RL78/G23
High-speed On-chip Oscillator (HOCO) Clock Frequency Correction

Introduction
This application note explains how to correct the oscillation clock frequency of the high-speed on-chip oscillator (HOCO) by using the high-speed on-chip oscillator trimming register (HIOTRM) incorporated in RL78/G23.

An error in the oscillation frequency of the high-speed on-chip oscillator (HOCO) is detected using a subsystem clock or an external input signal and the high-speed on-chip oscillator trimming register (HIOTRM) is adjusted to set the oscillation frequency of the HOCO close to 32 MHz.

Target Device
RL78/G23

When applying the sample program covered in this application note to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.
Contents

1. Specifications .......................................................................................................................... 3
   1.1 Overview of Specifications ................................................................................................. 3
   1.2 Outline of Operation .......................................................................................................... 4
   1.3 Description of Calibration Methods .................................................................................. 6

2. Operation Confirmation Conditions .................................................................................. 9

3. Hardware Descriptions ...................................................................................................... 10
   3.1 Example of hardware configuration ................................................................................... 10
   3.2 List of Pins Used .............................................................................................................. 11

4. Software Explanation ........................................................................................................... 12
   4.1 Setting of Option Byte ....................................................................................................... 12
   4.2 List of Constants ............................................................................................................... 12
   4.3 List of Variables ............................................................................................................... 13
   4.4 List of Functions ............................................................................................................... 13
   4.5 Specification of Functions ............................................................................................... 14
   4.6 Flowcharts ...................................................................................................................... 16
       4.6.1 Main Processing ........................................................................................................... 16
       4.6.2 Calibration with XT1 Oscillation ................................................................................ 18
       4.6.3 Calibration with External Input Clock ......................................................................... 19
       4.6.4 HOCO Correction Function ....................................................................................... 21
   4.7 Changes on peripheral driver ............................................................................................ 23

5. Sample Code ........................................................................................................................ 24

6. Reference Documents ......................................................................................................... 24

Revision History ...................................................................................................................... 25
1. Specifications

1.1 Overview of Specifications

In this application note, an error in the clock oscillation frequency of the HOCO is detected using a subsystem clock or an external input signal. Then, the HIOTRM register is adjusted to set the oscillation frequency of the HOCO close to 32 MHz.

Whether to use the subsystem clock or the external input signal is determined by the parameter switch. When the start switch is pressed, the 32-bit interval timer counts the frequency (pulse interval) or the pulse width of the subsystem clock or the external input signal. The HOCO is used for the count clock of the 32-bit interval timer. If the count value measured by the 32-bit interval timer is beyond the target range, the HIOTRM register is adjusted to set the oscillation frequency of the HOCO close to 32 MHz. The HIOTRM register is adjusted so that the count value is within the target range. The target range of the HOCO oscillation frequency is 32 MHz ± 0.1% (31.968 MHz to 32.032 MHz).

When the subsystem clock is used, the 32-bit interval timer measures the frequency (pulse interval) of the subsystem clock. To enhance accuracy, the pulse interval is measured four times to detect an error in the oscillation frequency of the HOCO.

When the external input signal is used, the 32-bit interval timer measures the frequency (pulse interval) of the timer input signal. A signal with a frequency of 512 Hz, a duty cycle of 50% is used as the timer input signal.

In this sample code, a pulse of 2 MHz \( \left( \frac{f_{\text{MAIN}}}{2^4} \right) \) is output from the clock output/buzzer output control circuit to always check correction results. To check the correction results, refer to the frequency of the output pulse on the PCLBUZ0 pin by using a frequency counter and the like.

Caution: Specified times and calibration methods in this sample code are used as examples. In this sample code, input from the start switch is used to start calibration, to simplify processing flows and to provide clear understanding. Adjust the timing of starting calibration and the intervals between start timings according to the system. This application note describes two calibration methods. Select the method most appropriate to the system for use.

Table 1-1 lists the peripheral functions to be used and their uses.

<table>
<thead>
<tr>
<th>Peripheral Function</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin input edge detection interrupt</td>
<td>Used for the correction start switch.</td>
</tr>
<tr>
<td>32-bit interval timer channel 0, 1</td>
<td>Used for calibration of HOCO.</td>
</tr>
<tr>
<td>32-bit interval timer channel 2, 3</td>
<td>Used to prevent chattering on the correction start switch.</td>
</tr>
<tr>
<td>Clock output/buzzer output control circuit</td>
<td>Performs 2-MHz clock output.</td>
</tr>
<tr>
<td>Logic &amp; Event Link Controller (ELCL)</td>
<td>Connects external input signal to the 32-bit interval timer</td>
</tr>
</tbody>
</table>
1.2 Outline of Operation

The following describes the settings of peripheral functions.

