SH7268/SH7269 Group

Graphics Library "RGA"

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Introduction

This application note describes the Graphics Library RGA (Renesas Graphics Architecture) of SH7268/SH7269.

The following lists features of the RGA.

- Allows high-speed drawing using the hardware acceleration.
- The API created based on the W3C standard HTML Canvas 2D Context achieves easy learning. In addition, the RGA provides C++API that is operable as an interface that is backward compatible with HTML Canvas 2D Context.
- The memory area provided by the application is available as a drawing destination or for input images.
- Allows drawing of translucent images and translucent drawing using an alpha mask.
- The RGA provides a conversion tool that can access image files as global variables. (This conversion tool operates on the host PC.)

Target Device

SH7268/SH7269 Group

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

Restrictions

This library is not compatible with the vector graphics supported by OpenVG™-Compliant Renesas Graphics Processor (R-GPVG).

The hardware acceleration is used only for a part of drawing (Table 1-2), (5.11.1).

This library cannot be used in multiple tasks. Use the RGA in a single task.

Contents

1. Specifications

The RGA is used to draw graphics images.

Table 1-1 lists Table 1-1 Peripheral Functions to Be Used and Applications,

Figure 1.1 shows a Block Diagram, and Table 1-2 and Table 1-3 list available pixel formats.

Table 1-1 Peripheral Functions to Be Used and Applications

Peripheral Function	Application
OpenVG™-Compliant Renesas Graphics Processor (R-GPVG)	Graphics drawing
JPEG Codec Unit (JCU)	JPEG decompression
Video Display Controller 4 (VDC4)	Screen display

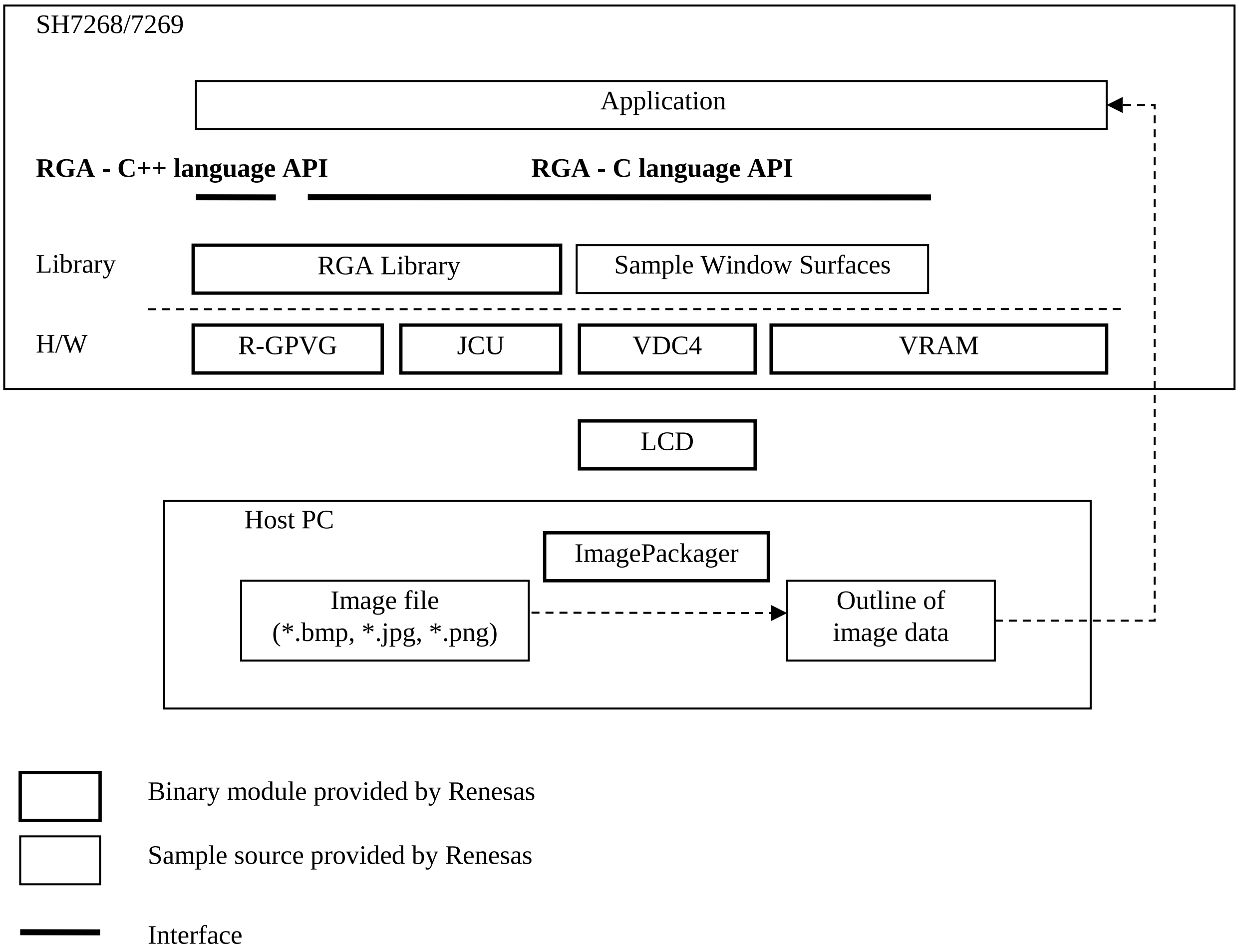


Figure 1.1 Block Diagram

The coordinate system of this library has an origin at the upper left. The value in the X-axis direction increases from left to right. The value in the Y-axis direction increases downward. The maximum width of a frame buffer to be drawn is 1280 pixels, and its maximum height is 1024 pixels. The maximum width of a source image to be drawn is 1280 pixels, and its maximum height is 1024 pixels, too.

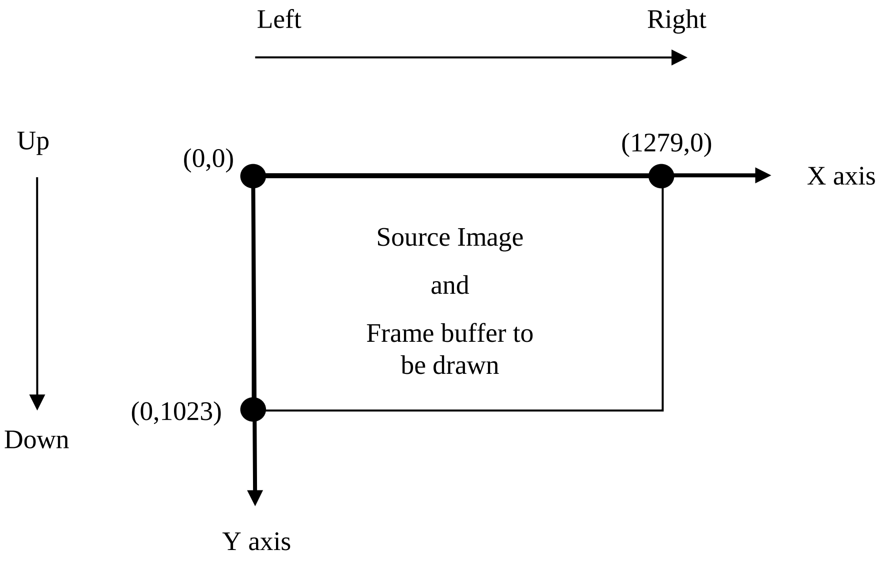


Figure 1.2 Max size of drawing target and source image

Table 1-2 Available Pixel Formats of Drawing Destination

	XRGB 8888	ARGB 8888	RGB 565	ARGB 1555	ARGB 4444	YUV 422[1]	CLUT8	CLUT4	CLUT1
Hardware rendering	✓	✓	✓	✓	✓	x	x	x	x
Software rendering	x	x	x	x	x	✓	✓	✓	✓
Matrix, enlargement/ reduction, blend	✓	✓	✓	✓	✓	x	x	x	x
Image drawing (5.7.1.26 etc.)	✓	✓	✓	✓	✓	✓	[2]	[2]	[2]
DrawImageChild (5.7.1.28)	✓	✓	✓	✓	✓	✓	x	x	x
Square fill	✓	✓	✓	✓	✓	✓	x	x	x

Table 1-3 Combinations of Available Pixel Formats of Images and Pixel Formats of Drawing Destination

Output Input Image	XRGB 8888	ARGB 8888	RGB 565	ARGB 1555	ARGB 4444	YUV 422[1]	CLUT8	CLUT4	CLUT1
JPEG	✓	✓	✓	✓	✓	x	x	x	x
XRGB8888	✓	✓	✓	✓	✓	x	x	x	x
ARGB8888	✓	✓	✓	✓	✓	x	x	x	x
RGB565	✓	✓	✓	✓	✓	x	x	x	x
ARGB1555	✓	✓	✓	✓	✓	x	x	x	x

[1] YUV422: FourCC = UYVY, CbCr center (grayscale) = 0x80

[2] Restrictions. For details, see the description on functions.

ARGB4444	✓	✓	✓	✓	✓	x	x	x	x
R8G8B8A8[3]	✓	✓	✓	✓	✓	x	x	x	x
YUV422[3]	x	x	x	x	x	✓	x	x	x
CLUT8	x	x	x	x	x	x	✓	x	x
CLUT4	x	x	x	x	x	x	x	✓	x
CLUT1	x	x	x	x	x	x	x	x	✓

The JPEG above is a case where JPEG data is specified for arguments of the image drawing function (R_GRAPHICS_DrawImage). The SH7269 uses hardware JPEG Codec Unit (JCU) and OpenVG™-Compliant Renesas Graphics Processor(R-GPVG). Table 1-4 shows supported JPEG format. When a JPEG file or PNG file is converted to the raw format (including XRGB8888) by using the ImagePackager tool, see the column of the pixel format.

A8,A4,A1 format is not supported.

Table 1-4 Supported JPEG format

Decoding module	JPEG Codec Unit (JCU) in SH7269
JPEG standard	baseline
Pixel format in JPEG	YCbCr420 (H=2:1:1,V=2:1:1) YCbCr422 (H=2:1:1,V=1:1:1)

The following tables describes the detail of pixel format. RGA for RZ/A1 is little endian. For example, Red of XRGB8888 is at first address of the pixel + 2.

XRGB8888

bit 31 24	23 16	15 8	7 0
0	Red	Green	Blue

ARGB8888

bit 31 24	23 16	15 8	7 0
Alpha	Red	Green	Blue

RGB565

bit 15 11	10 5	4 0
Red	Green	Blue

ARGB1555

bit 15	14 10	9 5	4 0
Alpha	Red	Green	Blue

[3] Renders by Software, if source image was R8G8B8A8 or YUV422 format.

ARGB4444

bit 15 12	11 8	7 4	3 0
Alpha	Red	Green	Blue

R8G8B8A8

address +0	+1	+2	+3
Red	Green	Blue	Alpha

YCbCr422

address +0	+1	+2	+3
Cb	Y (Left)	Cr	Y (Right)

FourCC = UYVY, CbCr center (grayscale) = 0x80

CLUT8

bit 7 0
Index

CLUT4

bit 7 4	3 0
Index (Left)	Index (Right)

CLUT1

bit 7	6	5	4	3	2	1	0
Index 0	Index 1	Index 2	Index 3	Index 4	Index 5	Index 6	Index 7

Index 0 is the most left pixel. Index 7 is the most right pixel.

2. File Configuration

SH7269_RGA

inc	C/C++ language header of RGA
lib	C/C++ language library of RGA
RGA	Example source of RGA
Sample_Common	Example source (common code for platforms)
Sample_SH7269	Example source (main for SH7269)
src\driver\ospl	Example of porting layer OSPL for OS less
scriptlib	Internal file of command
README.txt	Description
RGA_Tools.vbs	Tool commands (See 6 Tools)

When you installed RGA library to your project folder, copy "inc" folder and "lib" folder. When link error was raised, copy source files defined error raised function. When an error of not found #include file, copy header files. And copy source files of drivers and common functions defined functions that was raised the unreferenced link error.

Write '#include "RGA.h"' in the application program using RGA.

Set the work buffer of RGA in uncached area and put in available memory area. The address of work buffer (the value of "work_buffer_address" member variable in "R_GRAPHICS_STATIC_OnInitializeDefault" function) is changed to uncached area by calling "R_OSPL_ToUncachedAddress" function in "r_ospl_memory.c" file from inside of RGA initialize function (or checked to be already in uncached area) and changed to physical address accessible from hardware by calling "R_OSPL_ToPhysicalAddress" function.

If memory area became few, reduce frame buffer to the size of showing only and set the size of work buffer B to 0. It is necessary to increase stack size depending on existing environment.

Add setting of section to Map Section Information. See 5.10 Sections.

Supply clock by setting bit4 of STBCR8 register to 0.

Main Header files (inc folder):

File Name	Description
clib_drivers.h	Shared code
frame_buffer.h	Frame buffer
ncg_*.h	Porting layer functions
r_typedefs.h	Basic types
RGA.h	Main of RGA
RGA_API.h	Sub of RGA : API related
RGA_Config.h	Sub of RGA : setting related
RGA_Cpp.h	Sub of RGA : C++ API related
RGA_raw_image.h	Raw format image
vsync.h	V-sync control
vsync_pl.h	V-sync control (porting layer)
window_surfaces.h	Sample of screen control (window_surfaces_t)
window_surfaces.hpp	Sample of screen control (window_surfaces_t) C++ API

Main Library files (lib folder):

File Name	Description
RGA.lib	API of RGA

RGAH.lib	OpenVG™-Compliant Renesas Graphics Processor (R-GPVG) driver for RGA

3. Operation Verification Conditions

Operations of the sample code of this application note are verified under the following conditions.

Table 3.1 Operation Verification Conditions

Item	Description
Microcomputer	SH7269
Operating frequency	266 MHz
Operating voltage	Internal: 1.25 V, I/O: 3.3 V
Integrated development environment	High-performance Embedded Workshop 4.09.01.007
C compiler	C/C++ compiler package for SuperH RISC engine family V.9.04 Release 00
Operating mode	
Board	See section 4.1, Example of Hardware Configuration.
Settings of jumper, etc.	CPU board (R0K572690B000BR): JP4=Open, JP5 - JP10=1-2, JP11=*, JP12 - JP16=1-2, SW5=1110, SW6=010100 Audio board (R0K572690B000BR): JP2=1-2, JP3=Open, JP4=1-2, JP5=2-3, JP6=Open, JP7=Open, JP8=1-2, JP9=2-3, JP10=Open, JP11=Open, JP12=* * is depend on power supply type.

4. Hardware

4.1 Example of Hardware Configuration

Figure 4.1 shows Example of Connection.

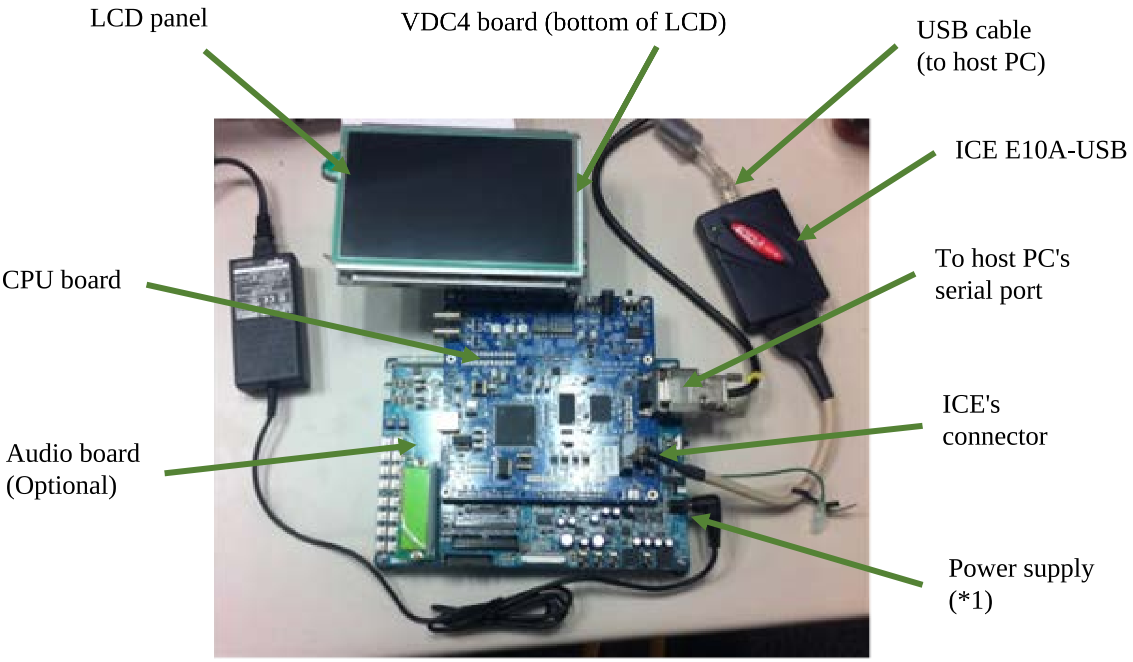


Figure 4.1 Example of Connection

(*1) Position of power supply shown at above picture is the position, when CPU board was connected with audio board. If CPU board was not connected with audio board, change the setting of jumper and connect the power supply with CPU board.

5. Software

5.1 Outline of Operations

5.1.1 When Drawing on a Buffer Defined by the Application

5.1.1.1 Flowchart

Figure 5.1 shows a flowchart of drawing on a frame buffer defined by the application.

