To our customers,

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

April 1st, 2010
Renesas Electronics Corporation

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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.
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 $V_{IL} \text{ (MAX)}$ and $V_{IH} \text{ (MIN)}$ 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 $V_{IL} \text{ (MAX)}$ and $V_{IH} \text{ (MIN)}$.

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

<table>
<thead>
<tr>
<th>[Function]</th>
<th>Function description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Function name]</td>
<td>Name of sample function</td>
</tr>
<tr>
<td>[Argument]</td>
<td>Type and overview of argument</td>
</tr>
<tr>
<td>[Processing content]</td>
<td>Processing content of sample function</td>
</tr>
<tr>
<td>[SFR(s) used]</td>
<td>Register name and setting content</td>
</tr>
<tr>
<td>[call function(s)]</td>
<td>Name and function of call function(s)</td>
</tr>
<tr>
<td>[Variable(s)]</td>
<td>Type, name, and overview of variable(s) used in sample function</td>
</tr>
<tr>
<td>[Interrupt(s)]</td>
<td>Name of function</td>
</tr>
<tr>
<td>[Interrupt source(s)]</td>
<td>Name</td>
</tr>
<tr>
<td>[File name]</td>
<td>Name of corresponding sample program file</td>
</tr>
<tr>
<td>[Caution(s)]</td>
<td>Caution(s) upon function usage</td>
</tr>
</tbody>
</table>

### Interrupt function(s)

<table>
<thead>
<tr>
<th>[Function name]</th>
<th>Name of interrupt function</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Processing content]</td>
<td>Processing content of interrupt function</td>
</tr>
<tr>
<td>[SFR(s) used]</td>
<td>Register name and setting content</td>
</tr>
<tr>
<td>[call function(s)]</td>
<td>None</td>
</tr>
<tr>
<td>[Variable(s)]</td>
<td>Name of variable, function</td>
</tr>
<tr>
<td>[File name]</td>
<td>Name of corresponding sample program file</td>
</tr>
<tr>
<td>[Caution(s)]</td>
<td>None</td>
</tr>
</tbody>
</table>
Product Differences

The differences between the V850E/IA4 and the V850E/IA3 related to the A/D converter are shown below.

<table>
<thead>
<tr>
<th>Item</th>
<th>V850E/IA4</th>
<th>V850E/IA3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog input</td>
<td>8 channels</td>
<td>6 channels</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Document Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverter Control by V850 Series Vector Control by Hole Sensor Application Note</td>
<td>Inverter Control by V850 Series Vector Control by Encoder Application Note</td>
</tr>
<tr>
<td>Manual for Using Sample Program Functions A/D Converter 2 (V850E/IA3, V850E/IA4) Application Note</td>
<td>This document</td>
</tr>
</tbody>
</table>
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   1-buffer serial mode ............................................................................................................ 7
A/D converter 2
   4-buffer parallel mode ....................................................................................................... 13
**A/D converter 2**

**1-buffer serial mode**

<table>
<thead>
<tr>
<th>Function</th>
<th>Converts signals input to the analog input pin (ANI20) to digital values. An A/D conversion end interrupt request signal (INTAD2) occurs upon completion of every A/D conversion.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function name</td>
<td>ad2_main</td>
</tr>
<tr>
<td>Argument</td>
<td>None</td>
</tr>
<tr>
<td>Processing content</td>
<td>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.</td>
</tr>
<tr>
<td>SFR used</td>
<td>AD2IC: 0x07 (Clears conversion end interrupt request signal (INTAD2), releases mask, sets to priority level 7)</td>
</tr>
<tr>
<td>Call functions</td>
<td>ad2_port_set, ad2_set, ad2_analog_on, ad2_start, ad2_stop, ad2_analog_off</td>
</tr>
<tr>
<td>Variables</td>
<td>unsigned short int buf[]: Conversion data storing buffer volatile unsigned char count: Conversion count variable unsigned char wait: WAIT variable</td>
</tr>
<tr>
<td>Interrupt</td>
<td>ad2_int</td>
</tr>
<tr>
<td>Interrupt source</td>
<td>INTAD2</td>
</tr>
<tr>
<td>File name</td>
<td>ad2.c</td>
</tr>
<tr>
<td>Caution</td>
<td>None</td>
</tr>
</tbody>
</table>