(1) Initialization of external interrupt (INTP0)

The settings are shown in Table 1-2.

Table 1-2 Initial Setting Conditions of External Interrupt (INTP0)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid edge</td>
<td>Falling edge</td>
</tr>
</tbody>
</table>

(2) Initialization of 32-bit interval timer

Use in 16-bit capture mode.

The settings are shown in Table 1-3 and Table 1-4.

Table 1-3 Initial Setting Conditions of 32-bit interval timer (Channel 0 and 1)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating mode</td>
<td>16-bit capture mode</td>
</tr>
<tr>
<td>Operating clock (fITL0)</td>
<td>fITL0</td>
</tr>
<tr>
<td>Count source division ratio</td>
<td>fITL0 (non-divided)</td>
</tr>
<tr>
<td>Capture clock</td>
<td>fSX</td>
</tr>
</tbody>
</table>

Table 1-4 Initial Setting Conditions of 32-bit interval timer (Channel 2 and 3)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating mode</td>
<td>16-bit capture mode</td>
</tr>
<tr>
<td>Operating clock (fITL1)</td>
<td>fITL1</td>
</tr>
<tr>
<td>Count source division ratio</td>
<td>fITL1 (non-divided)</td>
</tr>
<tr>
<td>Interval period</td>
<td>10 ms</td>
</tr>
</tbody>
</table>

(3) Initialization of Clock Output/Buzzer Output Controller

The settings are shown in Table 1-5.

Table 1-5 Initial setting Conditions of Clock Output/Buzzer Output Controller

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Clock</td>
<td>2 MHz (fMAIN/2^4)</td>
</tr>
</tbody>
</table>
(4) Initialization of Logic and Event Link Controller

Link external input signal (P50) to 32-bit interval timer (as ITL capture trigger)
The settings are shown in Table 1-6.

Table 1-6 Initial setting Conditions of Logic and Event Link Controller

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event Source</td>
<td>Input pin (P50/SI11/INTP1)</td>
</tr>
<tr>
<td>Used Input Signal Selector</td>
<td>0</td>
</tr>
<tr>
<td>Used Event Controller</td>
<td>L1, Pass-through</td>
</tr>
<tr>
<td>Used Output Signal Selector</td>
<td>7</td>
</tr>
<tr>
<td>Destination</td>
<td>Capture trigger of ITL</td>
</tr>
</tbody>
</table>
1.3 Description of Calibration Methods

This section describes the two calibration methods to be used in this application note.

(1) Calibration with the subsystem clock

The subsystem clock cycle is measured on channel 0 and 1 of 32-bit interval timer used in 16-bit capture mode.

The subsystem clock (32.768 kHz, a cycle of 30.517578125 μs) is selected as the capture trigger, and the HOCO clock (32 MHz) is selected as the count clock. The subsystem clock cycle is measured using the input pulse interval measurement function of the TAU.

Select subsystem clock (32.768kHz, 30.517578125 μs per cycle) as capture trigger, and HOCO (32MHz) as count clock.

To enhance accuracy, the subsystem clock cycle is measured four times, and the four captured values are added up to calculate an error in the HOCO oscillation clock frequency.

The table below lists the calculated count values that are obtained through four times of capture when the frequency is 32 MHz, 32 MHz - 0.1% (31.968 MHz), or 32 MHz + 0.1% (32.032 MHz).

<table>
<thead>
<tr>
<th>HOCO Clock Frequency (f_HOCO)</th>
<th>Count Value Obtained through Four Times of Capture (Calculated Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 MHz</td>
<td>3906.25</td>
</tr>
<tr>
<td>32 MHz – 0.1%</td>
<td>3902.34375</td>
</tr>
<tr>
<td>32 MHz + 0.1%</td>
<td>3910.15625</td>
</tr>
</tbody>
</table>

According to Table 1 - 7, the target range of the count value obtained through four times of capture is set to 3903 to 3909 when the target frequency range is 32 MHz ± 0.1% (31.968 to 32.032 MHz). If the obtained count value is 3902 or less, this means that the HOCO clock is slower than the target frequency. If it is 3910 or more, this means that the HOCO clock is faster than the target frequency. Determine the direction of correction of the HIOTRM register value (speeding up/slowing down), according to the count value, and perform calibration by incrementing the HIOTRM register value by ±1. When the count value is within the target range, the calibration is completed.

