

To our customers,

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April 1<sup>st</sup>, 2010  
Renesas Electronics Corporation

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# Manual for Using Sample Program Functions A/D Converters 0 and 1 (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2)

This manual explains the sample program functions of A/D converters 0 and 1 for the V850/IA4 microcontroller. The explanations are based on usage with the V850E/IA4 microcontroller. Refer to this manual when using the V850E/IA3, V850ES/IK1, and V850ES/IE2 microcontrollers.

## Caution

**This sample program is provided for reference purposes only and operations are therefore not subject to guarantee by NEC Electronics Corporation. When using this sample program, we advise customers to sufficiently evaluate this product based on their system before usage.**

## 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. Download the program used in this manual from the NEC Electronics Website (<http://www.necel.com/>).

2. When using this sample program, reference the following startup file and link directive file and adjust them if as necessary.

- Startup file: IA4\_start.s
- Link directive file: IA4\_link.dir

**Conventions** The function lists are structured as follows.

### Hardware name

[Function]	Function description
[Function name]	Name of sample function
[Argument]	Type and overview of argument
[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
[Processing content]	Processing content of interrupt function
[SFR(s) used]	Register name and setting content
[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/IA4 and the V850E/IA3, V850ES/IK1, and V850ES/IE2 related to A/D converters 0 and 1 are shown below.

Item	V850E/IA4	V850E/IA3	V850ES/IK1	V850ES/IE2
Analog input	Total of two circuits: 8 channels A/D converter 0: 4 channels A/D converter 1: 4 channels	Total of two circuits: 6 channels A/D converter 0: 2 channels A/D converter 1: 4 channels	Total of two circuits: 8 channels A/D converter 0: 4 channels A/D converter 1: 4 channels	
Operational amplifier for input level amplification	Total of two circuits: 6 channels A/D converter 0: 3 channels A/D converter 1: 3 channels	Total of two circuits: 5 channels A/D converter 0: 2 channels: A/D converter 1: 3 channels	None	
Overvoltage detection comparator	Total of two circuits: 6 channels A/D converter 0: 3 channels A/D converter 1: 3 channels	Total of two circuits: 5 channels A/D converter 0: 2 channels A/D converter 1: 3 channels	None	
AV <sub>DD0</sub> , AV <sub>DD1</sub> , AV <sub>REF0</sub> , AV <sub>REF1</sub>	Alternate-function pin	Alternate-function pin	Independent pin	

**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/IA3, V850E/IA4, V850ES/IK1, and V850ES/IE2**

Document Name	Document No.
V850E1 Architecture User's Manual	U14559E
V850E/IA3, V850E/IA4 Hardware User's Manual	U16543E
V850ES Architecture User's Manual	U15943E
V850ES/IK1 Hardware User's Manual	U16910E
V850ES/IE2 Hardware User's Manual	U17716E
Inverter Control by V850 Series Vector Control by Hole Sensor Application Note	U17338E
Inverter Control by V850 Series Vector Control by Encoder Application Note	U17324E
Inverter Control by V850 Series 120° Excitation Method Control by Zero-Cross Detection Application Note	U17209E
Manual for Using Sample Program Functions Serial Communication (UARTA) (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18233E
Manual for Using Sample Program Functions Serial Communication (CSIB) (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18234E
Manual for Using Sample Program Functions DMA Functions (V850E/IA3, V850E/IA4) Application Note	U18235E
Manual for Using Sample Program Functions Timer M (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18236E
Manual for Using Sample Program Functions Watchdog Timer (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18237E
Manual for Using Sample Program Functions Timer P (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18238E
Manual for Using Sample Program Functions Timer Q (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18239E
Manual for Using Sample Program Functions Timer ENC (V850E/IA3, V850E/IA4) Application Note	U18240E
Manual for Using Sample Program Functions Port Functions (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18241E
Manual for Using Sample Program Functions Clock Generator (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18242E
Manual for Using Sample Program Functions Standby Function (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18243E
Manual for Using Sample Program Functions Interrupt Functions (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	U18244E
Manual for Using Sample Program Functions A/D Converters 0 and 1 (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note	This document
Manual for Using Sample Program Functions A/D Converter 2 (V850E/IA3, V850E/IA4) Application Note	U18246E

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## A/D converters 0 and 1

### External trigger mode (continuous scan mode)

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to external trigger mode of the hardware trigger mode.
[Function name]	ad0_external_main
[Argument]	None
[Processing content]	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, ANI01pin, ANI02 pin, and ANI03 pin and continuously performing A/D conversion when a trigger is input from the ADTRG0 pin.  An A/D0 conversion end interrupt request signal (INTAD0) occurs upon completion of conversion operation of the specified analog input pins.  Performs A/D conversion for 10 times.
[SFR used]	AD0IC:           0x07 (Clears A/D0 conversion end interrupt request signal, releases mask, sets to priority level 7.)
[call functions]	ad_trgger_port_set, 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_external_trigger.c
[Caution]	None

[Function name]	ad_trigger_port_set
[Processing content]	Sets the alternate-function pin.
[SFR used]	PMC0:           0x10 (Specifies P40 pin as ADTRG0 input pin.)
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c

[Function name]	ad_port_set
[Processing content]	Sets the analog input pin.
[SFR used]	ADA0S: 0x03 (Sets analog input pins to ANI00 pin, ANI01 pin, ANI02 pin and ANI03 pin.)
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c

