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April 1st, 2010
Renesas Electronics Corporation

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Manual for Using Sample Program Functions
A/D Converter 2
(V850E/IA3, V850E/IA4)

This manual explains the sample program functions of the A/D converter 2 for the V850E/IA4 microcontroller.

The explanations are based on usage with the V850E/IA4 microcontroller. Refer to this manual when using the V850E/IA3 microcontroller.

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, customers are kindly advised to sufficiently evaluate this product based on their system before usage.

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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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M8E 02. 11-1

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(s)

[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 related to the A/D converter 2 are shown below.

Item	V850E/IA4	V850E/IA3
Analog input	8 channels	6 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/IA3 and V850E/IA4

Document Name	Document No.
V850E1 Architecture User's Manual	U14559E
V850E/IA3, V850E/IA4 Hardware User's Manual	U16543E
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 Functions (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	U18245E
Manual for Using Sample Program Functions A/D Converter 2 (V850E/IA3, V850E/IA4) Application Note	This document

CONTENTS

A/D converter 2
1-buffer serial mode

[Function]	Converts signals input to the analog input pin (ANI20) to digital values. An A/D2 conversion end interrupt request signal (INTAD2) occurs upon completion of every A/D conversion.
[Function name]	ad2_main
[Argument]	None
[Processing content]	Stores the A/D conversion result to buf[] by A/D converting signals input to the ANI20 pin when the ADA2CTL0.ADA2CE bit is set to 1. An A/D2 conversion end interrupt request signal (INTAD2) occurs upon completion of every A/D conversion. Performs A/D conversion for 10 times.
[SFR used]	AD2IC: 0x07 (Clears conversion end interrupt request signal (INTAD2), releases mask, sets to priority level 7)
[call functions]	ad2_port_set, ad2_set, ad2_analog_on, ad2_start, ad2_stop, ad2_analog_off
[Variables]	unsigned short int buf[ ]: Conversion data storing buffer volatile unsigned char count: Conversion count variable 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 to the ANI20 input pin.
[SFR used]	PMC7: 0x01 (Sets P70 pin to ANI20 input pin.)
[call function]	None
[Variable]	None
[File name]	ad2.c
[Caution]	None

[Function name]	ad2_analog_on
[Processing content]	Turns on the analog power supply
[SFR used]	ADA2CTL0.ADA2PON: 1 (Turns on analog power supply.)
[call function]	None
[Variable]	unsigned char wait: WAIT variable
[File name]	ad2.c
[Caution]	Do not set the analog power supply control bit (ADA2PON) and A/D conversion operation control bit (ADA2CE) of the ADA2CTL0 register to 1 at the same time. Set the ADA2CE bit to 1 at least 5 μs after the ADA2PON bit is set to 1. If the ADA2CE bit is set to 1 before the lapse of 5 μs, A/D conversion is executed but the accuracy of the result of the first conversion cannot be guaranteed.

[Function name]	ad2_set
[Processing content]	Sets the A/D conversion control register.
[SFRs used]	ADA2CTL3: 0x00 (Sets to 1-buffer mode, serial mode.) ADA2CTL1: 0x03 (Sets to fxx/16 (4 MHz), 10-bit (2048 times) resolution.) ADA2CTL2: 0x00 (Sets analog input pin to ANI20 pin.)
[call function]	None
[Variable]	None
[File name]	ad2.c
[Caution]	None

