Smart Analog

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Rev.1.00
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System development procedure by using SA-Designer (RX family)

Introduction

This application note is intended to explain the steps involved in developing a simple system in an environment that uses the Smart Analog, assuming the RX63N.

- Design of the Analog Front-end Circuit
- Creating Program
- Register and Build the Circuit Data
- Testing

Contents

1. Introduction

This application note is intended to explain the steps involved in developing a simple system in an environment that uses the Smart Analog, assuming the RX63N. The system uses a temperature sensor built into the "smart analog IC". Depending on the temperature, change the blink rate of the LED. The system uses “Smart Analog IC” and “GR-SAKURA” as CPU board. The application note explains the procedures of the load module that uses the High-performance Embedded Workshop and the SA-Designer, and the procedures of testing program.

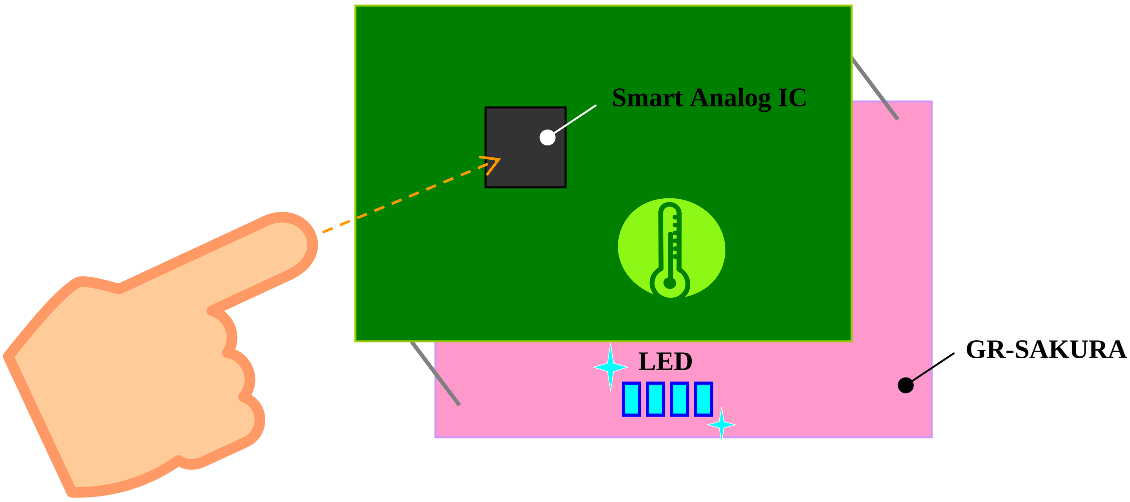


Figure 1 System summary

1.1 Development Environment

The application note uses the following development environments.

1.1.1 Hardware

・Host PC

・evaluation board: GR-SAKURA (RX63N), Smart Analog IC500

・E1 emulator

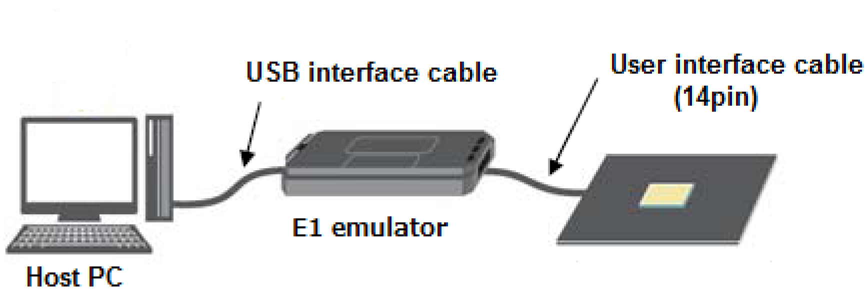


Figure 2 Hardware construction

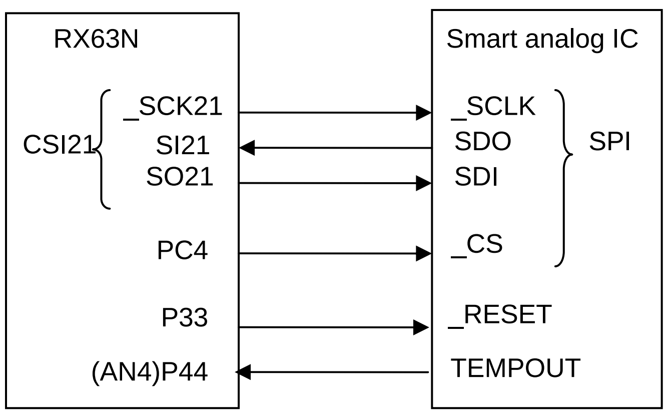


Figure 3 Constructing RX63N and Analog chip

1.1.2 Software

・SA-Designer (V1.00.00)

・IDE CubeSuite+ (Version 1.02.01)

2. Development Procedure

2.1 Overview

The following instructions describe the construction procedures of the system.

It will be used the CubeSuite+ and the SA-Designer for the construction procedures. Followings are the steps of the system development.

(1) Design the analog front-end circuit

Design the analog front-end circuit using with the SA-Designer.

(2) Programming the source codes

Program the source codes that set the clock, the ports, the A/D conversion functions of the microcomputer, also for the operation of the system.

(3) Registering the setting program of the circuit data.

Register the C source codes made by the SA-Designer to the CubeSuite+, then build the codes.

(4) Operation check

Connect the E1 emulator and write the program to the microcomputer, then check the operations of the program.

Note: It will be needed to install the CubeSuite+ (At least Version V1.02.00) and the SA-Designer for the program operations.

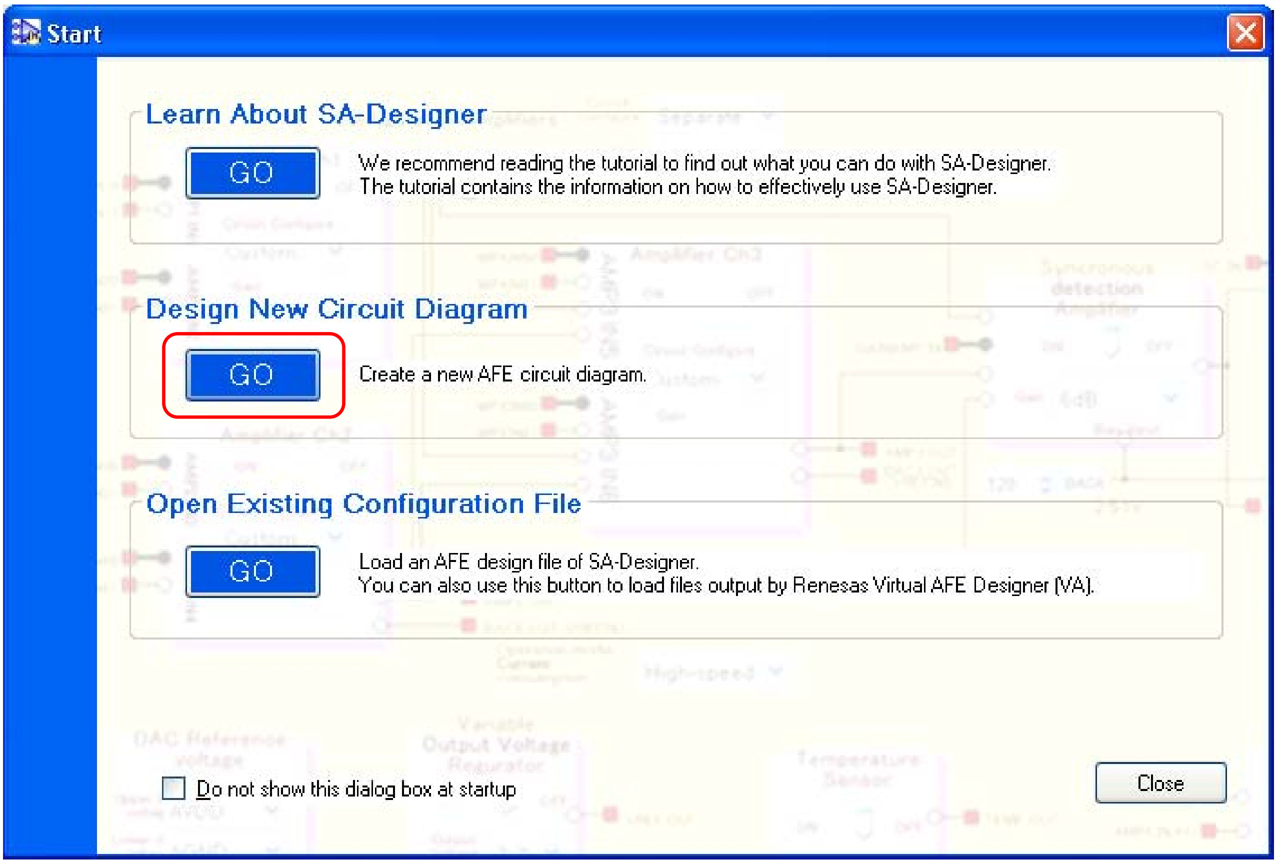
2.1.1 Design of the Analog Front-end Circuit

(1) Starting the SA-Designer

Start the SA-Designer by selecting the [SA-Designer] from the Start menu.

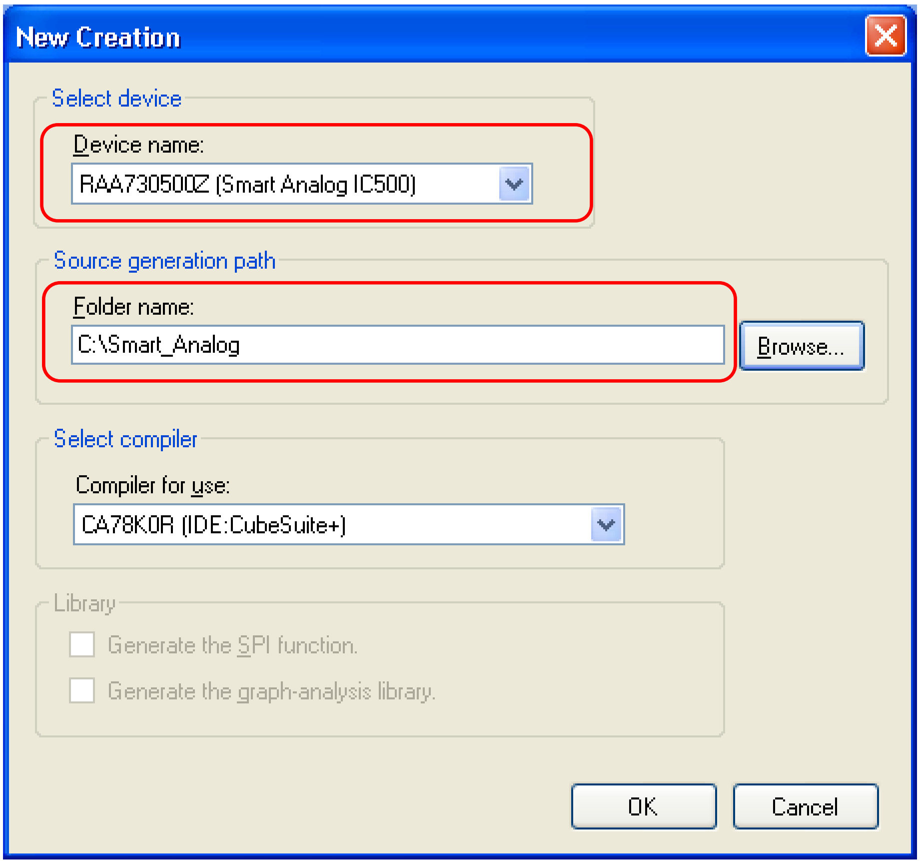
(2) The Design of the New Circuit

For the design of the analog front-end circuit, choose the destination device and the folder.



Click the GO in "Design New Circuit Diagram".

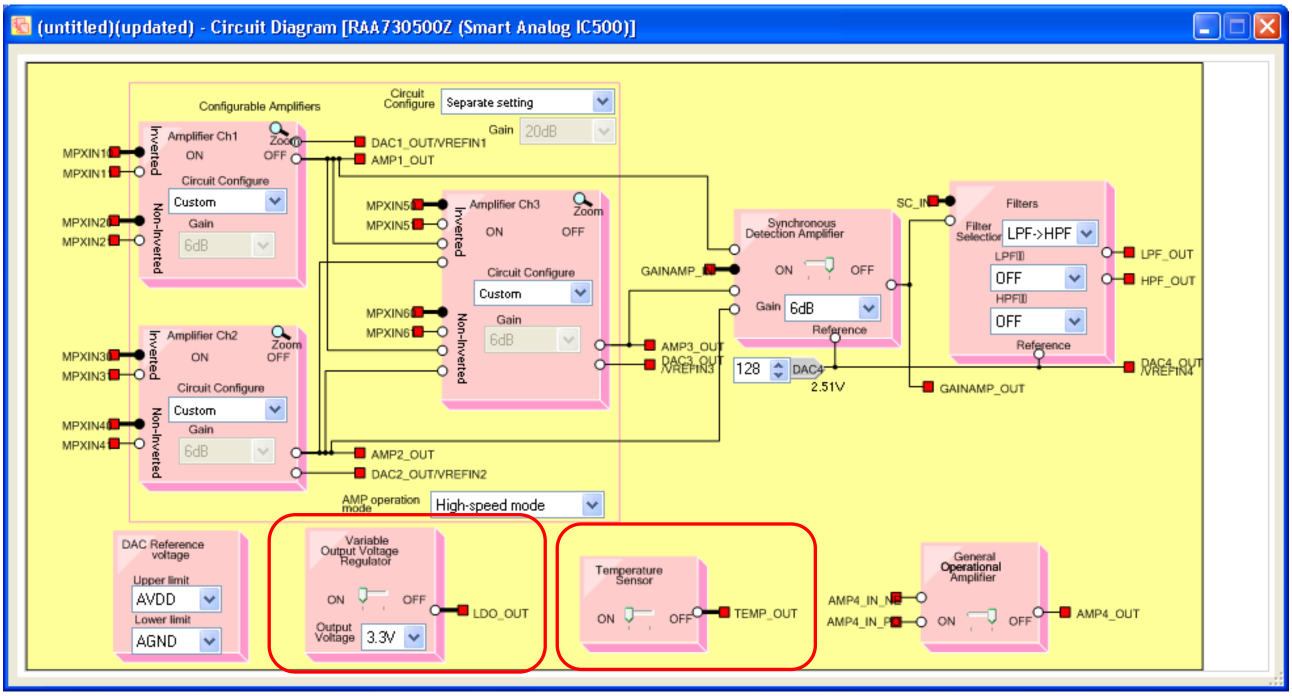
Choose the device and the folder for creating the codes in the "New dialog".