For the actual operation procedure, see the attached document, RGA Tutorial.

When using the C++ language API, see the description below using the C language API and the relationship between the C language API described in section 5.11.1, Correspondence to Canvas 2D and Correspondence to Hardware Acceleration, and the C++ language API.

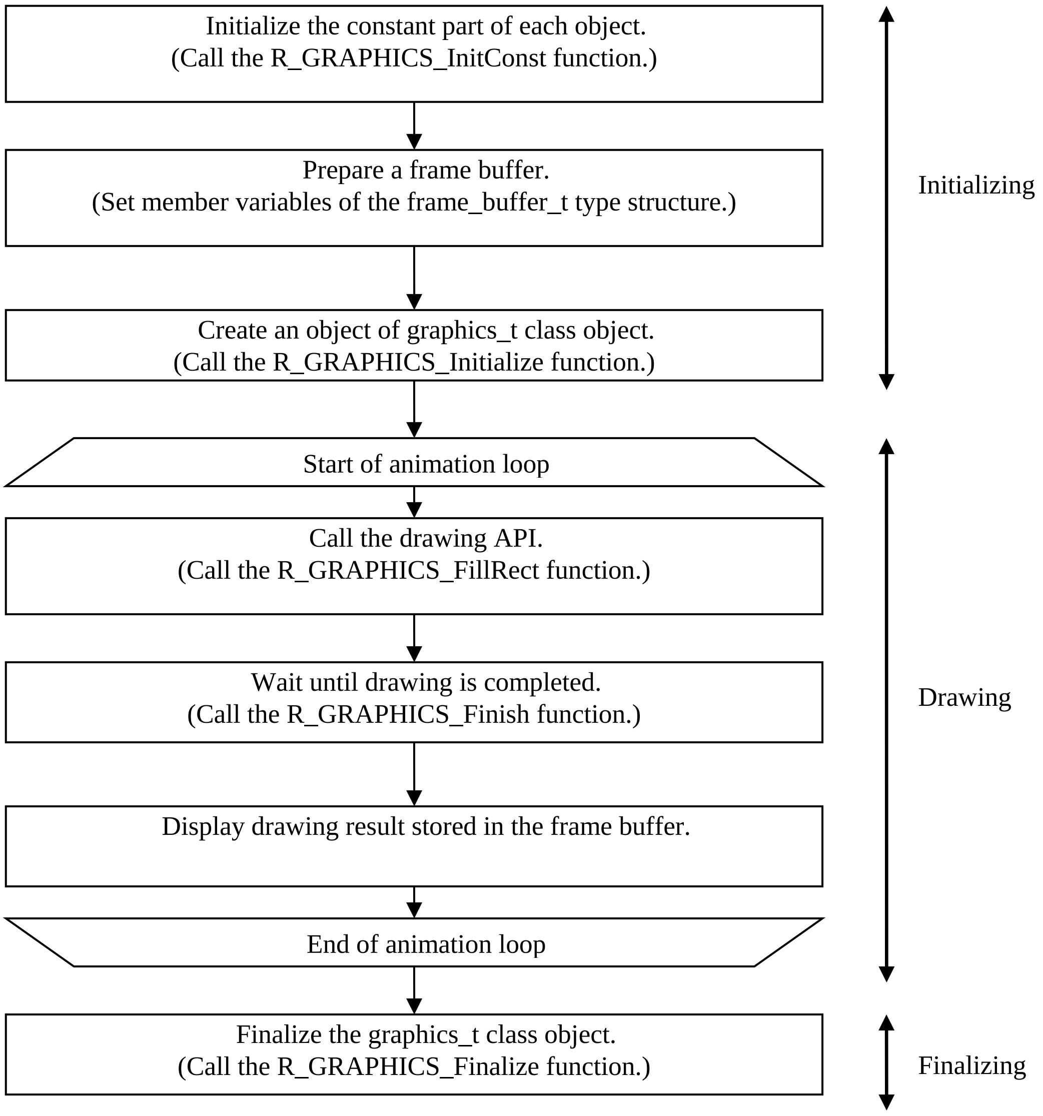
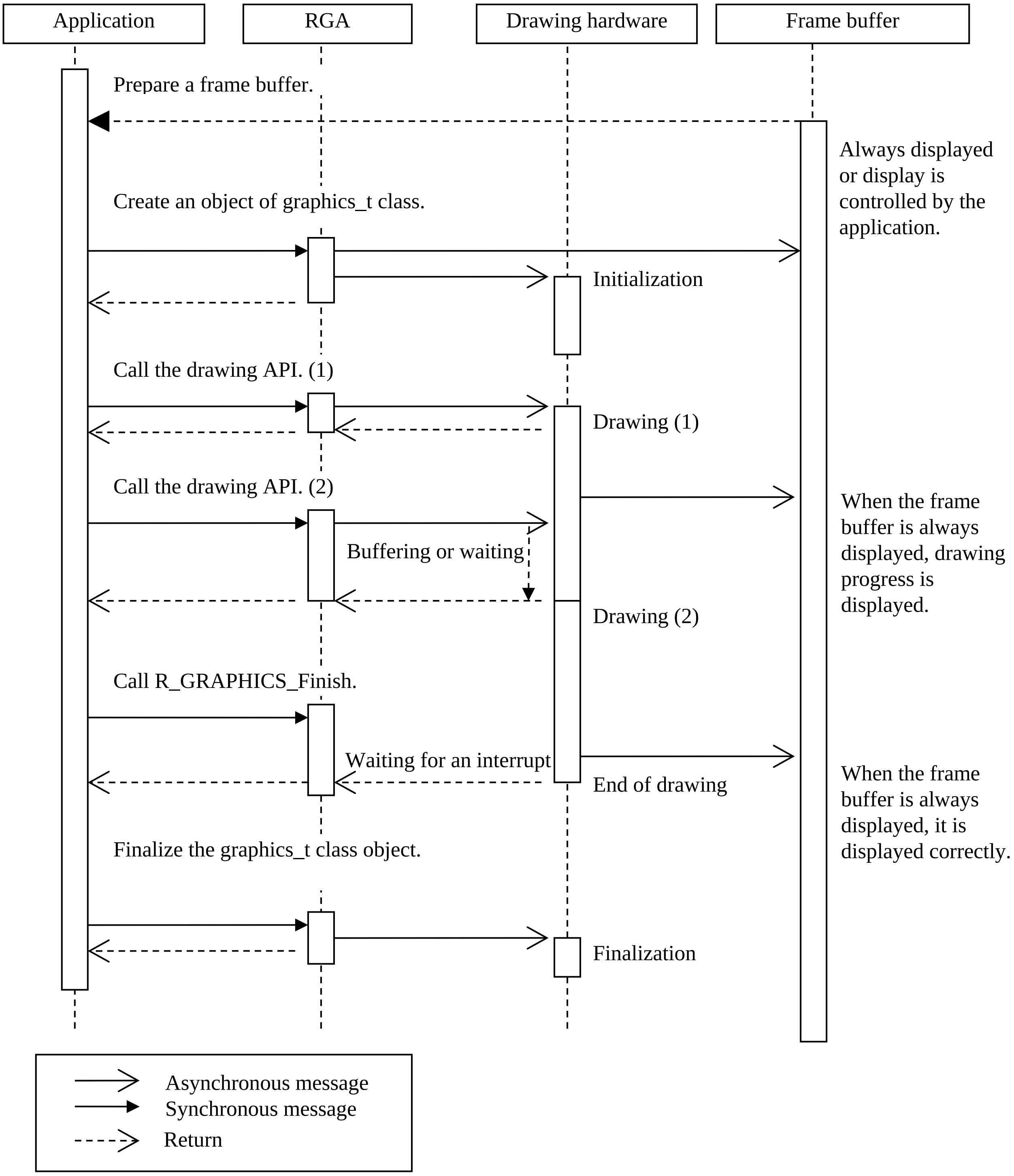

Initialize the constant part of each object.
(Call the R_GRAPHICS_InitConst function.)
Prepare a frame buffer.
(Set member variables of the frame_buffer_t type structure.)
Create an object of graphics_t class object.
(Call the R_GRAPHICS_Initialize function.)
Initializing
Start of animation loop
Call the drawing API.
(Call the R_GRAPHICS_FillRect function.)
Wait until drawing is completed.
(Call the R_GRAPHICS_Finish function.)
Display drawing result stored in the frame buffer.
End of animation loop
Drawing
Finalize the graphics_t class object.
(Call the R_GRAPHICS_Finalize function.)
Finalizing

Figure 5.1 Drawing on a Buffer Defined by the Application - Flowchart

5.1.1.2 Sequence Chart

The following shows an operation timing chart of the software (application and library) and hardware (drawing hardware and display hardware) in the case of drawing on the frame buffer provided by the application.


Application
RGA
Drawing hardware
Frame buffer
Prepare a frame buffer.
Always displayed or display is controlled by the application.
Create an object of graphics_t class.
Initialization
Call the drawing API. (1)
Drawing (1)
Call the drawing API. (2)
When the frame buffer is always displayed, drawing progress is displayed.
Buffering or waiting
Drawing (2)
Call R_GRAPHICS_Finish.
Waiting for an interrupt
End of drawing
When the frame buffer is always displayed, it is displayed correctly.
Finalize the graphics_t class object.
Finalization
Asynchronous message
Synchronous message
Return

5.1.2 Drawing on the Display Screen

5.1.2.1 Flowchart

Figure 5.2 shows a flowchart of drawing on the display screen.

For the actual operation procedure, see the attached document, RGA Tutorial.

When using the C++ language API, see the description below using the C language API and the relationship between the C language API described in section 5.11.1, Correspondence to Canvas 2D and Correspondence to Hardware Acceleration, and the C++ language API.

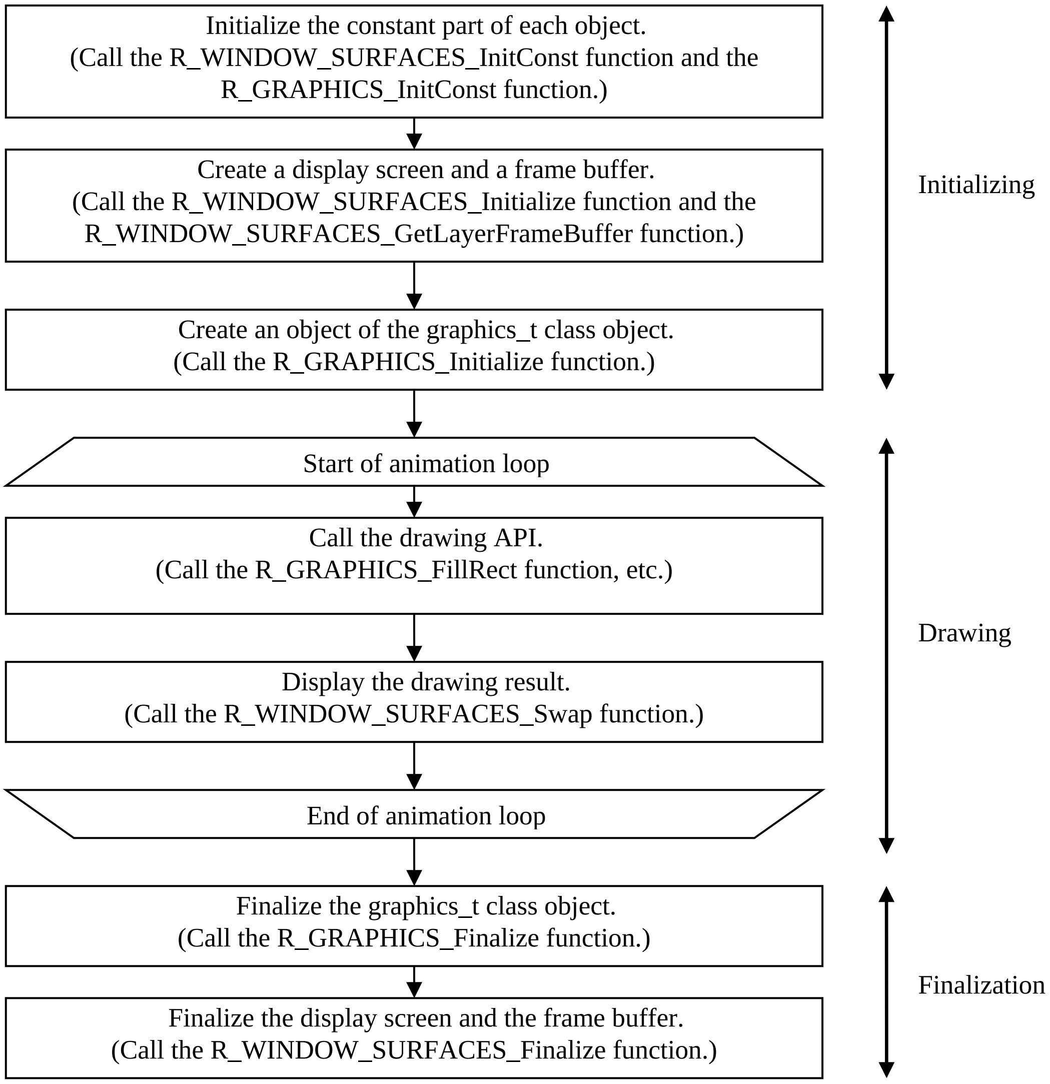
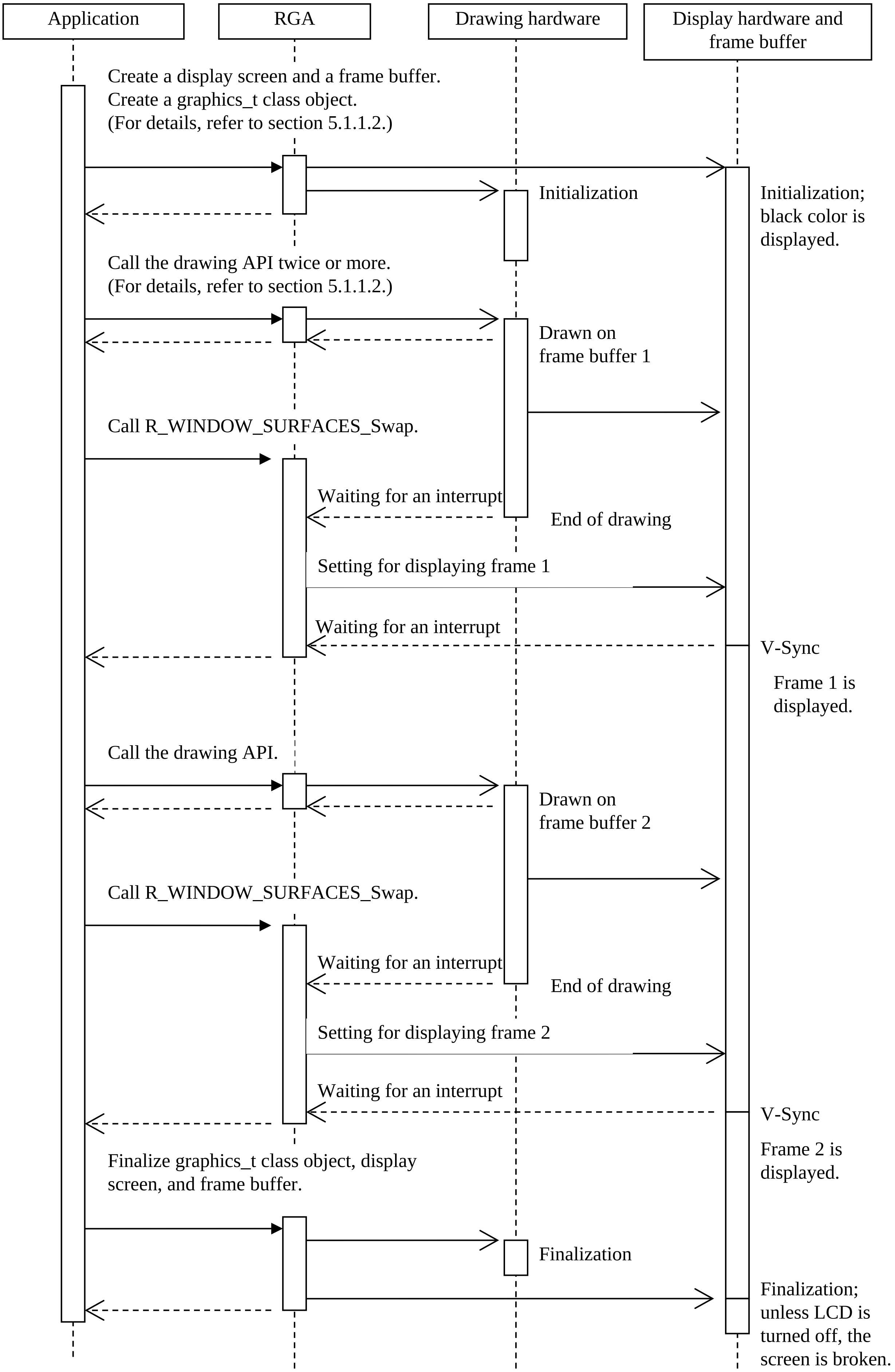

Initialize the constant part of each object.
(Call the R_WINDOW_SURFACES_InitConst function and the R_GRAPHICS_InitConst function.)
Create a display screen and a frame buffer.
(Call the R_WINDOW_SURFACES_Initialize function and the R_WINDOW_SURFACES_GetLayerFrameBuffer function.)
Create an object of the graphics_t class object.
(Call the R_GRAPHICS_Initialize function.)
Initializing
Start of animation loop
Call the drawing API.
(Call the R_GRAPHICS_FillRect function, etc.)
Display the drawing result.
(Call the R_WINDOW_SURFACES_Swap function.)
End of animation loop
Drawing
Finalize the graphics_t class object.
(Call the R_GRAPHICS_Finalize function.)
Finalize the display screen and the frame buffer.
(Call the R_WINDOW_SURFACES_Finalize function.)
Finalization

Figure 5.2 Drawing on the Display Screen - Flowchart Processing

5.1.2.2 Sequence Chart

The following shows an operation timing chart of the software (application and library) and hardware (drawing hardware and display hardware) in the case of drawing on the frame buffer provided by the RGA's WindowSurfaces library.


