1. **Abstract**

This document describes pulse-width measurement using the time measurement function of intelligent I/O groups 0 and 1.

2. **Introduction**

The application example described in this document applies to the following microcomputers (MCUs): 

MCUs: R32C/116 Group, R32C/117 Group, and R32C/118 Group

This application note can be used with other R32C/100 Series MCUs which have the same special function registers (SFRs) as the above groups. Check the manuals for any modifications to functions. Careful evaluation is recommended before using the program described in this application note.
3. Application Example

Intelligent I/O groups 0 and 1 each consist of one free-running 16-bit base timer and eight 16-bit registers (channels 0 to 7) for time measurement or waveform generation.

Figure 3.1 shows the Reference Input Pulse and Time Measurement.

![Figure 3.1 Reference Input Pulse and Time Measurement](image)

The figure above applies under the following condition:
- Bits CTS1 and CTS0 in the GiTMCRj register are set to 11b (both edges) (i = 0, 1; j = 6, 7).

This section describes how to measure a pulse input applied to the IIO0_0 pin using time measurement channel 0.

Other conditions are as follows:
- Select the time measurement trigger: Both edges of the IIO0_0 pin
- Intelligent I/O group 0 input pin: Port P1
- Select gating: Gating disabled
- Base timer count source (fBT0): f1 (no division)
3.1 Timing

(1) When the BT0S bit in the BTSR register is set to 1, the group 0 base timer count starts.

(2) If a trigger input is applied to the to the IIO0_0 pin, the interrupt of group 0 time measurement channel 0 (TM00) is generated. The value in the G0TM0 register is read in the interrupt handler. The difference from the value previously read is the measurement time.

Figure 3.2 shows an Operating Example of Pulse-Width Measurement Using the Time Measurement Function.

![Operating Example of Pulse-Width Measurement Using the Time Measurement Function](image)

3.2 Notes on Intelligent I/O

If an interrupt is accepted, the IR bit in the IIOiIC register is automatically set to 0. However, even if an interrupt is accepted, each bit in the IIOiIR register is not automatically set to 0 (i = 0 to 11). They should be set to 0 by either the AND or BCLR instruction. Note that every generated interrupt request is ignored until these bits are set to 0.
### 3.3 Flowcharts

Figure 3.3 and Figure 3.4 show the Main Function, and Figure 3.5 shows Intelligent I/O Interrupt 1.

![Flowchart](image)

#### Figure 3.3 Main Function (1/2)

- **main**
  - (1) Disable maskable interrupts
  - **Set PLL Clock**
  - (2) G2BCR0 ← 7Fh
    - BTSR ← 00h
    - G2BCR0 ← 00h
  - (3) G0BCR0 ← 7Fh
  - (4) G0BCR1 ← 00h
  - **Set group 0 base timer control register 0.**
    - **Set group 0 base timer control register 1.**
      - Base timer reset source select bit 0: No reset
      - Base timer reset source select bit 1: No reset
      - Base timer start bit: Base timer reset
      - Increment/decrement counting control bit: Increment counting mode.
  - (5) G0TMCR0 ← 03h
  - (6) G0FS ← 01h
  - (7) G0FE ← 01h
  - **Insert wait time**
  - (8) IIO1IR ← 00h
    - IIO1IE ← 01h (Note 2)
    - IIO1IE ← 03h (Note 2)
    - IIO1IC ← 03h
  - (9) IFS20 ← 0
  - (10) P1_0S ← 00h
    - PD1_0 ← 0
  - **Set the IIO0 pin.**
  - **Notes:**
    1. Refer to the hardware user’s manual for initializing the clock.
    2. The initial settings of bits and registers for the intelligent I/O are required as follows:
       - (1) Set the G2BCR0 register to provide the clock to the group 2 base timer.
       - (2) Set the G2BCR0 register to provide the clock to the group 2 base timer.
       - (3) Set the G2BCR0 register to provide the clock to the group 2 base timer.
    3. Write 1 to bits 1 to 4, 6, and 7 after setting the IRLT bit in the IIO1IE register to 1.

**Note 1:** Initialize intelligent I/O. (Note 1)

**Note 2:** Set the BTiS bit allows the base timers of two or all groups to start counting simultaneously (i = 0 to 2).

To start counting individually, the BTiS bit should be set to 0 and the BTS bit in the GiBCR1 register should be used.
Enable maskable interrupts

Start the base timer count.

**Figure 3.4** Main Function (2/2)

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Set the group 0 base timer control register.

- Count source: f1
- Count source divide ratio: No division
- Base timer interrupt source: Overflow of bit 15 or bit 9

**Figure 3.5** Intelligent I/O Interrupt 1

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1. **_intelligent_io_int1**
2. **TM00 interrupt requested?**
   - **No**
   - **Yes**
   - Clear TM00 interrupt request
3. Read the G0TM0 register
4. Calculate pulse width
5. Update data for next calculation

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4. Sample Program
A sample program can be downloaded from the Renesas Electronics website.

5. Reference Documents
User’s Manuals
R32C/116 Group User’s Manual: Hardware Rev.1.00
R32C/117 Group User’s Manual: Hardware Rev.1.00
R32C/118 Group User’s Manual: Hardware Rev.1.00
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.

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

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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.
   - 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.

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.

5. Differences between Products
   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.
   - 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.
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