Abstract

This document describes how to determine a 50 Hz or 60 Hz commercial power frequency using timer A event counter mode with the M16C/63, 64A, 64C, 65, 65C, 6C, 5LD, 56D, 5L, 56, 5M, and 57 Groups.

Products

M16C/63, 64A, 64C, 65, 65C, 6C, 5LD, 56D, 5L, 56, 5M, and 57 Groups

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

A zero-crossing signal is output using a zero-crossing detector from an AC power input voltage. The output zero-crossing signal is input to the TA0IN pin, and its rising edge is counted. Rising edges are counted for 1 second, then a 50 Hz or 60 Hz commercial power frequency is determined. Timer A0 event counter mode is used to count the number of rising edges.

Table 1.1 lists the Peripheral Functions and Their Applications. Figure 1.1 shows the Connection Example, and Figure 1.2 shows Detecting Zero-Crossing of AC Power Voltage.

Table 1.1 Peripheral Functions and Their Applications

<table>
<thead>
<tr>
<th>Peripheral Function</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer (timer A0)</td>
<td>Counts rising edges of zero-crossing signals using event counter mode</td>
</tr>
<tr>
<td>Timer (timer A1)</td>
<td>Measures time to operate timer A0 (1 second)</td>
</tr>
</tbody>
</table>

**Figure 1.1** Connection Example

**Figure 1.2** Detecting Zero-Crossing of AC Power Voltage
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>M16C/65 Group</td>
</tr>
<tr>
<td>Operating frequencies</td>
<td>• XIN Clock: 8 MHz</td>
</tr>
<tr>
<td></td>
<td>• CPU clock: 32 MHz (PLL operation mode: divided by 2, multiplied by 8)</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>5 V (available between 2.7 to 5.5 V)</td>
</tr>
<tr>
<td>Integrated development</td>
<td>Renesas Electronics Corporation</td>
</tr>
<tr>
<td>environment</td>
<td>High-performance Embedded Workshop Version 4.09</td>
</tr>
<tr>
<td>C compiler</td>
<td>Renesas Electronics Corporation</td>
</tr>
<tr>
<td></td>
<td>M16C Series/R8C Family C Compiler V.5.45 Release 01</td>
</tr>
<tr>
<td></td>
<td>Compile options</td>
</tr>
<tr>
<td></td>
<td>-c -finfo -dir &quot;$(CONFIGDIR)&quot;</td>
</tr>
<tr>
<td></td>
<td>(The 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. Hardware

3.1 Pin Used

Table 3.1 lists the Pin Used and Its Function.

Table 3.1 Pin Used and Its Function

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>I/O</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P7_1/TA0IN</td>
<td>Input</td>
<td>Inputs zero-crossing signals from the zero-crossing detector</td>
</tr>
</tbody>
</table>
4. Software

Timer A0 (event counter mode) and timer A1 (timer mode) are used in the sample code. Count the rising edges of zero-crossing signals for 1 second, and determine whether commercial power frequency is 50 Hz or 60 Hz according to Table 4.1.

<table>
<thead>
<tr>
<th>Number of Edges Counted for 1 Second</th>
<th>Determination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than or equal to 44</td>
<td>Error</td>
</tr>
<tr>
<td>More than or equal to 45, and less than or equal to 54</td>
<td>50 Hz</td>
</tr>
<tr>
<td>More than or equal to 55, and less than or equal to 64</td>
<td>60 Hz</td>
</tr>
<tr>
<td>More than or equal to 65</td>
<td>Error</td>
</tr>
</tbody>
</table>

