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# Current Measurement in Different Power Modes and Clock Frequencies for RE01 256KB Group

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## Summary

This application note describes a sample code using the RE01 256KB CMSIS driver package. The sample code can be found in the project delivered with this application note.

This sample code displays the modes and clock settings in MIP display. This sample code is intended to assist current consumption measurement. When used together with current measurement tool, users can easily see current consumption of different modes and clock settings of RE01 256KB Group product.

## Target Device

RE01 256KB Group

## Note

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

## Related Document

Startup Guide to Development Using CMSIS Package for RE01 1500 KB Group (R01AN4660).

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## 1. Specifications

### 1.1 Description of Project

A sample code project "r01an5509\_current\_measurement\_re\_256kb.zip" is delivered with this application note.

r01an5509\_current\_measurement\_re\_256kb.zip is a project which operation has been confirmed on the Evaluation Kit RE01 256KB Board. This project is configured to match the settings of RE01 256KB (R7F0E01182CFP) mounted on the Evaluation Kit RE01 256KB Board. When using another RE01 256KB device, change the device settings in the project to those of the target device.

### 1.2 Overview

This program shows the information of the active modes (power control modes/low power consumption modes/ power supply modes) and clock setting (frequency and division). The example of mode and clock information display is shown below.



Figure 1.1 Modes and Clock Information Display

The overview of the functions used in this program is shown below.

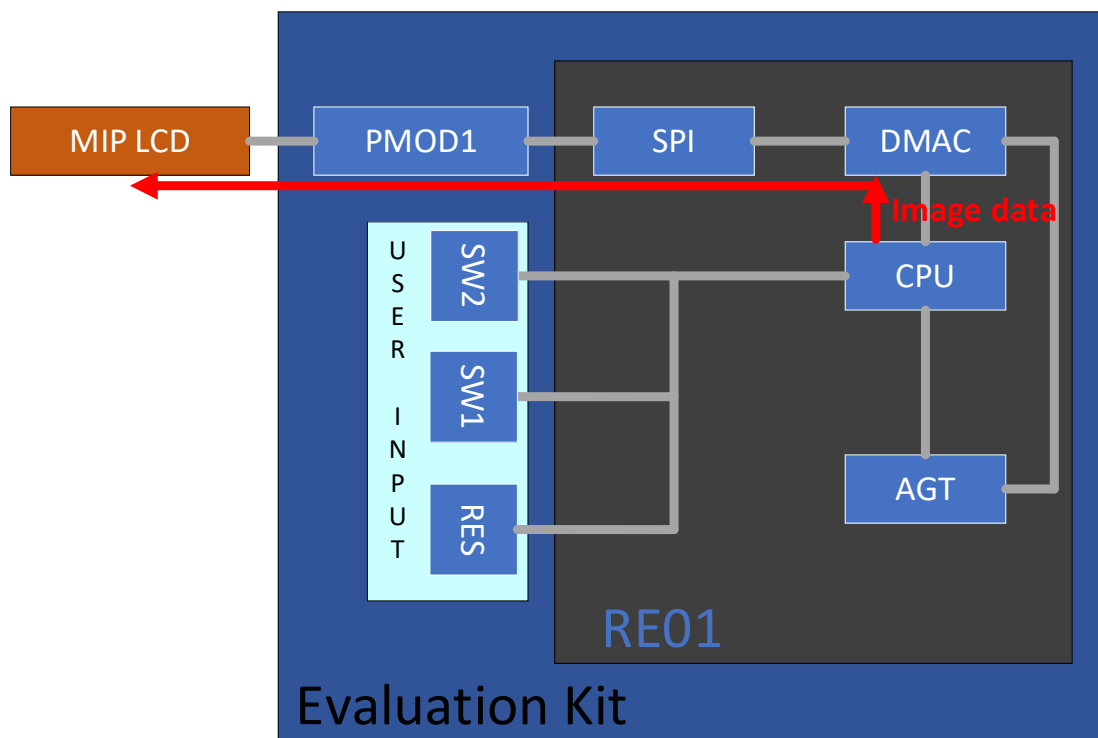


Figure 1.2 Program Overview

### 1.3 Pins Used

The pins used by the sample code are shown below.

