RE01 256KB Group

How to reduce power consumption by using an external DC/DC converter

Introduction

The RE01 256KB Group can be supplied with power from a highly efficient external DC/DC converter instead of the internal regulator (LDO) to help reduce the devices power consumption.

This application note describes the software operation and the hardware configuration required to supply power using an external DC/DC converter.

Target Device

RE01 256KB Group

Caution

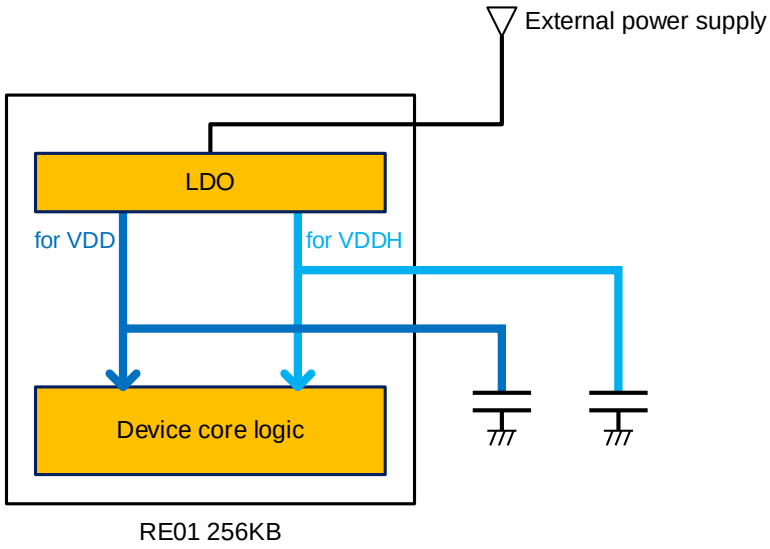
If you apply this application note to another device, it is necessary to modify the software according to the specification of the MCU you use and evaluate it adequately.

Contents

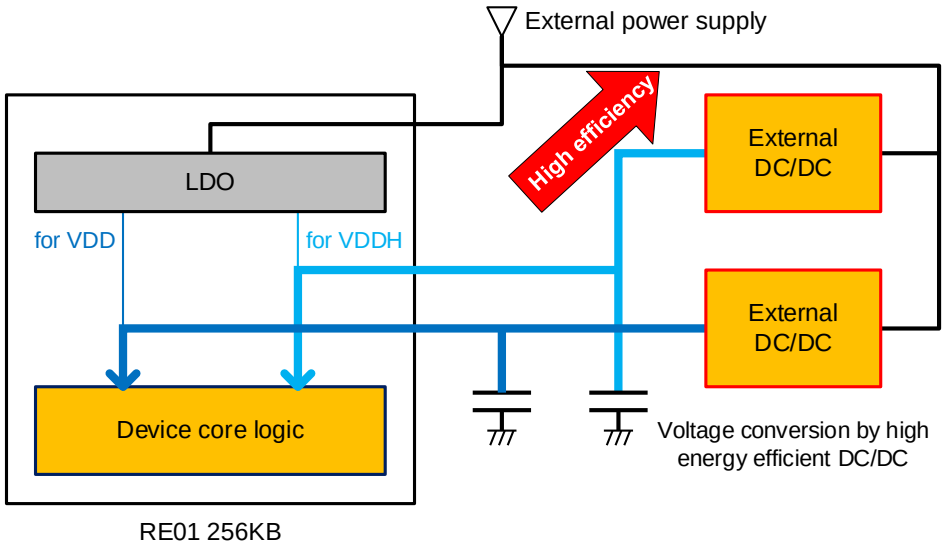
1. Overview of operation when using the external DC/DC

The RE01 256KB group (hereinafter, this device) supplies the voltage generated by an internal regulator (LDO) to the device core logic for the operation of the internal circuits.

The current consumption of the device can be reduced by using the external DC/DC instead of the internal LDO which can generate the required voltage more efficiently.



Power supply configuration using the internal LDO



Power supply configuration using external DC/DCs

Figure 1-1 Image of the different power supply configurations

2. Voltage and supply of internal circuits

This device requires two separate power supply voltages, VDD and VDDH, for the operation of the internal circuits. There are two different ways to supply voltage to VDD and VDDH.

2.1 Supplied from the internal regulator (LDO)

Immediately after turning on the power to the device, the internal LDO supplies the VDD and VDDH voltages.

When the device switches to boost mode, the voltage of VDD changes. VDDH is constant regardless of the operating mode. Table 2-1 shows the electrical characteristics of VDD and VDDH when the internal LDO operates.

Table 2-1 Electrical characteristics of VDD and VDDH (when the internal LDO operates)

Item		Voltage
VDD	Other than boost mode	0.79V
	Boost mode	1.0V
VDDH		1.25V

2.2 Supplied from external DC/DCs

This device can stop the internal LDO and supply voltage to the internal circuits from external DC/DCs. In this case, supply the voltage from the VCL pin to VDD and the voltage from the VCLH pin to VDDH.

It is recommended to use the regulator ISL9123 from Renesas for the external DC/DCs. If you use other devices, please evaluate them thoroughly.

The voltage supplied from the ISL9123 to the VCL and VCLH pins should be as shown in Table 2-2.

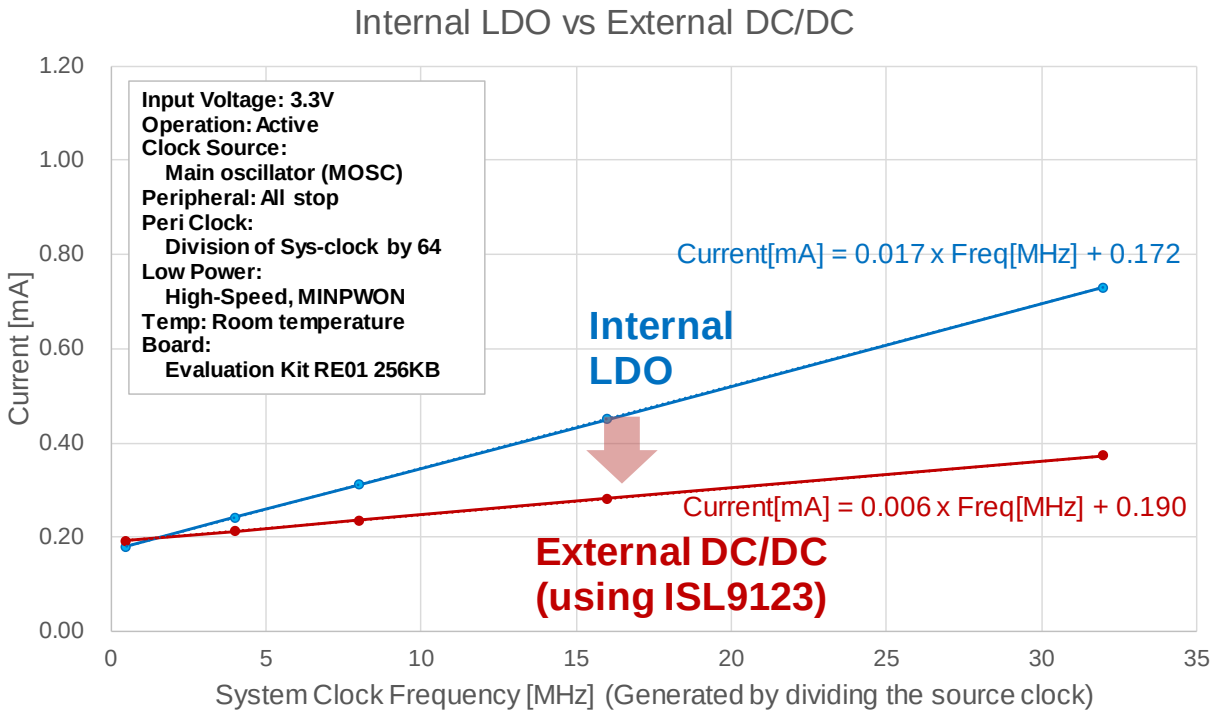
Table 2-2 Voltage supplied from ISL9123 to VCL and VCLH pins

Item		Min	Typ	Max	Unit
Voltage supplied to VCL pin	Other than boost mode	0.819	0.85	0.881	V
	Boost mode	0.988	1.025	1.062	V
Voltage supplied to VCLH pin		1.205	1.25	1.295	V

3. Advantage, disadvantage, and restriction of using external DC/DCs

3.1 Advantage: reduced power consumption

The current consumption can be reduced by changing the voltage supply to the internal circuits from the internal LDO to external DC/DCs. Figure 3-1 shows the difference in current consumption between the internal LDO and external DC/DCs.



Note: The values in the figure are reference values.

Figure 3-1 Difference in current consumption between the internal LDO and external DC/DCs

3.2 Disadvantage: increased number of parts

The number of components increases because external DC/DCs and components around them are required.

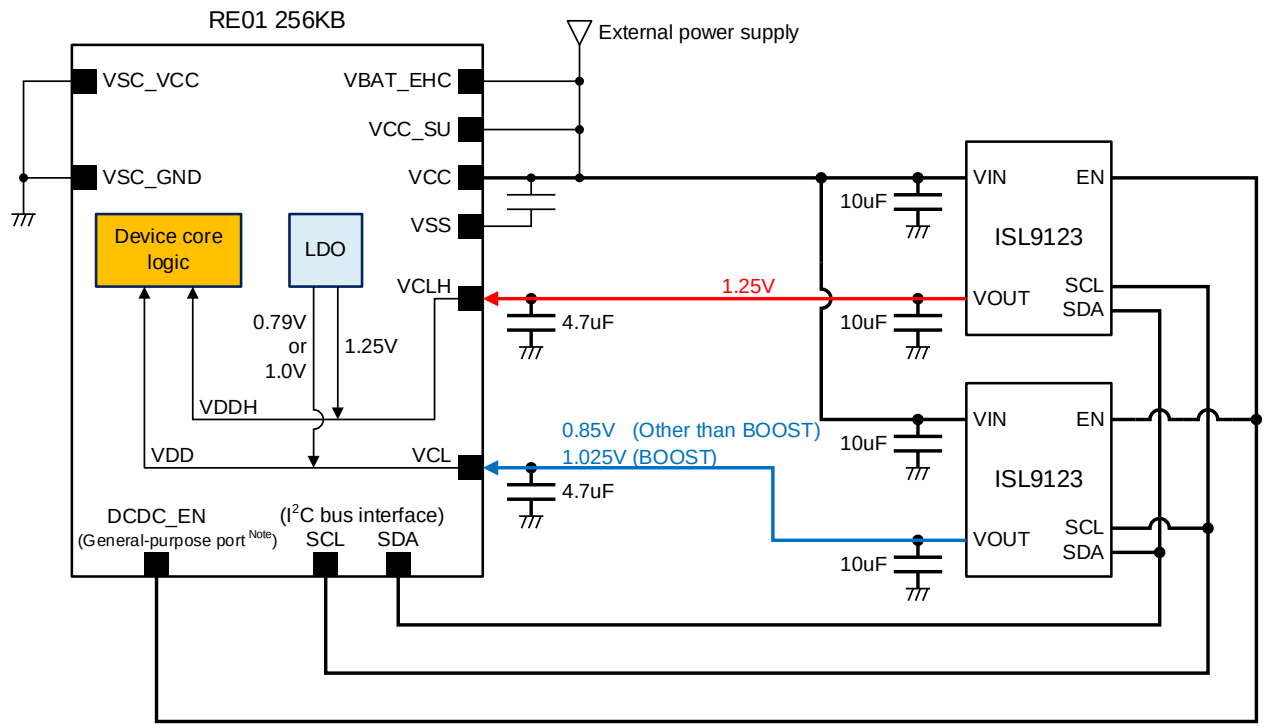
3.3 Restriction: restriction when transitioning to boost mode

When transitioning to boost mode, the voltage of VDD changes. When the voltage is supplied from the internal LDO, the VDD voltage changes at the same time as the mode transition. When using the external DC/DC in both boost mode and other modes, the voltage output of the external DC/DC must be changed dynamically.