Setting conditions for timers A0 and A1 are listed below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation mode</td>
<td>Event counter mode</td>
</tr>
<tr>
<td>Count source</td>
<td>External signal that is input to the TA0IN pin (rising edges)</td>
</tr>
<tr>
<td>Count operation</td>
<td>Increment</td>
</tr>
<tr>
<td>TA0IN pin function</td>
<td>Count source input</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation mode</td>
<td>Timer mode</td>
</tr>
<tr>
<td>Count source</td>
<td>f64TIMAB</td>
</tr>
<tr>
<td>Count operation</td>
<td>Decrement</td>
</tr>
</tbody>
</table>
### 4.1 Operation Outline

1. Initialize the CPU.
   - Set the PLL clock divided by 2, and multiplied by 8 as the CPU clock.
2. Initialize timers A0 and A1.
   - Set timer A0 to event counter mode, and timer A1 to timer mode.
4. Count rising edges of zero-crossing signals for 1 second.
   - Measure 1 second with timer A1, and count the rising edges of input zero-crossing signals for 1 second with timer A0.
5. Determine commercial power frequency.
   - Determine commercial power frequency using the timer A0 register value.

Figure 4.1 shows the Operation Outline.
4.2 Required Memory Size

Table 4.4 lists the Required Memory Size.

<table>
<thead>
<tr>
<th>Memory Used</th>
<th>Size</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROM</td>
<td>239 bytes</td>
<td>In the r01an0806_src.c module</td>
</tr>
<tr>
<td>RAM</td>
<td>4 bytes</td>
<td>In the r01an0806_src.c module</td>
</tr>
<tr>
<td>Maximum user stack usage</td>
<td>10 bytes</td>
<td></td>
</tr>
<tr>
<td>Maximum interrupt stack usage</td>
<td>18 bytes</td>
<td></td>
</tr>
</tbody>
</table>

The required memory size varies depending on the C compiler version and compile options.

4.3 Constants

Table 4.5 lists the Constants Used in the Sample Code.

<table>
<thead>
<tr>
<th>Constant Name</th>
<th>Setting Value</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA1_1S</td>
<td>10</td>
<td>For measuring 1 second</td>
</tr>
<tr>
<td>TA1_100MS</td>
<td>(50000 - 1)</td>
<td>Timer A1 register setting value</td>
</tr>
<tr>
<td>HZ_JDG_ERR</td>
<td>FFh</td>
<td>The determination is an error.</td>
</tr>
<tr>
<td>HZ_JDG_50</td>
<td>01h</td>
<td>The determination is 50 Hz.</td>
</tr>
<tr>
<td>HZ_JDG_60</td>
<td>02h</td>
<td>The determination is 60 Hz.</td>
</tr>
</tbody>
</table>

4.4 Variables

Table 4.6 lists the Global Variables.

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Name</th>
<th>Contents</th>
<th>Function Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>unsigned char</td>
<td>cnt_ta1_100ms</td>
<td>100 ms counter</td>
<td>main</td>
</tr>
<tr>
<td>unsigned short</td>
<td>cnt_result</td>
<td>Store the timer A0 register value.</td>
<td>main</td>
</tr>
<tr>
<td>unsigned char</td>
<td>hz_jdg</td>
<td>Store the determination result.</td>
<td>main</td>
</tr>
</tbody>
</table>

4.5 Functions

Table 4.7 lists the Functions.

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>main</td>
<td>Main processing</td>
</tr>
<tr>
<td>mcu_init</td>
<td>CPU initialization</td>
</tr>
<tr>
<td>peripheral_init</td>
<td>Peripheral function initialization</td>
</tr>
</tbody>
</table>
4.6 Function Specifications

The following tables list the sample code function specifications.