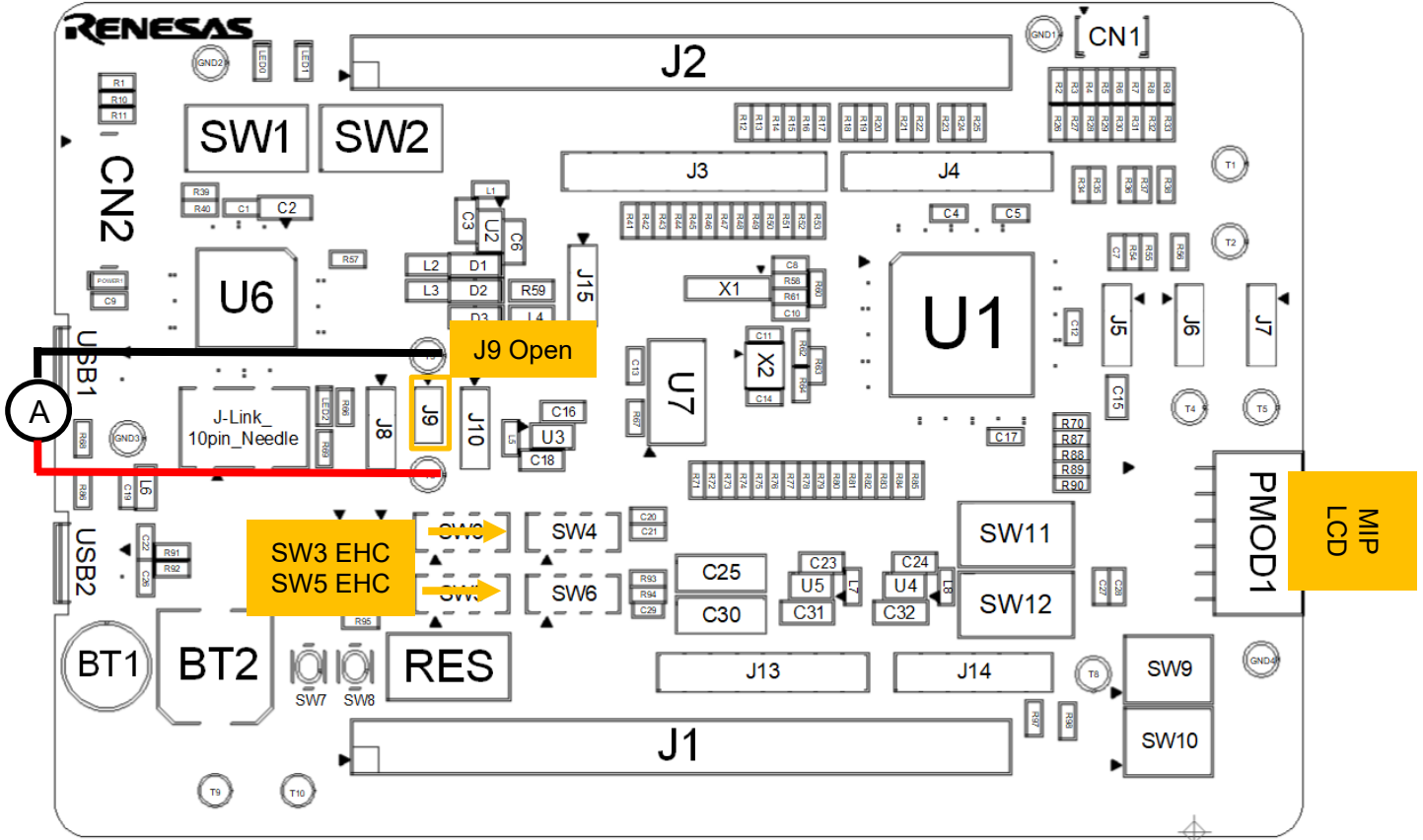
Pin Used	Purpose of Use
P010	MOSIA_B (SPI)
P011	RSPCKA_B (SPI)
P015	SCS (SPI)
P509	SW1 (user input)
P508	SW2 (user input)
P813	RESET (SPI)
P814	VCOM (SPI)
RES#	MCU RESET BUTTON (user input)

