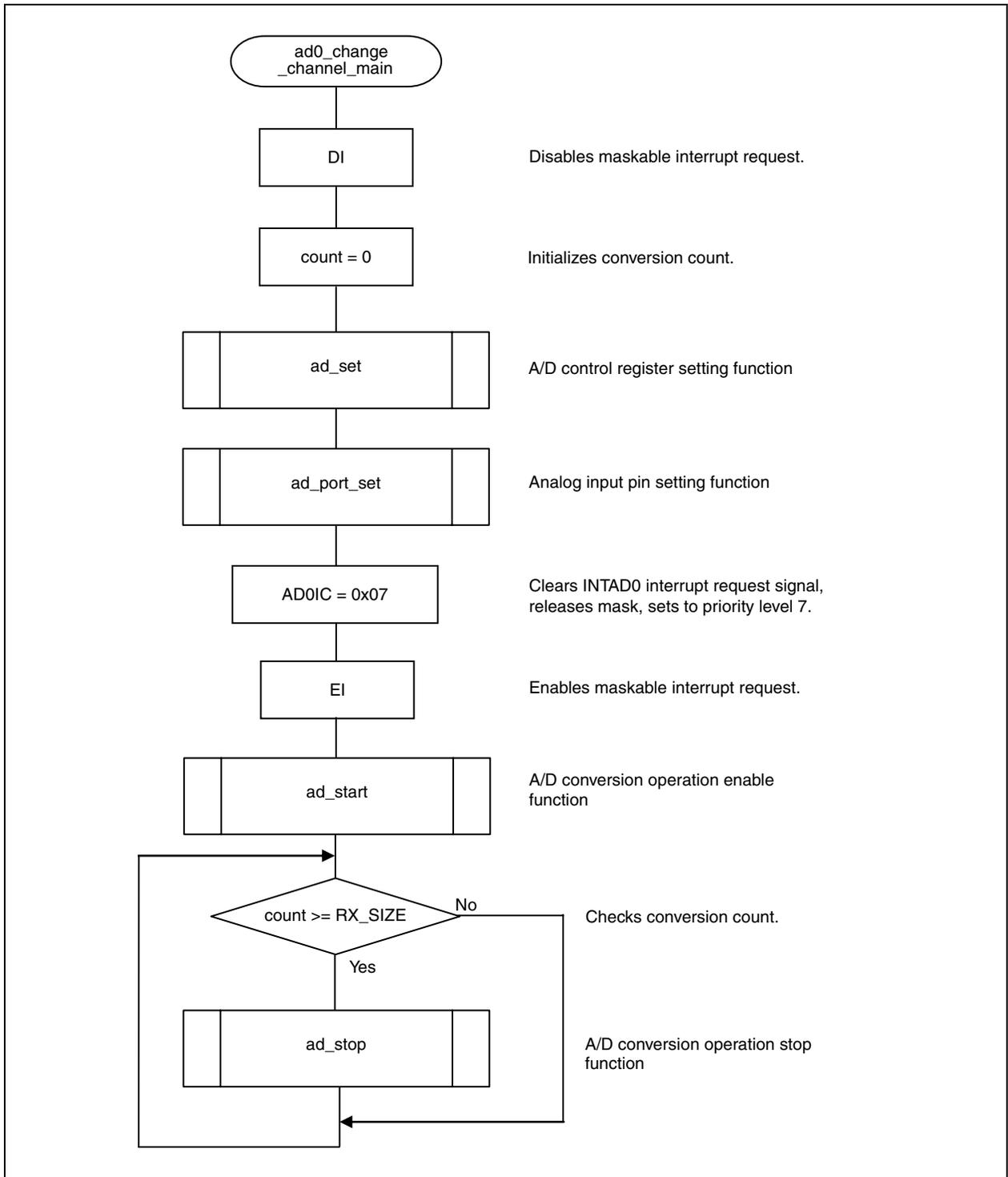