<table>
<thead>
<tr>
<th>Function</th>
<th>Outline</th>
<th>Header</th>
<th>Declaration</th>
<th>Description</th>
<th>Argument</th>
<th>Returned value</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>mcu_init</td>
<td>CPU initialization</td>
<td>None</td>
<td>void mcu_init(void)</td>
<td>Set the PLL clock divided by 2, and multiplied by 8 as the CPU clock.</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>peripheral_init</td>
<td>Peripheral function initialization</td>
<td>None</td>
<td>void peripheral_init(void)</td>
<td>• Timer A0: Set to event counter mode. • Timer A1: Set to timer mode.</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
4.7 Flowcharts

4.7.1 Main Processing

Figure 4.2 shows the Main Processing.

```
Figure 4.2 Main Processing
```

```
main

Disabled maskable interrupt
I flag ← 0

Initialize the CPU
mcu_init()

Set the PLL clock divided by 2, and multiplied by 8 as the CPU clock.

Initialize timers A0 and A1
peripheral_init()

Initialize timers A0 and A1.
Timer A0: Event counter mode
(count external signals that are input to the TA0IN pin).
Timer A1: Timer mode (measure 1 second).

Initialize variables used

Start counting timers A0 and A1

Count the rising edges of zero-crossing signals that are input to the TA0IN pin for 1 second.

Stop counting timers A0 and A1

Timer A0 overflowed?
Yes
No

Read the timer A0 register value
cnt_result ← TA0 register

45 ≤ counter value ≤ 54
Yes

55 ≤ counter value ≤ 64
No

Determined to be an error

Frequency is 50 Hz
Frequency is 60 Hz
Determined to be an error
```

Determined to be an error
4.7.2 Peripheral Function Initialization

Figure 4.3 shows the Peripheral Function Initialization.

```plaintext
peripheral_init

Set timer A0

TA0MR register ← 09h
  Bits TMOD1 and TMOD0 = 01b: Event counter mode
  MR0 bit = 0: Pulse is not output
  MR1 bit = 1: Count rising edges of external signals
  TCK0 bit = 0: Reload type

ONSF register
  Bits TA0TGL and TA0TGH ← 00b: Input on TA0IN pin selected

UDF register
  TA0UD bit ← 1: Increment
  TA0 register ← 0000h

Clear the interrupt request bit for timer A0

TA0IC register ← 00h
  Bits ILVL2 to ILVL0 = 000b: Level 0 (interrupt disabled)
  IR bit ← 0: Interrupt not requested

Set timer A1

TA1MR register ← 00h
  Bits TMOD1 and TMOD0 = 00b: Timer mode
  MR0 bit = 0: Pulse is not output

TACS0 register ← 80h
  Bits TCS6 to TCS4 = 011b: f64TIMAB
  TCS7 bit = 1: TCK0, TCK1 disabled, TCS4 to TCS6 enabled

TA1 register ← 50000 - 1

Clear the interrupt request bit for timer A1

TA1IC register ← 00h
  Bits ILVL2 to ILVL0 = 000b: Level 0 (interrupt disabled)
  IR bit ← 0: Interrupt not requested

return
```

Figure 4.3 Peripheral Function Initialization
5. Sample Code
Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents
M16C/63 Group User’s Manual: Hardware Rev. 2.00
M16C/64A Group User’s Manual: Hardware Rev. 2.00
M16C/64C Group User’s Manual: Hardware Rev. 1.00
M16C/65 Group User’s Manual: Hardware Rev. 2.00
M16C/65C Group User’s Manual: Hardware Rev. 1.00
M16C/6C Group User’s Manual: Hardware Rev. 2.00
M16C/5L Group, M16C/56 Group User’s Manual: Hardware Rev. 1.10
M16C/5LD Group, M16C/56D Group User’s Manual: Hardware Rev. 1.10
M16C/5M Group, M16C/57 Group User’s Manual: Hardware Rev. 1.10
The latest versions can be downloaded from the Renesas Electronics website.

Technical Update/Technical News
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C Compiler Manual
M16C Series/R8C Series C Compiler Package V.5.45
C Compiler User’s Manual Rev. 2.00
The latest version can be downloaded from the Renesas Electronics website.

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

Inquiries
http://www.renesas.com/inquiry
<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Nov. 30, 2011</td>
<td>First edition issued</td>
</tr>
</tbody>
</table>

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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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