[Device]	Choose the device "RAA730500Z (Smart Analog IC500)"
[Folder name]	Choose the folder arbitrarily. Choose "Smart_Analog" as above image. Choose the folder as above image. The folder must be existed in the computer.

(3) **Creating a Circuit Diagram**

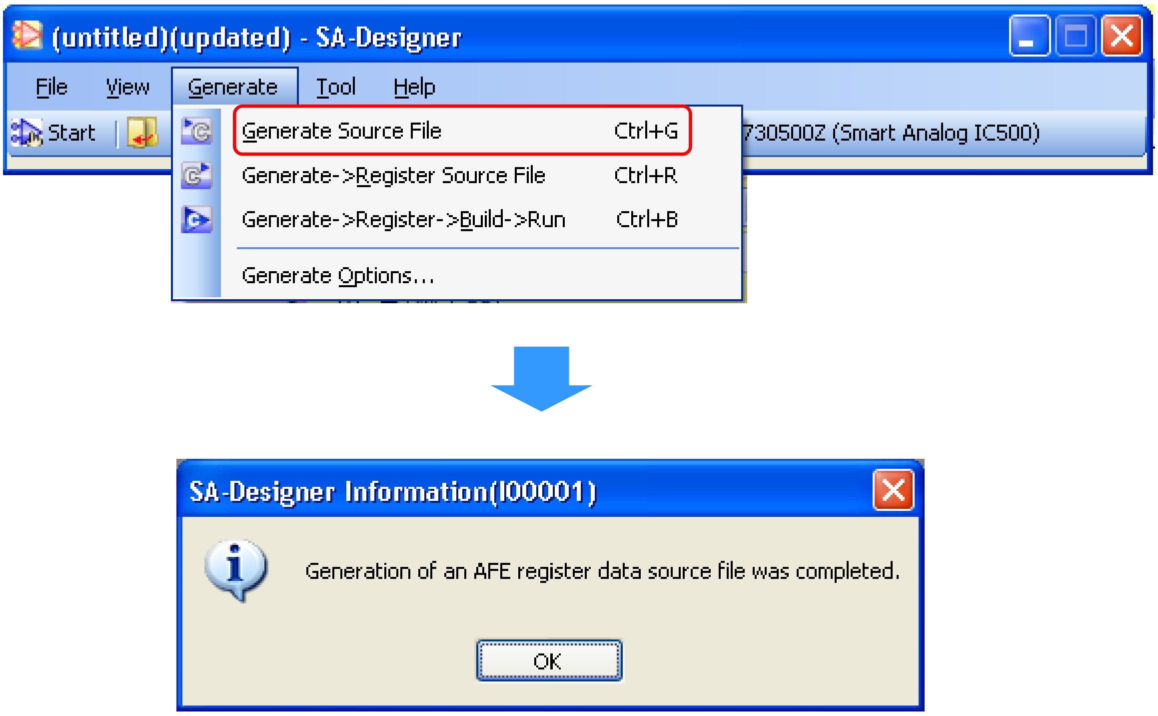
Design the analog front-end circuit to use a temperature sensor. Change the settings from the initial state of the circuit diagram as follows.



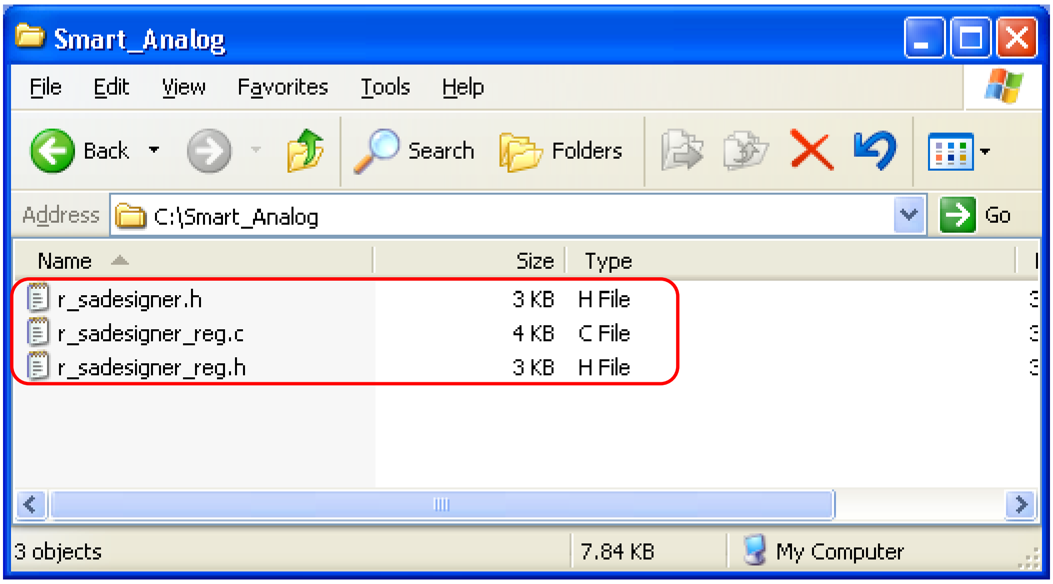
[Variable Output Voltage Regulator]	Set the switch to "ON".
[Temperature Sensor]	Set the switch to "ON".

(4) **Generation Source File**

Program the source codes to set the data of the designed circuits. Completion dialog will be displayed when you click the "[Generate] - [Generate Source File]".



Three “C source files” will be made in the folder that you choose.

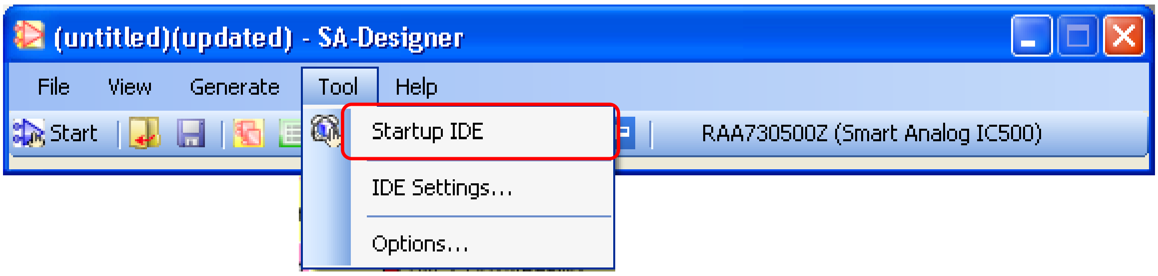


2.1.2 Creating Program

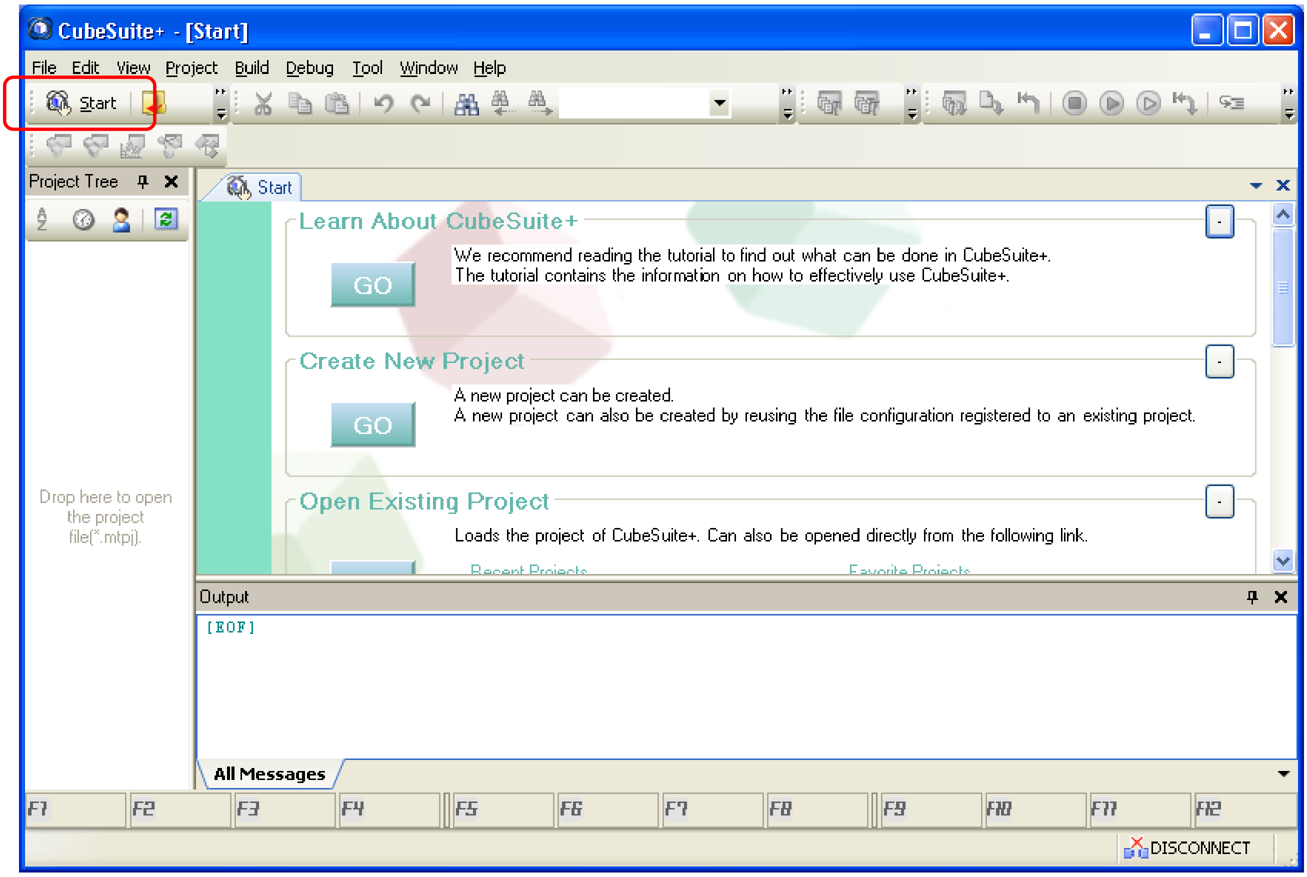
(1) **Starting CubeSuite+**

Launch the CubeSuite+, from menu of SA-Designer. It also can be launched from “Windows Start menu”.

And you need to install ”CubeSuite+” beforehand. Click [Startup IDE] of SA-Designer from “Tool”, then “CubeSuite+” will be launched.