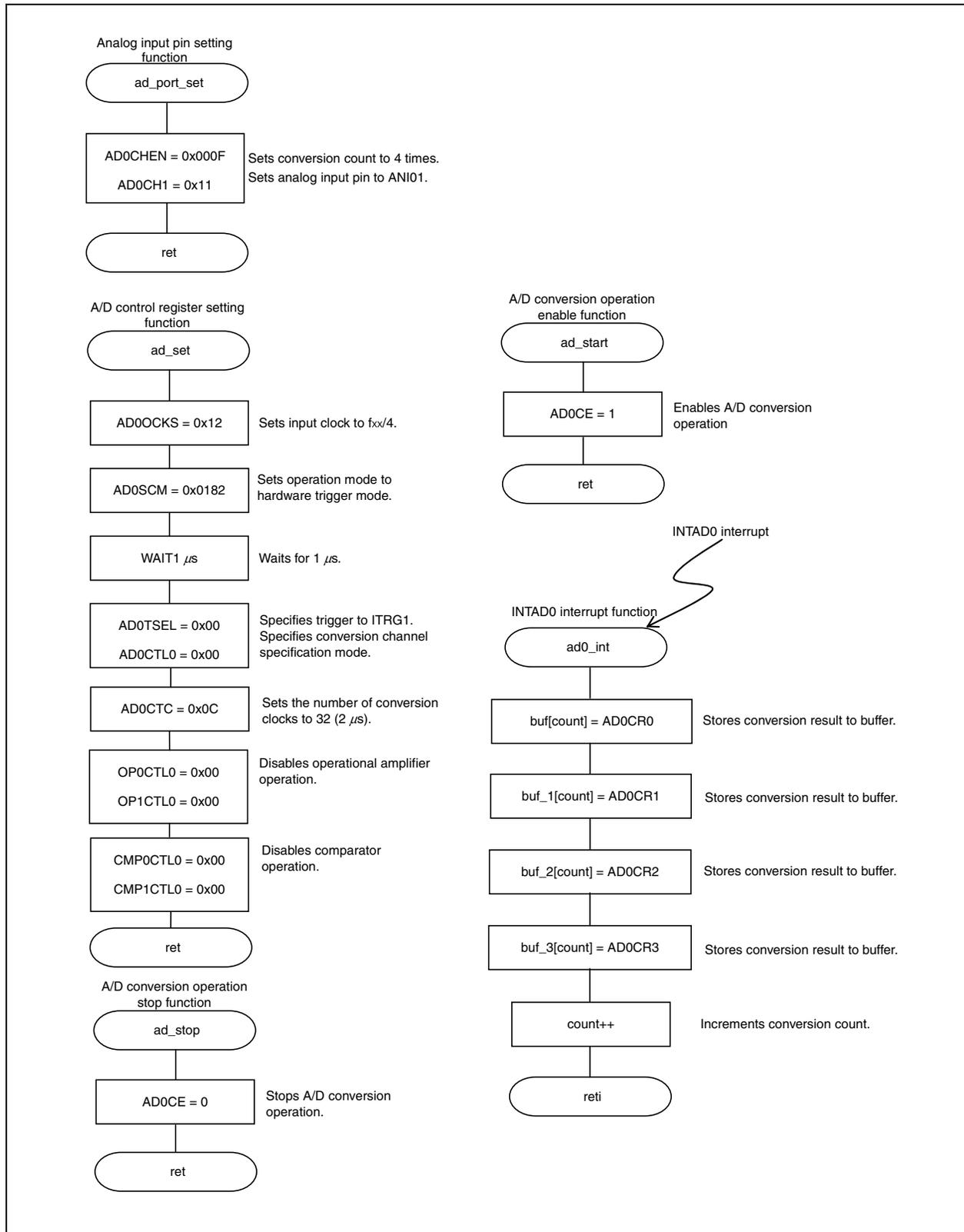


