To our customers,

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: http://www.renesas.com

April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (http://www.renesas.com)

Send any inquiries to http://www.renesas.com/inquiry.

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: "Standard", "High Quality", and "Specific". The recommended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as "Specific" without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as "Specific" or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is "Standard" unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.

   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.

   "Specific": Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.
8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

H8/38076R

Voltage Measurement Using 4-Channel Successive Approximation A/D Conversion

Introduction

In this example the internal A/D converter is used to measure voltage by 4-channel A/D conversion.

Target Device

H8/38076R

Contents

1. Specifications

- In this sample task the A/D converter is used to measure voltage by 4-channel A/D conversion.
- The end of conversion is determined by referencing the ADSF bit by software polling.
- The four channel voltages are input to AN0 to AN3, and the A/D conversion results are stored in RAM.
- A sample connection diagram is shown in figure 1.

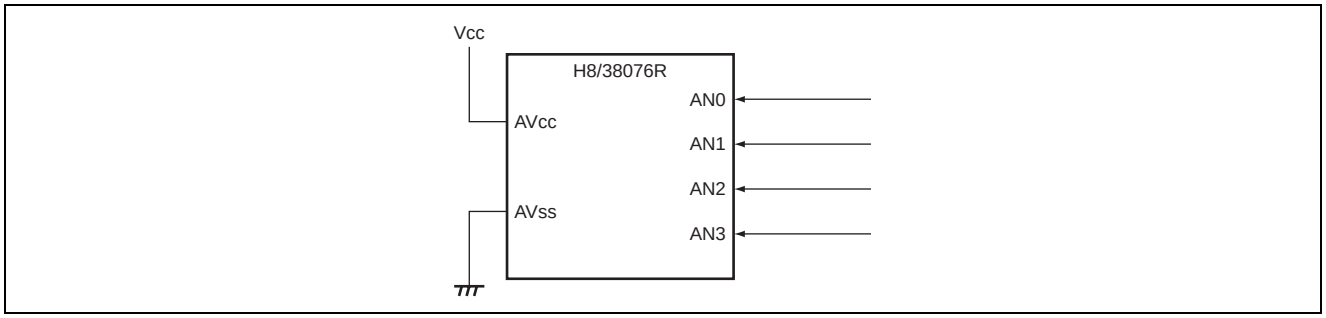


Figure 1 Voltage Measurement by 4-Channel A/D Conversion

2. Functions Used

2.1 Functions

In this sample task the A/D converter is used to measure voltage by 4-channel A/D conversion. A block diagram of the A/D converter is shown in figure 2 and its operation is described below.

1. A/D Converter
   The H8/38076R includes a successive approximation type 10-bit A/D converter that allows up to eight analog input channels to be selected.

- A/D result register (ADRR)
  ADRR is a 16-bit read-only register that stores the result of A/D conversion. The upper 10 bits of the data are stored in ADRR. ADRR can be read by the CPU at any time, but the ADRR value during A/D conversion is undefined. After A/D conversion is completed, the conversion result is stored as 10-bit data, and this data is retained until the next conversion operation starts. The initial value of ADRR is undefined.

- A/D mode register (AMR)
  AMR sets the conversion time for the A/D converter, selects the external trigger, and specifies the analog input pins. In this sample task AN3 is set as the input pin.

- A/D start register (ADSR)
  ADSR starts and stops A/D conversion.