Figure 1-1 gives an example of calibration in which the subsystem clock is used.
The period of external input signal is measured on channel 0 and 1 of 32-bit interval timer used in 16-bit capture mode.

A square wave (512Hz, a duty cycle of 50%) input to P50 is linked as a capture trigger by Logic and Event Link Controller (ELCL).

The HOCO clock (32 MHz) is selected as the count clock.

Accurate measurement of signal low-level width detects an error in the HOCO clock.

The table below lists the calculated count values that are obtained when the frequency is 32 MHz, 32 MHz - 0.1% (31.968 MHz), or 32 MHz + 0.1% (32.032 MHz).

<table>
<thead>
<tr>
<th>HOCO Clock Frequency (f_{IH})</th>
<th>Count Value (Calculated Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 MHz</td>
<td>62500</td>
</tr>
<tr>
<td>32 MHz - 0.1%</td>
<td>31.968 MHz</td>
</tr>
<tr>
<td>32 MHz + 0.1%</td>
<td>32.032 MHz</td>
</tr>
</tbody>
</table>

According to table 1.3, the target range of the count value is set to 62438 to 62561 for the target frequency range 32 MHz ± 0.1% (31.968 to 32.032 MHz). If the obtained count valued is 62437 or less, this means that the HOCO clock is slower than the target frequency. If it is 62562 or more, this means that the HOCO clock is faster than the target frequency. Determine the direction of correction of the HIOTRM register value (speeding up/slowing down), according to the count value, and perform calibration by incrementing the HIOTRM register value by ±1. When the count value is within the target range, the calibration is completed.

Figure 1.2 gives an example of calibration in which the external signal is used.
Figure 1-2  Example of Calibration in which the External Signal is Used

External input signal

512Hz

32MHz

32-bit interval timer channel 0, 1

Obtain count value

Count value

get frequency

Speed up
HIOTRM ← +1
2. Operation Confirmation Conditions

The sample code of this application note has been tested under the following conditions.

Table 2-1 Operation Confirmation Conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU used</td>
<td>RL78/G23 (R7F100GLG)</td>
</tr>
<tr>
<td>Board used</td>
<td>RL78/G23 Fast Prototyping Board (RTK7RLG230CLG000BJ)</td>
</tr>
<tr>
<td>Operating frequency</td>
<td>High-speed on-chip oscillator clock: 32 MHz</td>
</tr>
<tr>
<td></td>
<td>CPU/peripheral hardware clock: 32 MHz</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>3.3 V (can be operated at 1.8 V to 5.5 V)</td>
</tr>
<tr>
<td>LVD0 detection voltage:</td>
<td>Reset mode</td>
</tr>
<tr>
<td>At rising edge TYP. 1.90 V (1.84 V to 1.95 V)</td>
<td></td>
</tr>
<tr>
<td>At falling edge TYP. 1.86 V (1.80 V to 1.91 V)</td>
<td></td>
</tr>
<tr>
<td>Integrated development environment (CS+)</td>
<td>CS+ V8.05.00 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>C compiler (CS+)</td>
<td>CC-RL V1.10.00 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>Integrated development environment (e2studio)</td>
<td>e2 studio V2021-04 (21.4.0) from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>C compiler (e2studio)</td>
<td>CC-RL V1.10.00 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>Integrated development environment (IAR)</td>
<td>IAR Embedded Workbench for Renesas RL78 V4.21.1 from IAR Systems Corp.</td>
</tr>
<tr>
<td>C compiler (IAR)</td>
<td>IAR C/C++ Compiler for Renesas RL78 V4.21.1 from IAR Systems Corp.</td>
</tr>
<tr>
<td>Smart configurator (SC)</td>
<td>V1.0.1 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>Board support package (BSP)</td>
<td>V1.00 from Renesas Electronics Corp.</td>
</tr>
</tbody>
</table>
3. Hardware Descriptions

3.1 Example of hardware configuration

Figure 3-1 shows an example of the hardware configuration used in the application note.