Figure 2-1. Conversion Channel Specification Mode (2/2)



## 2.2 Extension Buffer Mode

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to extension buffer mode of the extended operation mode.
[Function name]	ad0_extension_buffer_main
[Argument]	None
[Processing content]	<p>Starts A/D conversion when the ITRG1 and ITRG2 signals are generated by setting the AD0CE bit to 1 and entering into the trigger wait status.</p> <p>Performs the A/D conversion every time the ITRG1 signal occurs, by switching the analog input pins in the order of ANI05 pin and ANI00 pin, and stores the A/D conversion results to the A/D0 conversion result extension buffer registers 0 to 2.</p> <p>Generates an A/D0 conversion end interrupt request signal (INTAD0) upon every completion of A/D conversion.</p> <p>Stores the values of the A/D0 conversion result extension buffer registers 0 to 2 to buf[ ] when the LDTRG1 signal is generated.</p> <p>Performs the A/D conversion every time the ITRG2 signal occurs, by switching the analog input pins in the order of ANI03 pin and ANI02 pin, and stores the A/D conversion results to the A/D0 conversion result extension buffer registers 3 and 4.</p> <p>Generates an A/D0 conversion end interrupt request signal (INTAD0) occurs upon every completion of A/D conversion. Stores the values of the A/D0 conversion result extension buffer registers 3 and 4 to buf[ ] when the LDTRG2 signal occurs. Performs A/D conversion once.</p>
[SFRs used]	<p>AD0IC: 0x07 (Clears A/D0 conversion end interrupt request signal (INTAD0), releases mask, sets to priority level 7.)</p> <p>TB0OVIC: 0x07 (Clears TAB0 overflow interrupt request signal (INTTB0OV), releases mask, sets to priority level 7.)</p> <p>TB0CCIC0: 0x07 (Clears TAB0 capture interrupt request signal, releases mask, sets to priority level 7.)</p>
[call function]	ad_port_set, ad_set, ad_start, ad_stop
[Variable]	unsigned short int buf[ ]: Conversion data storing buffer
[Interrupt]	ad0_int, ad0_int_tabcc0, ad0_int_tab0ov
[Interrupt source]	INTAD0, INTTB0CC0, INTTB0OV
[File name]	ad01_extension_buffer.c
[Caution]	None

[Function name]	ad_set
[Processing content]	Sets A/D conversion control register.
[SFRs used]	AD0OCKS: 0x12 (Sets input clock to $f_{xx}/4$ ) AD0SCM: 0x0182 (Sets hardware trigger mode.) AD0TSEL: 0x90 (Sets selection trigger 1 to ITRG1, selection load trigger 1 to LDTRG1, selection trigger 2 to ITRG2, and selection load trigger 2 to LDTRG2.) AD0CTL0: 0x03 (Sets extension buffer mode.) AD0CTC: 0x0C (Sets the number of conversion clocks to 32 (2 $\mu$ S).) ADLTS1: 0x00 (Specifies TABTIOV0 as input signal to LDTRG1.) ADLTS2: 0x00 (Specifies TABTICCO as input signal to LDTRG2.) OPOCTL0: 0x00 (Disables operational amplifier 0 operation.) OP1CTL0: 0x00 CMP0CTL0: 0x00 (Disables comparator 0 operation.) CMP1CTL0: 0x00
[call function]	None
[Variable]	None
[File name]	ad01_extension_buffer.c
[Caution]	None

[Function name]	ad_port_set
[Processing content]	Sets analog input pin.
[SFRs used]	AD0CHEN: 0x0001 AD0CH1: 0x05 (Sets analog input pin corresponding to selection trigger 1 to ANI05 pin and ANI00 pin.) AD0CH2: 0x23 (Sets analog input pin corresponding to selection trigger 2 to ANI03 pin and ANI02 pin.)
[call function]	None
[Variable]	None
[File name]	ad01_extension_buffer.c
[Caution]	None

[Function name]	ad_start
[Processing content]	Enables A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_extension_buffer.c
[Caution]	None

[Function name]	ad_stop
[Processing content]	Stops A/D conversion operation.
[SFR used]	AD0SCM.AD0CE: 0 (Stops A/D convert operation.)
[call function]	None
[Variable]	None
[File name]	ad01_extension_buffer.c
[Caution]	None

### Interrupt function

[Function name]	ad0_int
[Processing content]	None
[SFR used]	None
[call function]	None
[Variable]	None
[File name]	ad01_extension_buffer.c
[Caution]	None

[Function]	ad0_int_tab0ov
[Processing content]	Stores A/D conversion result data to buffer.
[SFRs used]	AD0ECR0:            A/D0 conversion result extension register 0 AD0ECR1:            A/D0 conversion result extension register 1 AD0ECR2:            A/D0 conversion result extension register 2
[call function]	None
[Variable]	unsigned short int buf [ ]:    Conversion data storing buffer
[File name]	ad01_extension_buffer.c
[Caution]	None