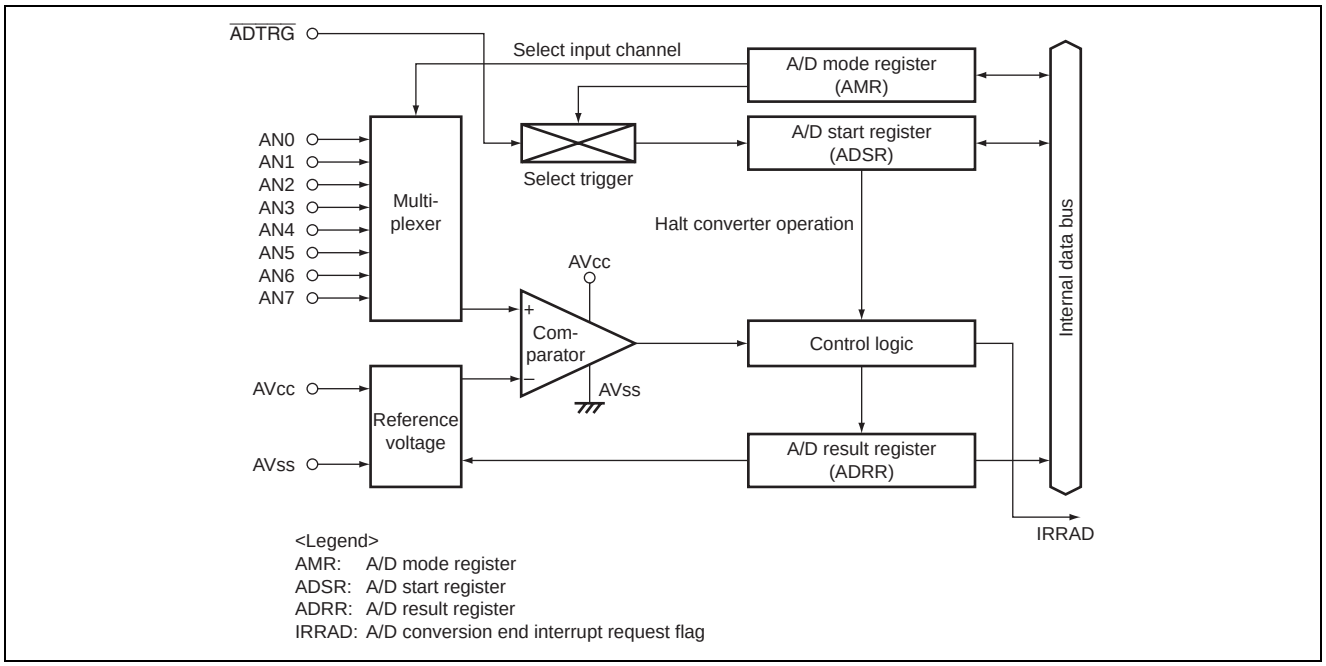


Figure 2 Block Diagram of A/D Converter

2. Port B
   Port B is an input-only port with pins that function as both interrupt input pins and analog input pins.

- Port mode register B (PMRB)
  PMRB controls the selection of functions for port B pins. In this sample task it is used to set AN0, AN1, and AN2 as input pins.

3. Module Standby Function
   The module-standby function can be specified for any peripheral module. In the module standby mode the clock supply to the specified module stops and it enters a power-down mode. Clearing a bit in CKSTPR1 or CKSTPR2 corresponding to a module sets it to the module standby mode. Setting the bit to 1 cancels the module standby mode for the corresponding module.

- Clock stop register 1 (CKSTPR1)
  CKSTPR1 allows the internal peripheral modules to enter the standby state in module units. In this sample task the A/D converter enters the standby state after A/D conversion completes.

2.2 Assignment of Functions

Table 1 shows the assignment of functions in this sample task. The watchdog timer is operated using functions assigned as shown in table 1.

Table 1 Assignment of Functions

Elements	Classification	Description
ADRR	A/D	Stores A/D conversion result (16-bit register)
AMR	A/D	Sets A/D conversion time, enables/disables A/D conversion by external trigger input, and selects analog input pins. In this sample task the A/D conversion time is set to 31 states, external trigger input is not used, and channels 0 to 3 are used.
ADSR	A/D	Specifies start and forced stop of A/D conversion
PMRB	I/O port	Function selection for analog input pins
CKSTPR1	Power-down	Sets the module standby mode of A/D converter
AN0 to AN7	Pin	Input pins of the A/D converter. Pins AN0 to AN3 are used in this sample task.
$\overline{\text{ADTRG}}$	Pin	External trigger input pin. Not used in this sample task.
AVcc, AVss	Pin	Power supply pins for analog block (reference voltage, comparator) of the A/D converter

3. Principles of Operation

The principles of operation of this sample task are illustrated in figure 3. Voltage is measured using the hardware and software processings shown in figure 3.