When changing to the boost mode or changing from the boost mode to another mode, the mode must be changed while the voltage is being supplied from the internal LDO.

4. Circuit configuration example

Figure 4-1 shows a circuit configuration example when using external DC/DCs. Use two ISL9123s to supply voltage to VCL and VCLH pins. The level input to the EN pin of ISL9123 is selected by the output of the general-purpose port. When using an external DC/DC in both boost mode and other modes, the I²C bus interface is used to change the output voltage of ISL9123 connected to VCL pin.



Note: Use P208 or P209 for the general-purpose port connected to the EN pin of ISL9123.
For details, see "6.1 General-purpose port to connect to external DC/DCs".

Figure 4-1 Circuit configuration example when using external DC/DCs

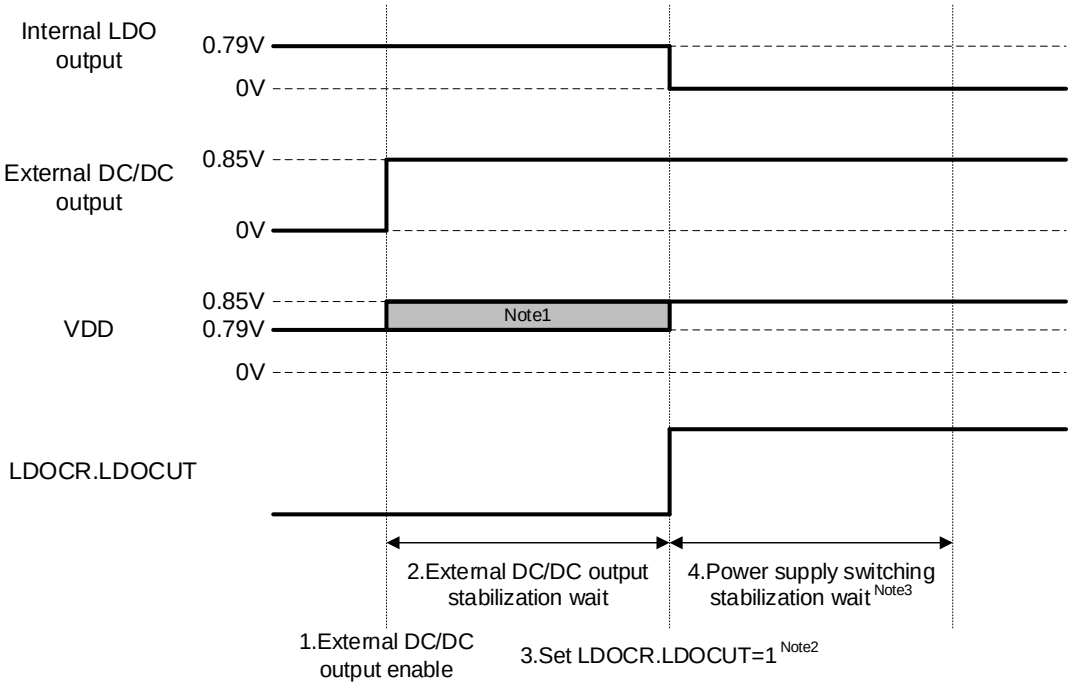
5. Procedure for using external DC/DCs

The following shows the procedure for switching the voltage supply to the internal circuits from the internal LDO to external DC/DCs and from external DC/DCs to the internal LDO. When changing to the boost mode or changing from the boost mode to another mode, the mode must be changed while the voltage is being supplied from the internal LDO.

5.1 Procedure to switch from the internal LDO to external DC/DCs (when not transitioning to boost mode)

1. Enable the external DC/DC voltage output.
2. Wait until the external DC/DC voltage output stabilizes. Note1
3. Set LDOCR.LDOCUT = 1 (LDO stops). Note2
4. Wait for the power supply switching to stabilize. Note3

Note: 1. VDD and VDDH voltages may become unstable due to the internal LDO and external DC/DC voltage output competition.
2. If necessary, reduce device power consumption before setting LDOCR.LDOCUT = 1. For details, see "5.5 Precautions when stopping the internal LDO".
3. Adjust the waiting time according to the system. For details, see "5.5 Precautions when stopping the internal LDO".



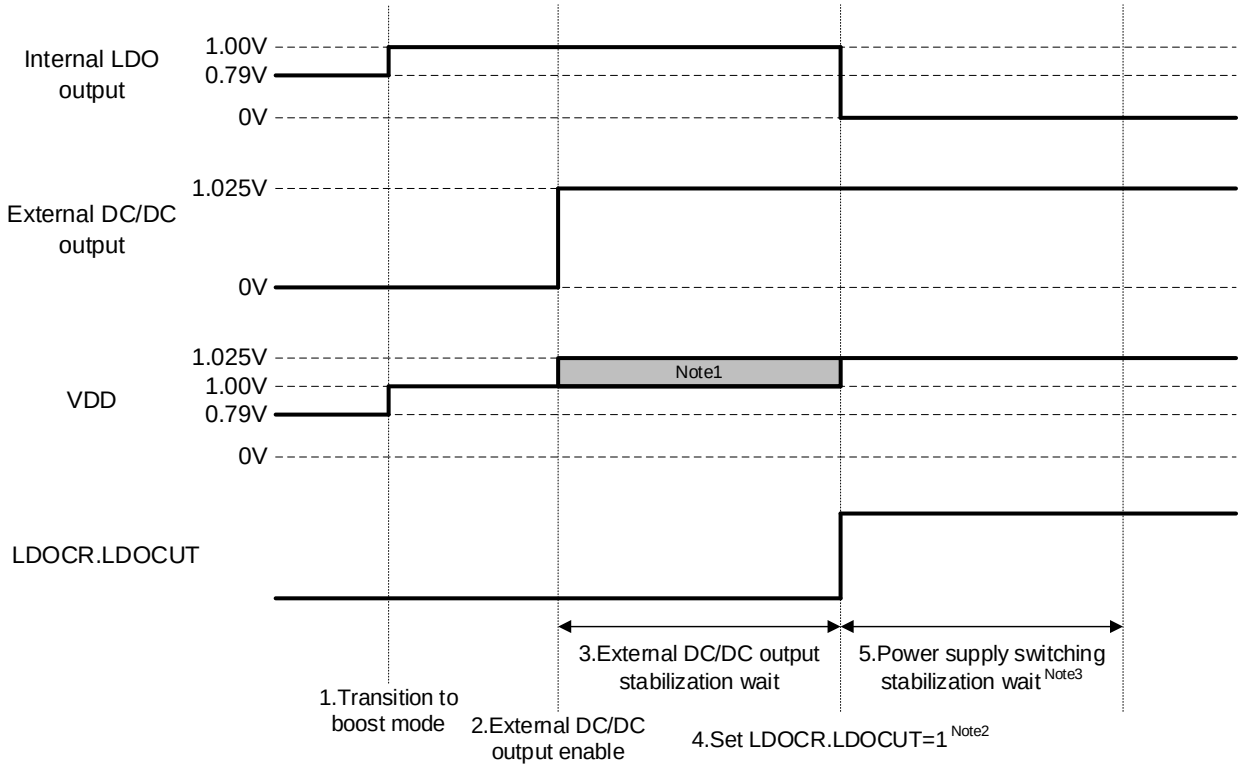
Note: 1. VDD and VDDH voltages may become unstable due to the internal LDO and external DC/DC voltage output competition.
2. If necessary, reduce device power consumption before setting LDOCR.LDOCUT = 1. For details, see "5.5 Precautions when stopping the internal LDO".
3. Adjust the waiting time according to the system. For details, see "5.5 Precautions when stopping the internal LDO".

Figure 5-1 Timing chart for enabling external DC/DCs (when not transitioning to boost mode)

5.2 Procedure to switch from the internal LDO to external DC/DCs (when transitioning to boost mode)

0. Set the external DC/DC output voltage to 1.025V. (Voltage output remains disabled)
1. Transition to boost mode with LDOCR.LDOCUT = 0 (LDO works).
2. Enable the external DC/DC voltage output.
3. Wait until the external DC/DC voltage output stabilizes. Note1
4. Set LDOCR.LDOCUT = 1 (LDO stops). Note2
5. Wait for the power supply switching to stabilize. Note3

Note: 1. VDD and VDDH voltages may become unstable due to the internal LDO and external DC/DC voltage output competition.
2. If necessary, reduce device power consumption before setting LDOCR.LDOCUT = 1. For details, see "5.5 Precautions when stopping the internal LDO".
3. Adjust the waiting time according to the system. For details, see "5.5 Precautions when stopping the internal LDO".



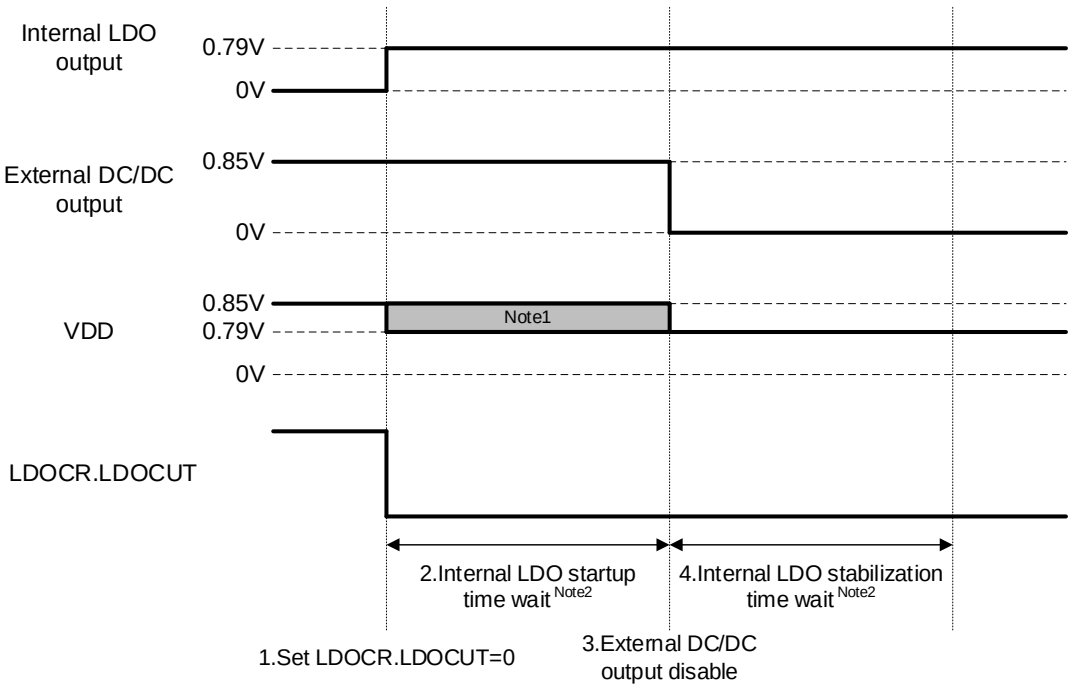
Note: 1. VDD and VDDH voltages may become unstable due to the internal LDO and external DC/DC voltage output competition.
2. If necessary, reduce device power consumption before setting LDOCR.LDOCUT = 1. For details, see "5.5 Precautions when stopping the internal LDO".
3. Adjust the waiting time according to the system. For details, see "5.5 Precautions when stopping the internal LDO".

Figure 5-2 Timing chart for enabling external DC/DCs (when transitioning to boost mode)

5.3 Procedure to switch from external DC/DCs to the internal LDO (when not transitioning mode)

1. Set LDOCR.LDOCUT = 0 (LDO works).
2. Wait for the internal LDO startup. Note1 Note2
3. Disable the external DC/DC voltage output.
4. Wait for the internal LDO stabilization. Note2

Note: 1. VDD and VDDH voltages may become unstable due to the internal LDO and external DC/DC voltage output competition.
2. For the waiting time, refer to the electrical characteristics of the user's manual.



