RL78 Family C Compiler Package (CC-RL)

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How to Divide Boot and Flash Areas

Introduction

This document describes the processing necessary to divide a program into boot and flash areas when using the C compiler for the RL78 family (CC-RL).

Versions of Tools with which Correct Operation has been Confirmed

The following tools and versions were used for the descriptions in this document.

- C compiler for the RL78 family (CC-RL): V1.08.00
- e² studio integrated development environment: V7.3.0
- CS+ for CC integrated development environment: V8.01.00

Contents

1.   Overview

1.1   Dividing the Boot and Flash Areas

The purpose of dividing the boot and flash areas is to ensure that only the program in the flash area can be modified without reconfiguring the program in the boot area.
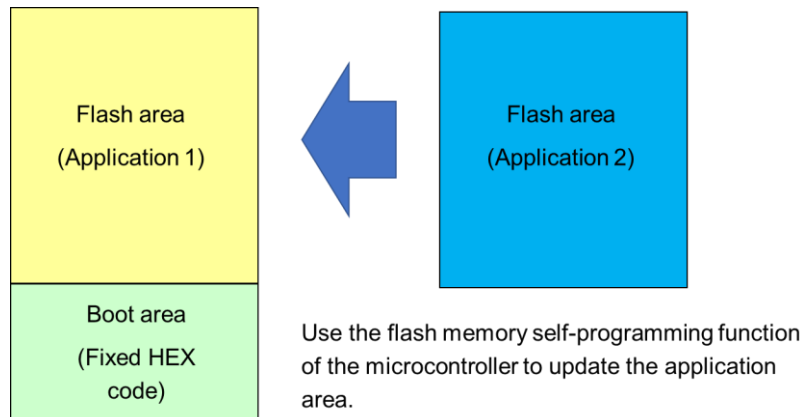
Figure 1   Divided Areas on System

Note: In this document, the boot area is defined as an area that cannot be modified following design of the system while the flash area is defined as an area that can be modified or replaced on the system.

To divide the boot and flash areas, create two projects, one to be used as the boot area project and the other to be used as the flash area project. These projects must satisfy the following conditions.

- The variables and functions in the boot area are accessible from the flash area.
  — The linker option -FSymbol should be used for the boot area project so that externally defined symbols will be output in a file.
  — The above externally defined symbol file should be specified as a target of building in the flash area project.
- The functions in the flash area can be called from the boot area through a function table.
  — When calling functions in the flash area, the boot area project should call the address of each branch instruction for a function that is specified in the function table.
  — A table of branch instructions for functions to be called from the boot area project should be created in the flash area project.
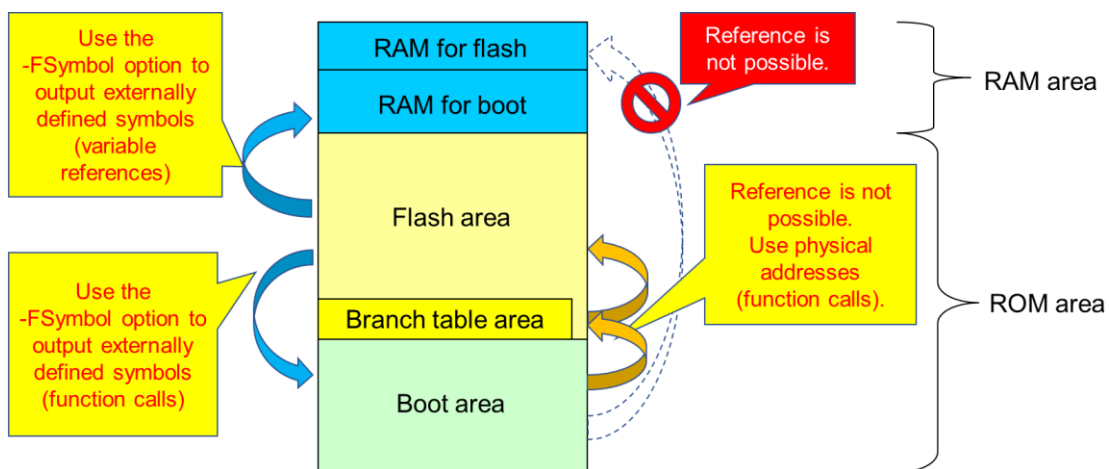
Figure 2   References to Variables and Functions between the Boot and Flash Areas

1.2   Allocating the Boot and Flash Areas

Allocate the boot and flash areas as follows.
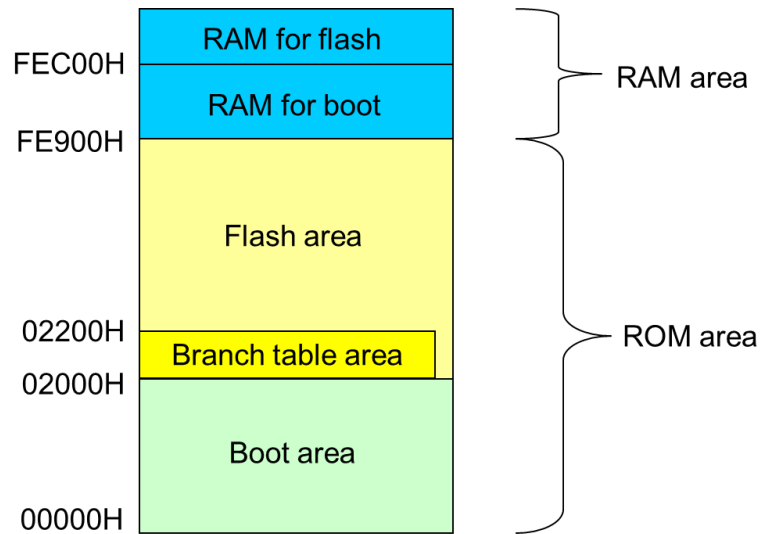
Figure 3   Example of Allocating the Boot and Flash Areas

1.3   Procedures for Creating the Boot Area and Flash Area Projects

Follow the procedures below to create the boot area and flash area projects.

1. Creating the boot area project
   A. Create boot area programs in the source file.
   B. Specify the necessary linker options.
   C. Build the boot area project before the flash area project because the boot area project is required for building the flash area project.

2. Creating the flash area project
   A. Create flash area programs in the source files.
   B. Specify the necessary linker options.

1.4   Overview of Build Processing for the Boot and Flash Areas

Figure 4 shows an overview of build processing for the boot and flash areas.
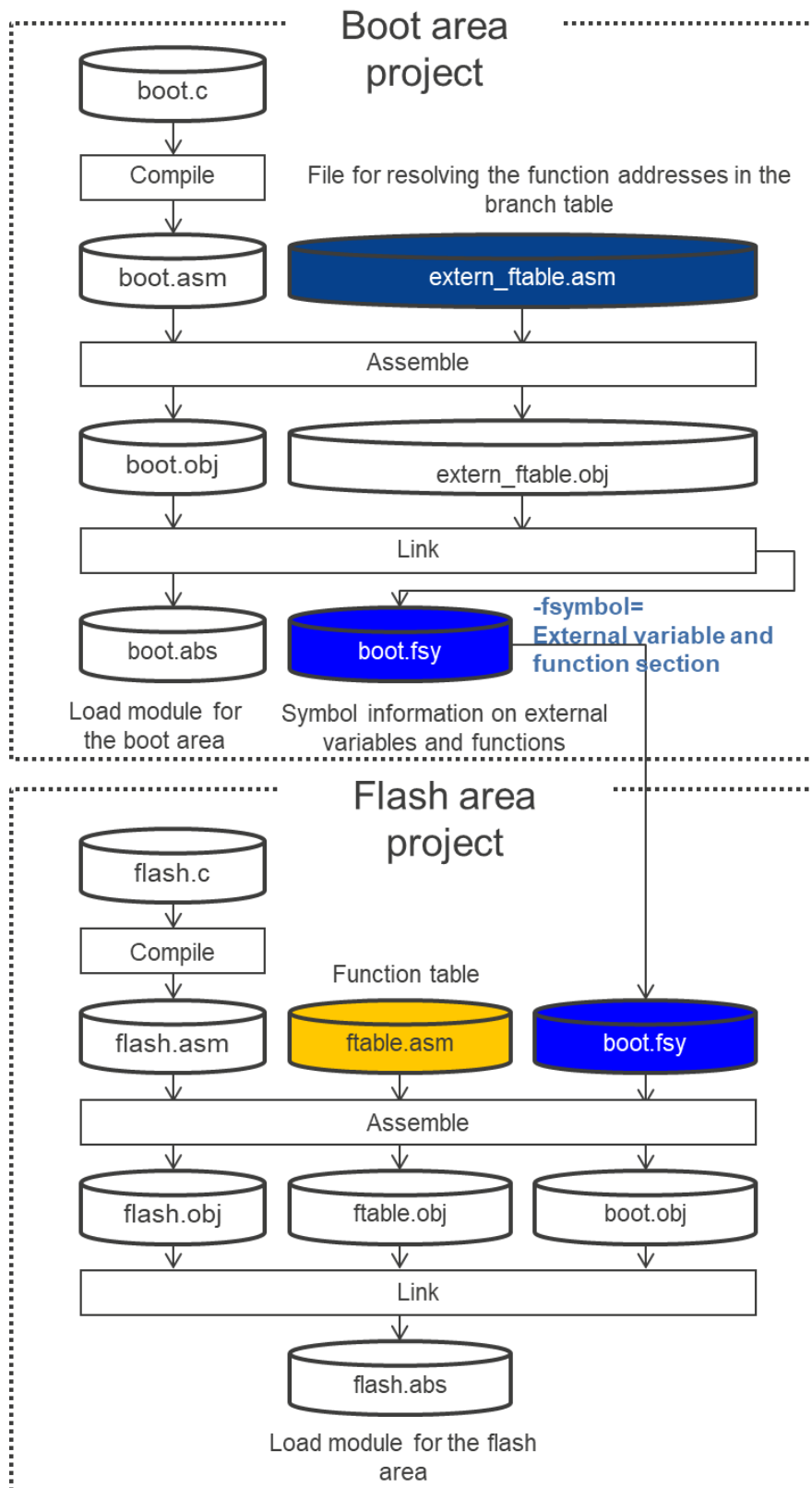
Figure 4   Build Processing for the Boot and Flash Areas

2.　Common Processing for the Boot and Flash Areas

2.1　Creating projects

2.1.1　e² studio

1.　Create projects

Create a boot area project and a flash area project by following the procedures given in section 1.3, Procedures for Creating the Boot and Flash Areas.