In this program, 2 IRQ buttons (SW1 and SW2) and 1 RES# button are used with the purposes as described below:

- SW2 button
  - To change active mode power control modes, low power consumption modes, and power supply modes.
  - To wake up from SSTBY mode.
- SW1 button: to change active clock (ICLK and PCLKB) frequency and division.
- RES button: to reset MCU and to wake up from DSTBY mode.

### 1.4 Board Setting

Figure 1-3 shows the board setting used to measure current consumption of the program used for this APN. MIP LCD current consumption is still included when it is connected to Evaluation Kit RE01 256KB board. To avoid this issue, please disconnect MIP LCD from this board during current measurement.



\*Other settings are in default settings

Figure 1.3 Board Setting

## 2. Conditions for Checking Operation

The operation of the sample code delivered with this application note has been checked under the following conditions (Table 2-1).

**Table 2-1 Conditions for Checking Operation**

Item		Description																								
Microcontroller used		R7F0E01182CFP (RE01 Group 256KB)																								
Operating frequency		Selectable with the following configurations: <table border="1"> <thead> <tr> <th>System Clock(ICLK)</th> <th>Peripheral module clock A (PCLKA)</th> <th>Peripheral module clocks B (PCLKB)</th> </tr> </thead> <tbody> <tr> <td>HOCO 64 MHz</td> <td>HOCO 64 MHz</td> <td>HOCO 1 MHz</td> </tr> <tr> <td>HOCO 32 MHz</td> <td>HOCO 32 MHz</td> <td>HOCO 0.5 MHz</td> </tr> <tr> <td>MOSC 32 MHz</td> <td>MOSC 32 MHz</td> <td>MOSC 0.5 MHz</td> </tr> <tr> <td>MOSC 16 MHz</td> <td>MOSC 16 MHz</td> <td>MOSC 0.25 MHz</td> </tr> <tr> <td>MOCO 2 MHz</td> <td>MOCO 2 MHz</td> <td>MOCO 31.25 kHz</td> </tr> <tr> <td>MOCO 1 MHz</td> <td>MOCO 1 MHz</td> <td>MOCO 15.625 kHz</td> </tr> <tr> <td>SOSC 32 kHz</td> <td>SOSC 32 kHz</td> <td>SOSC 32 kHz</td> </tr> </tbody> </table>	System Clock(ICLK)	Peripheral module clock A (PCLKA)	Peripheral module clocks B (PCLKB)	HOCO 64 MHz	HOCO 64 MHz	HOCO 1 MHz	HOCO 32 MHz	HOCO 32 MHz	HOCO 0.5 MHz	MOSC 32 MHz	MOSC 32 MHz	MOSC 0.5 MHz	MOSC 16 MHz	MOSC 16 MHz	MOSC 0.25 MHz	MOCO 2 MHz	MOCO 2 MHz	MOCO 31.25 kHz	MOCO 1 MHz	MOCO 1 MHz	MOCO 15.625 kHz	SOSC 32 kHz	SOSC 32 kHz	SOSC 32 kHz
System Clock(ICLK)	Peripheral module clock A (PCLKA)	Peripheral module clocks B (PCLKB)																								
HOCO 64 MHz	HOCO 64 MHz	HOCO 1 MHz																								
HOCO 32 MHz	HOCO 32 MHz	HOCO 0.5 MHz																								
MOSC 32 MHz	MOSC 32 MHz	MOSC 0.5 MHz																								
MOSC 16 MHz	MOSC 16 MHz	MOSC 0.25 MHz																								
MOCO 2 MHz	MOCO 2 MHz	MOCO 31.25 kHz																								
MOCO 1 MHz	MOCO 1 MHz	MOCO 15.625 kHz																								
SOSC 32 kHz	SOSC 32 kHz	SOSC 32 kHz																								
Operating voltage		<ul style="list-style-type: none"> <li>3.3 V</li> </ul>																								
Target board		Evaluation Kit RE01 256KB Board																								
Development environment	GCC	e <sup>2</sup> studio 2020-07 made by Renesas Electronics																								
	IAR	IAR Embedded Workbench for ARM Version 8.40.2.22891																								
C compiler	GCC	GCC ARM Embedded V6.3.1.20170620 GNU 6-2017-q2-update																								
	IAR	IARC/C++ Compiler for ARM Version 8.40.2 or later																								
Version of I/O header		Rev. 1.00																								
Version of CMSIS driver package		Rev. 1.00																								