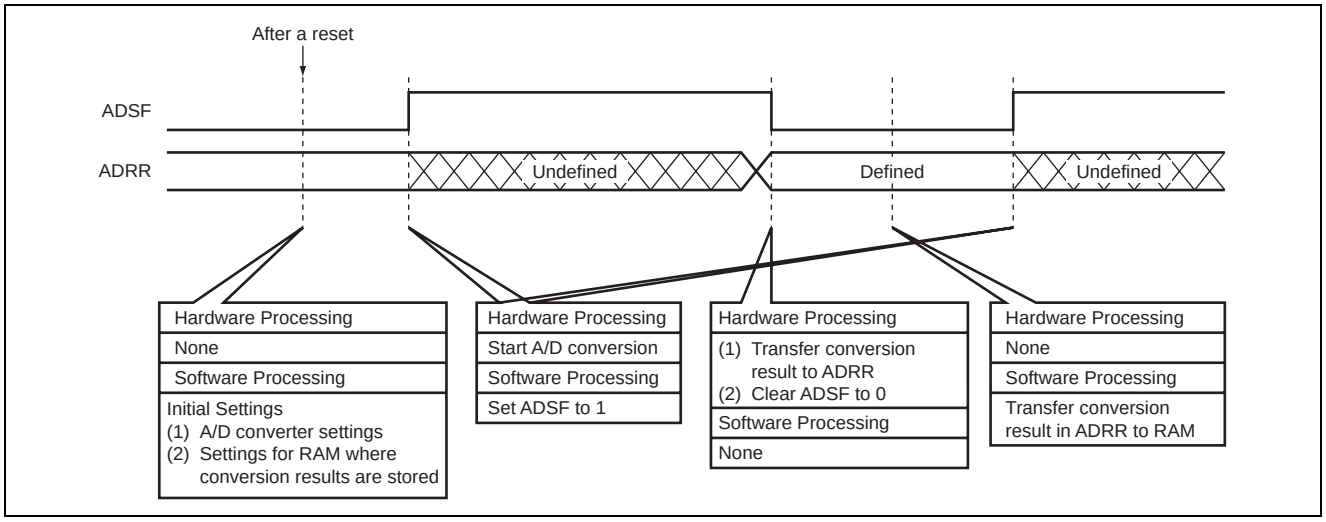


Figure 3 Principles of Operation of Voltage Measurement by A/D Conversion

3.1 Usage Notes

- Permissible signal source impedance
  The analog input of the H8/38076R is designed to guarantee conversion accuracy for an input signal with a signal source impedance of10 kΩ or less. This specification enables the A/D converter's sample-and-hold circuit input capacitance to be charged within the sampling time. If the sensor output impedance exceeds 10 kΩ, charging may be insufficient and it may not be possible to guarantee A/D conversion accuracy. However, if a large capacitance is provided externally, the input load will essentially comprise only the internal input resistance of 10 kΩ, and the signal source impedance will be unnecessary. However, as a low-pass filter effect is obtained in this case, it may not be possible to accurately convert analog signals having a large differential coefficient (e.g., 5 mV/μs or greater) in some cases. When converting high-speed analog signals, a low-impedance buffer should be inserted.

- Influences on absolute accuracy
  Adding capacitance results in coupling with the ground, and therefore noise from the ground may adversely affect absolute accuracy. Be sure to make a connection to an electrically stable ground. Care is also required to ensure that filter circuits do not interfere with digital signals or act as antennas on the mounting board.