| 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: ad2_stop

**Processing content**: Stops the A/D conversion operation.

**SFR used**: ADA2CTL0.ADA2CE: 0 (Stops A/D conversion operation.)

**Call function**: None

**Variables**: None

**File name**: ad2.c

**Caution**: None

### Function: ad2_analog_off

**Processing content**: Turns off the analog power supply.

**SFR used**: ADA2CTL0.ADA2PON: 0 (Turns off analog power supply.)

**Call function**: None

**Variables**: 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
A/D converter 2
1-buffer serial mode (1/3)

- **ad2_main**: The main entry point.
- **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**: Checks conversion count.
  - **No**: Flow back to **ad2_start**.
  - **Yes**: Proceeds to next steps.
- **ad2_stop**: A/D conversion operation stop function.
- **ad2_analog_off**: Function for turning off analog power supply.
A/D converter 2
1-buffer serial mode (2/3)

Alternate-function pin specify function

\texttt{ad2\_port\_set} \rightarrow \texttt{PMCM7 := 0x01} \rightarrow \texttt{ret}

Sets alternate-function pin to ANI20

A/D converter 2 control register setting function

\texttt{ad2\_set} \rightarrow \texttt{ADA2CTL3 = 0x00} \rightarrow \texttt{ret}

Sets buffer mode to 1 buffer
Sets operation mode to serial mode

\texttt{ADA2CTL1 = 0x03} \rightarrow \texttt{ret}

Sets sampling clock as fxx/16 (4 MHz)
Sets resolution to 10 bits (2048 times)

\texttt{ADA2CTL2 = 0x00} \rightarrow \texttt{ret}

Sets analog input pin to ANI20

Function for turning on analog power supply

\texttt{ad2\_analog\_on} \rightarrow \texttt{ADA2PON = 1} \rightarrow \texttt{ret}

Turns on analog power supply

\texttt{WAIT (at least 5 \(\mu\)s)} \rightarrow \texttt{ret}

Leaves a lapse of at least 5 \(\mu\)s without setting the A/D conversion operation control bit (ADA2CE) after setting the analog power supply control bit (ADA2PON)

A/D conversion operation start function

\texttt{ad2\_start} \rightarrow \texttt{ADA2CE = 1} \rightarrow \texttt{ret}

Enables A/D2 conversion operation
A/D converter 2

1-buffer serial mode (3/3)

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

ret
**A/D converter 2**

**4-buffer parallel mode**

| **[Function]** | Converts signals input to the analog input pin (ANI20) to digital values. An A/D 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 |

