User's Manual

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RL78/G22 Multiwavelength Smoke Detector Evaluation Board

User's Manual: Software

RL78 Family

Renesas Electronics
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Rev.1.00 Feb 2025

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(Rev.5.0-1 October 2020)

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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.
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.

How to Use This Manual

1. Purpose and Target Readers

This manual is designed to provide the user with an understanding of the hardware functions and electrical characteristics of the MCU. It is intended for users designing application systems incorporating the MCU. A basic knowledge of electric circuits, logical circuits, and MCUs is necessary in order to use this manual.
The manual comprises an overview of the product; descriptions of the CPU, system control functions, peripheral functions, and electrical characteristics; and usage notes.

> Particular attention should be paid to the precautionary notes when using the manual. These notes occur within the body of the text, at the end of each section, and in the Usage Notes section.

> The revision history summarizes the locations of revisions and additions. It does not list all revisions. Refer to the text of the manual for details.

The following documents apply to the Multiwavelength Smoke Detector solution. Make sure to refer to the latest versions of these documents. The newest versions of the documents listed may be obtained from the Renesas Electronics Web site.

Document Type	Description	Document Title	Document No.
User's manual for Software	Description of CPU instruction set	RL78/G22 Multiwavelength Smoke Detector Evaluation Board User's Manual: Software	This User's manual
User's manual for Hardware	Hardware specifications (pin assignments, memory maps, peripheral function specifications, electrical characteristics, timing charts) and operation description Note: Refer to the application notes for details on using peripheral functions.	RL78/G22 Multiwavelength Smoke Detector Evaluation Board User's Manual: Hardware	R01UH1161EJ0100
Application Note	Information on using peripheral functions and application examples Sample programs Information on writing programs in C language	Available from Renesas Electronics Web site.	
Renesas Technical Update	Product specifications, updates on documents, etc.		

Table of Contents

1. Introduction

1.1 Overview

The purpose of this User's Manual (Software) is to explain the architecture and features of the sample software for the Multiwavelength Smoke Detector. By using this sample software together with the Multiwavelength Smoke Detector POC substrate (hereinafter referred to as the POC substrate), Multiwavelength Smoke Detector can be easily developed.

The hardware and sample software in this case are for reference purposes only for development, and we do not guarantee that they will operate as products. When using hardware and sample software, please use it after thorough evaluation in an appropriate environment.

The development environment IDE used for this software project is the RL78 version of e^{2}studio, which also includes the configurator tool.

1.2 Development environment

The sample software development environment is shown in Table 1-1 and Table 1-2.

Table 1-1. Hardware Development Environment

Microcomputer	AFE	Evaluation Board
R7F102GBE2DNP#YJ1	RAA23910X	RTK7RL22SMD00000BJ

Table 1-2. Software Development Environment

e^{2}studio Version	Smart Configurator Version	Toolchain Version
V2025-01	V1.12.0	CC-RL V1.15.00

For purchase and technical support, please contact our sales and special agent.

2. Memory Resources and Timing Constraints

2.1 Memory Resources

This section describes the memory resources of the RL78/G22 microcontroller (R7F102GBE2DNP#YJ1), which is the core of the overall configuration of the Multiwavelength Smoke Detector.

- 64KB code Flash memory
- 2KB data flash memory
- 4KB RAM

2.2 Timing constraints

You must consider the timing constraints of the Table 2-1.

Table 2-1. Timing Constraints

Item	Description	Constraints
AFE Ready pin	Latency from AFE EN signal	AFE EN and AFE Ready signals require a max 50 us latency
LED	LED light stabilization time	It is necessary to wait for the time for the LED emission to output stably.
A/D converter	Analog input and standard voltage stabilization time	It is necessary to wait for analog-to-digital conversion until the analog input and reference voltage stabilize.

3. Hardware Configuration

3.1 POC Board Overview

The POC board has the following features:

- "OR" type power supply configuration (DC24V~40V main power supply, USB power supply, E2_Lite emulator power supply, user serial power supply, main unit debug power supply)
- Compact, low-power, high-performance microcontroller
- Analog front-end ICs provide smoke detection drivers and operational amplifiers
- Alarm LED (red) and external notification signal circuit
- Photoelectric smoke detection of multi-wavelength light with three types of LEDs

3.2 System configuration

Figure 3-1 shows the Multiwavelength Smoke Detector system configuration.

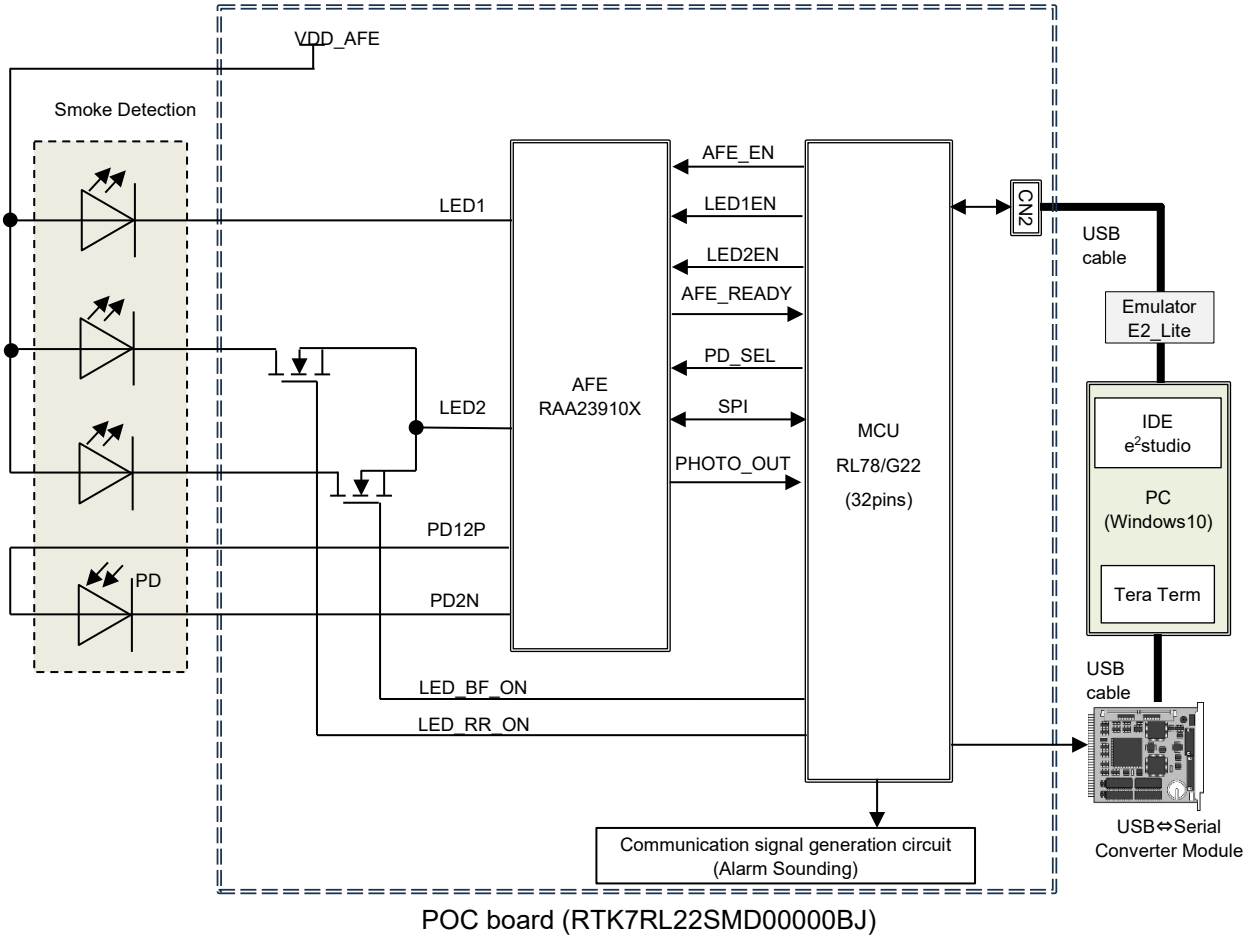

Figure 3-1. System Configuration Diagram

3.3 User Interface

Table 3-1 shows the POC board user interface.

Table 3-1. User Interface

Item	Interface Components	Function
ERROR RESET	Push Switch (SW1)	User Switch
LED1	Green LED	User LED
LED2	Red LED	・When an error is detected: Turning-on ・During normal operation: Light-off
LED3	LED	transmit light LED1
LED4	LED	transmit light LED2
LED5	LED	transmit light LED3
PD	PD	PD for light detection

3.4 RL78/G22 Block

Figure 3-2 shows the MCU block diagram. current configuration uses timer array unit, GPIOs, analog-to-digital converters (channel 2 and internal reference), 32-bit interval timers (for cyclic triggering) ,SPI communication (for communication with AFE ICs),UART communication .

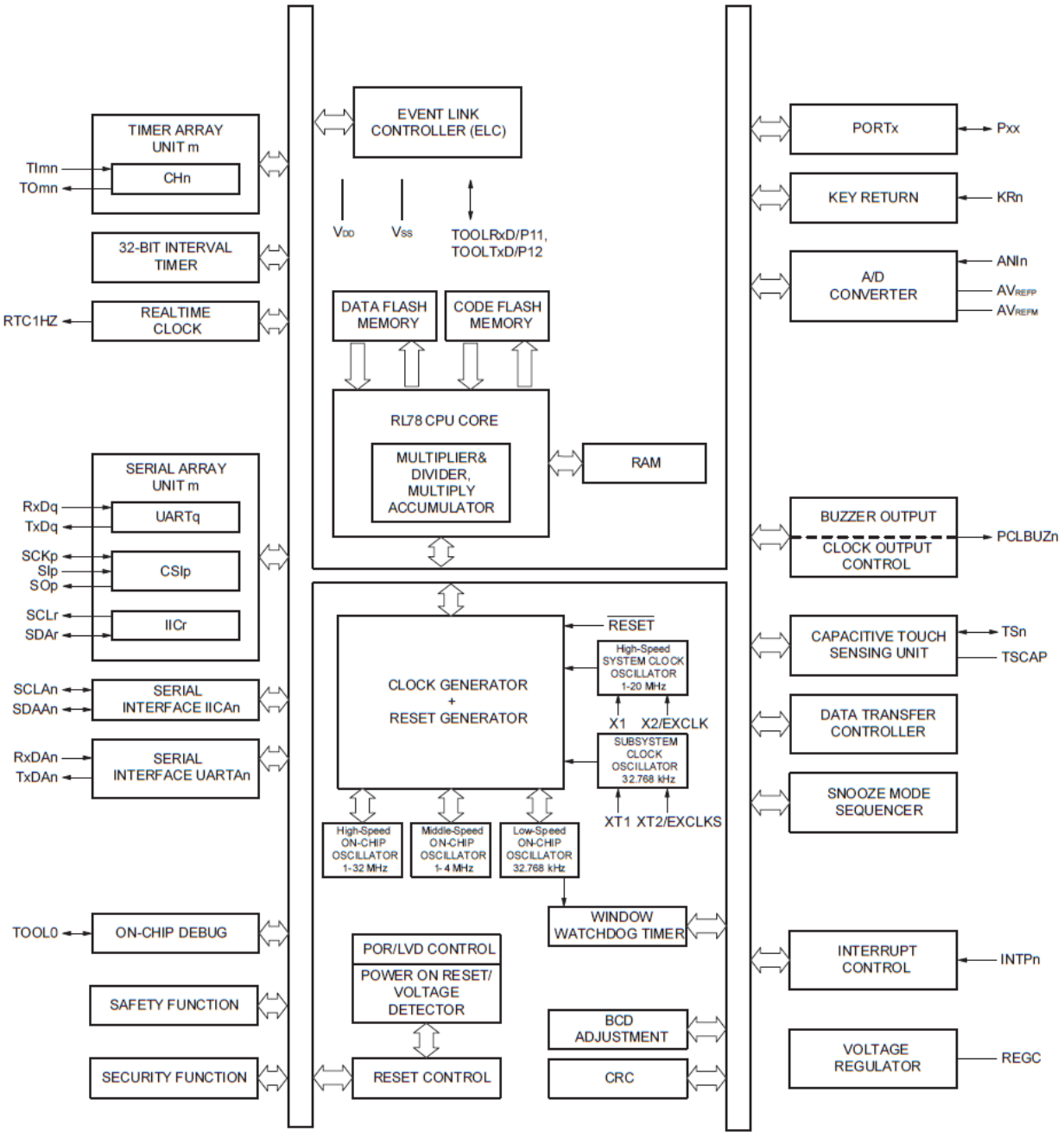

Figure 3-2. RL78/G22 Block Diagram

Notes: 1. SERIAL INTERFACE ICA is only available for 24~48-pin products (this manual uses 32-pin products).
2. SERIAL INTERFACE UARTA is only available for 36~48-pin products (not applicable in this document).
3. KEY RETURN is only available for 40~48 pin products (not applicable in this document).