- Usage notes
  The ADRR register should be read only when the ADSF bit in ADSR is cleared to 0.
  Changing the digital input signal at an adjacent pin during A/D conversion may adversely affect conversion accuracy.
  When A/D conversion is started after clearing the module standby mode, wait for 10 ϕ clock cycles before starting A/D conversion.
  In the active mode and the sleep mode, the analog power supply current flows in the ladder resistor even when the A/D converter is on standby. Therefore, it is recommended that AVcc be connected to the system power supply and the ADCKSTP bit in CKSTPR1 be cleared to 0 if the A/D converter is not used.

4. Description of Software

4.1 Functions

Table 2 shows the functions used in this sample task.

Table 2 List of Functions

Function Name	Description
main	Initializes RAM area to be used, stores A/D conversion result
init_ad	Makes initial settings for A/D converter
meas_ad	Starts A/D conversion from arguments, returns result as return value
stop_ad	Sets A/D converter to the module standby mode

4.2 Constants

No constants are used in this sample task.

4.3 RAM Usage

The RAM usage in this sample task is shown in table 3.

Table 3 RAM Usage

Label Name	Description	Amount of Memory Used	Used in
data[0] to data[3]	Buffer for storing A/D conversion result	4 words	main

4.4 Modules

4.4.1 main() Function

1. Module Specifications

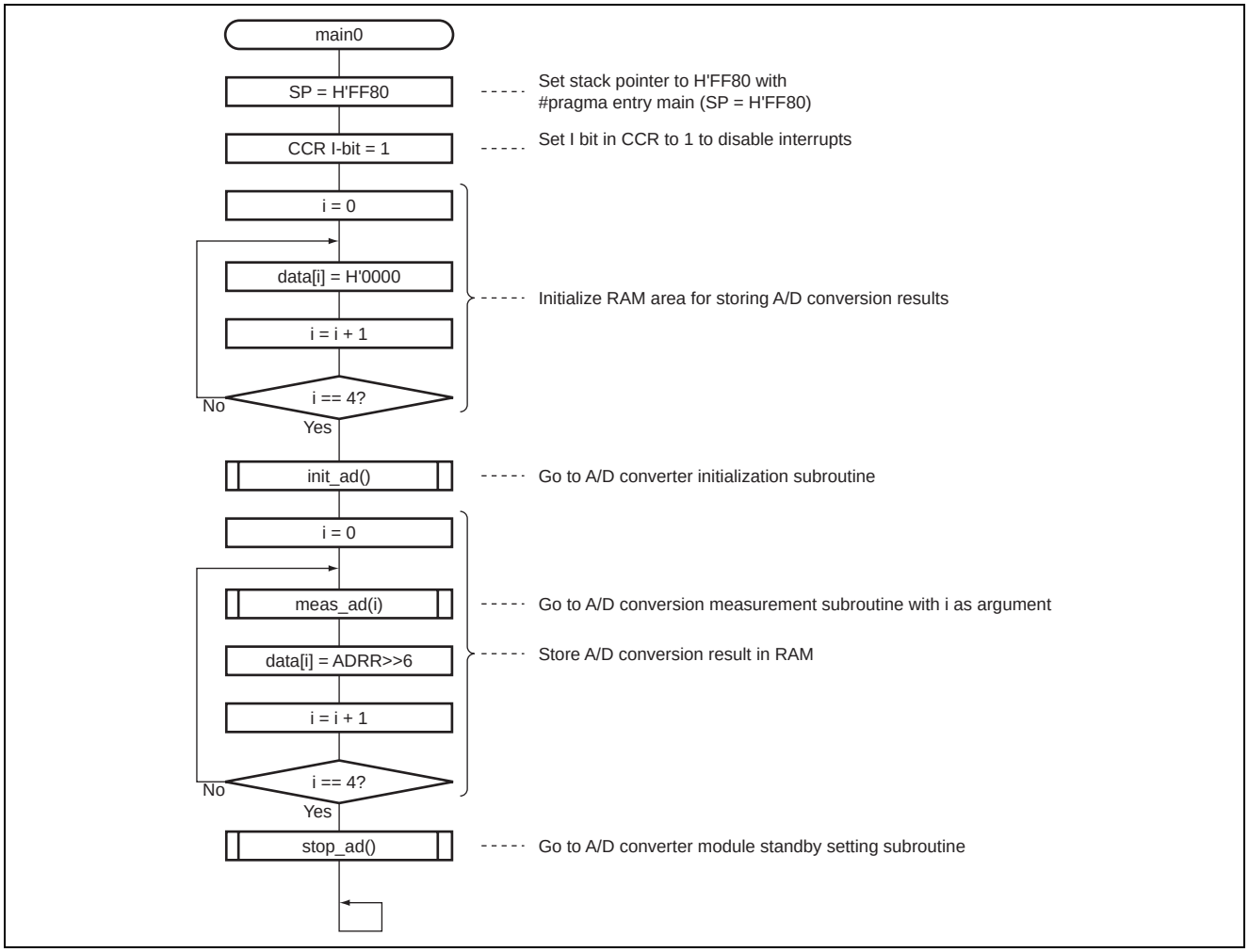
- Initializes RAM area to be used, stores A/D conversion result