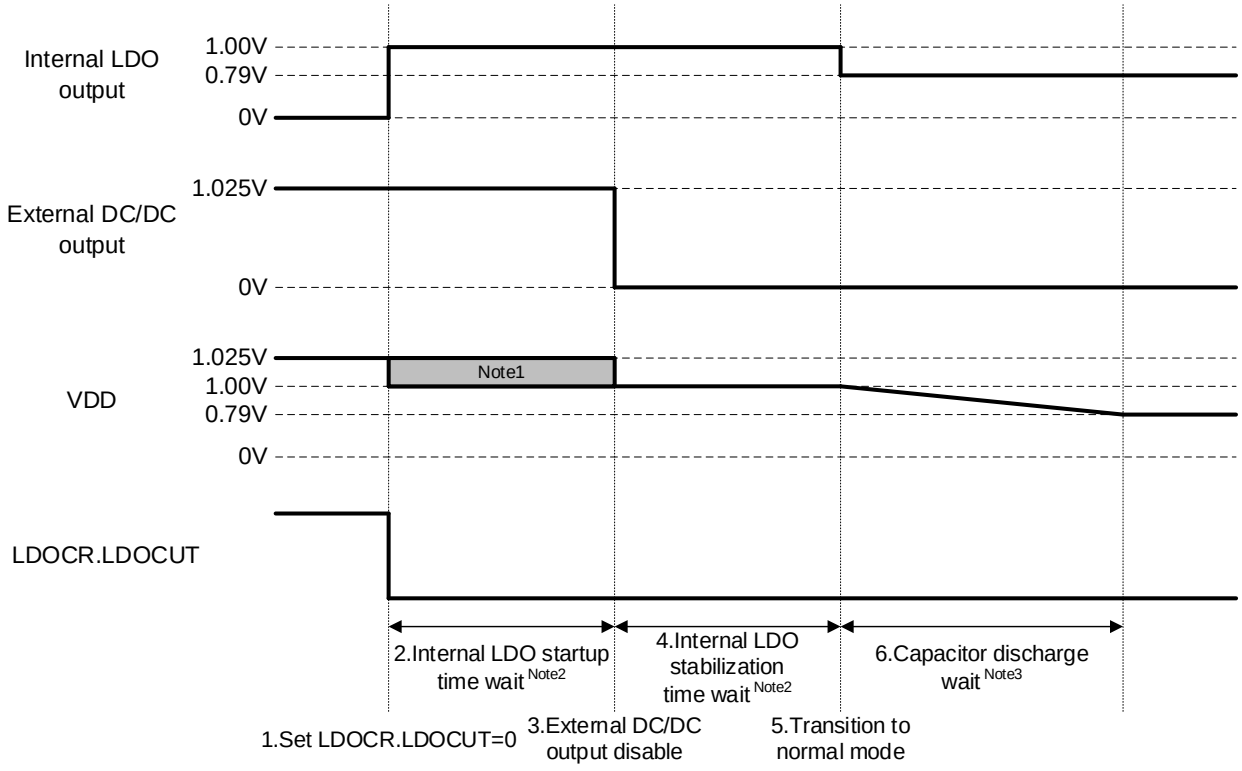
Note: 1. VDD and VDDH voltages may become unstable due to the internal LDO and external DC/DC voltage output competition.
2. For the waiting time, refer to the electrical characteristics of the user's manual.

Figure 5-3 Timing chart for disabling external DC/DCs (when not transitioning mode)

5.4 Procedure to switch from external DC/DCs to the internal LDO (when transitioning from boost mode to another mode)

1. Set LDOCR.LDOCUT = 0 (LDO works).
2. Wait for the internal LDO startup. Note1 Note2
3. Disable the external DC/DC voltage output.
4. Wait for the internal LDO stabilization. Note2
5. Transition from boost mode to another mode.
6. Wait for the capacitor connected to the VCL pin to discharge. Note3

Note: 1. VDD and VDDH voltages may become unstable due to the internal LDO and external DC/DC voltage output competition.
2. For the waiting time, refer to the electrical characteristics of the user's manual.
3. Adjust the waiting time according to the system. By using the internal voltage discharge by the VBBCR.IVDIS bit, the capacitor can be discharged faster.



Note: 1. VDD and VDDH voltages may become unstable due to the internal LDO and external DC/DC voltage output competition.
2. For the waiting time, refer to the electrical characteristics of the user's manual.
3. Adjust the waiting time according to the system. By using the internal voltage discharge by the VBBCR.IVDIS bit, the capacitor can be discharged faster.

Figure 5-4 Timing chart for disabling external DC/DCs (when transitioning from boost mode to normal mode)

5.5 Precautions when stopping the internal LDO

When setting LDOCR.LDOCUT = 1 (LDO stops), the power supply from the internal LDO to the internal circuit stops, and the load on external DC/DCs increases. If the external DC/DCs cannot withstand the load, the VDD and VDDH voltages will drop.

After setting LDOCR.LDOCUT = 1, wait by software until the VDD and VDDH voltages stabilize. Adjust the waiting time according to the system.

The voltage drop associated with switching from the internal LDO to external DC/DCs can be reduced by reducing the power consumption of the device. If necessary, reduce device power consumption before setting LDOCR.LDOCUT = 1. The followings are examples of how to reduce the power consumption of the device.

- Decrease the operating frequency.
- Change the power control mode or the power supply mode to a mode with lower power consumption.
- Stop unnecessary peripheral functions. (Set the module stop)

6. Precautions when using external DC/DCs

6.1 General-purpose port to connect to external DC/DCs

Use P208 or P209 for the general-purpose port connected to the EN pin of ISL9123s.

When setting LDOCR.LDOCUT = 1 (LDO stops), these ports outputs at the time of setting LDOCR.LDOCUT = 1 are retained. This prevents the external DC/DC voltage outputs from stopping while the internal LDO is stopped.

When setting LDOCR.LDOCUT = 0 (LDO works), P208 and P209 are in the state according to the register value of the I/O port. When switching the voltage supply source from the external DC/DCs to the internal LDO, set the register so that the general-purpose port is High output before setting LDOCR.LDOCUT = 0.

6.2 Reset

The LDOCR register is not initialized by resets other than RES# pin reset, power-on reset and voltage monitor 0 reset. The generated reset source can be confirmed by the reset status register 0 (RSTSR0) and reset status register 1 (RSTSR1).

If a reset other than RES# pin reset, power-on reset and voltage monitor 0 reset occurs when LDOCR.LDOCUT = 1 (LDO stops), the state of LDOCR.LDOCUT = 1 is retained even after reset. At this time, the outputs of P208 and P209 also retain the state before reset, but the I/O port register values return to their initial values.

When switching the voltage supply source from the external DC/DCs to the internal LDO after reset, set the register so that the general-purpose port connected to the EN pin of ISL9123s becomes High output before setting LDOCR.LDOCUT = 0 (LDO works).

Note The sample code included in this application note does not support the processing after reset shown above.

6.3 Precautions when using boost mode

The voltage supplied to the VCL pin differs between boost mode and other modes.

The power control mode after device reset is normal mode.

If the device is reset while using the boost mode, it will transition to normal mode. When supplying the voltage from external DC/DCs again after reset, supply the voltage according to the device mode to the VCL pin.

If a reset other than RES# pin reset, power-on reset and voltage monitor 0 reset occurs when boost mode and LDOCR.LDOCUT = 1 (LDO stops), the device transitions to normal mode after reset. However, the voltage applied to the VCL pin remains high. In this state, there is no problem in the operation of the device, but the current consumption increase.

Therefore, switch the voltage supply to the internal LDO as soon as possible after reset and stop the external DC/DC voltage output. At this time, set the register so that the general-purpose port connected to the EN pin of ISL9123s becomes High output before setting LDOCR.LDOCUT = 0 (LDO works).

Note The sample code included in this application note does not support the processing after reset shown above.

6.4 Current consumption when transitioning to boost mode

When transitioning to boost mode, the current consumption increases instantaneously because the capacitor connected to the VCL pin is charged by increasing the voltage of VDD.

6.5 Wait time when switching from the internal LDO to external DC/DCs

Please switch from the internal LDO to external DC/DCs while the external DC/DC voltage output is stable. For the waiting time from the activation of the external DC/DC voltage output to the switching of the voltage supply source, generate a wait loop in software to meet the electrical characteristics of the external DC/DC.

6.6 Input voltage range from external DC/DCs

The voltage supplied from the external DC/DC to the VCL and VCLH pins should be as shown in Table 2-2. The correct operation is not guaranteed if the voltage value cannot be observed.

In particular, note that the voltage supplied to the VCL pin differs between boost mode and other modes.

6.7 VCC voltage and external DC/DC input voltage range

If the lower limit of the external DC/DC input voltage is higher than the lower limit of the VCC voltage of this device (1.62V), make sure that the VCC voltage does not become lower than the lower limit of the external DC/DC input voltage.

Also, if the upper limit of the external DC/DC input voltage is lower than the upper limit of the VCC voltage of this device (3.3V), make sure that the VCC voltage does not become higher than the upper limit of the external DC/DC input voltage.

If the VCC voltage is outside the range of the input voltage of the external DC/DC, the external DC/DC becomes inoperable and the voltage supply to the VCL and VCLH pins stops, and the device stops operating.

Example) When ISL9123 is used for the external DC/DC

VCC voltage of this device: 1.62V to 3.3V

Input power supply voltage of ISL9123: 1.8V to 5.5V

In this case, make VCC = 1.8V to 3.3V.

6.8 Power supply to the internal circuit

To prevent interruption of the voltage supply to VDD and VDDH, be sure to operate either the internal LDO or external DC/DCs. If both stops at the same time and the supply of voltage to VDD or VDDH stops, device operation stops.

7. Sample code

7.1 Overview

This application note includes sample code to switch between the internal LDO and external DC/DCs.

The sample codes operation has been confirmed on the Evaluation Kit RE01 256KB (RTK70E0118CxxxxxBJ). The setting of this sample code is consistent with the R7F0E01182CFP implemented on the Evaluation Kit RE01 256KB. Modify the device setting in the project when you use other devices.

7.2 Specification

7.2.1 List of used ports

Table 7-1 shows the used ports in the sample code

Table 7-1 Used ports in the sample code

Used ports	Functions
P210	LED0: Flashes after reset release, flashes before switching between the internal LDO and the external DC/DC
P410	LED1: Flashes before transition to boost mode, flashes before transition from boost mode to normal mode
P508	SW2: IRQ4 interrupt
P208	DCDC_Ext_EN: Controls the level input to the EN pin of the external DC/DC (ISL9123)
P012	Ext_SDA0: Serial data input/output used for I^2C communication with the external DC/DC (ISL9123)
P013	Ext_SCL0: Serial clock output used for I^2C communication with the external DC/DC (ISL9123)

7.2.2 Target board settings

Evaluation Kit RE01 256KB requires switch settings to use the external DC/DCs.

Table 7-2 shows the switch settings of Evaluation Kit RE01 256KB.

Figure 7-1 shows the parts layout of Evaluation Kit RE01 256KB.