Remarks: m: Unit number, n: Channel number, p: Simple SPI (CSI) number, q: UART number, r: Simple I2C number, xx: Port number

3.5 Terminal Interface

Table 3-2 shows the terminal interfaces used in this system.

Table 3-2. List of MCU Terminals

No.	Terminal Name	Peripheral Function Name	Connect to	Remarks
1	P40	TOOL0	E2Lite	
2	RESET_B	/RESET	E2Lite	
3	P137	–	TP32	(Unused)
4	P122	General-purpose I/O (output)	Red Rear LED (FET)	LED_RR_ON
5	P121	General-purpose I/O (output)	Blue Forward LED (FET)	LED_BF_ON
6	REGC	–	capacitor	
7	VSS	–	GND	
8	VDD	–	VDD_MCU	3.3V
9	P60	–	TP31	(Unused)
10	P61	–	TP29	(Unused)
11	P62	–	TP28	(Unused)
12	P31	General-purpose I/O (input)	AFE	AFE_READY
13	P70	General-purpose I/O (output)	AFE	SEN
14	P30	SCK11	AFE	SCLK
15	P50	SI11	AFE	SDO
16	P51	SO11	AFE	SDI
17	P17	General-purpose I/O (output)	AFE	LED1_EN
18	P16	General-purpose I/O (output)	AFE	LED2_EN
19	P15	General-purpose I/O (input)	USER button	
20	P14	General-purpose I/O (output)	LED green	LEDs on board
21	P13	General-purpose I/O (output)	LED red	LEDs on board
22	P12	TxD0	Serial⇒USB	RxD
23	P11	–	No connection	(Unused)
24	P10	–	TP27	(Unused)

25	P147	General-purpose I/O (output)	AFE	AFE_EN
26	P23	General-purpose I/O (output)	AFE	PD_SEL
27	P22	ANI2	AFE	PHOTO_OUT
28	P21	AVREFM	GND	
29	P20	AVREFP	Reference voltage IC	OUT terminal (2.048V)
30	P01	－	TP30	(Unused)
31	P00	General-purpose I/O (output)	Reference voltage IC	SHDN_B
32	P120	General-purpose I/O (output)	SMOKE_DET	For communication signal generation circuits (alarm)

Once these settings are applied, no changes are allowed. Only when a new configuration is started.

4. Software Layer

This sample software process is divided into a driver section that controls the peripheral functions of the MCU, a middleware section that controls the Multiwavelength Smoke Detector, and a user application section that operates the middleware. The overall configuration of the sample software is shown in Figure 4-1.

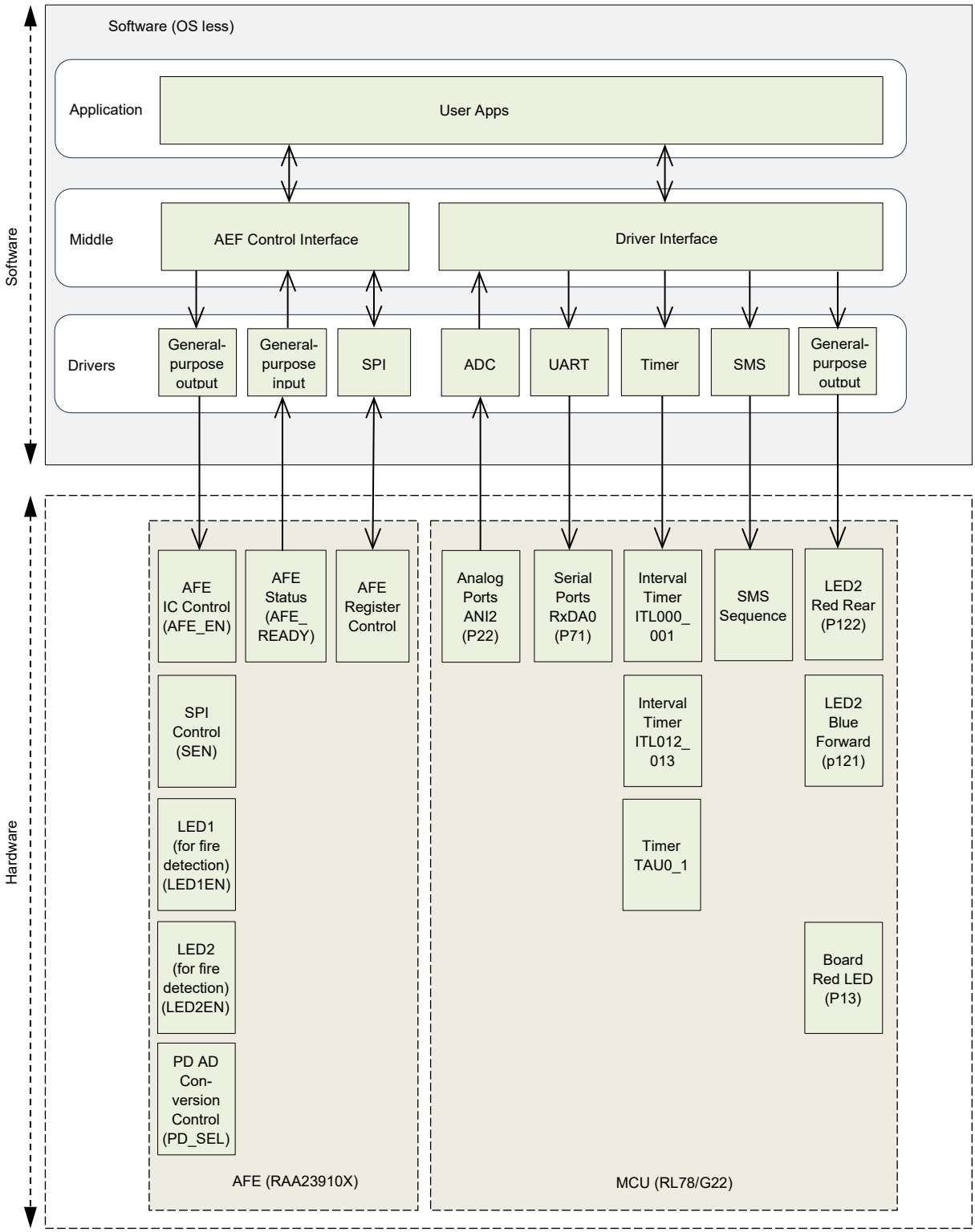

Figure 4-1. Software Configuration

5. Software Description

5.1 State Transitions

The state transitions are shown in Figure 5-1.

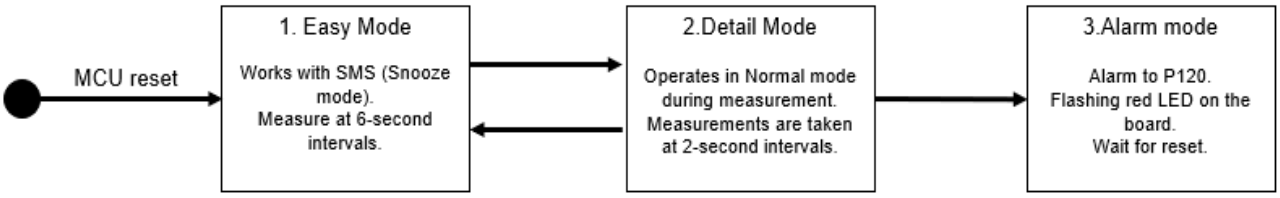

Figure 5-1. State Transition Diagram

5.2 System Initialization

Figure 5-2 shows the initialization sequence after a power-on reset.

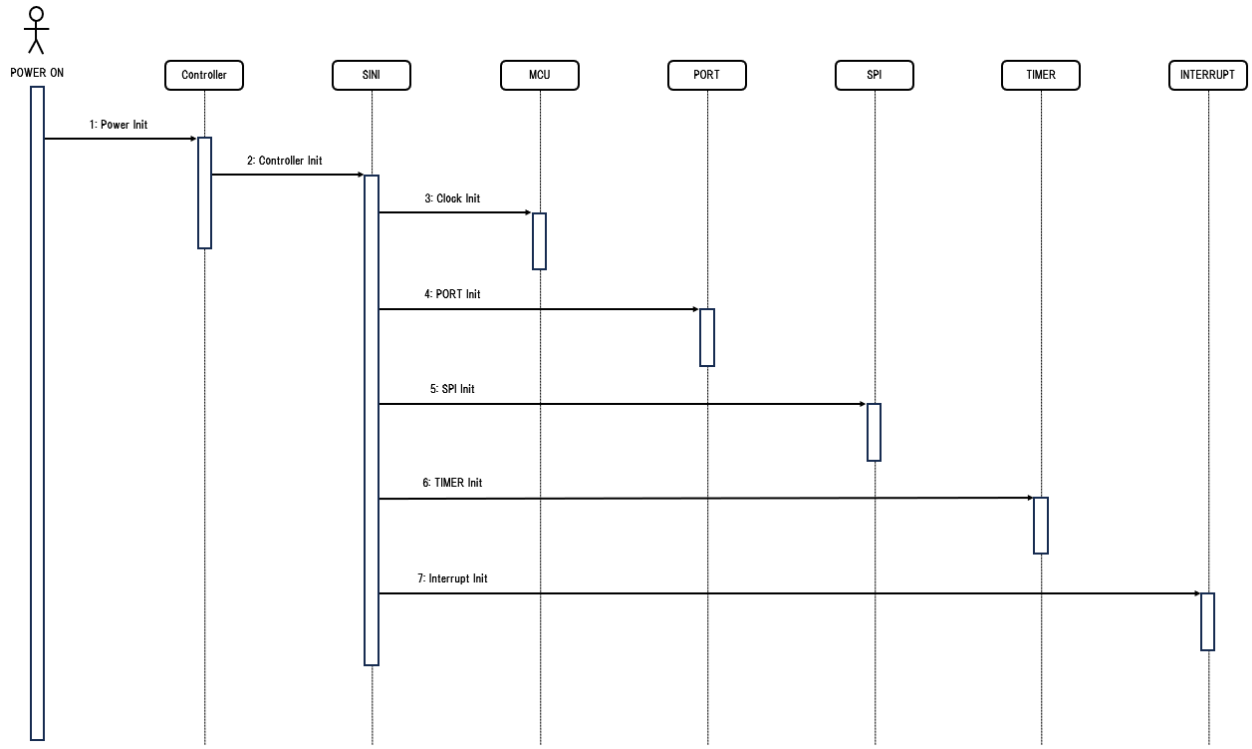

Figure 5-2. System Initialization

The first step after a power-on reset is to initialize the basic controller. The clock tree and microcontroller hardware components are then initialized. The sequence ends with the initialization of the AFE IC port.

5.3 Interrupts

Table 5-1 lists all the interrupts used in the sample software.

Table 5-1. Interrupts

Interrupt Vector	Interrupt Handling Functions	Priority	Interrupt Factors	Processing Contents
RESET	main	Level 0	Power-on or microcontroller reset	Main process
INTSMSE	r_Config_SMS_interrupt	Level 0	Exit SMS Mode	Exit SMS mode and return to normal process
INTSR0	r_Config_UART0_interrupt_send	Level 3	Completed transfer of UART0 transmission	Send the contents of the send buffer
INTCSI11	r_Config_CSI11_interrupt	Level 3	Completed serial transfer	SPI data transmission and reception processing
INTTM01	r_Config_TAU0_2_interrupt	Level 3	Specified counter elapsed	Waiting process for [usec] order
INTAD	r_Config_ADC_interrupt	Level 3	Completed AD conversion	Set AD conversion termination flag
INTITL	R_Config_ITL001_ITL002_Callback_Shared_Interrupt	Level 3	Specified counter elapsed	Waiting process for [msec] order
INTITL	R_Config_ITL012_ITL013_Callback_Shared_Interrupt	Level 3	Specified counter elapsed	Waiting process for [msec] order

6. Process Flow

6.1 Main Process Flow

Figure 6-1 shows the main process flow.