### 3. Description of Software

This sample code shows the information of power modes and clock frequencies in MIP LCD display.

This sample code performs the following operations. Details of the program flow is shown in Figure 3-1.

- Press SW2 button to display the first mode (BOOST ALLPWON HOCO 64 MHz)
- Press SW2 to go to the next mode, or SW1 button to change the clock frequency and/or division.
- After going to SSTBY mode, press SW2 button to wake up from SSTBY mode and continue to DSTBY mode.
- After going to DSTBY mode, press RES button to wake up from DSTBY mode and continue to BOOST ALLPWON mode.
- The program restarts from the beginning and wait for SW2 button press to show the first mode (BOOST ALLPWON) again.

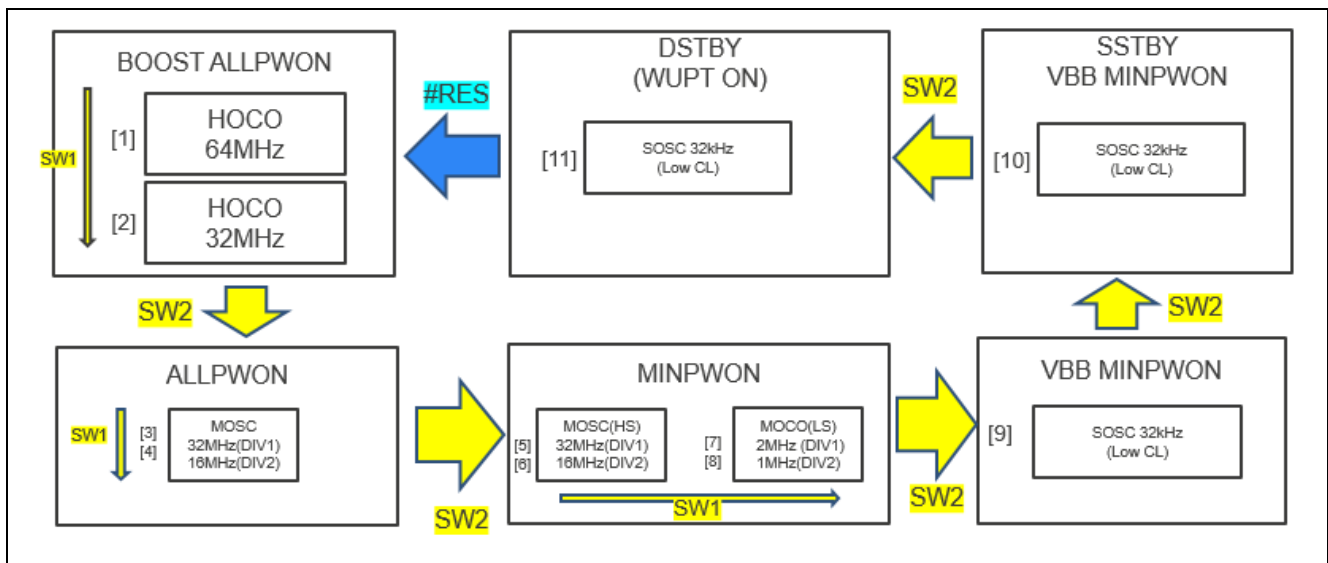


Figure 3.1 Program Flow

There are 11 available combinations of modes and clock settings. Details of the selectable modes and clock settings are shown in Table 3-1. The numbering system for the modes in Table 3-1 corresponds with the numbering system in Figure 3-1.