Table 7-2 Switch settings of Evaluation Kit RE01 256KB

Switch	Settings	Content
SW11.1-4	ON	Supply power to the VIN pin of the external DC/DC (ISL9123)
SW11.2-3	ON	Supply power to the VIN pin of the external DC/DC (ISL9123)
SW12.1-4	ON	Connect the VCL pin to the VOUT pin of the external DC/DC (ISL9123)
SW12.2-3	ON	Connect the VCLH pin to the VOUT pin of the external DC/DC (ISL9123)

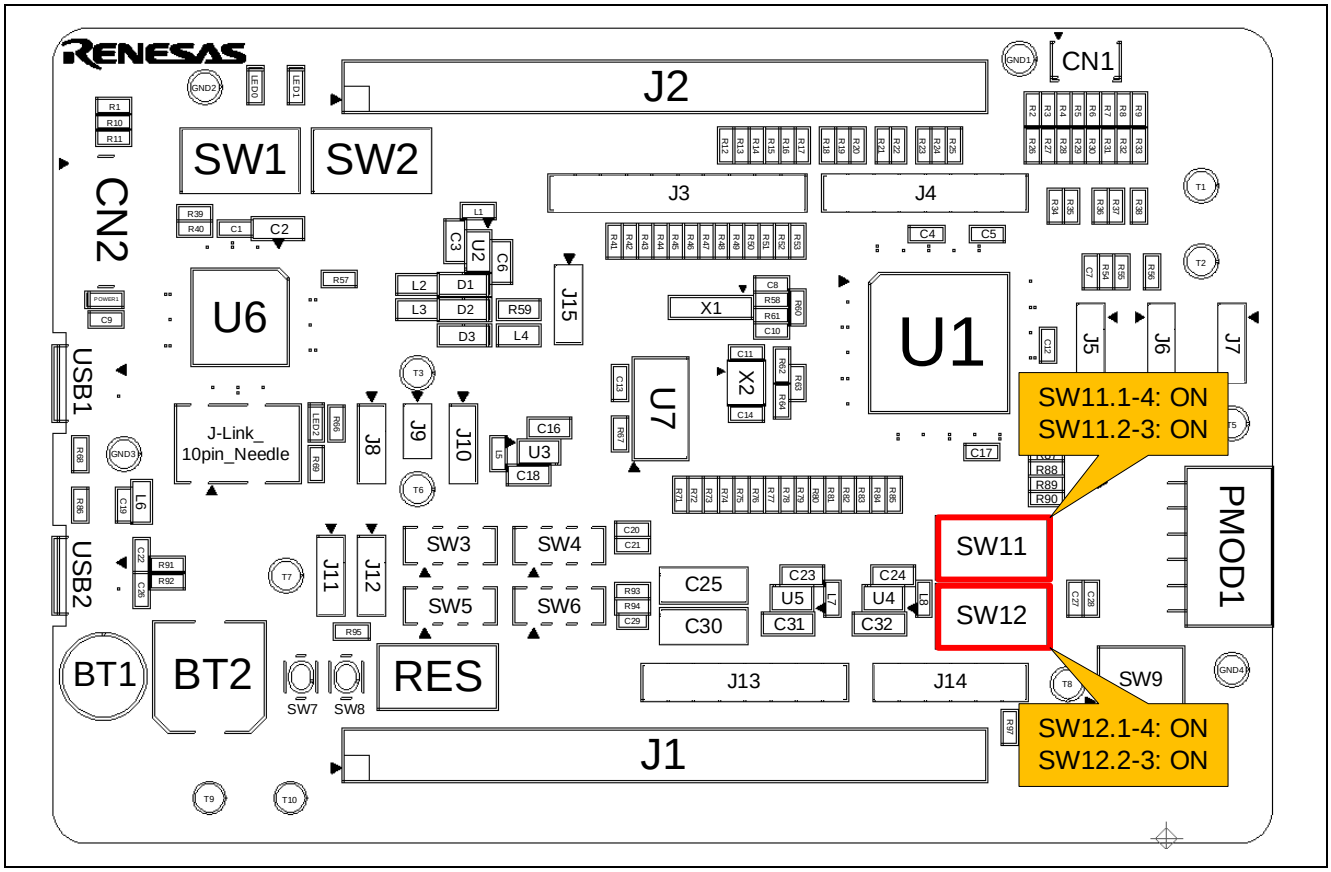


Figure 7-1 Parts layout of Evaluation Kit RE01 256KB

7.2.3 File Configuration

This sample code uses the RE01 256KB group CMSIS Driver Package.

Table 7-3 shows the files added or changed in the sample code.

Table 7-3 Files added or changed in the sample code

Name	Outline	Remarks
main.c	Main processing	-
main_cfg.h	Constants used in sample code	Added file
nop.c	NOP processing	Added file
nop.h	Definition of NOP processing function	Added file
pin.c	The ports used in the sample code are set in this file	Select P508 for IRQ4 pin Select P013 for SCL0 pin Select P012 for SDA0 pin
r_system_cfg.h[Note]	The IRQ event link numbers used in the sample code are set in this file	Set IRQ event channel of IRQ4 to 4 Set IRQ event channel of IIC0_RXI to 0 Set IRQ event channel of IIC0_TXI to 1 Set IRQ event channel of IIC0_TEI to 2 Set IRQ event channel of IIC0_EEI to 3
r_i2c_cfg.h	The I^2C bus speed is set in this file	Disable the automatic calculation of bus speed Set the bus speed to 50kbps

Note For interrupt settings in r_system_cfg.h, see the section “Interrupt (NVIC) Settings” in RE01 256KB CMSIS Package Startup Guide.

7.2.4 Option-setting Memory

Table 7-4 shows Option-setting memory settings of the sample code. Set the optimal value for the system as necessary.

Table 7-4 Option-setting memory settings of the sample code

Symbol	Address	Setting value	Content
AWS	0100A164h~0100A167h	FFFF FFFFh	No access window setting
OSIS	0100A150h~0100A15Fh	FFFF FFFFh	No protection of ID code (all bytes are FFh)
SECMPUxxx	00000408h~0000043Bh	FFFF FFFFh	Security MPU disabled
OFS1	00000404h~00000407h	FFFF FFFFh	LVD0 reset invalid after reset release HOCO oscillation stop after reset release
OFS0	00000400h~00000403h	FFFF FFFFh	IWDT stop WDT stop after reset release

7.3 Conditions for Confirming Operation

This sample code has been confirmed to operate under the conditions shown in Table 7-5.

Table 7-5 Confirmed operating conditions

Item		**Conditions**
MCU		R7F0E01182CFP 100pin
Operating frequency	After reset release (Initial value)	• Middle-speed on-chip oscillator (MOCO) : 2MHz • System clock (ICLK) : 2MHz (MOCO * 1/1) • Peripheral module clock A (PCLKA) : 2MHz (MOCO * 1/1) • Peripheral module clock B (PCLKB) : 2MHz (MOCO * 1/1)
Operating voltage		3.3V
Target board		Evaluation Kit RE01 256KB (RTK70E0118CxxxxxBJ)
Integrated Development Environment	GCC	Renesas e^2 studio 2020-07
	IAR	IAR Embedded Workbench for Arm® Version 8.40
C compiler	GCC	GCC Arm® Embedded Version 6.3.1.20170620 GNU 6-2017-q2-update
	IAR	IAR C/C++ Compiler for Arm® Version 8.40
Debugger		Segger J-Link
I/O header version		Rev1.00
CMSIS Driver Package version		Rev1.00

Note The current consumption can be measured by modifying the target board as follows.
J9 : Open, T3 and T6 : Connect to ammeter.
For details, refer to the Evaluation Kit RE01 256KB user's manual.

7.4 Software Description

This sample code operates as follows by using the R_SYSTEM driver and I²C driver functions.

1. After reset release, the sample code flashes the LED0 Note three times.
2. The sample code then turns off the LED0 Note and wait for an IRQ4 interrupt.
3. When an IRQ4 interrupt occurs, the sample code flashes the LED0 Note four times quickly, then it enables the voltage output of the external DC/DC and changes the voltage supply to the internal circuit to the external DC/DC.
4. When IRQ4 interrupt occurs again, the sample code flashes LED0 Note twice at low speed, then it changes the voltage supply to the internal circuit to the internal LDO and stops the external DC/DC voltage output.
5. When IRQ4 interrupt occurs again, the sample code flashes LED0 and LED1 Note four times quickly, then it transitions to boost mode, enables the voltage output of the external DC/DC and changes the voltage supply to the internal circuit to the external DC/DC.
6. When IRQ4 interrupt occurs again, the sample code flashes LED0 and LED1 Note twice at low speed, then it changes the voltage supply to the internal circuit to the internal LDO and stops the external DC/DC voltage output.
7. When IRQ4 interrupt occurs again, the sample code flashes LED1 Note twice at low speed, then it transitions from boost mode to normal mode.
8. Repeat from 3 to 7 by pressing SW2.

Note By changing the main_cfg.h file settings, the LED blink can be disabled and so removes the current flowing to LED.

Figure 7-2 shows the state transition diagram of the sample code.

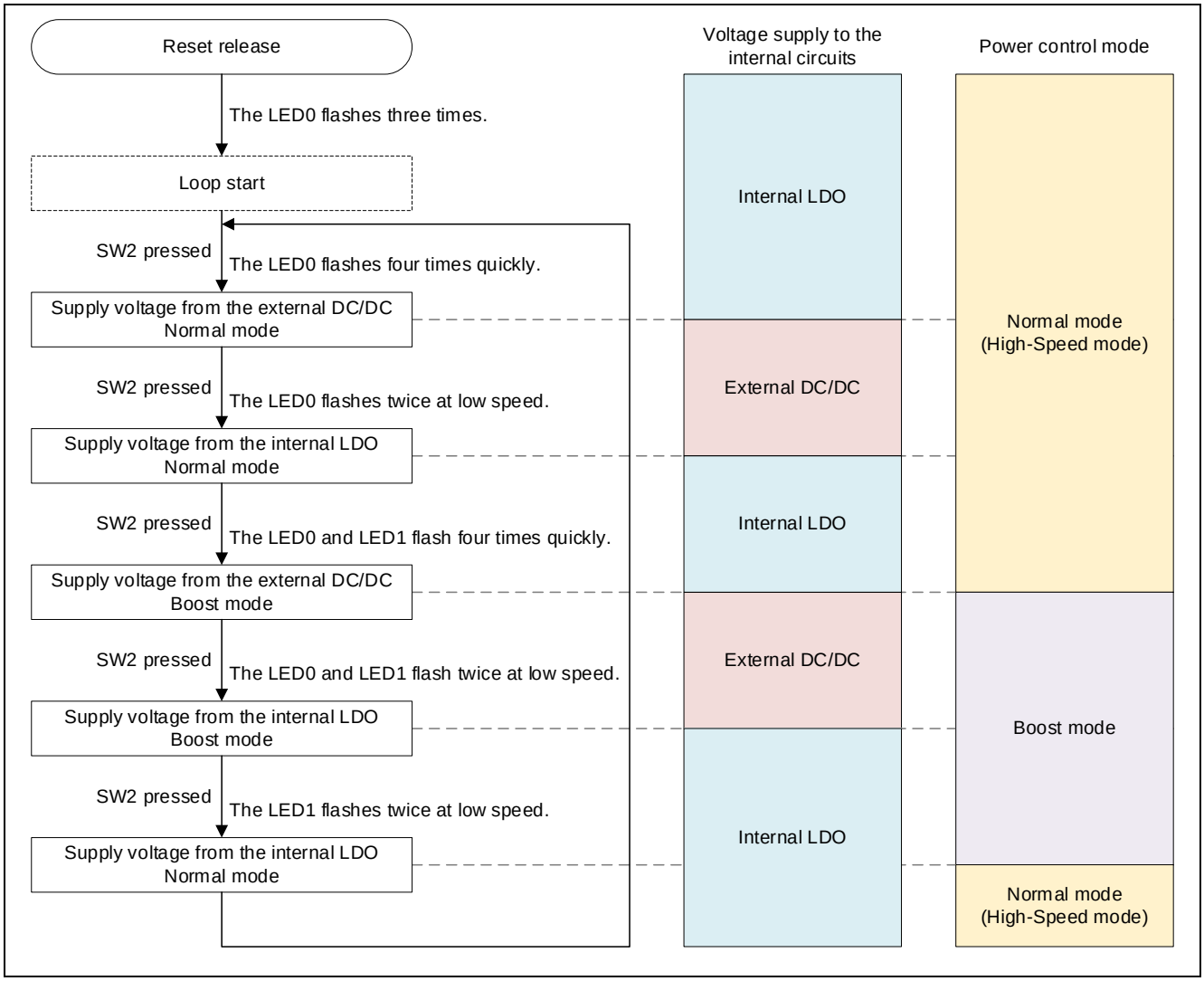


Figure 7-2 State transition diagram of the sample code

7.4.1 List of Functions

The specification of the functions added to this sample code are shown below.