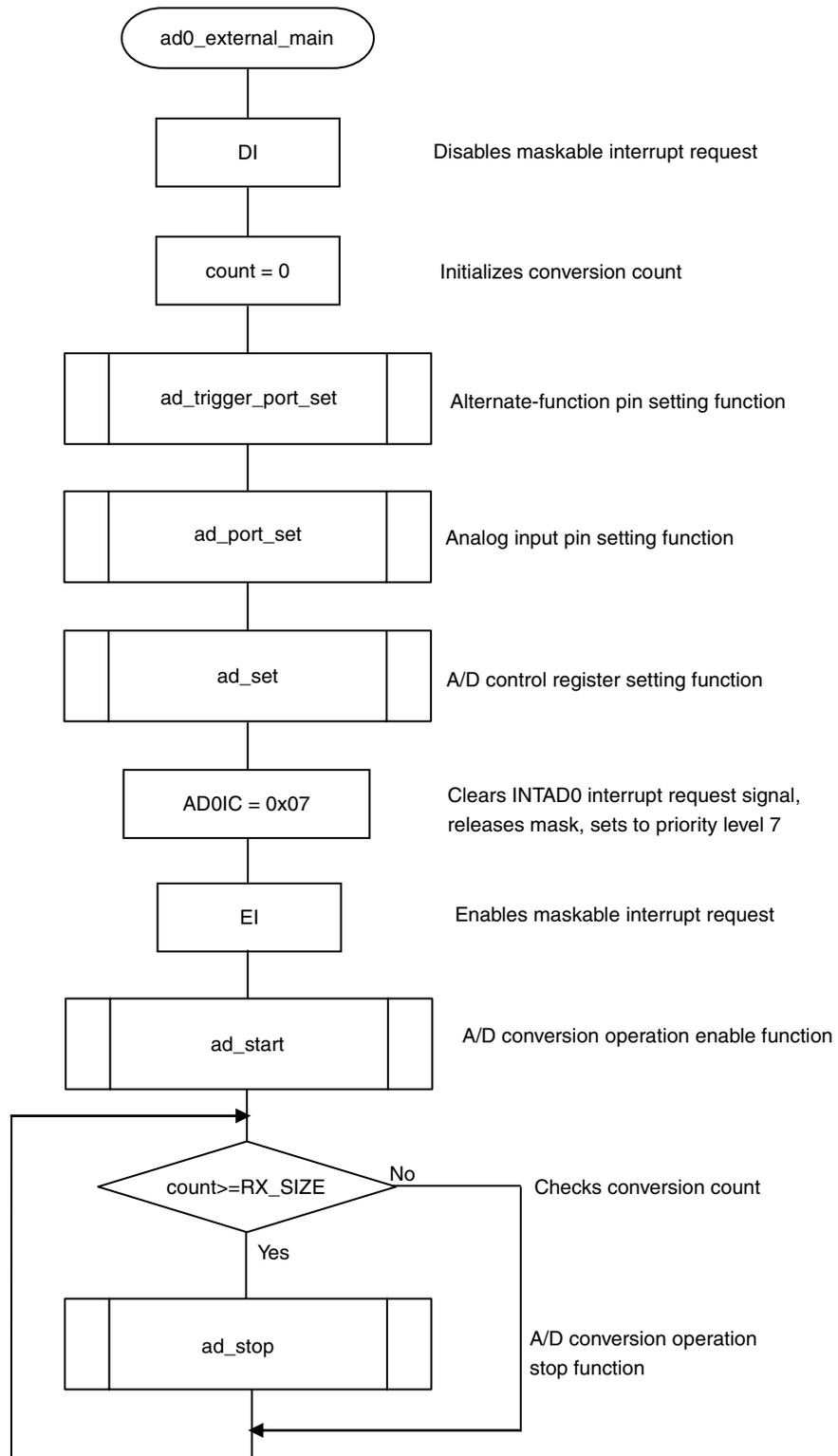
[Function name]	ad_set
[Processing content]	Sets the A/D conversion control register.
[SFRs used]	ADA0M0: 0x16 (Sets to continuous scan mode, hardware trigger mode, and sets valid edge to falling edge.)
	ADA0M2: 0x00 (Sets to 1-buffer mode and external trigger mode.)
	ADA0M1: 0x02 (Sets conversion clock number to 186 (2.91 $\mu$ s).)
	OP0CTL0: 0x00 (Disables operation of operational amplifier 0.)
	OP0CTL1: 0x00 (Disables operation of comparator 0.)
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c

[Function name]	ad_start
[Processing content]	Enables A/D conversion operation.
[SFR used]	ADA0M0.ADA0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c

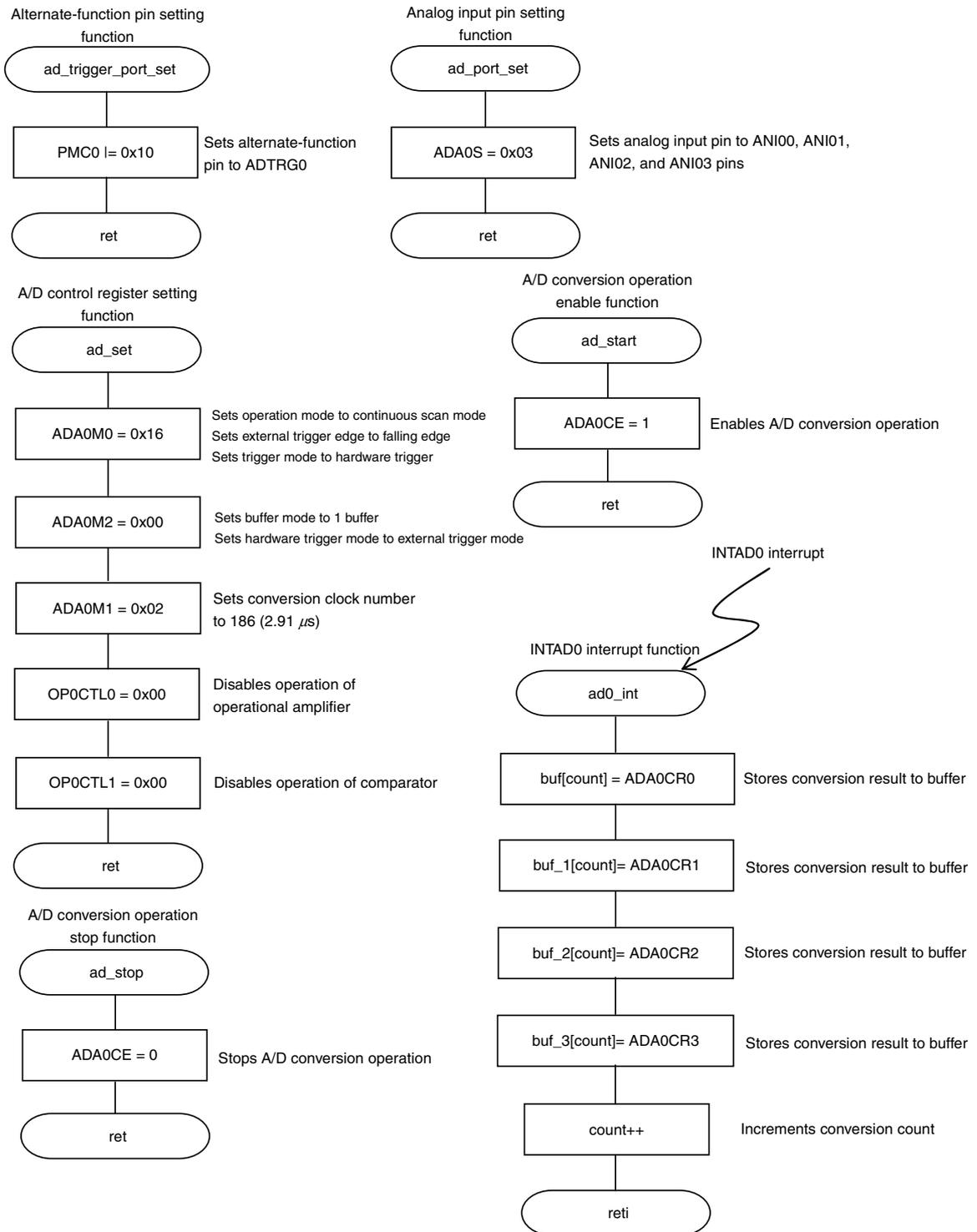
[Function name]	ad_stop
[Processing content]	Stops A/D conversion operation.
[SFR used]	ADA0M0.ADA0CE: 0 (Stops A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_external_trigger.c