Application
RGA
Drawing hardware
Display hardware and frame buffer
Create a display screen and a frame buffer.
Create a graphics_t class object.
(For details, refer to section 5.1.1.2.)
Initialization
Initialization; black color is displayed.
Call the drawing API twice or more.
(For details, refer to section 5.1.1.2.)
Drawn on frame buffer 1
Call R_WINDOW_SURFACES_Swap.
Waiting for an interrupt
End of drawing
Setting for displaying frame 1
Waiting for an interrupt
V-Sync
Frame 1 is displayed.
Call the drawing API.
Drawn on frame buffer 2
Call R_WINDOW_SURFACES_Swap.
Waiting for an interrupt
End of drawing
Setting for displaying frame 2
Waiting for an interrupt
V-Sync
Frame 2 is displayed.
Finalize graphics_t class object, display screen, and frame buffer.
Finalization
Finalization; unless LCD is turned off, the screen is broken.

5.2 Required Memory Size

Table 5.1 shows Required Memory Size.

Table 5.1 Required Memory Size

Memory	Size	Note
ROM	43114	Section *_RGA, *_RGAH, *_JCU
RAM	1644	Section *_RGA, *_RGAH, *_JCU
	See R_RGA_CalcWorkBufferSize 5.7.14.3.	Work buffer
	See R_RGA_CalcWorkBufferB_Size 5.7.14.4.	Work buffer B
	1536000 (2x800x480x16bit)	Frame buffer
	2304000 (3x800x480x16bit) 0 (If it is not necessary)	Back buffer for the application
	1700	Used stack size of the sample program

Note: These required memory sizes vary depending on the C compiler version and the compile option.

5.3 List of Constants

Table 5.2 lists Constants Used for the Sample Code.

Table 5.2 Constants Used for the Sample Code

Constant Name	Value	Description
RGA_VERSION	210	RGA version
RGA_VERSION_STRING	"2.10"	RGA version string
RGA_FRAME_BUFFER_ADDRESS_ALIGNMENT	32	Address alignment of drawing target frame buffer (bytes)
RGA_SOURCE_IMAGE_STRIDE_ALIGNMENT	32	Byte count alignment to next line (stride) of source image (bytes)
RGA_DESTINATION_STRIDE_ALIGNMENT	32	Byte count alignment to next line (stride) of drawing target (bytes)
RGA_JPEG_ADDRESS_ALIGNMENT	8	Address alignment of JPEG data (bytes)
RGA_JPEG_MAX_WIDTH_ALIGNMENT	16	Maximum width of MCU of source JPEG image. (pixel)
RGA_JPEG_MAX_HEIGHT_ALIGNMENT	16	Maximum height of MCU of source JPEG image. (pixel)
RGA_VDC4_BUFFER_ADDRESS_ALIGNMENT	64	First address alignment of the frame buffer shown by Video Display Controller 4 (VDC4) (bytes)
RGA_WORK_BUFFER_STRIDE	64	One-line size of work buffer (bytes)
RGA_WORK_BUFFER_ADDRESS_ALIGNMENT	64	First address alignment of work buffer (bytes)
RGA_WORK_BUFFER_HEIGHT_ALIGNMENT	8	Height alignment of work buffer (pixel)
RGA_WORK_BUFFER_B_ADDRESS_ALIGNMENT	32	First address alignment of work buffer B (bytes)

5.4 Types and Classes

5.4.1 Basic Types and Values

Symbol	Description
int_t	Signed high-speed integer (a 32-bit integer in this library)
uint32_t	Unsigned 32-bit integer
int32_t	Signed 32-bit integer
uint16_t	Unsigned 16-bit integer
int16_t	Signed 16-bit integer
uint8_t	Unsigned 8-bit integer
int8_t	Signed 8-bit integer
uint64_t	Unsigned 64-bit integer
int64_t	Signed 64-bit integer
bit_field_t	Bit field (an unsigned 32-bit integer in this library)
bit_field32_t	32-bit bit field, an unsigned integer
bool_t	Logic type, value: true (= 1), false (= 0)
true	Logic-type integer value 1
false	Logic-type integer value 0
float32_t	32-bit floating point
float64_t	64-bit floating point
float128_t	128-bit floating point
char_t	8-bit character
physical_address32_t	32-bit physical address
errnum_t	Error code, 0 = no error; see section 5.4.2.

5.4.2 Error Codes

Symbol	Value	Description
0	0	No error
E_OTHERS	0x0001=1	Parameter error; see section 6.2, Searching for Error Information.
E_LIMITATION	0x040F=1039	Restrictions
E_FEW_ARRAY	0x0411=1041	Insufficient number of array elements
E_NOT_SUPPORTED_PIXEL_FORMAT	0x9400 =37888	Unsupported pixel format
E_ACCESS_DENIED	0x0417=1047	Access denied

5.4.3 Types Only for the C Language

The following are types supplied by the RGA and used only for the C language.

Type definitions shown in this section are also available for the C++ language, but there are classes available for the C++ language. For details, see section 5.4.4.

For types available for the C language, also see section 5.4.5, Types/Classes Available for C Language and C++ Language.

5.4.3.1 List of Types

Table 5.3 C Language-Dedicated Types Provided by RGA

Section	Type	Description
5.4.3.2	graphics_t	Graphics drawing context
5.4.3.3	graphics_image_t	Input image
5.4.3.4	graphics_pattern_t	Image arranged pattern

5.4.3.2 graphics_t

```
#include  <RGA.h>
typedef struct _graphics_t  graphics_t;
```

This is a graphics drawing context type.

The OpenVG™-Compliant Renesas Graphics Processor (R-GPVG) or software rendering is used in the SH7269.

The application must not access any member variable.

Function equivalent to the member function: See section 5.7.1.

5.4.3.3 graphics_image_t

```
#include  <RGA.h>
typedef struct _graphics_image_t  graphics_image_t;
```

This is an image type.

The ImagePackager tool converts this type from an image file and outputs this type data.

It is also possible to dynamically generate a graphics_image_t-class object without using the ImagePackager tool.

The application must not access any member variable.

Function equivalent to the member function: See section 5.7.1.39.

5.4.3.4 graphics_pattern_t

```
#include  <RGA.h>
typedef struct _graphics_pattern_t  graphics_pattern_t;
```

This is an image-arranged pattern type.

The application must not access any member variable.

Function equivalent to the member function: See section 5.7.3.

5.4.4 Classes Only for the C++ Language

The following describes C++ language classes provided by the RGA.

Be careful of coding because classes provided by the RGA are created to be compatible with JavaScript. For details, see section 5.11.9, Compatibility between C++ Language and JavaScript Object.

For classes/types available for the C language, also see section 5.4.5, Types/Classes Available for C Language and C++ Language.

5.4.4.1 List of Types

Table 5.4 C++ Language-Dedicated Types Provided by RGA

Section	Type	Description
5.4.4.2	Canvas2D_ContextClass	Graphics drawing context
5.4.4.3	Canvas2D_ContextConfigClass	Settings of Canvas2D_ContextClass
5.4.4.4	Canvas2D_ImageClass	Input image
5.4.4.5	Canvas2D_PatternClass	Image-arranged pattern
5.4.4.6	WindowSurfacesClass	Frame buffer and showing screen
5.4.4.7	WindowSurfacesConfigClass	Argument of "WindowSurfacesClass::initialize"
5.4.4.8	LayerAttributesClass	Argument of "WindowSurfacesClass::access_layer_attributes"

5.4.4.2 Canvas2D_ContextClass

```
#include  <RGA.h>
class  Canvas2D_ContextClass;
```

This is a graphics drawing context class only for the C++ language. This class follows a coding rule of JavaScript.

The OpenVG™-Compliant Renesas Graphics Processor (R-GPVG) or software rendering is used in the SH7269.

For the description on properties, refer to property specifications (section 5.6.1).

For the description on member functions, refer to function specifications (sections 5.7.5 and 5.7.4.2).

The graphics_t type member functions are made available by using the c_LanguageContext property. See section 5.7.1.

Sample:

```
Canvas2D_ContextClass  canvas2d = R_RGA_New_Canvas2D_ContextClass( frame );

/* JavaScript start of compatible part */
canvas2d.clearRect( 0, 0, frame_width, frame_height );
canvas2d.Style = "#0f0";
canvas2d.fillRect( 100, 100, 200, 100 );
/* JavaScript end of compatible part */

if ( canvas2d.errNum != 0 ) { /* error */ }

R_WINDOW_SURFACES_SwapBuffers( ... );
canvas2d.destroy();
```

5.4.4.3 Canvas2D_ContextConfigClass

Outline	This is a setting of "Canvas2D_ContextClass" for the C++ language
Header	RGA.h

Description	Default value is set by the constructor.	
Member Variable	frame_buffer_t* frame_buffer	Drawing target frame buffer. This variable must be set. Set the address of frame_buffer_t type structure.
	bool_t is_fast_manual_flush	Fast manual flush mode (section 5.11.4) or not. Default value is "false".

5.4.4.4 Canvas2D_ImageClass

```
#include  <RGA.h>
class  Canvas2D_ ImageClass;
```

This is a referable image object type only for the C++ language. This class follows a coding rule of JavaScript.

For the description on properties, refer to property specifications (section 5.6.2).

For the description on member functions, refer to function specifications (section 5.7.6).

5.4.4.5 Canvas2D_PatternClass

```
class  Canvas2D_PatternClass;
```

This is an image-arranged pattern class only for the C++ language. This class follows a coding rule of JavaScript.

For the description on member functions, refer to function specifications (section 5.7.7).

5.4.4.6 WindowSurfacesClass

```
#include  "RGA.h"
class  WindowSurfacesClass;
```

This is a frame buffer and showing screen class only for the C++ language. This class follows a coding rule of mbed.

For the description on member functions, refer to function specifications (section 5.7.8).

5.4.4.7 WindowSurfacesConfigClass

```
#include  "RGA.h"
class  WindowSurfacesConfigClass;
```

This is a class of argument for "WindowSurfacesClass::initialize" member function for C++ language. This class follows a coding rule of mbed.

Member variables of this class are inherited from "window_surfaces_config_t" type. See 5.4.5.6. Also, member variables are initialized to default value by constructor. It is not necessary to set "flags" member variable.

5.4.4.8 LayerAttributesClass

```
#include  "RGA.h"
class  LayerAttributesClass;
```

This is a class of argument for "WindowSurfacesClass::access_layer_attributes" member function for C++ language. This class follows a coding rule of mbed.

Member variables of this class are inherited from "layer_attributes_t" type. See 5.4.5.7. Also, member variables are initialized to default value by constructor. It is not necessary to set "flags" member variable.

5.4.5 Types/Classes Available for C Language and C++ Language

For types available from the C language, also see section 5.4.3, Types Only for the C Language.

For types available from the C++ language, also see section 5.4.4, Classes Only for the C++ Language.

5.4.5.1 List of Classes/Types

Table 5.5 Types/Classes Provided by RGA, which are Available for C Language and C++ Language

Section	Type	Description
5.4.5.2	frame_buffer_t	Drawing destination frame buffer
5.4.5.3	graphics_config_t	Type for setting graphics_t
5.4.5.4	graphics_quality_flags_t	Defaultable flag indicating drawing quality
5.4.5.5	window_surfaces_t	Frame buffer and screen display
5.4.5.6	window_surfaces_config_t	window_surfaces_t setting
5.4.5.7	layer_attributes_t	Parameter of the R_WINDOW_SURFACES_AccessLayerAttributes function
5.4.5.8	access_t	Operations such as specifying set values (write) and acquiring set values (read)
5.4.5.9	byte_per_pixel_t	Number of bytes per pixel
5.4.5.10	pixel_format_t	Pixel format
5.4.5.11	frame_buffer_delegate_t	Application defined data
5.4.5.12	v_sync_t	V-Sync signal synchronization of display screen
5.4.5.13	vram_ex_stack_t	Stack for off-screen buffer in external RAM
5.4.5.14	graphics_image_properties_t	Properties of the image
5.4.5.15	graphics_composite_operation_t	Type of composite operation
5.4.5.16	graphics_status_t	Area to store graphics drawing context
5.4.5.17	graphics_matrix_float_t	Element of matrix
5.4.5.18	repetition_t	Pattern repetition type
5.4.5.19	r8g8b8a8_t	Pixel format arranged in the order of R, G, B, and A
5.4.5.20	animation_timing_function_t	Timing of animation (Bezier function)
5.4.5.21	graphics_jpeg_decoder_t	A kind of JPEG decoder

5.4.5.2 frame_buffer_t

Outline Drawing destination frame buffer type

Header RGA.h, frame_buffer.h

Description

Member Variable

uint8_t* buffer_address[ ]	Array of starting address of the frame buffer, logical address of cache area (same as normal variables). Specify a multiple of 32.
int_fast32_t buffer_count	Number of buffer_address array elements (1: Single buffer, 2: Double buffers)
int_fast32_t show_buffer_index	Buffer number being displayed or used as source image (buffer_address array number)
int_fast32_t draw_buffer_index	Buffer number being drawn (buffer_address array number)
int_fast32_t width	Frame buffer width (pixels)
byte_per_pixel_t byte_per_pixel	Number of bytes per pixel. See Table 1-2
int_fast32_t stride	Number of bytes of pixels having the same x coordinate in the previously below line. Specify a multiple of 32.

int_fast32_t height	Frame buffer height (pixels)
pixel_format_t pixel_format	Pixel format
frame_buffer_delegate_t* delegate	User-defined variable

Sample:

```
static uint8_t  gs_frame_buffer_memory[2][800][480][4];
frame_buffer_t  frame;
frame.buffer_address[0] = gs_frame_buffer_memory [0];
frame.buffer_address[1] = gs_frame_buffer_memory [1];
frame.buffer_count = 2;
frame.show_buffer_index = 0;
frame.draw_buffer_index = 1;
frame.width = 800;
frame.byte_per_pixel = 4;
frame.stride = 800 * 4;
frame.height = 480
frame.pixel_format = PIXEL_FORMAT_ARGB8888;
frame.delegate = NULL;
```

5.4.5.3 graphics_config_t

Outline Configuration of graphics_t type

Header RGA.h

Description To customize default values or assemble essential settings, use the function described in section 5.8.1.2, R_GRAPHICS_OnInitialize_FuncType.

Member Variable

bit_flags_fast32_t flags	See section 5.11.6, Flagged Structure Parameters. (mandatory) F_GRAPHICS_FRAME_BUFFER F_GRAPHICS_WORK_BUFFER_ADDRESS F_GRAPHICS_WORK_BUFFER_SIZE F_GRAPHICS_MAX_HEIGHT_OF_FRAME_BUFFER F_GRAPHICS_QUALITY_FLAGS F_GRAPHICS_BACKGROUND_COLOR F_GRAPHICS_IS_FAST_MANUAL_FLUSH F_GRAPHICS_WORK_BUFFER_B_ADDRESS F_GRAPHICS_WORK_BUFFER_B_SIZE F_GRAPHICS_JPEG_DECODER F_GRAPHICS_INTERNAL_EVENT_VALUE F_GRAPHICS_LOCK_OBJECT
frame_buffer_t* frame_buffer	Frame buffer to be drawn for which member variables must be set. Set the address of frame_buffer_t type structure.
void* work_buffer_address	Work buffer starting address that must be set, if in following condition. Set this address in uncached area. ● Drawing Raw format image ● Using work buffer B
size_t work_buffer_size	Size (bytes) of work buffer used internally Set this with "work_buffer_address" See section 5.7.14.3, R_RGA_CalcWorkBufferSize.
int_fast32_t max_height_of_frame_buffer	Maximum height of frame buffer to be drawn Set this with "work_buffer_address"

graphics_quality_flags_t quality_flags	Drawing quality; see section 5.4.5.4.
r8g8b8a8_t background_color	Background color; see section 5.7.1.22.
bool_t is_fast_manual_flush	Whether the mode is fast manual flush mode (section 5.11.4)
void* work_buffer_b_address	Work buffer B starting address that must be set, if in following condition. ● X coord value of left of JPEG image is not alignment by 4, when frame buffer was 16-bit color. ● X coord value of left of JPEG image is not alignment by 2, when frame buffer was 32-bit color. ● Drawing JPEG image with matrix
size_t work_buffer_b_size	Size (bytes) of work buffer B Set this with "work_buffer_b_address" See section 5.7.14.4.5, R_RGA_CalcWorkBufferB_Size.
graphics_jpeg_decoder_t jpeg_decoder	Using JPEG decoder
bit_flags32_t internal_event_value	The value of thread attached event. Default value is R_OSPL_UNUSED_FLAG. Application cannot wait this value. See application note of OSPL.
BSP_CFG_USER_LOCKING_TYPE* lock_object	Lock object managing right to use RGA. Lock area is from "R_GRAPHICS_Initialize" function to "R_GRAPHICS_Finalize" function. See application note of OSPL.