main	
Outline	Main processing
Header	None
Declaration	int main(void)
Description	Repeat changing between the internal LDO and the external DC/DCs, normal mode and boost mode triggered by pressing SW2.
Argument	None
Return value	0

demo_error	
Outline	Error processing
Header	None
Declaration	static void demo_error(void)
Description	Execute endless loop in case that return value of function is error.
Argument	None
Return value	None

ext_dcdc_enable	
Outline	Validation of voltage supply from the external DC/DCs
Header	None
Declaration	static void ext_dcdc_enable(void)
Description	This function flashes LED0 four times quickly, then it enables the voltage output of the external DC/DCs and changes the voltage supply to the internal circuit to the external DC/DC.
Argument	None
Return value	None

ext_dcdc_disable	
Outline	Disabling voltage supply from the external DC/DCs
Header	None
Declaration	static void ext_dcdc_disable(void)
Description	This function flashes LED0 twice at low speed, then it changes the voltage supply to the internal circuit to the internal LDO and stops the external DC/DC voltage outputs.
Argument	None
Return value	None

ext_dcdc_enable_boost	
Outline	Validation of voltage supply from the external DC/DCs (in the boost mode)
Header	None
Declaration	static void ext_dcdc_enable_boost(void)
Description	This function flashes LED0 and LED1 four times quickly, then by I^2C communication, it stops the voltage output of the external DC/DC connected to the VCL pin and changes the output voltage. After that, it transitions to the boost mode, enables the voltage output of the external DC/DC and changes the voltage supply source from the internal LDO to the external DC/DCs.
Argument	None
Return value	None

ext_dcdc_disable_boost	
Outline	Disabling voltage supply from the external DC/DCs (in the boost mode)
Header	None
Declaration	static void ext_dcdc_disable_boost(void)
Description	This function flashes LED0 and LED1 twice at low speed, then it changes the voltage supply source from the external DC/DCs to the internal LDO and stops the external DC/DC voltage outputs.
Argument	None
Return value	None

ext_dcdc_exit_boost	
Outline	Transition from the boost mode to the normal mode
Header	None
Declaration	static void ext_dcdc_exit_boost(void)
Description	This function flashes LED1 twice at low speed, then it transitions to the normal mode (High-Speed mode) and waits for the capacitor connected to the VCL pin to discharge.
Argument	None
Return value	None

irq4_wait	
Outline	Wait for IRQ4
Header	None
Declaration	static void irq4_wait(void)
Description	Execute endless loop until IRQ4 interrupt occurs.
Argument	None
Return value	None

led_port_init	
Outline	Initial setting for LED port
Header	None
Declaration	static void led_port_init(void)
Description	Initializes the ports used for the LEDs, and flashes LED0 three times.
Argument	None
Return value	None

led0_set		
Outline	Controlling LED0	
Header	None	
Declaration	static void led0_set(uint8_t flag)	
Description	Turn on or turn off LED0	
Argument	flag	0: Tern on 1: Tern off
Return value	None	

led1_set		
Outline	Controlling LED1	
Header	None	
Declaration	static void led1_set(uint8_t flag)	
Description	Turn on or turn off LED1	
Argument	flag	0: Tern on 1: Tern off
Return value	None	

irq4_setup	
Outline	Setting for IRQ4 interrupt
Header	None
Declaration	static void irq4_setup(void)
Description	Set the IRQ4 interrupt
Argument	None
Return value	None

irq4_int	
Outline	Interrupt handling of IRQ4
Header	None
Declaration	static void irq4_int(void)
Description	Execute the interrupt handler by IRQ4 interrupt
Argument	None
Return value	None

iic_init	
Outline	I^2C communication initialization
Header	None
Declaration	static void iic_init(void)
Description	Initialize the I^2C driver.
Argument	None
Return value	None

iic_uninit	
Outline	Invalidation I^2C communication
Header	None
Declaration	static void iic_init(void)
Description	Disable the I^2C driver.
Argument	None
Return value	None

iic_reg_write		
Outline	Writing register by I²C communication	
Header	None	
Declaration	static void iic_reg_write(uint32_t dev_addr, uint8_t reg_addr, uint8_t wt_val)	
Description	Write the register of the external DC/DC (ISL9123) by I²C communication.	
Argument	dev_addr	Device address
	reg_addr	Register address
	wt_val	Write value
Return value	None	

iic_callback		
Outline	Callback function of I²C communication	
Header	None	
Declaration	static void iic_callback(uint8_t event)	
Description	This function is called by the I²C driver.	
Argument	event	Callback event code
Return value	None	

BoardInit	
Outline	Terminal settings on the using board
Header	None
Declaration	void BoardInit(void)
Description	This function is called by SystemInit() function after reset release
Argument	None
Return value	None

7.4.2 List of Constants

The modifiable constants are shown in Table 7-6.

Table 7-6 Confirmed operating conditions

Contents	Initial value	Setting	File
MAIN_CFG_LED_ENABLE	1	0: Disable LED0 control Note 1: Enable LED0 control	main_cfg.h

Note This setting can reduce the current flowing to LED.

7.4.3 Flowcharts

The following show the flowcharts of the sample code.

Table 7-7 Flowchart list

Figure	Function name	Outline
Figure 7-3 Figure 7-4	main	Main process of changing the voltage supply to the internal circuit
Figure 7-5	ext_dcdc_enable	Enable the voltage supply from the external DC/DCs
Figure 7-6	ext_dcdc_disable	Disable the voltage supply from the external DC/DCs
Figure 7-7	ext_dcdc_enable_boost	Enable the voltage supply from the external DC/DCs (in the boost mode)
Figure 7-8	ext_dcdc_disable_boost	Disable the voltage supply from the external DC/DCs (in the boost mode)
Figure 7-9	ext_dcdc_exit_boost	Change the mode from the boost mode to the normal mode
Figure 7-10	iic_init	I^2C-BUS communication initialization
Figure 7-11	iic_uninit	I^2C-BUS communication finalization
Figure 7-12 Figure 7-13	iic_reg_write	Write a register on the ISL9123 through I^2C-BUS communication
Figure 7-14	iic_callback	Callback function of I^2C-BUS communication

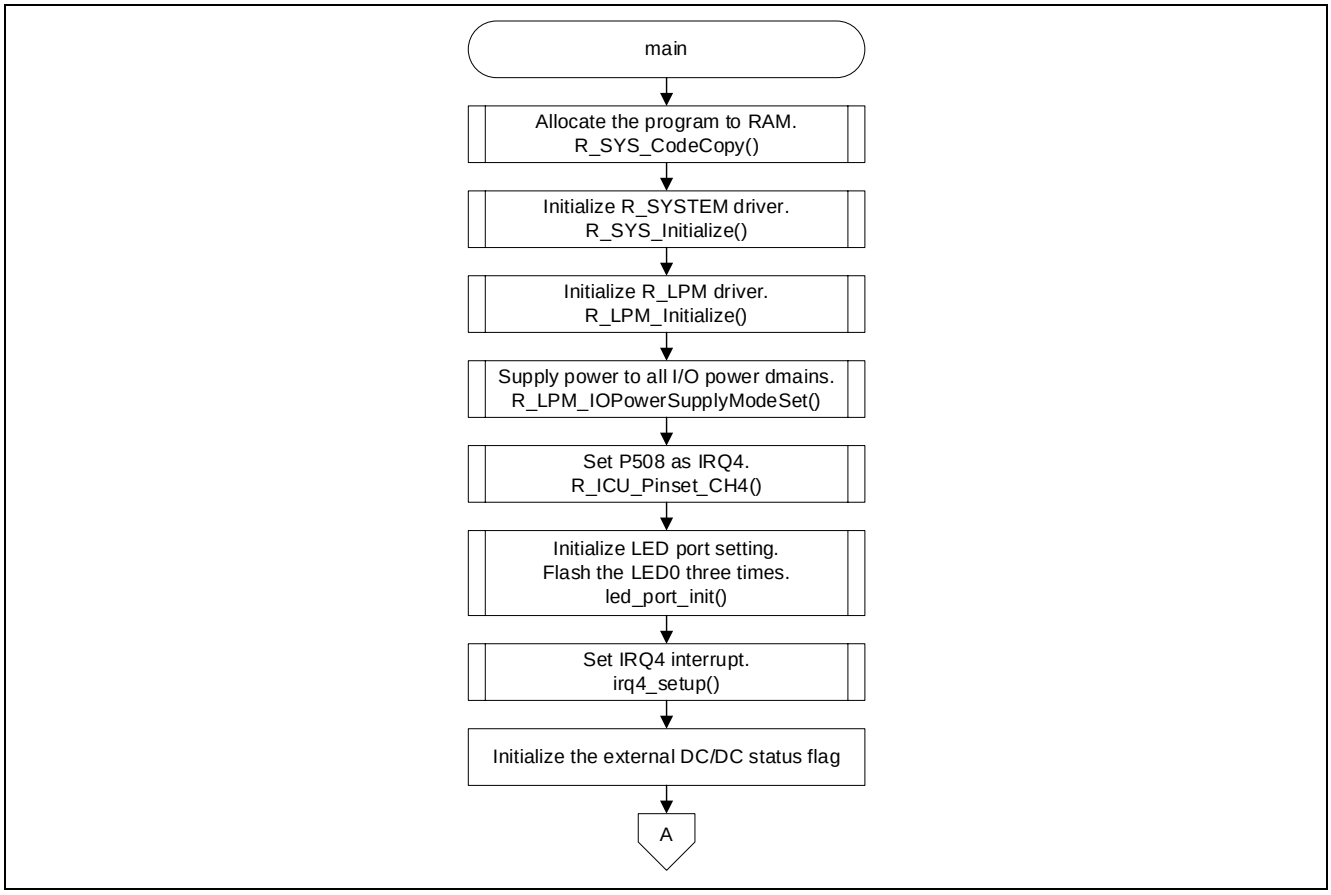


Figure 7-3 Main process of changing the voltage supply to the internal circuit (1/2)