## Interrupt function

[Function name]	ad0_int
[Processing content]	Stores A/D conversion result data to buffer.
[SFRs used]	ADA0CR0                    A/D0 conversion result register 0 ADA0CR1                    A/D0 conversion result register 1 ADA0CR2                    A/D0 conversion result register 2 ADA0CR3                    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



External trigger mode (continuous scan mode) (2/2)



## A/D converters 0 and 1

### Software trigger mode (continuous select mode, 1 buffer)

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to software trigger mode.
[Function name]	ad0_software_main
[Argument]	None
[Processing content]	Starts A/D conversion by setting the ADA0M0.ADA0CE bit to 1. Stores the A/D conversion result to buf[] by A/D converting the ANI00 pin input. An A/D0 conversion end interrupt request signal (INTAD0) occurs upon completion of every 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 functions]	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
[Interrupt]	ad0_int
[Interrupt source]	INTAD0
[File name]	ad01_software_trigger.c
[Caution]	None

[Function name]	ad_port_set
[Processing content]	Sets the analog input pin.
[SFR used]	ADA0S: 0x04 (Sets analog input pin to ANI00 + operational amplifier.)
[call function]	None
[Variable]	None
[File name]	ad01_software_trigger.c

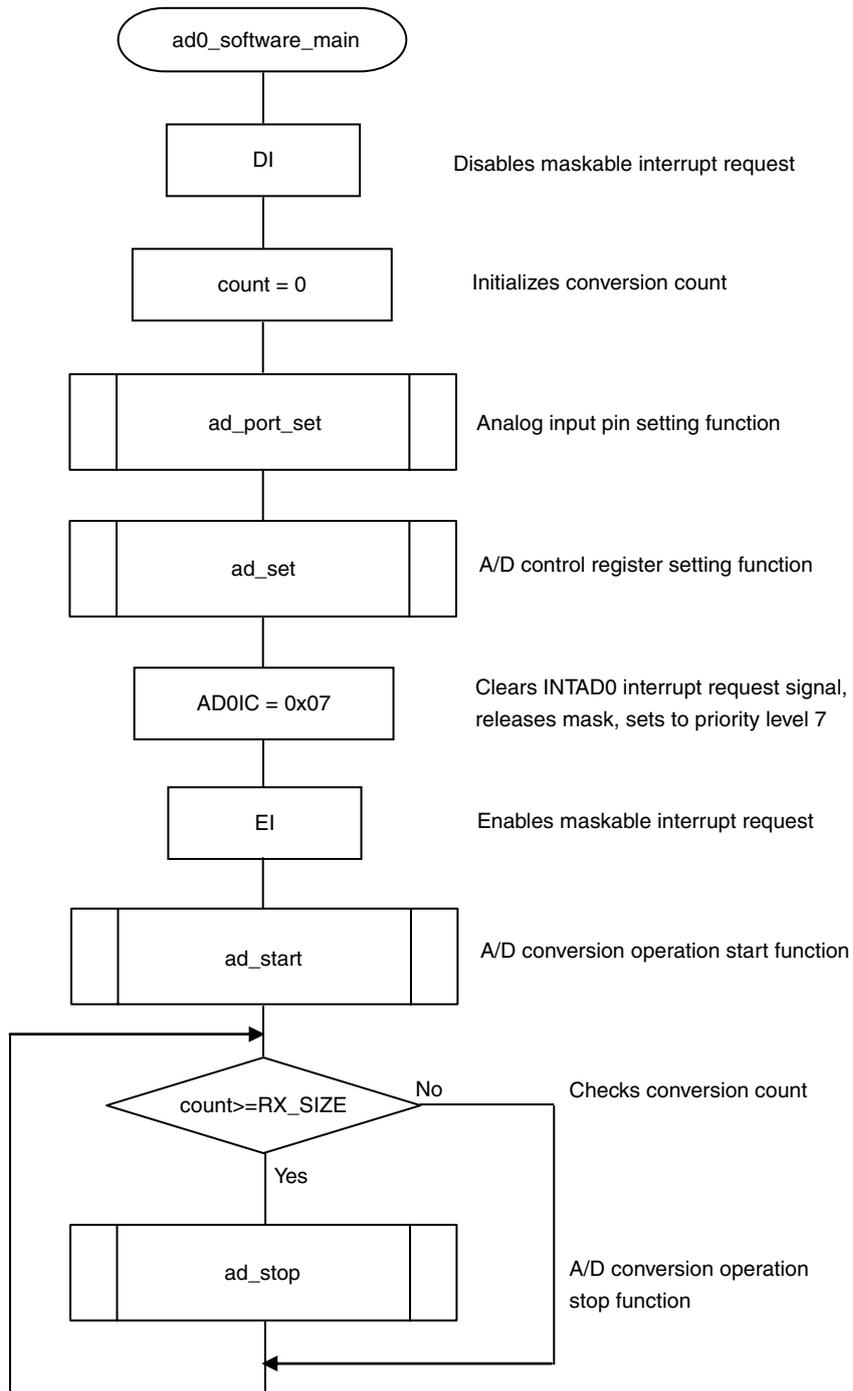
[Function name]	ad_set
[Processing content]	Sets the A/D conversion control register.
[SFRs used]	ADA0M0: 0x00 (Sets to continuous select mode, software trigger mode, and sets valid edge to “No edge detection”.) ADA0M2: 0x00 (Sets to 1-buffer mode.) ADA0M1: 0x02 (Sets conversion clock number to 186 (2.91 $\mu$ s).) OP0CTL0: 0x10 (Enables operation of operational amplifier 0, sets amplification (gain) to 2.5 times.) OP0CTL1: 0x10 (Enables operation of comparator 0.)
[call function]	None
[Variable]	unsigned int wait_co
[File name]	ad01_software_trigger.c
[Caution]	A stabilization time of 50 $\mu$ s is required after operations of the operational amplifier and the comparator are enabled.