**Table 3-1 Selectable Modes and Clock Setting (Temperature Condition: 25°C VCC=3.3V)**

No	Mode	Clock	ICLK	PCLKB	Expected Current Measurement Value (uA)
1	BOOST ALLPWON	HOCO	64MHz	1MHz(1/64)	1800
2	BOOST ALLPWON	HOCO	32MHz	0.5MHz(1/64)	1000
3	ALLPWON	MOSC	32MHz	0.5MHz(1/64)	840
4	ALLPWON	MOSC	16MHz	0.25MHz(1/64)	490
5	MINPWON (High Speed Mode)	MOSC	32MHz	0.5MHz(1/64)	780
6	MINPWON (High Speed Mode)	MOSC	16MHz	0.25MHz(1/64)	N/A
7	MINPWON (Low Speed Mode)	MOCO	2MHz	31.25kHz(1/64)	60
8	MINPWON (Low Speed Mode)	MOCO	1MHz	15.625kHz(1/64)	N/A
9	VBB MINPWON	SOSC	32kHz	32kHz(1/1)	1.7
10	SSTBY VBB MINPWON	SOSC	32kHz	32kHz(1/1)	0.5
11	DSTBY (WUPT ON)	SOSC	32kHz	32kHz(1/1)	0.345



#### 4. Specifications of Driver APIs

The specifications of drivers in the CMSIS driver package can be found in the directory shown below. Refer to the specifications and notes for each driver inside the folder.

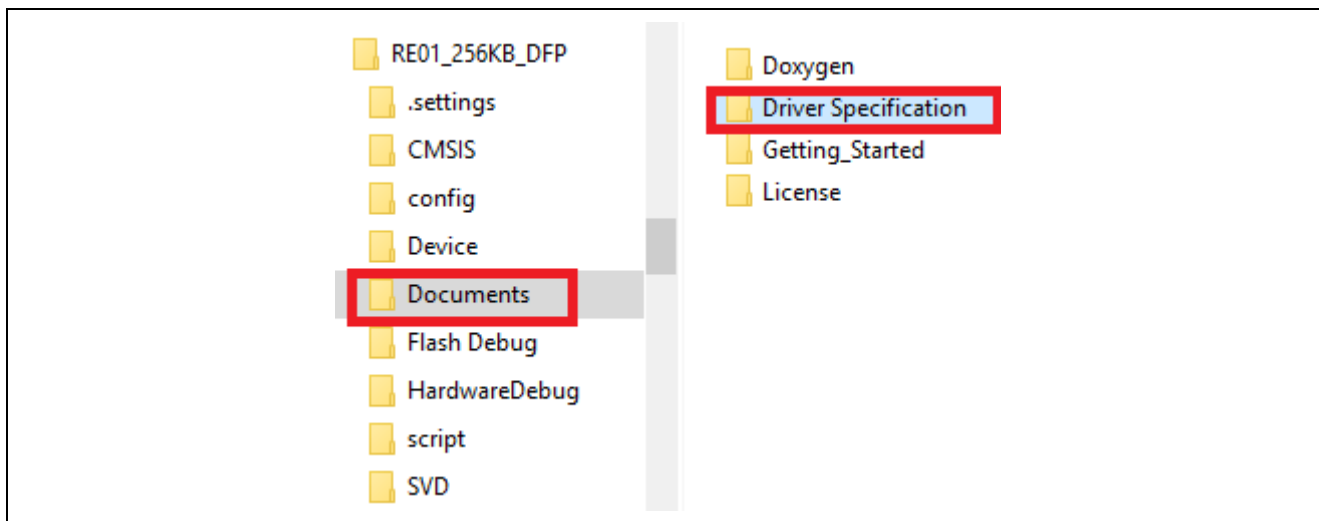


Figure 4.1 Location of Driver Specification

#### 5. Usage Notes

Only the main notes related to the DMAC and MIP LCD pin setting are introduced in this chapter. Note that not all notes are given here.