Place a tick in the "boot" checkbox to configure the flash area project to allow reference to the boot area project from the flash area project when the flash area project is built. In such cases, the boot area project is built before the flash area project.
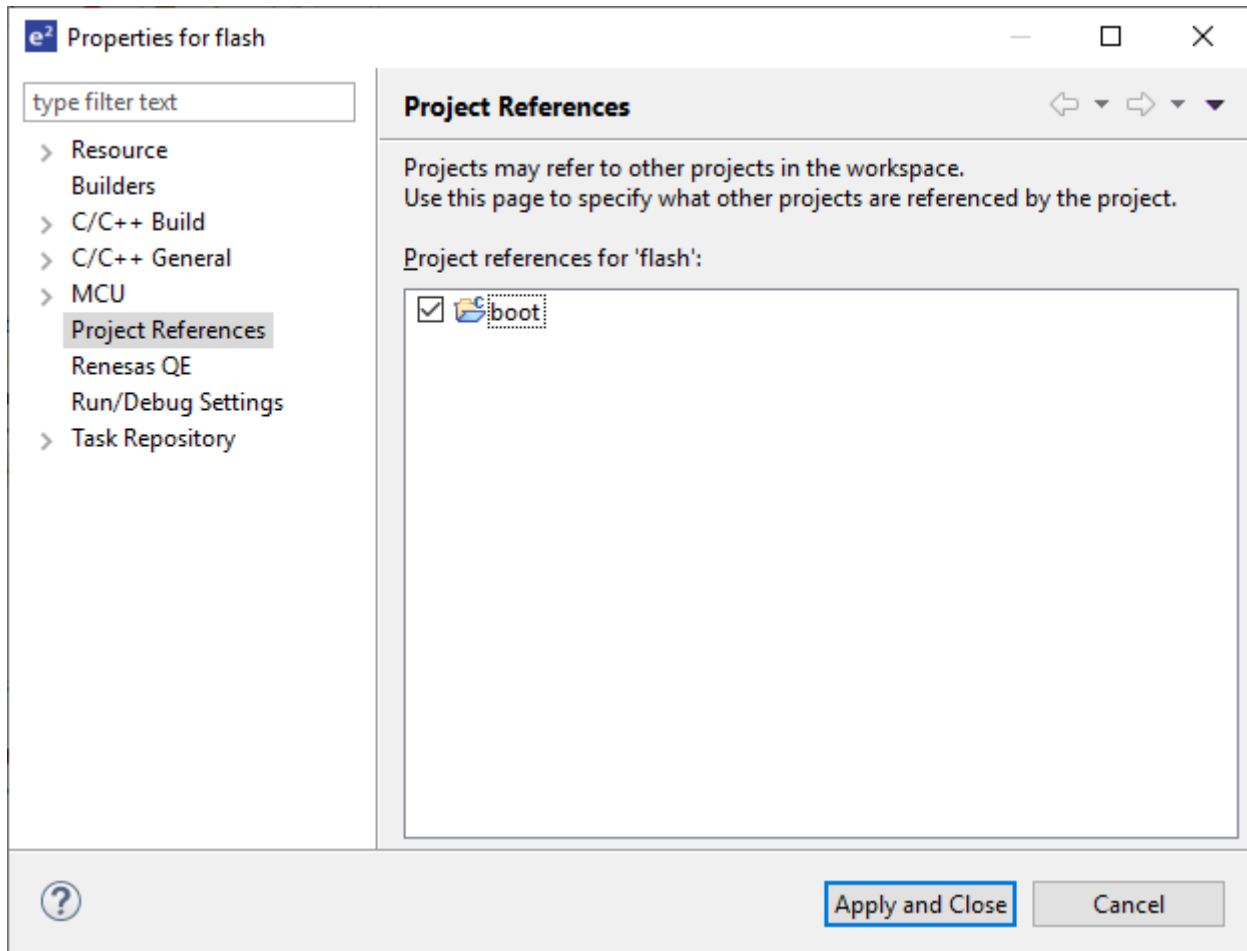
Figure 5　　Setting the Flash Area Project to Allow Reference to the Boot Area Project

2. Add files as targets of building
   A. Add the following files to the boot area project as targets of building.
      - extern_ftable.asm
      - ftable.inc
      - ocdmon_ce.asm
   B. Add the following files to the flash area project as targets of building.
      - boot.fsy (this file is generated after the boot area project is built)
      - ftable.asm
      - ftable.inc
      - int.c
      - sub_mot.txt
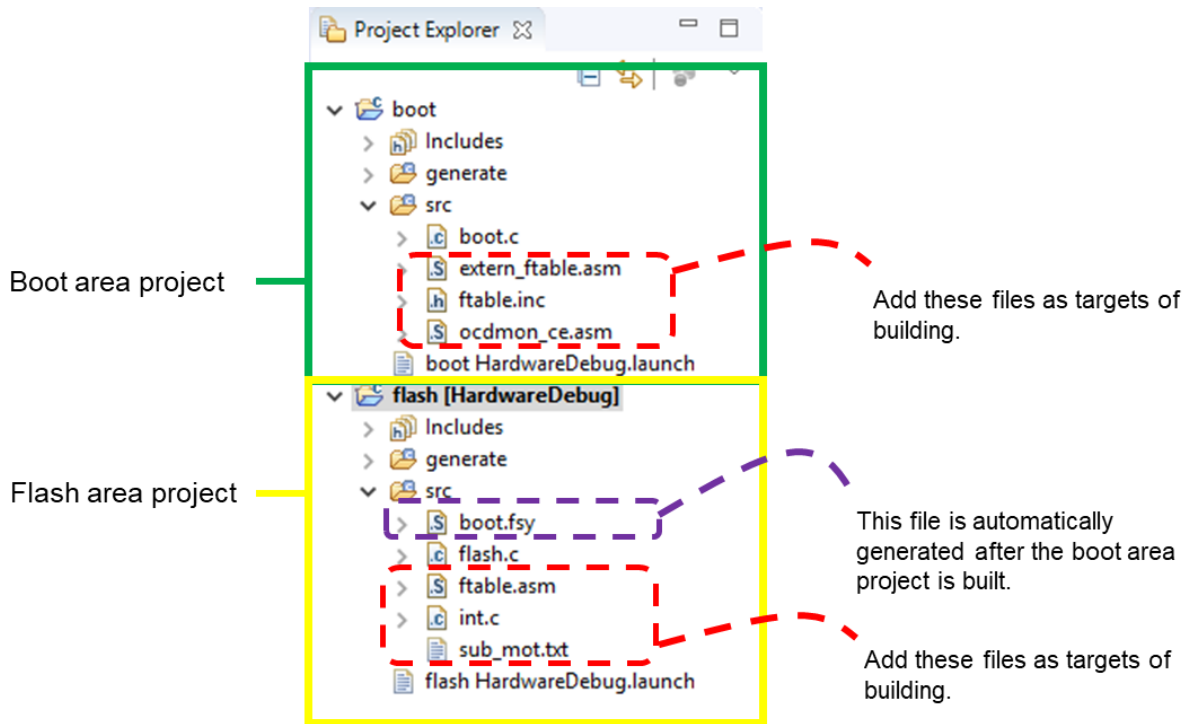
Figure 6   Example of Creating Projects with the e^2 studio

2.1.2 CS+

1. Create projects

Create the flash area project as the main project and the boot area project as a sub-project*.

Note: The build order in CS+ should be [Sub-project] -> [Main project].
The boot area program will not be modified once it is created. Therefore, when creating the second- or a later generation flash area project, the sub-project can be deleted.

2. Exclude the automatically generated file from the targets of building

Exclude the following file from the boot area and flash area projects.

- main.c

3. Add files as targets of building
   A. Add the following files to the boot area project.
      - boot.c
      - extern_ftable.asm
      - ftable.inc
      - ocdmon_ce.asm
   B. Add the following files to the flash area project.
      - flash.c
      - ftable.asm
      - ftable.inc
      - int.c
      - boot.fsy
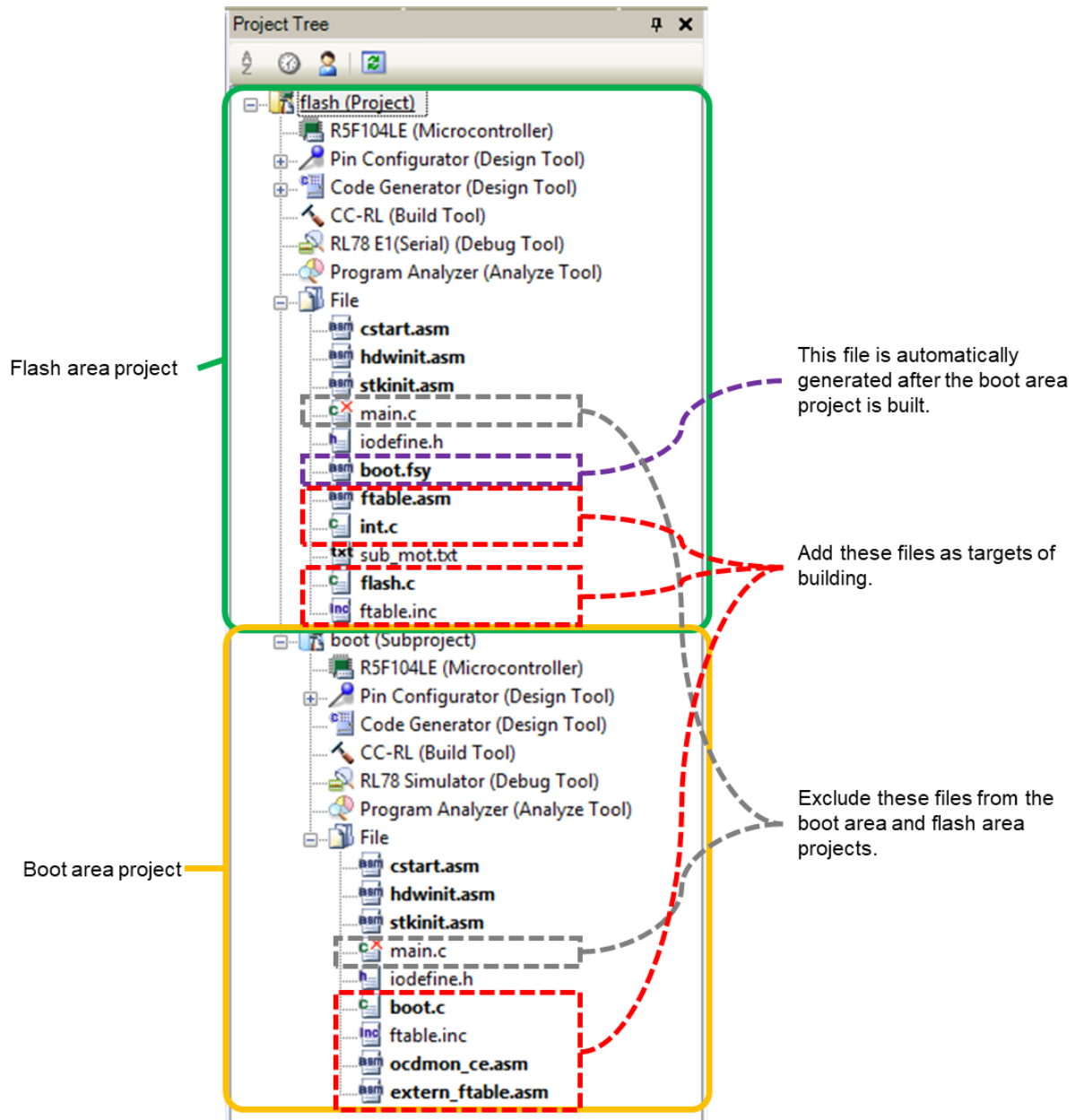
Figure 7　　Example of Creating Projects with CS+

2.2   Creating a common program for the boot and flash areas

2.2.1   Address definition file for the branch table (assembly language)

- Create ftable.inc, which is the address definition file for the branch table for reference from both the boot and flash areas.
    - FLASH_TABLE: Start address of the branch table
    - INTERRUPT_OFFSET: Size of the interrupt area in the branch table

Example: ftable.inc

```
FLASH_TABLE       .EQU  0x2000
INTERRUPT_OFFSET  .EQU  0x100
```

2.3   Hex files for the boot and flash areas

File names used in this document are listed below (output procedures are described later).