[Function name]	ad_start
[Processing content]	Starts A/D conversion operation.
[SFR used]	ADA0M0.ADA0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_software_trigger.c

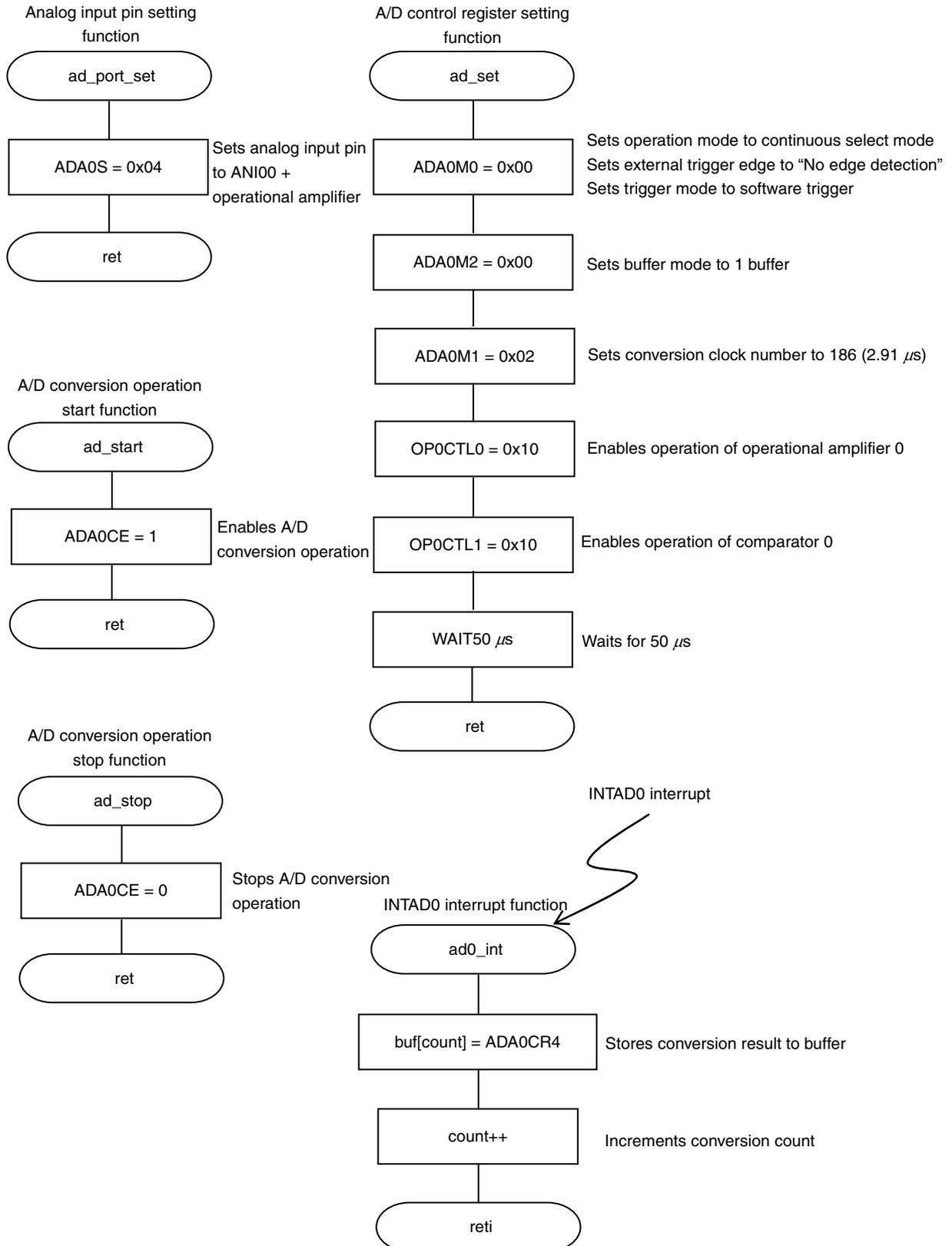
[Function name]	ad_stop
[Processing content]	Stops A/D conversion operation.
[SFR used]	ADA0M0.ADA0CE: 0 (Stops A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_software_trigger.c

## Interrupt function

[Function name]	ad0_int
[Processing content]	Stores A/D conversion result data to buffer.
[SFR used]	ADA0CR4                      A/D conversion result register 4
[call function]	None
[Variables]	unsigned short int buf [ ]:    Conversion data storing buffer volatile unsigned char count: Conversion count variable
[File name]	ad01_software_trigger.c