5.4.5.4 graphics_quality_flags_t

This is a defaultable flag indicating the drawing quality. See section 5.11.7, Defaultable Flags.

```
#include  "RGA.h"
```

Constant Name	Value	Description
GRAPHICS_RENDERING_QUALITY_ANTIALIASED	0x00001	Enable the antialiasing at the borders
GRAPHICS_RENDERING_QUALITY_NONANTIALIASED	0x10000	Disable the antialiasing at the borders
GRAPHICS_IMAGE_QUALITY_ANTIALIASED	0x00002	Enable the interpolation filter for image
GRAPHICS_IMAGE_QUALITY_NONANTIALIASED	0x20000	Disable the interpolation filter for image

5.4.5.5 window_surfaces_t

Outline This is a sample type of the frame buffer and screen display

Header RGA.h, window_surfaces.h

Description For the function equivalent to the member function, see section 5.7.

Member Variable

Access Inhibit	

5.4.5.6 window_surfaces_config_t

Outline This is a type that sets window_surfaces_t.

Header RGA.h, window_surfaces.h

Description

Member Variable

bit_flags_fast32_t flags	For flags, see section 5.11.6, Flagged Structure Parameters. F_WINDOW_SURFACES_PIXEL_FORMAT F_WINDOW_SURFACES_LAYER_COUNT F_WINDOW_SURFACES_BUFFER_HEIGHT F_WINDOW_SURFACES_BACKGROUND_COLOR
pixel_format_t pixel_format	Pixel format of showing window. See section 5.4.5.10. [Condition] The following value can be set for the sample of SH7269. ● PIXEL_FORMAT_ARGB8888 ● PIXEL_FORMAT_XRGB8888 ● PIXEL_FORMAT_RGB565 (default) ● PIXEL_FORMAT_ARGB4444 ● PIXEL_FORMAT_ARGB1555 ● PIXEL_FORMAT_YCbCr422 ● PIXEL_FORMAT_CLUT1 ● PIXEL_FORMAT_CLUT4 ● PIXEL_FORMAT_CLUT8
pixel_format_t overlay_pixel_format	Reserved
int_fast32_t layer_count	Count of creating layer. Default is 1. [Condition] Example of SH7269 can be set 1 only.
int_fast32_t buffer_height	Height of the frame buffer. Default is the height of the screen.
r8g8b8a8_t background_color	Background color. See 5.4.5.19. Default is "R_RGA_Get_R8G8B8A8(255, 255, 255, 0)".

5.4.5.7 layer_attributes_t

Outline The following lists parameter types of the "R_WINDOW_SURFACES _AccessLayerAttributes" function

Header RGA.h, window_surfaces.h

Description See 5.11.5 Sample Screen Control Layer Configuration

Member Variable

access_t access	Whether to set or acquire values (essential)
bit_flags_fast32_t flags	Section 5.11.6, Flagged Structure Parameters (essential) Above value logical or. (e.g.) F_LAYER_ID
int_fast32_t id	Layer number to be accessed (-1: background) (essential). See 5.11.5.
int_fast32_t priority	Reserved
bool_t is_show	Reserved
bool_t is_color_key	Reserved
r8g8b8a8_t color_key	Reserved
r8g8b8a8_t layer_color	Color of entire layer (available only for ID = -1). See 5.4.5.19.
int_fast32_t x	Reserved
int_fast32_t y	Reserved
int_fast32_t width	Reserved

int_fast32_t height	Reserved
int_fast32_t offset_x	Reserved
int_fast32_t offset_y	Reserved
uint32_t* CLUT	Array of colors to set to CLUT (Color Look Up Table). (optional) Set "CLUT" of graphics_image_properties_t (section 5.4.5.14). Pixel format is ARGB8888. If CLUT was overwritten for second image, first image using CLUT is not shown correctly.
int_fast32_t CLUT_count	Count of elements of CLUT. Set this with "CLUT" variable. Set "CLUT_count" of graphics_image_properties_t (section 5.4.5.14). [Setting range] Max is 256(CLUT8), 16(CLUT4), 2(CLUT2).

5.4.5.8 access_t

This is a type that specifies Write (setting set values) or Read (acquiring set values).

Constant Name	Value	Description
ACCESS_READ	1	Read values
ACCESS_WRITE	2	Write values

5.4.5.9 byte_per_pixel_t

```
#include  <RGA.h>
typedef int  byte_per_pixel_t;
```

This is a type of number of bytes per pixel.

When one pixel is less than one byte (BitPerPixel < 8), a value shifted from the number of bits per pixel is set.

When 1 pixel is 1 byte or more:

	15 8	7 0
0	0	Number of bytes

When 1 pixel is less than 1 byte:

	15 8	7 0
0	Number of bits	0

For related functions, see section 5.7.9.2.

5.4.5.10 pixel_format_t

This is a pixel format type.

See Table 1-3.

```
#include  "RGA.h"  /* or "frame_buffer.h" */
```

Constant Name	Value	Value	Description
PIXEL_FORMAT_UNKNOWN	0	0x00	Unknown
PIXEL_FORMAT_ARGB8888	1	0x01	ARGB8888

PIXEL_FORMAT_RGB565	3	0x03	RGB565
PIXEL_FORMAT_ARGB4444	5	0x05	ARGB4444
PIXEL_FORMAT_A1	13	0x0D	1bit alpha (Reserved)
PIXEL_FORMAT_A4	14	0x0E	4bit alpha (Reserved)
PIXEL_FORMAT_A8	11	0x0B	8bit alpha (Reserved)
PIXEL_FORMAT_RGB888	15	0x0F	RGB888 (Reserved)
PIXEL_FORMAT_R8G8B8A8	6 | (1 << 4)	0x16	R8G8B8A8
PIXEL_FORMAT_XRGB8888	0 | (1 << 6)	0x40	XRGB8888
PIXEL_FORMAT_ARGB1555	4 | (1 << 6)	0x44	ARGB1555
PIXEL_FORMAT_YCbCr422	2 | (1 << 16)	0x10002	YCbCr422
PIXEL_FORMAT_YUV422	2 | (1 << 16)	0x10002	YUV422
PIXEL_FORMAT_YUV422_GRAY_SCALE_IS_0x80	2 | (1 << 16)	0x10002	YCbCr422 Cb, Cr = 0x80 is gray
PIXEL_FORMAT_JPEG	12 | (2 << 8)	0x20C	JPEG
PIXEL_FORMAT_PNG	12 | (3 << 8)	0x30C	PNG (Reserved)
PIXEL_FORMAT_GIF	12 | (4 << 8)	0x40C	GIF (Reserved)
PIXEL_FORMAT_CLUT1	12 | (1 << 12)	0x100C	1-bit CLUT
PIXEL_FORMAT_CLUT4	12 | (4 << 12)	0x400C	4-bit CLUT
PIXEL_FORMAT_CLUT8	12 | (8 << 12)	0x800C	8-bit CLUT

5.4.5.11 frame_buffer_delegate_t

This is a class of objects referenced from the delegate member variable of frame_buffer_t.

This class can be defined by libraries that use frame_buffer_t or by the application.

This class is defined as follows by default. Therefore, frame_buffer_t::delegate is a void* type.

```
#include  <RGA.h>
typedef  void  frame_buffer_delegate_t;
```

To change the type, define the type before performing #include for the header file that defines frame_buffer_delegate_t, and then perform #define frame_buffer_delegate_t frame_buffer_delegate_t.

```
typedef  MyFrameBufferClass       frame_buffer_delegate_t;
#define  frame_buffer_delegate_t  frame_buffer_delegate_t

#include  <RGA.h>  /* default define frame_buffer_delegate_t */
```

5.4.5.12 v_sync_t

Outline	Synchronization with the V-Sync signal of the display screen.	
Header	RGA.h, vsync.h	
Description	Function equivalent to the member function: See section 5.7.11.	
Member Variable	Access Inhibit	

5.4.5.13 vram_ex_stack_t

Outline	This is a sample code of stack class for off-screen buffer in external RAM	
Header	RGA.h, window_surfaces.h	
Description	Function equivalent to the member function: See section 5.7.12. For SH7269, Video Display Controller 4 (VDC4) must not show the frame buffer in external RAM. Show the frame buffer in internal RAM copied from external RAM.	
Member Variable	Access Inhibit	

5.4.5.14 graphics_image_properties_t

Outline	This is a type of image properties.
Header	RGA.h
Description	Related function : (5.7.2.6) R_GRAPHICS_IMAGE_GetProperties If the source image is created in the program, call "R_GRAPHICS_IMAGE_InitByShareFrameBuffer" function (5.7.2.5).

Member Variable

int_fast32_t width	Width of image (pixel)
int_fast32_t height	Height of image (pixel)
uint8_t* data	First address of array of image pixels. If the image format is not R8G8B8A8, this value is NULL
void* pixels	First address of array of image pixels. Even if the image format is not R8G8B8A8, this value is available.
pixel_format_t pixelFormat	Pixel format
uint32_t* CLUT	CLUT (Color Look Up Table, Palette). Array of colors. If the image does not have CLUT, this value is NULL. Set to "layer_attributes_t" (5.4.5.7).
int_fast32_t CLUT_count	Count of array elements of CLUT. Set to "layer_attributes_t" (5.4.5.7).

5.4.5.15 graphics_composite_operation_t

This is a calculation method type for alpha blend.

```
#include "RGA.h"
```

Constant Name	Value	Description
GRAPHICS_SOURCE_OVER	1	Performs calculation (SRC over DST) of general alpha blend. Whether the calculation formula is the premultiplied alpha expression depends on whether alpha is present in the flag included in the header of an image to be drawn or in the drawing target pixel format. (default)
GRAPHICS_DESTINATION_OUT	7	This type is used for drawing the inverted alpha mask. Only the alpha component of drawing destination varies according to the following expression. a_dst = a_dst * (1 - a_src) When drawing an image on a frame buffer without alpha component, GRAPHICS_DESTINATION_OUT cannot be set. When the final drawing destination is XRGB8888, draw the inverted alpha mask on the back buffer of ARGB8888. Set 255 for the R_GRAPHICS_SetGlobalAlpha function or the globalAlpha property.
GRAPHICS_COPY	0	Performs no alpha blend and copy from source image data. It may be fast at that rate. For faster, when PNG image with alpha channel was decoded to the back buffer, if CRAPHICS_COPY was specified, it is not necessary to clear the back buffer on ahead.

5.4.5.16 graphics_status_t

Outline	This is an area type that stores graphics drawing context.
Header	RGA.h
Description	Function equivalent to the member function: ● 5.7.1.8, R_GRAPHICS_Save ● 5.7.1.9. R_GRAPHICS_Restore

Member Variable	Access Inhibit	

5.4.5.17 graphics_matrix_float_t

```
    #include <RGA.h>
    typedef float graphics_matrix_float_t;
```

This is a matrix element type.

5.4.5.18 repetition_t

This is a type that specifies the pattern repetition method.

```
#include "RGA.h"
```

Constant Name	Value	Description
GRAPHICS_REPEAT	1	Repeating

5.4.5.19 r8g8b8a8_t

Outline	Pixel format in which bytes are arranged in the order of red, green, blue, and alpha	
Header	RGA.h	
Description	[Setting range] A value of 0 (black, transparent) to 255 (light, opaque) is specified for each of red, green, blue, and alpha.	
Member Variable	uint8_t u.red	Red
	uint8_t u.green	Green
	uint8_t u.blue	Blue
	uint8_t u.alpha	Alpha, opaque level

5.4.5.20 animation_timing_function_t

Outline	This is an object describing timing of animation (Bezier function).	
Header	RGA.h	
Description	For the function equivalent to the member function, see section 5.7.13.	
Member Variable	Access Inhibit	

5.4.5.21 graphics_jpeg_decoder_t

Constant value of a kind of JPEG decoder.

```
    #include "RGA.h"
```

Constant Name	Value	Description
GRAPHICS_JPEG_DECODER_NONE	0	Not used JPEG decoder. JPEG hardware decoder can be used from any other than RGA.
GRAPHICS_JPEG_DECODER_HARD	1	JPEG hardware decoder. (default)

5.4.6 String Format

5.4.6.1 #rrggbb, #rgb

This format describes a color by hex number of CSS Color format

Target : fillStyle (5.6.1.3)

e.g.) "#FFFF00" : Red component is 255, Green component is 255, Blue component is 0 and Alpha component is 1.0

e.g.) "#FF0" : Red component is 255, Green component is 255, Blue component is 0 and Alpha component is 1.0

5.4.7 Type of porting layers

5.4.7.1 List

Type	Description
NCGvoid	Abstract of void type for NCG
NCGenum	Abstract of enumeration type for NCG [4]
NCGboolean	Abstract of _Bool type for NCG
NCGbitfield	Abstract of bit flags type for NCG [4]
NCGchar	Abstract of string type for NCG
NCGint8	Abstract of int8_t type for NCG [4]
NCGint16	Abstract of int16_t type for NCG [4]
NCGint32	Abstract of int32_t type for NCG
NCGint64	Abstract of int64_t type for NCG [4]
NCGuint8	Abstract of uint8_t type for NCG [4]
NCGuint16	Abstract of uint16_t type for NCG [4]
NCGuint32	Abstract of uint32_t type for NCG
NCGuint64	Abstract of uint64_t type for NCG [4]
NCGfloat32	Abstract of IEEE 754 single precision floating point number type for NCG [4]
NCGfloat64	Abstract of IEEE 754 double precision floating point number type for NCG [4]
NCGsizei	Unsigned integer type described a size for NCG [4]
NCGclampf	Abstract of floating point number type let the value from 0.0 to 1.0 for NCG [4]
NCGfixed	Abstract of fixed point number type for NCG [4]

[4] Not used in RGA

5.4.8 Changing state of class

Figure 6-1 shows a Figure of changing state of graphics_t class, and Table 6-1 shows List of functions of each class having R_*_Finalize member function. The function not changing state can be called at Normal state.

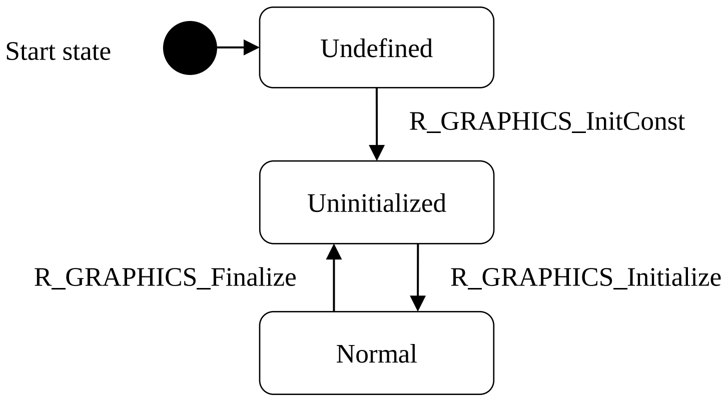


Figure 5-1 Figure of changing state of graphics_t class

Table 5-1 List of functions of each class having R_*_Finalize member function

Class	Undefined to Uninitialized	Uninitialized to Normal	Normal to Uninitialized
graphics_t	R_GRAPHICS_InitConst	R_GRAPHICS_Initialize	R_GRAPHICS_Finalize

Figure 6-2 shows a Figure of changing state of graphics_pattern_t class, and Table 6-2 shows List of functions of each class not having R_*_Finalize member function. The function not changing state can be called at Normal state.

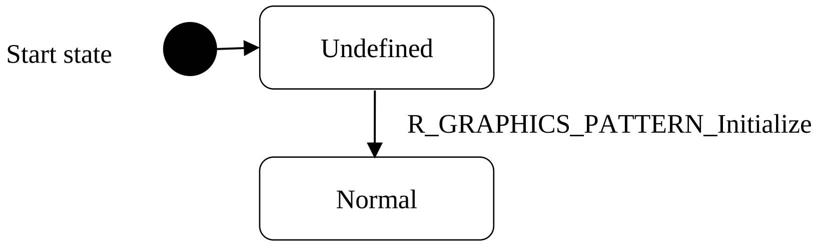


Figure 5-2 Figure of changing state of graphics_pattern_t class

Table 5-2 List of functions of each class not having R_*_Finalize member function

Class	Undefined to Normal
graphics_image _t	R_GRAPHICS_IMAGE_InitR8G8B8A8 R_GRAPHICS_IMAGE_InitSameSizeR8G8B8A8 R_GRAPHICS_IMAGE_InitCopyFrameBufferR8G8B8A8 R_GRAPHICS_IMAGE_InitByShareFrameBuffer The object created by ImagePackager is Normal state at the start state.
graphics_pattern_t	R_GRAPHICS_PATTERN_Initialize

5.5 List of Variables

Table 5.6 shows Global Variables, Table 5.7 shows Static-Type Variables, and Table 5.8 shows Const-Type Variables.