Table 4 Module Specifications

Item	Type	Variable	Description
Arguments	None	None	None
Return values	None	None	None

2. Internal Registers Used
   No internal registers are used in this function.

3. Flowchart



4.4.2 init_ad() Function

1. Module Specifications

- Makes initial settings for A/D converter

Table 5 Module Specifications

Item	Type	Variable	Description
Arguments	None	None	None
Return values	None	None	None

2. Internal Registers Used

The internal registers used in this sample task are shown below. The set values shown are those used in the sample task and differ from the initial values.

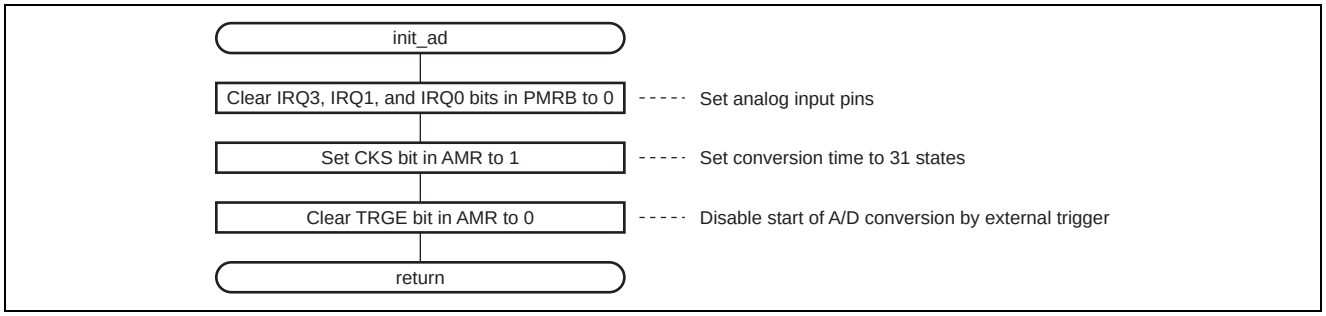
- AMR A/D mode register Address: H'FFBE

Bit	Bit Name	Set Value	R/W	Description
7	CKS	1	R/W	Clock selection Sets the A/D conversion time. 0: Conversion time = 62 states 1: Conversion time = 31 states
6	TRGE	0	R/W	External trigger selection Enables or disables start of A/D conversion by external trigger input. 0: A/D conversion start by external trigger input disabled 1: A/D conversion starts at rising or falling edge of $\overline{\text{ADTRG}}$ pin The edge of the $\overline{\text{ADTRG}}$ signal is selected by the ADTRGNEG bit in IEGR.
3	CH3	0	R/W	Channel selection 3 to 0
2	CH2	0	R/W	Selects the analog input channel.
1	CH1	0	R/W	00xx: No channel selected
0	CH0	0	R/W	0100: AN0 0101: AN1 0110: AN2 0111: AN3 1000: AN4 1001: AN5 1010: AN6 1011: AN7 11xx: Use prohibited Channel selection should be made while the ADSF bit is cleared to 0. Legend: x: Don't care