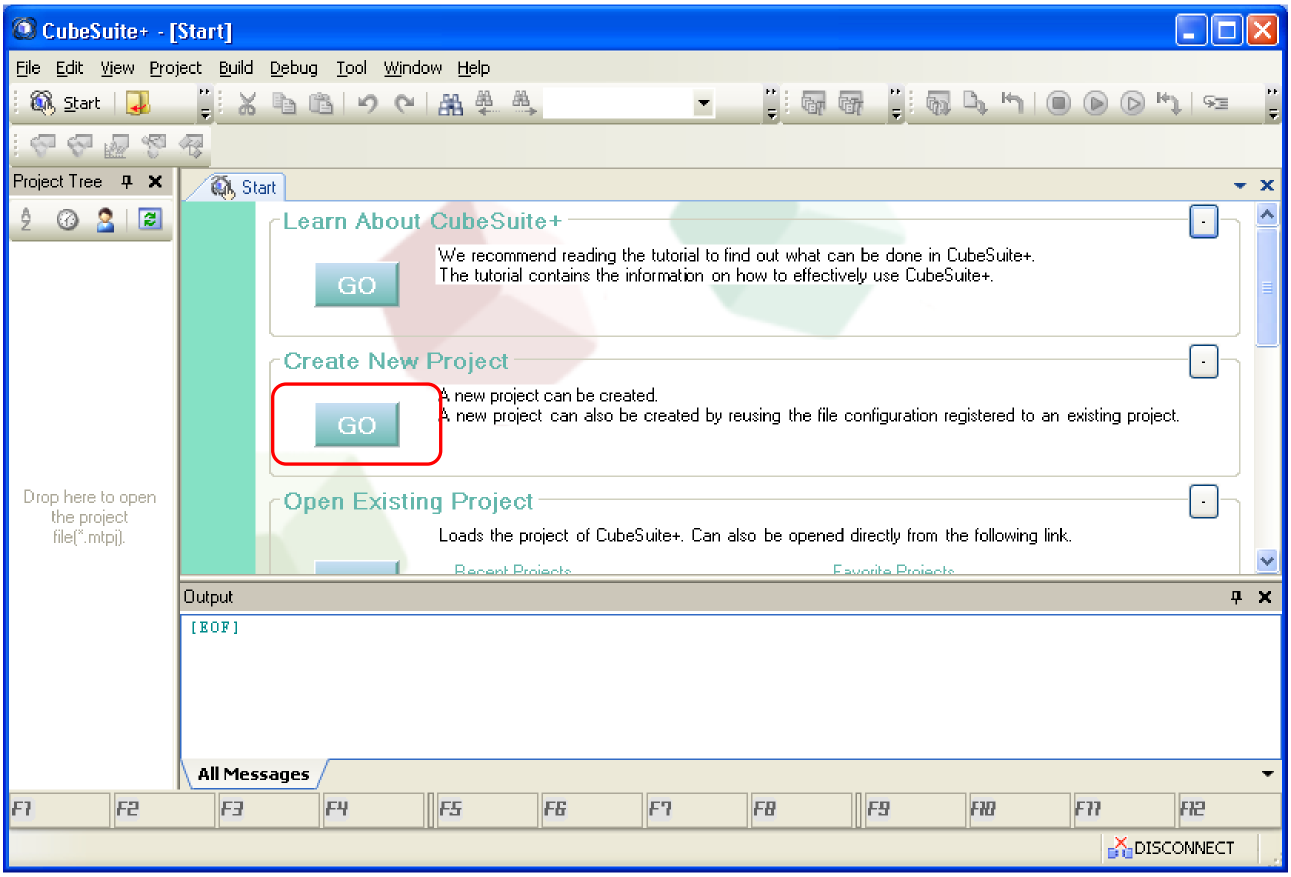


Open “Menu Window” with pressing [Start] after starting CubeSuite+.



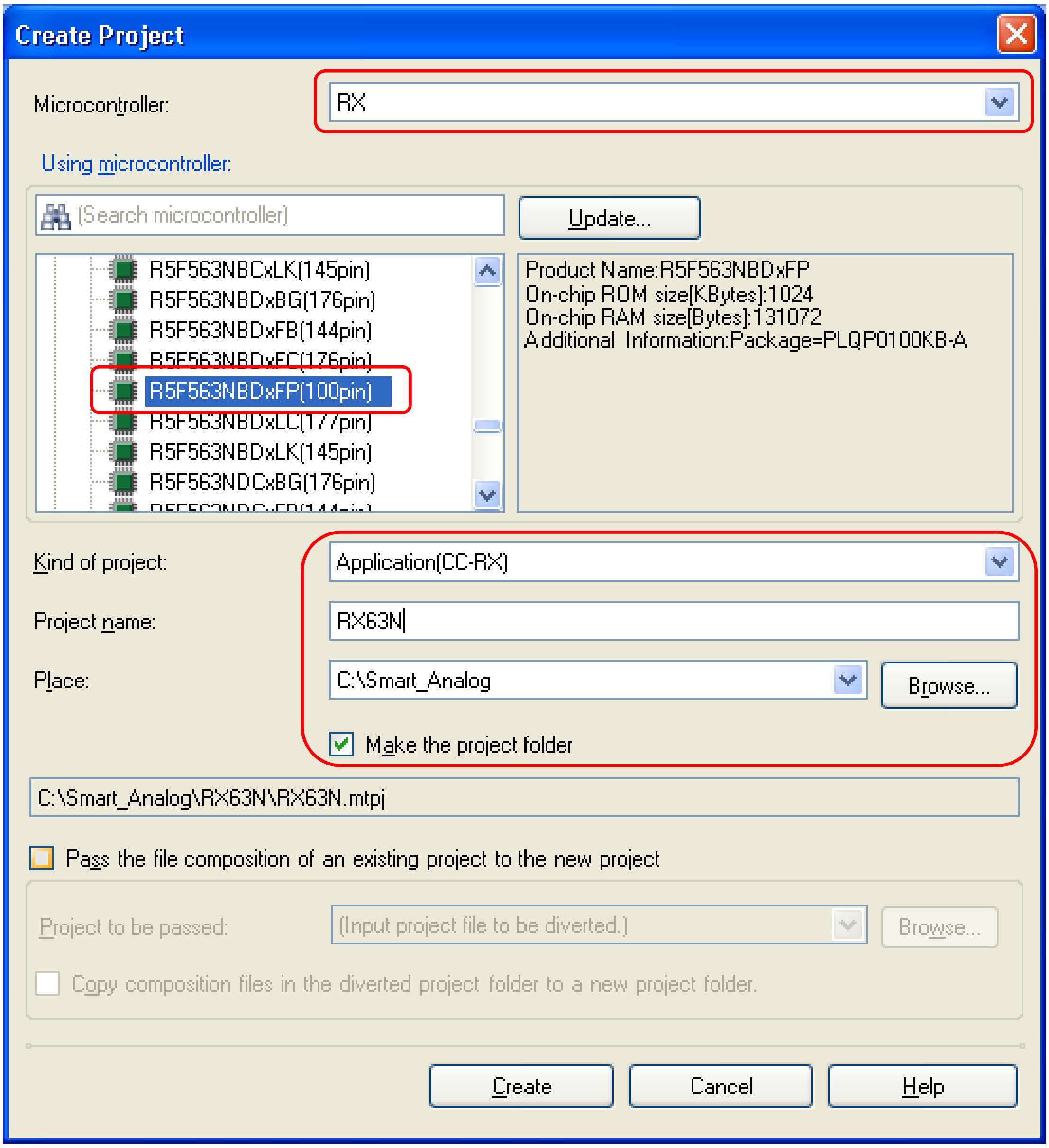
(2) **New Project**

Create a project workspace in the CubeSuite+.



Press “GO” button in “Create New Project”.

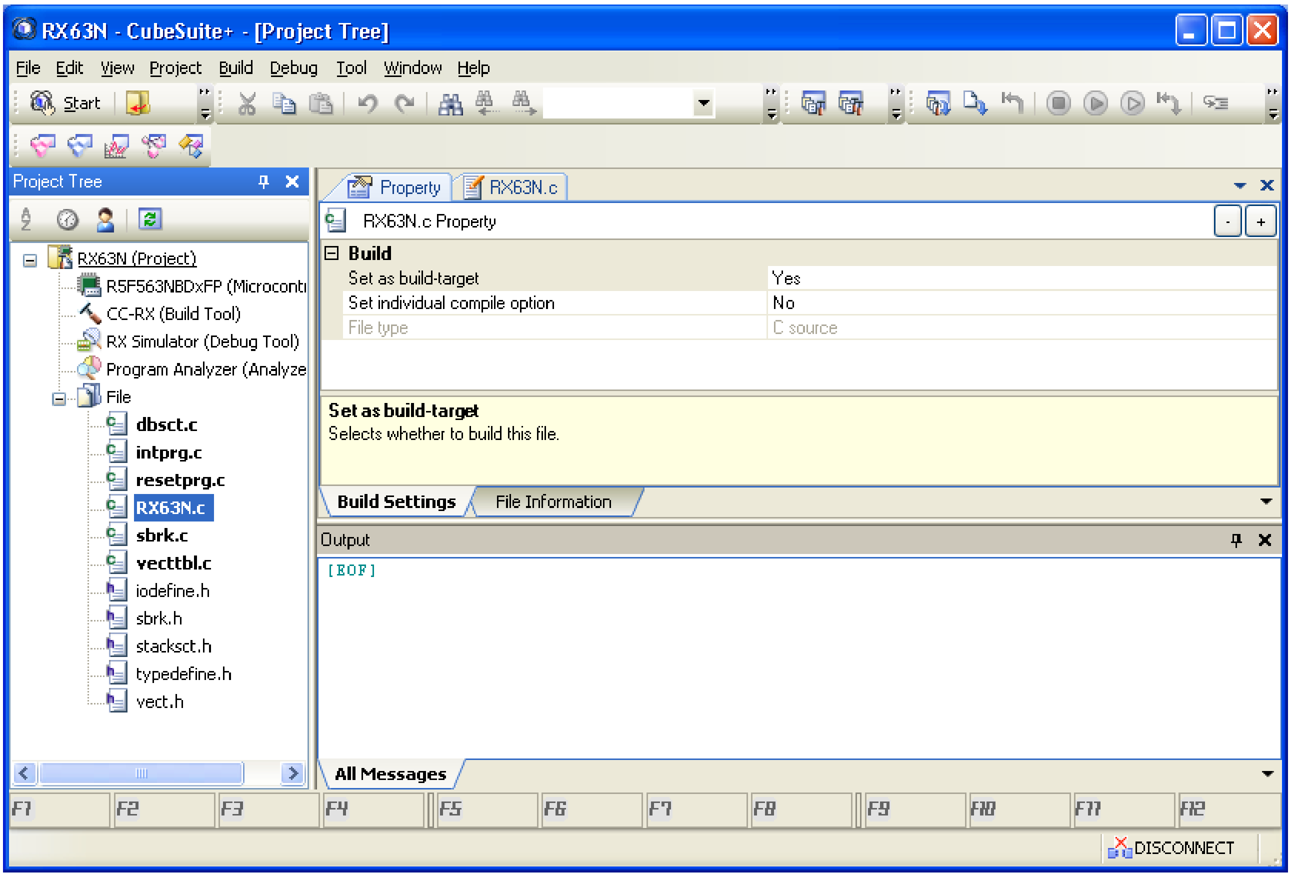
Set the project information in [Create Project] dialog.



[Microcontroller]	Choose "RX".
[Using microcontroller]	Choose "R5F563NEDxFP(100pin)" in "RX63N".
[Kind of project]	Choose "Applications(CC-RX)".
[Project name]	Type "RX63N" as above image.
[Place]	Choose “Smart_Analog” as above image. Check “Make the project folder”.

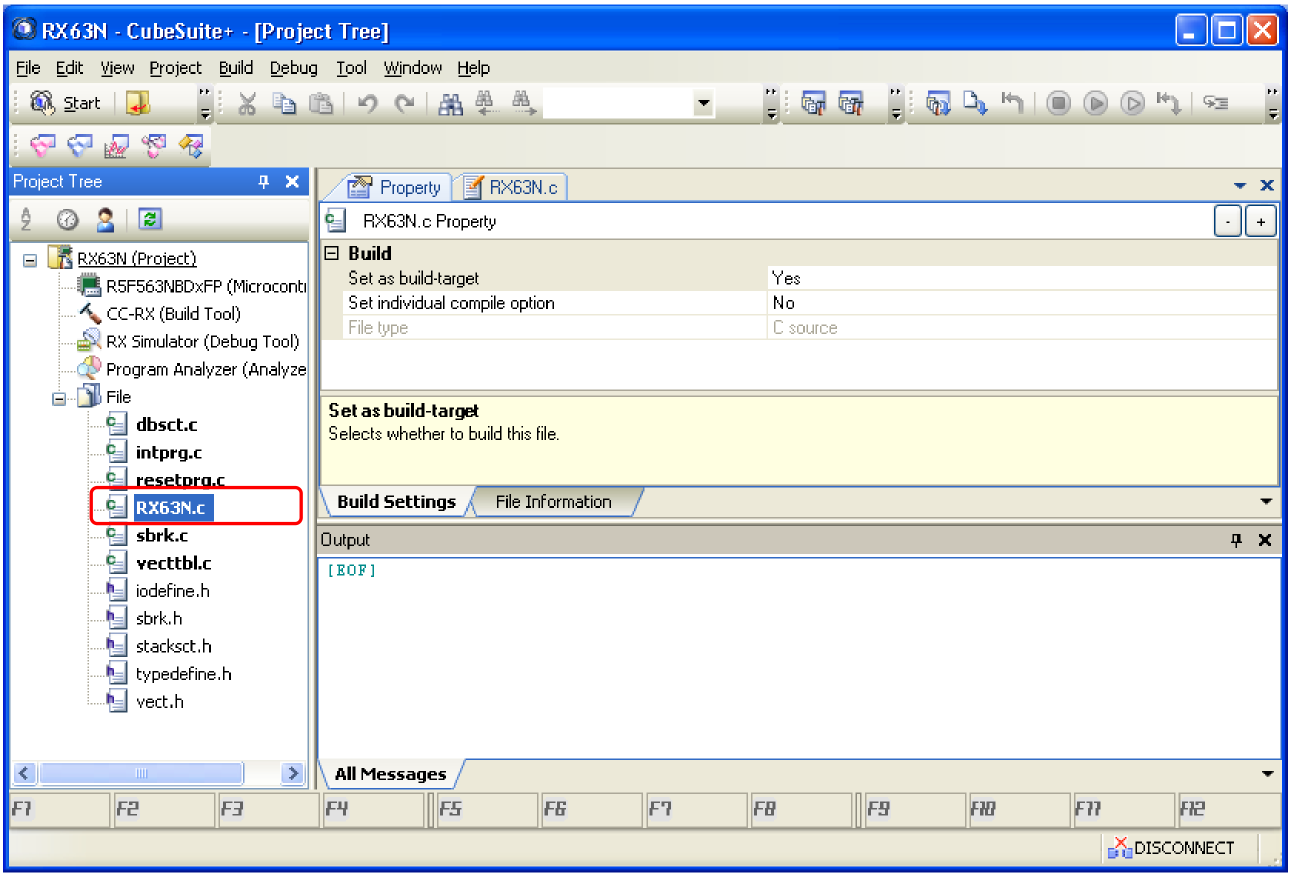
Press “Create” button.