Table 5.6 Global Variables

Type	Variable	Description	Applicable Function
None			

Table 5.7 Static-Type Variables

Type	Variable	Description	Applicable Function
None			

Table 5.8 Const-Type Variables

Type	Variable	Description	Applicable Function
None			

5.6 Properties

5.6.1 Canvas2D_ContextClass Properties

5.6.1.1 List of Properties

Section	Property	Description
5.6.1.2	c_LanguageContext	Context available for the C language API
5.6.1.3	fillStyle	Fill style
5.6.1.4	globalAlpha	One alpha value (opacity) multiplied by all drawings
5.6.1.5	globalCompositeOperation	Calculation method for alpha blend

5.6.1.2 c_LanguageContext

```
graphics_t*  Canvas2D_ContextClass::c_LanguageContext;  /* get only */
```

This property is a context available for the C language API.

Refer to this property when using a function that is provided by the C language API but is not provided by the C++API.

5.6.1.3 fillStyle

```
char* Canvas2D_ContextClass::fillStyle;  /* set only */ /* CSS color */
Canvas2D_PatternClass  Canvas2D_ContextClass::fillStyle;  /* set only */
Canvas2D_GradientClass  Canvas2D_ContextClass::fillStyle;  /* set only */
```

This property specifies a fill method. This property has the value of either type shown below.

For the char* type, this property specifies the single-color fill color expressed by CSS Color.

For the Canvas2D_PatternClass type, this property specifies pattern.

When the char* type is specified, the fill method is single-color fill. Refer to #rrggbb, #rgb (5.4.6.1), rgb (5.7.15.2), rgba (5.7.15.3)

The initial value is opaque black.

Use the fillRect method for drawing patterns.

5.6.1.4 globalAlpha

```
float32_t  Canvas2D_ContextClass::globalAlpha;  /* get,set */
```

This property retains a single alpha value (opacity) to be multiplied by all drawings.

The default value is 1.0.

If a value less than 0.0 is set, 0.0 is retained.

If a value larger than 1.0 is set, 1.0 is retained.

This property affects the following drawing functions.

- Figure fill functions such as fillRect (Canvas2D_ContextClass)
- Pattern drawing functions such as fillRect (Canvas2D_ContextClass)
- Border drawing functions such as strokeRect (Canvas2D_ContextClass)
- Image drawing functions such as drawImage (Canvas2D_ContextClass)

This property does not affect the following drawing function.

- clearRect (Canvas2D_ContextClass)

5.6.1.5 globalCompositeOperation

```
char*  Canvas2D_ContextClass::globalCompositeOperation;  /* get,set */
```

This property retains the calculation method for alpha blend. See 5.4.5.15 graphics_composite_operation_t.

5.6.2 Canvas2D_ImageClass Properties

5.6.2.1 List of Properties

Section	Property	Description
5.6.2.2	src	Image data structure
5.6.2.3	width	Image width
5.6.2.4	height	Image height
5.6.2.5	data	Array containing pixel color components

5.6.2.2 src

```
GraphicsImageClass*  Canvas2D_ImageClass::src;  /* set only */
```

This property retains the raw image data structure created by ImagePackager.

5.6.2.3 width

```
int_t  Canvas2D_ImageClass::width;  /* get only */
```

This property retains the image width.

5.6.2.4 height

```
int_t  Canvas2D_ImageClass::height;  /* get only */
```

This property retains the image height.

5.6.2.5 data

```
uint8_t*  Canvas2D_ImageClass::data;  /* get only */
```

This property is an array containing pixel color components.

Upper left is the top.

Color components are arranged in the order of R, G, B, and A.

R, G, B, A: 0 to 255

5.7 Functions and Methods

5.7.1 Functions Equivalent to graphics_t Class Member Function

5.7.1.1 List of Functions

Section	Function Name	Description
5.7.1.2	R_GRAPHICS_InitConst	Initializes the constant part.
5.7.1.3	R_GRAPHICS_Initialize	Initializes the graphics drawing context object.
5.7.1.4	R_GRAPHICS_Finalize	Finalizes the graphics drawing context object.
5.7.1.5	R_GRAPHICS_SetFrameBuffer	Changes the drawing target.
5.7.1.6	R_GRAPHICS_SetFrameBuffer	Changes the drawing target.
5.7.1.7	R_GRAPHICS_Finish	Waits until drawing is completed.
5.7.1.8	R_GRAPHICS_Save	Saves the set value of context to the specified status structure.
5.7.1.9	R_GRAPHICS_Restore	Returns the status structure content to context.
5.7.1.10	R_GRAPHICS_ResetMatrix	Resets the target matrix of the matrix calculation function to the unit matrix.
5.7.1.11	R_GRAPHICS_SetMatrix_2x3	Sets each element of the matrix. (2x3)
5.7.1.12	R_GRAPHICS_SetMatrix_3x3	Sets each element of the matrix. (3x3)
5.7.1.13	R_GRAPHICS_GetMatrix_3x3	Acquires each element of the matrix.
5.7.1.14	R_GRAPHICS_TranslateMatrixI	Translates matrix from the current matrix. (integer type specified)
5.7.1.15	R_GRAPHICS_TranslateMatrix	Translate matrix from the current matrix. (floating-point type specified)
5.7.1.16	R_GRAPHICS_ScaleMatrix	Enlarges or reduces matrix from the current matrix.
5.7.1.17	R_GRAPHICS_RotateMatrixDegree	Rotates matrix from the current matrix. Rotation center: (0,0)
5.7.1.18	R_GRAPHICS_ShearMatrix	Makes shear deformation from the current matrix.
5.7.1.19	R_GRAPHICS_TransformMatrix	Multiplies the current matrix by the specified 2x3 matrix.
5.7.1.20	R_GRAPHICS_MultiplyMatrix	Multiplies the current matrix by the specified 3x3 matrix.
5.7.1.21	R_GRAPHICS_GetProjectiveMatrix	Acquires a matrix that deforms a random profile quadrangle to a random profile quadrangle.
5.7.1.22	R_GRAPHICS_SetBackgroundColor	Sets the background color.
5.7.1.23	R_GRAPHICS_GetBackgroundColor	Acquires the background color.
5.7.1.24	R_GRAPHICS_GetClearColor	Acquires the color used for R_GRAPHICS_Clear.
5.7.1.25	R_GRAPHICS_Clear	Clears rectangle area.
5.7.1.26	R_GRAPHICS_DrawImage	Draws an image.
5.7.1.27	R_GRAPHICS_DrawImageResized	Enlarges or reduces an image and draws it in a rectangle.
5.7.1.28	R_GRAPHICS_DrawImageChild	Draws a part of an image.
5.7.1.29	R_GRAPHICS_FillRect	Fills a rectangle.
5.7.1.30	R_GRAPHICS_SetFillColor	Sets the color used for single-color fill for the current fill paint object.
5.7.1.31	R_GRAPHICS_SetFillPattern	Sets a pattern for the current fill paint object.
5.7.1.32	R_GRAPHICS_BeginPath	Resets the default path content to null.
5.7.1.33	R_GRAPHICS_Rect	Adds a rectangle to the default path.
5.7.1.34	R_GRAPHICS_Clip	Sets the shape of the current default path to a clipping area.
5.7.1.35	R_GRAPHICS_SetGlobalAlpha	Sets an alpha value (opacity) to be multiplied by all drawings.
5.7.1.36	R_GRAPHICS_GetGlobalAlpha	Acquires an alpha value (opacity) to be multiplied by all drawings.

5.7.1.37	R_GRAPHICS_SetGlobalCompositeOperation	Sets the calculation method for alpha blend.
5.7.1.38	R_GRAPHICS_GetGlobalCompositeOperation	Acquires the calculation method for alpha blend.
5.7.1.39	R_GRAPHICS_STATIC_SetOnInitialize	Registers a callback function that sets the default graphics_config_t value.
5.7.1.40	R_GRAPHICS_STATIC_SetOnFinalize	Registers a function that releases the memory allocated in the R_GRAPHICS_OnInitialize_FuncType function.
5.7.1.41	R_GRAPHICS_SetQualityFlags	Sets the drawing quality.
5.7.1.42	R_GRAPHICS_GetQualityFlags	Acquires the current drawing quality.
5.7.1.43	R_GRAPHICS_SetStrokeColor	Sets the color used for filling the current border.
5.7.1.44	R_GRAPHICS_StrokeRect	Draws sides of rectangle.
5.7.1.45	R_GRAPHICS_BeginSoftwareRendering	Notifies the graphics library of the start of software rendering.
5.7.1.46	R_GRAPHICS_EndSoftwareRendering	Notifies the graphics library of the end of software rendering.
5.7.1.47	R_GRAPHICS_EndRenderingInFin	Call this function from the end of the function that performs software rendering.

5.7.1.2 R_GRAPHICS_InitConst

Outline	Initializes the constant part used by the RGA.	
Header	RGA.h	
Declaration	void R_GRAPHICS_InitConst(graphics_t* self);	
Description	Refer to section 5.11.8, Function to Initialize Internal Variables with Constants (*_initConst Function).	
Argument	graphics_t* self	Graphics drawing context
Return value	None	

5.7.1.3 R_GRAPHICS_Initialize

Outline	Initializes the graphics drawing context object.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_Initialize (graphics_t* self, graphics_config_t* config);	
Description	Initializes internal variables. Initializes OpenVG™-Compliant Renesas Graphics Processor (R-GPVG) and JPEG Codec Unit (JCU). When "self" is no longer be used, call R_GRAPHICS_Finalize. There is only one context. When two or more frame buffers was drawn, change the frame buffer by "R_GRAPHICS_SetFrameBuffer" function.	
Argument	graphics_t* self	Graphics drawing context
	graphics_config_t* config	See section 5.4.5.3.
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.4 R_GRAPHICS_Finalize

Outline	Finalizes the graphics drawing context object.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_Finalize(graphics_t* self, errnum_t e);	
Description		
Argument	graphics_t* self	Graphics drawing context
	errnum_t e	Errors that have occurred. No error = 0
Return value	Error code or e 0 = successful and e = 0	

5.7.1.5 R_GRAPHICS_SetFrameBuffer

Outline	Changes the drawing target.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_SetFrameBuffer(graphics_t* self, frame_buffer_t* frame_buffer);	
Description		
Argument	graphics_t* self	Graphics drawing context
	frame_buffer_t* frame_buffer	Frame buffer to be drawn
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.6 R_GRAPHICS_GetFrameBuffer

Outline	Gets the drawing target.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_GetFrameBuffer(graphics_t* self, frame_buffer_t** out_frame_buffer);	
Description		
Argument	graphics_t* self	Graphics drawing context
	frame_buffer_t** out_frame_buffer	(Output) Frame buffer to be drawn

Return value	Error code. If there is no error, the return value is 0.

5.7.1.7 R_GRAPHICS_Finish

Outline: Waits until drawing is completed.

Header: RGA.h

Declaration: errnum_t R_GRAPHICS_Finish(graphics_t* self);

Description: In fast manual flush mode (see section 5.11.4), when the CPU directly reads or writes frame buffer data in the cache area or non-cache area after the graphics library API of hardware rendering is called, enclose by calling R_GRAPHICS_BeginSoftwareRendering to R_GRAPHICS_EndSoftwareRendering. In these functions, the R_GRAPHICS_Finish function is called only if necessary and the CPU cache is also controlled.

Argument	graphics_t* self	Graphics drawing context
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.8 R_GRAPHICS_Save

Outline: Saves the set value of context to the specified status structure.

Header: RGA.h

Declaration: errnum_t R_GRAPHICS_Save(graphics_t* self, graphics_status_t* out_status);

Description:

Argument	graphics_t* self	Graphics drawing context
	graphics_status_t* out_status	(Output) Set value of context
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.9 R_GRAPHICS_Restore

Outline: Returns the status structure content to context.

Header: RGA.h

Declaration: errnum_t R_GRAPHICS_Restore(graphics_t* self, graphics_status_t* status, errnum_t e);

Description:

Argument	graphics_t* self	Graphics drawing context
	graphics_status_t* status	Set value of context
	errnum_t e	Errors that have occurred. No error = 0
Return value	Error code or e 0 = successful and e = 0	

5.7.1.10 R_GRAPHICS_ResetMatrix

Outline: Resets the matrix to be a matrix calculation function target to the unit matrix.

Header: RGA.h

Declaration: errnum_t R_GRAPHICS_ResetMatrix(graphics_t* self);

Description:

Argument	graphics_t* self	Graphics drawing context
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.11 R_GRAPHICS_SetMatrix_2x3

Outline Sets each element of the current matrix. (2x3)

Header RGA.h

Declaration

```
errnum_t   R_GRAPHICS_SetMatrix_2x3( graphics_t* self,
        graphics_matrix_float_t sx,    graphics_matrix_float_t ky,
        graphics_matrix_float_t kx,    graphics_matrix_float_t sy,
        graphics_matrix_float_t tx,    graphics_matrix_float_t ty );
```

Description: When the library was ported, take care computing error.

Argument	graphics_t* self	Graphics drawing context
	graphics_matrix_float_t sx, graphics_matrix_float_t ky, graphics_matrix_float_t kx, graphics_matrix_float_t sy, graphics_matrix_float_t tx, graphics_matrix_float_t ty	2x3 matrix $\begin{pmatrix} sx & kx & tx \\ ky & sy & ty \\ 0 & 0 & 1 \end{pmatrix}$
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.12 R_GRAPHICS_SetMatrix_3x3

Outline	Sets each element of the current matrix (Matrix[]) (3x3).	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_SetMatrix_3x3(graphics_t* self, graphics_matrix_float_t * matrix);	
Description	When the library was ported, take care computing error.	
Argument	graphics_t* self	Graphics drawing context
	graphics_matrix_float_t * matrix	3x3 matrix (array) $\begin{pmatrix} Matrix[0] & Matrix[3] & Matrix[6] \\ Matrix[1] & Matrix[4] & Matrix[7] \\ Matrix[2] & Matrix[5] & Matrix[8] \end{pmatrix}$
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.13 R_GRAPHICS_GetMatrix_3x3

Outline	Acquires each element of the current matrix (Matrix[]).	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_GetMatrix_3x3(graphics_t* self, graphics_matrix_float_t * out_matrix);	
Description		
Argument	graphics_t* self	Graphics drawing context
	graphics_matrix_float_t * out_matrix	(Output) 3x3 matrix (array) $\begin{pmatrix} Matrix[0] & Matrix[3] & Matrix[6] \\ Matrix[1] & Matrix[4] & Matrix[7] \\ Matrix[2] & Matrix[5] & Matrix[8] \end{pmatrix}$
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.14 R_GRAPHICS_TranslateMatrixI

Outline
Translates the current matrix (M). (Integer type specified)

Header
RGA.h

Declaration
errnum_t R_GRAPHICS_TranslateMatrixI(graphics_t* self,
int_fast32_t tx, int_fast32_t ty);

Description

$$M=M\cdot\begin{pmatrix} 1 & 0 & tx \\ 0 & 1 & ty \\ 0 & 0 & 1 \end{pmatrix}$$

[Limitation] RGA often stops by drawing image with matrix set translated whole of image to out of frame buffer.

Argument	graphics_t* self	Graphics drawing context
	int_fast32_t tx, int_fast32_t ty	Displacement (When the origin is at the upper left, plus of X means right direction and plus of Y means downward direction.)
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.15 R_GRAPHICS_TranslateMatrix

Outline: Translates the current matrix (M). (Floating-point type specified)

Header: RGA.h

Declaration:

```
errnum_t   R_GRAPHICS_TranslateMatrix( graphics_t* self,
      graphics_matrix_float_t tx, graphics_matrix_float_t ty );
```

Description:

$$M=M\cdot\begin{pmatrix} 1 & 0 & tx \\ 0 & 1 & ty \\ 0 & 0 & 1 \end{pmatrix}$$

[Limitation] RGA often stops by drawing image with matrix set translated whole of image to out of frame buffer.

Argument:

graphics_t* self	Graphics drawing context
graphics_matrix_float_t tx graphics_matrix_float_t ty	Displacement (When the origin is at the upper left, plus of X means right direction and plus of Y means downward direction.)

Return value: Error code. If there is no error, the return value is 0.

5.7.1.16 R_GRAPHICS_ScaleMatrix

Outline: Enlarges or reduces the current matrix (M).

Header: RGA.h

Declaration:

```
errnum_t   R_GRAPHICS_ScaleMatrix( graphics_t* self,
            graphics_matrix_float_t sx, graphics_matrix_float_t sy );
```

Description:

$$M=M\cdot\begin{pmatrix} sx & 0 & 0 \\ 0 & sy & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

When the library was ported, take care computing error.

Argument:

graphics_t* self	Graphics drawing context
graphics_matrix_float_t tx graphics_matrix_float_t ty	Magnification (Enlargement/reduction center: Origin)

Return value: Error code. If there is no error, the return value is 0.

5.7.1.17 R_GRAPHICS_RotateMatrixDegree

Outline: Rotates the current matrix (M). The center coordinates of rotation are (0,0).

Header: RGA.h

Declaration:

```
errnum_t   R_GRAPHICS_RotateMatrixDegree( graphics_t* self,
graphics_matrix_float_t angle );
```

Description:

$$M=M\cdot\begin{pmatrix} \cos(angle) & -\sin(angle) & 0 \\ \sin(angle) & \cos(angle) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

When the library was ported, take care computing error.

Argument:

graphics_t* self	Graphics drawing context
graphics_matrix_float_t angle	Rotation angle (degrees) (When the origin is at the upper left, plus means clockwise direction.)

Return value: Error code. If there is no error, the return value is 0.

5.7.1.18 R_GRAPHICS_ShearMatrix

Outline: Makes shear deformation of the current matrix (M).