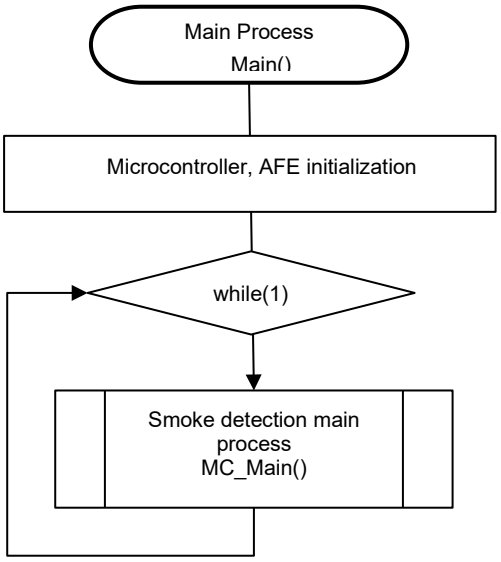

Figure 6-1. Main Process Flow

6.2 Main Process Flow for Smoke Detection

Figure 6-2 shows the main process flow for smoke detection.

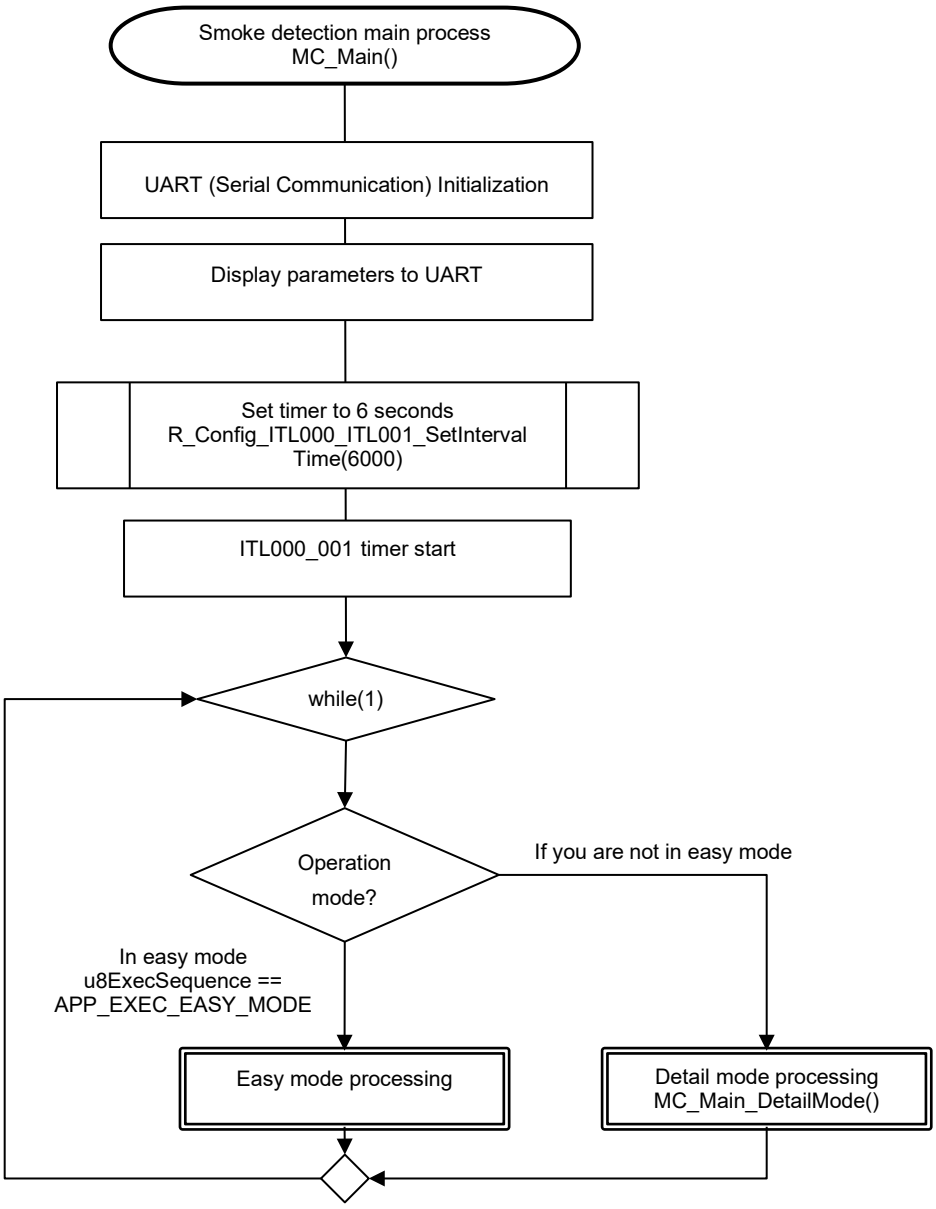

Figure 6-2. Smoke Detection Main Process Flow

6.3 Easy Mode Processing

Figure 6-3 shows the easy mode process flow.

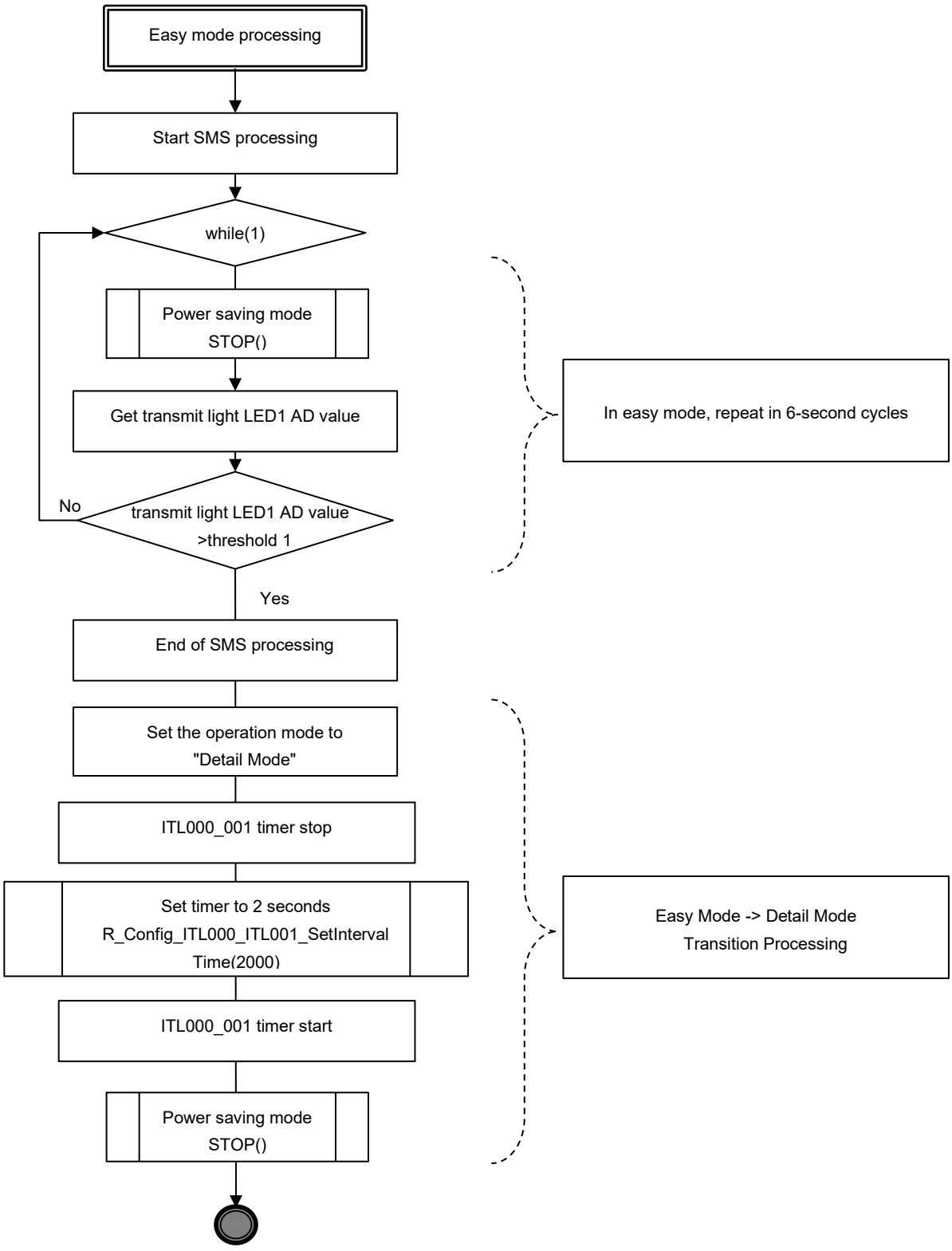

Figure 6-3. Easy Mode Process Flow

6.4 Detail Mode Process Flow

Figure 6-4, Figure 6-5, and Figure 6-6 show the detail mode process flow.

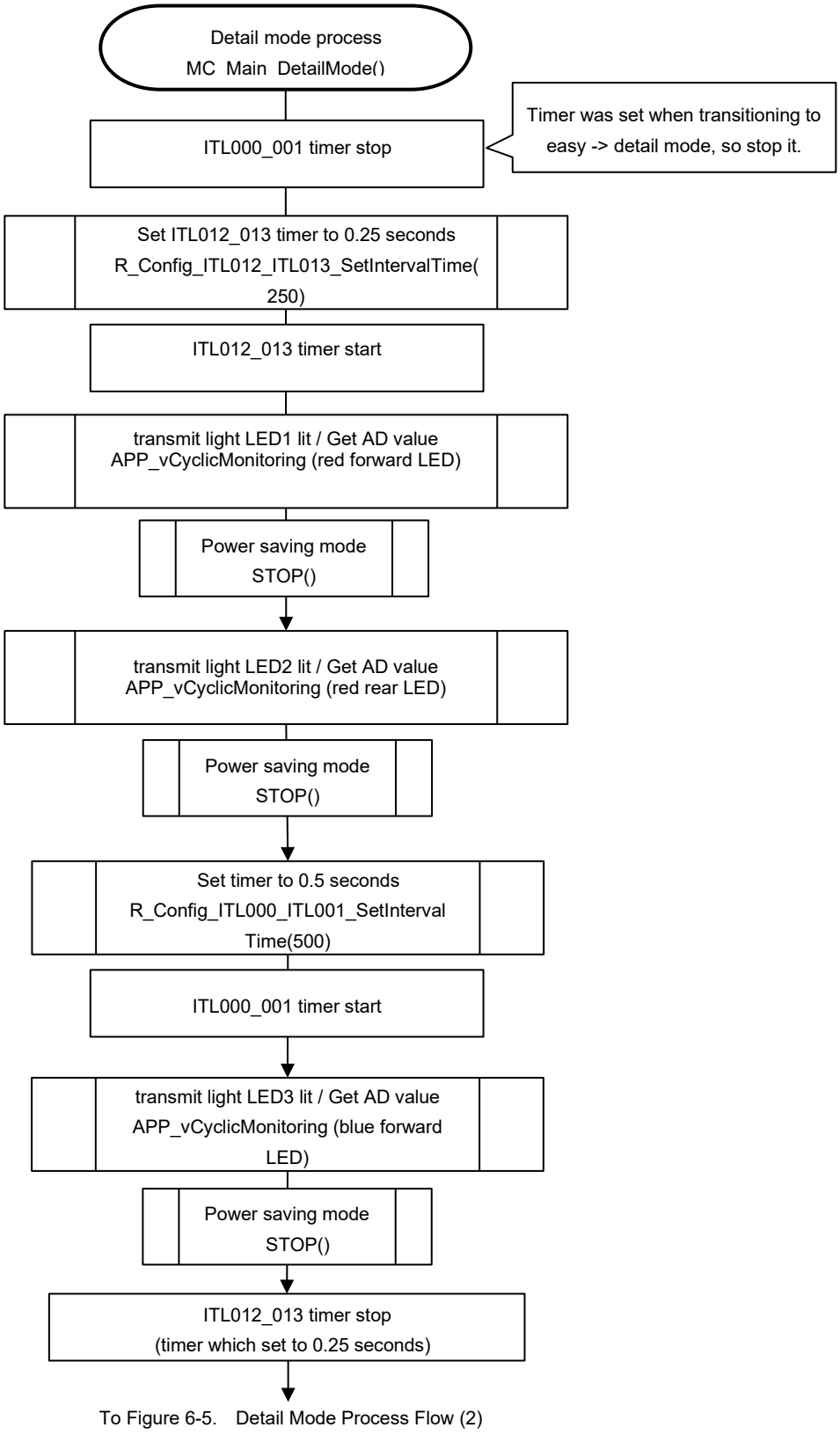

Figure 6-4. Detail Mode Process Flow (1)

