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April 1st, 2010
Renesas Electronics Corporation

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H8/300H Tiny Series
Measuring Voltages by 4-Channel A/D Conversion

Introduction
The A/D converter is used to measure the four voltages by 4-channel A/D conversion.

Target Device
H8/3664

Contents

1. Specifications ...................................................................................................................... 2
2. Description of Functions Used .......................................................................................... 2
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4. Description of Software ...................................................................................................... 5
5. Flowchart ......................................................................................................................... 8
6. Program Listing .................................................................................................................. 9
1. Specifications

- The A/D converter is used to measure the four voltages by 4-channel A/D conversion.
- Inputs voltage to the H8/3664 Series through four channels, and stores the A/D conversion result in RAM, as shown in figure 1.

![Figure 1 Voltage Measurement by 4-Channel A/D Conversion](image)

2. Description of Functions Used

In this sample task, the voltages are measured using the A/D converter for 4-channel A/D conversion.

- In this sample task, the A/D conversion time is set to 12.4 µs per channel.
- The four A/D data registers (ADDRA to ADDRD) are 16-bit read-only ADDR registers used to store the results of A/D conversion. The converted 10-bit data is stored in bits 15 to 6 of the respective ADDR. The lower 6 bits are always read as 0. The data bus between the CPU and the A/D converter is 8 bits wide. The upper byte can be read directly from the CPU, however the lower byte should be read via a temporary register. The temporary register contents are transferred from the ADDR when the upper byte of data is read. When reading from ADDR, read the upper byte only or read in word units. Each ADDR is initialized to H'0000.
- The A/D control/status register (ADCSR) contains the control bits and conversion end status bits of the A/D converter.
- Analog input pins 0 to 7 (AN0 to AN7) are input pins for input voltage channels 0 to 7.
- The analog power supply (AVCC) is a power supply and reference voltage pin for the analog block.
- The analog ground (AVSS) is a ground and reference voltage pin for the analog block.
- In this sample task, the voltages of analog input pins 0 to 3 (AN0 to AN3) are measured by 4-channel A/D conversion.
Table 1 lists the function allocation for this sample task. The functions listed in table 1 are allocated for measuring voltages by 4-channel A/D conversion.

### Table 1  Function Allocation

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADCSR</td>
<td>Sets start, end, status, and conversion time of A/D conversion, and selects analog input pins</td>
</tr>
<tr>
<td>ADDRA to ADDRD</td>
<td>Stores the A/D conversion result</td>
</tr>
<tr>
<td>AN0 to AN7</td>
<td>Input pins for input voltage channels 0 to 7 (in this sample task, only AN0 to AN3 are used)</td>
</tr>
<tr>
<td>AV_{CC}</td>
<td>Power supply and reference voltage pin for the analog block</td>
</tr>
<tr>
<td>AV_{SS}</td>
<td>Ground and reference voltage pin for the analog block</td>
</tr>
</tbody>
</table>
3. Description of Operations

Figure 3 shows this sample task's principle of operation. The hardware and software processing shown in figure 3 applies 4-channel A/D conversion to measure voltages.

![Diagram showing the operation principle of voltage measurement by 4-channel A/D conversion.]

**Figure 3  Operation Principle: Voltage Measurement by 4-Channel A/D Conversion**
4. Description of Software

4.1 Description of Module

Table 2 describes the software used in this sample task.

Table 2 Description of Modules

<table>
<thead>
<tr>
<th>Module Name</th>
<th>Label Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main routine</td>
<td>main</td>
<td>Sets the A/D converter, enables interrupts, selects the analog input channel, starts A/D conversion, moves the A/D conversion result stored in ADDRA to ADDRD to RAM after A/D conversion ends, and the A/D converter stops after performing A/D conversion by analog input channels 0 to 3.</td>
</tr>
</tbody>
</table>

4.2 Description of Arguments

Table 3 describes the arguments used in this sample task.

Table 3 Description of Arguments

<table>
<thead>
<tr>
<th>Argument Names</th>
<th>Function</th>
<th>Used in</th>
<th>Data Length</th>
<th>I/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDRA</td>
<td>Stores the A/D conversion result of analog input channel 0.</td>
<td>Main routine</td>
<td>2 bytes</td>
<td>Output</td>
</tr>
<tr>
<td>ADDRB</td>
<td>Stores the A/D conversion result of analog input channel 1.</td>
<td>Main routine</td>
<td>2 bytes</td>
<td>Output</td>
</tr>
<tr>
<td>ADDRC</td>
<td>Stores the A/D conversion result of analog input channel 2.</td>
<td>Main routine</td>
<td>2 bytes</td>
<td>Output</td>
</tr>
<tr>
<td>ADDRD</td>
<td>Stores the A/D conversion result of analog input channel 3.</td>
<td>Main routine</td>
<td>2 bytes</td>
<td>Output</td>
</tr>
</tbody>
</table>
4.3 **Description of Internal Registers**

Table 4 describes the internal registers used in this sample task.