The Project will be made and be displayed in the tree of the Project Tree panel.

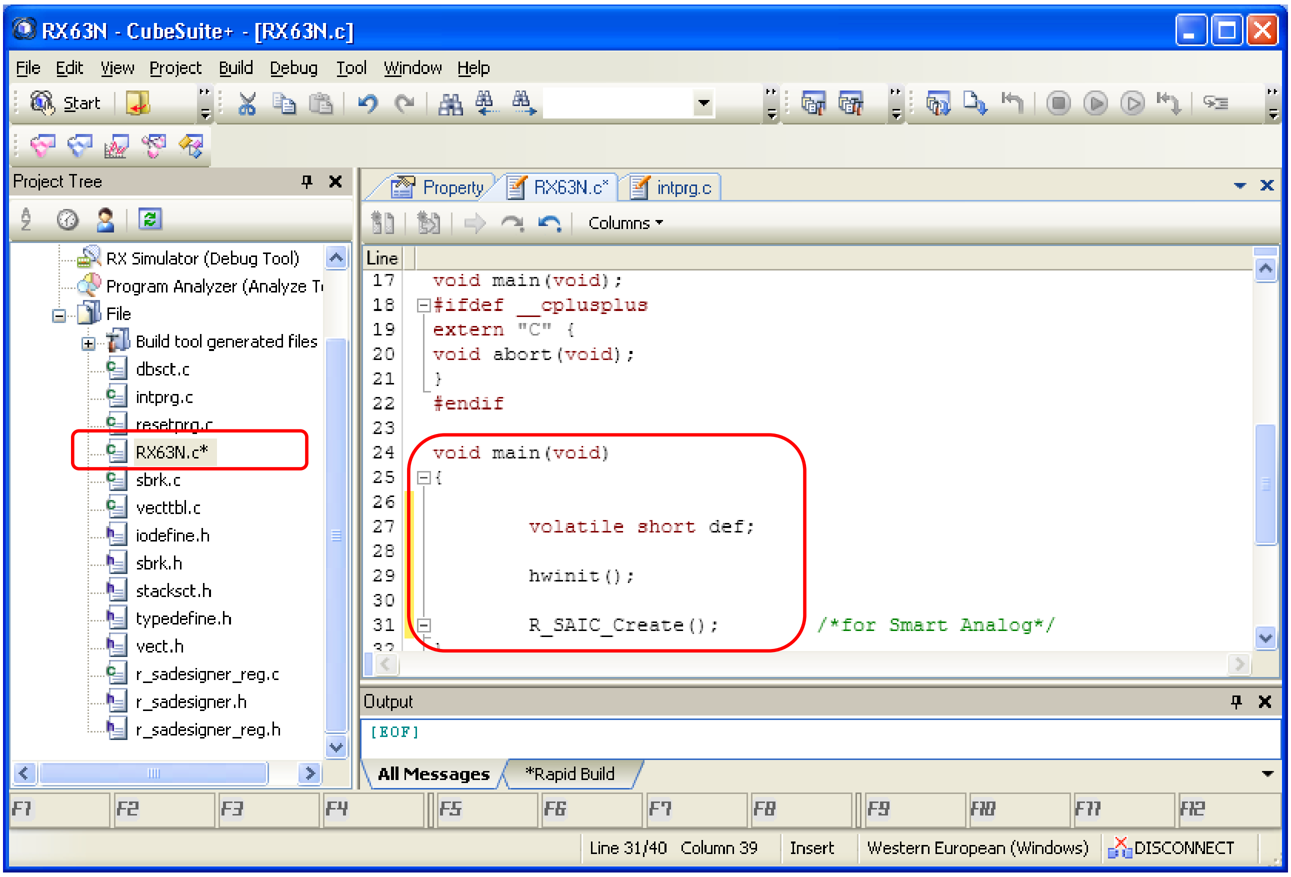


(3) **Creating Program**

Program the codes for using the clock settings and the function of A/D. As follows, the codes will be programmed in the RX63N.c and ntprg.c samples which are made by the CubeSuite+ as sample. Refer to “3. Sample Programs” for the programs that you need.



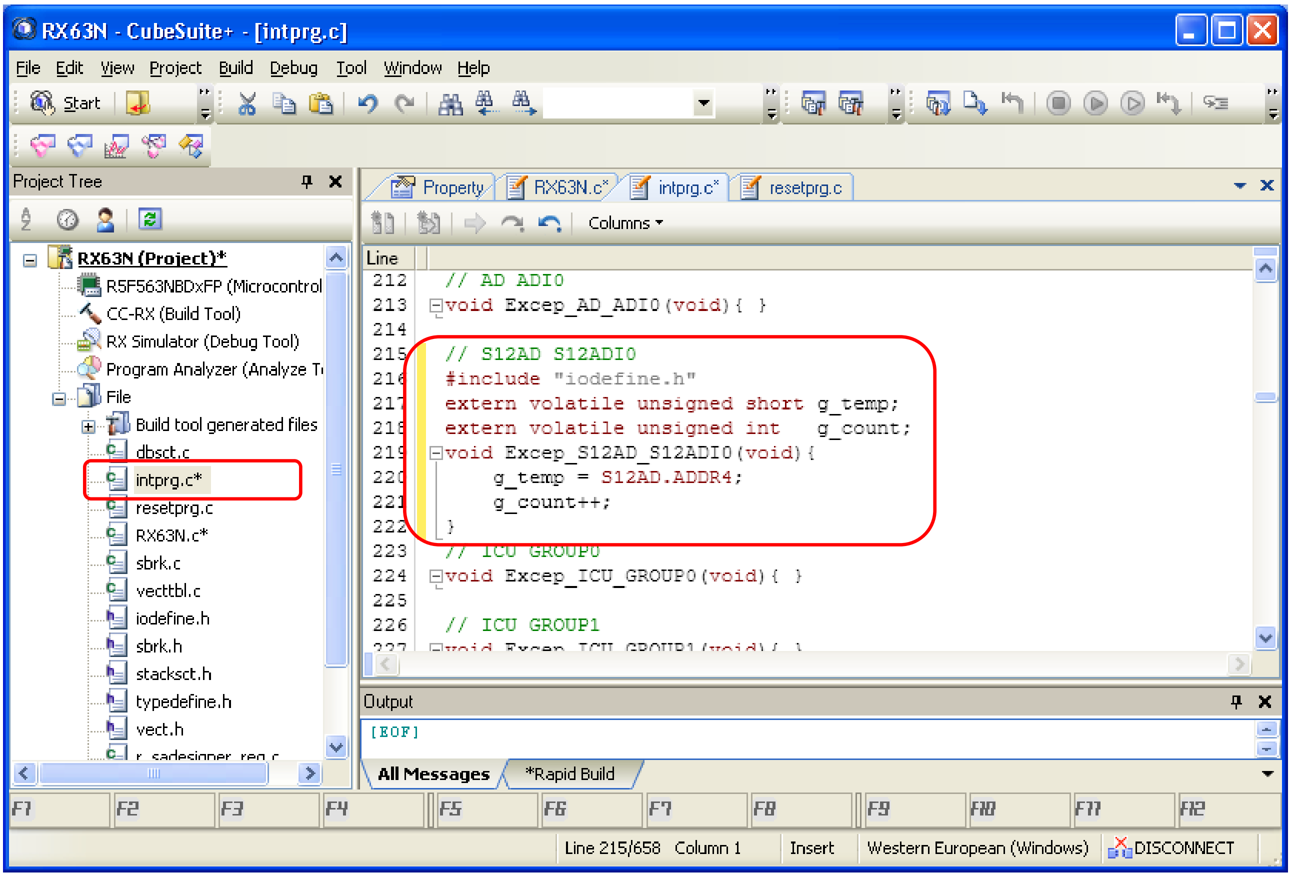
Open the source file “RX63N.c.”



Add procedures to the main function of the source file RX63N.c.

Also add the function hwinit and SPI initialization function to the RX63N.c.

Refer to “3. Sample Programs” for the programs that you need.



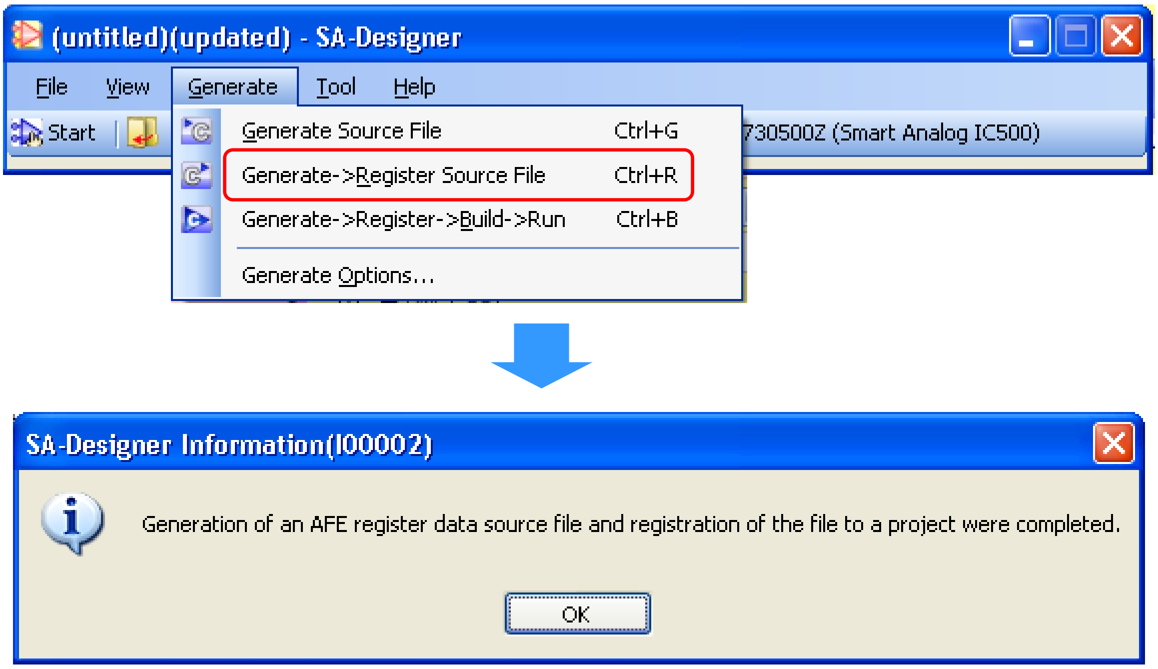
Add processing of Excep_S12AD_S12ADI0 interrupt function of the source file intprg.c.

Refer to “3. Sample Programs” for the programs that you need.

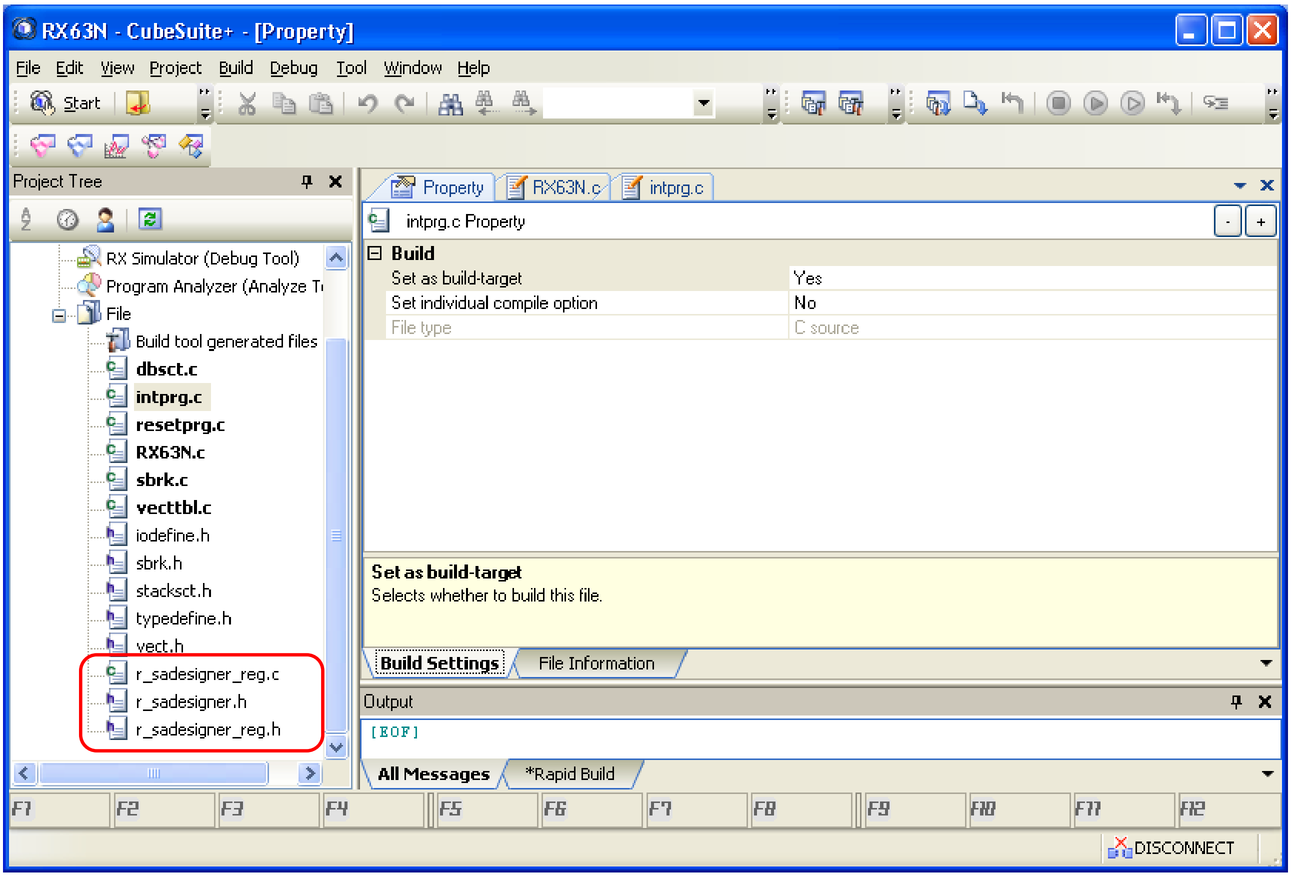
2.1.3 Register and Build the Circuit Data

(1) Register the Source Files to CubeSuite+

Register the source file, which is made by the SA-Designer to the project that you created in the CubeSuite+.