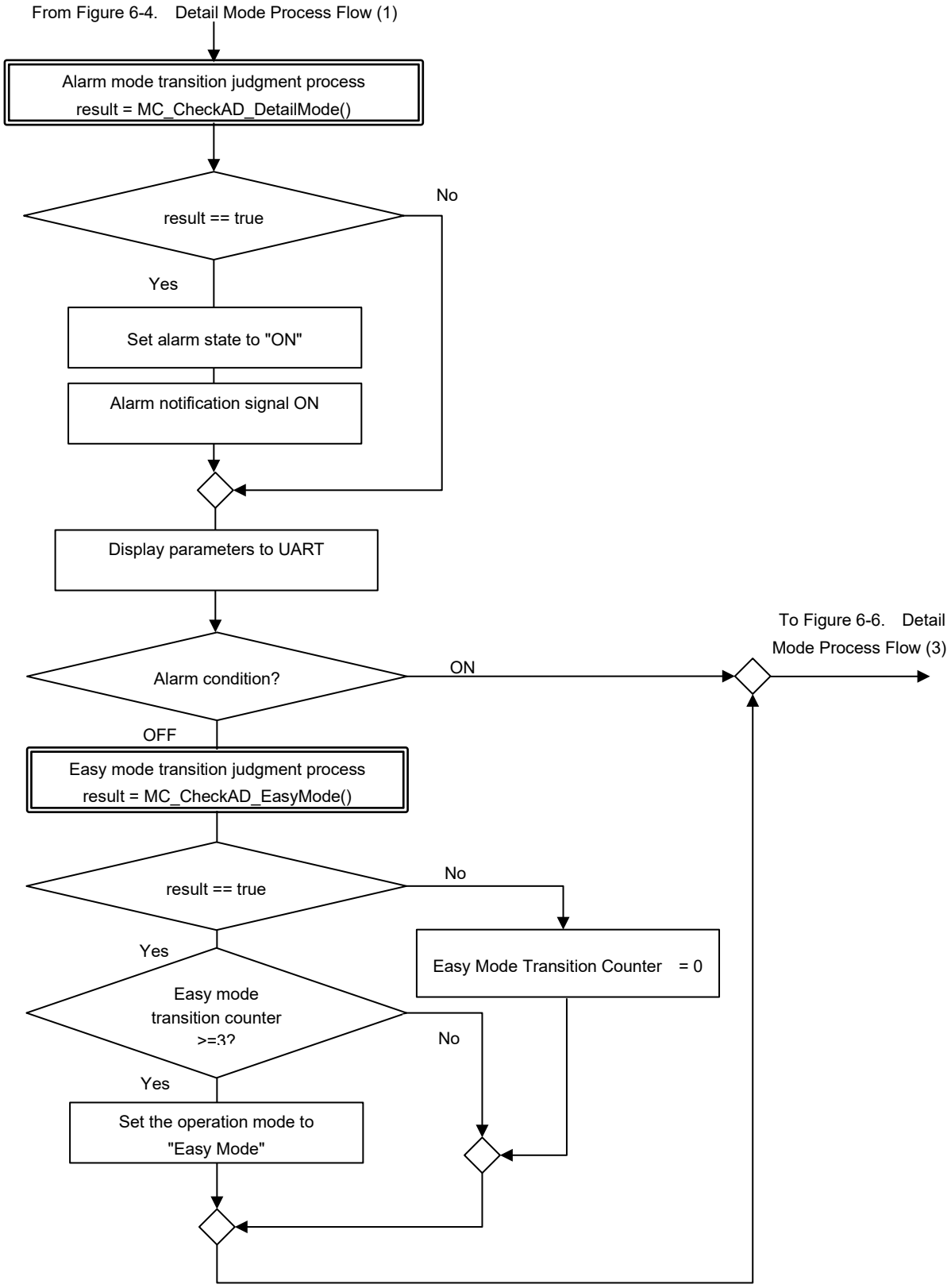

Figure 6-5. Detail Mode Process Flow (2)

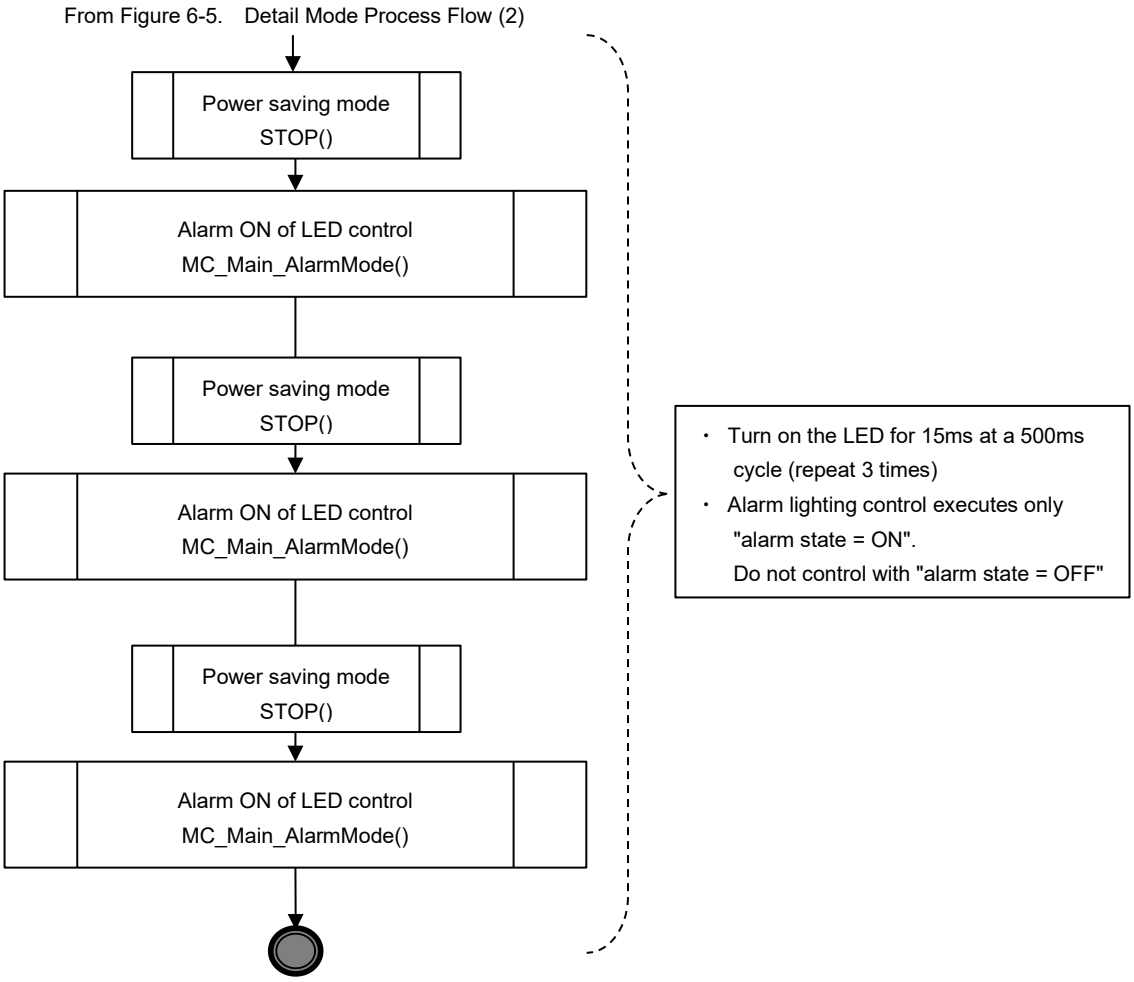

Figure 6-6. Detail Mode Process Flow (3)

6.5 Alarm Mode Transition Judgment Process Flow

Figure 6-7 shows the alarm mode transition judgment process flow.

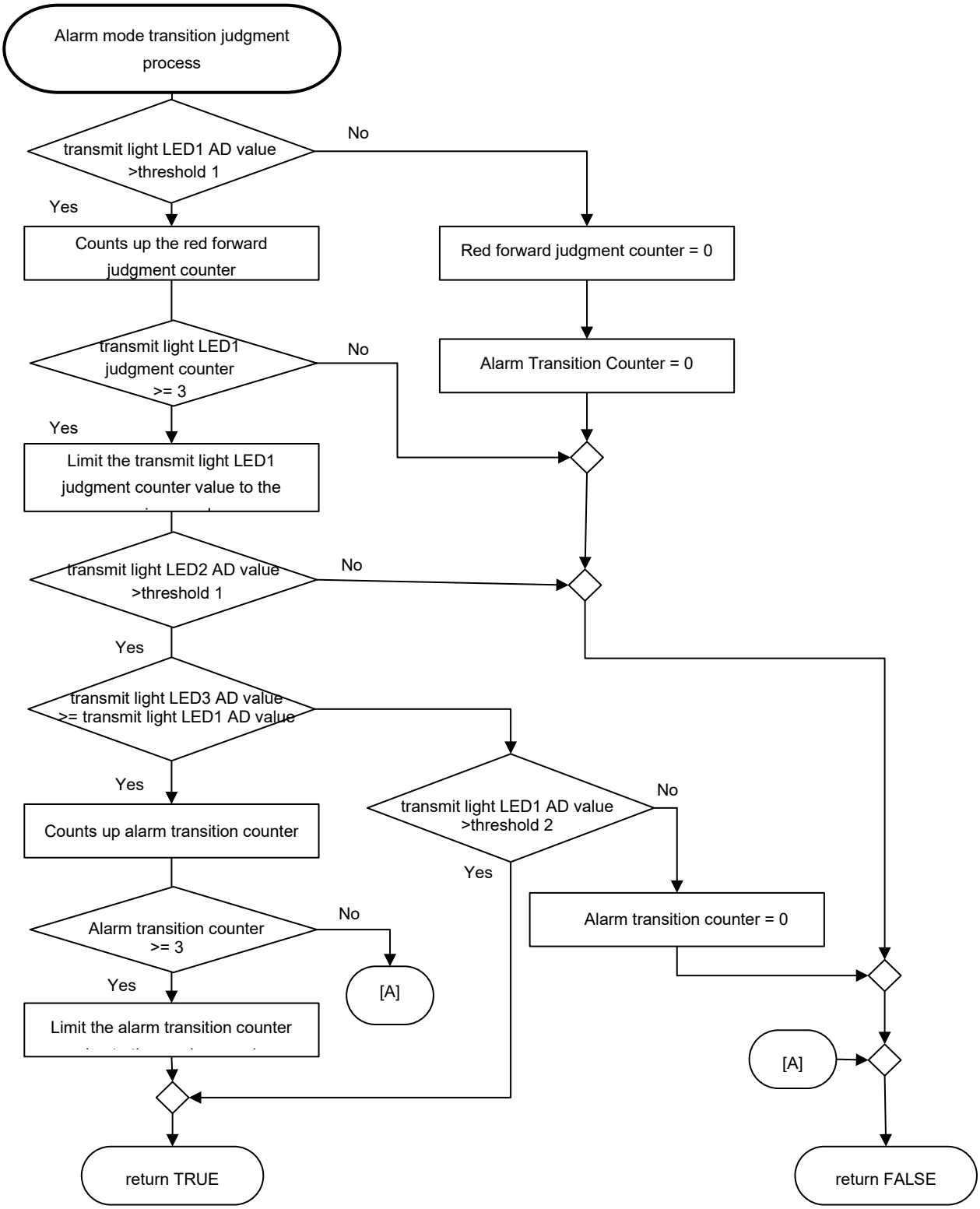

Figure 6-7. Alarm Mode Transition Judgment Process Flow

6.5.1 Easy Mode Transition Judgment Process

Figure 6-8 shows the judgment process flow for easy mode transition.