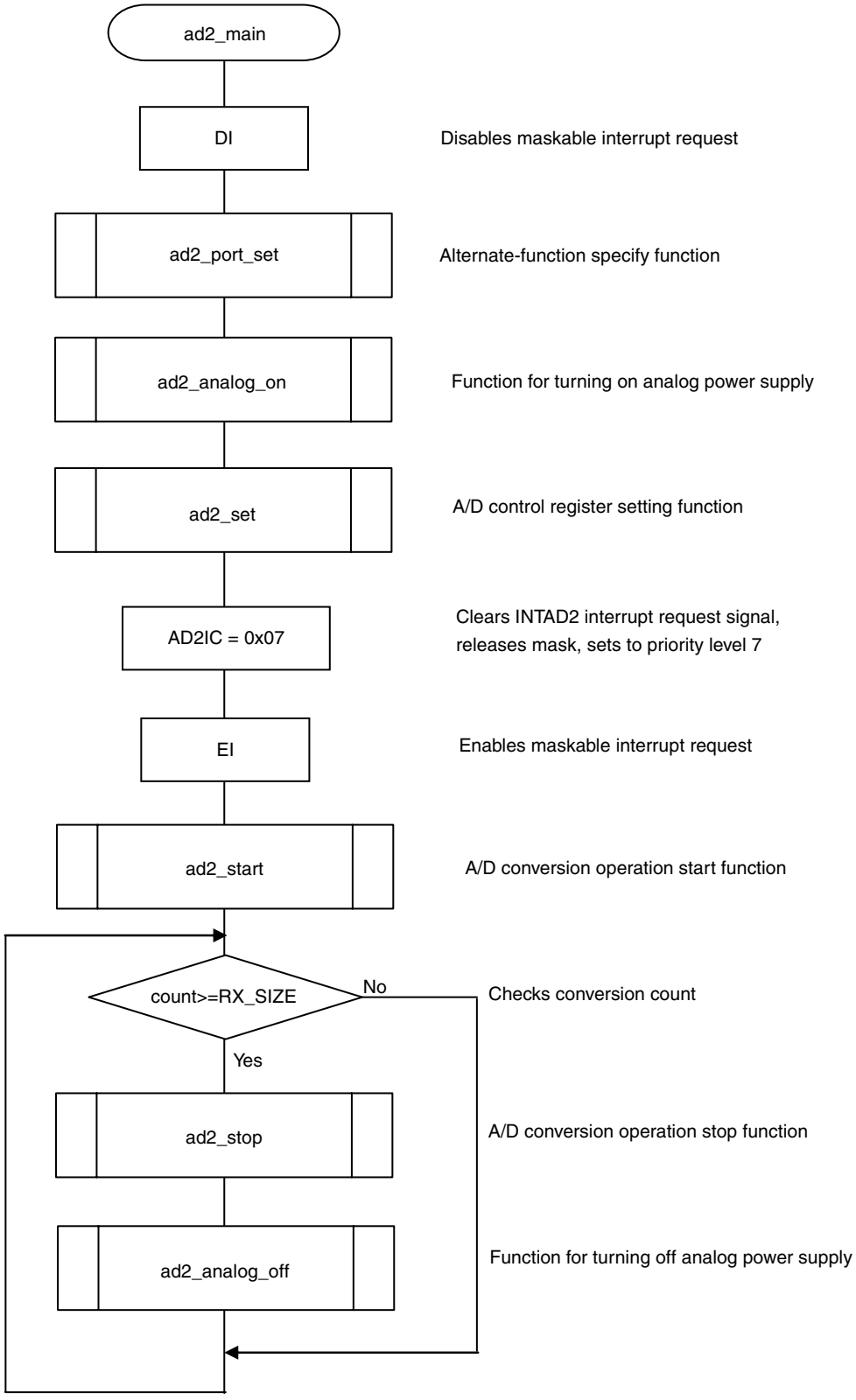
[Function name]	ad2_start
[Processing content]	Starts the A/D conversion operation.
[SFR used]	ADA2CTL0.ADA2CE: 1 (Starts A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad2.c
[Caution]	Do not set the analog power supply control bit (ADA2PON) and A/D conversion operation control bit (ADA2CE) of the ADA2CTL0 register to 1 at the same time. Set the ADA2CE bit to 1 at least 5 μs after the ADA2PON bit is set to 1. If the ADA2CE bit is set to 1 before the lapse of 5 μs, A/D conversion is executed but the accuracy of the result of the first conversion cannot be guaranteed.