- PMRB Port mode register B Address: H'FFCA

Bit	Bit Name	Set Value	R/W	Description
2	IRQ3	0	R/W	PB2/AN2/$\overline{\text{IRQ3}}$ pin function switch Selects whether pin PB2/AN2/$\overline{\text{IRQ3}}$ is used as PB2/AN2 or as $\overline{\text{IRQ3}}$. 0: Functions as PB2/AN2 input pin 1: Functions as $\overline{\text{IRQ3}}$ input pin
1	IRQ1	0	R/W	PB1/AN1/$\overline{\text{IRQ1}}$ pin function switch Selects whether pin PB1/AN1/$\overline{\text{IRQ1}}$ is used as PB1/AN1 or as $\overline{\text{IRQ1}}$. 0: Functions as PB1/AN1 input pin 1: Functions as $\overline{\text{IRQ1}}$ input pin
0	IRQ0	0	R/W	PB0/AN0/$\overline{\text{IRQ0}}$ pin function switch Selects whether pin PB0/AN0/$\overline{\text{IRQ0}}$ is used as PB0/AN0 or as $\overline{\text{IRQ0}}$. 0: Functions as PB0/AN0 input pin 1: Functions as $\overline{\text{IRQ0}}$ input pin

3. Flowchart



4.4.3 meas_ad() Function

1. Module Specifications

- Starts A/D conversion from arguments, returns result as return value

Table 6 Module Specifications

Item	Type	Variable	Description
Arguments	unsigned char	ch	Specifies the input channels to be used. The specified values of 0 to 7 correspond to AN0 to AN7.
Return values	unsigned short	—	Returns the A/D conversion result. The values of the upper 6 bits are 0 and values of the lower 10 bits are valid.

2. Internal Registers Used

The internal registers used in this sample task are shown below. The set values shown are those used in the sample task and differ from the initial values.

- AMR A/D mode register Address: H'FFBE

Bit	Bit Name	Set Value	R/W	Description
3	CH3	Undefined	R/W	Channel select 3 to 0
2	CH2	Undefined	R/W	Selects the analog input channel.
1	CH1	Undefined	R/W	00xx: No channel selected
0	CH0	Undefined	R/W	0100: AN0 0101: AN1 0110: AN2 0111: AN3 1000: AN4 1001: AN5 1010: AN6 1011: AN7 11xx: Use prohibited Channel selection should be made while the ADSF bit is cleared to 0. Legend: x: Don't care.

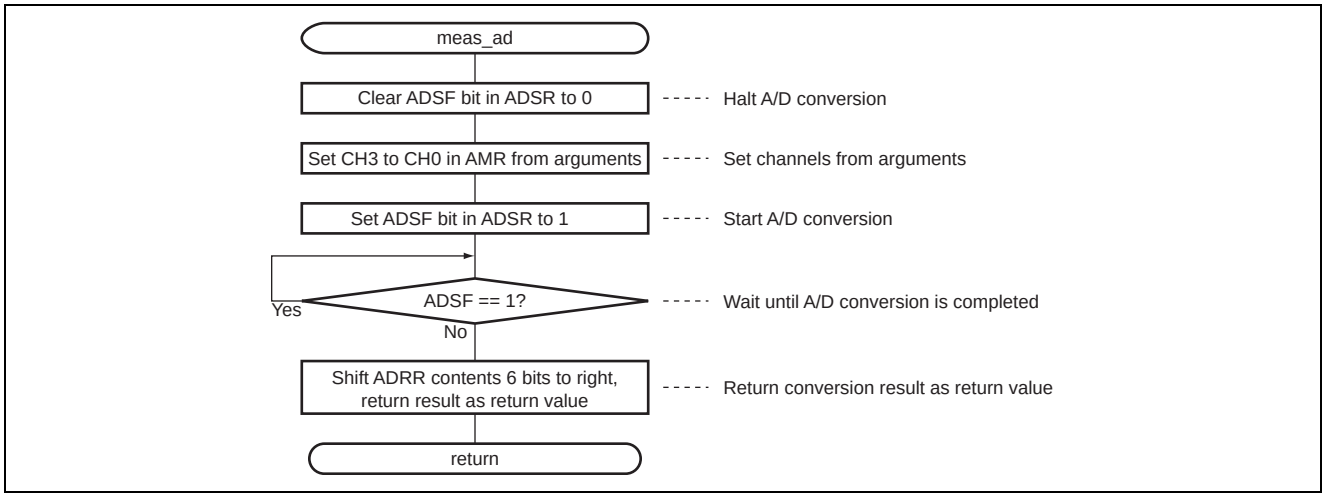
- ADSR A/D start register Address: H'FFBF