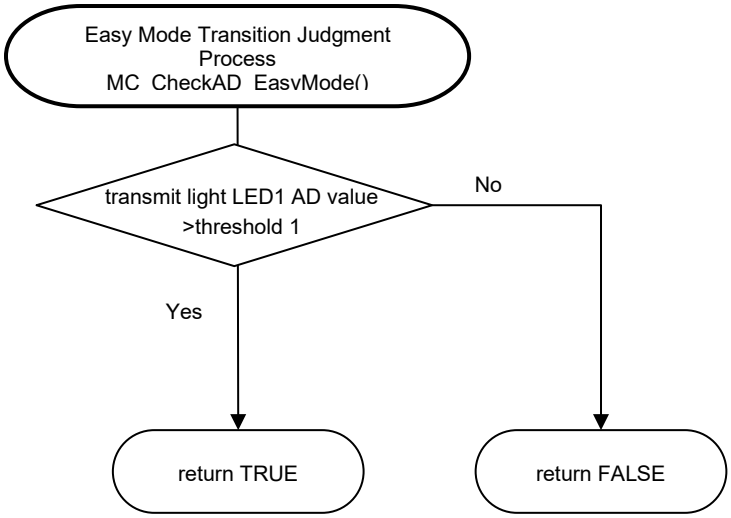

Figure 6-8. Easy Mode Transition Judgment Process Flow

7. Peripherals Configuration

7.1 Configuring Clock

Figure 7-1 shows the clock settings. The RL78/G22 clock tree contains a high-speed on-chip oscillator with an operating frequency of 32MHz. This frequency value reduces power consumption, but the main system clock can also be set to 1 MHz (medium main mode).

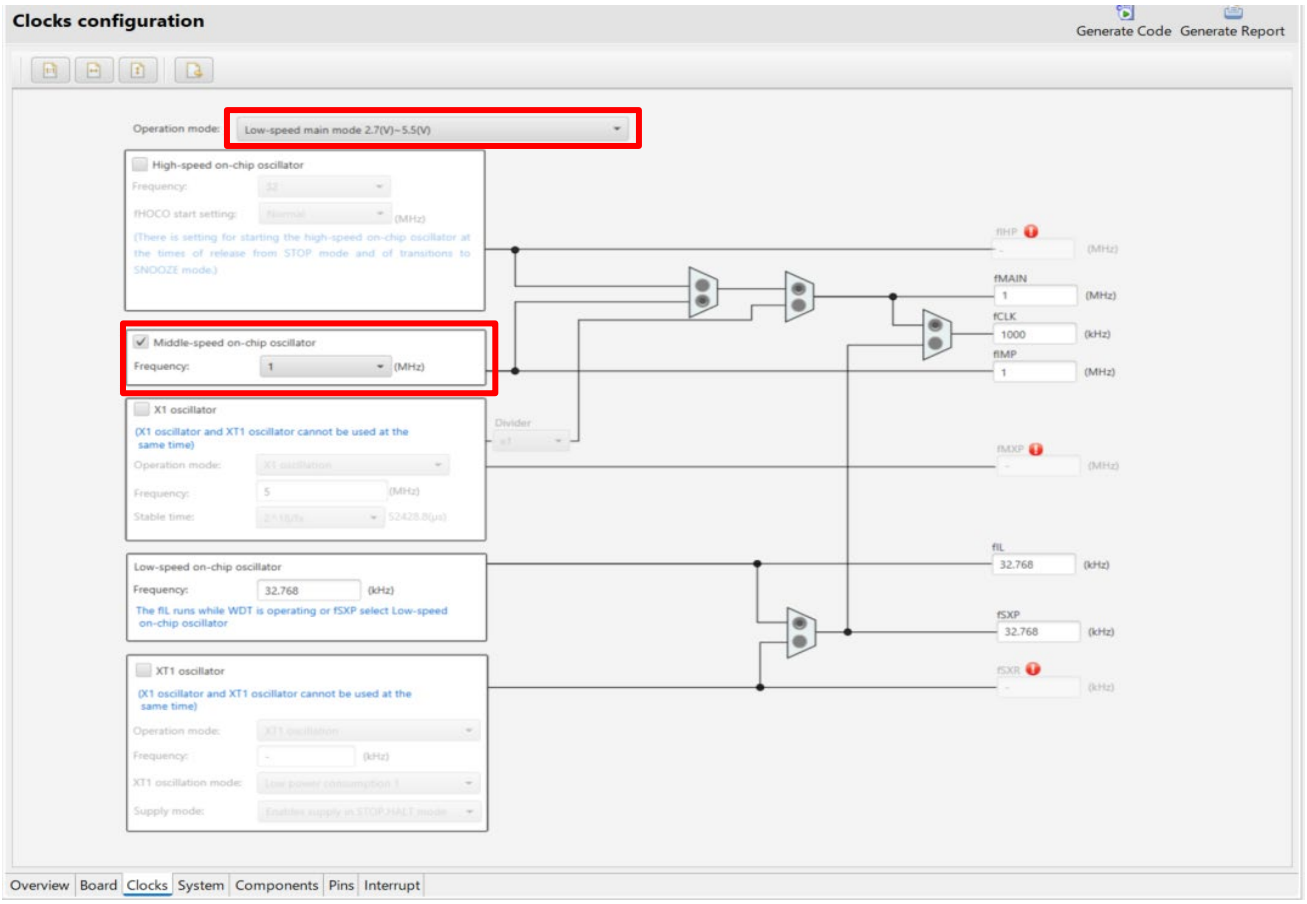

Figure 7-1. Configuring Clock

7.2 Configuring Ports

Figure 7-2 - Figure 7-9 shows the configuration for each port. The RL78/G22 R7F102GBE2DNP#YJ1 has 28 digital I/O pins that can control a variety of operations. In addition, these pins have some alternative features.