[Function]	ad0_int_tabcc0
[Processing content]	Stores A/D conversion result data to buffer.
[SFRs used]	AD0ECR3:            A/D0 conversion result extension register 3 AD0ECR4:            A/D0 conversion result extension register 4
[call function]	ad_stop
[Variable]	unsigned short int buf [ ]:    Conversion data storing buffer
[File name]	ad01_extension_buffer.c
[Caution]	None

Figure 2-2. Extension Buffer Mode (1/3)

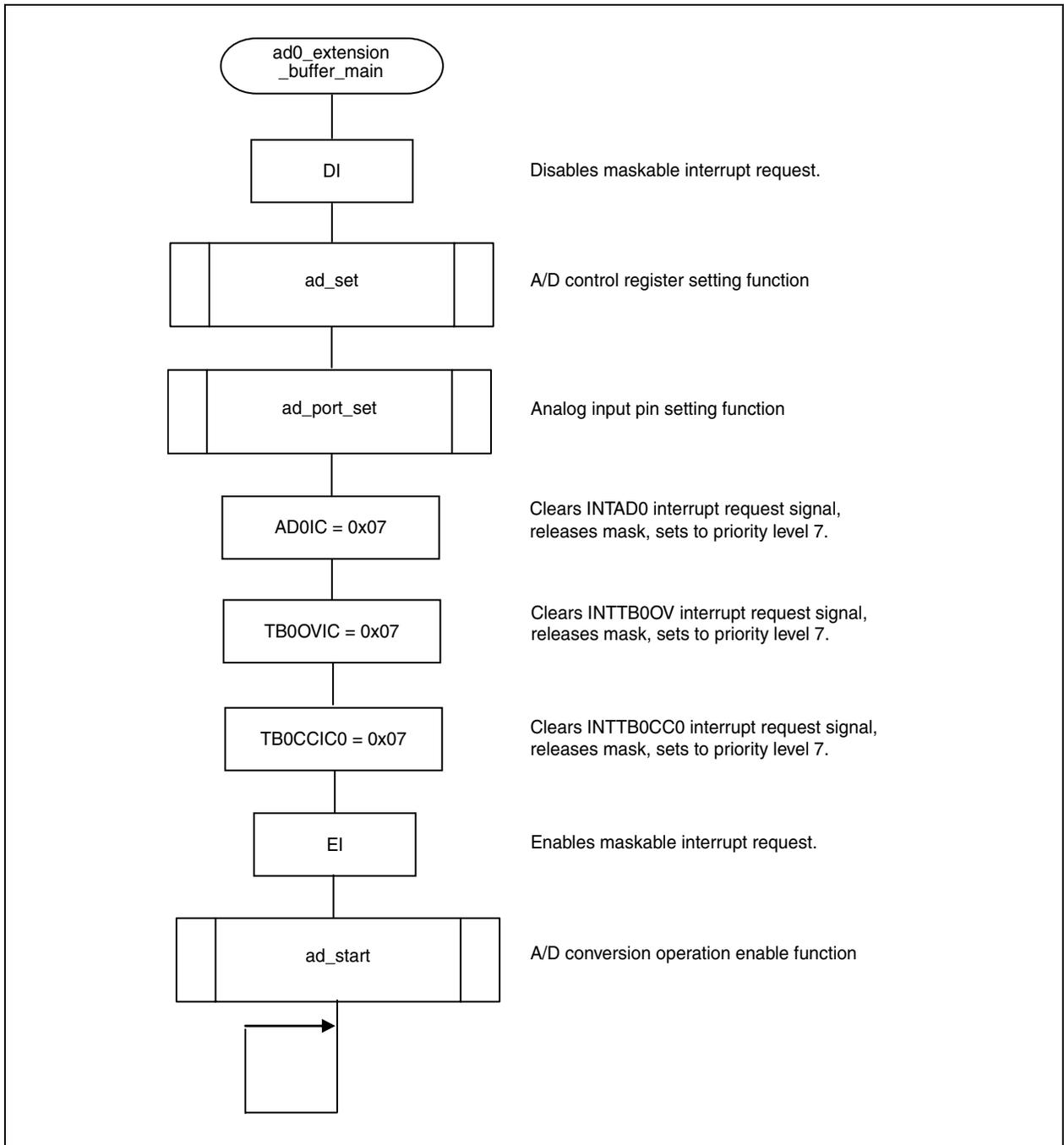


Figure 2-2. Extension Buffer Mode (2/3)