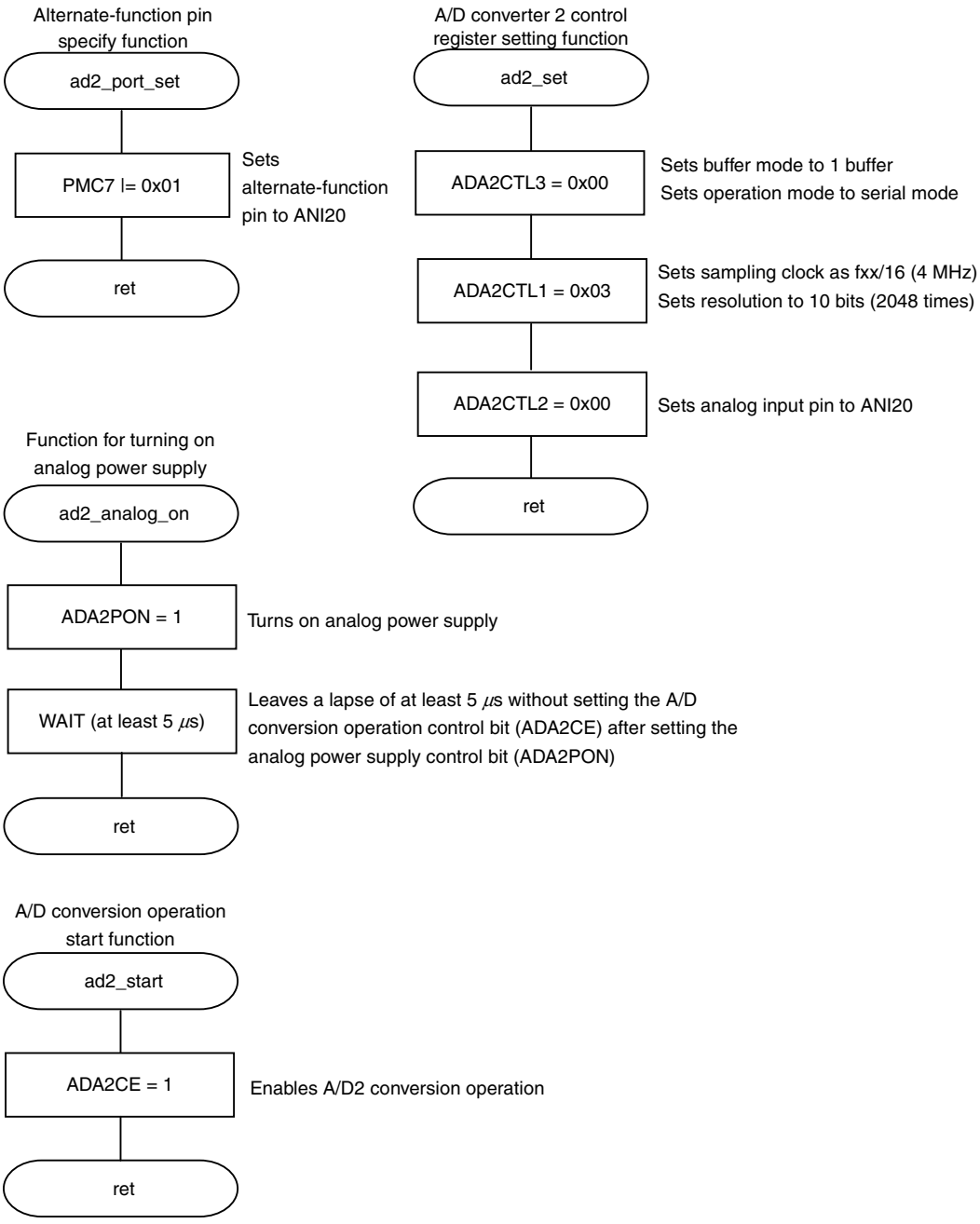
[Function name]	ad2_stop	
[Processing content]	Stops the A/D conversion operation.	
[SFR used]	ADA2CTL0.ADA2CE:	0 (Stops A/D conversion operation.)
[call function]	None	
[Variable]	None	
[File name]	ad2.c	
[Caution]	None	

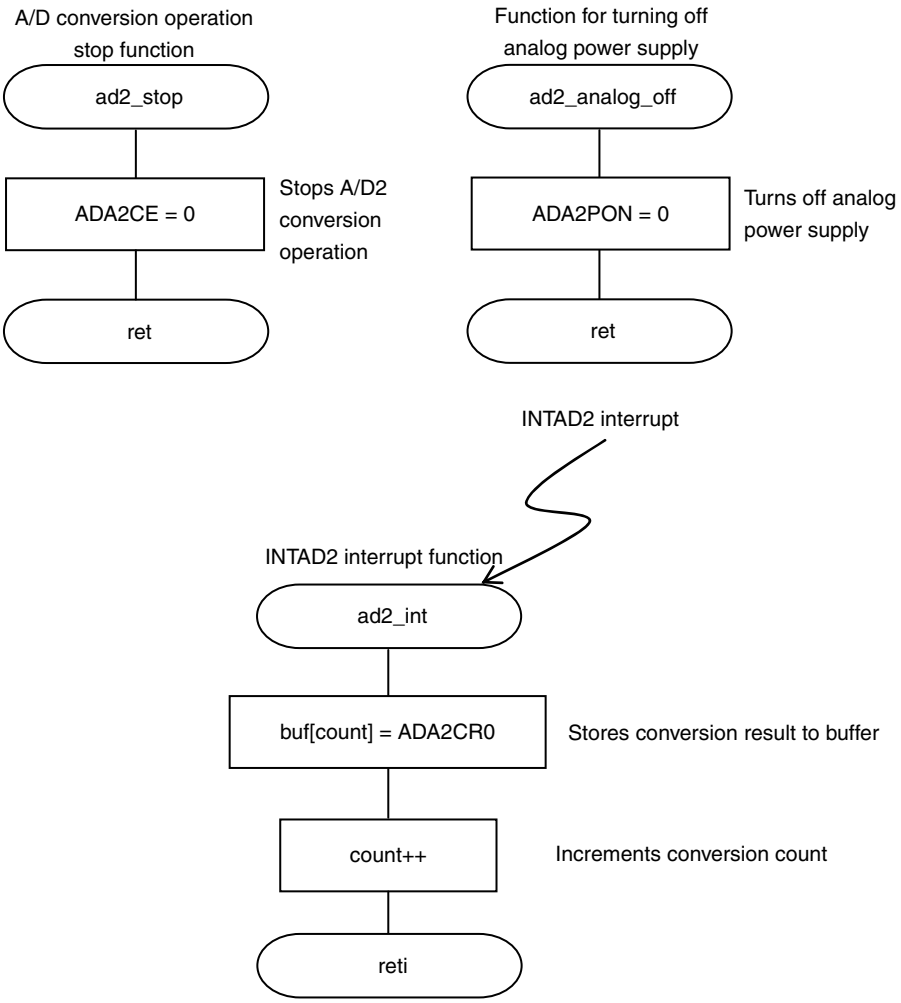
[Function name]	ad2_analog_off	
[Processing content]	Turns off the analog power supply.	
[SFR used]	ADA2CTL0.ADA2PON:	0 (Turns off analog power supply.)
[call function]	None	
[Variable]	None	
[File name]	ad2.c	
[Caution]	None	