Header: RGA.h

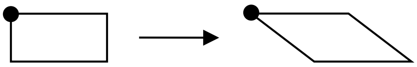
Declaration:

```
errnum_t   R_GRAPHICS_ShearMatrix( graphics_t* self,
            graphics_matrix_float_t shx, graphics_matrix_float_t shy );
```

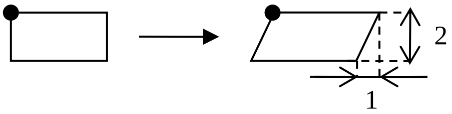
Description: M=M· 1 shx 0

$$\begin{pmatrix} shy & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

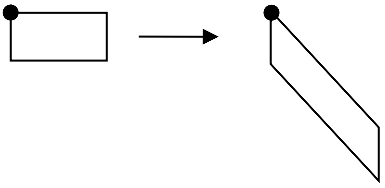
When (shx, shy) = (1.0, 0.0), a parallelogram is generated with perpendicular sides tilted 45 degrees.
Note, however, that the matrix is shifted unless the origin is at the upper left of the rectangle.



When (shx, shy) = (-0.5, 0.0), a parallelogram is generated with hypotenuses of a triangle (base : height = 1 : 2).



When (shx, shy) = (0.0, 1.0), a parallelogram is generated with horizontal sides tilted 45 degrees.



When the library was ported, take care computing error.

Argument	graphics_t* self	Graphics drawing context
	graphics_matrix_float_t shx graphics_matrix_float_t shy	Rate of shear (Shear center: Origin)
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.19 R_GRAPHICS_TransformMatrix

Outline Multiplies the current matrix (M) by the specified 2x3 matrix.

Header RGA.h

Declaration

```
errnum_t   R_GRAPHICS_TransformMatrix( graphics_t* self,
      graphics_matrix_float_t sx,   graphics_matrix_float_t ky,
      graphics_matrix_float_t kx,   graphics_matrix_float_t sy,
      graphics_matrix_float_t tx,   graphics_matrix_float_t ty );
```

Description

$$M=M\cdot\begin{pmatrix} sx & kx & tx \\ ky & sy & ty \\ 0 & 0 & 1 \end{pmatrix}$$

When the library was ported, take care computing error.

Argument	graphics_t* self	Graphics drawing context
	graphics_matrix_float_t sx graphics_matrix_float_t ky graphics_matrix_float_t kx graphics_matrix_float_t sy graphics_matrix_float_t tx graphics_matrix_float_t ty	2x3 matrix to be multiplied
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.20 R_GRAPHICS_MultiplyMatrix

Outline Multiplies the current matrix (M) by the specified 3x3 matrix (Matrix[]).

Header RGA.h

Declaration errnum_t R_GRAPHICS_MultiplyMatrix(graphics_t* self, graphics_matrix_float_t * matrix);

Description

$$M=M\cdot\begin{pmatrix} \mathrm{Matrix[0]} & \mathrm{Matrix[3]} & \mathrm{Matrix[6]} \\ \mathrm{Matrix[1]} & \mathrm{Matrix[4]} & \mathrm{Matrix[7]} \\ \mathrm{Matrix[2]} & \mathrm{Matrix[5]} & \mathrm{Matrix[8]} \end{pmatrix}$$

When the library was ported, take care computing error.

Argument

graphics_t* self	Graphics drawing context
graphics_matrix_float_t * matrix	2x3 matrix to be multiplied (array with nine elements)

Return value

Error code. If there is no error, the return value is 0.

5.7.1.21 R_GRAPHICS_GetProjectiveMatrix

Outline Acquires a matrix that deforms a random profile quadrangle to a random profile quadrangle.

Header RGA.h

Declaration

```
errnum_t   R_GRAPHICS_GetProjectiveMatrix(
   graphics_matrix_float_t source_top_left_x,              graphics_matrix_float_t source_top_left_y,
   graphics_matrix_float_t source_top_right_x,             graphics_matrix_float_t source_top_right_y,
   graphics_matrix_float_t source_bottom_left_x,           graphics_matrix_float_t source_bottom_left_y ,
   graphics_matrix_float_t source_bottom_right_x,          graphics_matrix_float_t source_bottom_right_y,
   graphics_matrix_float_t destination_top_left_x,       graphics_matrix_float_t destination_top_lLeft_y,
   graphics_matrix_float_t destination_top_right_x,      graphics_matrix_float_t destination_top_right_y,
   graphics_matrix_float_t destination_bottom_left_x,    graphics_matrix_float_t destination_bottom_left_y,
   graphics_matrix_float_t destination_bottom_right_x, graphics_matrix_float_t destination_bottom_right_y,
   graphics_matrix_float_t * out_matrix );
```

Description When the library was ported, take care computing error.

Argument

graphics_matrix_float_t source*	Four-point coordinates before conversion
graphics_matrix_float_t destination*	Four-point coordinates after conversion
graphics_matrix_float_t * out_matrix	(Output) 3x3 matrix (array with nine elements)

Return value

Error code. If there is no error, the return value is 0.

5.7.1.22 R_GRAPHICS_SetBackgroundColor

Outline Sets the background color.

Header RGA.h

Declaration errnum_t R_GRAPHICS_SetBackgroundColor(graphics_t* self, r8g8b8a8_t color);

Description When a frame buffer without alpha is to be drawn, the background color is the same as the clear color. The default background color is white.

When a frame buffer with alpha is to be drawn, the background color is specified color and the clear color drawing to the target is transparent black even if any color specified. The default background color is transparent white.

Argument

graphics_t* self	Graphics drawing context
r8g8b8a8_t color	Use R_RGA_Get_R8G8B8A8() to acquire the background color.

Return value

Error code. If there is no error, the return value is 0.

5.7.1.23 R_GRAPHICS_GetBackgroundColor

Outline Acquires the background color.

Header RGA.h

Declaration	errnum_t R_GRAPHICS_GetBackgroundColor(graphics_t* self, r8g8b8a8_t* out_color);	
Description		
Argument	graphics_t* self	Graphics drawing context
	r8g8b8a8_t* out_color	(Output) Background color
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.24 R_GRAPHICS_GetClearColor

Outline	Acquires the color used for R_GRAPHICS_Clear.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_GetClearColor(graphics_t* self, r8g8b8a8_t* out_color);	
Description	Use R_GRAPHICS_SetBackgroundColor() to set the clear color.	
Argument	graphics_t* self	Graphics drawing context
	r8g8b8a8_t* out_color	(Output) Clear color
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.25 R_GRAPHICS_Clear

Outline	Clears the rectangle area.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_Clear(graphics_t* self, int_fast32_t min_x, int_fast32_t min_y, int_fast32_t width, int_fast32_t height);	
Description	Use R_GRAPHICS_SetBackgroundColor() to set the clear color. When a double-buffer is used, the drawing buffer is cleared. Therefore, the cleared content is not displayed only by calling this function. Use R_WINDOW_SURFACES_SwapBuffers() to apply display. This function is affected by clipping.	
Argument	graphics_t* self	Graphics drawing context
	int_fast32_t min_x, int_fast32_t min_y, int_fast32_t width, int_fast32_t height	Rectangle area
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.26 R_GRAPHICS_DrawImage

Outline	Draws an image at coordinates (min_x, min_y) with the same size.
Header	RGA.h
Declaration	errnum_t R_GRAPHICS_DrawImage(graphics_t* self, graphics_image_t* image, int_fast32_t min_x, int_fast32_t min_y);
Description	Image data to be specified for the image argument can be created by using section 6.1, Image Format Conversion by ImagePackager. JPEG data can be directly specified for arguments. See section 5.11.3, Identifying Image Format. This function is affected by R_GRAPHICS_SetGlobalAlpha. This function is also affected by the current matrix and clipping. When drawing an image in the YUV422 format, if the X coord value converted by the matrix is not an even number, an error occurs. When the alpha component is included in the image and is not included in the drawing target frame buffer, RGB components to be drawn in the frame buffer are blended to values that have been multiplied by the alpha component. When the alpha component is included in the drawing target frame buffer, RGB components are blended to values that have not been multiplied by the alpha component.

An example of pixel format including the alpha component:
ARGB8888, ARGB4444, ARGB1555
An example of pixel format without alpha component:
XRGB8888, RGB565, YUV422

Specify a CLUT-format image as same bit count as the frame buffer for drawing in the CLUT format frame buffer. Only min_x = 0 and min_y = 0 can be specified as a drawing position. If source image's width was not byte unit, an error is raised. If CLUT color in the video controller was fit with drawing image, set CLUT of graphics_image_properties_t (5.4.5.14) to the video controller.

In fast manual flush mode (see section 5.11.4), when the image data specified for the image argument exists in the array variables prepared by the application, flushing is required. However, flushing is not required when ROM data is used.
When performing flush, directly flush the CPU cache or enclose the image data read/write processing by R_GRAPHICS_BeginSoftwareRendering to R_GRAPHICS_EndSoftwareRendering.

Argument	graphics_t* self	Graphics drawing context
	graphics_image_t* image	Image
	int_fast32_t min_x, int_fast32_t min_y	Minimum X and Y coordinates
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.27 R_GRAPHICS_DrawImageResized

Outline: Enlarges or reduces an image and draws it in the specified rectangle.
Header: RGA.h
Declaration: errnum_t R_GRAPHICS_DrawImageResized(graphics_t* self, graphics_image_t* image, int_fast32_t min_x, int_fast32_t min_y, int_fast32_t width, int_fast32_t height);
Description: See the description on the R_GRAPHICS_DrawImage function.

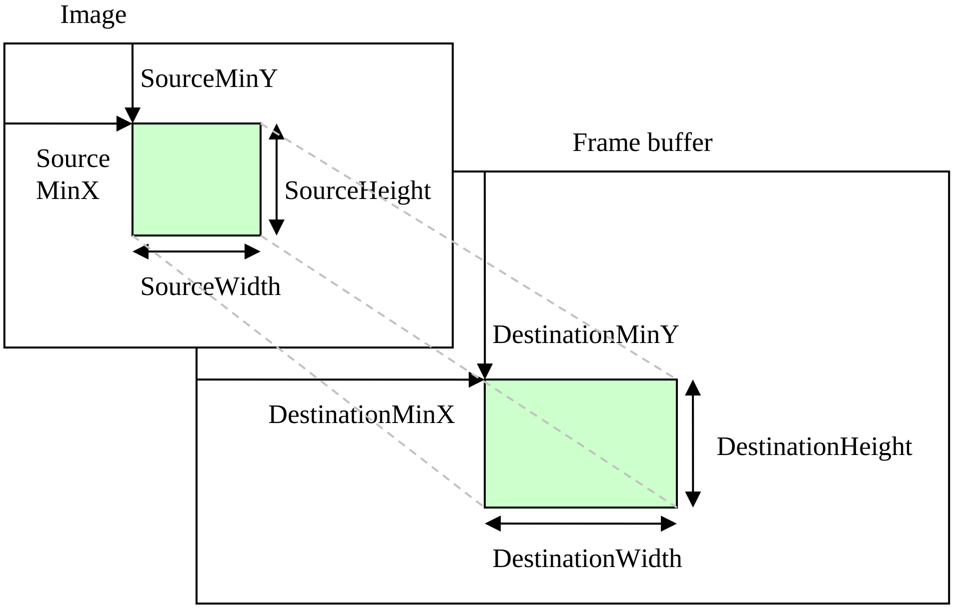
Argument	graphics_t* self	Graphics drawing context
	graphics_image_t* image	Image
	int_fast32_t min_x, int_fast32_t min_y	Minimum X and Y coordinates
	int_fast32_t width, int_fast32_t height	Width and height of the drawing target
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.28 R_GRAPHICS_DrawImageChild

Outline: Draws a part of an image.
Header: RGA.h
Declaration:

```
errnum_t   R_GRAPHICS_DrawImageChild( graphics_t* self,   graphics_image_t*
image,
       int_fast32_t   source_min_x,        int_fast32_t   source_min_y,
       int_fast32_t   source_width,         int_fast32_t   source_height,
       int_fast32_t   destination_min_x,   int_fast32_t   destination_min_y,
       int_fast32_t   destination_width,   int_fast32_t   destination_height );
```

Description



When source_width ≠ destination_width or source_height ≠ destination_height, images are enlarged or reduced.
See the description on the R_GRAPHICS_DrawImage function.

Argument

graphics_t* self	Graphics drawing context
graphics_image_t* image	Image
int_fast32_t source_min_x int_fast32_t source_min_y	Minimum X and Y coordinates in the image
int_fast32_t source_width int_fast32_t source_height	Width and height in the image
int_fast32_t destination_min_x int_fast32_t destination_min_y	Minimum X and Y coordinates of the drawing target
int_fast32_t destination_width int_fast32_t destination_height	Width and height of the drawing target

Return value

Error code. If there is no error, the return value is 0.

5.7.1.29 R_GRAPHICS_FillRect

Outline Fills the rectangle area specified by the argument.

Header RGA.h

Declaration errnum_t R_GRAPHICS_FillRect(graphics_t* self, int_fast32_t min_x, int_fast32_t min_y, int_fast32_t width, int_fast32_t height);

Description This function is affected by the current matrix, the current fill, and clipping.
No border is drawn.
This function is affected by R_GRAPHICS_SetGlobalAlpha.

Argument

graphics_t* self	Graphics drawing context
int_fast32_t min_x, int_fast32_t min_y	Minimum X and Y coordinates of rectangle
int_fast32_t width, int_fast32_t height	Width and height of rectangle

Return value

Error code. If there is no error, the return value is 0.

5.7.1.30 R_GRAPHICS_SetFillColor

Outline Changes the paint object of the current fill to single-color fill and sets the fill color.

Header RGA.h

Declaration errnum_t R_GRAPHICS_SetFillColor(graphics_t* self, r8g8b8a8_t Color);

Description The initial value is opaque black.

Argument	graphics_t* self	Graphics drawing context
	r8g8b8a8_t color	Fill color. Use R_RGA_Get_R8G8B8A8() for the fill color setting.
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.31 R_GRAPHICS_SetFillPattern

Outline	Sets the pattern for the current fill paint object.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_SetFillPattern(graphics_t* self, graphics_pattern_t* pattern);	
Description	Use R_GRAPHICS_FillRect for drawing.	
Argument	graphics_t* self	Graphics drawing context
	graphics_pattern_t* pattern	Use R_GRAPHICS_PATTERN_Initialize() to initialize the pattern object.
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.32 R_GRAPHICS_BeginPath

Outline	Resets the default path content to null.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_BeginPath(graphics_t* self);	
Description		
Argument	graphics_t* self	Graphics drawing context
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.33 R_GRAPHICS_Rect

Outline	Adds a rectangle to the default path.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_Rect(graphics_t* self, int_fast32_t min_x, int_fast32_t min_y, int_fast32_t width, int_fast32_t height);	
Description	This function is used to set the clipping area.	
Argument	graphics_t* self	Graphics drawing context
	int_fast32_t min_x, int_fast32_t min_y	Minimum X and Y coordinates of rectangle
	int_fast32_t width, int_fast32_t height	Width and height of rectangle
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.34 R_GRAPHICS_Clip

Outline	Sets the shape of the current default path to a clipping area.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_Clip(graphics_t* self);	
Description	When the current default path is empty or is not a rectangle, an error occurs. When the current default path is empty, drawing is disabled in any area. If this function is called when the current clipping area is a part of the frame buffer, the area common to the previous clipping area and the default path becomes a new clipping area. To restore entire drawing, call R_GRAPHICS_Restore.	
Argument	graphics_t* self	Graphics drawing context
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.35 R_GRAPHICS_SetGlobalAlpha

Outline	Sets an alpha value (opacity) to be multiplied by all drawings.
Header	RGA.h

Declaration errnum_t R_GRAPHICS_SetGlobalAlpha(graphics_t* self, uint8_t alpha_value);

Description The default value is 255.
This function affects the following drawing functions.
Figure fill functions such as R_GRAPHICS_FillRect
Pattern drawing function R_GRAPHICS_FillRect
Border drawing functions such as R_GRAPHICS_StrokeRect
Image drawing functions such as R_GRAPHICS_DrawImage
This function does not affect the following drawing function.
R_GRAPHICS_Clear

Argument

graphics_t* self	Graphics drawing context
uint8_t alpha_value	Alpha value (0 to 255). A smaller value makes drawing light.

Return value

Error code. If there is no error, the return value is 0.

5.7.1.36 R_GRAPHICS_GetGlobalAlpha

Outline Acquires an alpha value (opacity) to be multiplied by all drawings.

Header RGA.h

Declaration errnum_t R_GRAPHICS_GetGlobalAlpha(graphics_t* self, uint8_t* out_alpha_value);

Description

Argument

graphics_t* self	Graphics drawing context
uint8_t* out_alpha_value	(Output) Alpha value (0 to 255). A smaller value makes drawing light.

Return value

Error code. If there is no error, the return value is 0.

5.7.1.37 R_GRAPHICS_SetGlobalCompositeOperation

Outline Sets the calculation method for alpha blend.

Header RGA.h

Declaration errnum_t R_GRAPHICS_SetGlobalCompositeOperation(graphics_t* self,
graphics_composite_operation_t composite_operation);

Description The following case other than GRAPHICS_SOURCE_OVER can be set.
Image drawing such as R_GRAPHICS_DrawImage

Argument

graphics_t* self	Graphics drawing context
graphics_composite_operation_t composite_operation	Calculation method

Return value

Error code. If there is no error, the return value is 0.