**Table 4 Description of Internal Registers**

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Function</th>
<th>Address</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADCSR</td>
<td>A/D control/status register (A/D end flag):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Setting conditions]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Completion of A/D conversion in single mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Completion of one round of conversion for all selected channels in scan mode.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Clearing condition]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Writing of 0 to the bit after having read it as 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H'FFB8</td>
<td>Bit 7</td>
<td>0</td>
</tr>
<tr>
<td>ADIE</td>
<td>A/D control/status register (A/D interrupt enable):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>When this bit is set to 1, A/D conversion end interrupt (ADI) requests from ADF are enabled.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H'FFB8</td>
<td>Bit 6</td>
<td>0</td>
</tr>
<tr>
<td>ADST</td>
<td>A/D control/status register (A/D start):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>When ADST is set to 1, A/D conversion starts. When A/D conversion ends in single mode, ADST is automatically cleared.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In scan mode, the sequence of A/D conversion for the selected channels is repeatedly performed until this bit is cleared by software, resetting, or entry to standby mode.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H'FFB8</td>
<td>Bit 5</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4 Description of Internal Registers (cont)

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Function</th>
<th>Address</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADCSR Scan</td>
<td>A/D control/status register (scan mode): Selection of the A/D conversion mode. 0: Single mode 1: Scan mode</td>
<td>H'FFB8</td>
<td>Bit 4 0</td>
</tr>
<tr>
<td>CKS</td>
<td>A/D control/status register (clock select): Setting for A/D conversion time. 0: A/D conversion time = 134 states (max.) 1: A/D conversion time = 70 states (max.) Note: Clear the ADST bit to 0 before switching the conversion time.</td>
<td>H'FFB8</td>
<td>Bit 3 0</td>
</tr>
<tr>
<td>CH2</td>
<td>A/D control/status register (channel select 2 to 0): When CH2, CH1, and CH0 are all cleared to 0, AN0 is selected. When CH2 and CH1 are both cleared to 0 and CH2 is set to 1, AN1 is selected. When CH2 and CH0 are both cleared to 0 and CH1 is set to 1, AN2 is selected. When CH2 is cleared to 0 and CH1 and CH0 are both set to 1, AN3 is selected.</td>
<td>H'FFB8</td>
<td>Bit 2 CH2 = 0 Bit 1 CH1 = 0 Bit 0 CH0 = 0</td>
</tr>
<tr>
<td>ADDRA</td>
<td>A/D data register A: Stores the 16-bit data of the A/D conversion result.</td>
<td>H'FFB0</td>
<td>H'0000</td>
</tr>
<tr>
<td>ADDR B</td>
<td>A/D data register B: Stores the 16-bit data of the A/D conversion result.</td>
<td>H'FFB2</td>
<td>H'0000</td>
</tr>
<tr>
<td>ADDRC</td>
<td>A/D data register C: Stores the 16-bit data of the A/D conversion result.</td>
<td>H'FFB4</td>
<td>H'0000</td>
</tr>
<tr>
<td>ADDRD</td>
<td>A/D data register D: Stores the 16-bit data of the A/D conversion result.</td>
<td>H'FFB6</td>
<td>H'0000</td>
</tr>
</tbody>
</table>

4.4 Description of RAM

Table 5 describes the RAM used in this sample task.

Table 5 Description of RAM

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Function</th>
<th>Address</th>
<th>Used in</th>
</tr>
</thead>
<tbody>
<tr>
<td>addata[4]</td>
<td>Data variables for RAM storage</td>
<td>H'FB80</td>
<td>Main routine</td>
</tr>
<tr>
<td>counter</td>
<td>Counts number of times of 4-channel A/D conversion</td>
<td>H'FB88</td>
<td>Main routine</td>
</tr>
</tbody>
</table>
5. Flowchart

[Flowchart image]

Main routine

1. Initialize PDRB to 0
2. Initialize addata[0] to addata[3] to 0
3. Assign address of ADDRA to addr_ptr
4. Assign address of addata[0] to save_ptr
5. Initialize adc_data to H'00
6. Initialize counter to 0

- counter < 4?
  - Yes: ADF = 0?
    - No: Clear ADST to 0 to end A/D conversion
    - Yes: Set ADST to 1 to start A/D conversion
  - No: Store A/D conversion results stored in addresses of A/D data registers (ADDRs) to address indicated by addata

Note: * In this sample task, the stack pointer is set in INIT.SRC (assembly).

Figure 4 Flowchart for Main Routine
6. Program Listing

INIT.SRC (Program listing)

```assembly
.EXPORT _INIT
.IMPORT _main 
;
.SECTION P, CODE
_INIT:
    MOV.W #H'FF80, R7
    LDC.B #B'10000000, CCR
    JMP @_main
;
.END
```

/**************************************************************/
/*                                                          */
/*  H8/300H Tiny Series -H8/3664-                          */
/*  Application Note                                        */
/*                                                          */
/*  'Voltage Measurement by 4-Channel A/D                   */
/*  Converter'                                             */
/*                                                          */
/*  Function                                                */
/*  : A/D Converter                                         */
/*                                                          */
/*  External Clock : 16MHz                                  */
/*  Internal Clock : 16MHz                                  */
/*  Sub Clock : 32.768kHz                                   */
/*                                                          */
/**************************************************************/