Interrupt function

[Function name]	ad2_int	
[Processing content]	Stores the A/D conversion result data to the buffer.	
[SFR used]	ADA2CR0	A/D2 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]	ad2.c	
[Caution]	None	


ad2_main
DI
Disables maskable interrupt request
ad2_port_set
Alternate-function specify function
ad2_analog_on
Function for turning on analog power supply
ad2_set
A/D control register setting function
AD2IC = 0x07
Clears INTAD2 interrupt request signal,
releases mask, sets to priority level 7
EI
Enables maskable interrupt request
ad2_start
A/D conversion operation start function
count>=RX_SIZE
No
Checks conversion count
Yes
ad2_stop
A/D conversion operation stop function
ad2_analog_off
Function for turning off analog power supply


Alternate-function pin specify function
ad2_port_set
PMC7 |= 0x01
Sets alternate-function pin to ANI20
ret
A/D converter 2 control register setting function
ad2_set
ADA2CTL3 = 0x00
Sets buffer mode to 1 buffer
Sets operation mode to serial mode
ADA2CTL1 = 0x03
Sets sampling clock as fxx/16 (4 MHz)
Sets resolution to 10 bits (2048 times)
ADA2CTL2 = 0x00
Sets analog input pin to ANI20
ret
Function for turning on analog power supply
ad2_analog_on
ADA2PON = 1
Turns on analog power supply
WAIT (at least 5 μs)
Leaves a lapse of at least 5 μs without setting the A/D conversion operation control bit (ADA2CE) after setting the analog power supply control bit (ADA2PON)
ret
A/D conversion operation start function
ad2_start
ADA2CE = 1
Enables A/D2 conversion operation
ret


A/D conversion operation stop function
ad2_stop
ADA2CE = 0
Stops A/D2 conversion operation
ret
Function for turning off analog power supply
ad2_analog_off
ADA2PON = 0
Turns off analog power supply
ret
INTAD2 interrupt
INTAD2 interrupt function
ad2_int
buf[count] = ADA2CR0
Stores conversion result to buffer
count++
Increments conversion count
reti

A/D converter 2
4-buffer parallel mode

[Function]	Converts signals input to the analog input pin (ANI20) to digital values. An A/D2 conversion end interrupt request signal (INTAD2) occurs upon completion of every A/D conversion.
[Function name]	ad2_1_main
[Argument]	None
[Processing content]	Stores the A/D conversion result to buf[], buf_1[], buf_2[] and buf_3[], by converting the signal input to the ANI20 pin four times in parallel, each with a time difference of 1/4 of the conversion time, when the ADA2CTL0.ADA2CE bit is set to 1. An A/D2 conversion end interrupt request signal (INTAD2) occurs upon completion of four A/D conversions. Performs A/D conversion for 10 times.
[SFR used]	AD2IC: 0x07 (Clears conversion end interrupt request signal (INTAD2), releases mask, sets to priority level 7)
[call functions]	ad2_port_set, ad2_analog_on, ad2_set, ad2_start, ad2_stop, ad2_analog_off
[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 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 to the ANI20 input pin.
[SFR used]	PMC7: 0x01 (Sets P70 pin to ANI20 input pin.)
[call function]	None
[Variable]	None
[File name]	ad2_1.c
[Caution]	None

[Function name]	ad2_analog_on
[Processing content]	Turns on the analog power supply
[SFR used]	ADA2CTL0.ADA2PON: 1 (Turns on analog power supply.)
[call function]	None
[Variable]	unsigned char wait: WAIT variable
[File name]	ad2_1.c
[Caution]	Do not set the analog power supply control bit (ADA2PON) and A/D conversion operation control bit (ADA2CE) of the ADA2CTL0 register to 1 at the same time. Set the ADA2CE bit to 1 at least 5 μs after the ADA2PON bit is set to 1. If the ADA2CE bit is set to 1 before the lapse of 5 μs, A/D conversion is executed but the accuracy of the result of the first conversion cannot be guaranteed.