Software trigger mode (continuous select mode, 1 buffer) (2/2)



## A/D converters 0 and 1

### Software trigger mode (continuous select mode, 4 buffers)

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to software trigger mode.
[Function name]	ad0_software1_main
[Argument]	None
[Processing content]	Starts A/D conversion by setting the ADA0M0.ADA0CE bit to 1. Stores A/D conversion result to buf[], buf_1[], buf_2[], and buf_3[] by A/D converting the ANI00 pin input for four times. An A/D0 conversion end interrupt request signal (INTAD0) occurs upon completion of four A/D conversions. 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 functions]	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
[Interrupt]	ad0_int
[Interrupt source]	INTAD0
[File name]	ad01_software1_trigger.c
[Caution]	None

[Function name]	ad_port_set
[Processing content]	Sets the analog input pin.
[SFR used]	ADA0S: 0x00 (Sets analog input pin to ANI00.)
[call function]	None
[Variables]	None
[File name]	ad01_software1_trigger.c

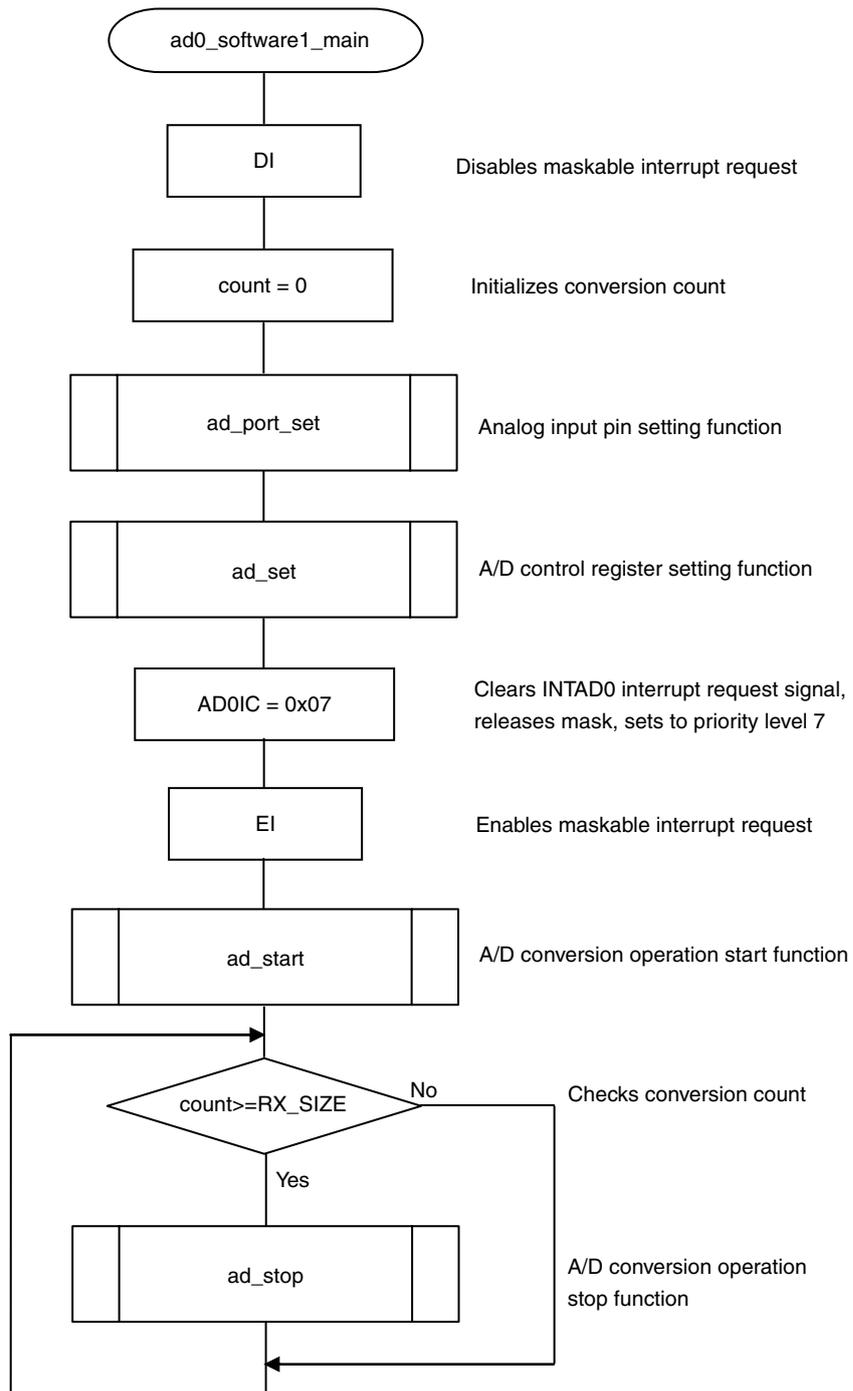
[Function name]	ad_set
[Processing content]	Sets the A/D conversion control register.
[SFR used]	ADA0M0: 0x00 (Sets to continuous select mode, software trigger mode, and sets valid edge to "No edge detection".) ADA0M2: 0x80 (Sets to 4-buffer mode.) ADA0M1: 0x02 (Sets conversion clock number to 186 (2.91 $\mu$ S).) OP0CTL0: 0x00 (Disables operation of operational amplifier 0.) OP0CTL1: 0x00 (Disables operation of comparator 0.)
[call function]	None
[Variable]	None
[File name]	ad01_software1_trigger.c

[Function name]	ad_start
[Processing content]	Starts A/D conversion operation.
[SFR used]	ADA0M0.ADA0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_software1_trigger.c