- Hex file for the boot and flash areas combined: boot_flash.mot
- Hex file for the flash area: flash2000_ffff.mot
- Hex file for the boot area: boot0000_1fff.mot

Note: A load module file (*.abs) is separately generated for each of the boot and flash areas.
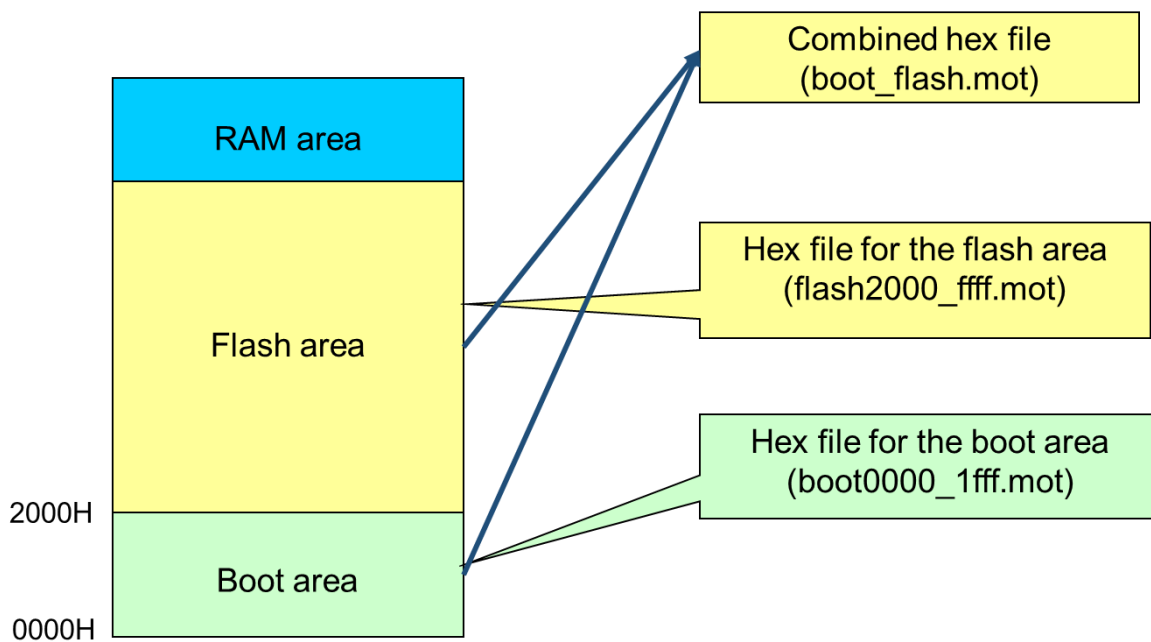
Figure 8   Hex Files for the Boot and Flash Areas

2.4 Initialization procedure

Figure 9 shows the initialization procedure.
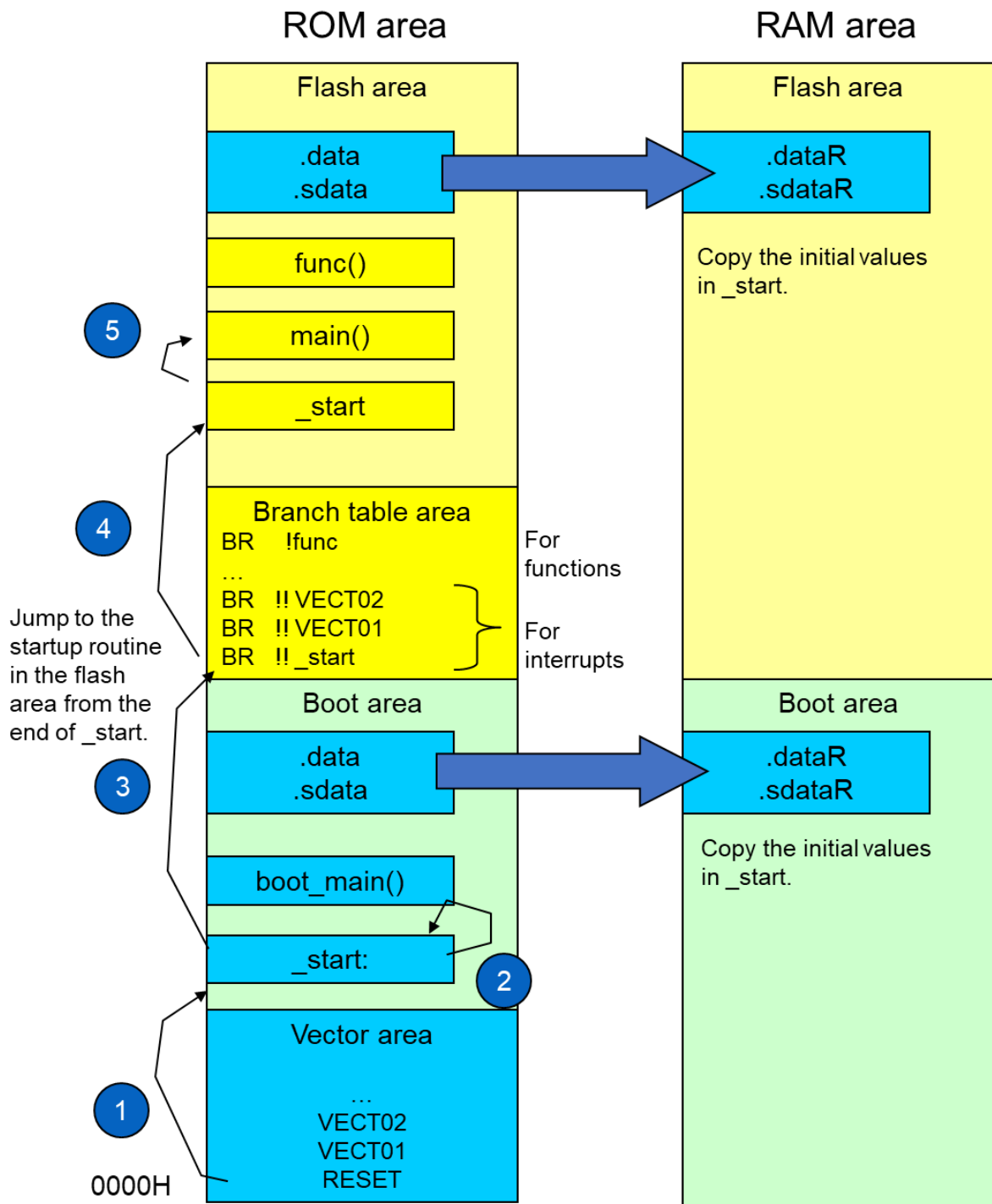
Figure 9　　Initialization Procedure

3. Boot Area

3.1 Creating boot area programs

The following steps are required for boot area programs.

— Modifying the startup routine
— Modifying hdwinit.asm and stkinit.asm
— Creating the program such that the on-chip debug area is secured
— Creating a file for resolving the function addresses in the branch table

3.1.1 Modifying the startup routine (cstart.asm)

The procedure for modifying the startup routine (cstart.asm) is given below.

1. Add inclusion of the address definition file for the branch table.

Example: Modifying cstart.asm (1/6)

```
$IFNDEF __RENESAS_VERSION__
__RENESAS_VERSION__  .EQU  0x01000000
$ENDIF

$INCLUDE "ftable.inc"
```

2. Comment out the conditional assembly control instructions to make the definition of the .stack_bss
   section valid.

Example: Modifying cstart.asm (2/6)

```
;$IF (__RENESAS_VERSION__ < 0x01010000); for CC-RL V1.00
;----------------------------------------------------------------
; stack area
;----------------------------------------------------------------
; !!! [CAUTION]!!!
; Set up stack size suitable for a project.
.SECTION .stack_bss, BSS
_stackend:
  .DS    0x200
_stacktop:
;$ENDIF
```

3. Modify the section name to exclude it from the target of the -FSymbol option (which is used to output
   externally defined symbols).

Example: Modifying cstart.asm (3/6)

```
;----------------------------------------------------------------------
; startup
;----------------------------------------------------------------------
.SECTION .btext, TEXT
_start:
```

4. Comment out the conditional assembly control instructions to specify the explicitly allocated .stack_bss section as the stack pointer.

Example: Modifying cstart.asm (4/6)

```
    ;-------------------------------------------------
    ; setting the stack pointer
    ;-------------------------------------------------
;$IF ( __RENESAS_VERSION__ >= 0x01010000)
; MOVW    SP,#LOWW(__STACK_ADDR_START)
;$ELSE   ; for CC-RL V1.00
  MOVW    SP,#LOWW(_stacktop)
;$ENDIF
```

5. Modify the main function call to the call to the main function for the boot area, and add a branch instruction to the flash area startup routine.

Example: Modifying cstart.asm (5/6)

```
    ;-------------------------------------------------
    ; call main function
    ;-------------------------------------------------
  CALL    !!_boot_main   ; main();
  BR      !!FLASH_TABLE
```

6. Comment out the definition of the .const section when no mirror source area is included in the boot area.

Example: Modifying cstart.asm (6/6)

```
; section
;-----------------------------------------------------------------------------
$IF ( __RENESAS_VERSION__ >= 0x01010000)
.SECTION .RLIB, TEXTF
.L_section_RLIB:
.SECTION .SLIB, TEXTF
.L_section_SLIB:
$ENDIF
.SECTION .textf, TEXTF
.L_section_textf:
;.SECTION .const, CONST
;.L_section_const:
```

3.1.2   Modifying hdwinit.asm and stkinit.asm

Modify the section name to exclude it from the target of the -FSymbol option (which is used to output externally defined symbols).

Example: Modifying hdwinit.asm and stkinit.asm

```
.btextf  .CSEG TEXTF
```

3.1.3   Creating the program such that the on-chip debug area is secured (ocdrom_ce.asm)

To use the on-chip debugging function, specific memory areas are required to be empty (filled with 0xff).

Specifying the -debug_monitor option of the linker leads to the generation of a load module file in which the addresses 0x0002 to 0x0003, 0x00ce to 0x00d7, and the last 512 bytes of ROM are filled with 0xff (set up according to the information in the device file specified with the -device option).

Since the last 512 bytes of ROM are part of the flash area, make the following settings for the boot area.

- Addresses 0x0002 to 0x0003
  Specify 0xffff with the linker option -VECTN.

- Addresses 0x00ce to 0x00d7
  Make definitions in the assembly source (see the following program).

Example: ocdrom_ce.asm

```
MON_CE   .CSEG AT 0x00ce
  .DB8 0xffffffffffffffff
  .DB2 0xffff
```

- Last 512 bytes of ROM
  Allocate this area through the flash area project.

3.1.4   Creating a file for resolving the function addresses in the branch table (extern_ftable.asm)

- Define symbols for resolving the addresses for the branch table to be used to call functions in the flash area from the boot area.
- Register this file in the project.

Example: Creating extern_ftable.asm

```
$INCLUDE "ftable.inc"
  .public _f1
_f1  .equ  (FLASH_TABLE + INTERRUPT_OFFSET + (0 * 4))
  .public _f2
_f2  .equ  (FLASH_TABLE + INTERRUPT_OFFSET + (1 * 4))
```

3.2   Specifying boot area options

Make the following option settings for the boot area.

— Output of a file for the externally defined symbols
— Specify the section allocation
— Specify a vector for branching to the interrupt function in the flash area
— Make necessary settings for the on-chip debugging function
— Specify hex file output only to the boot area address range

3.2.1   Output of a file for the externally defined symbols

The externally defined symbols need to be output to a file so that the flash area project has access to the variables and functions in the boot area.

Register all target sections with the -FSymbol option.