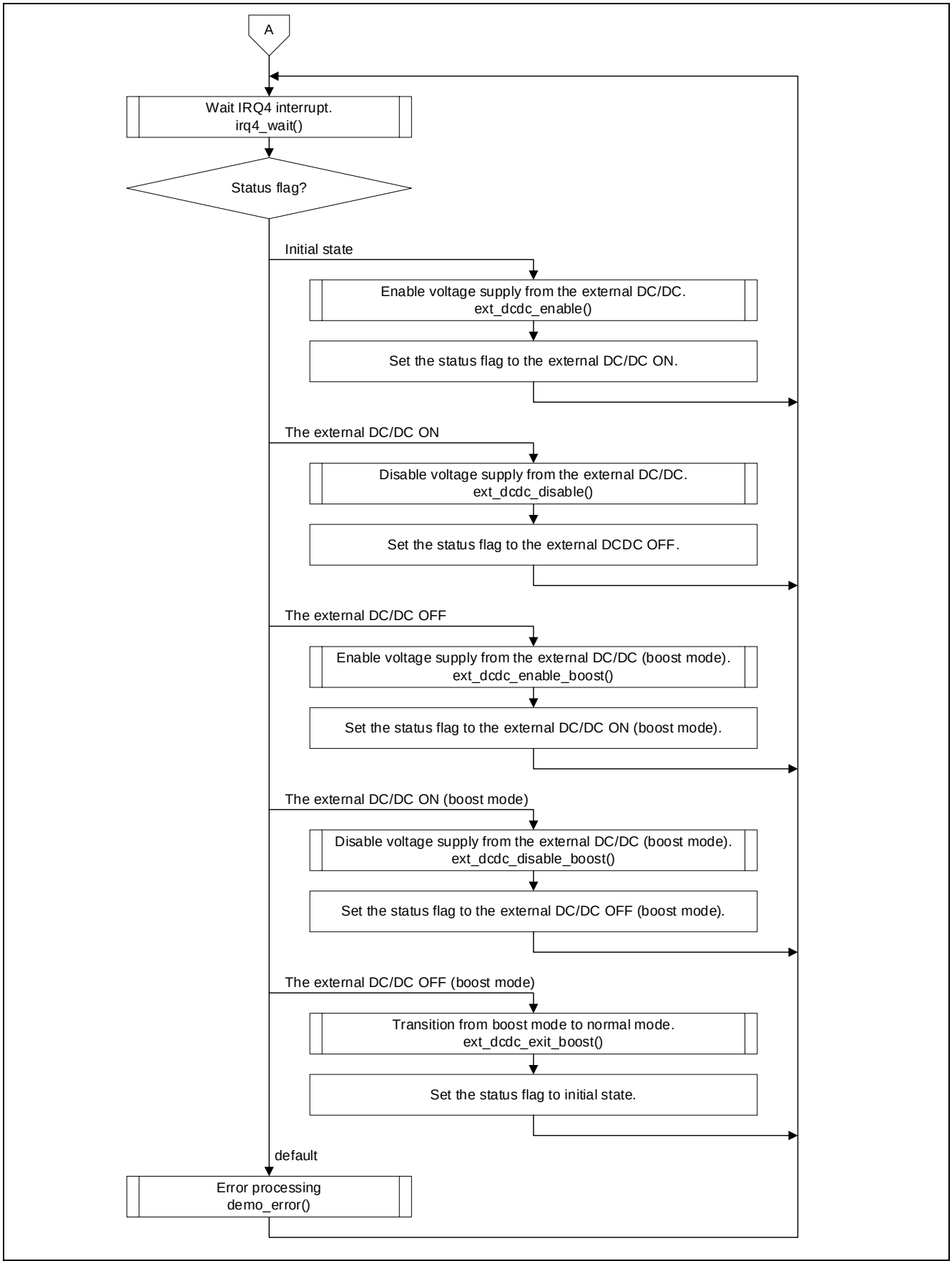


Figure 7-4 Main process of changing the voltage supply to the internal circuit (2/2)

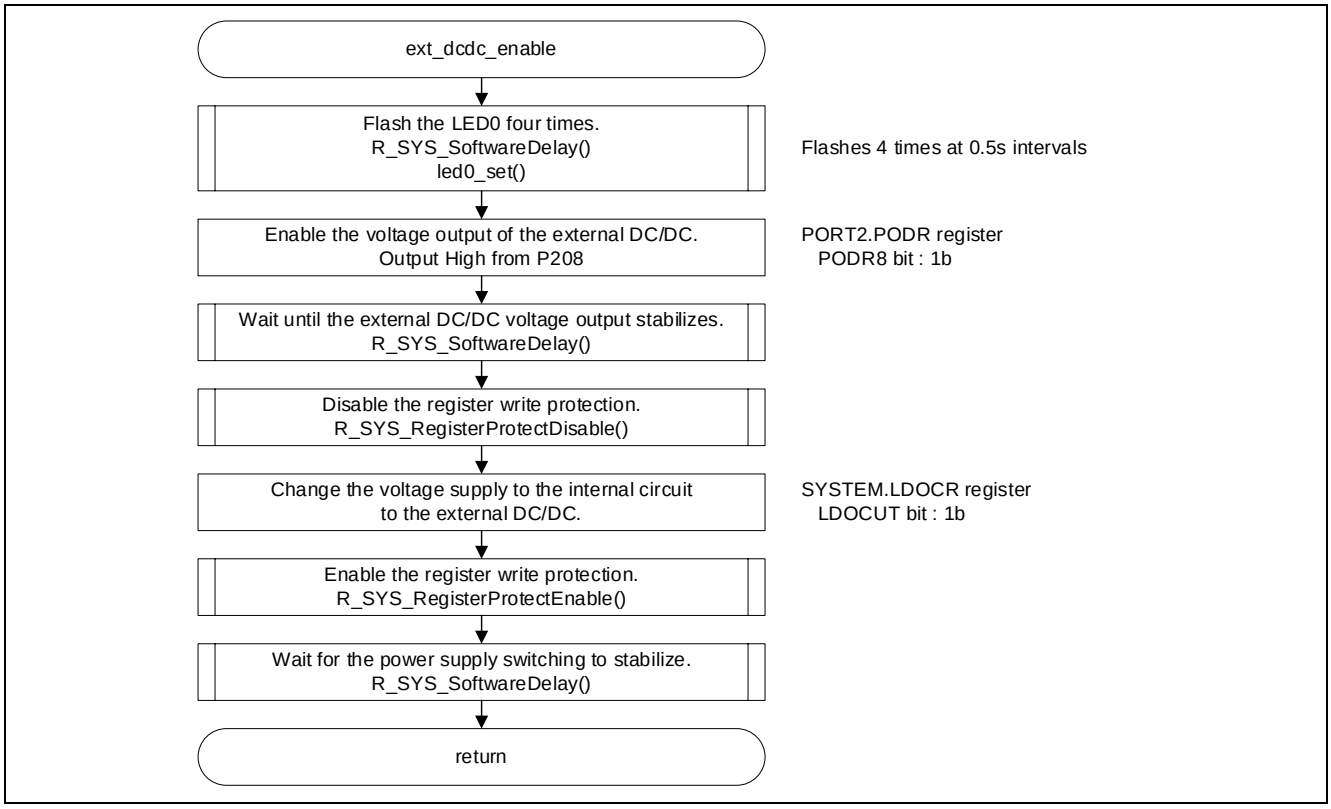


Figure 7-5 Enable the voltage supply from the external DC/DCs

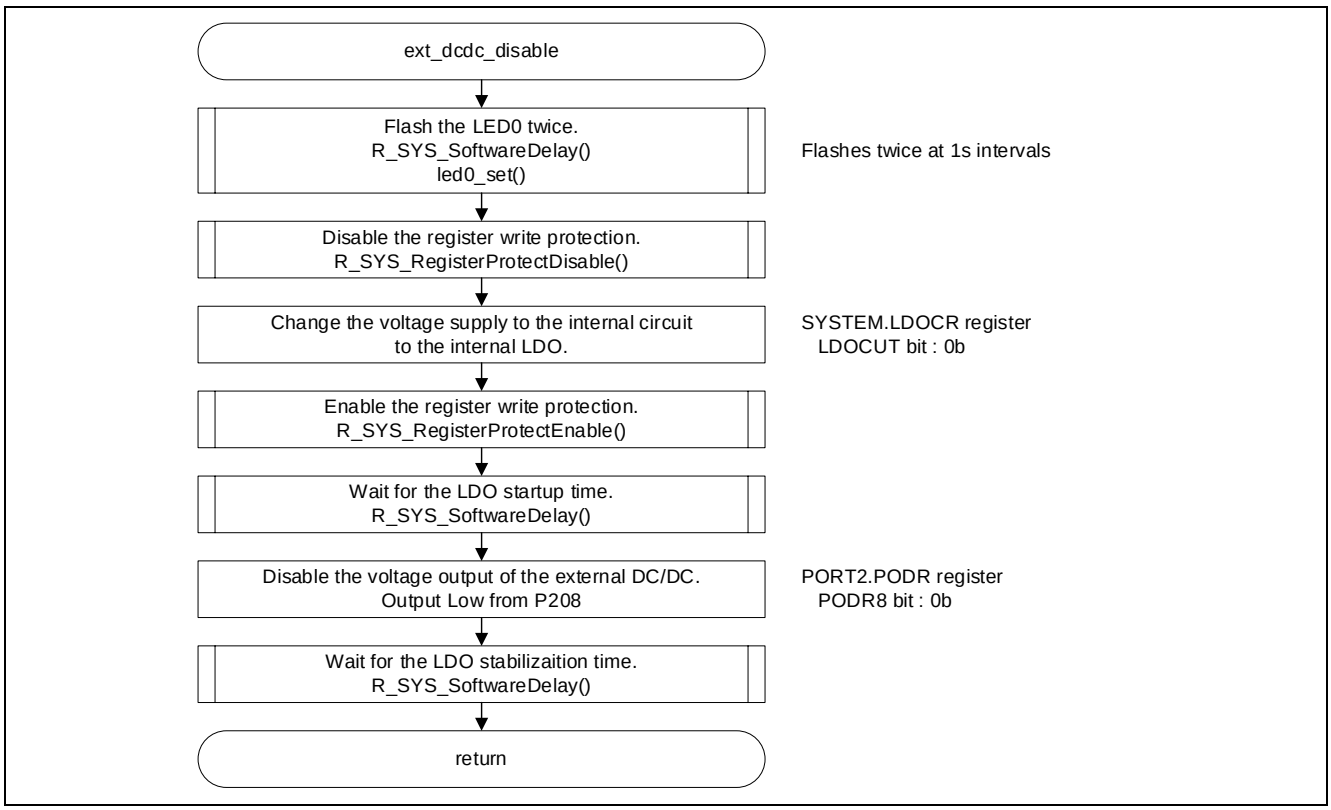


Figure 7-6 Disable the voltage supply from the external DC/DCs

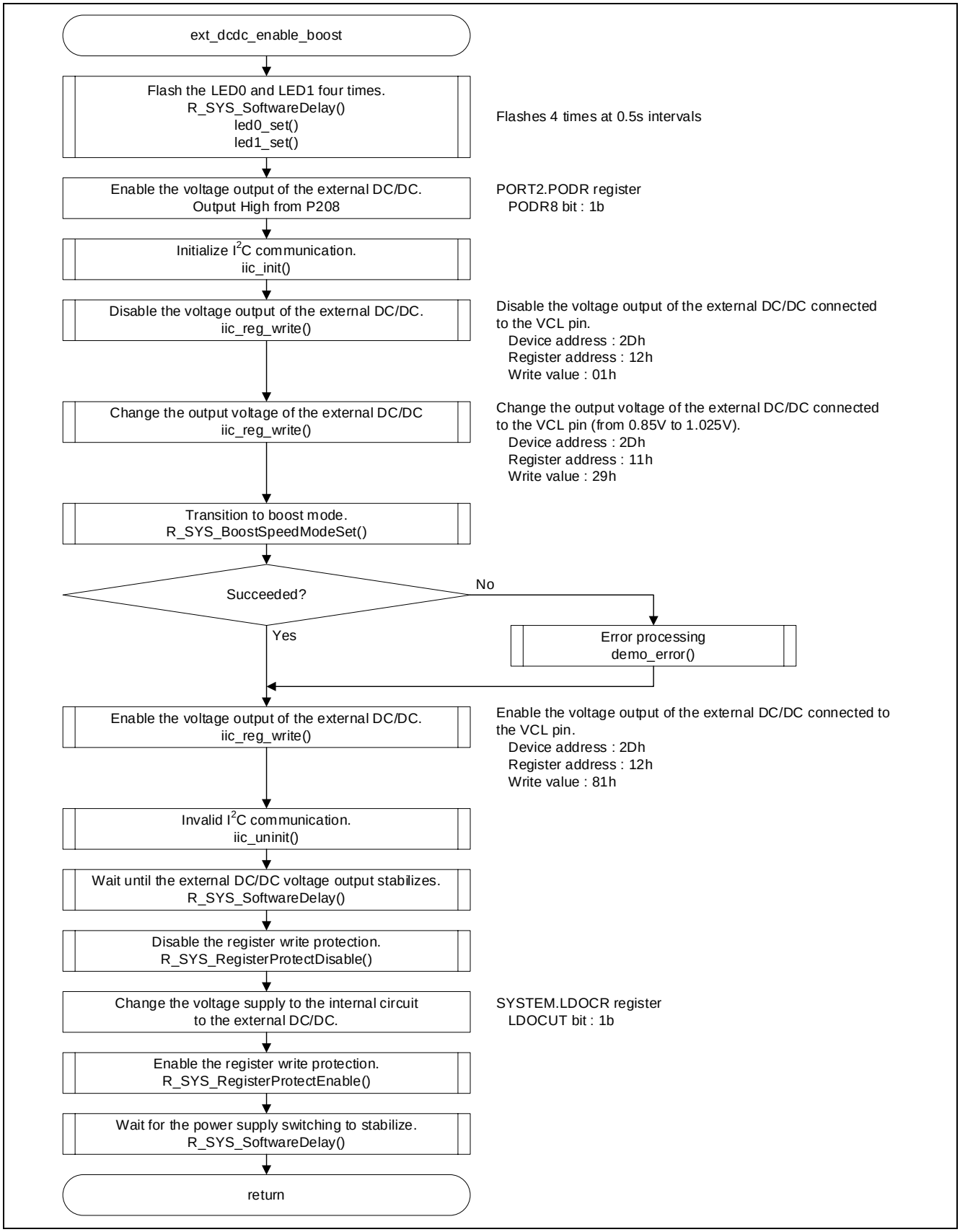


Figure 7-7 Enable the voltage supply from the external DC/DCs (in the boost mode)