Bit	Bit Name	Set Value	R/W	Description
7	ADSF	1	R/W	A/D conversion starts when this bit is set to 1. When conversion is completed, the converted data is set in ADRR and at the same time this bit is cleared to 0. A/D conversion can be forcibly terminated by writing 0 to this bit.

- ADRR A/D result register Address: H'FFBC

Bit	Bit Name	Set Value	R/W	Description
15	ADR9	Undefined	R	ADRR is a 16-bit read-only register that stores the result of A/D conversion. The upper 10 bits of the data are stored in ADRR. ADRR can be read by the CPU at any time, but the ADRR values during A/D conversion is undefined. After A/D conversion is completed, the conversion result is stored as 10-bit data, and this data is retained until the next conversion operation starts. The initial value of ADRR is undefined.
14	ADR8	Undefined	R	
13	ADR7	Undefined	R	
12	ADR6	Undefined	R	
11	ADR5	Undefined	R	
10	ADR4	Undefined	R	
9	ADR3	Undefined	R	
8	ADR2	Undefined	R	
7	ADR1	Undefined	R	
6	ADR0	Undefined	R	

3. Flowchart



4.4.4 stop_ad() Function

1. Module Specifications

- Sets A/D converter to the module standby mode

Table 7 Module Specifications

Item	Type	Variable	Description
Arguments	None	None	None

2. Internal Registers Used

The internal registers used in this sample task are shown below. The set values shown are those used in the sample task and differ from the initial values.

- AMR A/D mode register Address: H'FFBE

Bit	Bit Name	Set Value	R/W	Description
3	CH3	0	R/W	Channel select 3 to 0
2	CH2	0	R/W	Selects the analog input channel.
1	CH1	0	R/W	00xx: No channel selected
0	CH0	0	R/W	0100: AN0 0101: AN1 0110: AN2 0111: AN3 1000: AN4 1001: AN5 1010: AN6 1011: AN7 11xx: Use prohibited Channel selection should be made while the ADSF bit is cleared to 0. Legend: x: Don't care.

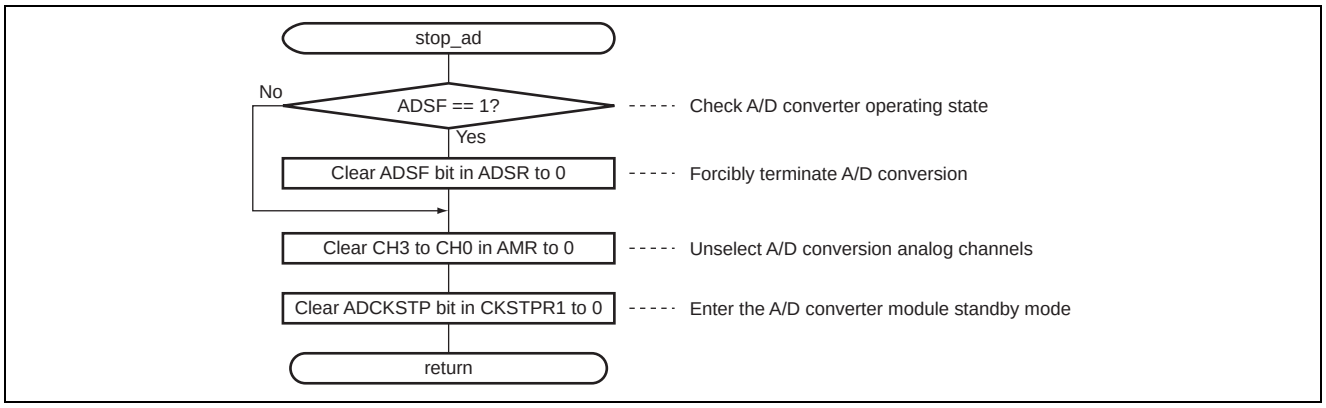
- ADSR A/D start register Address: H'FFBF

