Abstract

This document describes a method for measuring a pulse width using the digital debounce function of the intelligent I/O.

Products

MCUs: R32C/120 Group, R32C/121 Group, R32C/151 Group, R32C/152 Group, R32C/153 Group, R32C/156 Group, R32C/157 Group, R32C/160 Group, R32C/161 Group

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.
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1. Specifications
The digital debounce function enables to determine the signal level when the pulse becomes longer than
the filter width set by a program after the signal is input on a rising or falling edge.
Table 1.1 lists the Peripheral Function and Its Application. Figure 1.1 shows Digital Debounce Filtering.

Table 1.1  Peripheral Function and Its Application

<table>
<thead>
<tr>
<th>Peripheral Function</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligent I/O group 0 (IIO0)</td>
<td>Pulse-width measurement using the digital debounce function</td>
</tr>
</tbody>
</table>

An example of digital debounce function of IIO0_7 signal (IC07DDR register = 03h)

![Digital Debounce Filtering Diagram]

The output signal changes after the counter reaches 00h.
The output signal holds the same level until the counter reaches 00h.
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>R5F64219JFB (R32C/121 Group)</td>
</tr>
<tr>
<td>Operating frequencies</td>
<td>Main clock: 8 MHz</td>
</tr>
<tr>
<td></td>
<td>PLL clock: 128 MHz</td>
</tr>
<tr>
<td></td>
<td>Base clock: 64 MHz</td>
</tr>
<tr>
<td></td>
<td>CPU clock: 64 MHz</td>
</tr>
<tr>
<td></td>
<td>Peripheral bus clock: 32 MHz</td>
</tr>
<tr>
<td></td>
<td>Peripheral function clock source: 32 MHz</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>5 V</td>
</tr>
<tr>
<td>Integrated development environment</td>
<td>Renesas Electronics Corporation</td>
</tr>
<tr>
<td></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></td>
<td>(Default setting is used in the integrated development environment.)</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>
</tbody>
</table>

3. Reference Application Notes

The application notes associated with this application note are listed below. Refer to the following application notes for additional information.

- R32C/100 Series Configuring PLL Mode (REJ05B1221-0100)
- R32C/100 Series How to Use Intelligent I/O Interrupt (REJ05B1416-0100)
- R32C/100 Series Intelligent I/O Single-phase Waveform Output Mode (REJ05B1226-0100)

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>P1_7/IIO0_7</td>
<td>Input</td>
<td>Pulse-width measurement using the digital debounce function</td>
</tr>
</tbody>
</table>
5. Software

5.1 Operation Overview

Input the signal pulse to the IIO0_7 pin and measure the pulse width.

(1) Intelligent I/O settings
   Use group 0 channel 7 in time measurement mode. Set both edges as a time measurement trigger.
   Set the filter width of the digital debounce function to 32 μs (IC07DDR register = 7Fh).

(2) Pulse-width measurement
   The time measurement interrupt of channel 7 is used, and the G0TM7 register is read during the time measurement interrupt handling. The difference from the value previously read is the pulse width.

Figure 5.1 shows operation using the sample code.

---

**Figure 5.1 Sample Code Operation**

(1) An external time measurement trigger input cannot be accepted if the pulse width signal is less than 32 μs.
(2) When the signal level at a rising edge becomes longer than the filter width, an external time measurement trigger input can be accepted, and the base timer value is stored in the G0TM7 register.
(3) When time measurement starts, interrupt requests for time measurement are generated. The G0TM7 register is read during the time measurement interrupt handling.
(4) An external time measurement trigger input cannot be accepted if the pulse width signal is less than 32 μs.
(5) When the signal level at a falling edge becomes longer than the filter width, an external time measurement trigger input can be accepted, and the base timer value is stored in the G0TM7 register.
(6) When time measurement starts, interrupt requests for time measurement are generated. The G0TM7 register is read during the time measurement interrupt handling. The difference from the value previously read from (3) is the pulse width.

5.2 Notes

In the sample code, the BT0R bit in intelligent I/O interrupt request register 7 becomes 1 (interrupt requested) when the base timer overflows. When the BT0E bit in intelligent I/O interrupt request register 7 is 0 (disabled), the BT0R bit does not need to be set to 0 (no interrupt requested).
5.3 Variable Tables

Table 5.1 lists the Global Variables.

Table 5.1 Global Variables

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Name</th>
<th>Contents</th>
<th>Function Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>uint8_t</td>
<td>tr_flg</td>
<td>First decision flag of time measurement</td>
<td>main, _intelligent_io_int7</td>
</tr>
<tr>
<td>uint16_t</td>
<td>tr_now</td>
<td>Time measurement value (new)</td>
<td>main, _intelligent_io_int7</td>
</tr>
<tr>
<td>uint16_t</td>
<td>tr_old</td>
<td>Time measurement value (old)</td>
<td>main, _intelligent_io_int7</td>
</tr>
<tr>
<td>uint16_t</td>
<td>tr_pulse</td>
<td>Pulse-width measurement</td>
<td>main, _intelligent_io_int7</td>
</tr>
</tbody>
</table>

5.4 Function Table

Table 5.2 lists the Functions.