5.7.1.38 R_GRAPHICS_GetGlobalCompositeOperation

Outline Acquires the calculation method for alpha blend.

Header RGA.h

Declaration errnum_t R_GRAPHICS_GetGlobalCompositeOperation(graphics_t* self,
graphics_composite_operation_t* out_composite_operation);

Description

Argument

graphics_t* self	Graphics drawing context
graphics_composite_operation_t* out_composite_operation	(Output) Calculation method

Return value

Error code. If there is no error, the return value is 0.

5.7.1.39 R_GRAPHICS_STATIC_SetOnInitialize

Outline Registers a callback function that sets the default graphics_config_t value.

Header RGA.h

Declaration errnum_t R_GRAPHICS_STATIC_SetOnInitialize(
R_GRAPHICS_OnInitialize_FuncType callback_function);

Description The R_GRAPHICS_STATIC_OnInitializeDefault function is called back when this function is not called.

Argument

R_GRAPHICS_OnInitialize_FuncType callback_function	Callback function or NULL

Return value Error code. If there is no error, the return value is 0.

5.7.1.40 R_GRAPHICS_STATIC_SetOnFinalize

Outline Registers a function that releases the memory allocated in the R_GRAPHICS_OnInitialize_FuncType function.

Header RGA.h

Declaration
```
errnum_t   R_GRAPHICS_STATIC_SetOnFinalize(
       R_GRAPHICS_OnFinalize_FuncType callback_function );
```

Description The R_GRAPHICS_STATIC_OnInitializeDefault function is called back when this function is not called.

Argument

R_GRAPHICS_OnFinalize_FuncType callback_function	Callback function or NULL

Return value Error code. If there is no error, the return value is 0.

5.7.1.41 R_GRAPHICS_SetQualityFlags

Outline Sets the drawing quality.

Header RGA.h

Declaration
```
errnum_t   R_GRAPHICS_SetQualityFlags( graphics_t* self,
       graphics_quality_flags_t qualities );
```

Description

Argument

graphics_t* self,	Graphics drawing context
graphics_quality_flags_t qualities	See section 5.4.5.4.

Return value Error code. If there is no error, the return value is 0.

5.7.1.42 R_GRAPHICS_GetQualityFlags

Outline Acquires the current drawing quality.

Header RGA.h

Declaration
```
errnum_t   R_GRAPHICS_GetQualityFlags( graphics_t* self,
       graphics_quality_flags_t* out_qualities );
```

Description

Argument

graphics_t* self,	Graphics drawing context
graphics_quality_flags_t* out_qualities	(Output) See section 5.4.5.4.

Return value Error code. If there is no error, the return value is 0.

5.7.1.43 R_GRAPHICS_SetStrokeColor

Outline Sets the color used for single-color fill for the paint object of the current border.

Header RGA.h

Declaration
```
errnum_t   R_GRAPHICS_SetStrokeColor( graphics_t* self, r8g8b8a8_t color );
```

Description

Argument

graphics_t* self,	Graphics drawing context
r8g8b8a8_t color	Border color

Return value Error code. If there is no error, the return value is 0. See section 6.2.

5.7.1.44 R_GRAPHICS_StrokeRect

Outline Draws sides of rectangle.

Header RGA.h

Declaration
```
errnum_t   R_GRAPHICS_StrokeRect( graphics_t* self,
   int_fast32_t   min_x,   int_fast32_t   min_y,   int_fast32_t   width,   int_fast32_t
height );
```

Description This function is affected by line width, border color, and clipping.
Fill is not made.
When the current matrix is not the unit matrix, an error occurs.
This function is affected by R_GRAPHICS_SetGlobalAlpha.

Argument	graphics_t* self,	Graphics drawing context
	int_fast32_t min_x, int_fast32_t min_y	Minimum X and Y coordinates of rectangle
	int_fast32_t width, int_fast32_t height	Width and height of rectangle
Return value	Error code. If there is no error, the return value is 0. See section 6.2.	

5.7.1.45 R_GRAPHICS_BeginSoftwareRendering

Outline Notifies the graphics library of the start of software rendering.
Header RGA.h
Declaration errnum_t R_GRAPHICS_BeginSoftwareRendering(graphics_t* self);
Description This function must be called in fast manual flush mode (see section 5.11.4).

Argument	graphics_t* self,	Graphics drawing context
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.46 R_GRAPHICS_EndSoftwareRendering

Outline Notifies the graphics library of the end of software rendering.
Header RGA.h
Declaration errnum_t R_GRAPHICS_EndSoftwareRendering(graphics_t* self);
Description This function must be called in fast manual flush mode (see section 5.11.4).
To call this function from functions that support error processing, also call R_GRAPHICS_EndRenderingInFin at the end of the function.

Argument	graphics_t* self,	Graphics drawing context
Return value	Error code. If there is no error, the return value is 0.	

5.7.1.47 R_GRAPHICS_EndRenderingInFin

Outline Call this function from the end of the function that performs software rendering.
Header RGA.h
Declaration errnum_t R_GRAPHICS_EndRenderingInFin(graphics_t* self, errnum_t e);
Description This function must be called in fast manual flush mode (see section 5.11.4).
To call this function from functions that support error processing, also call R_GRAPHICS_EndRenderingInFin at the end of the function.

Argument	graphics_t* self,	Graphics drawing context
	errnum_t e	Errors that have occurred. No error = 0
Return value	Error code. If there is no error, the return value is 0.	

5.7.2 Functions Equivalent to graphics_image_t Class Member Function

5.7.2.1 List of Functions

Section	Function Name	Description
5.7.2.2	R_GRAPHICS_IMAGE_InitR8G8B8A8	Initializes the r8g8b8a8_t image object.
5.7.2.3	R_GRAPHICS_IMAGE_InitSameSizeR8G8B8A8	Initializes the image object to the same width and height.
5.7.2.4	R_GRAPHICS_IMAGE_InitCopyFrameBufferR8G8B8A8	Initializes the image object to which a part of frame buffer being displayed is copied.
5.7.2.5	R_GRAPHICS_IMAGE_InitByShareFrameBuffer	Initializes the frame buffer data as an image.
5.7.2.6	R_GRAPHICS_IMAGE_GetProperties	Get properties of the image.

5.7.2.2 R_GRAPHICS_IMAGE_InitR8G8B8A8

Outline Initializes the r8g8b8a8_t image object.

Header RGA.h

Declaration errnum_t R_GRAPHICS_IMAGE_InitR8G8B8A8(
graphics_image_t* self, void* image_data_array, size_t image_data_array_size,
int_fast32_t width, int_fast32_t height);

Description Initializes internal variables.
Acquirable image data is arranged in a uint8_t-type array in the order of Red, Green, Blue, and Alpha from the upper-left pixel to the lower-right pixel.

Argument

graphics_image_t* self	Image
void* image_data_array	Starting address of an array to be a memory area that stores images
size_t image_data_array_size	Size (bytes) of the memory area indicated by image_data_array
int_fast32_t width, int_fast32_t height	Width and height of image

Return value Error code. If there is no error, the return value is 0.

5.7.2.3 R_GRAPHICS_IMAGE_InitSameSizeR8G8B8A8

Outline Initializes the image object to the same width and height.

Header RGA.h

Declaration errnum_t R_GRAPHICS_IMAGE_InitSameSizeR8G8B8A8(
graphics_image_t* self, void* image_data_array, size_t image_data_array_size,
graphics_image_t* same_size_image);

Description Initializes internal variables.

Argument

graphics_image_t* self	Image
void* image_data_array	Starting address of an array to be a memory area that stores images
size_t image_data_array_size	Size (bytes) of the memory area indicated by image_data_array
graphics_image_t* same_size_image	Image object that references width and height

Return value Error code. If there is no error, the return value is 0.

5.7.2.4 R_GRAPHICS_IMAGE_InitCopyFrameBufferR8G8B8A8

Outline Initializes the image object to which a part of frame buffer being displayed is copied.

Header RGA.h

Declaration errnum_t
R_GRAPHICS_IMAGE_InitCopyFrameBufferR8G8B8A8(graphics_image_t* self,

void* image_data_array, size_t image_data_array_size, graphics_t* context, int_t min_fast32_x, int_fast32_t min_y, int_fast32_t width, int_fast32_t height);

Description
Initializes internal variables.
Acquirable image data is arranged in a uint8_t-type array in the order of Red, Green, Blue, and Alpha from the upper-left pixel to the lower-right pixel.

Argument

graphics_image _t* self	Image
void* image_data_array	Starting address of an array to be a memory area that stores images
size_t image_data_array_size	Size (bytes) of the memory area indicated by "image_data_array" argument
graphics_t* context	Context with copy source frame buffer to be drawn
int_fast32_t min_x, int_fast32_t min_y	Minimum X and Y coordinates (frame buffer coordinates) of the range to be acquired
int_fast32_t width, int_fast32_t height	Width and height of the range to be acquired

Return value
Error code. If there is no error, the return value is 0.

5.7.2.5 R_GRAPHICS_IMAGE_InitByShareFrameBuffer

Outline
Initializes the frame buffer data as an image.

Header
RGA.h

Declaration
errnum_t R_GRAPHICS_IMAGE_InitByShareFrameBuffer(graphics_image _t* self, frame_buffer_t* frame_buffer);

Description
Initializes internal variables.
The VRAM area indicated by frame_buffer->buffer_address [frame_buffer->show_buffer_index] at the time when this function is called is shared with image (self).

Argument

graphics_image _t* self	Image
frame_buffer_t* frame_buffer	Frame buffer that contains the image

Return value
Error code. If there is no error, the return value is 0.

5.7.2.6 R_GRAPHICS_IMAGE_GetProperties

Outline
Get image properties.

Header
RGA.h

Declaration
errnum_t R_GRAPHICS_IMAGE_GetProperties(graphics_image _t* self, graphics_image_properties_t* out_properties);

Description
In the case of fast manual flush mode (5.11.4):

Flush operation must be done before the array pointed by "out_properties->address" is read or written.

The data in the ROM does not have to be flushed.

When you want to flush, flush CPU cache directly, call "R_GRAPHICS_Finish" or sandwich reading or writing the image data between "R_GRAPHICS_BeginSoftwareRendering" and "R_GRAPHICS_EndSoftwareRendering".

Argument

graphics_image _t* self	Image
graphics_image_properties _t* out_properties	(Output) Image properties (5.4.5.14)

Return value
Error code. If there is no error, the return value is 0.

5.7.3 Functions Equivalent to graphics_pattern_t Class Member Function

5.7.3.1 List of Functions

Section	Function Name	Description
5.7.3.2	R_GRAPHICS_PATTERN_Initialize	Initializes the pattern object.

5.7.3.2 R_GRAPHICS_PATTERN_Initialize

Outline	Initializes the pattern object.	
Header	RGA.h	
Declaration	errnum_t R_GRAPHICS_PATTERN_Initialize(graphics_pattern_t* self, graphics_image_t* image, repetition_t repetition, graphics_t* context);	
Description	Initializes internal variables. Set the object of GraphicsPatternClass to R_GRAPHICS_SetFillPattern.	
Argument	graphics_pattern_t* self	Pattern object
	graphics_image_t* image	Pattern component image
	repetition_t repetition	Repetition setting (normally GRAPHICS_REPEAT)
	graphics_t* context	Belonging context
Return value	Error code. If there is no error, the return value is 0.	

5.7.4 Functions Related to Canvas2D_ContextClass

5.7.4.1 List of Functions

Section	Function Name	Description
5.7.4.2	R_RGA_New_Canvas2D_ContextClass	Creates an object of Canvas2D_ContextClass.
5.7.4.3	R_RGA_New_Canvas2D_ImageClass	Creates an object of Canvas2D_ImageClass

5.7.4.2 R_RGA_New_Canvas2D_ContextClass

Outline	Creates an object of Canvas2D_ContextClass.	
Header	RGA.h	

Declaration	Canvas2D_ContextClass R_RGA_New_Canvas2D_ContextClass(Canvas2D_ContextConfigClass& in_out_config);
	Canvas2D_ContextClass R_RGA_New_Canvas2D_ContextClass(frame_buffer_t* in_frame_buffer);	

Description	Initializes internal variables. When the object is not used, call the destroy method.	
Argument	Canvas2D_ContextConfigClass& in_out_config	See section 5.4.4.3
	frame_buffer_t* in_frame_buffer	See section 5.4.5.3.
Return value	Canvas2D context object. Error = undefined	

5.7.4.3 R_RGA_New_Canvas2D_ImageClass

Outline	Creates an object of Canvas2D_ImageClass	
Header	RGA.h	
Declaration	Canvas2D_ImageClass R_RGA_New_Canvas2D_ImageClass();	
Description	This function is corresponding to new Image() of Canvas2D.	
Argument	None	
Return value	Created an object as Canvas2D_ImageClass. Error = undefined	

5.7.5 Canvas2D_ContextClass Member Functions

5.7.5.1 List of Functions

Section	Function Name	Description
5.7.5.2	destroy	Deletes the object of Canvas2D_ContextClass.
5.7.5.3	clearError	Clears the error in the object of Canvas2D_ContextClass.
5.7.5.4	clearRect	Clears the rectangle area.
5.7.5.5	save	Saves the set value of context in the internal stack.
5.7.5.6	restore	Returns the set value of context to the context from the internal stack.
5.7.5.7	drawImage	Draws an image.
5.7.5.8	createImageData	Generates an image object of r8g8b8a8_t.
5.7.5.9	getImageData	Generates an image to which a part of frame buffer being displayed is copied.
5.7.5.10	putImageData	Draws an image.
5.7.5.11	fillRect	Fill the rectangle area.
5.7.5.12	createPattern	Generates a pattern object.
5.7.5.13	beginPath	Resets the default path content to null.
5.7.5.14	rect	Adds a rectangle to the default path.
5.7.5.15	clip	Sets the shape of the current default path to a clipping area.
5.7.5.16	setTransform	Sets each element of the matrix.
5.7.5.17	translate	Translates the current matrix.
5.7.5.18	scale	Enlarges or reduces the current matrix.
5.7.5.19	rotate	Rotates the current matrix. Rotation center: (0,0)
5.7.5.20	transform	Multiplies the specified 2x3 matrix by the current matrix.

5.7.5.2 destroy (Canvas2D_ContextClass)

Outline	Deletes the object of Canvas2D_ContextClass.	
Header	RGA.h	
Declaration	void Canvas2D_ContextClass::destroy();	
Description		
Argument	None	
Return value	None	

5.7.5.3 clearError (Canvas2D_ContextClass)

Outline	Clears the error in the object of Canvas2D_ContextClass.	
Header	RGA.h	
Declaration	void Canvas2D_ContextClass::clearError();	
Description	Canvas2D does not have this interface.	
Argument	None	
Return value	None	

5.7.5.4 clearRect (Canvas2D_ContextClass)

Outline
Clears the rectangle area.

Header
RGA.h

Declaration
```
void    Canvas2D_ContextClass::clearRect(
                 int_t MinX, int_t MinY, int_t Width, int_t Height );
```

Description
Use R_GRAPHICS_SetBackgroundColor() for setting the clear color. Specify the c_LanguageContext (Canvas2D_ContextClass) property for the first argument.

Clear color can be gotten by "R_GRAPHICS_GetClearColor" function.

Since the drawing buffer content is cleared, cleared content is not displayed only by calling this function. To apply the displayed content, use R_WINDOW_SURFACES_SwapBuffers().

	This function is affected by clipping.	
Argument	int_t MinX, int_t MinY	Minimum X and Y coordinates of rectangle
	int_t Width, int_t Height	Width and height of rectangle
Return value	None	

5.7.5.5 save (Canvas2D_ContextClass)

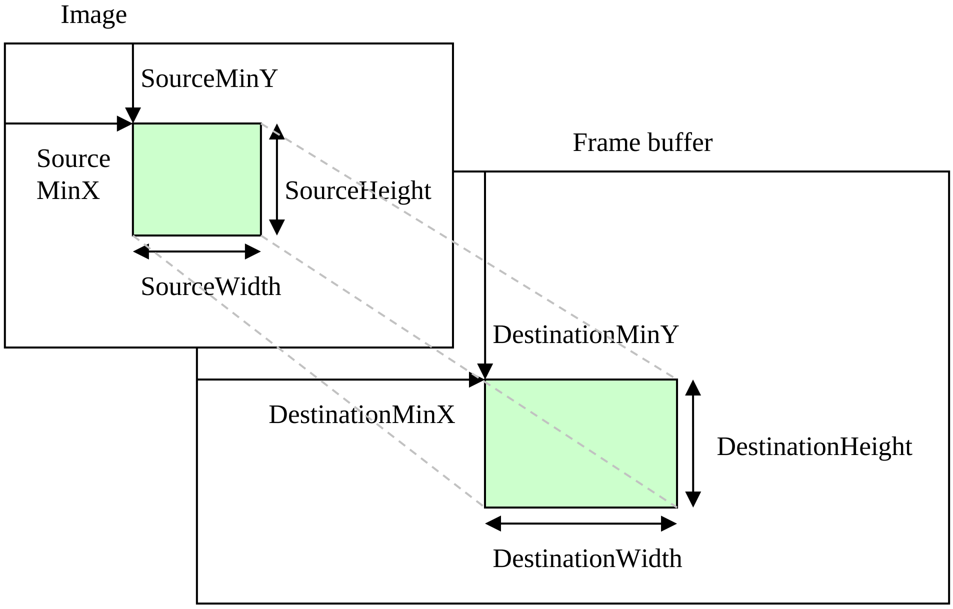
Outline	Saves the set value of context in the internal stack.	
Header	RGA.h	
Declaration	void Canvas2D_ContextClass::save();	
Description	A heap area is secured internally for the internal stack.	
Argument	None	
Return value	None	

5.7.5.6 restore (Canvas2D_ContextClass)

Outline	Returns the set value of context to the context from the internal stack.	
Header	RGA.h	
Declaration	void Canvas2D_ContextClass::restore();	
Description	Releases the heap area used internally as an internal stack.	
Argument	None	
Return value	Error code. If there is no error, the return value is 0.	