For other notes, see the external specification document described in "4. Specifications of Driver APIs".

##### 5.1 VCOM and SCS pin for MIP LCD

When using serial MIP LCD, VCOM pin output level must be set to high before setting SCS pin to high. Also note that waiting time is required when changing VCOM output level.

For more information about VCOM waiting time, see TN0181ANVNANN-\*N\*03 published by Kyocera.

##### 5.2 DMAC Interrupts

When data transfer of the specified count is complete (DMCRA register), an interrupt is signaled to the CPU. There are 2 types of DMA activation sources: software trigger and interrupt requests from peripheral modules/trigger from external interrupt input pins.

To use interrupt requests from peripheral modules as DMA activation source, register it to NVIC in `r_system_cfg.c` and set the interrupt request for DMA activation source in `DELSRn` register.

Figure 5.1 shows an example of registering interrupts to the NVIC. Figure 5.2 shows an example of enabling `DMACn_INT` interrupt.

```

...
#define SYSTEM_CFG_EVENT_NUMBER_PORT_IRQ0
    (SYSTEM_IRQ_EVENT_NUMBER_NOT_USED)          /*!< Numbers 0/4/8/12/16/20/24/28 only */
#define SYSTEM_CFG_EVENT_NUMBER_DMAC0_INT
    (SYSTEM_IRQ_EVENT_NUMBER0)                  /*!< Numbers 0/4/8/12/16/20/24/28 only */
#define SYSTEM_CFG_EVENT_NUMBER_DTC_COMPLETE
    (SYSTEM_IRQ_EVENT_NUMBER_NOT_USED)          /*!< Numbers 0/4/8/12/16/20/24/28 only */
...
    
```

Figure 5.1 Example of Registering Interrupts to NVIC

```

interrupt_init()
{
    ...

    /*set DMAC source: SPI1_SPT1*/
    ICU->DELSR0_b.DELS=0x9F;

    /*DMAC transfer end interrupt*/
    /*Set priority*/
    R_NVIC_SetPriority(SYSTEM_CFG_EVENT_NUMBER_DMAC0_INT,3);

    /*Set IRQ channel 0 for DMAC0_INT interrupt*/
    R_SYS_IrqEventLinkSet(SYSTEM_CFG_EVENT_NUMBER_DMAC0_INT, 0x02, dmac0_int_callback);

    /*Clear interrupt flag*/
    R_SYS_IrqStatusClear(SYSTEM_CFG_EVENT_NUMBER_DMAC0_INT);

    /*Enable NVIC_IUSER bit*/
    R_NVIC_EnableIRQ(SYSTEM_CFG_EVENT_NUMBER_DMAC0_INT);

    ...
}

main()
{
    ...
    interrupt_init();
    ...
}

/*****
* callback function
*****/
static void dmac0_int_callback)(void)
{
    /* Write the code for DMAC0 transfer end interrupt below */
}

```

Figure 5.2 Example of Enabling DMAC Interrupt

### 5.3 Setting DMAC Transfer Source and Transfer Destination Addresses

Specify transfer source and transfer destination addresses in DMSAR and DMDAR register. The address alignment in these registers must match the transfer data size value selected in SZ bits in DMTMD register.