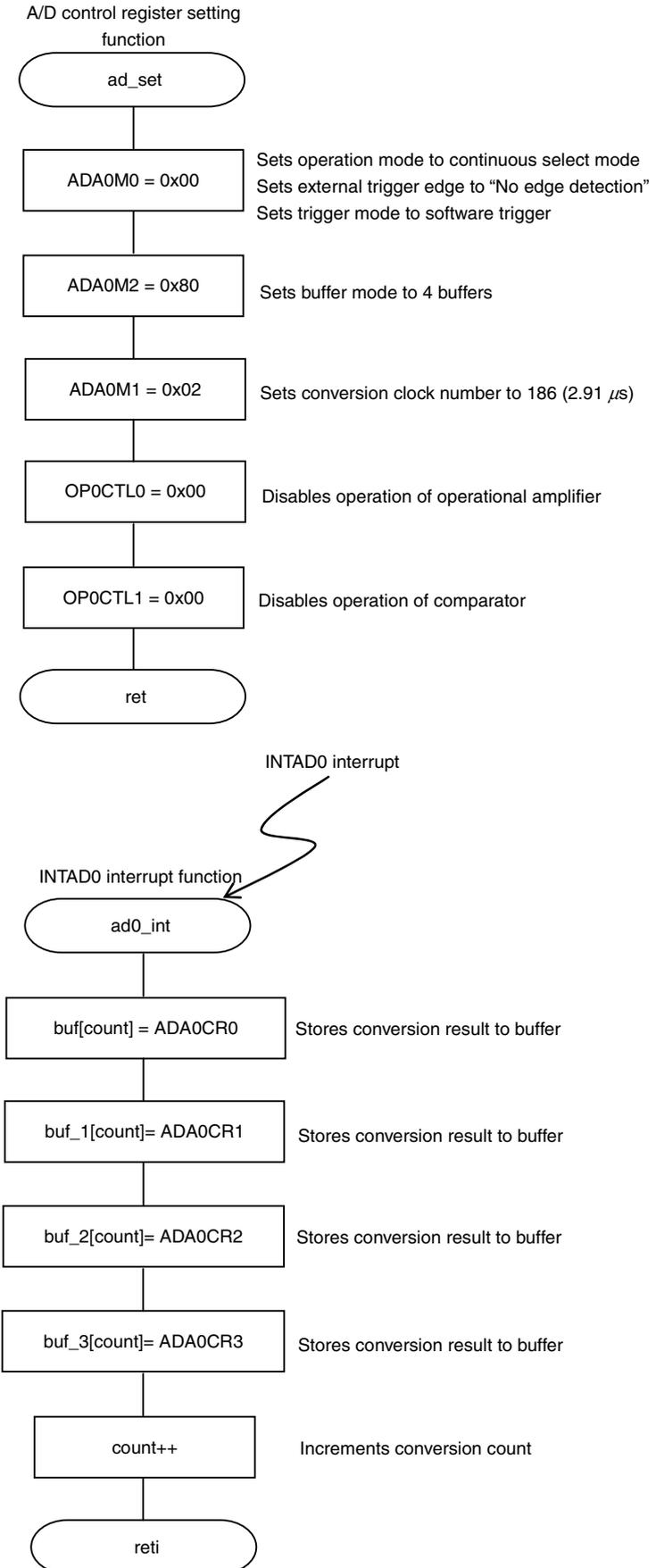
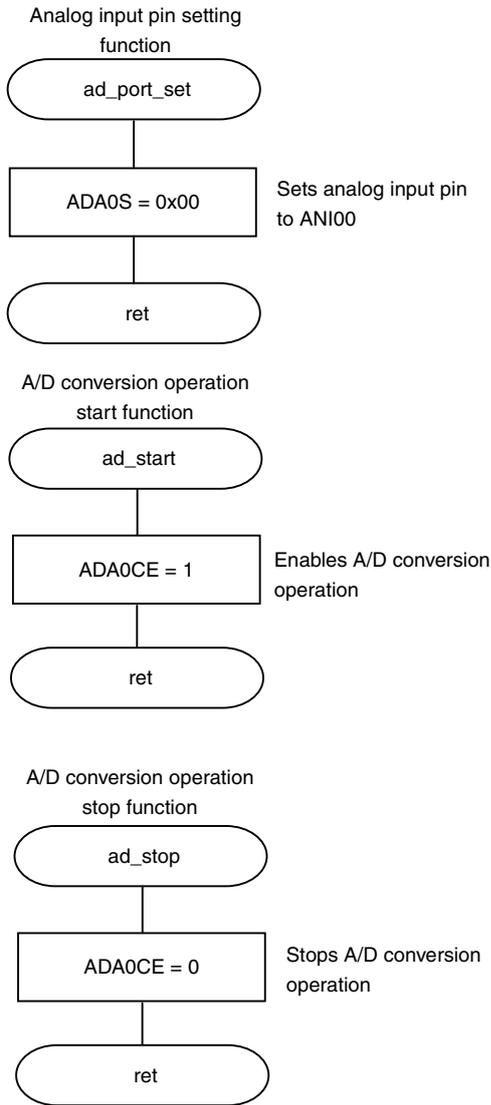
[Function name]	ad_stop
[Processing content]	Stops A/D conversion operation.
[SFR used]	ADA0M0.ADA0CE: 0 (Stops A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_software1_trigger.c

## Interrupt function

[Function name]	ad0_int
[Processing content]	Stores A/D conversion result data to buffer.
[SFRs used]	ADA0CR0                      A/D conversion result register 0 ADA0CR1                      A/D conversion result register 1 ADA0CR2                      A/D conversion result register 2 ADA0CR3                      A/D conversion result register 3
[call functions]	None
[Variable]	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



Software trigger mode (continuous select mode, 4 buffers) (2/2)



## A/D converters 0 and 1

### Timer trigger mode (one-shot select mode, 1 buffer)

[Function]	Performs A/D conversion by setting the A/D conversion operation start timing to timer trigger mode 0 of the hardware trigger mode.
[Function name]	ad0_timer_main
[Argument]	None
[Processing content]	Starts A/D conversion when the A/D conversion start trigger signal of the timer (motor control function) is input. Stores the A/D conversion result to buf[] by A/D converting the ANI00 pin input. An A/D0 conversion end interrupt request signal (INTAD0) occurs upon completion of every 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 functions]	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
[Interrupt]	ad01_int
[Interrupt source]	INTAD0
[File name]	ad01_timer_trigger.c
[Caution]	None