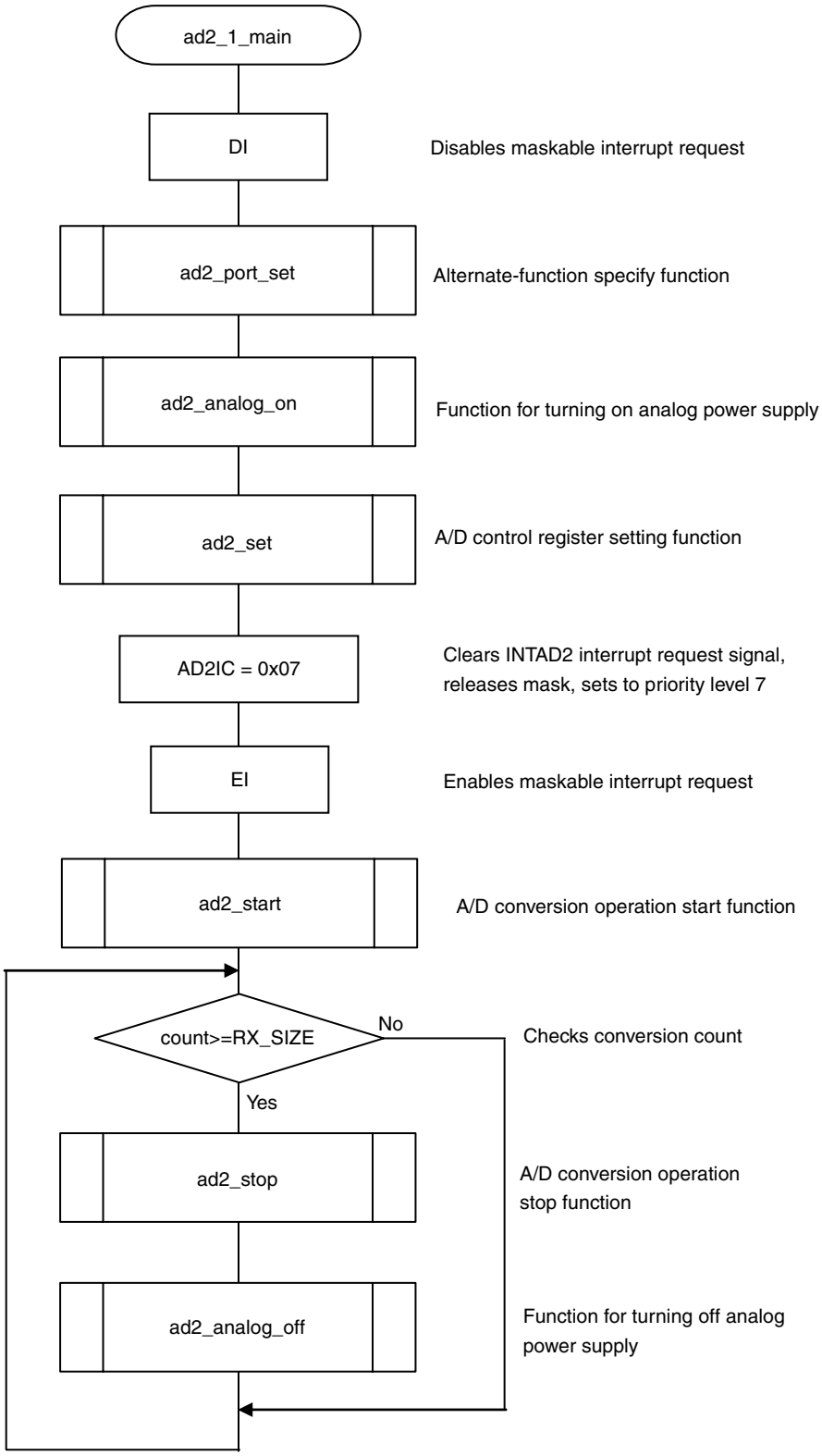
[Function name]	ad2_set
[Processing content]	Sets the A/D conversion control register.
[SFRs used]	ADA2CTL3: 0xC0 (Sets to 4-buffer mode, parallel mode.) ADA2CTL1: 0x03 (Sets to fxx/16 (4 MHz), 10-bit (2048 times) resolution.) ADA2CTL2: 0x00 (Sets analog input pin to ANI20 pin.)
[call function]	None
[Variable]	None
[File name]	ad2_1.c
[Caution]	None