Example: e^2 studio

[Properties]→[C/C++ Build]→[Settings]→[Tool Settings] tabbed page

→[Linker]→[Output]→[Section that outputs external defined symbols to the file]

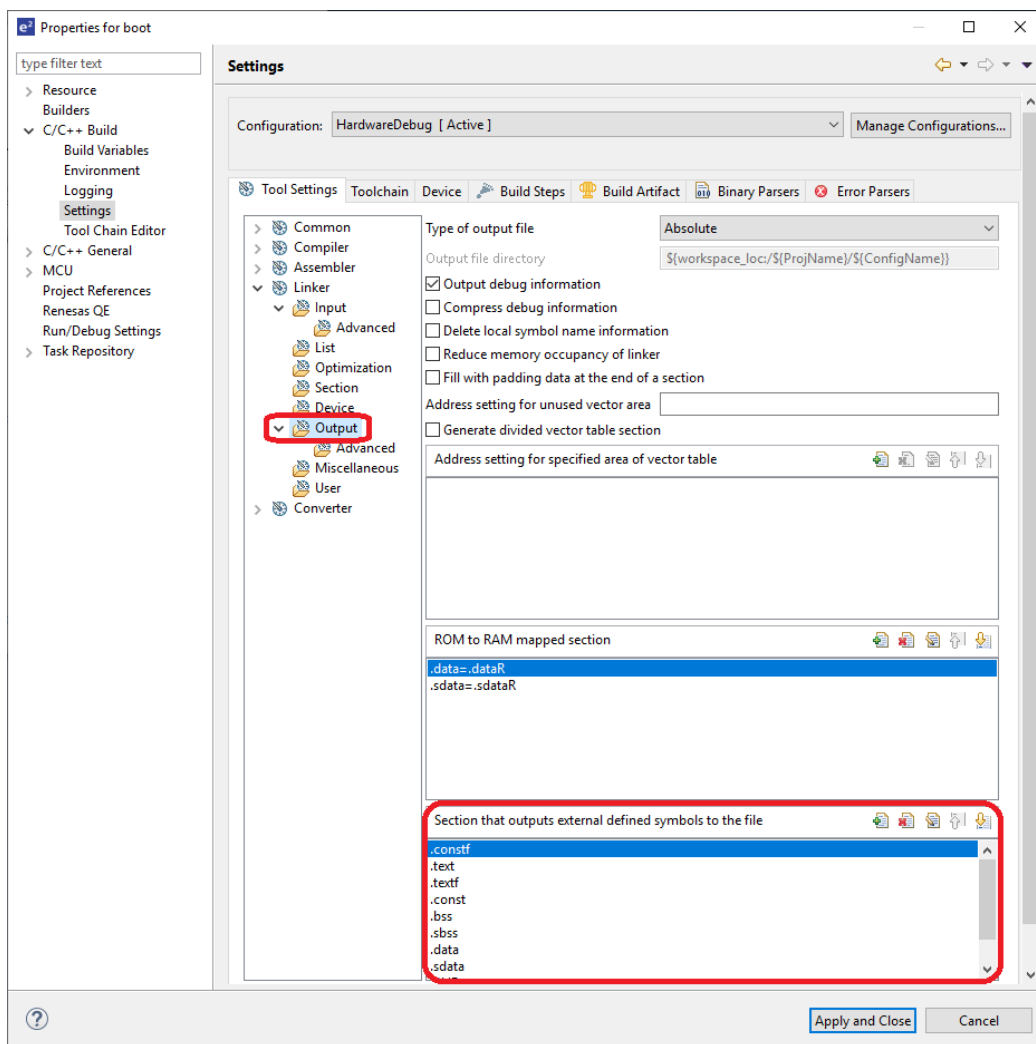**Figure 10   Example of Option Setting with the e^2 studio**

Example: CS+

[CC-RL (Build Tool)]→[Link Options] tabbed page

→[Section]→[Section that outputs external defined symbols to the file]
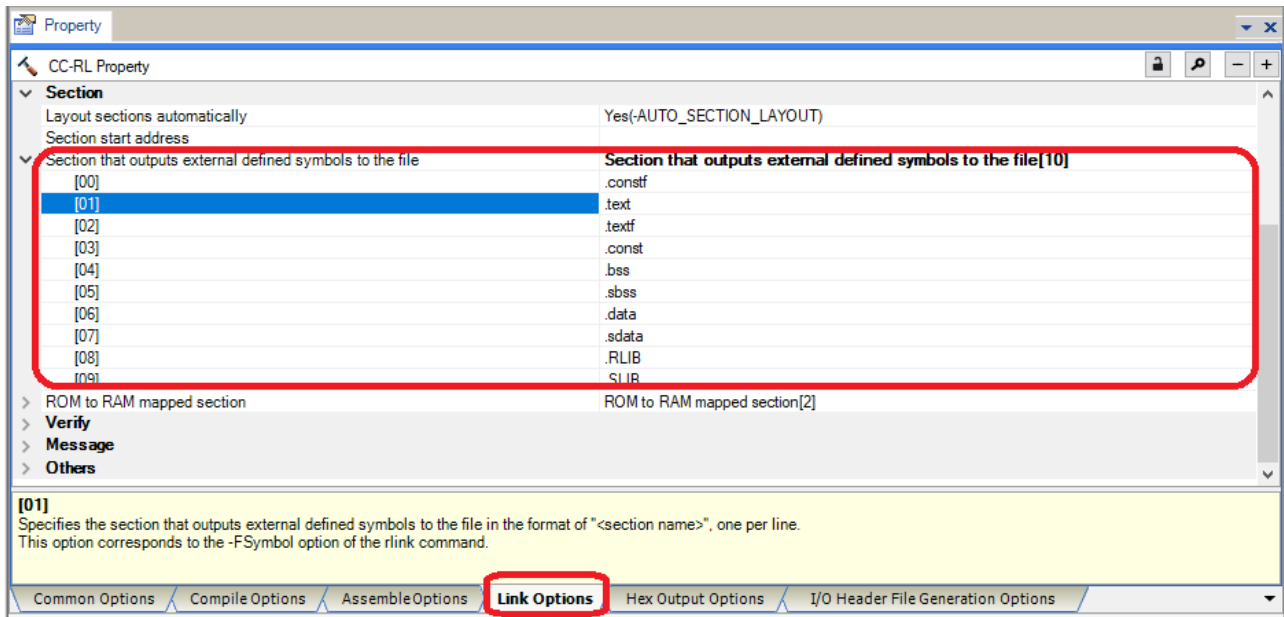
Figure 11　　Example of Option Setting with CS+

3.2.2　Specifying the section allocation

Specify the section allocation in the boot area with the linker option -start. Make sure that the sections do not overlap those in the flash area.

In addition, specify the stack area section.

Example: e^2 studio

[Properties]→[C/C++ Build]→[Settings]→[Tool Settings] tabbed page

→[Linker]→[Section]→[Section Viewer]
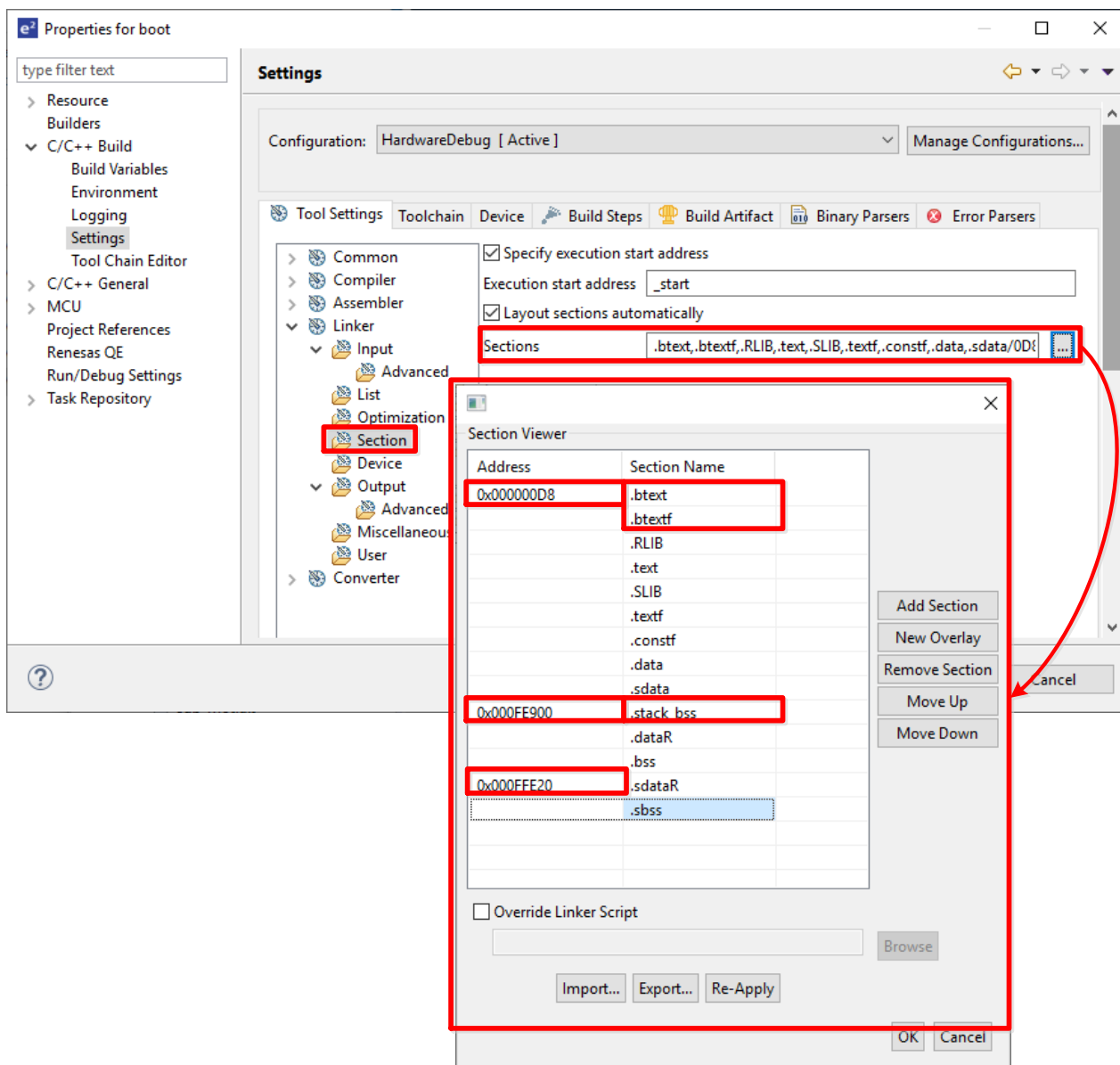
Figure 12　　Example of Option Setting with the e^2 studio

Example: CS+

[CC-RL (Build Tool)]→[Link Options] tabbed page

→[Section]→[Section start address]
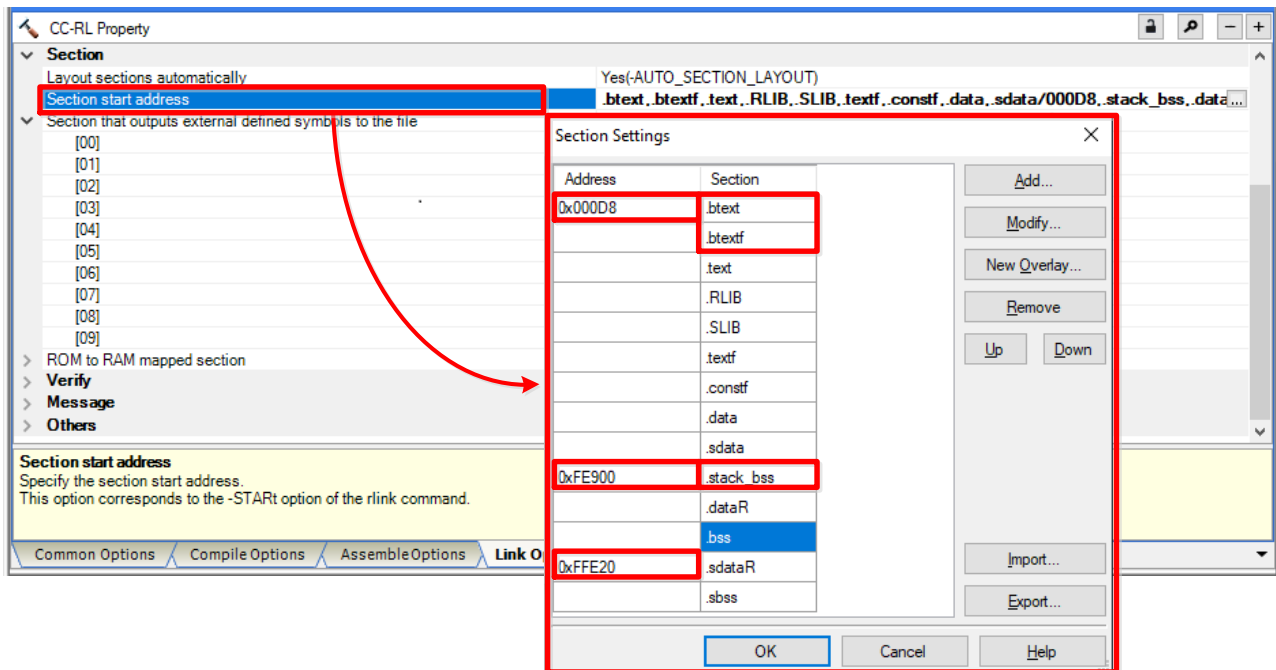
Figure 13   Example of Option Setting with CS+

3.2.3   Specifying a vector for branching to the interrupt function in the flash area

Specify the address in the branch table with the linker option -VECTN.