[Function name]	ad_port_set
[Processing content]	Sets the analog input pin.
[SFR used]	ADA0S: 0x04 (Sets analog input pin to ANI00 + operational amplifier.)
[call function]	None
[Variable]	None
[File name]	ad01_timer_trigger.c

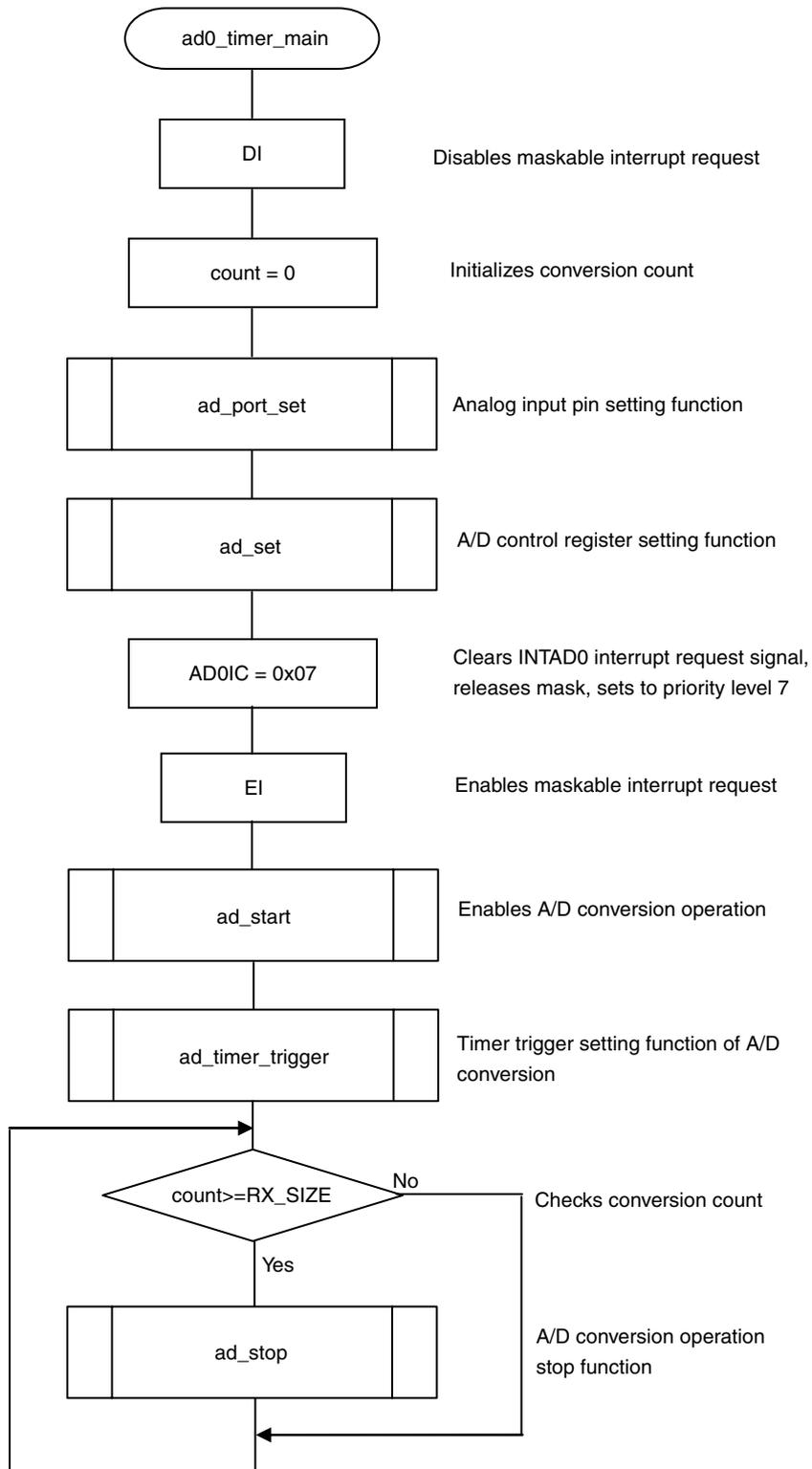
[Function name]	ad_set
[Processing content]	Sets the A/D conversion control register.
[SFRs used]	ADA0M0: 0x22 (Sets to one-shot select mode, hardware trigger mode, and sets valid edge to “No edge detection”.) ADA0M2: 0x01 (Sets to 1-buffer mode, timer trigger mode 0.) ADA0M1: 0x02 (Sets conversion clock number to 186 (2.91 $\mu$ s).) OP0CTL0: 0x10 (Enables operation of operational amplifier 0, sets amplification (gain) to 2.5 times.) OP0CTL1: 0x10 (Enables operation of comparator 0.)
[call function]	None
[Variable]	unsigned int wait_co
[File name]	ad01_timer_trigger.c
[Caution]	A stabilization time of 50 $\mu$ s is required after operations of the operational amplifier and the comparator are enabled.

[Function name]	ad_start
[Processing content]	Enables A/D conversion operation.
[SFR used]	ADA0M0.ADA0CE: 1 (Enables A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_timer_trigger.c