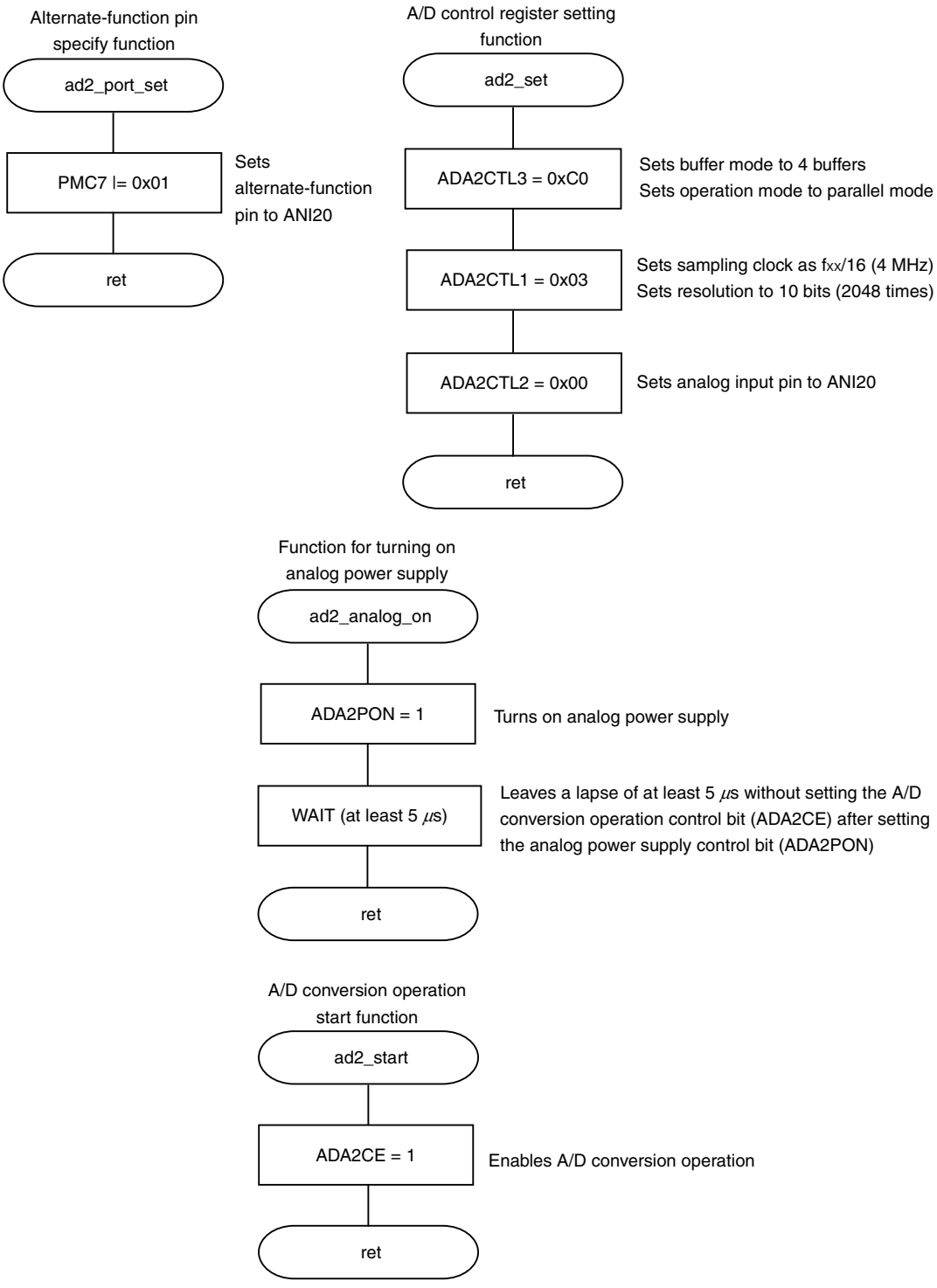
[Function name]	ad2_start
[Processing content]	Starts the A/D conversion operation.
[SFR used]	ADA2CTL0.ADA2CE: 1 (Starts A/D conversion operation.)
[call function]	None
[Variable]	None
[File name]	ad2_1.c
[Caution]	Do not set the analog power supply control bit (ADA2PON) and A/D conversion operation control bit (ADA2CE) of the ADA2CTL0 register to 1 at the same time. Set the ADA2CE bit to 1 at least 5 μs after the ADA2PON bit is set to 1. If the ADA2CE bit is set to 1 before the lapse of 5 μs, A/D conversion is executed but the accuracy of the result of the first conversion cannot be guaranteed.