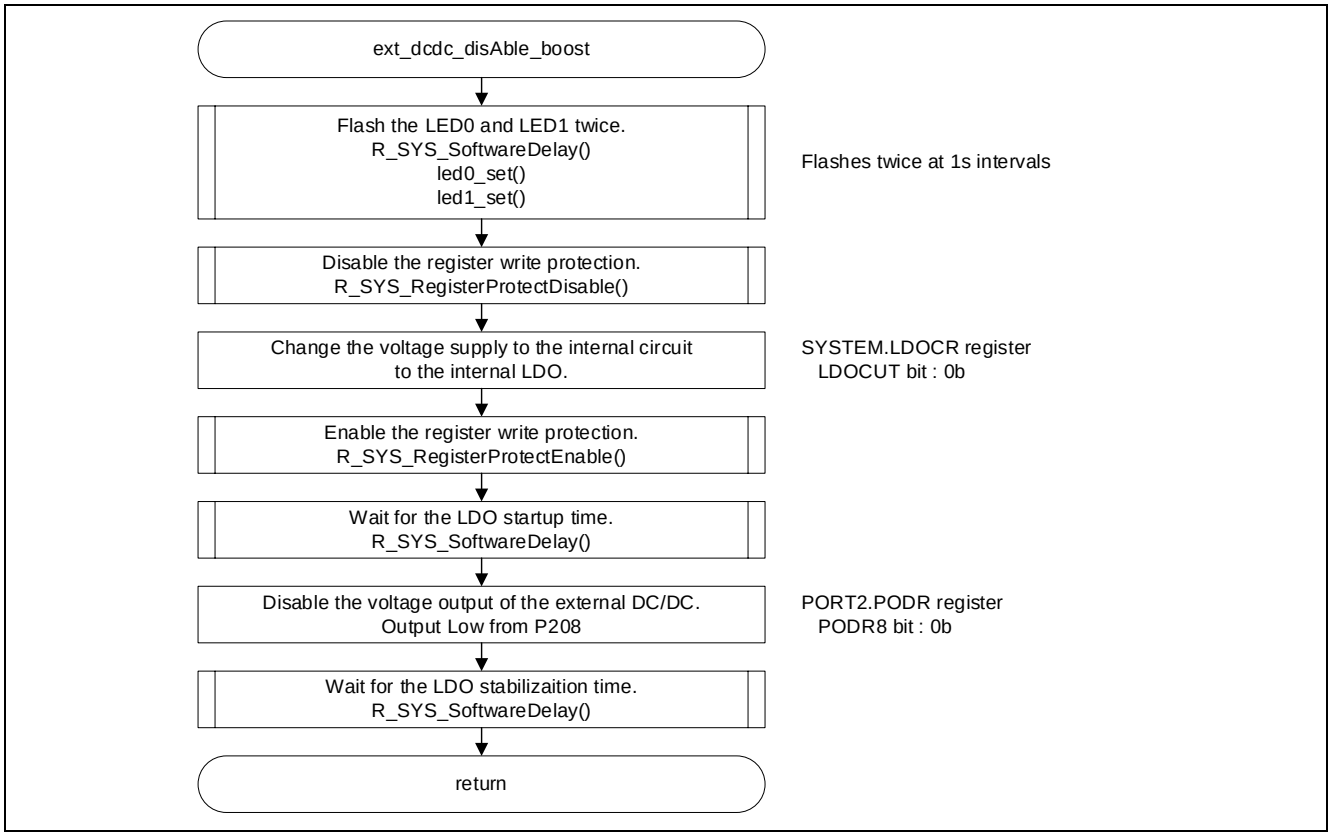


Figure 7-8 Disable the voltage supply from the external DC/DCs (in the boost mode)