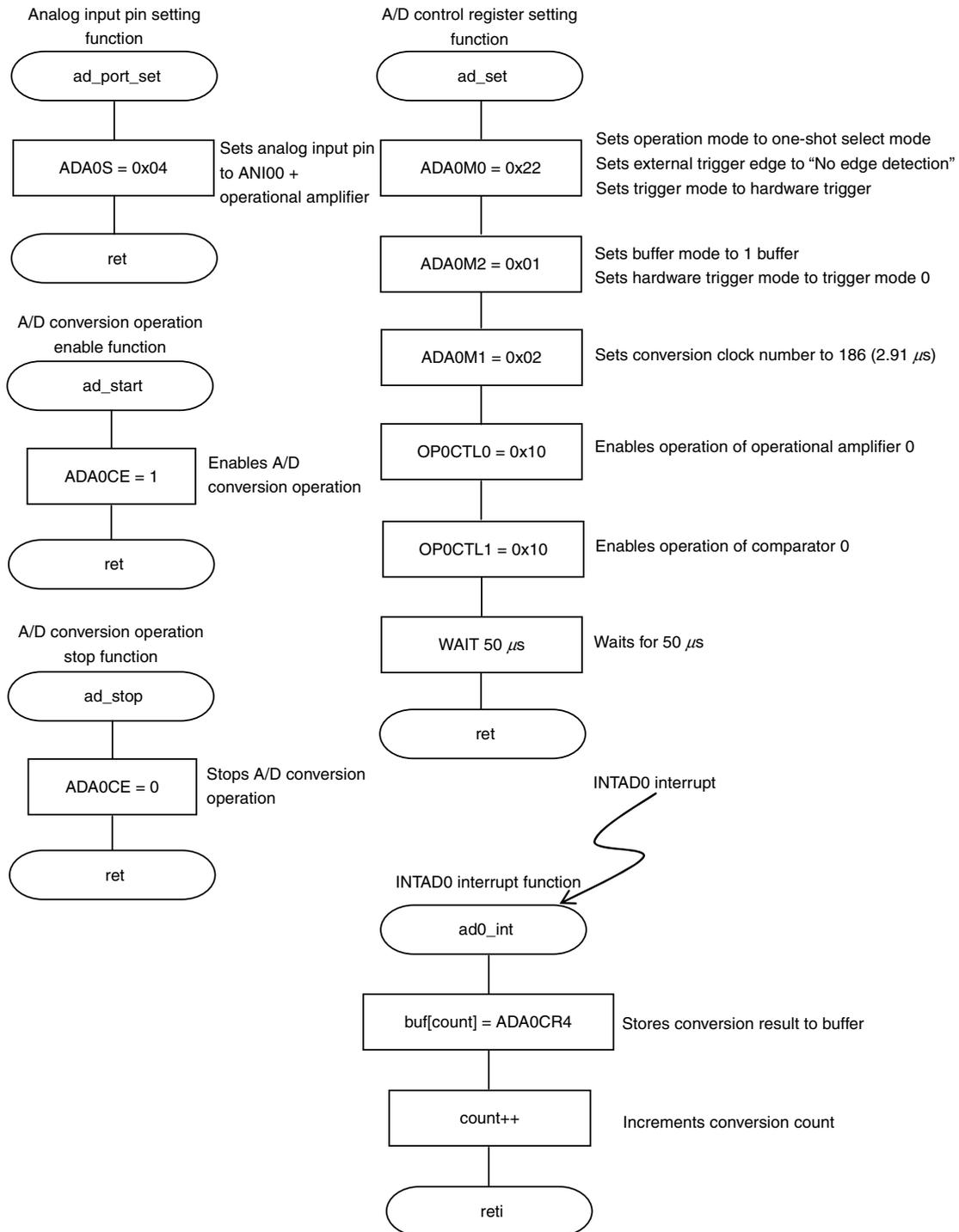
[Function name]	ad_timer_trigger
[Processing content]	Sets the timer trigger of the A/D conversion.
[SFR used]	TP0CTL0.TP0CE: 1 (Starts TMP0 operation.) TQ0CTL0.TQ0CE: 1 (Starts TMQ0 operation.)
[call function]	None
[Variable]	None
[File name]	ad01_timer_trigger.c
[Caution]	Omitted due to the same settings of the int_tmp_init, int_tmq_init, int_tmq_op_init functions in interrupt.c. For details of interrupt.c, refer to <b>Manual for Using Sample Program Functions Interrupt Functions (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note (U18244E)</b> .

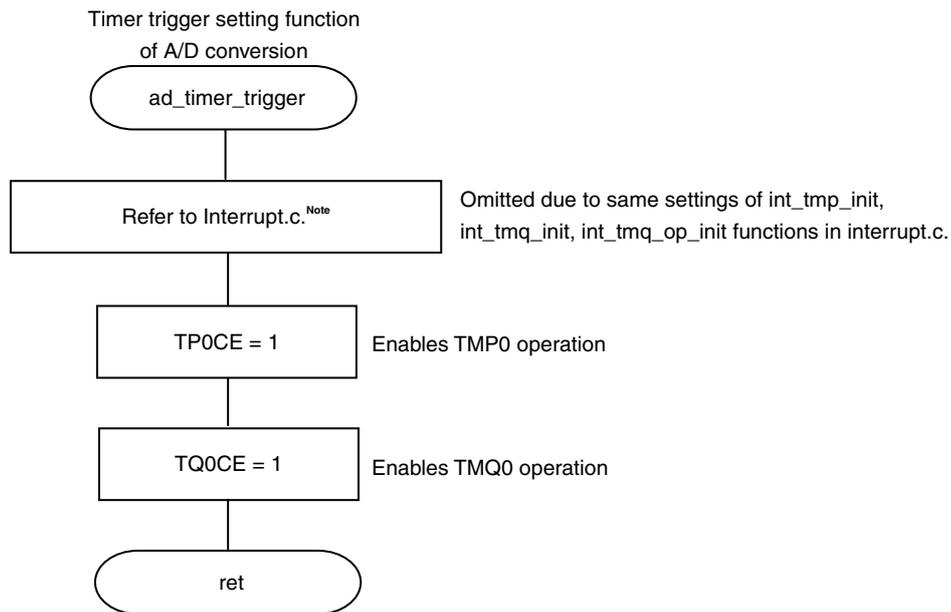
[Function name]	ad_stop
[Processing content]	Stops A/D conversion operation.
[SFR used]	ADA0M0.ADA0CE: 0 (Stops A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad01_timer_trigger.c

[Function name]	ad0_int
[Processing content]	Stores A/D conversion result data to buffer.
[SFR used]	ADA0CR4 A/D conversion result register 4
[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



Timer trigger mode (one-shot select mode, 1 buffer) (2/3)





**Note** For details of interrupt.c, refer to **Manual for Using Sample Program Functions Interrupt Functions (V850E/IA3, V850E/IA4, V850ES/IK1, V850ES/IE2) Application Note (U18244E)**.

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