Note: 1. Input a signal with 512 Hz, a duty cycle of 50%.
   2. Calibration sets the output frequency close to 2 MHz. Check the frequency using a frequency counter.

Caution: 1. The purpose of this circuit is only to provide the connection outline and the circuit is simplified accordingly. When designing and implementing an actual circuit, provide proper pin treatment and make sure that the hardware's electrical specifications are met (connect the input-only ports separately to VDD or VSS via a resistor).
   2. Connect any pins whose name begins with EVss to VSS and any pins whose name begins with EVDD to VDD, respectively.
   3. VDD must be held at not lower than the reset release voltage (VLVD) that is specified as LVD.
3.2 List of Pins Used

Table 3-1 lists the pins used and their functions.

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>I/O</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P137/INTP0</td>
<td>Input</td>
<td>Parameter switch:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connects the switch for selecting a calibration method.</td>
</tr>
<tr>
<td>P43</td>
<td>Input</td>
<td>Correction completion LED:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connects the LED that indicates correction completion.</td>
</tr>
<tr>
<td>P53</td>
<td>Output</td>
<td>Subsystem clock:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connects a 32.768-kHz crystal oscillator.</td>
</tr>
<tr>
<td>P123/XT1</td>
<td>Input</td>
<td>External input signal pin:</td>
</tr>
<tr>
<td>P124/XT2</td>
<td>Input</td>
<td>Input a signal with 512 Hz, a duty cycle of 50%.</td>
</tr>
<tr>
<td>P140/PCLBUZ0</td>
<td>Output</td>
<td>Clock output:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Always outputs f_{MAIN/2^4} (2 MHz).</td>
</tr>
</tbody>
</table>

Caution: In this application note, only the used pins are processed. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements.
4. Software Explanation

4.1 Setting of Option Byte

Table 4-1 shows the option byte settings.

Table 4-1 Option Byte Settings

<table>
<thead>
<tr>
<th>Address</th>
<th>Setting Value</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>00C0H/010C0H</td>
<td>11101111B</td>
<td>Disables the watchdog timer. (Counting stopped after reset)</td>
</tr>
<tr>
<td>00C1H/010C1H</td>
<td>11111110B</td>
<td>LVD0 detection voltage: Reset mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At rising edge TYP. 1.90 V (1.84 V to 1.95 V)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At falling edge TYP. 1.86 V (1.80 V to 1.91 V)</td>
</tr>
<tr>
<td>00C2H/010C2H</td>
<td>11101000B</td>
<td>HS mode, High-speed on-chip oscillator clock (f_{IH}): 32 MHz</td>
</tr>
<tr>
<td>00C3H/010C3H</td>
<td>10000101B</td>
<td>Enables on-chip debugging</td>
</tr>
</tbody>
</table>

4.2 List of Constants

Table 4-2 lists the constants that are used in the sample code.

Table 4-2 Constants

<table>
<thead>
<tr>
<th>Constant Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIOTRM_MAX</td>
<td>00111111B</td>
<td>Maximum value of the HIOTRM register</td>
</tr>
<tr>
<td>HIOTRM_MIN</td>
<td>00000000B</td>
<td>Minimum value of the HIOTRM register</td>
</tr>
<tr>
<td>CCNT_XT1_MAX</td>
<td>3910</td>
<td>Upper threshold of subsystem clock count</td>
</tr>
<tr>
<td>CCNT_XT1_MIN</td>
<td>3902</td>
<td>Lower threshold of subsystem clock count</td>
</tr>
<tr>
<td>CCNT_EXT_MAX</td>
<td>62562</td>
<td>Upper threshold of external input signal count</td>
</tr>
<tr>
<td>CCNT_EXT_MIN</td>
<td>62437</td>
<td>Lower threshold of external input signal count</td>
</tr>
</tbody>
</table>
4.3 List of Variables
Table 4-3 lists the global variables.