7.2.1 Configuring Port 0

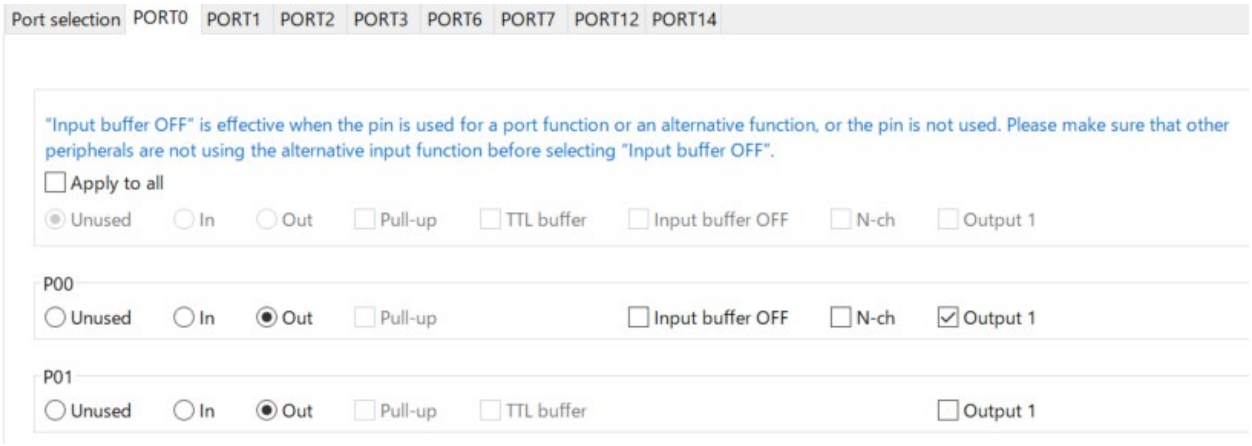

Figure 7-2. Configuring Port 0Configuring Port 1

7.2.2 Configuring Port 1

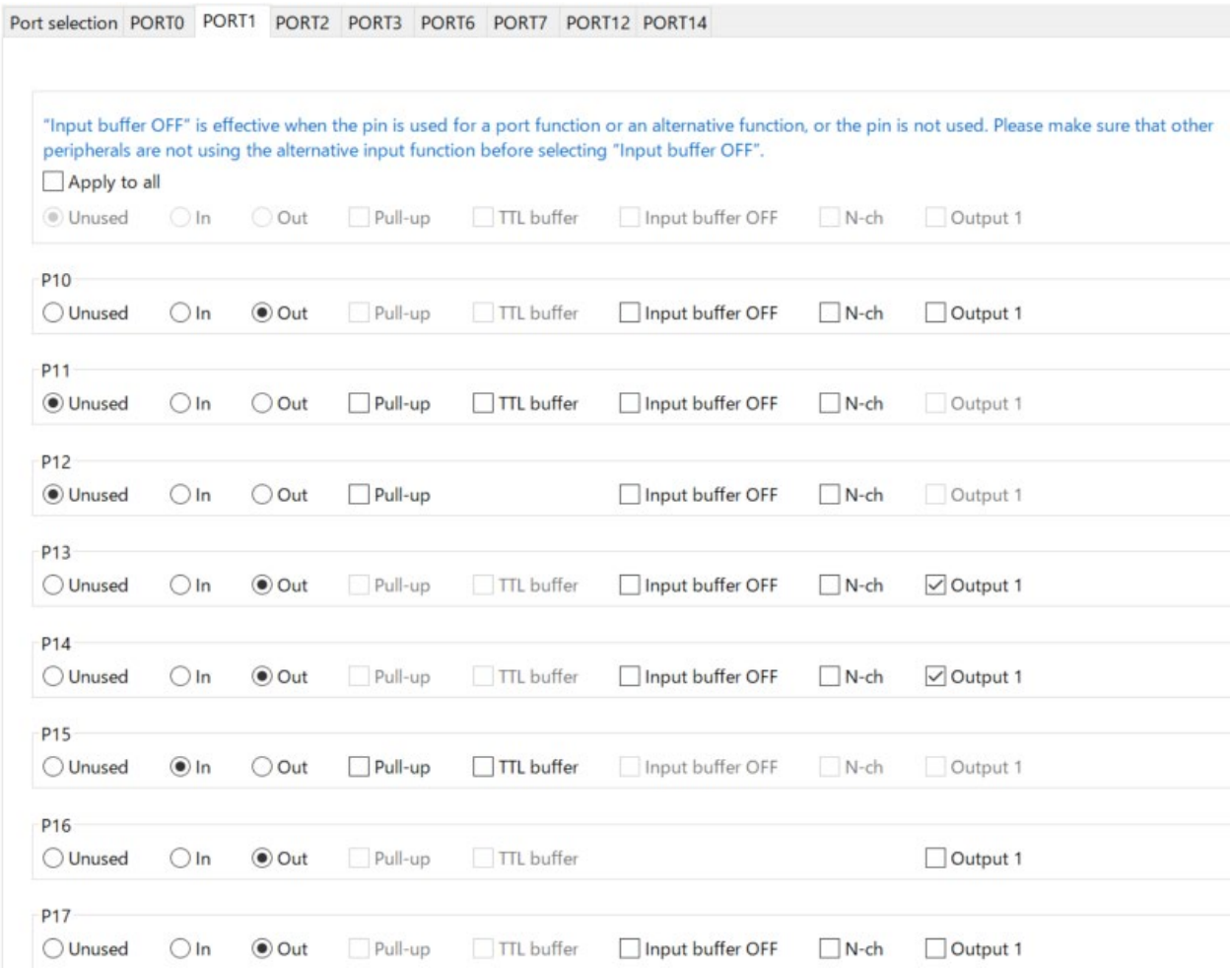

Figure 7-3. Configuring Port 1

7.2.3 Configuring Port 2

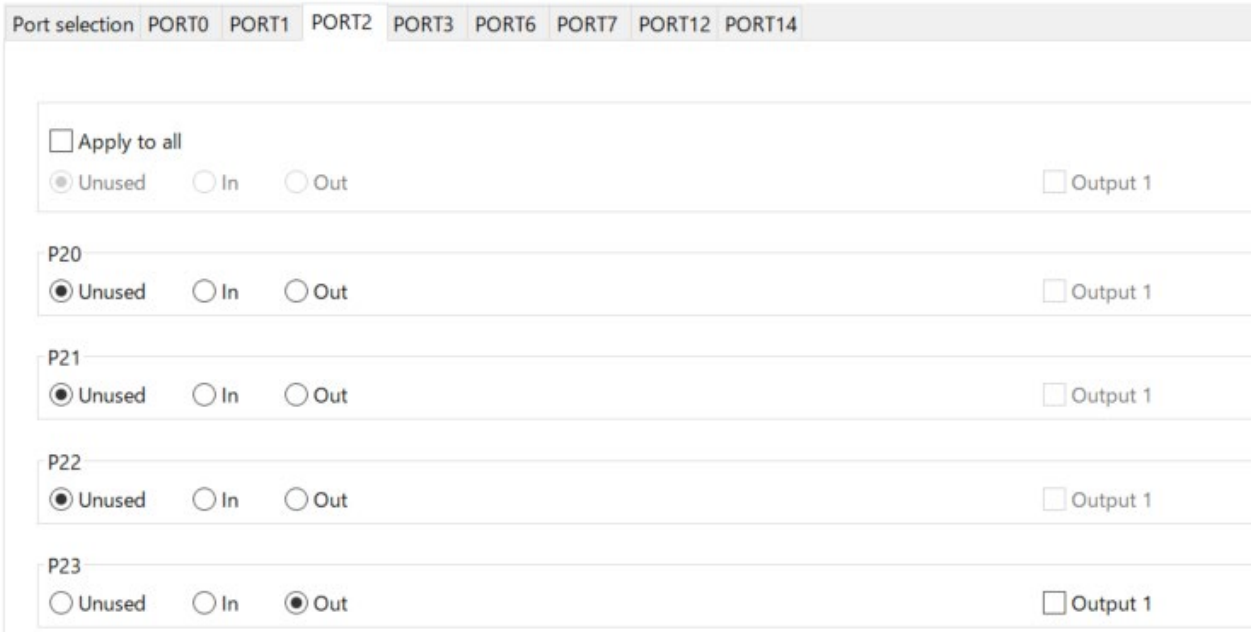

Figure 7-4. Configuring Port 2

7.2.4 Configuring Port 3

Figure 7-5. Configuring Port 3

7.2.5 Configuring Port 6

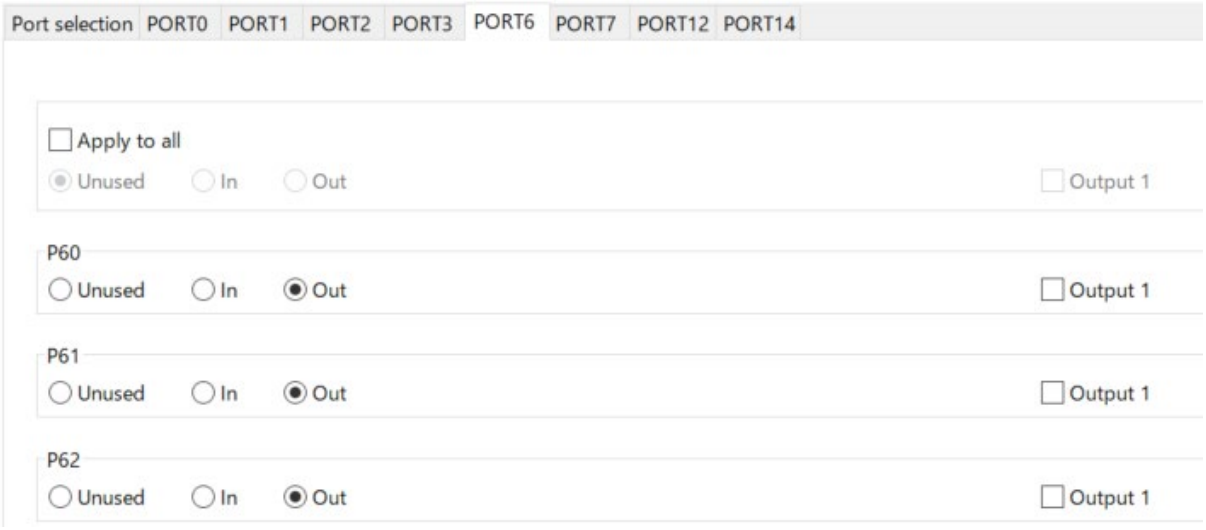

Figure 7-6. Configuring Port 6

7.2.6 Configuring Port 7

Figure 7-7. Configuring Port 7

7.2.7 Configuring Port 12

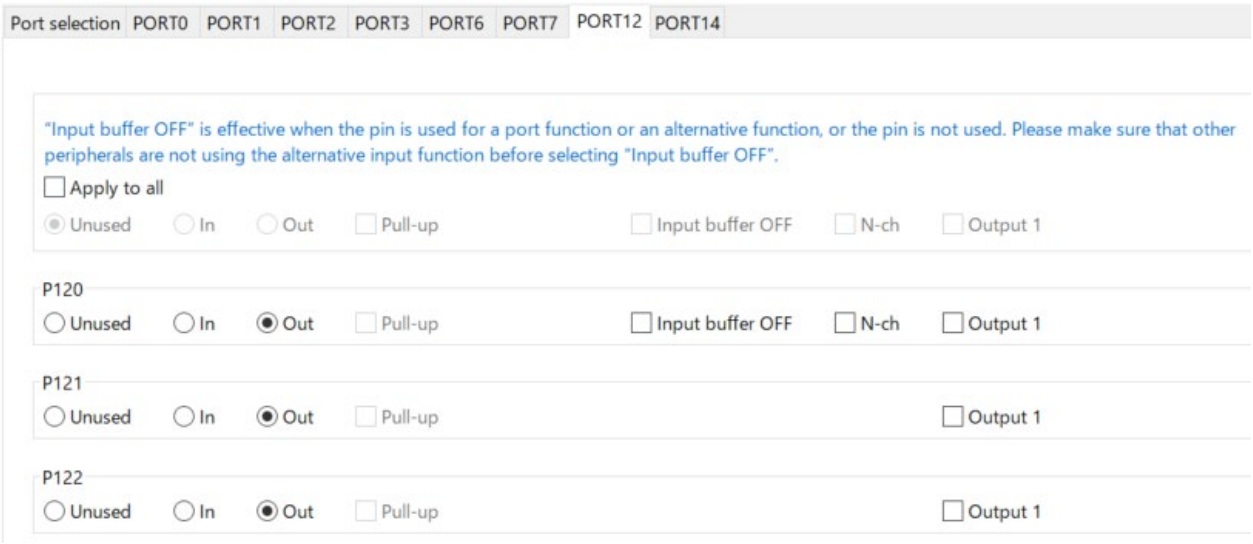

Figure 7-8. Configuring Port 12

7.2.8 Configuring Port 14

Figure 7-9. Configuring Port 14

7.3 Configuring Serial Array

7.3.1 Configuring SPI

Figure 7-10 shows the SPI (CSI11) configuration.

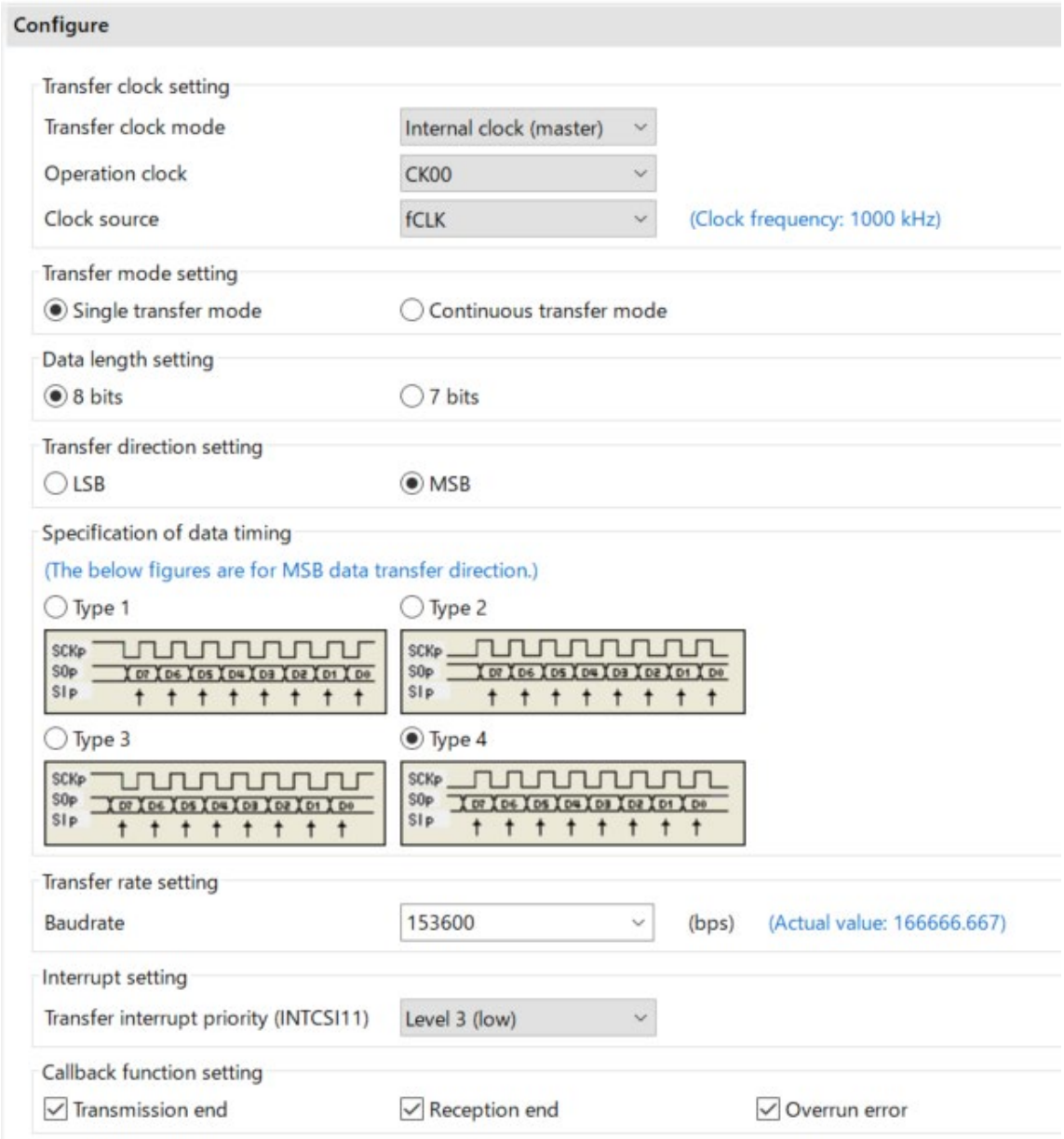

Figure 7-10. Configuring SPI(CSI11)

7.3.2 Configuring UART0

Figure 7-11 shows the UART0 configuration.

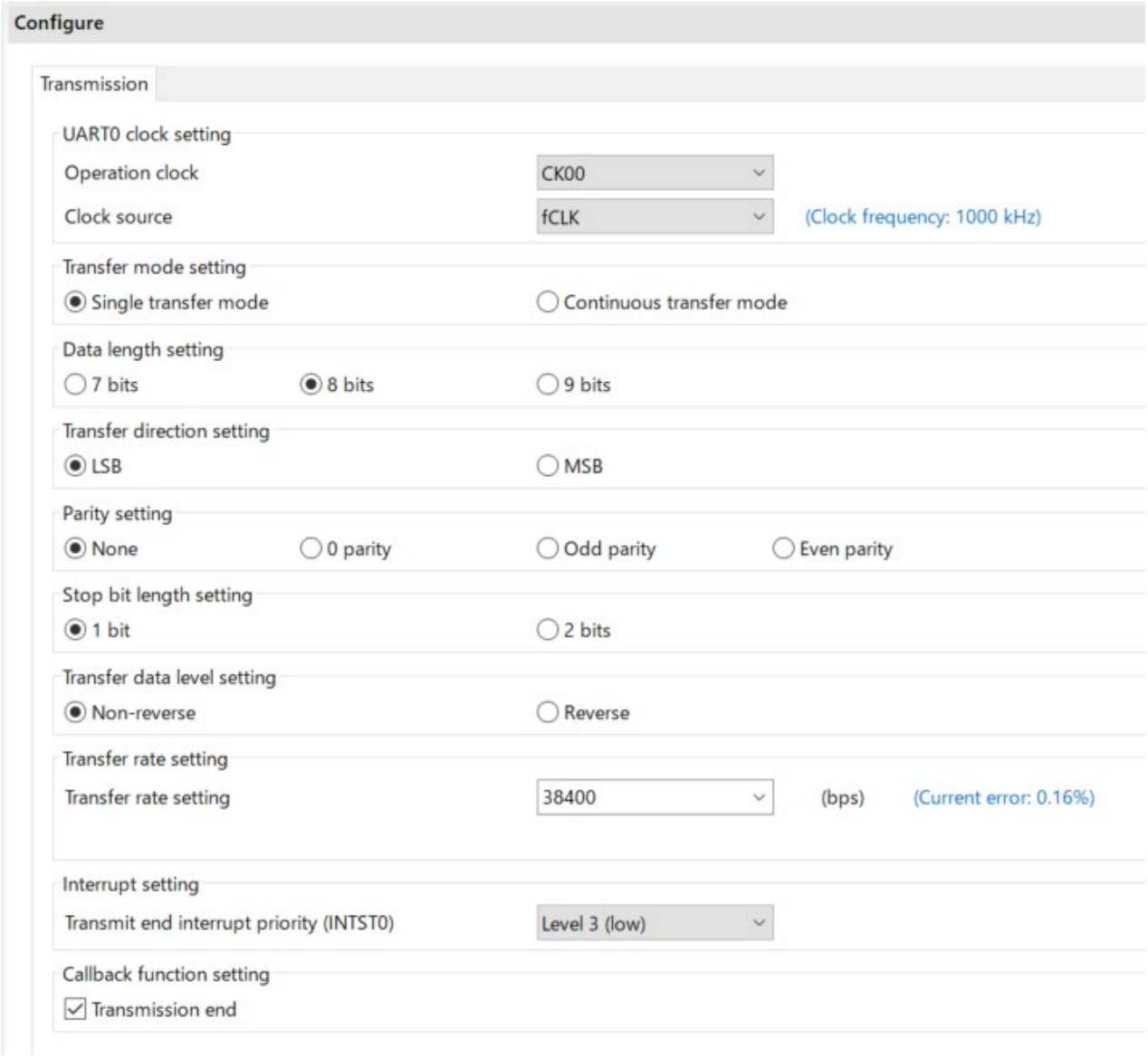

Figure 7-11. Configuring UART0

7.4 Configuring A/D Converter

Figure 7-12 shows A/D converter configuration.