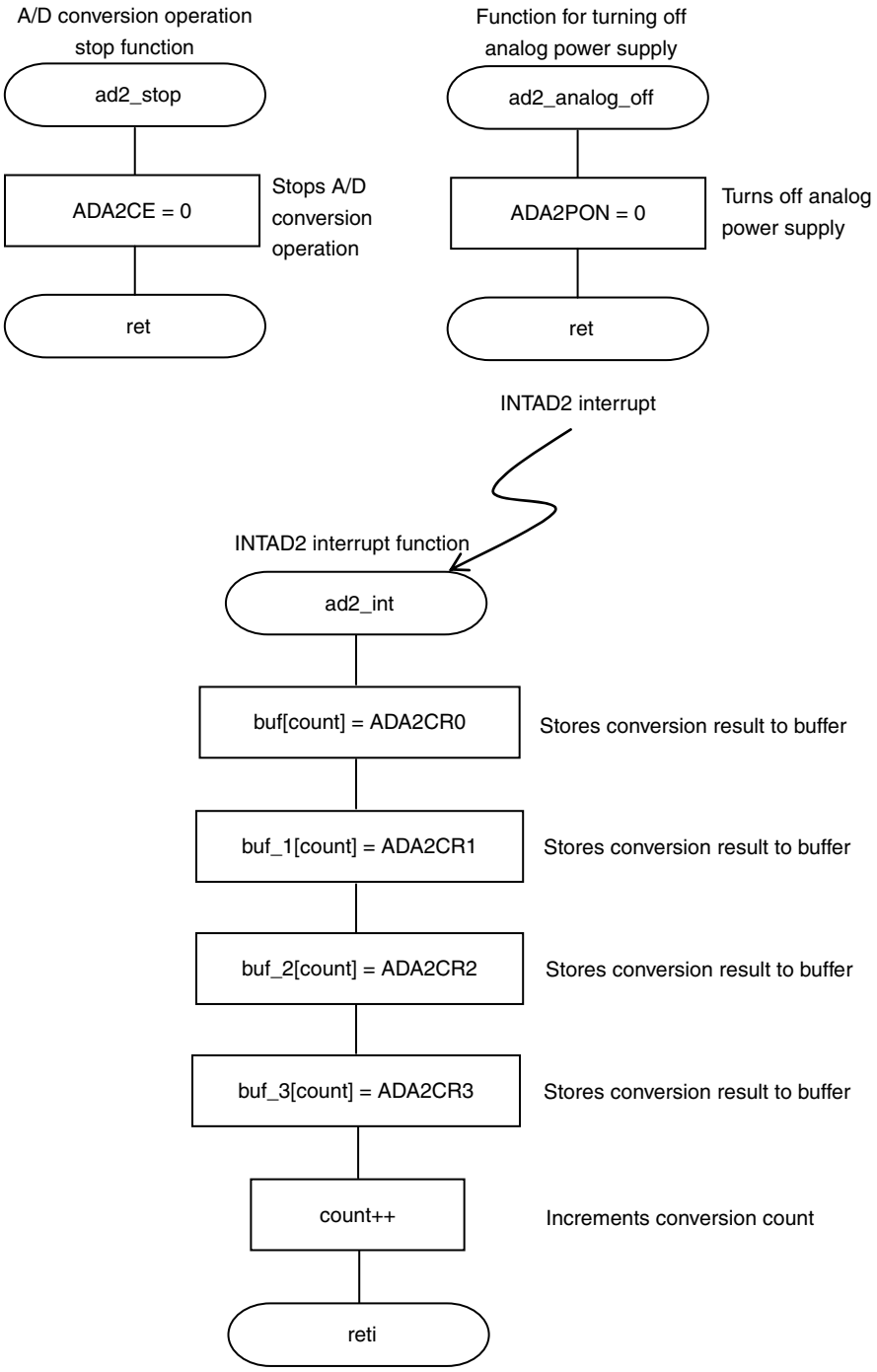
[Function name]	ad2_stop	
[Processing content]	Stops the A/D conversion operation.	
[SFR used]	ADA2CTL0.ADA2CE:	0 (Stops A/D conversion operation.)
[call function]	None	
[Variable]	None	
[File name]	ad2_1.c	
[Caution]	None	

[Function name]	ad2_analog_off	
[Processing content]	Turns off the analog power supply.	
[SFR used]	ADA2CTL0.ADA2PON:	0 (Turns off analog power supply.)
[call function]	None	
[Variable]	None	
[File name]	ad2_1.c	
[Caution]	None	

[Function name]	ad2_int	
[Processing content]	Stores the A/D conversion result data to the buffer upon completion of each conversion.	
[SFR used]	ADA2CR0	A/D2 conversion result register 0
[call function]	None	
[Variables]	unsigned short int buf[ ]:	Conversion data storing buffer
	unsigned short int buf1_[ ]:	Conversion data storing buffer
	unsigned short int buf_2[ ]:	Conversion data storing buffer
	unsigned short int buf_3[ ]:	Conversion data storing buffer
	unsigned char count:	Conversion count variable
[File name]	ad2_1.c	
[Caution]	None	


ad2_1_main
DI
Disables maskable interrupt request
ad2_port_set
Alternate-function specify function
ad2_analog_on
Function for turning on analog power supply
ad2_set
A/D control register setting function
AD2IC = 0x07
Clears INTAD2 interrupt request signal,
releases mask, sets to priority level 7
EI
Enables maskable interrupt request
ad2_start
A/D conversion operation start function
count>=RX_SIZE
No
Checks conversion count
Yes
ad2_stop
A/D conversion operation
stop function
ad2_analog_off
Function for turning off analog
power supply