#include <machine.h>
/**********************************************************/
/* Symbol Definition                                       */
/**********************************************************/

struct BIT {
    unsigned char b7:1; /* bit7 */
    unsigned char b6:1; /* bit6 */
    unsigned char b5:1; /* bit5 */
    unsigned char b4:1; /* bit4 */
    unsigned char b3:1; /* bit3 */
    unsigned char b2:1; /* bit2 */
    unsigned char b1:1; /* bit1 */
    unsigned char b0:1; /* bit0 */
};

#define TMA    *(volatile unsigned char *)0xFFA6 /* Timer Mode Register A */
#define TCA    *(volatile unsigned char *)0xFFA7 /* Timer Counter A */
#define PDR8   *(volatile unsigned char *)0xFFDB /* Port Data Register 8 */
#define P81    PDR8_BIT.b1 /* Port Data Register 8 bit1 */
#define PCR8   *(volatile unsigned char *)0xFFEB /* Port Control Register 8 */
#define PCR81  PCR8_BIT.b1 /* Port Control Register 8 bit1 */
#define IENR1_BIT (*(struct BIT *)0xFFF4) /* Interrupt Enable Register 1 */
#define IENTA  IENR1_BIT.b6 /* Timer A Interrupt Enable */
#define IRR1_BIT (*(struct BIT *)0xFFF6) /* Interrupt Request Register 1 */
#define IRRTA  IRR1_BIT.b6 /* Timer A Interrupt Request Flag */
#define ADDRA  *(volatile unsigned int *)0xFFB0 /* A/D Data Register A */
#define ADDR8  *(volatile unsigned int *)0xFFB2 /* A/D Data Register B */
#define ADDRC  *(volatile unsigned int *)0xFFB4 /* A/D Data Register C */
#define ADDR4  *(volatile unsigned int *)0xFFB6 /* A/D Data Register D */
#define ADCSR  *(volatile unsigned char *)0xFFB8 /* A/D Control/Status Register */
#define ADCSR_BIT (*(struct BIT *)0xFFB8) /* A/D Control/Status Register */
#define ADF    ADCSR_BIT.b7 /* A/D END Flag */
#define ADIE   ADCSR_BIT.b6 /* A/D Interrupt Enable */
#define ADST   ADCSR_BIT.b5 /* A/D Start */
#define SCAN   ADCSR_BIT.b4 /* A/D Scan Mode */
#define CRS    ADCSR_BIT.b3 /* A/D Clock Select */
#define CH2    ADCSR_BIT.b2 /* Channel Select 2 */
#define CH1    ADCSR_BIT.b1 /* Channel Select 1 */
#define CH0    ADCSR_BIT.b0 /* Channel Select 0 */
#define PD8    *(volatile unsigned char *)0xFFDD /* Port Data Register B */

/************************************************************/
/*  Function Definition                                      */
/************************************************************/
extern  void    INIT( void );                    /* SP Set                                         */
void    main    ( void );
/************************************************************/
/*  RAM define                                              */
/************************************************************/
unsigned int    addata[4];
unsigned char   counter;
/************************************************************/
/*  Vector Address                                         */
/************************************************************/
#pragma section     V1                           /* VECTOR SECTIOIN SET                             */
void (*const VEC_TBL1[])(void) = {
    /* 0x00 - 0x0f */
    INIT                                         /* 00 Reset                                       */
};
#pragma section                                  /* P                                              */
/************************************************************/
/*  Main Program                                           */
/************************************************************/
void main ( void )
{
    unsigned int    *addr_ptr,*save_ptr;
    unsigned char   adc_data;
    unsigned int    cnt;

    PDRB = 0;                                    /* Clear PDRB                                     */
    addata[0] = 0;                               /* Clear adddata[0]                               */
    addata[1] = 0;                               /* Clear adddata[1]                               */

    addr_ptr = &ADDRA;
    save_ptr = &addata[0];
    adc_data = 0x00;                             /* Clear adc_data                                 */
    counter = 0;                                 /* Clear counter                                  */
    while( counter < 4 ){                        /* A/D Convert END ?                              */
        ADCSR = adc_data;                        /* Select A/D Convert Time & Analog Input Channel */
        ADF = 0;                                 /* Initialize ADF                                 */
        ADST = 1;                                /* Start A/D Convert                              */

        while(ADF == 0){                         /* A/D Convert End ?                              */
            ;
        }

        ADST = 0;                                /* Stop A/D Convert                               */
        *(save_ptr + counter) = *(addr_ptr + counter);
        adc_data++;                              /* Decrement A/D Convert Counter                  */
        counter++;                              /* Decrement A/D Convert Counter                  */
    }
}
while(1){
    ;
}

Link Address Setting:

<table>
<thead>
<tr>
<th>Section Name</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV1</td>
<td>H'0000</td>
</tr>
<tr>
<td>P</td>
<td>H'0100</td>
</tr>
<tr>
<td>B</td>
<td>H'FB80</td>
</tr>
</tbody>
</table>
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<table>
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<th>Date</th>
<th>Page</th>
<th>Summary</th>
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</tbody>
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