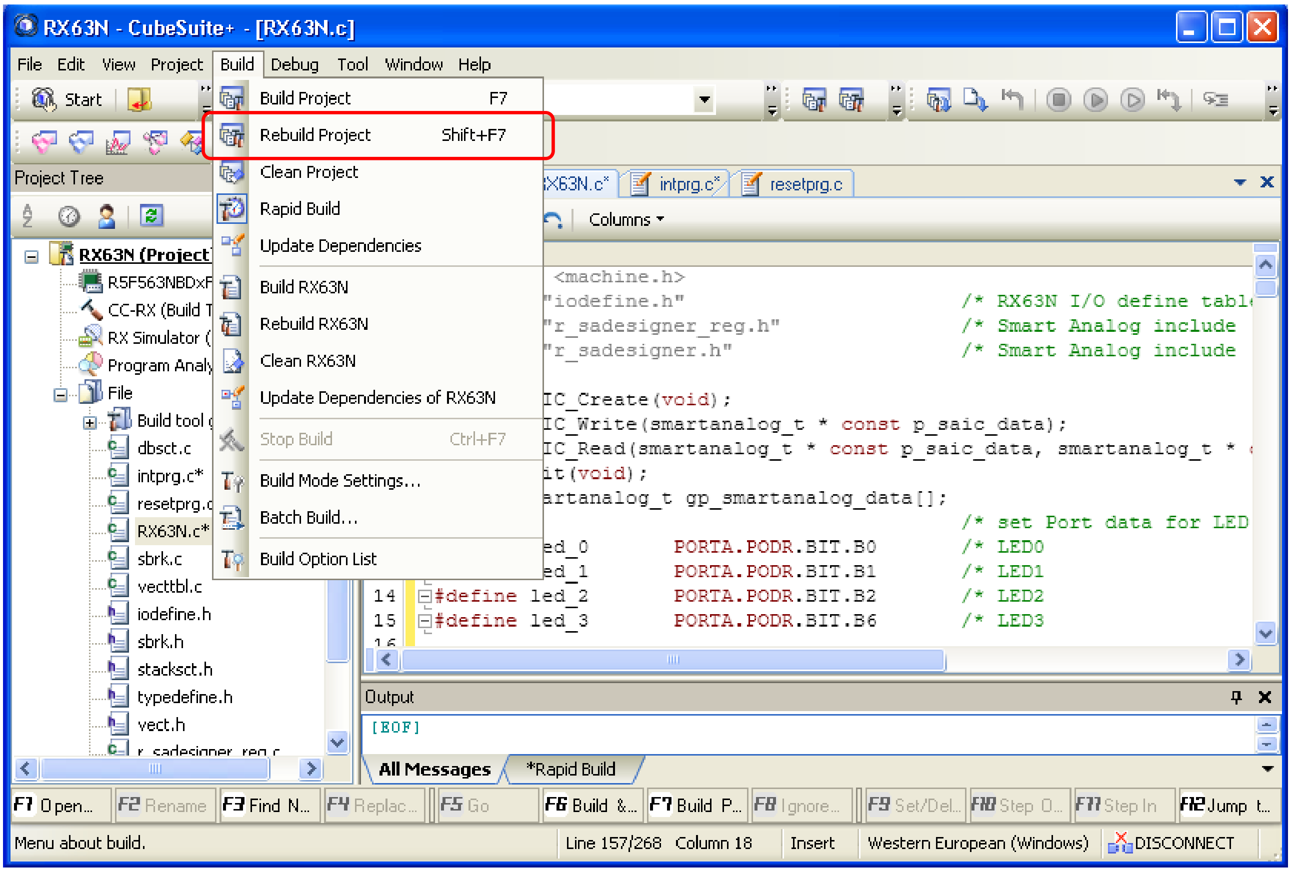


The Circuit data source file will be registered in the project tree.



(2) **Build**

Choose “Rebuild Project”, then make the load module file.



【Caution】

The following warning message will be shown after the link is started.

** L1100 (W) Cannot find "L" specified in option "start"

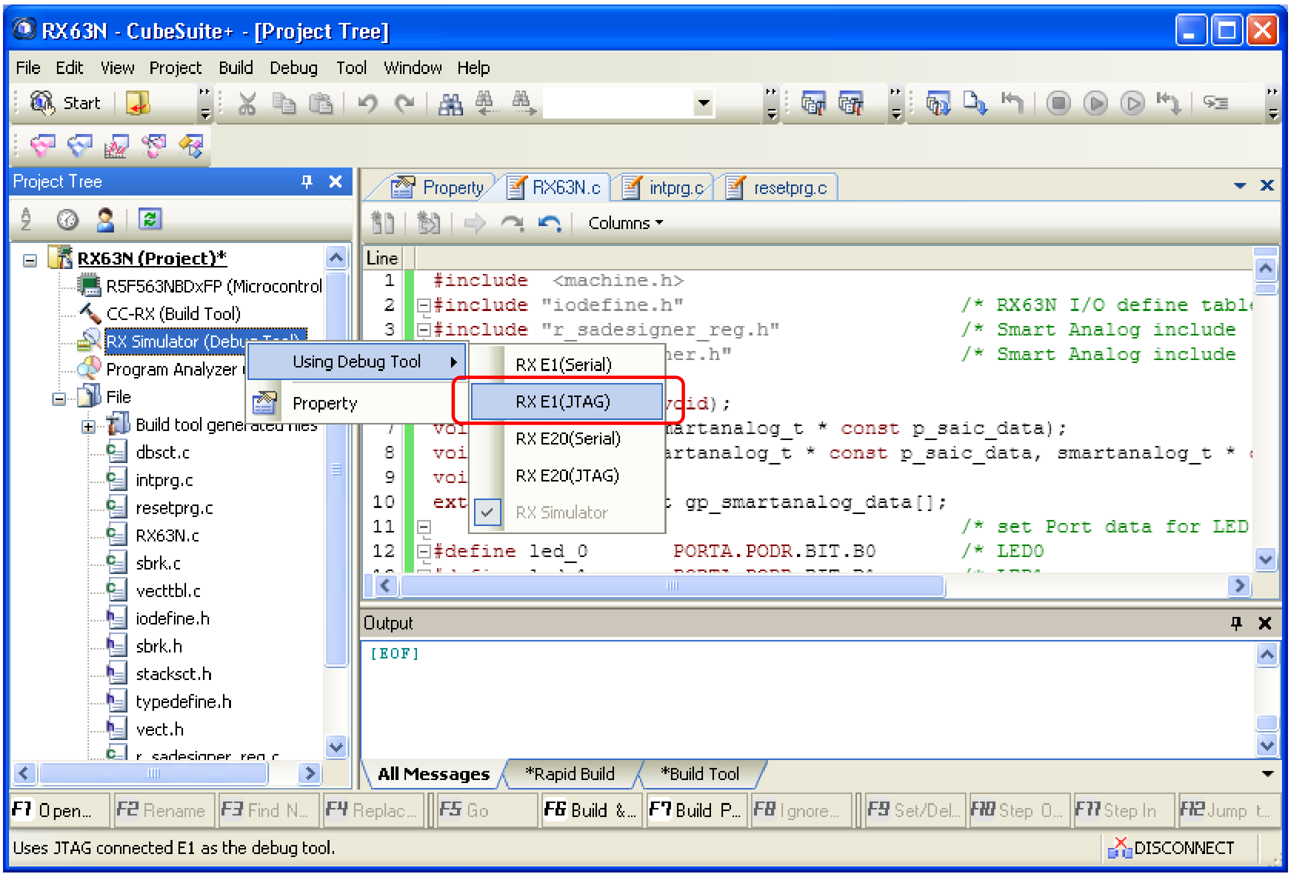
This message can be removed by deleting the section "L" which is specified by default during project creation.

To delete this section, go to [CC-RX(Build Tools)] - [Properties] - [Link Options] - [Section] in the project tree.

2.1.4 Testing

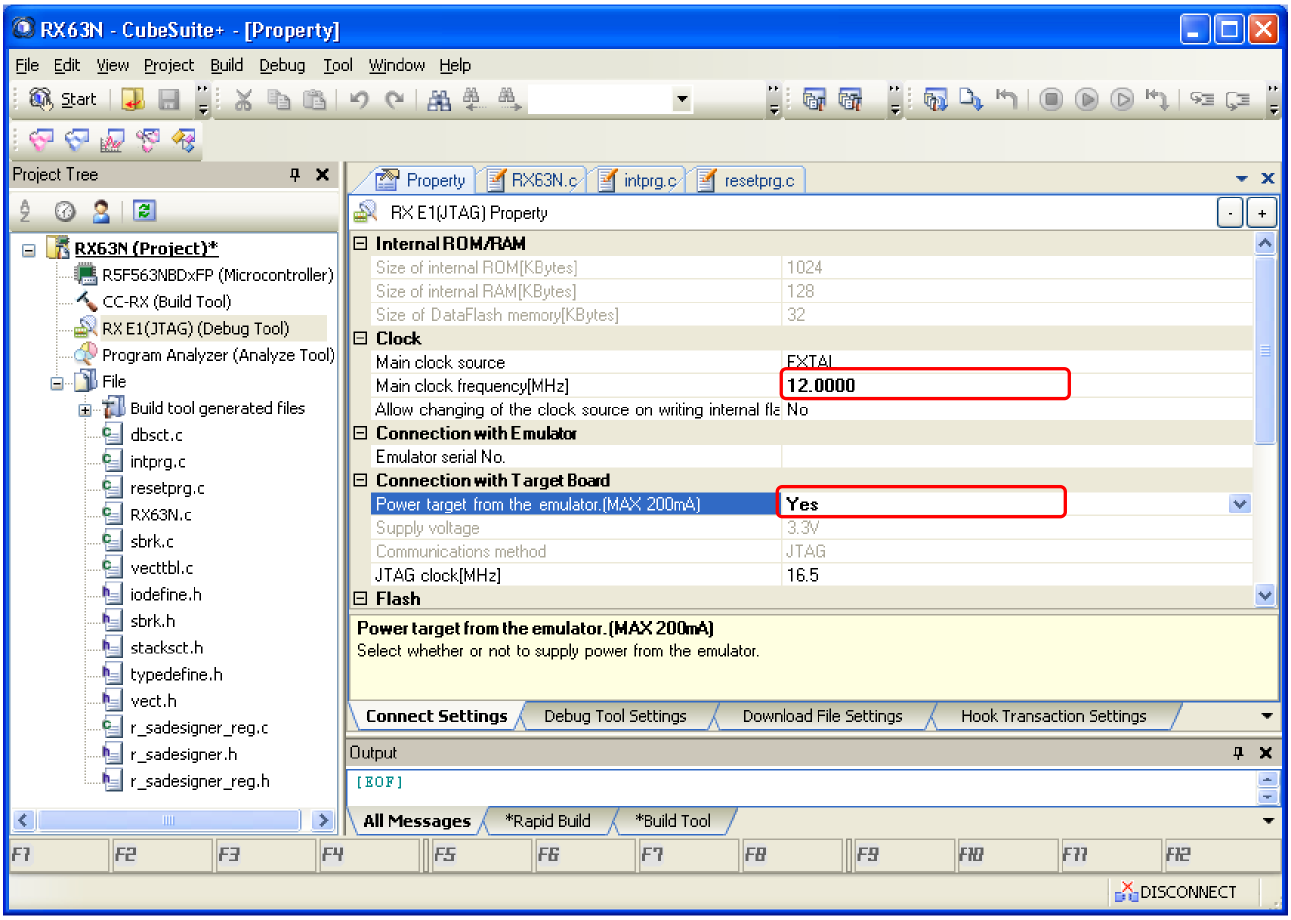
(1) Download the Load Module

Set the debug tool to use from the "Using Debug Tool" in the project tree of the CubeSuite+.



