Introduction
This application note explains how to use the Clock Frequency Accuracy Measurement Circuit (CAC) to detect stopped oscillation.

Target Device
Renesas Synergy™ S7G2 MCU Group

Contents
1. Overview ........................................................................................................................................ 2
2. Oscillation Stop Detection by CAC Frequency Error Interrupt (CAC_FERRI) ............................... 3
3. CAC Operation for Frequency Error Interrupt (CAC_FERRI) .......................................................... 3
   3.1 CAC Register Initial Setting .......................................................................................................... 3
   3.2 CAC Operation Flow .................................................................................................................... 4
4. Usage Notes ..................................................................................................................................... 7
   4.1 Estimated maximum frequency error detection time ................................................................. 7
1. **Overview**

There are two ways to detect an oscillation stop:

1. Use the oscillation stop detection circuit (See the Oscillation Stop Detection function in the SSP User’s Manual)
2. Use the CAC frequency counter circuit and detect the clock oscillation stop through its error interrupt (CAC_FERRI)

This application note explains the second method. The CAC has a frequency error interrupt that can be used for oscillation stop detection.

In the CAC function, the target clock is the Main Oscillator, and the reference clock is MOCO or HOCO (see figure below).

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**Figure 1  Oscillation stop detection by CAC**

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*Note 1.* Interrupt Signal of CAC_FERRI. CAC_FERRI’s interrupt handler must set another clock.
2. Oscillation Stop Detection by CAC Frequency Error Interrupt (CAC_FERRI)

The CAC counts Main Oscillator clock pulses to check the frequency. If the MOSC’s frequency is irregular, it triggers the frequency error interrupt. The interrupt can be used for oscillation stop detection.

3. CAC Operation for Frequency Error Interrupt (CAC_FERRI)

3.1 CAC Register Initial Setting

Table 1 is an example of the CAC’s register initial settings. Section 3.2 shows the settings and data flow for CAC operation.

<table>
<thead>
<tr>
<th>Register name</th>
<th>Bit setting</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CACR0</td>
<td>CFME = 1</td>
<td>Clock frequency measurement enable</td>
</tr>
<tr>
<td>CACR1</td>
<td>FMCS = 011b</td>
<td>Measurement target clock = MOSC</td>
</tr>
<tr>
<td>CACR2</td>
<td>RPS = 1</td>
<td>1 = Internal clock</td>
</tr>
<tr>
<td></td>
<td>RSCS = 011b or 010b</td>
<td>Measurement reference clock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>011b = MOCO clock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>010b = HOCO clock</td>
</tr>
<tr>
<td></td>
<td>RSDS = 10b</td>
<td>Measurement reference clock frequency division ratio select</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10b = 1/1024 clock*1</td>
</tr>
<tr>
<td>CAICR</td>
<td>FERRIE = 1</td>
<td>Frequency error interrupt request enable</td>
</tr>
<tr>
<td>CAULVR</td>
<td></td>
<td>In case of MOCO (8 MHz)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAULVR = 1228d = 4cch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAULVR is set as 9.6 MHz</td>
</tr>
</tbody>
</table>

Figure 2  CAC frequency error interrupt for oscillation detection stop

Note 1.
In case of MOCO (8 MHz): Tref = 1/FMOCO * Frequency division ratio
In case of HOCO (16 MHz): Tref = 1/FHOCO * Frequency division ratio
Frequency division ratio is set by CACR2.RSDS.

Note 2. Estimated maximum frequency error detection time
See *1 in table 2
### 3.2 CAC Operation Flow

Figures 3 and 4, below show an example of the flow for the frequency error interrupt used for oscillation stop detection by CAC.

- Target clock is MOSC (8 MHz)
- The reference clock is MOCO (8 MHz) or HOCO (16 MHz) which is divided
- Use the Frequency error interrupt when MOSC is less than 4 MHz

In the Figure 3 and Figure 4, (3) – (7) are the initial settings for the CAC. After that, if the frequency error occurs at (8), flow passes to the interrupt handler of CAC_FERRI which sets another system clock by software.

Figure 3 shows the case of reference clock MOCO (8 MHz).

Figure 4 shows the case of reference clock HOCO (16 MHz).
Example of the oscillation stop detection by CAC

1. Set for the interrupt (CAC_FEERI)
   - IELSR20 = 00000087h
   - Enable the interrupt in NVIC

2. Clear the module stop bit for CAC
   MSTPCRC,MSTPC0 = 0

3. Set target clock to Main clock oscillator
   CACR1.FMCS = 000b

4. Set target reference clock and Measurement Reference Clock Frequency Division Ratio Select
   CACR2 = 27h
   - RPS = 1 = Internal clock
     - (RSCS = 011b = Reference is MOCO)
     - (RCD = 10b = 1/1024 clock)

5. CAULVR = 4CCh
   CALLVR = 200h

6. CAICR.FERRIE = 1

7. CACR0.CFME = 1

8. 
   