Table 4-3  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>calibration_count</td>
<td>Calibration count value</td>
<td>R_Main_UseXT1()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Main_ExternalClock()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Trimming_OCO()</td>
</tr>
<tr>
<td>uint8_t</td>
<td>calibrate_history</td>
<td>Calibration history</td>
<td>R_Main_UseXT1()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Main_ExternalClock()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Trimming_OCO()</td>
</tr>
<tr>
<td>uint16_t</td>
<td>count_value</td>
<td>Count value (Used as an argument of R_Trimming_OCO)</td>
<td>R_Main_UseXT1()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Main_ExternalClock()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Trimming_OCO()</td>
</tr>
<tr>
<td>uint16_t</td>
<td>max</td>
<td>Upper threshold of count</td>
<td>R_Main_UseXT1()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Main_ExternalClock()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Trimming_OCO()</td>
</tr>
<tr>
<td>uint16_t</td>
<td>min</td>
<td>Lower threshold of count</td>
<td>R_Main_UseXT1()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Main_ExternalClock()</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R_Trimming_OCO()</td>
</tr>
</tbody>
</table>

4.4 List of Functions
Table 4-4 shows a list of functions.

Table 4-4 Functions

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_Main_UseXT1</td>
<td>Calibration with the subsystem clock</td>
</tr>
<tr>
<td>R_Main_ExternalClock</td>
<td>Calibration with the external input signal</td>
</tr>
<tr>
<td>R_ELCL_Enable</td>
<td>Enable operation of ELCL</td>
</tr>
<tr>
<td>R_ELCL_Disable</td>
<td>Disable operation of ELCL</td>
</tr>
<tr>
<td>R_Trimming_OCO</td>
<td>HOCO clock correction</td>
</tr>
</tbody>
</table>
4.5 Specification of Functions

The function specifications of the sample code are shown below.

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Outline</th>
<th>Header</th>
<th>Declaration</th>
<th>Description</th>
<th>Argument</th>
<th>Return Value</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_Main_UseXT1</td>
<td>Calibration with the subsystem clock</td>
<td>None</td>
<td>void R_Main_UseXT1(void)</td>
<td>This function captures the subsystem clock count value and performs correction processing.</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>R_Main_ExternalClock</td>
<td>Calibration with the external input signal</td>
<td>None</td>
<td>void R_Main_ExternalClock(void)</td>
<td>This function captures the external input signal count value and performs correction processing.</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>R_ELCL_Enable</td>
<td>Enable operation of ELCL</td>
<td>None</td>
<td>void R_ELCL_Enable(void);</td>
<td>Link external input signal (P50) to 32-bit interval timer</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>R_ELCL_Disable</td>
<td>Disable operation of ELCL</td>
<td>None</td>
<td>void R_ELCL_Disable(void);</td>
<td>Disable operation of ELCL</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
### R_Trimming_OCO

**Outline**
HOCO clock correction

**Header**
None

**Declaration**

```
uint8_t R_Trimming_OCO(uint16_t count)
```

**Description**
This function sets the HIOTRM according to the argument and then determines whether to continue calibration.

**Argument**
count : [Target clock count value]

**Return Value**

- [0]: Calibration ends.
- [1]: Calibration continues.

**Outline**
None
4.6 Flowcharts

4.6.1 Main Processing

Figure 4-1 and Figure 4-2 shows the flowchart of the main processing.

Figure 4-1 Main Processing (1 / 2)

```
main()

Disable interrupts
DI()

Start PCLBUZ0
R_Config_PCLBUZ0_Start()

Enable INTP0 interrupt
R_Config_INTC_INTP0_Start()

HALT instruction
HALT()

INTP0 interrupt?
yes

PCLOE0 = 1
PIF0 = 0
PMK0 = 0

no

Disable INTP0 interrupt

PMK0 = 1
PIF0 = 0

Clear the ITF02 interrupt request flag

ITLS0 &= 0xFB
ITLIF = 0

Start 32-bit interval timer channel 2, 3
(16-bit counter)

INTITL2 interrupt?
no

ITLEN02 = 1

yes

A

B
```
Figure 4-2 Main Processing (2 / 2)

A

Stop 32-bit interval timer channel 2, 3 (16-bit counter)

ITLEN02 = 0

Level of the start switch is low?

no

yes

Turn off the correction completion LED

P5.bit3 = 1

XT is used?

no

yes

Calibration with XT1 oscillation

R_Main_UseXT1()

Calibration with external input clock

R_Main_ExternalClock()

Turn on the correction completion LED

P5.bit3 = 0

B
4.6.2 Calibration with XT1 Oscillation

Figure 4-2 show the flowchart for calibration with XT1 oscillation.