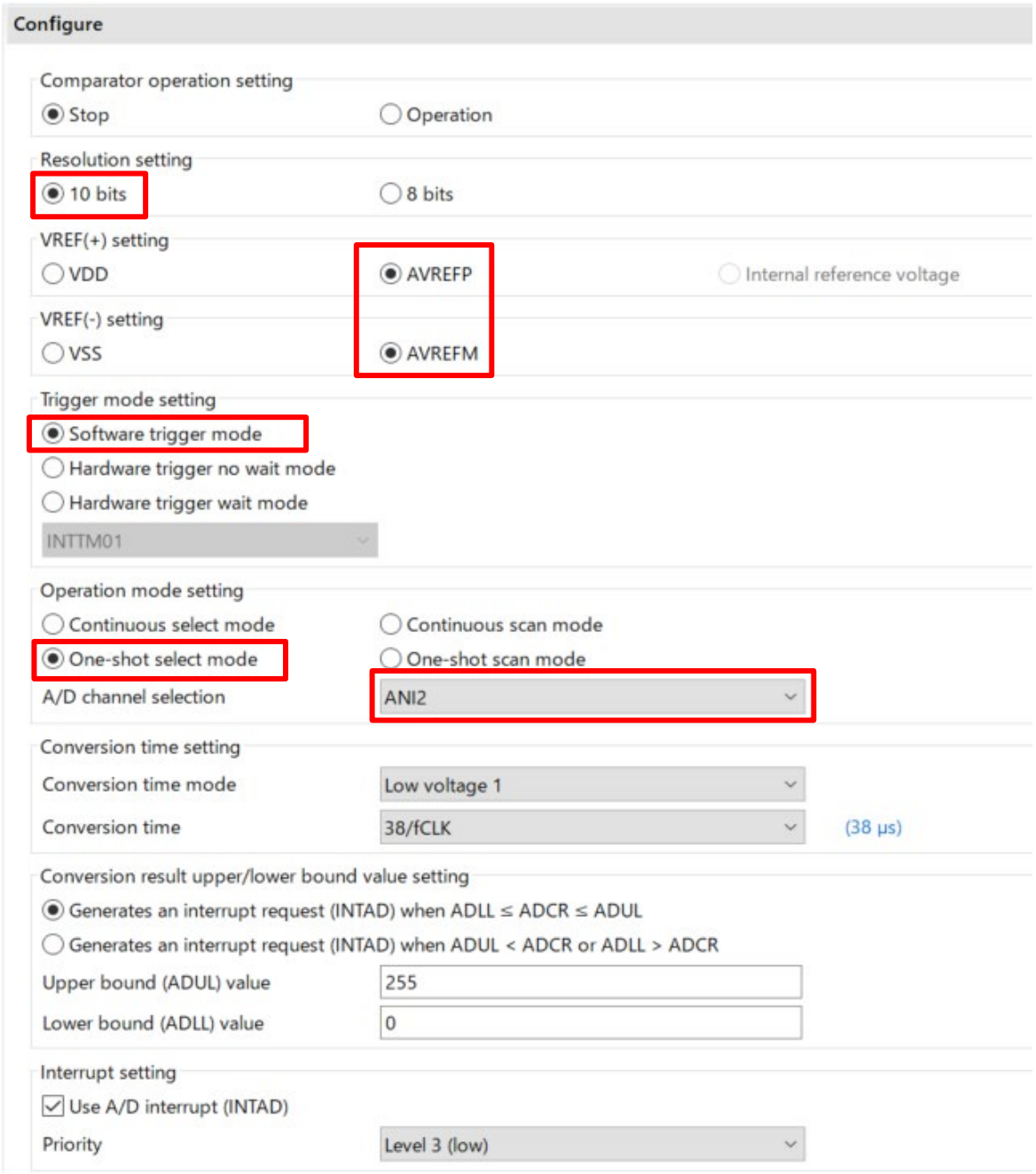

Figure 7-12. Configuring A/D Converter

7.5 Configuring Timer Array Unit

Figure 7-13 shows the TAU configuration. This setting generates the waiting time until the reference voltage is determined in detail mode. The default is 130ms.

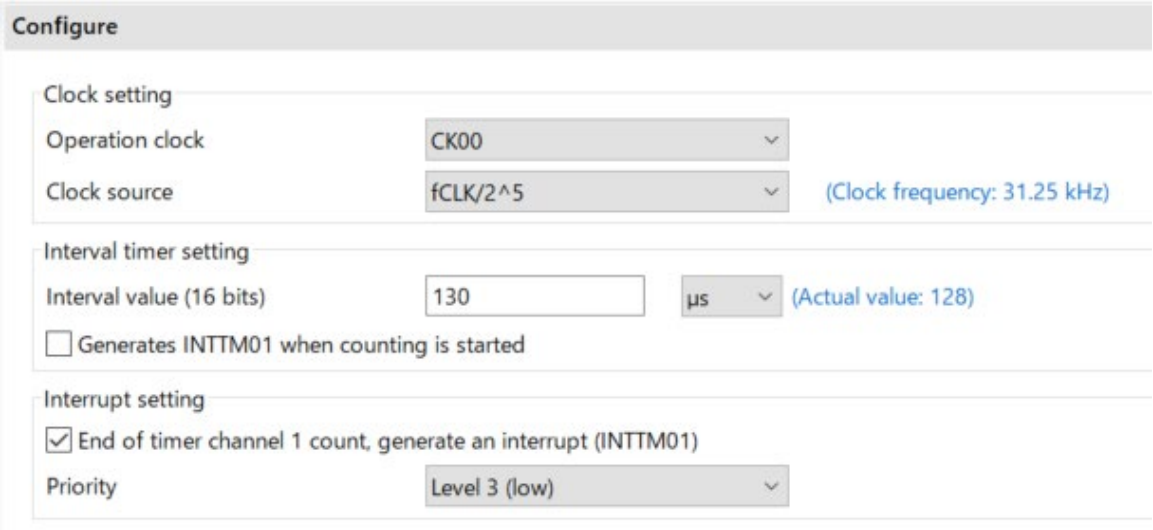

Figure 7-13. Configuring Timer Array Unit TAU0_1

7.6 Configuring 32-Bit Interval Timer

The 32-bit interval timer is used as a 16-bit, two channes, as shown in Figure 7-14, Figure 7-15.

7.6.1 Configuring ITL000 and ITL001

Figure 7-14 shows the ITL000 and ITL001 settings. This setting generates a measurement interval (SMS activation interval) for the easy mode. The default is 6000ms. In addition, the detail mode is changed to 2000 ms to generate the measurement interval. In alarm mode, it is changed to 500ms to generate a blinking interval for the red LED.

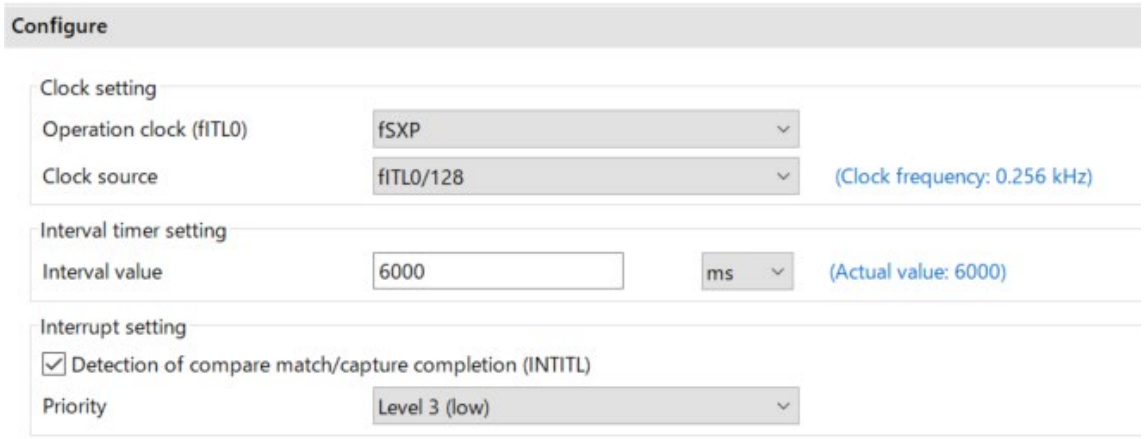

Figure 7-14. Configuring Interval Timer ITL000 and ITL001

7.6.2 Configuring ITL012 and ITL013

Figure 7-15 shows the ITL012 and ITL013 settings. This setting generates the measurement interval for the three LEDs in detail mode. The default is 250ms. It is also changed to 25ms in alarm mode to generate a red LED illumination time. It is not used in easy mode.

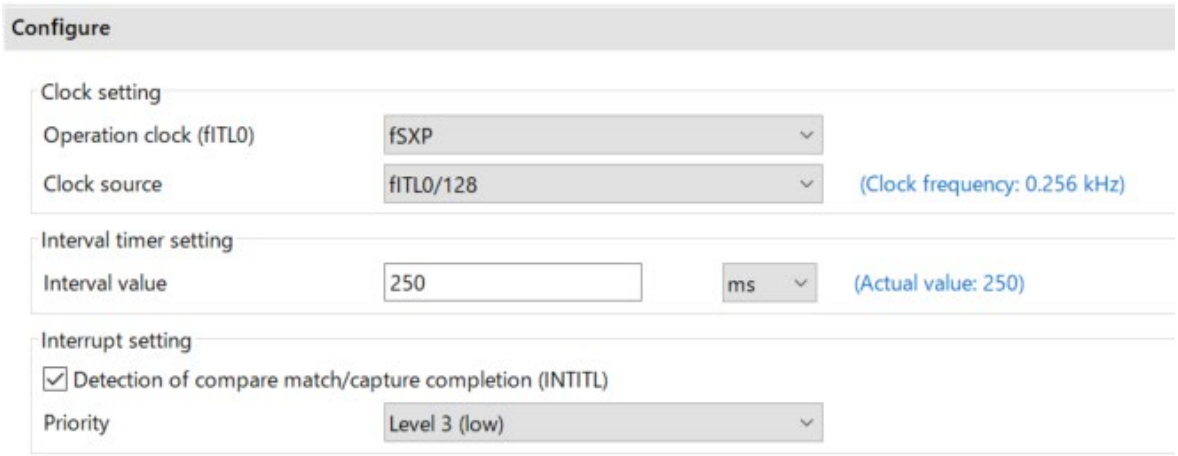

Figure 7-15. Configuring Interval Timer ITL012 and ITL013

8. Software Processing

8.1 List of Functions

This chapter describes the function of each function.