<table>
<thead>
<tr>
<th>CASTR.FERRF = 1 ?</th>
</tr>
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<tbody>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
</tr>
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9. Interrupt handler for CAC_FEERI
   - Main OSC is stopped, so set another system clock here
   - CAICR.FERRF = 1
     (to clear FERRF)
   - IELSR20.IR = 0
   - CACR0.CFME = 0

Figure 3  CAC frequency error interrupt for oscillation stop detection
(Reference Clock is 8 MHz MOCO)
Example of the oscillation stop detection by CAC

1. Set for the interrupt (CAC_FEERI)
   - IELSR20 = 00000087h
   - Enable the interrupt in NVIC

2. Clear the module stop bit for CAC
   MSTPCR.MSTPC0 = 0

3. Set target clock to Main clock oscillator
   CACR1.FMCS = 000b

4. Set target reference clock and Measurement Reference Clock
   Frequency Division Ratio Select
   CACR2 = 25h
   (RPS = 1 = Internal clock)
   (RSCE = 010b = Reference is HOCO)
   (RCDS=10b = 1/1024 clock)

5. CAULVR = 266h
   CALLVR = 100h

6. CAICR.FERRIE = 1

7. CACRD.CFME = 1

8. CASTR.FERRF = 1?
   No
   Wait for the frequency error interrupt (CAC_FEERI)
   Yes

9. Interrupt handler for CAC_FEERI
   [1] Main OSC is stopped, so set another system clock here
   [2] CAICR.FERRF=1
   (To clear FERRF)
   [3] IELSR20.IR = 0
   [4] CACRD.CFME = 0

Figure 4   CAC Frequency Error Interrupt for Oscillation Stop Detection
(Reference Clock is 16 MHz HOCO)
4. Usage Notes

4.1 Estimated maximum frequency error detection time

Table 2 shows the estimated maximum frequency error detection time.

Table 2 CAC frequency error detection time

- Measurement clock: Main Oscillator Clock (MOSC) (8 MHz)
- Criteria for oscillation stopping: Main Oscillator Clock \( \leq 4 \) MHz

<table>
<thead>
<tr>
<th>Case</th>
<th>Reference clock (RSCS[2:0])</th>
<th>Division ratio (RCDS[1:0])</th>
<th>Estimated maximum frequency error detection time (( \mu s ))*1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOCO (8 MHz) x 3</td>
<td></td>
<td>20.9</td>
</tr>
<tr>
<td>2</td>
<td>MOCO (8 MHz) x 128</td>
<td></td>
<td>47.6</td>
</tr>
<tr>
<td>3</td>
<td>MOCO (8 MHz) x 1024</td>
<td></td>
<td>296.5</td>
</tr>
<tr>
<td>4</td>
<td>MOCO (8 MHz) x 8192</td>
<td></td>
<td>2287.5</td>
</tr>
<tr>
<td>5</td>
<td>HOCO (16 MHz) x 32</td>
<td></td>
<td>16.2</td>
</tr>
<tr>
<td>6</td>
<td>HOCO (16 MHz) x 128</td>
<td></td>
<td>28.5</td>
</tr>
<tr>
<td>7</td>
<td>HOCO (16 MHz) x 1024</td>
<td></td>
<td>144.0</td>
</tr>
<tr>
<td>8</td>
<td>HOCO (16 MHz) x 8192</td>
<td></td>
<td>1067.7</td>
</tr>
</tbody>
</table>

Note: See *2 in Figure 2.

The calculation formula is:

\[
\frac{1}{(F \times freq\_accuracy) \times Division\_ratio \times 2 + PCLKB \times 3}
\]

- \( F \) (clock frequency): MOCO (8 MHz), HOCO (16 MHz)
- \( freq\_accuracy \) (frequency accuracy): MOCO (0.9), HOCO (0.97)
- \( PCLKB \times 3 = (1/8 \text{ MHz} \times 32) \times 3 = (125 \text{ ns} \times 32) \times 3 = 12 \text{ \( \mu s \)} \)
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<td>Initial version</td>
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<td>1.01</td>
<td>Nov 18, 2016</td>
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<td>1.02</td>
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