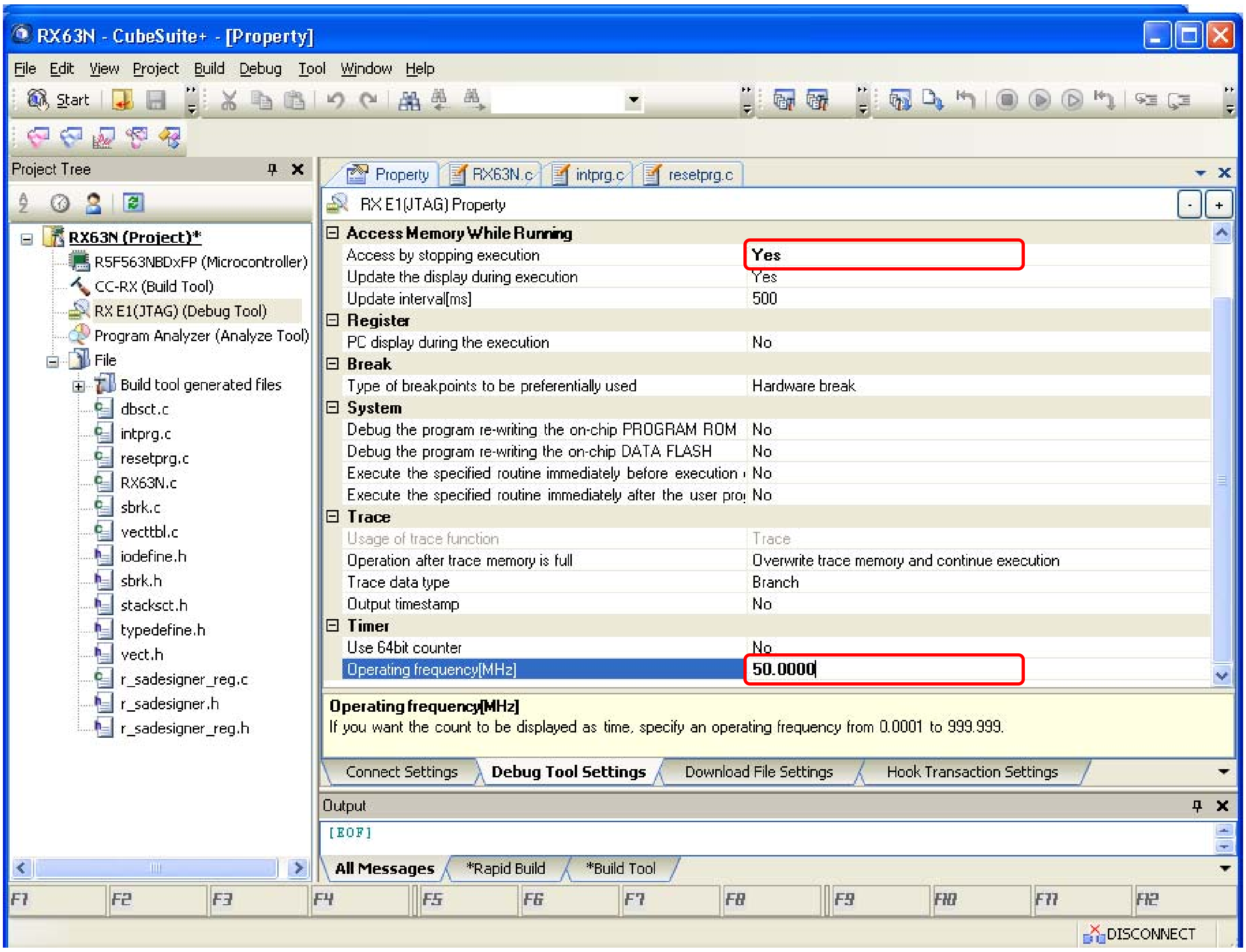
[RX Simulator(Debug Tool)] - [Using Debug Tool]	Choose the " RX E1(JTAG)".

Set the clock and choose “Power target from the emulator” in Property window of Debug Tool.



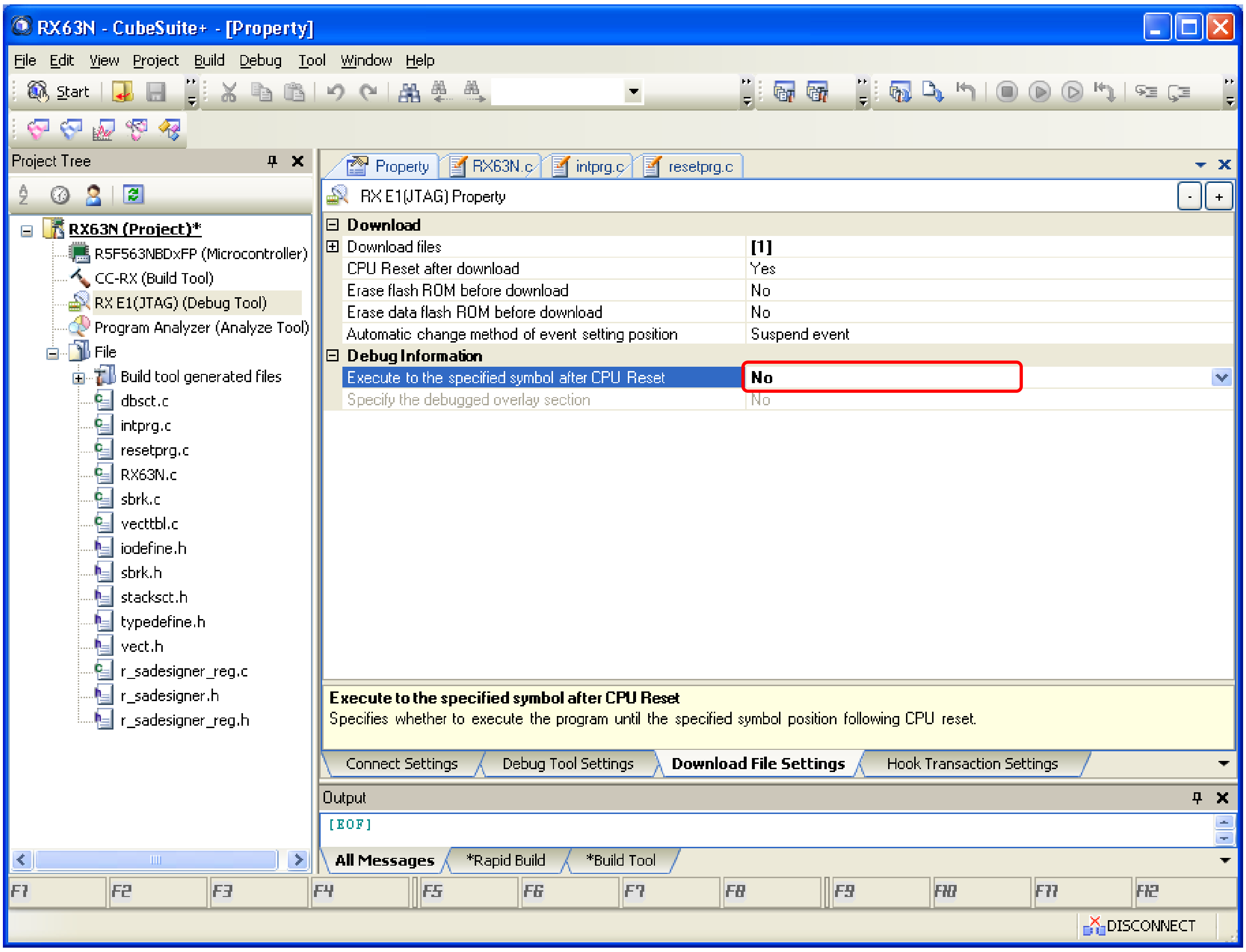
[Clock] - [Main clock frequency]	Specify "12.0000".
[Connection with Target Board] - [Power target from the emulator]	Choose "YES".

Set the Timer and Memory access in Property window of Debug Tool.



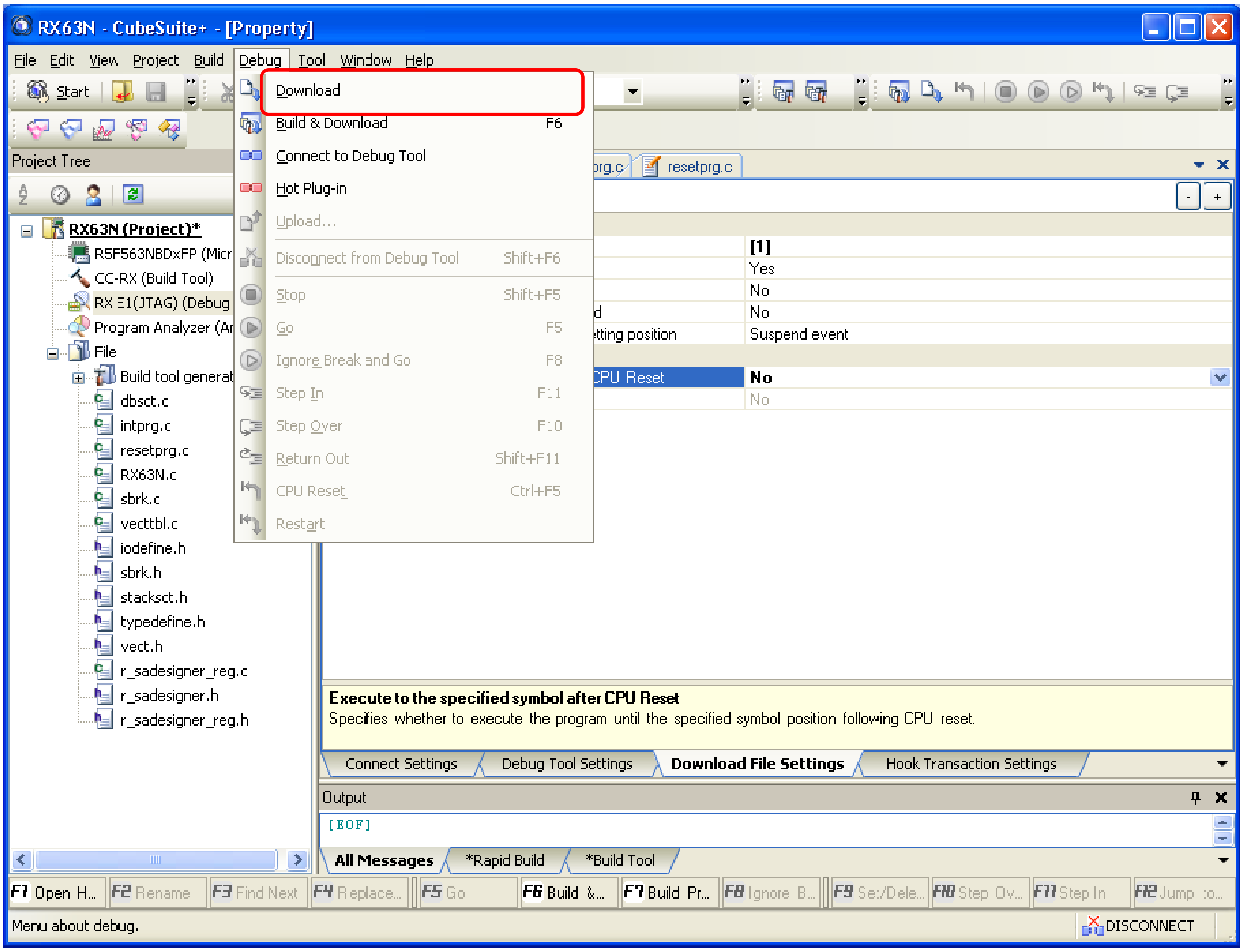
[Access Memory While Running] - [Access by stopping execution]	Choose "YES".
[Timer] - [Operating frequency]	Specify "50.0000".

Set the “debug information” in Property window of Debug Tool.