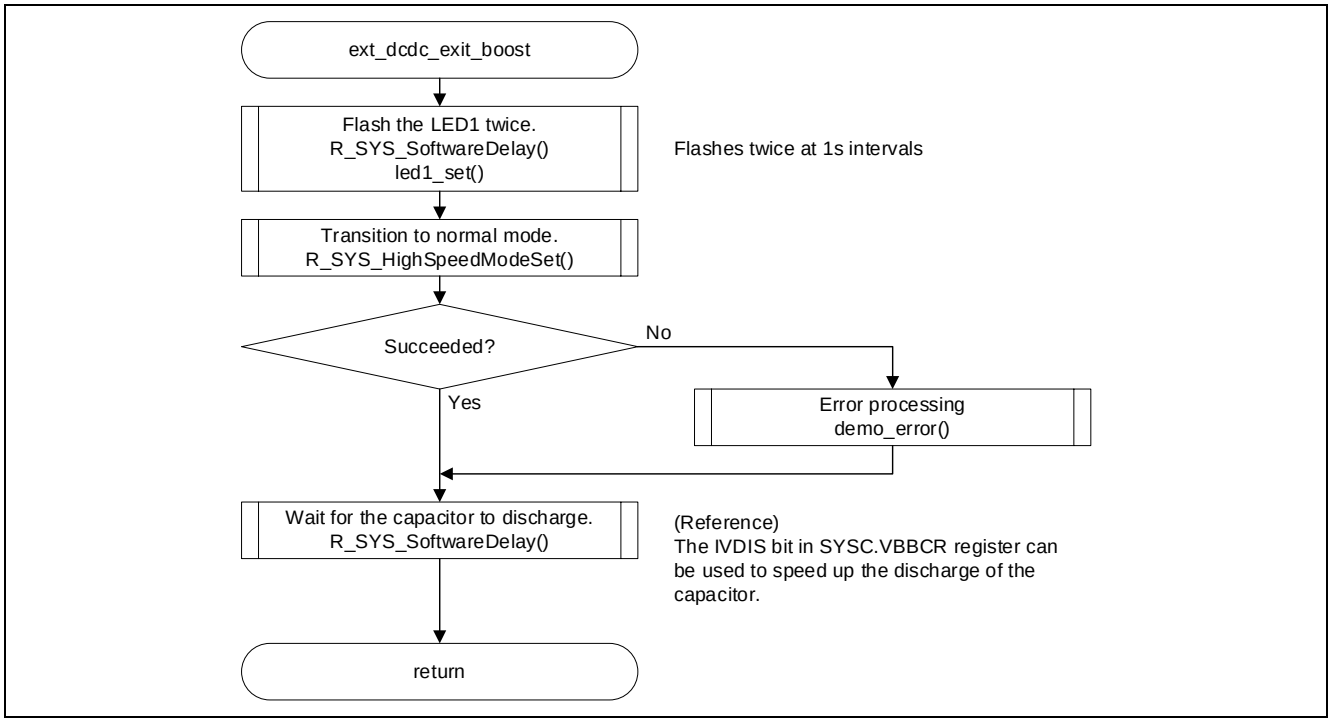


Figure 7-9 Change the mode from the boost mode to the normal mode

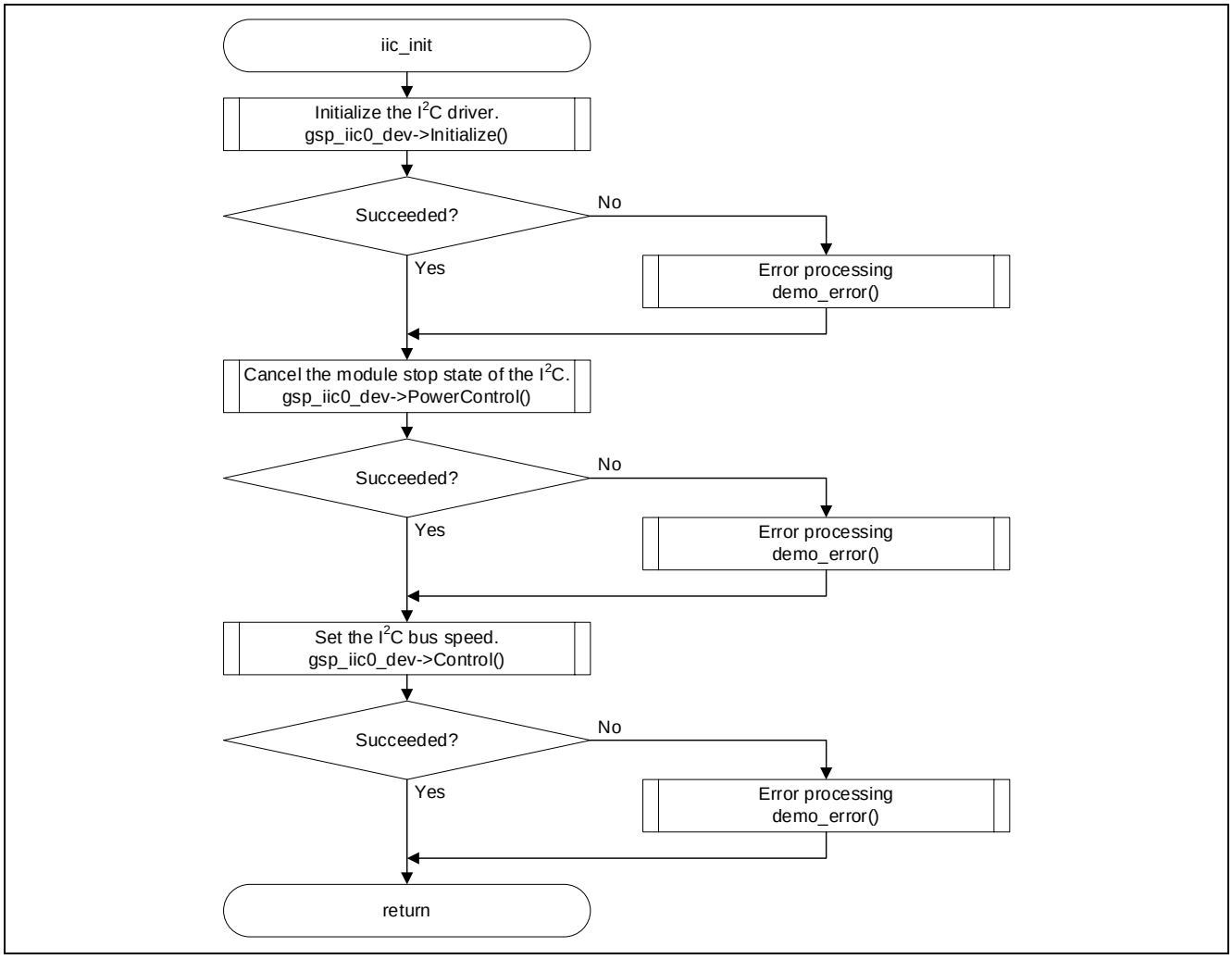


Figure 7-10 I²C-BUS communication initialization

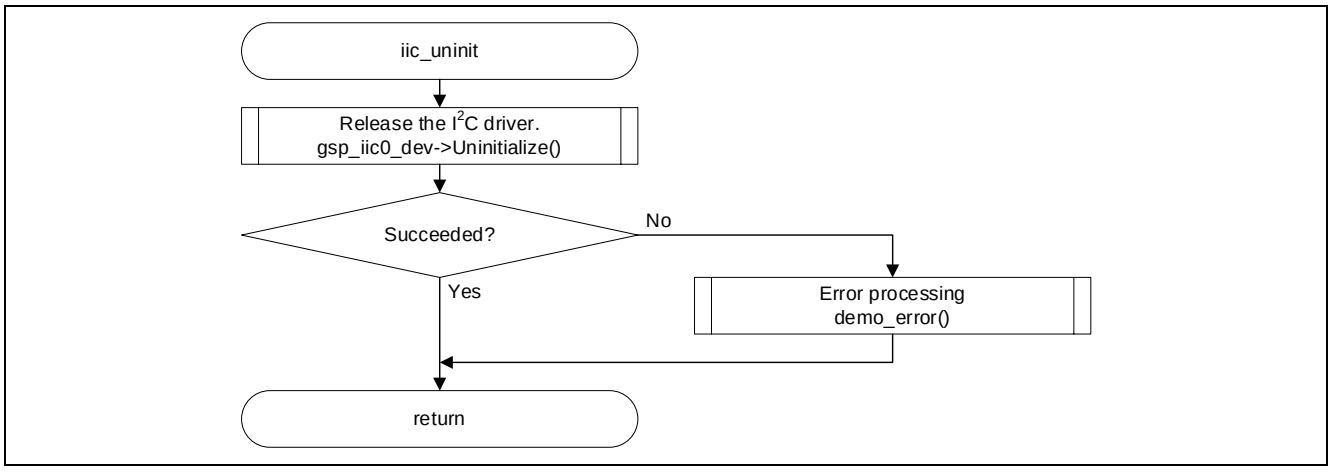


Figure 7-11 I²C-BUS communication finalization

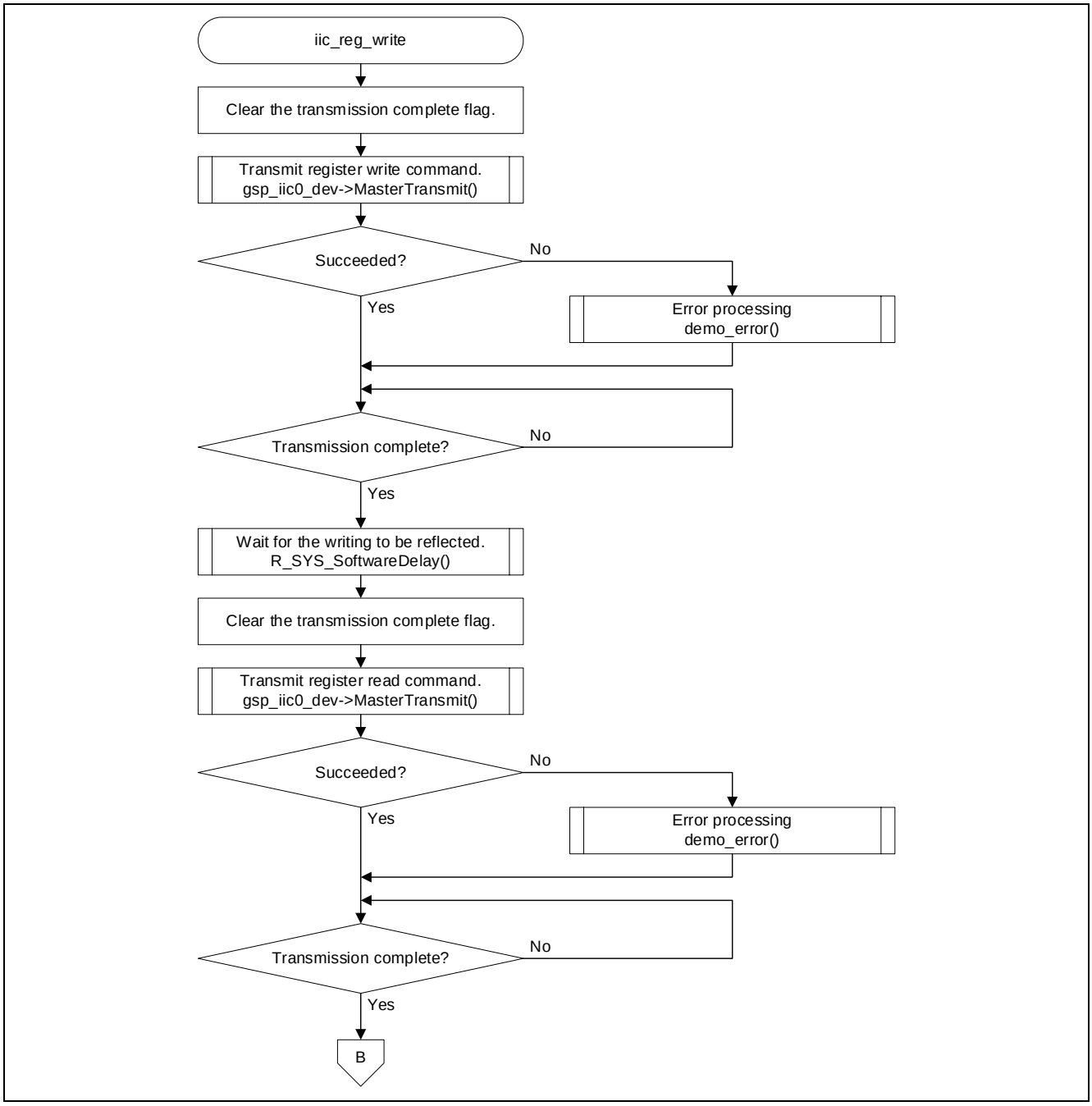


Figure 7-12 Write a register on the ISL9123 through I²C-BUS communication (1/2)

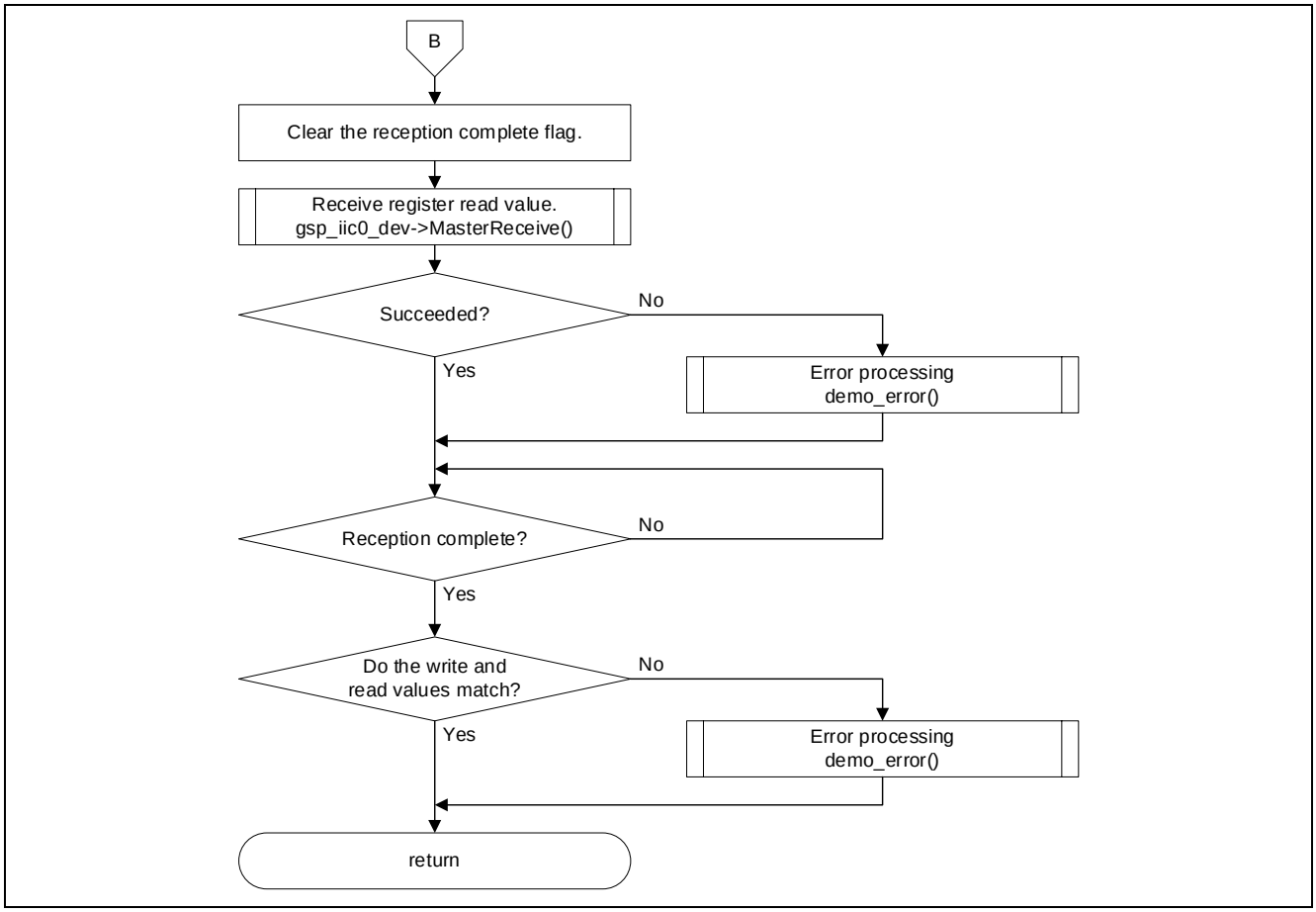


Figure 7-13 Write a register on the ISL9123 through I²C-BUS communication (2/2)

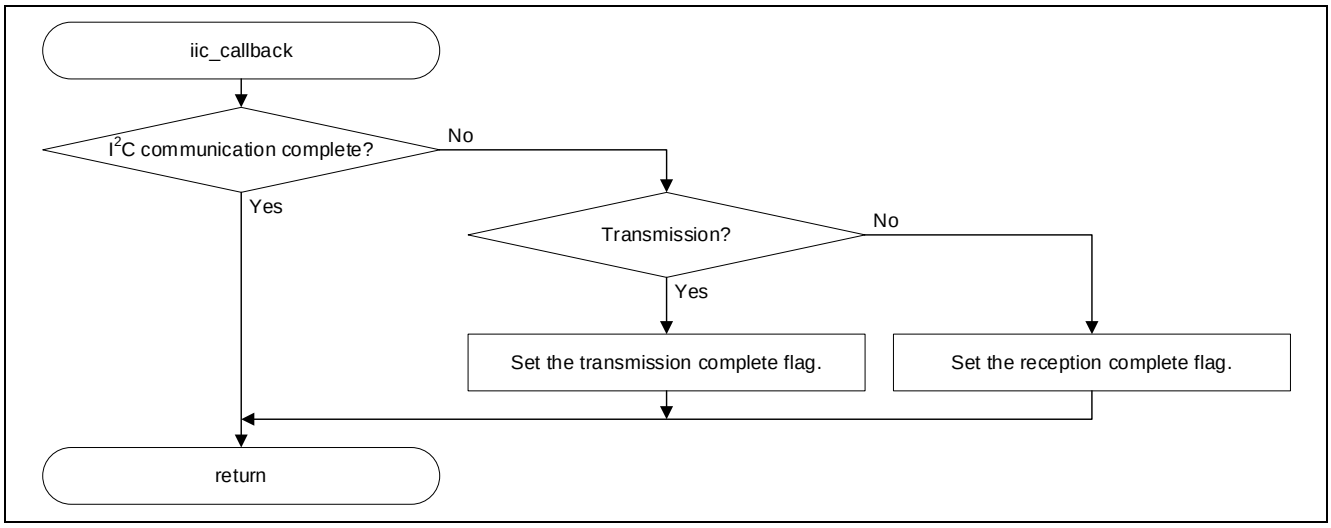


Figure 7-14 Callback function of I²C-BUS communication

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jul.02.2020	-	First edition, issued
1.01	Aug.17.2020	17	Table 7-3 Files added or changed in the sample code • The setting of r_i2c_cfg.h was added.

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.

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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
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