Example: e² studio

[Properties]→[C/C++ Build]→[Settings]→[Tool Settings] tabbed page

→[Linker]→[Output]→[Address setting for specified area of vector table]

→8=0x2010 (to specify 0x2010 for address 8)

Figure 14   Example of Option Setting with the e² studio

Example: CS+

[CC-RL (Build Tool)]→[Link Options] tabbed page

→[Output Code]→[Address setting for specified area of vector table]

→8=2010 (to specify 0x2010 for address 8)
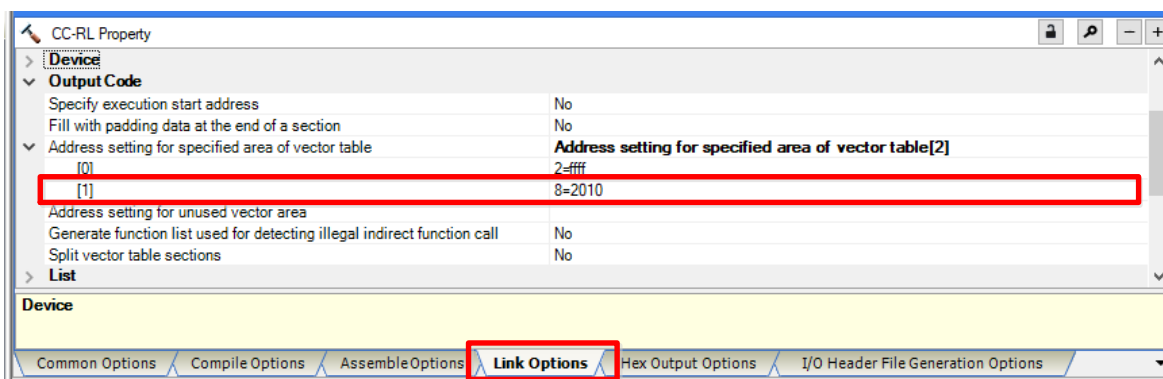
Figure 15   Example of Option Setting with CS+

3.2.4   Making necessary settings for the on-chip debugging function

1. Allocate the area of addresses 0x0002 and 0x0003 with the linker option -VECTN (if you are using the e2 studio, this area is automatically allocated).
2. Set the linker option –OCDBG to be enabled and specify the value for the on-chip debug option byte.

Example: e² studio

[Properties]→[C/C++ Build]→[Settings]→[Tool Settings] tabbed page

→[Linker]→[Device]→[Set enable/disable on-chip debug by link option]

Note: If you are using a hardware-debug build configuration (i.e. with "E1/E2", "E2", or "E2 Lite" selected as the debugger hardware), deselect the [Secure memory area of OCD monitor] checkbox.
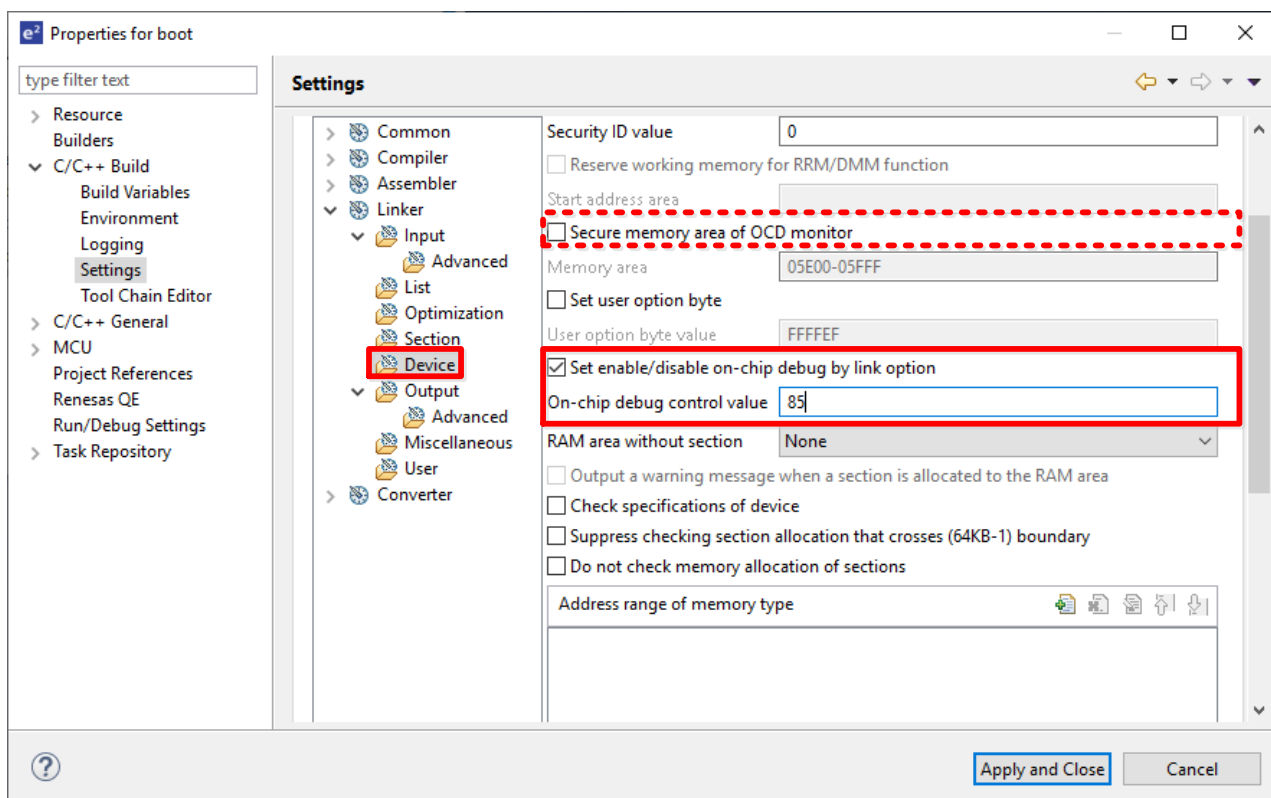
Figure 16   Example of Option Setting with the e² studio

Example: CS+

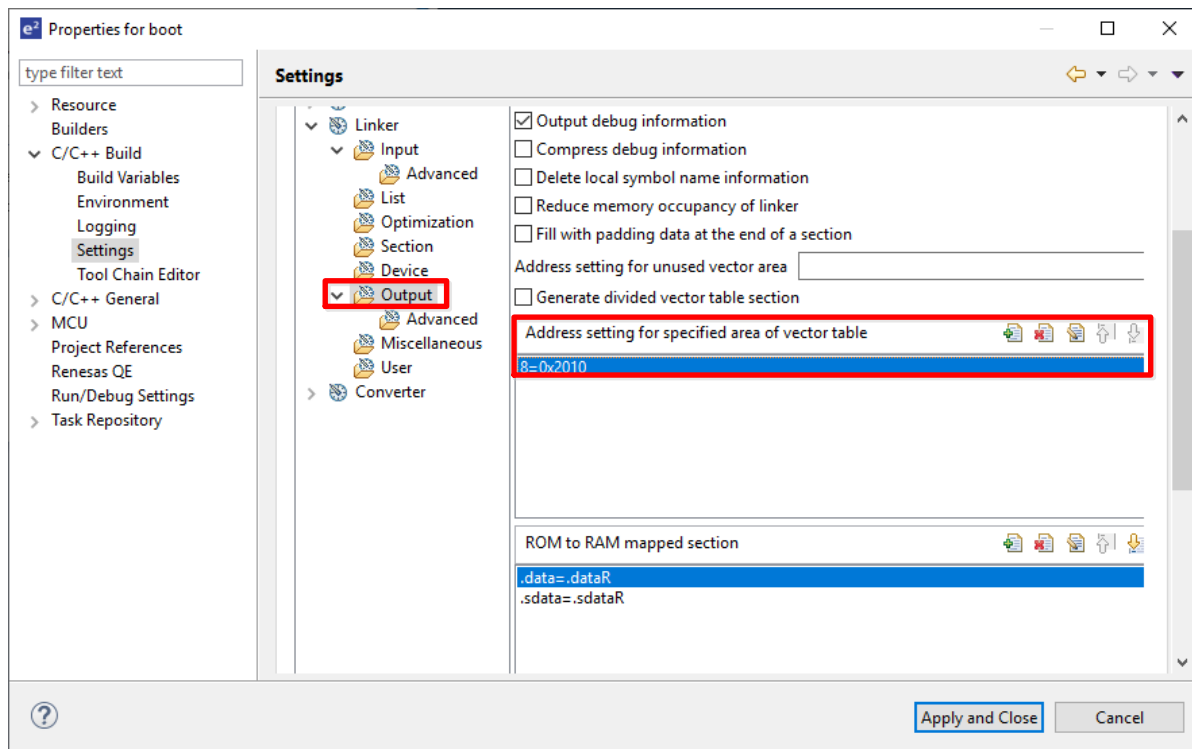[CC-RL (Build Tool)]→[Link Options] tabbed page

→[Device]→[Option byte values for OCD]

→[Section]→[Address setting for specified area of vector table]

→2=ffff (to set 0xffff at address 2)

CC-RL Property		
Device		
Set enable/disable on-chip debug by link option	Yes(-OCDBG)	
Option byte values for OCD	HEX 85	
Set debug monitor area	No	
Set user option byte	Yes(-USER_OPT_BYTE)	
User option byte value	HEX FFFFEF	
Control allocation to self RAM area	No	
Output Code		
Specify execution start address	No	
Fill with padding data at the end of a section	No	
Address setting for specified area of vector table	Address setting for specified area of vector table[2]	
[0]	2=ffff	
[1]	8=2010	
Address setting for unused vector area		

Device

Common Options / Compile Options / Assemble Options / **Link Options** / Hex Output Options / I/O Header File Generation Options

Figure 17   Example of Option Setting with CS+

3.2.5 Specifying hex file output only to the boot area address range

Specify the output file name and output addresses.

Example: e² studio

[Properties]→[C/C++ Build]→[Settings]→[Tool Settings] tabbed page

→[Converter]→[Output]

→Select the [Output hex file] checkbox.

→Select [Motorola S-record file] as the output file format.