**Figure 4-2 Calibration with XT1 Oscillation**

```
R_Main_UseXT1()
Initialize the number of times of captures to 0
Set the correction continuation flag to 1
Initialize the number of times of correction to 0
Initialize the correction history to 0
Specify the range of correction
Set f_{EXP} as capture trigger
Measure cycle (The number of captures = 0; <4; +1)
INTITLC interrupt?
no
yes
Accumulate the capture value
Clear the capture completion flag, Capture detection flag, 32-bit interval timer interrupt request flag
Period measurement
Stop capture operation
ITLEN00 = 0
Increment the number of times of correction by 1
HOCO correction function R_Trimming_OCO()
Correction (Correction flag = 0)
return
```
4.6.3 Calibration with External Input Clock

Figure 4-3 and Figure 4-4 show the flowcharts for calibration with an external input clock.

**Figure 4-3 Calibration with External Input Clock (1/2)**

R_Main_ExternalClock()

Set the correction continuation flag to 1

Initialize the number of times of correction to 0

Clear the measurement results to 0

Initialize the correction history to 0

Specify the range of correction Correction

Enable ELCL
  • Input the signals from the input pins (P50/SI11/INTP1) to input 0 of logic cell 0 in logic cell block L1 using input signal selector 0.
  • Logic cell 0 of logic cell block L1 is set to through.
  • The Output signal selector 7 is used to output the output signal [0] of logic cell block L1 as a capture trigger for the 32-bit interval timer.

Set capture trigger to $f_{\text{ELCL}}$

ELISEL0 = 05H
ELL1SEL0 = 01H
ELL1LNK0 = 01H
ELL1CTL = 00H
ELOSEL7 = 01H
ELOENCTL = 80H

ITLCC0 &= FCH
ITLCC0 |= 03H
Correction

Clear capture completion flag, capture detection flag, and interrupt request flag of ITL32

Enable capture operation

INTILTC interrupt?

no

Stop capture operation

Clear capture completion flag, capture detection flag, and interrupt request flag of ITL32

Store the measurement results

Increment the number of times of correction by 1

HOCO correction function R_Trimming_OCO()

Correction (Correction flag = 0)

Disable ELCL
-Clear each SFR of ELCL

return
4.6.4 HOCO Correction Function

Figure 4-5 and Figure 4-6 show the flowcharts for the HOCO correction function.

Figure 4-5 HOCO Correction Function (1/2)
Figure 4-6 HOCO Correction Function (2/2)

1. Decrement the HIOTRM register value by 1.
2. Update the correction history.
3. Check if the measured value is greater than or equal to the upper limit.
   - If yes, go to step 4.
   - If no, continue.
4. Check if the specified value is greater than the lower limit.
   - If yes, set the correction continuation flag and return.
   - If no, continue.
5. Check if the number of times of correction is less than 3.
   - If yes, go to step 6.
   - If no, continue.
6. Check if the correction history shows no repetition.
   - If yes, set the correction continuation flag and return.
   - If no, continue.
7. Set the correction continuation flag.
4.7 Changes on peripheral driver

In this application note, the source code of the peripheral driver generated by the Smart Configurator is used with the following changes.

For the setting values for Smart Configurator, please refer to the sample program.

<table>
<thead>
<tr>
<th>Function</th>
<th>Before changes</th>
<th>After changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>void R_Config_ITL012_ITL013_Create(void);</td>
<td>/* Stop 32-bit interval timer <em>/ ITLCTL0 = 0x00U; /</em> Stop 32-bit interval timer <em>/ ITLCTL0 = 0x00U; /</em> Mask INTITL interrupt */ ITLMKF0</td>
<td>= _04_ITL_CHANNEL2_COUNT_MATCH_MASK; ITLMKF0</td>
</tr>
</tbody>
</table>
5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

RL78/G23 User's Manual: Hardware (R01UH0896)
RL78 family user's manual software (R01US0015)
The latest versions can be downloaded from the Renesas Electronics website.

Technical update
The latest versions can be downloaded from the Renesas Electronics website.

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## Revision History

<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Page</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Apr.01.21</td>
<td>—</td>
<td>First Edition</td>
</tr>
<tr>
<td>1.01</td>
<td>May.18.21</td>
<td>9</td>
<td>Updated the Operation Confirmation Condition</td>
</tr>
</tbody>
</table>
General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can 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 must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on
   The state of the product is undefined at the time 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 time 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 time 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 time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. 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. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins
   Handle unused pins in accordance 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 the 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.

5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is 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. Additionally, 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.

6. 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, for example, 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 $V_{IH\text{ (Min.)}}$.

7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.
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