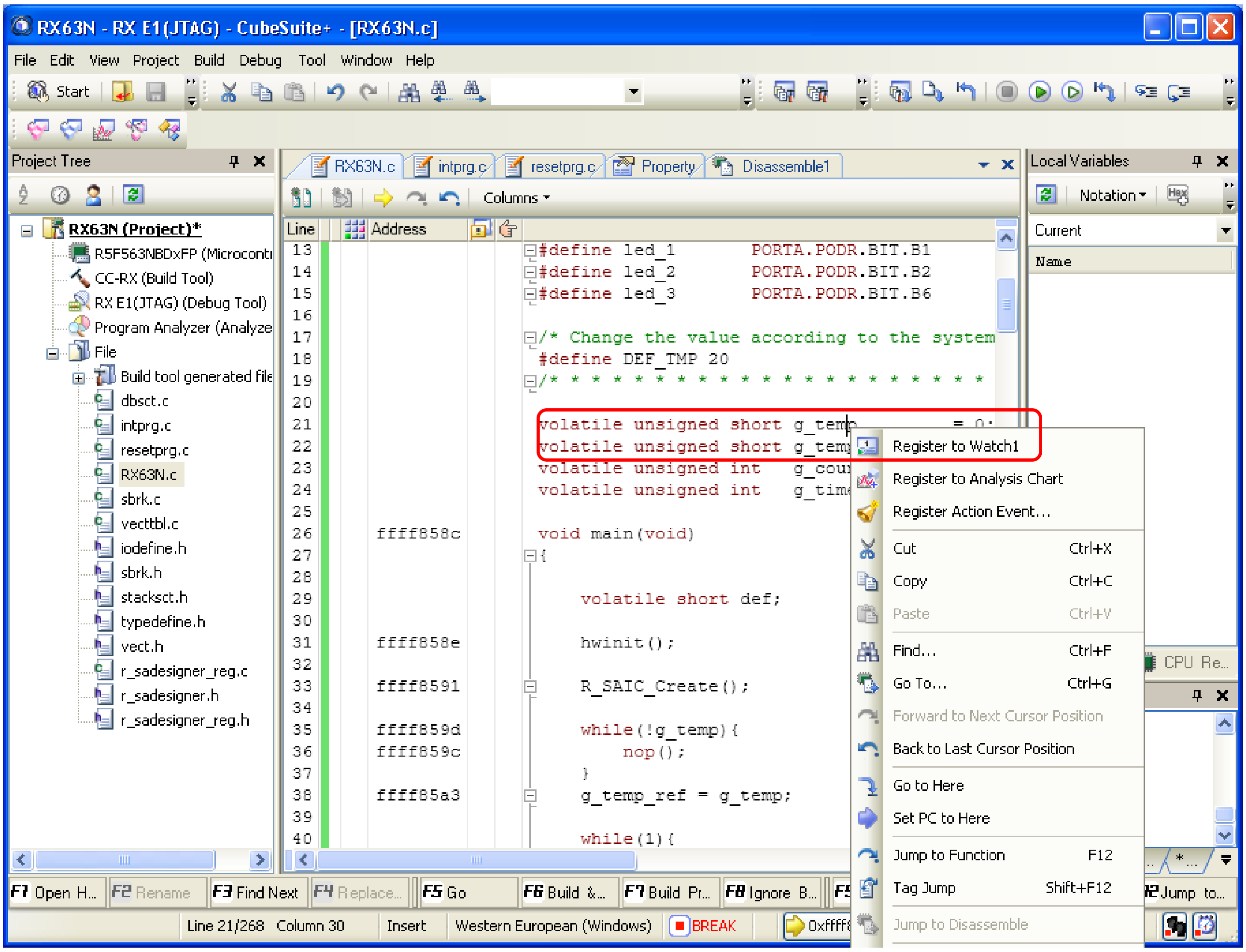
[Debug Information] - [Execute to the specified symbol after CPU Reset]	Choose "No".

Choose [Download] from the [Debug]. Connect to the Debug Tool for downloading the load module.



(2) **Registration Variable to the Watch Window**

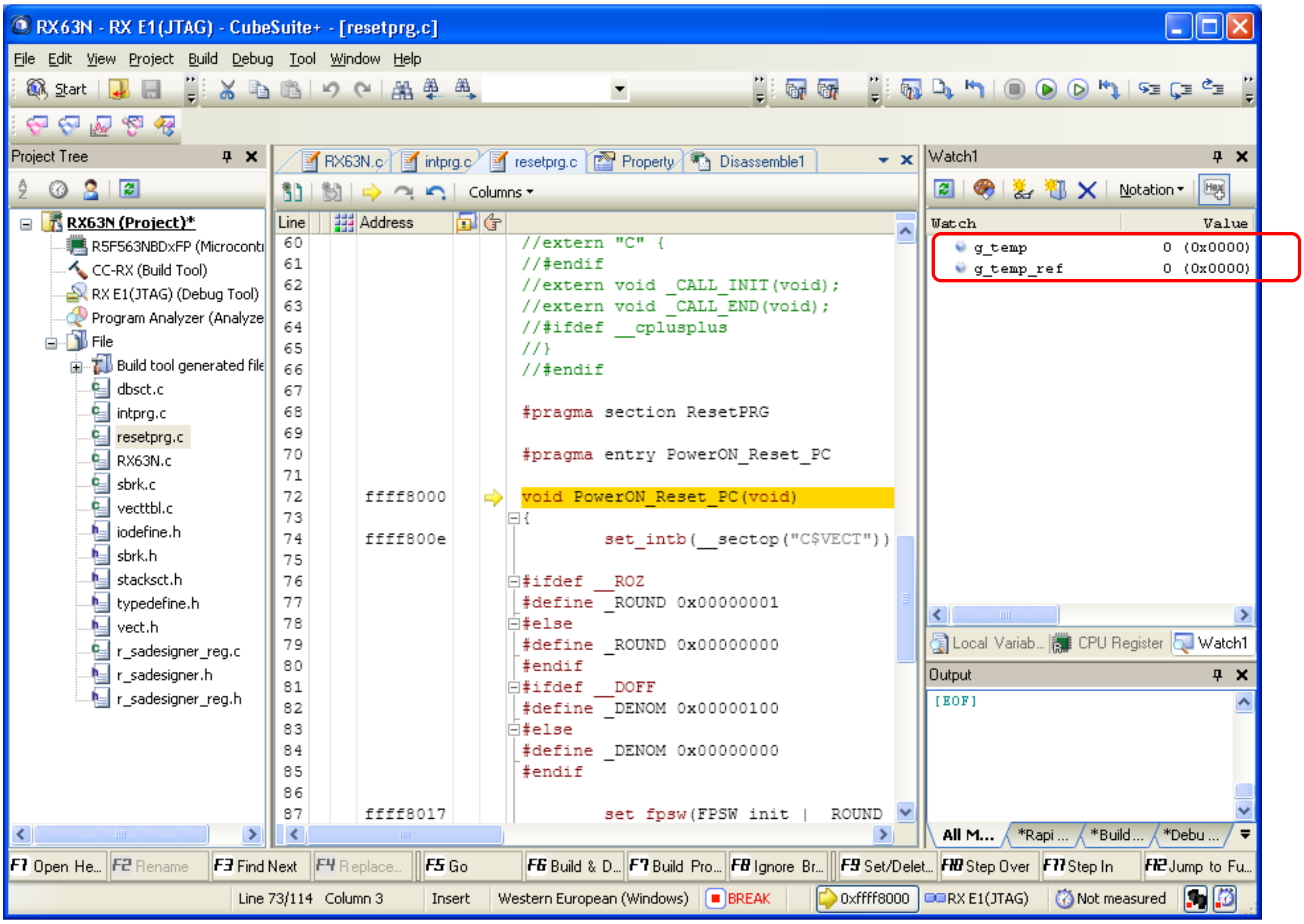
Register the variables to the watch window for checking the operation of the program.



Choose “g_temp” in the “RX63N.c” and click the right button and then choose “Register to Watch1”.

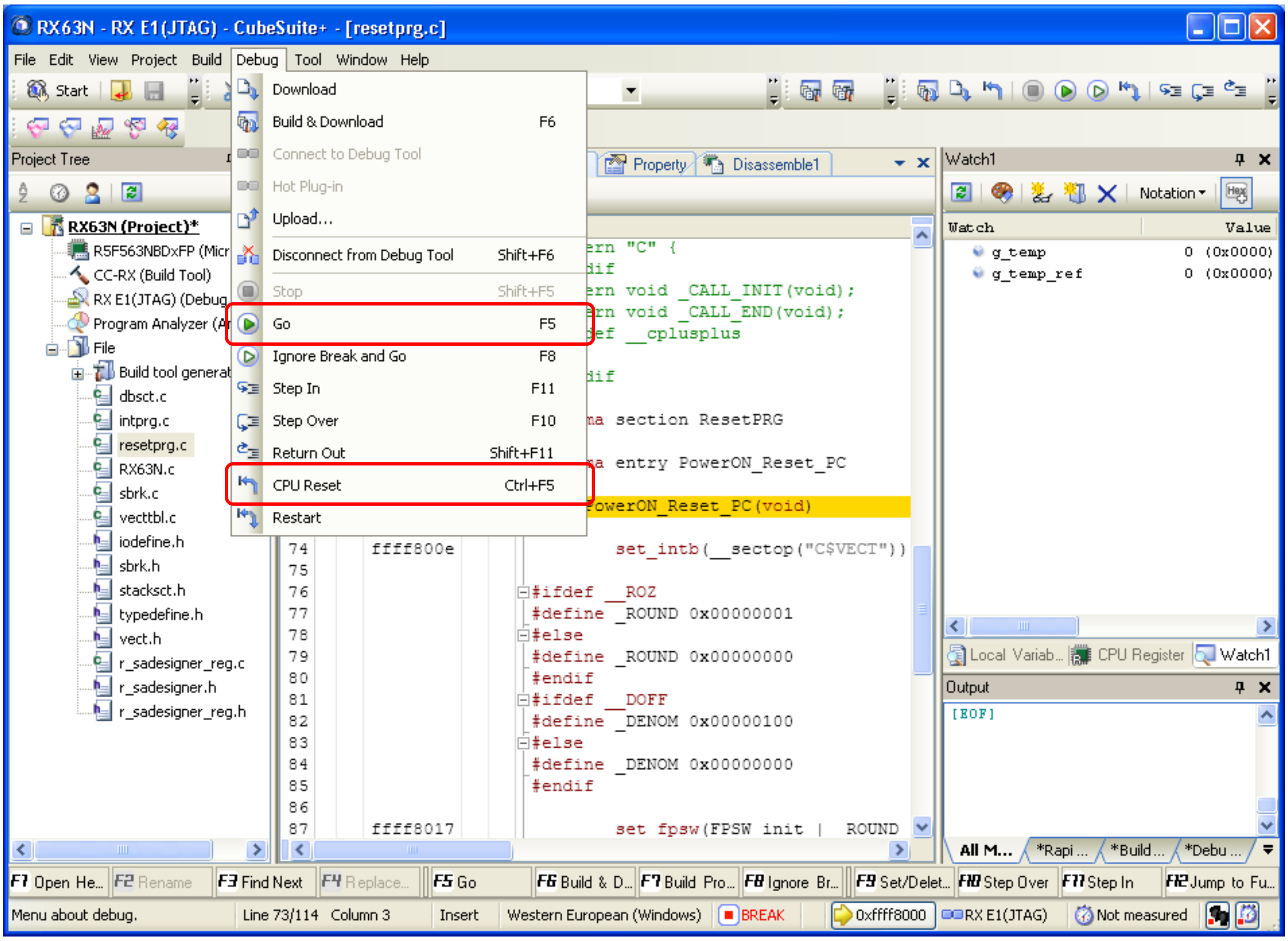
And register “g_temp_ref” in the same operation.

The variables will be displayed in the "Watch1 window".



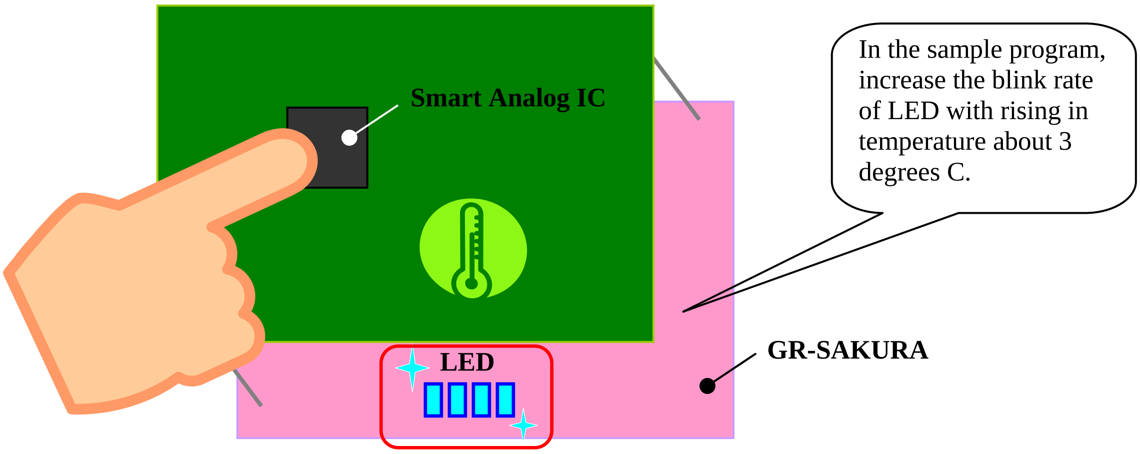
(3) **Run Program**

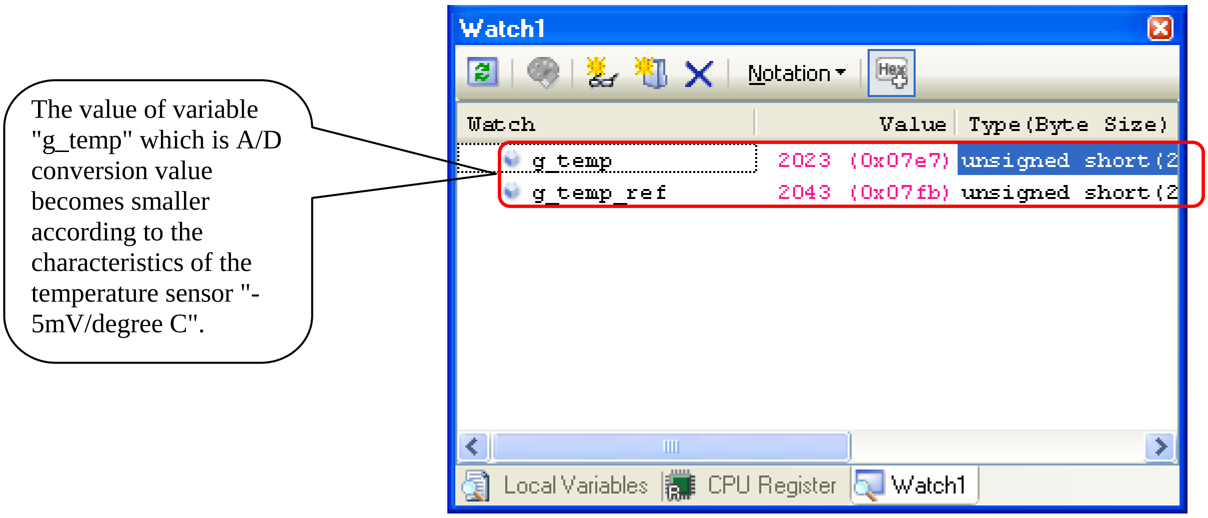
Check the system operations. “CPU Reset” must be chosen before execute the program.