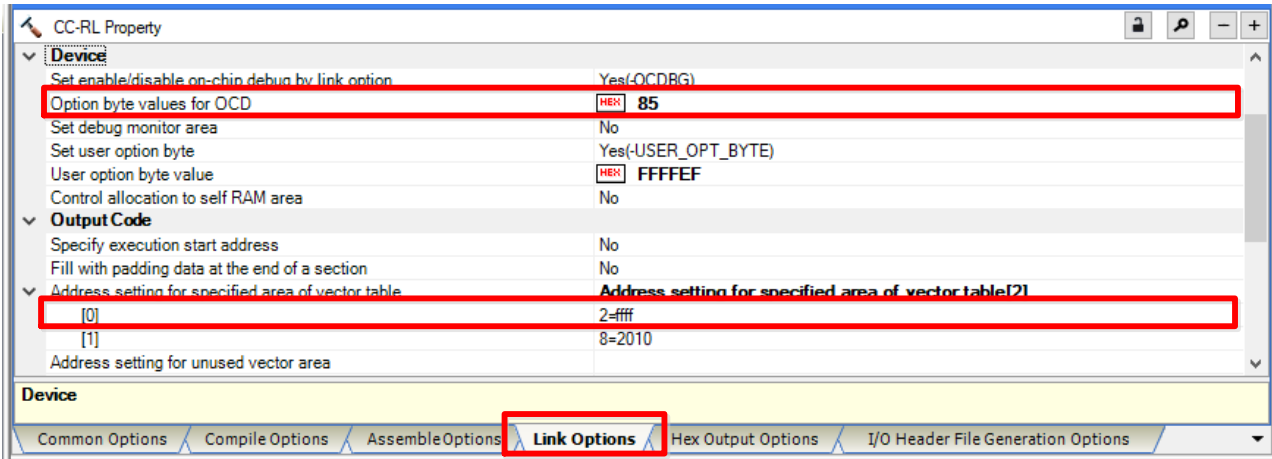→Specify the output file name and output addresses in [Division output file].
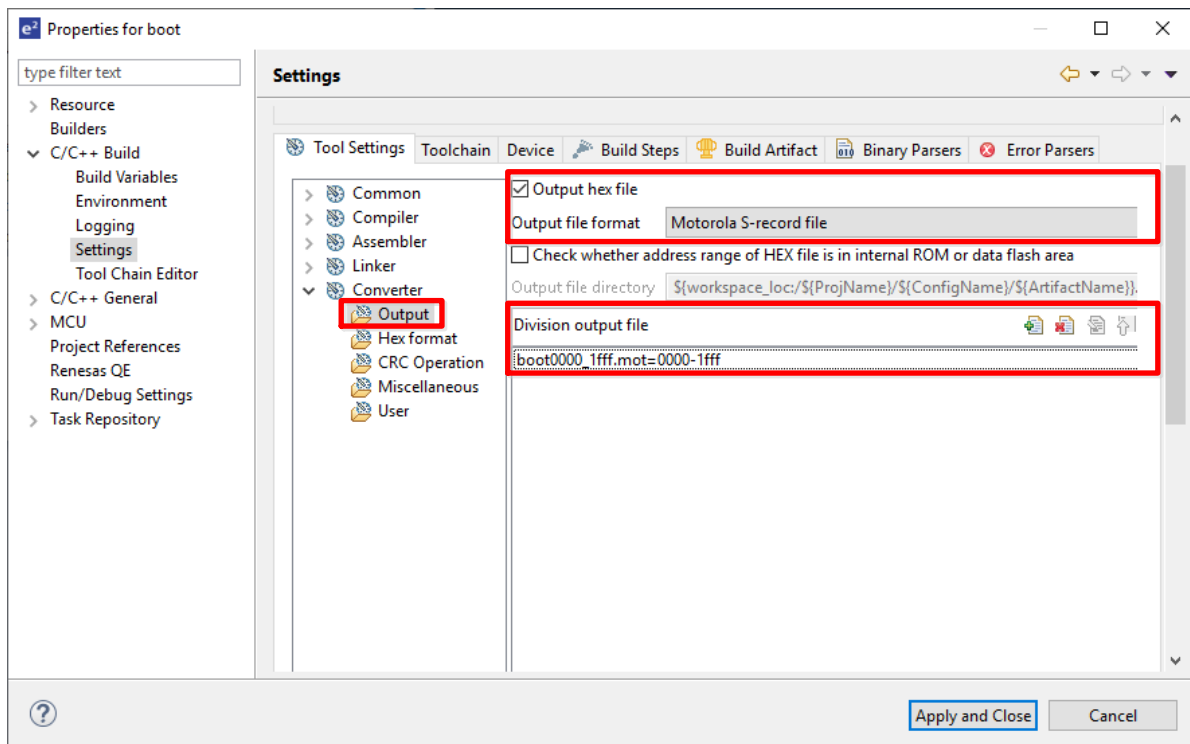

Figure 18   Example of Option Setting with the e² studio

Example: CS+

[CC-RL (Build Tool)]→[Hex Output Options] tabbed page

→[Output File]→Specify the output file name and output addresses in [Division output file].
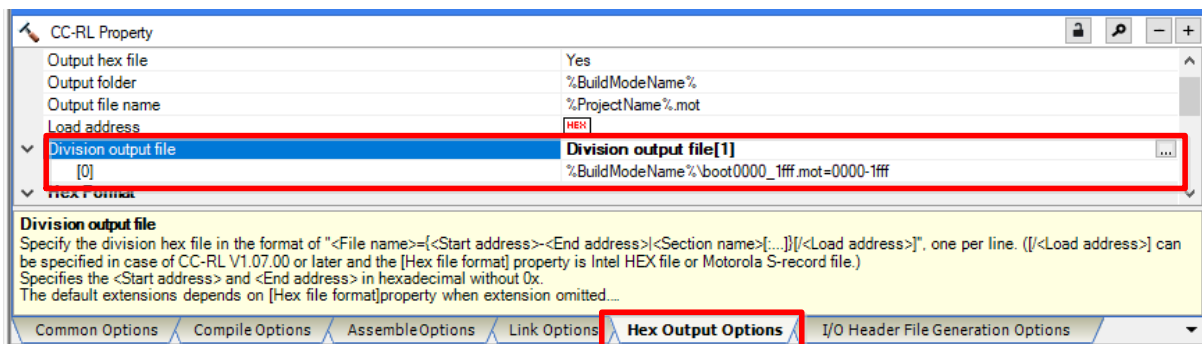

Figure 19   Example of Option Setting with CS+

4. Flash Area

4.1 Creating flash area programs

The following steps are required for flash area programs.

— Modifying the startup routine
— Creating a branch table program
— Defining an interrupt function

4.1.1 Modifying the startup routine (cstart.asm)

Comment out the stack pointer settings. The stack pointer specified in the boot area startup routine should be used; a stack pointer must not be specified again in the flash area.

Example: cstart.asm

```
  ;-------------------------------------------------
  ; setting the stack pointer
  ;-------------------------------------------------
;$IF (__RENESAS_VERSION__ >= 0x01010000)
; MOVW   SP,#LOWW(__STACK_ADDR_START)
;$ELSE   ; for CC-RL V1.00
; MOVW   SP,#LOWW(_stacktop)
;$ENDIF
```

4.1.2 Creating a branch table program (ftable.asm)

At the addresses called from the boot area, write instructions for branching to the function addresses in the flash area.

Example: ftable.asm

```
$INCLUDE "ftable.inc"
  .EXTERN _start
  .EXTERN _f1
  .EXTERN _f2
.jtext    .CSEG AT FLASH_TABLE
  br      !!_start       ; RESET
  .DB4    0xffffffff     ;
  .DB4    0xffffffff     ; INTWDTI
  .DB4    0xffffffff     ; INTLVI
  br      !!_int_INTP0   ; INTP0
  .DB4    0xffffffff     ; INTP1
  .DB4    0xffffffff     ; INTP2
    Omitted
.jtext2   .CSEG AT FLASH_TABLE+INTERRUPT_OFFSET
  br      !!_f1
  br      !!_f2
```

For interrupts

For functions

4.1.3 Defining an interrupt function

- The interrupt vector should be defined in the boot area project.
- Do not specify the vector address (vect) with the #pragma interrupt directive in the flash area.

Example: int.c

```
#include "iodefine.h"
#pragma interrupt int_INTP0
volatile char f;
void int_INTP0(void)
{
  f = 1;
}
```

4.2 Specifying flash area options

Make the following option settings for the flash area.

— Register the externally defined symbol file with the project
— Specify the section allocation
— Specify hex file output only to the flash area address range
— Combine the hex files for the boot and flash areas

4.2.1 Registering the externally defined symbol file with the project

Register the externally defined symbol file created in the boot area with the project to allow access to the variables and functions in the boot area.

Example: e² studio

If you are using the e² studio, build the boot area project and then manually register the externally defined symbol file (boot.fsy) created in the boot area with the flash area project.
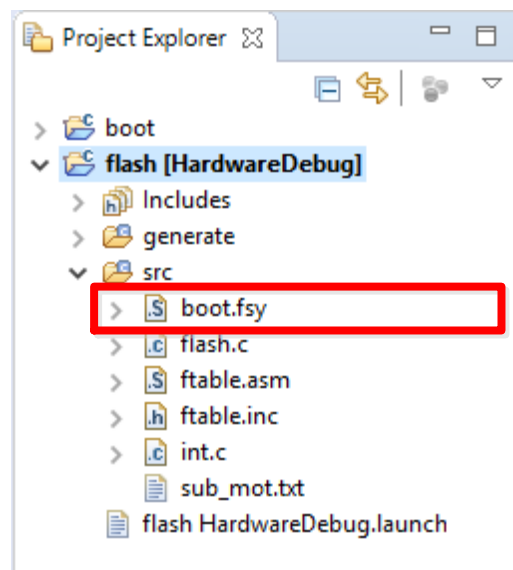

Figure 20   Example of Option Setting with the e² studio

Example: CS+

If you are using CS+, building the boot area project will automatically register the externally defined symbol file (boot.fsy) with the flash area project.
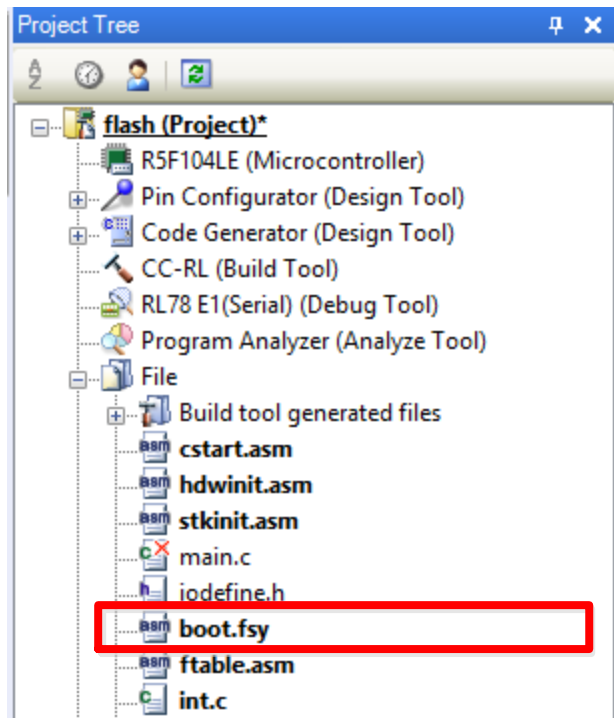

Figure 21　　Example of Option Setting with CS+

4.2.2 Specifying the section allocation

Specify the section allocation in the flash area with the linker option -start.

- Make sure that the sections do not overlap those in the boot area.
- Do not allocate anything to the branch table area.

