Abstract

This document describes the DMA transfer of A/D conversion results (using the A/D converter in one-shot mode) to internal RAM for the R32C/100 Series microcomputer (MCU).

Products

MCU: R32C/100 Series

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.
1. Specifications ................................................................................................... 3
2. Operation Confirmation Conditions ................................................................. 4
3. Reference Application Notes ......................................................................... 4
4. Hardware ........................................................................................................ 4
   4.1 Pin Used ..................................................................................................... 4
5. Software .......................................................................................................... 5
   5.1 Operation Overview ..................................................................................... 5
   5.2 Constant ..................................................................................................... 6
   5.3 Variable ..................................................................................................... 6
   5.4 Flowcharts ................................................................................................. 7
      5.4.1 Main Processing ................................................................................... 7
      5.4.2 Timer A0 Initial Setting ...................................................................... 9
      5.4.3 Timer A0 Interrupt Handling ............................................................ 9
6. Sample Code ................................................................................................. 10
7. Reference Documents .................................................................................. 10
8. Website and Support .................................................................................. 10
1. Specifications

Perform A/D conversion at a given period, and transfer the conversion result to a conversion result storage buffer using DMAC. As the conversion result storage buffer is used repeatedly, the DMA uses repeat transfer mode.

Table 1.1 lists the Peripheral Functions and Their Applications. Figure 1.1 shows the Block Diagram.

<table>
<thead>
<tr>
<th>Peripheral Function</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/D converter</td>
<td>Performs A/D conversion on the input voltage from the AN_0 pin</td>
</tr>
<tr>
<td>DMAC</td>
<td>Transfers A/D converted result to internal RAM area</td>
</tr>
<tr>
<td>Timer A0</td>
<td>Trigger to start A/D conversion (software trigger)</td>
</tr>
</tbody>
</table>

![Figure 1.1 Block Diagram](image-url)
2. Operation Confirmation Conditions

The sample code accompanying this application note has been run and confirmed under the conditions below.

Table 2.1 Operation Confirmation Conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU used</td>
<td>R5F64112DFD (R32C/111 Group)</td>
</tr>
<tr>
<td>Operating frequencies</td>
<td>• Main clock: 16 MHz</td>
</tr>
<tr>
<td></td>
<td>• PLL clock: 100 MHz</td>
</tr>
<tr>
<td></td>
<td>• Base clock: 50 MHz</td>
</tr>
<tr>
<td></td>
<td>• CPU clock: 50 MHz</td>
</tr>
<tr>
<td></td>
<td>• Peripheral bus clock: 25 MHz</td>
</tr>
<tr>
<td></td>
<td>• Peripheral function clock source: 25 MHz</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>5 V</td>
</tr>
<tr>
<td>Integrated development</td>
<td>Renesas Electronics Corporation</td>
</tr>
<tr>
<td>environment</td>
<td>High-performance Embedded Workshop Version 4.07</td>
</tr>
<tr>
<td>C compiler</td>
<td>Renesas Electronics Corporation</td>
</tr>
<tr>
<td></td>
<td>R32C/100 Series C Compiler V.1.02 Release 01</td>
</tr>
<tr>
<td></td>
<td>Compile options</td>
</tr>
<tr>
<td></td>
<td>-D_STACKSIZE_ =0X300 -D__ISTACKSIZE__ =0X300</td>
</tr>
<tr>
<td></td>
<td>-DVECTOR_ADR=0xFFFFFBDC -c -finfo -dir &quot;${CONFIGDIR}&quot;</td>
</tr>
<tr>
<td>Operating mode</td>
<td>Single-chip mode</td>
</tr>
<tr>
<td>Sample code version</td>
<td>Version 1.00</td>
</tr>
<tr>
<td>Board used</td>
<td>Renesas Starter Kit for R32C/111 (product name: R0K564112S000BE)</td>
</tr>
</tbody>
</table>

3. Reference Application Notes

Application notes associated with this application note are listed below. Refer to these application notes for additional information.

• R32C/100 Series Configuring PLL Mode (REJ05B1221-0100)
• R32C/100 Series Configuring DMAC (REJ05B1220-0100)
• R32C/100 Series Using DMAC in Repeat Transfer Mode (R01AN0448EJ0100)
• R32C/100 Series A/D Converter Operation in One-Shot Mode Using DMAC (R01AN0491EJ0100)

4. Hardware

4.1 Pin Used

Table 4.1 lists the Pin Used and Its Function.

Table 4.1 Pin Used and Its Function

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>I/O</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P10_0/AN_0</td>
<td>Input</td>
<td>A/D converter input voltage</td>
</tr>
</tbody>
</table>
5. **Software**

Using a periodic timer (timer A0), start A/D conversion every 100 µs. When conversion is completed, use DMA transfer (repeat transfer) to transfer the result to the RAM storage buffer.

### 5.1 Operation Overview

Operations for this program are as follows.

1. **Initial setting**
   - Initialize the DMAC, A/D converter, and timer A0.