Bit	Bit Name	Set Value	R/W	Description
7	ADSF	0	R/W	A/D conversion starts when this bit is set to 1. When conversion is completed, the converted data is set in ADRR and at the same time this bit is cleared to 0. A/D conversion can be forcibly terminated by writing 0 to this bit.

- CKSTPR1 Clock stop register 1 Address: H'FFFA

Bit	Bit Name	Set Value	R/W	Description
4	ADCKSTP	0	R/W	A/D converter module standby The A/D converter enters the standby mode when this bit is cleared to 0.

3. Flowchart



4.5 Link Address Specifications

Section Name	Address
CVECT	H'0000
P	H'0100
B	H'F780

Revision Record

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Mar.18.05	—	First edition issued

Keep safety first in your circuit designs!

1. Renesas Technology Corp. puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage.
   Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of nonflammable material or (iii) prevention against any malfunction or mishap.

Notes regarding these materials

1. These materials are intended as a reference to assist our customers in the selection of the Renesas Technology Corp. product best suited to the customer's application; they do not convey any license under any intellectual property rights, or any other rights, belonging to Renesas Technology Corp. or a third party.
2. Renesas Technology Corp. assumes no responsibility for any damage, or infringement of any third-party's rights, originating in the use of any product data, diagrams, charts, programs, algorithms, or circuit application examples contained in these materials.
3. All information contained in these materials, including product data, diagrams, charts, programs and algorithms represents information on products at the time of publication of these materials, and are subject to change by Renesas Technology Corp. without notice due to product improvements or other reasons. It is therefore recommended that customers contact Renesas Technology Corp. or an authorized Renesas Technology Corp. product distributor for the latest product information before purchasing a product listed herein.
   The information described here may contain technical inaccuracies or typographical errors.
   Renesas Technology Corp. assumes no responsibility for any damage, liability, or other loss rising from these inaccuracies or errors.
   Please also pay attention to information published by Renesas Technology Corp. by various means, including the Renesas Technology Corp. Semiconductor home page (http://www.renesas.com).
4. When using any or all of the information contained in these materials, including product data, diagrams, charts, programs, and algorithms, please be sure to evaluate all information as a total system before making a final decision on the applicability of the information and products. Renesas Technology Corp. assumes no responsibility for any damage, liability or other loss resulting from the information contained herein.
5. Renesas Technology Corp. semiconductors are not designed or manufactured for use in a device or system that is used under circumstances in which human life is potentially at stake. Please contact Renesas Technology Corp. or an authorized Renesas Technology Corp. product distributor when considering the use of a product contained herein for any specific purposes, such as apparatus or systems for transportation, vehicular, medical, aerospace, nuclear, or undersea repeater use.
6. The prior written approval of Renesas Technology Corp. is necessary to reprint or reproduce in whole or in part these materials.
7. If these products or technologies are subject to the Japanese export control restrictions, they must be exported under a license from the Japanese government and cannot be imported into a country other than the approved destination.
   Any diversion or reexport contrary to the export control laws and regulations of Japan and/or the country of destination is prohibited.
8. Please contact Renesas Technology Corp. for further details on these materials or the products contained therein.