Alternate-function pin specify function
ad2_port_set
PMC7 |= 0x01
Sets alternate-function pin to ANI20
ret
A/D control register setting function
ad2_set
ADA2CTL3 = 0xC0
Sets buffer mode to 4 buffers
Sets operation mode to parallel mode
ADA2CTL1 = 0x03
Sets sampling clock as fxx/16 (4 MHz)
Sets resolution to 10 bits (2048 times)
ADA2CTL2 = 0x00
Sets analog input pin to ANI20
ret
Function for turning on analog power supply
ad2_analog_on
ADA2PON = 1
Turns on analog power supply
WAIT (at least 5 μs)
Leaves a lapse of at least 5 μs without setting the A/D conversion operation control bit (ADA2CE) after setting the analog power supply control bit (ADA2PON)
ret
A/D conversion operation start function
ad2_start
ADA2CE = 1
Enables A/D conversion operation
ret


A/D conversion operation stop function
ad2_stop
ADA2CE = 0
Stops A/D conversion operation
ret
Function for turning off analog power supply
ad2_analog_off
ADA2PON = 0
Turns off analog power supply
ret
INTAD2 interrupt
INTAD2 interrupt function
ad2_int
buf[count] = ADA2CR0
Stores conversion result to buffer
buf_1[count] = ADA2CR1
Stores conversion result to buffer
buf_2[count] = ADA2CR2
Stores conversion result to buffer
buf_3[count] = ADA2CR3
Stores conversion result to buffer
count++
Increments conversion count
reti

For further information, please contact:

NEC Electronics Corporation
1753, Shimonumabe, Nakahara-ku,
Kawasaki, Kanagawa 211-8668,
Japan
Tel: 044-435-5111
http://www.necel.com/

[America]

NEC Electronics America, Inc.
2880 Scott Blvd.
Santa Clara, CA 95050-2554, U.S.A.
Tel: 408-588-6000
800-366-9782
http://www.am.necel.com/

[Europe]

NEC Electronics (Europe) GmbH
Arcadiastrasse 10
40472 Düsseldorf, Germany
Tel: 0211-65030
http://www.eu.necel.com/

Hanover Office
Podbielskistrasse 166 B
30177 Hannover
Tel: 0 511 33 40 2-0

Munich Office
Werner-Eckert-Strasse 9
81829 München
Tel: 0 89 92 10 03-0

Stuttgart Office
Industriestrasse 3
70565 Stuttgart
Tel: 0 711 99 01 0-0

United Kingdom Branch
Cygnus House, Sunrise Parkway
Linford Wood, Milton Keynes
MK14 6NP, U.K.
Tel: 01908-691-133

Succursale Française
9, rue Paul Dautier, B.P. 52
78142 Velizy-Villacoublay Cédex
France
Tel: 01-3067-5800

Sucursal en España
Juan Esplandiu, 15
28007 Madrid, Spain
Tel: 091-504-2787

Tyskland Filial
Täby Centrum
Entrance S (7th floor)
18322 Täby, Sweden
Tel: 08 638 72 00

Filiale Italiana
Via Fabio Filzi, 25/A
20124 Milano, Italy
Tel: 02-667541

Branch The Netherlands
Steijgerweg 6
5616 HS Eindhoven
The Netherlands
Tel: 040 265 40 10

[Asia & Oceania]

NEC Electronics (China) Co., Ltd
7th Floor, Quantum Plaza, No. 27 ZhiChunLu Haidian
District, Beijing 100083, P.R.China
Tel: 010-8235-1155
http://www.cn.necel.com/

NEC Electronics Shanghai Ltd.
Room 2511-2512, Bank of China Tower,
200 Yincheng Road Central,
Pudong New Area, Shanghai P.R. China P.C:200120
Tel: 021-5888-5400
http://www.cn.necel.com/

NEC Electronics Hong Kong Ltd.
12/F., Cityplaza 4,
12 Taikoo Wan Road, Hong Kong
Tel: 2886-9318
http://www.hk.necel.com/

NEC Electronics Taiwan Ltd.
7F, No. 363 Fu Shing North Road
Taipei, Taiwan, R. O. C.
Tel: 02-8175-9600
http://www.tw.necel.com/

NEC Electronics Singapore Pte. Ltd.
238A Thomson Road,
#12-08 Novena Square,
Singapore 307684
Tel: 6253-8311
http://www.sg.necel.com/

NEC Electronics Korea Ltd.
11F., Samik Lavied'or Bldg., 720-2,
Yeoksam-Dong, Kangnam-Ku,
Seoul, 135-080, Korea
Tel: 02-558-3737
http://www.kr.necel.com/

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