Choose “CPU Reset” from “Debug” and then choose “Go” to execute the program.

Touch your finger to the microcomputer of ”Smart Analog IC500”. When you touch the “Smart Analog IC”, then the temperature of the microcomputer will increase and get lower value of the variable “g_temp” of A/D conversion. Also, the blink rate of LED will be increased.





3. Sample Programs

The followings are the sample programs which are used in the application note.

(1) Function main (In addition to the main function of RX63N.c)

```
#include  <machine.h>
#include "iodefine.h"                       /* RX63N I/O define table       */
#include "r_sadesigner_reg.h"               /* Smart Analog include         */
#include "r_sadesigner.h"                   /* Smart Analog include         */

void R_SAIC_Create(void);
void R_SAIC_Write(smartanalog_t * const p_saic_data);
void R_SAIC_Read(smartanalog_t * const p_saic_data, smartanalog_t * const p_saic_read_buf);
void hwinit(void);
extern smartanalog_t gp_smartanalog_data[];
                                            /* set Port data for LED        */
#define led_0       PORTA.PODR.BIT.B0       /* LED0                         */
#define led_1       PORTA.PODR.BIT.B1       /* LED1                         */
#define led_2       PORTA.PODR.BIT.B2       /* LED2                         */
#define led_3       PORTA.PODR.BIT.B6       /* LED3                         */

/* Change the value according to the system  * * * * * * * * * * * * * * * * */
#define DEF_TMP 20
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

volatile unsigned short g_temp        = 0;
volatile unsigned short g_temp_ref;
volatile unsigned int   g_count       = 0;
volatile unsigned int   g_timeofswitch = 10000;

void main(void)
{

    volatile short def;

    hwinit();

    R_SAIC_Create();                        /* for Smart Analog             */

    while(!g_temp){
        nop();
    }
    g_temp_ref = g_temp;                    /* read start condition         */

    while(1){
        def = g_temp_ref - g_temp;
        if ( g_count > g_timeofswitch ) {
            led_0 = ~led_0;
            led_1 = ~led_1;
            led_2 = ~led_2;
            led_3 = ~led_3;

            g_count = 0;

            if ( def > DEF_TMP ) {
                g_timeofswitch = 5000;
            } else {
                g_timeofswitch = 25000;
            }
        }
    }
}
```

(2) **Initialization function (Add to RX63N.c)**

```
#define PSW_I_FLG 0x00010000
#define PSW_I_CLR 0x00000000
void hwinit(void)
{
    set_psw(PSW_I_CLR);

    SYSTEM.PRCR.WORD     = 0xA503;          /* disable Register protection   */

    SYSTEM.MSTPCRA.LONG = 0xFFFDFFFF;       /* enable MSTP S12AD             */
    SYSTEM.MSTPCRB.LONG = 0xFFFDFFFF;       /* enable MSTP RSPI0             */
    SYSTEM.MSTPCRC.LONG = 0xFFFF0000;       /*                               */

    SYSTEM.SCKCR3.WORD  = 0x0200;           /* select Main Clock             */
    SYSTEM.MOSCCR.BIT.MOSTP = 0;            /* enable Main Clock             */

    MPC.PWPR.BIT.BOWI    = 0;               /* disable MPC protection        */
    MPC.PWPR.BIT.PFSWE   = 1;

    MPC.PC5PFS.BYTE      = 0x0D;            /* set SPI RSPCKA/MOSIA/MISOA    */
    MPC.PC6PFS.BYTE      = 0x0D;
    MPC.PC7PFS.BYTE      = 0x0D;
    MPC.P44PFS.BIT.ASEL = 1;                /* set Smart Analog TEMP_OUT     */

    MPC.PWPR.BIT.BOWI    = 1;               /* enable MPC protection         */
    MPC.PWPR.BIT.PFSWE   = 0;

    PORT1.PDR.BIT.B2     = 1;               /* init Port for SAIC RESET      */
    PORT1.PMR.BIT.B2     = 0;
    PORT1.PODR.BIT.B2    = 1;

    SYSTEM.PRCR.WORD     = 0xA500;          /* enable Register protection    */

    PORTA.PODR.BYTE      = 0;               /* set Port for LED              */
    PORTA.PDR.BYTE       = 0x47;

    PORT4.PDR.BIT.B4     = 0;               /* set Port for TEMP_OUT         */
    PORT4.PMR.BIT.B4     = 0;

    PORTC.PDR.BYTE       = 0x70;            /* set Port Output PC4,PC5,PC6   */
    PORTC.PMR.BYTE       = 0xE0;            /* set Port General PC5,PC6,PC7  */

    PORTC.PODR.BIT.B4    = 1;               /* set Port PC4 for CS           */
                                            /* set S12AD                     */
    S12AD.ADCSR.BYTE     = 0;               /* clear ADST,CKS                */
    S12AD.ADANS0.WORD    = 0x0010;          /* set AN004                     */
    S12AD.ADCSR.BYTE     = 0xD0;            /* set ADST,ADCS,ADIE            */

    led_0                = 1;
    led_2                = 1;

    set_psw(PSW_I_FLG);
}
```

(3) **Interrupt function (Add to intprg.c)**

```
// S12AD S12ADI0
#include "iodefine.h"
extern volatile unsigned short g_temp;
extern volatile unsigned int   g_count;
void Excep_S12AD_S12ADI0(void){
    g_temp = S12AD.ADDR4;
    g_count++;
}
```

(4) **Function SPI (Add to RX63N.c)**

(a) **R_SAIC_Create()**

```
/******************************************************************************/
/*  R_SAIC_Create();                                                          */
/******************************************************************************/
void R_SAIC_Create(void)
{
    volatile uint16_t w_count;

    PORT1.PODR.BIT.B2 = 0;                  /* Analog IC Reset                */

    /* Change the waiting time according to the system */
    for (w_count = 0U; w_count < 0x82; w_count++)
    {
        nop();
    }

    PORT1.PODR.BIT.B2 = 1;                  /* Analog IC Reset release        */

    R_SAIC_Write(gp_smartanalog_data);
}
```

(b) **R_SAIC_Write()**

```
/******************************************************************************/
/*  R_SAIC_Write(gp_smartanalog_data);                                        */
/******************************************************************************/
void R_SAIC_Write(smartanalog_t * const p_saic_data)
{
    volatile uint8_t adrs;
    volatile uint8_t dat;
    volatile uint8_t wait;

    smartanalog_t *p_saic_write;
    p_saic_write = p_saic_data;

    RSPI0.SPCR.BYTE      = 0;               /* clear SPE,SPTIE            */
                                            /* set ICU                    */
    ICU.IPR[102].BYTE    = 1;               /* set interrupt priority S12AD */
    ICU.IR[102].BIT.IR   = 0;               /* clear interrupt S12AD      */
    ICU.IR[40].BIT.IR    = 0;               /* clear interrupt RSPI SPTI  */
    ICU.IER[5].BIT.IEN0  = 1;               /* enable interrupt RSPI SPTI */

    ICU.IER[12].BIT.IEN6 = 1;               /* enable interrupt S12AD     */

    RSPI0.SPCR.BYTE      = 0x0B;            /* set SPMS,MSTR,TXMD         */
    RSPI0.SPCMD0.WORD    = 0x0703;          /* set SPB,LSBF,CPOL,CPHA     */
    RSPI0.SPBR           = 0x05;

    RSPI0.SPCR.BIT.SPE   = 1;               /* set SPE                    */
    RSPI0.SPCR.BIT.SPTIE = 1;               /* set SPTIE                  */

    while (p_saic_write->address != 0xff)
    {
        PORTC.PODR.BIT.B4= 0;
        for (wait = 0U; wait < 10U; wait++) /* SA Stable waiting time (tSKA) */
        {
            nop();
        }

        adrs = (p_saic_write->address & 0x7f) | 0x80; /* 0x80 data write mode*/
        RSPI0.SPDR.WORD.H = adrs;           /* send SAIC Address data     */

        while (ICU.IR[40].BIT.IR == 0U);    /* wait for CSI send          */
        ICU.IR[40].BIT.IR = 0U;

        dat = p_saic_write->data;
        RSPI0.SPDR.WORD.H = dat;

        while (ICU.IR[40].BIT.IR == 0U);    /* wait for CSI send          */
        ICU.IR[40].BIT.IR = 0U;

        for (wait = 0U; wait < 10U; wait++) /* SA Stable waiting time (tKSA) */
        {
            nop();
        }
        PORTC.PODR.BIT.B4= 1;               /* SAIC CS=H                  */
        for (wait = 0U; wait < 10U; wait++) /* SA Stable waiting time (tSHA) */
        {
            nop();
        }
        p_saic_write++;
    }
    RSPI0.SPCR.BIT.SPTIE = 0;
    RSPI0.SPCR.BIT.SPE = 0;
}
```

(c) **R_SAIC_Read()**

```
/*************************************************************************/
/*  R_SAIC_Read(gp_smartanalog_data, saic_read_buf);                     */
/*************************************************************************/
void R_SAIC_Read(smartanalog_t * const p_saic_data, smartanalog_t * const p_saic_read_buf)
{
    volatile uint8_t adrs;
    volatile uint8_t wait;
    smartanalog_t *p_saic_write;
    smartanalog_t *p_saic_read;

    p_saic_write = p_saic_data;
    p_saic_read  = p_saic_read_buf;

    RSPI0.SPCR.BYTE      = 0;             /* clear SPE,SPTIE             */
                                          /* set ICU                     */
    ICU.IPR[102].BYTE    = 1;             /* set interrupt priority S12AD */
    ICU.IR[102].BIT.IR   = 0;             /* clear interrupt S12AD       */
    ICU.IR[40].BIT.IR    = 0;             /* clear interrupt RSPI SPTI   */
    ICU.IER[5].BIT.IEN0  = 1;             /* enable interrupt RSPI SPTI  */

    RSPI0.SPCR.BYTE      = 0x09;          /* set SPMS,MSTR               */
    RSPI0.SPCMD0.WORD    = 0x0703;        /* set SPB,LSBF,CPOL,CPHA      */
    RSPI0.SPBR           = 0x05;

    RSPI0.SPCR.BIT.SPE   = 1;             /* set SPE                     */
    RSPI0.SPCR.BIT.SPTIE = 1;             /* set SPTIE                   */

    while (p_saic_write->address != 0xff)
    {
        PORTC.PODR.BIT.B4= 0;
        for (wait = 0U; wait < 10U; wait++) /* SA Stable waiting time (tSKA) */
        {
            nop();
        }

        adrs = (p_saic_write->address) & 0x7f;
        p_saic_read->address = adrs;      /* send SAIC Address data      */
        RSPI0.SPDR.WORD.H = adrs;         /* send SAIC Address data      */

        while (ICU.IR[40].BIT.IR == 0U);  /* wait for CSI send           */
        ICU.IR[40].BIT.IR = 0U;

        RSPI0.SPDR.WORD.H = 0xff;         /* send CSI dummy data         */

        while (ICU.IR[40].BIT.IR == 0U);  /* wait for CSI send           */
        ICU.IR[40].BIT.IR = 0U;

        p_saic_read->data =  (unsigned char)RSPI0.SPDR.WORD.H;

        for (wait = 0U; wait < 10U; wait++) /* SA Stable waiting time (tKSA) */
        {
            nop();
        }
        PORTC.PODR.BIT.B4= 1;             /* SAIC CS=H                   */
        for (wait = 0U; wait < 10U; wait++) /* SA Stable waiting time (tSHA) */
        {
            nop();
        }
        p_saic_write++;
        p_saic_read++;
    }
    RSPI0.SPCR.BIT.SPTIE = 0;
    RSPI0.SPCR.BIT.SPE = 0;
}
```

Website and Support

Renesas Electronics Website
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Revision Record

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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 type number, confirm that the change will not lead to problems.
   — The characteristics of MPU/MCU in the same group but having different type numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different type numbers, implement a system-evaluation test for each of the products.

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Refer to "http://www.renesas.com/" for the latest and detailed information.

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