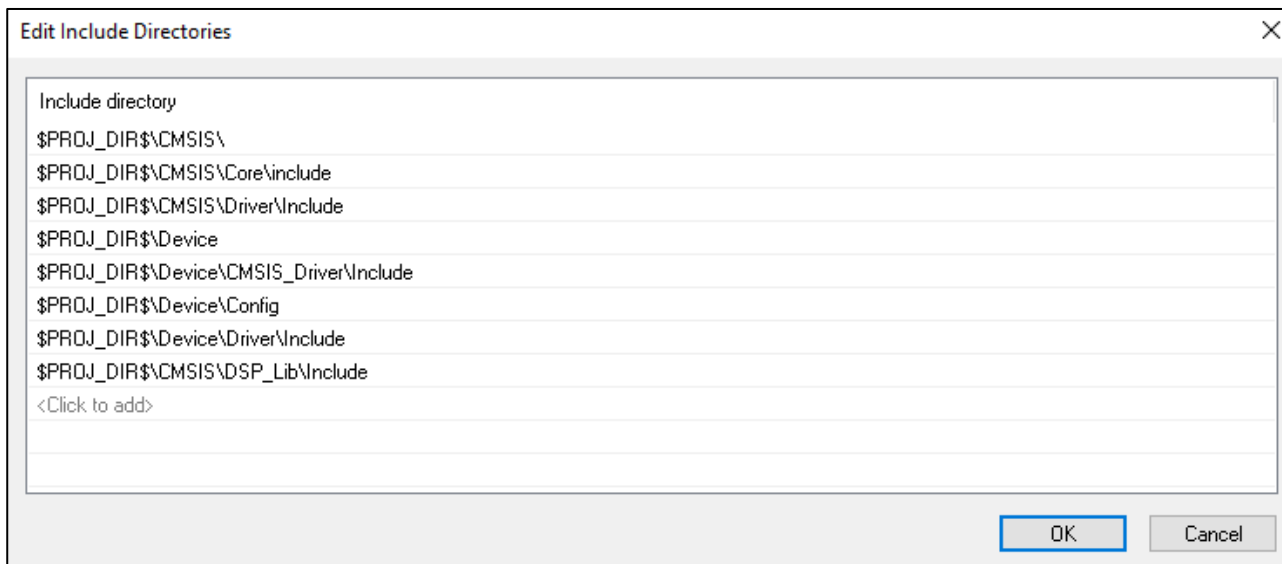
## 6. Troubleshooting

### 6.1 Occurrence of Build Error

A-1) Have the include directories been specified correctly?

When using EWARM, we recommend that the include directories be specified as shown in the example below.

The include directories can be specified from IDE Options [C/C++ Compiler] → [Preprocessor].



### 6.2 Occurrence of HardFault Error when API of CMSIS Driver Is Called

A) The API has possibly not been copied to RAM.

Before calling an API function that was assigned to RAM, make sure that it has been copied to RAM by the R\_SYS\_CodeCopy function. For details, refer to the related document No. R01AN4660.

### 6.3 Peripheral Function Fails to Operate when API Is Called

A) Has the API been set up correctly?

Check the API's return value to see if an error has occurred.

In particular, errors are often caused by problems related to interrupts not being set in r\_system\_cfg.h. For details, refer to the related document No. R01AN4660.

### 6.4 Normal API Return Value But No Pin Output from Peripheral Function

A) Are the pin settings correct?

Check to make sure the pins have been set up correctly by the functions in pin.c.

For details, refer to the related document No. R01AN4660.

### 6.5 Peripheral Function's Input or Output Does Not Operate as Expected

A) Check to make sure the VOCR register has been set up correctly before making the initial settings for peripheral functions.

For details, refer to the related document No. R01AN4660.

## 7. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

## 8. Reference Documents

User's Manual: Hardware

RE01 Group User's Manual: Hardware

(The latest version can be downloaded from the Renesas Electronics website.)

Technical Update/Technical News

(The latest version can be downloaded from the Renesas Electronics website.)

User's Manual: Development Tools

(The latest version can be downloaded from the Renesas Electronics website.)

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## Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jun. 16, 2020	—	First edition issued

# 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  $V_{IL}$  (Max.) and  $V_{IH}$  (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  $V_{IL}$  (Max.) and  $V_{IH}$  (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.

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