---

<p>| <strong>[Function name]</strong> | ad2_port_set |
| <strong>[Processing content]</strong> | Sets the alternate-function pin to the ANI20 input pin. |
| <strong>[SFR used]</strong> | PMC7: 0x01 (Sets P70 pin to ANI20 input pin.) |
| <strong>[call function]</strong> | None |
| <strong>[Variable]</strong> | None |
| <strong>[File name]</strong> | ad2_1.c |
| <strong>[Caution]</strong> | None |</p>
<table>
<thead>
<tr>
<th>Function name</th>
<th>ad2_analog_on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing content</td>
<td>Turns on the analog power supply</td>
</tr>
<tr>
<td>SFR used</td>
<td>ADA2CTL0.ADA2PON: 1 (Turns on analog power supply.)</td>
</tr>
<tr>
<td>call function</td>
<td>None</td>
</tr>
<tr>
<td>Variable</td>
<td>unsigned char wait: WAIT variable</td>
</tr>
<tr>
<td>File name</td>
<td>ad2_1.c</td>
</tr>
<tr>
<td>Caution</td>
<td>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.</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Function name</th>
<th>ad2_start</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing content</td>
<td>Starts the A/D conversion operation.</td>
</tr>
<tr>
<td>SFR used</td>
<td>ADA2CTL0.ADA2CE: 1 (Starts A/D conversion operation.)</td>
</tr>
<tr>
<td>call function</td>
<td>None</td>
</tr>
<tr>
<td>Variable</td>
<td>None</td>
</tr>
<tr>
<td>File name</td>
<td>ad2_1.c</td>
</tr>
<tr>
<td>Caution</td>
<td>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.</td>
</tr>
<tr>
<td>Function name</td>
<td>ad2_stop</td>
</tr>
<tr>
<td>---------------</td>
<td>----------</td>
</tr>
<tr>
<td>Processing content</td>
<td>Stops the A/D conversion operation.</td>
</tr>
<tr>
<td>SFR used</td>
<td>ADA2CTL0.ADA2CE: 0 (Stops A/D conversion operation.)</td>
</tr>
<tr>
<td>call function</td>
<td>None</td>
</tr>
<tr>
<td>variable</td>
<td>None</td>
</tr>
<tr>
<td>File name</td>
<td>ad2_1.c</td>
</tr>
<tr>
<td>Caution</td>
<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function name</th>
<th>ad2_analog_off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing content</td>
<td>Turns off the analog power supply.</td>
</tr>
<tr>
<td>SFR used</td>
<td>ADA2CTL0.ADA2PON: 0 (Turns off analog power supply.)</td>
</tr>
<tr>
<td>call function</td>
<td>None</td>
</tr>
<tr>
<td>variable</td>
<td>None</td>
</tr>
<tr>
<td>File name</td>
<td>ad2_1.c</td>
</tr>
<tr>
<td>Caution</td>
<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function name</th>
<th>ad2_int</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing content</td>
<td>Stores the A/D conversion result data to the buffer upon completion of each conversion.</td>
</tr>
<tr>
<td>SFR used</td>
<td>ADA2CR0 A/D2 conversion result register 0</td>
</tr>
<tr>
<td>call function</td>
<td>None</td>
</tr>
<tr>
<td>variables</td>
<td>unsigned short int buf[]: Conversion data storing buffer</td>
</tr>
<tr>
<td></td>
<td>unsigned short int buf1[]: Conversion data storing buffer</td>
</tr>
<tr>
<td></td>
<td>unsigned short int buf2[]: Conversion data storing buffer</td>
</tr>
<tr>
<td></td>
<td>unsigned short int buf3[]: Conversion data storing buffer</td>
</tr>
<tr>
<td></td>
<td>unsigned char count: Conversion count variable</td>
</tr>
<tr>
<td>File name</td>
<td>ad2_1.c</td>
</tr>
<tr>
<td>Caution</td>
<td>None</td>
</tr>
</tbody>
</table>
A/D converter 2
4-buffer parallel mode (1/3)

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
- Checks conversion count

No

ad2_stop
- A/D conversion operation stop function

Yes

ad2_analog_off
- Function for turning off analog power supply
Alternate-function pin specify function

ad2_port_set

Sets alternate-function pin to ANI20

PMC7 |= 0x01

ret

A/D control register setting function

ad2_set

Sets buffer mode to 4 buffers
Sets operation mode to parallel mode

ADA2CTL3 = 0xC0

ret

Sets sampling clock as fx/16 (4 MHz)
Sets resolution to 10 bits (2048 times)

ADA2CTL1 = 0x03

ADA2CTL2 = 0x00

Sets analog input pin to ANI20

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 converter 2

4-buffer parallel mode (3/3)

A/D conversion operation stop function

ad2_stop

ADA2CE = 0

ret

Function for turning off analog power supply

ad2_analog_off

ADA2PON = 0

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

Function for turning off analog power supply

ad2_analog_off

ADA2PON = 0

ret

INTAD2 interrupt

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

Function for turning off analog power supply

ad2_analog_off

ADA2PON = 0

ret

INTAD2 interrupt

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

Function for turning off analog power supply

ad2_analog_off

ADA2PON = 0

ret
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