Table 5.2 Functions

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Outline</th>
<th>Header</th>
<th>Declaration</th>
<th>Explanation</th>
<th>Argument</th>
<th>Returned value</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>iio_init</td>
<td>Intelligent I/O initialization</td>
<td>None</td>
<td>void iio_init(void)</td>
<td>Initializes the intelligent I/O.</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>_intelligent_io_int7</td>
<td>Intelligent I/O interrupt 7 handling</td>
<td>None</td>
<td>void _intelligent_io_int7(void)</td>
<td>Enable the intelligent I/O interrupt for channel 7</td>
<td>None</td>
<td>None</td>
<td>Measure a pulse width using the digital debounce function.</td>
</tr>
</tbody>
</table>

5.5 Function Specifications

The following tables list the sample code function specifications.

iio_init

Outline Intelligent I/O initialization
Header None
Declaration void iio_init(void)
Explanation Initializes the intelligent I/O.
Argument None
Returned value None
Remark

_intelligent_io_int7

Outline Intelligent I/O interrupt 7 handling
Header None
Declaration void _intelligent_io_int7(void)
Explanation Enable the intelligent I/O interrupt for channel 7
Argument None
Returned value None
Remark Measure a pulse width using the digital debounce function.
5.6 Flowcharts

5.6.1 Main Processing

Figure 5.2 shows the Main Processing.

![Flowchart of Main Processing]

- **Set PLL clock**
  - `SetPLLclock()`
  - Set each clock frequency in PLL mode. (1)

- **Initialize variables**
  - `tr_flg ← 0`
  - `tr_now ← 00h`
  - `tr_old ← 00h`
  - `tr_pulse ← 00h`

- **Initialize intelligent I/O**
  - `iio_init()`

- **Enable maskable interrupts**
  - `I flag ← 0`

- **Intelligent I/O group 0 base timer count starts**
  - `G0BCR1 register BTS bit ← 1`
  - : Count starts.

**Note:**
1. Refer to the hardware user’s manual for initializing the clock.

*Figure 5.2 Main Processing*
Figure 5.2 shows Intelligent I/O Initialization.

(1) Set group 0 base timer

```
iio_init
```

G0BCR0 register ← 7Fh
- Bits BCK1 and BCK0 = 11b
- Bits DIV4 to DIV0 = 11111b
- IT bit = 0

: Set count source to f1.
: Set count source divide ratio to no division.
: Set base timer interrupt source select bit to 0 (overflow of bit 15 or bit 9).

(2) Group 0 base timer reset

G0BCR1 register ← 00h
- BTS bit = 0

: Reset base timer.

(3) Set intelligent I/O group 0 time measurement trigger

G0TMCR7 register ← 03h
- Bits CTS1 and CTS0 = 11b
- Bits DF1 and DF0 = 00b

: Set both edges as a time measurement trigger.
: Set as no digital filter.

(4) Set II00_7 digital debounce register

IC07DDR register ← 7Fh

: Only the signal whose pulse is longer than 32 μs is input to the IIOi_7 pin.

(5) Set intelligent I/O group 0 time measurement

G0FS register ← 80h
- FSC7 bit = 1

G0FE register ← 80h
- IFE7 bit = 1

: Select the time measurement as a function of channel 7.
: Set operating mode for channel 7.

(6) Wait two or more fBT0 clock cycles

(7) Set interrupts

IIO7IR register ← 00h

: Clear TM07R interrupt request.

(8) Set intelligent I/O interrupt enable register 7 (1)

IIO7IE register ← 01h
- IRLT bit = 1

: Use interrupt requests for interrupt. (1)

(9) Set intelligent I/O interrupt enable register 7 (2)

IIO7IE register ← 03h
- IRLT bit = 1
- TM07R bit = 1

: Use interrupt requests for interrupt. (1)
: Enable TM07R interrupt. (1)

(10) Set interrupt request level

IIO7IC register ← 01h
- Bits ILVL2 and ILVL0 = 001b

: Set interrupt request level to level 1.

(11) Set input port

IFS2 register ← 01h
- Bits IFS21 and IFS20 = 01b

: Assign the IIO0 input to port P1.

P1_7S register ← 00h
- Bits P1_7S = 0

: Set P1_7 as I/O port.

PD1 register ← 00h
- PD1_7 bit = 0

: Set P1_7 as input port.

Note:
1. To use interrupt requests for interrupt, the IRLT bit should be set to 1, then bit 1 should be set to 1.

Figure 5.3  Intelligent I/O Initialization
5.6.2 Intelligent I/O Interrupt 7 Handling

Figure 5.4 shows Intelligent I/O Interrupt 7 Handling.

![Diagram of Intelligent I/O Interrupt 7 Handling]

1. Is the TM07R bit 1?
   - No
   - Yes

2. Clear TM07R bit
   \[ \text{TM07R} \leftarrow 0 \] : Clear interrupt request.

3. Read the G0TM7 register to obtain the base timer value.

4. Calculate pulse width

**Figure 5.4** Intelligent I/O Interrupt 7 Handling
6. **Sample Code**

   Sample code can be downloaded from the Renesas Electronics website.

7. **Reference Documents**

   - R32C/120 Group User's Manual: Hardware Rev.1.10
   - R32C/121 Group User's Manual: Hardware Rev.1.10
   - R32C/152 Group User's Manual: Hardware Rev.1.10
   - R32C/156 Group User's Manual: Hardware Rev.1.03
   - R32C/157 Group User's Manual: Hardware Rev.1.03
   - R32C/160 Group User's Manual: Hardware Rev.1.02
   - R32C/161 Group User's Manual: Hardware Rev.1.02

   The latest versions 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>Mar. 15, 2011</td>
<td>First edition issued</td>
</tr>
</tbody>
</table>

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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.

1. Handling of Unused Pins
   Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.
   - 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.

2. Processing at Power-on
   The state of the product is undefined at the moment when power is supplied.
   - 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.
     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.
     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.

3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
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4. Clock Signals
   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.
   - 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.

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