8.1.1 Initialization and Monitoring Related Functions

Table 8-1 shows the list of functions related to initialization and monitoring processing. It is responsible for communicating with the data flash (reading and writing data), reading the supply voltage, and implementing smoke circulation monitoring.

Table 8-1. List of Functions Related to Initialization and Monitoring Processing

File Name	Function Name	Function
APP.c	APP_vInit()	RL78 register, initializing variable
	APP_vCyclicMonitoring()	Getting AD value process
	APP_vInitMeasurement()	Initialization before starting PD value measurement
	APP_vDinitMeasurement()	Stopping PD value measurement
	APP_delay()	Wait for AFE to stabilize
	APP_vInitRegisterForSMS()	Setting AFE register for LED light emission
	APP_vGetMcuADValue()	Getting AD value
	APP_vReferenceIC_SHDN_B_Toggle()	Charging process

8.1.2 AFE Driver Related Functions

Table 8-2 shows the list of the functions of the AFE module. It has the function of direct access to AFE pins and hardware modules.

Table 8-2. List of AFE Module Functions

File Name	Function Name	Function
AFE_Driver.c	AFE_vInit()	Initializing AFE
	AFE_vEnableUnit()	Enable AFE Unit
	AFE_vDisableUnit()	Disable AFE unit
	AFE_vStartADC()	Requesting AD conversion start
	AFE_vSetLEDCurrent()	Setting the LED Current Value
	AFE_vSetTIA()	Setting the Amplification Degree
	AFE_vSetTIA_Icomp()	Setting the Offset Voltage
	AFE_vSetADCEnable()	Setting AD Conversion
	AFE_u16ReadADC()	Confirmation of completion of AD conversion
	AFE_WaitForTransferConfirmation()	Waiting for SPI transmission and reception completion
	AFE_enRead()	Reading AFE register values via SPI
	AFE_enwrite()	Writing AFE register value via SPI
	AFE_Driver_SPI_Error_Notification()	SPI Communication Error Notification
	AFE_Driver_SPI_RX_Confirmation()	SPI Communication Reception Completion Notification
	AFE_Driver_SPI_TX_Confirmation()	SPI Communication Transmission Completion Notification
	AFE_vSetADCEnableAndConfig()	Initial settings for AFE unit AD conversion

Functions Related to Generation of Measurement Timing

Table 8-3 shows the list of the functions for measurement timing generation.

Table 8-3. List of Measurement Timing Generation Functions

File Name	Interface	Contents
MeasureCtrl.c	MC_Init()	Initializing variables
	MC_Main()	Generating measurement timing
	MC_Main_EasyMode()	Easy mode processing
	MC_Main_DetailMode()	Detail mode processing
	MC_Main_AlarmMode()	Alarm Mode Processing
	MC_CheckAD_EasyMode()	Transition judgment process from easy mode
	MC_CheckAD_DetailMode()	Transition judgment process from detail mode

8.1.3 Functions Related to Serial Communication Transmission Processing

Table 8-4 shows the list of the serial communication transmit processing functions.

Table 8-4. List of Serial Communication Transmission Processing Functions

File Name	Interface	Contents
SerialComm.c	SC_TransmitParamInfo()	Full parameter setting output processing
	SC_TransmitMeasurementResult()	AD conversion value output processing
	SC_TransmitParam()	Parameter name and setting value output processing
	SC_TransmitParamName()	Parameter name output processing
	SC_TransmitParamValue()	Parameter value output processing
	SC_SetMeasureCounter()	Measurement counter value output processing
	SC_AddMeasureTime()	Time Calculation Process
	SC_SetMeasureValue()	Measured value ASCII conversion process

8.1.4 Parameter Management Related Functions

Table 8-5 shows the list of the parameter management functions.

Table 8-5. List of Parameter Management Functions

File Name	Interface	Contents
UserParam.c	APP_InitMeasureParameter()	Measurement parameter initialization processing
	APP_CheckMeasureParameter()	Measurement parameter matching processing

9. POC Software Update

The application software can be updated using Renesas E2_Lite debugger and Renesas Flash programmer tools. This feature can be used for both data flash and code flash rewriting. The update requires a *.hex file that contains the data flash parameter values or the new version of the firmware. Also, you just have to follow the following steps:

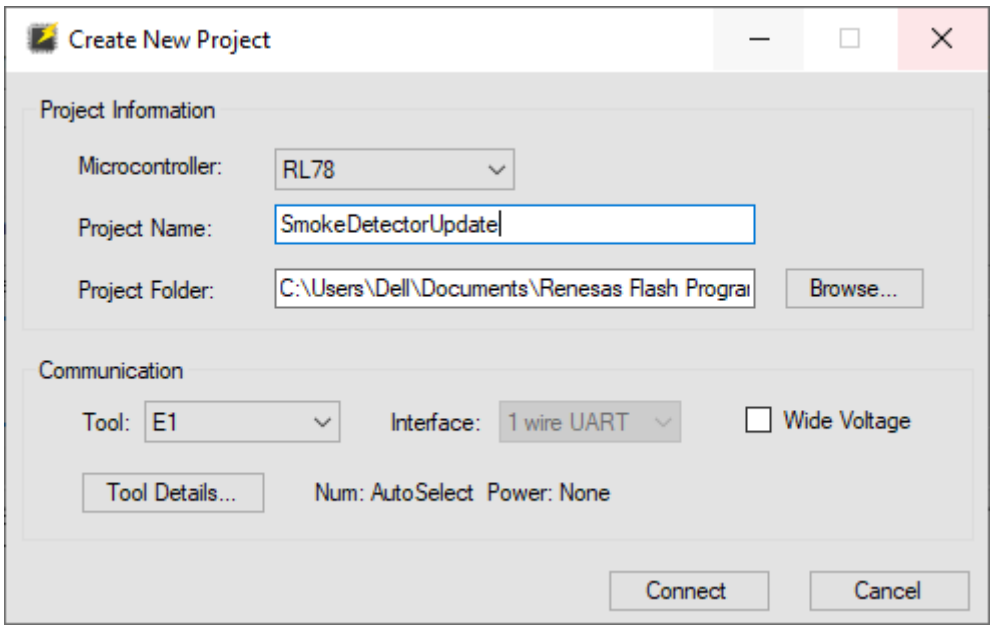

Figure 9-1. Create a New Project with the Renesas Flash Programmer Tool

Connect each tool to your development board. Load the .hex file using the Browse button shown in Figure 9-2 and start the update by pressing the Start button at the end.

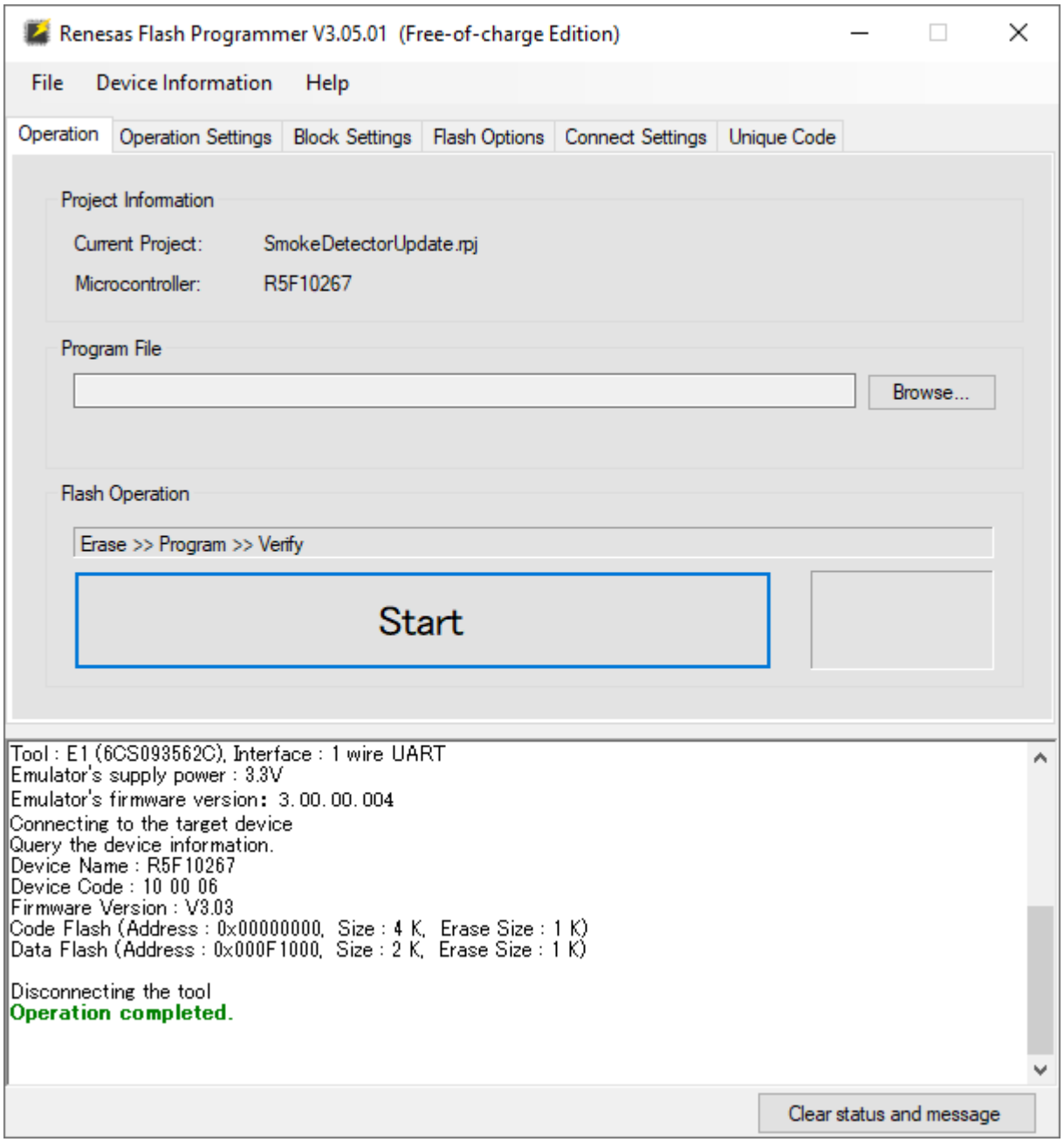

Figure 9-2. Use the Renesas Flash Programmer Tool to Connect to Boards and Flash .hex Files

10. Nomenclature

- IC Integrated Circuit
- POC Proof Of Concept
- SW SoftWare
- HW HardWare
- MCU Micro Controller Unit
- CPU Central Processing Unit
- AFE Analog Front End
- LED Light-Emitting Diode
- PD PhotoDiode
- IR Infrared Radiation
- TIA Transimpedance Input Amplifier
- PGA Programmable Gain Amplifiers
- DAC D/A converter or digital-to-analog Converter
- ADC A/D converter or analog-to-digital Converter
- SPI Serial Peripheral Interface
- UART Universal Acsynchronous Receiver Transmitter
- ROM Read-Only Memory
- RAM Random Access Memory
- DC Direct Current
- AC Alternating Current
- LDO Low-DropOut voltage regulator
- GPIO General-Purpose Input and Output
- TX Transmission
- RX Reception
- USB Universal Serial Bus
- PCB PolyChlorinated Biphenyl
- PC Personal Computer
- SINI System INItialization
- APP APPlication
- IDE Integrated Development Environment
- UL Underwriters Laboratories

11. References

[1] RL78/G22 User's Manual: Hardware
(r01uh0978ej0110-rl78g22.pdf)

[2] SCHEMATIC DIAGRAM SMOKE DETECTOR
(RENESAS_SMOKEDETECTOR_R1_20230309.pdf)

[3] MCP1501 High-Precision Buffered Voltage Reference (Datasheet)
(MCP1501_Data_Sheet_DS20005474-3499863.pdf)

[4] Sunhayato USB Serial Conversion Module MM-FT232 Instruction Manual
(manual-mm-ft232-ja.pd

Revision History	RL78/G22 Multiwavelength Smoke Detector Evaluation Board User's Manual: Software

Rev.	Date	Description	
		Page	Summary
1.00	Feb.20.25	—	First Edition issued

RL78/G22 Multiwavelength Smoke Detector Evaluation Board User's Manual: Software

Publication Date: Rev.1.00 Feb.20.25

Published by: Renesas Electronics Corporation

RL78 Family

Renesas Electronics Corporation

R01US0776EJ0100