Example: e^2 studio

[Properties]→[C/C++ Build]→[Settings]→[Tool Settings] tabbed page

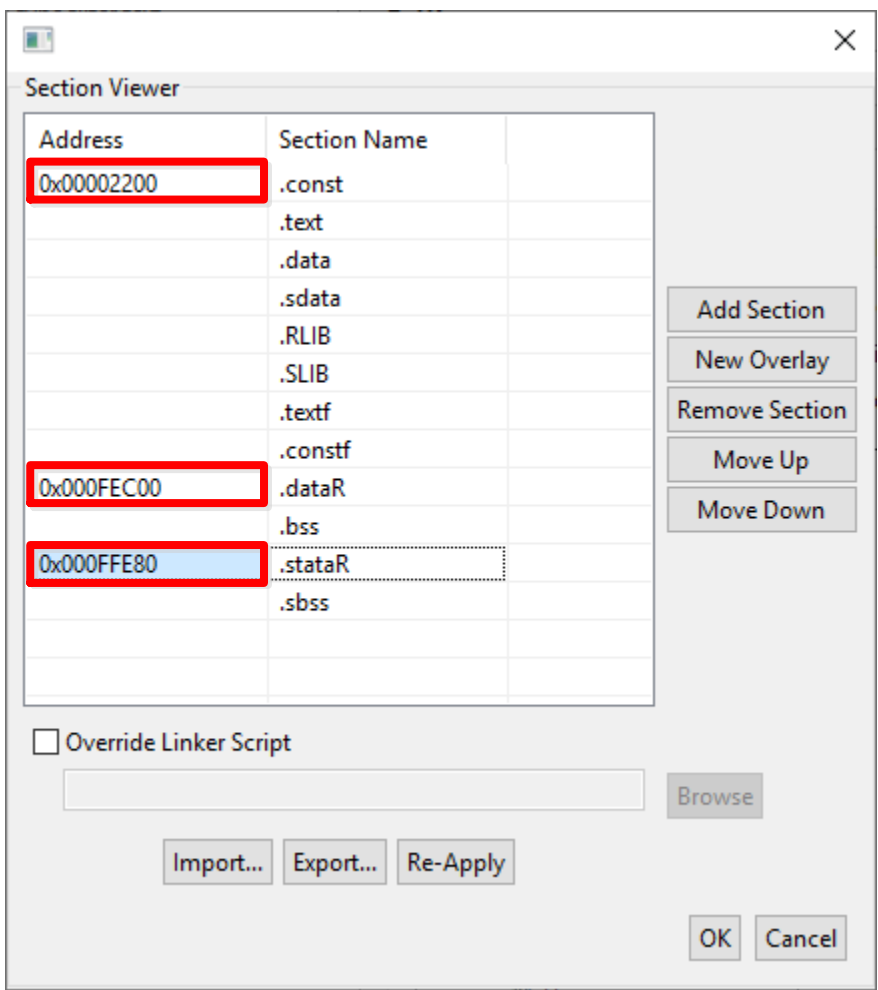→[Linker]→[Section]→[Section Viewer]

Figure 22   Example of Option Setting with the e^2 studio

Example: CS+

[CC-RL (Build Tool)]→[Link Options] tabbed page
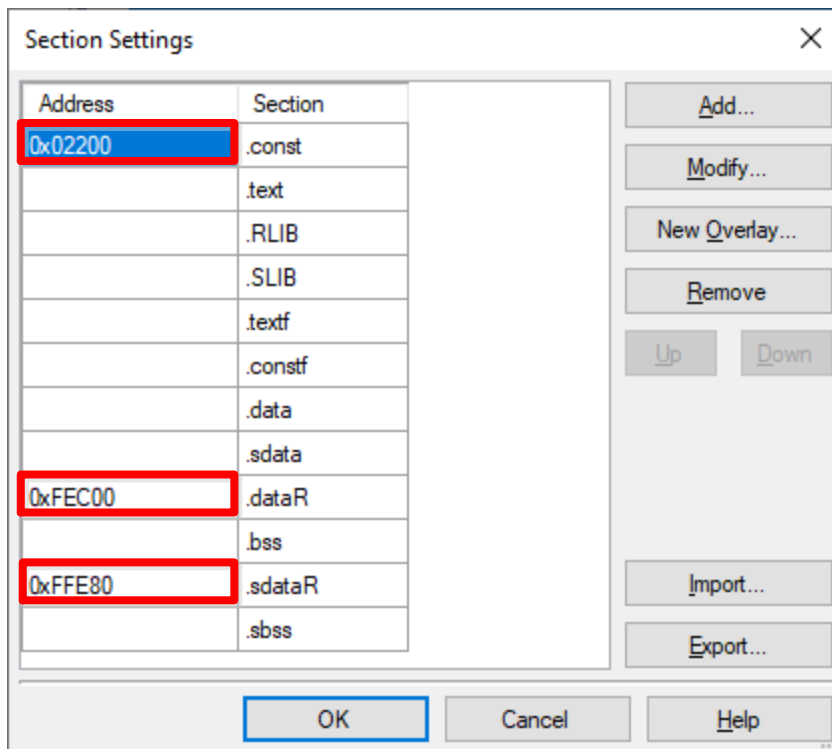
→[Section]→[Section start address]

Figure 23　　Example of Option Setting with CS+

4.2.3 Specifying hex file output only to the flash area address range

Specify the output file name and output addresses.

Example: e² studio

[Properties]→[C/C++ Build]→[Settings]→[Tool Settings] tabbed page

→[Converter]→[Output]

→Select the [Output hex file] checkbox.

→Select [Motorola S-record file] as the output file format.

→Specify the output file name and output addresses in [Division output file].
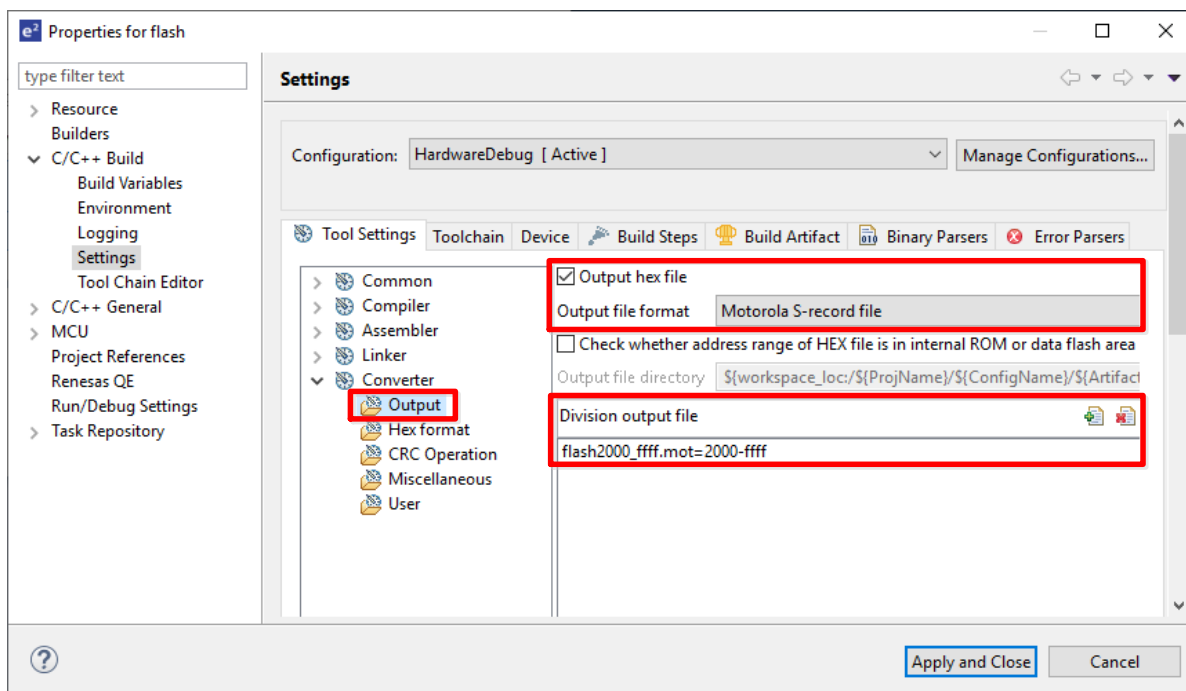

Figure 24   Example of Option Setting with the e² studio

Example: CS+

[CC-RL (Build Tool)]→[Hex Output Options] tabbed page

→[Output File]→Specify the output file name and output addresses in [Division output file].
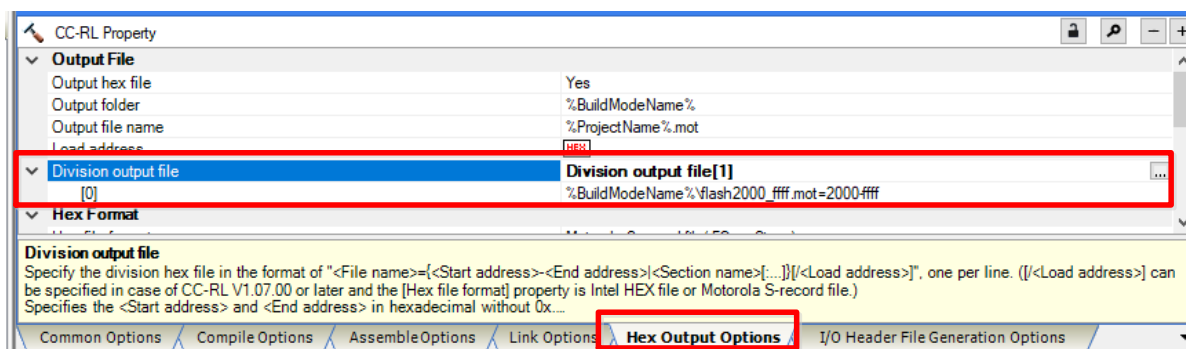
Figure 25   Example of Option Setting with CS+

4.2.4 Combining the hex files for the boot and flash areas

To combine the hex files for the boot and flash areas into one file, add the linker execution step after the build processing.

Example: e² studio

[Properties]→[C/C++ Build]→[Settings]→[Build Steps] tabbed page→[Post-build steps]
→Add the command to execute the linker (rlink.exe -subcommand=..¥src¥sub_mot.txt) to [Command(s):].
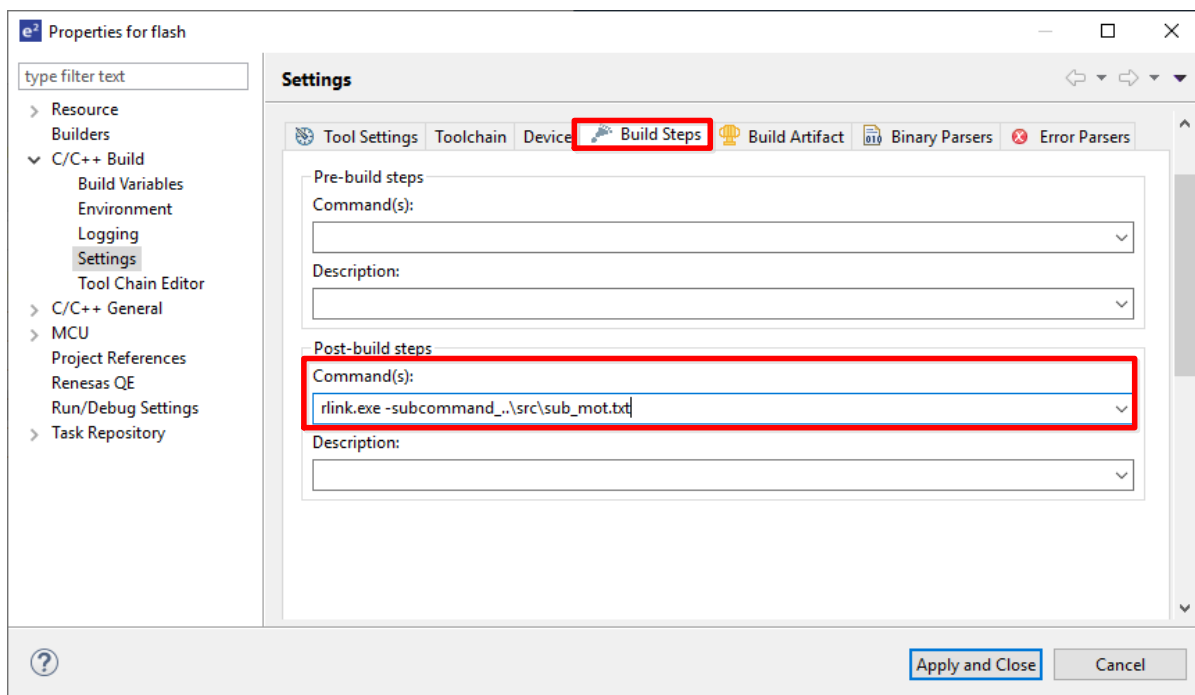
Figure 26   Example of Option Setting with the e² studio