2. **Start the timer A0 count**
   - Set the TA0S bit in the TABSR register to 1 (start counter).

3. **Timer A0 interrupt handling**
   - A timer A0 interrupt is generated every 100 µs. In the timer A0 interrupt handler, set the ADST bit in the AD0CON0 register to 1 (A/D conversion started).

4. **A/D conversion completed, DMA transfer started**
   - When A/D conversion is completed, the conversion result is transferred to the AD00 register, the ADST bit becomes 0 (A/D conversion stopped), the IR bit in the AD0IC register becomes 1 (interrupt requested), and the conversion result in the AD00 register is transferred to an internal RAM area using DMA transfer.

Figure 5.1 shows the Timing Diagram.

![Figure 5.1 Timing Diagram](image-url)
5.2 Constant

Table 5.1 lists the Constant Used in the Sample Code.

<table>
<thead>
<tr>
<th>Constant Name</th>
<th>Setting Value</th>
<th>Contents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BUF_SIZE</td>
<td>16</td>
<td>Buffer size in which A/D conversion result is stored</td>
<td></td>
</tr>
</tbody>
</table>

5.3 Variable

Table 5.2 lists the Global Variable.

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Name</th>
<th>Contents</th>
<th>Function Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>unsigned short</td>
<td>ad_result[]</td>
<td>Array in which A/D conversion result is stored</td>
<td>Not used with functions</td>
</tr>
</tbody>
</table>
5.4 Flowcharts

5.4.1 Main Processing

Figures 5.2 and 5.3 show the main processing.

![Flowchart](image-url)

**Figure 5.2 Main Processing (1/2)**
application example of A/D conversion
operation in one-shot mode using DMAC

Figure 5.3  Main Processing (2/2)
5.4.2 Timer A0 Initial Setting

Figure 5.4 shows the Timer A0 Initial Setting.

```
init_ta0
Set timer A0 to underflow every 100 μs
TA0MR register ← 00h
Bits TMOD1 and TMOD0 = 00b : Timer mode
Bits MR1 and MR0 = 00b : No gate function
Bits TCK1 and TCK0 = 00b : f1
TA0 register ← 2500 - 1 : Underflow occurs every 100 μs
TA0IC register ← 01h : Level 1
return
```

Figure 5.4 Timer A0 Initial Setting

5.4.3 Timer A0 Interrupt Handling

Figure 5.5 shows the Timer A0 Interrupt Handling.

```
_timer_a0
Start A/D conversion
AD0CON0 register ← C0h
ADST bit = 1 : A/D conversion started
return
```

Figure 5.5 Timer A0 Interrupt Handling
6. **Sample Code**  
Sample code can be downloaded from the Renesas Electronics website.

7. **Reference Documents**  
R32C/111 Group User's Manual: Hardware Rev.1.10  
The latest version can be downloaded from the Renesas Electronics website.

Technical Update/Technical News  
The latest information can be downloaded from the Renesas Electronics website.

C Compiler Manual  
R32C/100 Series C Compiler Package V.1.02  
C Compiler User's Manual Rev.2.00  
The latest version can be downloaded from the Renesas Electronics website.

8. **Website and Support**  
Renesas Electronics website  
http://www.renesas.com/

Inquiries  
http://www.renesas.com/inquiry
## Revision History

<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>May 31, 2011</td>
<td>First edition issued</td>
</tr>
</tbody>
</table>

R32C/100 Series
Application Example of A/D Converter Operation in One-shot Mode Using DMAC

All trademarks and registered trademarks are the property of their respective owners.
General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Handling of Unused Pins</td>
<td>Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.</td>
</tr>
<tr>
<td></td>
<td>The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.</td>
</tr>
<tr>
<td>2. Processing at Power-on</td>
<td>The state of the product is undefined at the moment when power is supplied.</td>
</tr>
<tr>
<td></td>
<td>The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.</td>
</tr>
<tr>
<td></td>
<td>In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.</td>
</tr>
<tr>
<td></td>
<td>In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.</td>
</tr>
<tr>
<td>3. Prohibition of Access to Reserved Addresses</td>
<td>Access to reserved addresses is prohibited.</td>
</tr>
<tr>
<td></td>
<td>The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.</td>
</tr>
<tr>
<td>4. Clock Signals</td>
<td>After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.</td>
</tr>
<tr>
<td></td>
<td>When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.</td>
</tr>
<tr>
<td>5. Differences between Products</td>
<td>Before changing from one product to another, i.e. to one with a different part number, confirm that the change will not lead to problems.</td>
</tr>
<tr>
<td></td>
<td>The characteristics of MPU/MCU in the same group but having different part numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different part numbers, implement a system-evaluation test for each of the products.</td>
</tr>
</tbody>
</table>
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 websites.

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 manufacturers, 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 depend 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.

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 design. Please be sure to implement safety measures to guard against the possibility of physical injury, and injury or damage caused by the 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 recomputing 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 2) "Renesas Electronics products" mean any product developed or manufactured by or for Renesas Electronics.