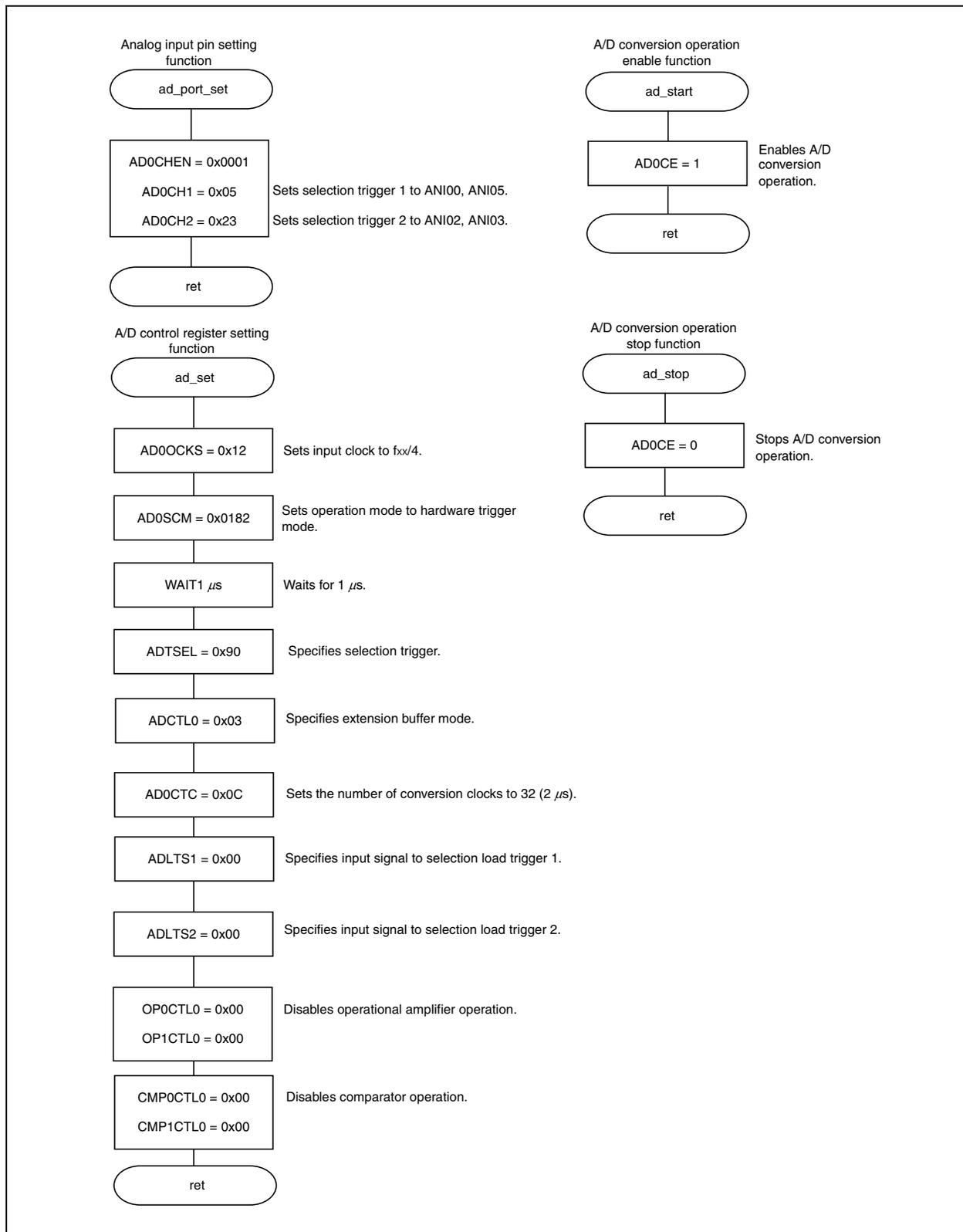
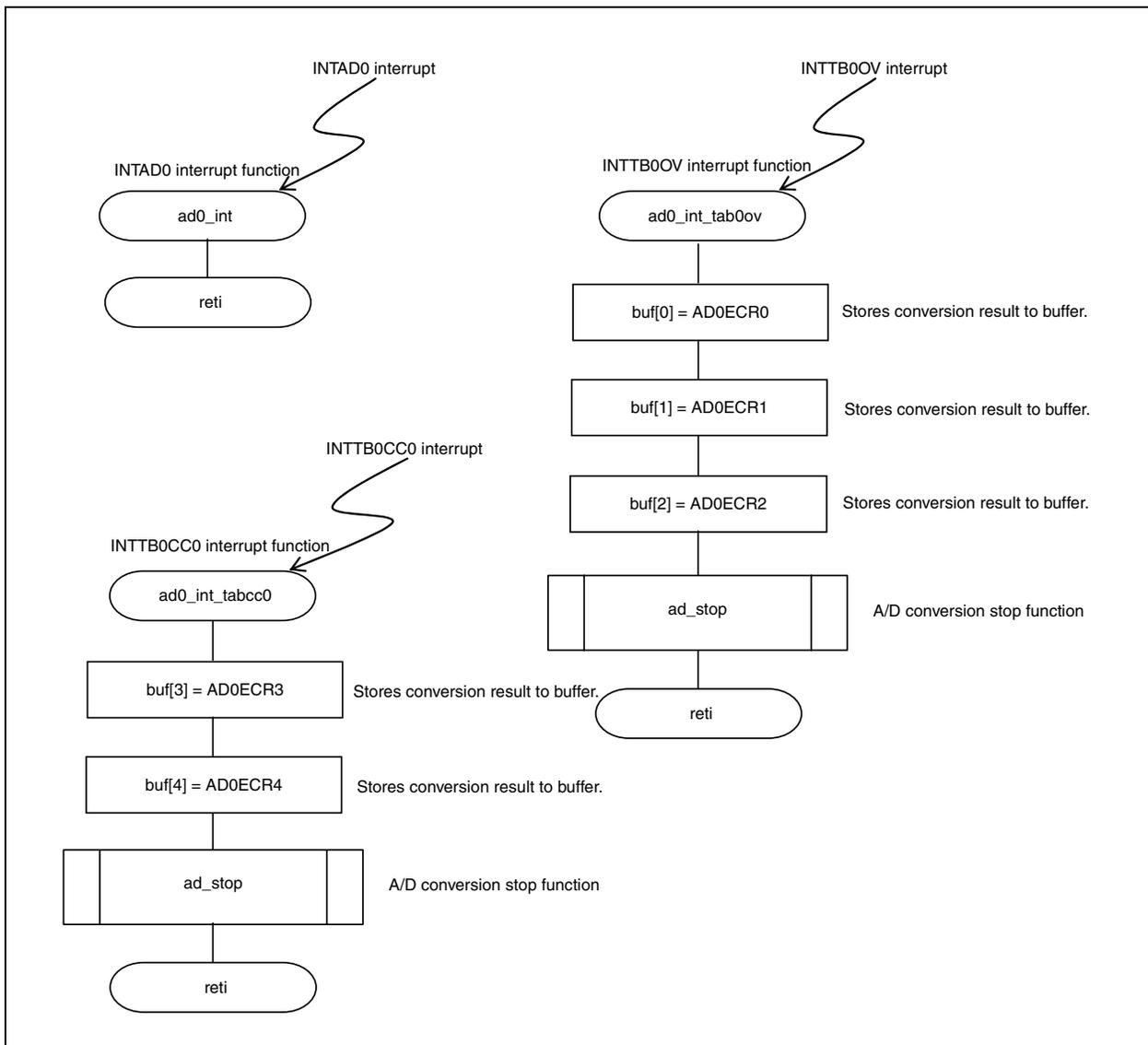


Figure 2-2. Extension Buffer Mode (3/3)



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