Example: CS+

[CC-RL (Build Tool)]→[Common Options] tabbed page→[Others]
→Add the command to execute the linker ("%MicomToolPath%¥CC-RL¥V1.08.00¥bin¥rlink.exe" -subcommand=sub_mot.txt) to [Commands executed after build processing].
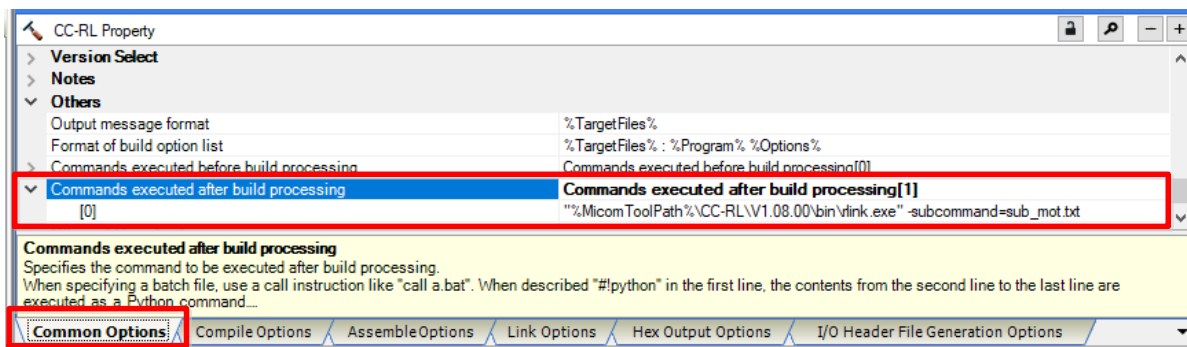
Figure 27   Example of Option Setting with CS+

Specify the input hex files, their format, and the output file name in the subcommand file for input to the linker.

Example: sub_mot.txt (e² studio)

```
-input=..¥..¥boot¥HardwareDebug¥boot0000_1fff.mot
-input=flash2000_ffff.mot
-form=stype
-output=boot_flash.mot
```

Example: sub_mot.txt (CS+)

```
-input=.¥boot¥DefaultBuild¥boot0000_1fff.mot
-input=.¥DefaultBuild¥flash2000_ffff.mot
-form=stype
-output=.¥DefaultBuild¥boot_flash.mot
```

5. Debugging Tool

5.1 Downloading to Debugging Tool

Two load module files (*.abs) are generated; one for each of the boot and flash areas. Download both of the load module files to the debugging tool.

Example: e² studio

[Debug]→[Debug Configurations]→[flash HardwareDebug]→[Startup] tabbed page

→[Load image and symbols]

Add the load module file for the boot area to the project for the flash area.
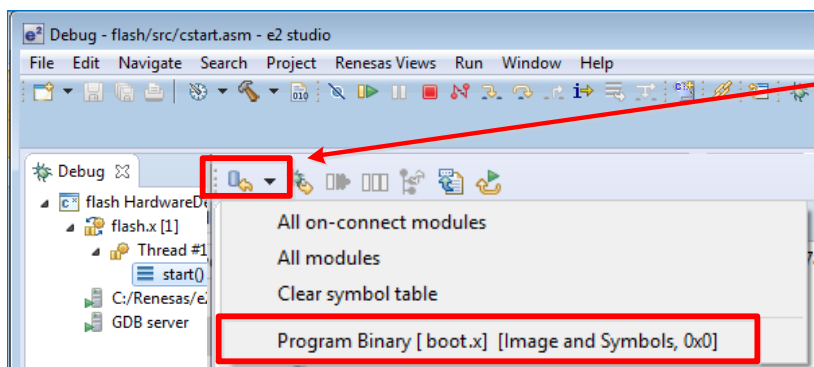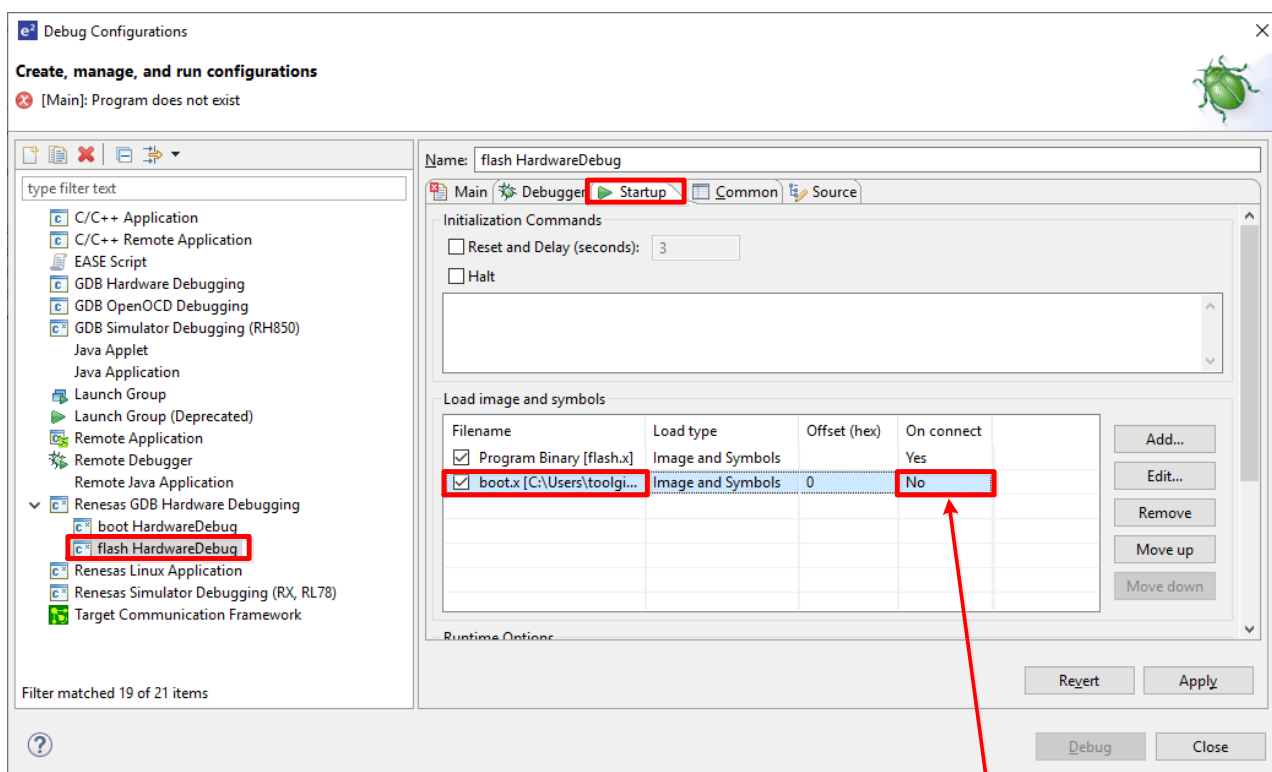
Figure 28   Example of Option Setting with the e² studio

Example: CS+

[RL78 Simulator (Debug Tool)]→[Download File Settings] tabbed page

→[Download]→[Download files]

Add the load module file for the boot area to the project for the flash area.
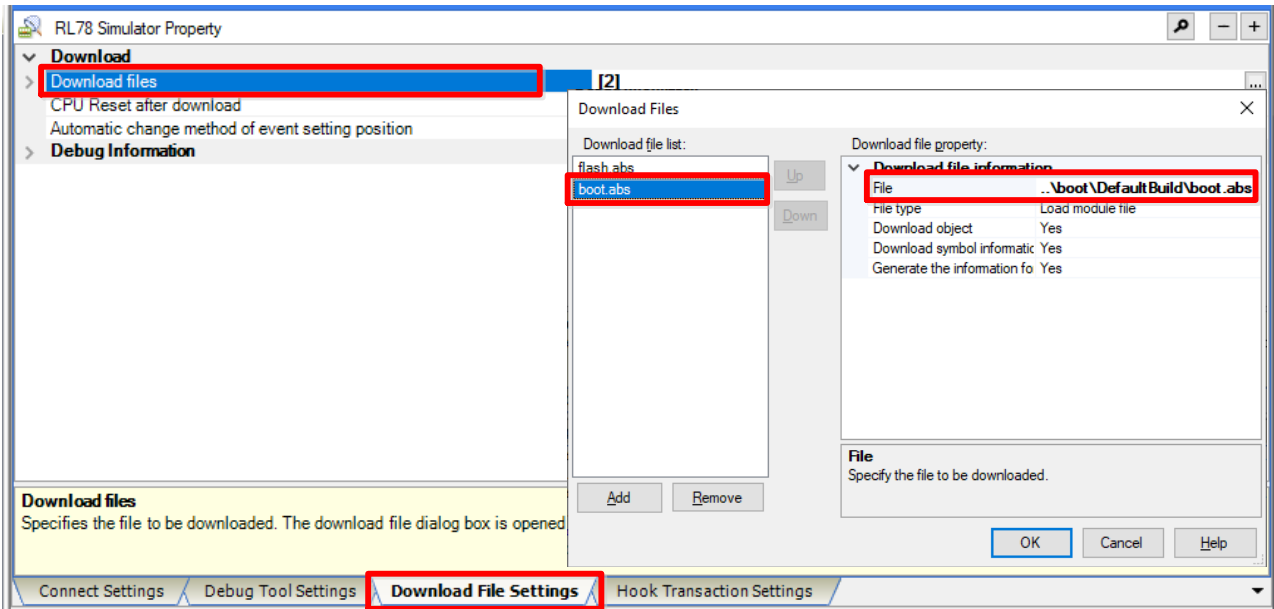
Figure 29   Example of Option Setting with CS+

6. Sample Programs

The following pages show examples of boot and flash area programs that were created through the procedures described in earlier sections.

6.1 Sample program for the boot area (boot.c)

```c
#include "iodefine.h"/* SFR definition file */
#pragma interrupt int_INTP1(vect=INTP1)/* Interrupt definition in the boot
area  */
int boot_a = 0x12;
int boot_b = 0x34;
extern int f1(int);  /* Prototype declaration of a function in the flash area
*/
extern int f2(int);  /* Prototype declaration of a function in the flash area
*/
void boot_main(void) /* Main function in the boot area  */
{
  /* Main processing in the boot area  */
}
void boot_func(void)
{
  boot_a = f1(boot_a);  /* Call of a function in the flash area */
  boot_b = f2(boot_b);  /* Call of a function in the flash area */
}
void int_INTP1(void) /* Interrupt processing in the boot area */
{
  boot_a = 1;
}
```

6.2　Sample program for the flash area (flash.c)

```
#include "iodefine.h"/* SFR definition file  */
int flash_a, b;
extern int boot_a, boot_b;     /* Functions defined in the boot area  */
extern void boot_func(void);  /* Function defined in the boot area  */
int f1(int a)
{
  return (++a);
}
int f2(int b)
{
  return (--b);
}
void main(void)      /* Main function in the flash area  */
{
  boot_a++;    /*  Access to a variable in the boot area */
  boot_b++;    /*  Access to a variable in the boot area */
  boot_func(); /*  Access to a variable in the boot area */
}
```

Revision History

Rev.	Date	Page	Summary
		Description	
		Page	Summary
1.00		-	New release
2.00		All	Changed the format of this document
		P3, P29, P32, P47	Updated the version numbers of tools
		P32, P33	Corrected the values to be specified with the -VECTN option
		P40	Corrected the branch instruction to the _int_INTP0 label
3.00		All	Changed the format of this document
			Updated the version numbers of tools

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