5.7.5.7 drawImage (Canvas2D_ContextClass)

Outline	Draws an image.
Header	RGA.h
Declaration	void Canvas2D_ContextClass::drawImage(GraphicsImageClass* Image, int_t MinX, int_t MinY); void Canvas2D_ContextClass::drawImage(GraphicsImageClass* Image, int_t MinX, int_t MinY, int_t Width, int_t Height); void Canvas2D_ContextClass::drawImage(GraphicsImageClass* Image, int_t SourceMinX, int_t SourceMinY, int_t SourceWidth, int_t SourceHeight, int_t DestinationMinX, int_t DestinationMinY, int_t DestinationWidth, int_t DestinationHeight);
Description	JPEG data can be directly specified for arguments. See section 5.11.3, Identifying Image Format. When neither width nor height is specified, the width and height of the drawing destination are the same as the image width and height. When SourceMinX to DestinationHeight are specified, a part of an image is drawn.



When SourceWidth ≠ DestinationWidth or SourceHeight ≠ DestinationHeight, images are enlarged or reduced.

This function is affected by Canvas2D_ContextClass::GlobalAlpha and the current matrix.

When drawing an image in the YUV422 format, if the value converted from MinX or MinY by the matrix is not an even number, an error occurs.

When the alpha component is included in the image and is not included in the drawing target frame buffer, RGB components to be drawn in the frame buffer are blended to values that have been multiplied by the alpha component. When the alpha component is included in the drawing target frame buffer, RGB components are blended to values that have not been multiplied by the alpha component.

An example of pixel format including the alpha component:
ARGB8888, ARGB4444, ARGB1555

An example of pixel format without alpha component:
XRGB8888, RGB565, YUV422

Argument	GraphicsImageClass* Image	Image
	int_t MinX, int_t MinY	Minimum X and Y coordinates of drawing destination
	int_t Width, int_t Height	Width and height of drawing destination
	int_t SourceMinX, int_t SourceMinY	Minimum X and Y coordinates in the image
	int_t SourceWidth, int_t SourceHeight	Width and height in the image
	int_t DestinationMinX, int_t DestinationMinY	Minimum X and Y coordinates of drawing destination
	int_t DestinationWidth, int_t DestinationHeight	Width and height of drawing destination
Return value	None	

5.7.5.8 createImageData (Canvas2D_ContextClass)

Outline	Generates an image object of r8g8b8a8_t.
Header	RGA.h
Declaration	Canvas2D_ImageClass Canvas2D_ContextClass::createImageData(int_t Width, int_t Height); Canvas2D_ImageClass Canvas2D_ContextClass::createImageData(

Canvas2D_ImageClass ImageReferencedWidthHeight);

Description	Secures a memory area internally from the heap area. This function calls "new" operator.	
Argument	int_t Width, int_t Height	Width and height of image
	Canvas2D_ImageClass ImageReferencedWidthHeight	Image object that references width and height
Return value	Generated Image object. undefined=Error or few memory.	

5.7.5.9 getImageData (Canvas2D_ContextClass)

Outline: Generates an image object to which a part of the frame buffer being displayed is copied.

Header: RGA.h

Declaration:

```
Canvas2D_ImageClass  Canvas2D_ContextClass::getImageData(
    int_t MinX,  int_t MinY,  int_t Width,  int_t Height );
```

Description

Argument	int_t MinX, int_t MinY	Minimum X and Y coordinates of range to be acquired (frame buffer coordinates)
	int_t Width, int_t Height	Width and height of range to be acquired
Return value	Generated Image object	

5.7.5.10 putImageData (Canvas2D_ContextClass)

Outline: Draws an image.

Header: RGA.h

Declaration:

```
void  Canvas2D_ContextClass::putImageData(
    Canvas2D_ImageClass ImageData,  int_t MinX,  int_t MinY );
void  Canvas2D_ContextClass::putImageData(
    Canvas2D_ImageClass ImageData,  int_t MinX,  int_t MinY,
    int_t DirtyX,  int_t DirtyY,  int_t DirtyWidth,  int_t DirtyHeight );
```

Description: When DirtyX, DirtyY, DirtyWidth, or DirtyHeight is specified, a part of the Image object image is drawn, but the image is not enlarged or reduced.

Argument	Canvas2D_ImageClass ImageData	Image object containing the image to be drawn
	int_t MinX, int_t MinY	Minimum X and Y coordinates of drawing destination (canvas coordinates)
	int_t DirtyX, int_t DirtyY	Minimum X and Y coordinates in Image (Image coordinates)
	int_t DirtyWidth, int_t DirtyHeight	Size in Image = Size to be drawn
Return value	None	

5.7.5.11 fillRect (Canvas2D_ContextClass)

Outline: Fill the rectangle area.

Header: RGA.h

Declaration:

```
void  Canvas2D_ContextClass::fillRect(
            int_t MinX, int_t MinY, int_t Width, int_t Height );
```

Description: This function is affected by the current matrix and paint of the current fill.
No border is drawn.
This function is affected by the globalAlpha property.

Argument	int_t MinX, int_t MinY	Minimum X and Y coordinates of rectangle
	int_t Width, int_t Height	Width and height of rectangle
Return value	None	

5.7.5.12 createPattern (Canvas2D_ContextClass)

Outline	Generates a pattern object.	
Header	RGA.h	
Declaration	Canvas2D_PatternClass Canvas2D_ContextClass::createPattern(GraphicsImageClass* Image, char* Repetition);	
Description	Set the pattern object for the fillStyle property.	
Argument	GraphicsImageClass* Image	Image as a pattern component
	char* Repetition	Repetition setting. Specify "repeat."
Return value	Generated pattern object	

5.7.5.13 beginPath (Canvas2D_ContextClass)

Outline	Resets the default path content to null.	
Header	RGA.h	
Declaration	void Canvas2D_ContextClass::beginPath();	
Description		
Argument	None	
Return value	None	

5.7.5.14 rect (Canvas2D_ContextClass)

Outline	Adds a rectangle to the default path.	
Header	RGA.h	
Declaration	void Canvas2D_ContextClass::rect(int_t MinX, int_t MinY, int_t Width, int_t Height);	
Description		
Argument	int_t MinX, int_t MinY	Minimum X and Y coordinates of rectangle
	int_t Width, int_t Height	Width and height of rectangle
Return value	None	

5.7.5.15 clip (Canvas2D_ContextClass)

Outline	Sets the shape of the current default path to a clipping area.	
Header	RGA.h	
Declaration	void Canvas2D_ContextClass::clip();	
Description	When the current default path is empty or is not a single rectangle, an error occurs. When the current default path is empty, drawing is disabled in any area. If this function is called when the current clipping area is a part of the frame buffer, the area common to the clipping area and the default path is a new clipping area. To restore entire drawing, call "restore."	
Argument	None	
Return value	None	

5.7.5.16 setTransform (Canvas2D_ContextClass)

Outline	Sets each element of the current matrix.	
Header	RGA.h	
Declaration	void Canvas2D_ContextClass::setTransform(graphics_matrix_float_t sx, graphics_matrix_float_t ky, graphics_matrix_float_t kx, graphics_matrix_float_t sy, graphics_matrix_float_t tx, graphics_matrix_float_t ty);	
Description		
Argument	graphics_matrix_float_t sx, graphics_matrix_float_t ky, graphics_matrix_float_t kx,	2x3 matrix sx kx tx ky sy ty

	graphics_matrix_float_t sy, graphics_matrix_float_t tx, graphics_matrix_float_t ty	$\begin{pmatrix} 0 & 0 & 1 \end{pmatrix}$
Return value	None	

5.7.5.17 translate (Canvas2D_ContextClass)

Outline Translates the current matrix (M).

Header RGA.h

Declaration void Canvas2D_ContextClass::translate(
graphics_matrix_float_t tx, graphics_matrix_float_t ty);

Description

$$M=M\cdot\begin{pmatrix} 1 & 0 & tx \\ 0 & 1 & ty \\ 0 & 0 & 1 \end{pmatrix}$$

Argument	graphics_matrix_float_t tx, graphics_matrix_float_t ty	Displacement (When the origin is at the upper left, plus of X means right direction and plus of Y means downward direction.)
Return value	None	

5.7.5.18 scale (Canvas2D_ContextClass)

Outline Enlarges or reduces the current matrix (M).

Header RGA.h

Declaration void Canvas2D_ContextClass::translate(
graphics_matrix_float_t sx, graphics_matrix_float_t sy);

Description

$$M=M\cdot\begin{pmatrix} sx & 0 & 0 \\ 0 & sy & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Argument	graphics_matrix_float_t tx, graphics_matrix_float_t ty	Magnification. Center of enlargement/reduction: Origin
Return value	None	

5.7.5.19 rotate (Canvas2D_ContextClass)

Outline Rotates the current matrix (M). Center coordinates of rotation: (0,0)

Header RGA.h

Declaration void Canvas2D_ContextClass::rotate(graphics_matrix_float_t angle);

Description

$$M=M\cdot\begin{pmatrix} \cos(angle) & -\sin(angle) & 0 \\ \sin(angle) & \cos(angle) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Argument	graphics_matrix_float_t angle	Rotation angle (unit: degree). When the origin is at the upper left, plus means clockwise direction.
Return value	None	

5.7.5.20 transform (Canvas2D_ContextClass)

Outline Multiplies the specified 2x3 matrix by the current matrix (M).

Header RGA.h

Declaration void Canvas2D_ContextClass::transform(
graphics_matrix_float_t sx, graphics_matrix_float_t ky,
graphics_matrix_float_t kx, graphics_matrix_float_t sy,
graphics_matrix_float_t tx, graphics_matrix_float_t ty);

Description

$$M=M\cdot\begin{pmatrix} sx & kx & tx \\ ky & sy & ty \\ 0 & 0 & 1 \end{pmatrix}$$

Argument	graphics_matrix_float_t sx graphics_matrix_float_t ky graphics_matrix_float_t kx graphics_matrix_float_t sy graphics_matrix_float_t tx graphics_matrix_float_t ty	A 2x3 matrix to be multiplied
Return value	None	

5.7.6 Functions Related to Canvas2D_ImageClass

5.7.6.1 List of Functions

Section	Function Name	Description
5.7.6.2	destroy	Deletes the Canvas2D_ImageClass object.

5.7.6.2 destroy (Canvas2D_ImageClass)

Outline	Deletes the Canvas2D_ImageClass object.	
Header	RGA.h	
Declaration	void Canvas2D_ImageClass::destroy();	
Description		
Argument	None	
Return value	None	

5.7.7 Functions Related to Canvas2D_PatternClass

5.7.7.1 List of Functions

Section	Function Name	Description
5.7.7.2	destroy	Deletes the Canvas2D_PatternClass object.

5.7.7.2 destroy (Canvas2D_PatternClass)

Outline	Deletes the Canvas2D_PatternClass object.	
Header	RGA.h	
Declaration	void Canvas2D_PatternClass::destroy();	
Description		
Argument		
Return value		

5.7.8 Functions Related to WindowSurfacesClass

5.7.8.1 List of Functions

Section	Function Name	Description
5.7.8.2	initialize	Initialize an object as WindowSurfacesClass
5.7.8.3	destroy	Destroy an object as WindowSurfacesClass
5.7.8.4	get_layer_frame_buffer	Acquires the pointer to the frame buffer structure of the specified layer.
5.7.8.5	swap_buffers	Swaps the buffer of the specified layer and displays the drawn content.
5.7.8.6	alloc_offscreen_stack	Allocates the off-screen buffer from VRAM stack.
5.7.8.7	free_offscreen_stack	Frees the off-screen buffer to VRAM stack.
5.7.8.8	do_message_loop	Enters the message loop.
5.7.8.9	access_layer_attributes	Accesses attributes of the specified display layer.

5.7.8.2 initialize (WindowSurfacesClass)

Outline	Initialize an object as WindowSurfacesClass	
Header	RGA.h	
Declaration	errnum_t WindowSurfacesClass::initialize(WindowSurfacesConfigClass& in_out_config);	
Description	See (5.7.9.3) R_WINDOW_SURFACES_Initialize	
Argument	WindowSurfacesConfigClass& in_out_config	Parameters. See 5.4.4.7.
Return value	Error code. If there is no error, the return value is 0.	

5.7.8.3 destroy (WindowSurfacesClass)

Outline	Destroy an object as WindowSurfacesClass	
Header	RGA.h	
Declaration	void WindowSurfacesClass::destroy();	
Description	See (5.7.9.4) R_WINDOW_SURFACES_Finalize	
Argument	None	
Return value	None	

5.7.8.4 get_layer_frame_buffer (WindowSurfacesClass)

Outline	Acquires the pointer to the frame buffer structure of the specified layer.	
Header	RGA.h	
Declaration	errnum_t WindowSurfacesClass::get_layer_frame_buffer(int_fast32_t layer_num, frame_buffer_t** out_frame_buffer);	
Description	See (5.7.9.5) R_WINDOW_SURFACES_GetLayerFrameBuffer	
Argument	int_fast32_t layer_num	Layer number 0: Innermost, +1: Next to the innermost layer
Outline	frame_buffer_t** out_frame_buffer	(Output) Frame buffer structure
Return value	Error code. If there is no error, the return value is 0.	

5.7.8.5 swap_buffers (WindowSurfacesClass)

Outline	Swaps the buffer of the specified layer and displays the drawn content.
Header	RGA.h
Declaration	errnum_t WindowSurfacesClass::swap_buffers(int_fast32_t layer_num, Canvas2D_ContextClass& context);
Description	See (5.7.9.7) R_WINDOW_SURFACES_SwapBuffers

Argument	int_fast32_t layer_num	Layer number 0: Innermost, +1: Next to the innermost layer
Outline	Canvas2D_ContextClass& context	Drawn graphics context
Return value	Error code. If there is no error, the return value is 0.	

5.7.8.6 alloc_offscreen_stack (WindowSurfacesClass)

Outline	Allocates the off-screen buffer from VRAM stack.	
Header	RGA.h	
Declaration	errnum_t WindowSurfacesClass::alloc_offscreen_stack(frame_buffer_t* in_out_frame_buffer);	
Description	See (5.7.9.11) R_WINDOW_SURFACES_AllocOffscreenStack	
Argument	frame_buffer_t* in_out_frame_buffer	(Input/output) The off-screen buffer
Return value	Error code. If there is no error, the return value is 0.	

5.7.8.7 free_offscreen_stack (WindowSurfacesClass)

Outline	Frees the off-screen buffer to VRAM stack.	
Header	RGA.h	
Declaration	errnum_t WindowSurfacesClass::free_offscreen_stack(const frame_buffer_t* frame_buffer);	
Description	See (5.7.9.12) R_WINDOW_SURFACES_FreeOffscreenStack	
Argument	frame_buffer_t** out_frame_buffer	(Input/output) The freeing off-screen buffer
Return value	Error code. If there is no error, the return value is 0.	

5.7.8.8 do_message_loop (WindowSurfacesClass)

Outline	Enters the message loop.	
Header	RGA.h	
Declaration	errnum_t WindowSurfacesClass::do_message_loop();	
Description	See (5.7.9.9) R_WINDOW_SURFACES_DoMessageLoop	
Argument	None	
Return value	Error code. If there is no error, the return value is 0.	

5.7.8.9 access_layer_attributes (WindowSurfacesClass)

Outline	Accesses attributes of the specified display layer.	
Header	RGA.h	
Declaration	errnum_t WindowSurfacesClass::access_layer_attributes(LayerAttributesClass& in_out_Attributes);	
Description	See (5.7.9.10) R_WINDOW_SURFACES_AccessLayerAttributes	
Argument	LayerAttributesClass& in_out_Attributes	(Input/output) Attributes of layer. See 5.4.4.8. Set read or write to "access" member variable.
Return value	Error code. If there is no error, the return value is 0.	

5.7.9 Functions Equivalent to window_surfaces_t Class Member Functions

5.7.9.1 List of Functions

Section	Function Name	Description
5.7.9.2	R_WINDOW_SURFACES_InitConst	Initializes internal variables with constants.
5.7.9.3	R_WINDOW_SURFACES_Initialize	Initializes the display device or window and starts displaying graphics.
5.7.9.4	R_WINDOW_SURFACES_Finalize	Finalizes the display device.
5.7.9.5	R_WINDOW_SURFACES_GetLayerFrameBuffer	Acquires the pointer to the frame buffer structure of the specified layer.
5.7.9.6	R_WINDOW_SURFACES_GetLayerCount	Acquires the number of layers.
5.7.9.7	R_WINDOW_SURFACES_SwapBuffers	Swaps the buffer of the specified layer and displays the drawn content.
5.7.9.8	R_WINDOW_SURFACES_WaitForVSync	Waits for V-Sync signal of the screen.
5.7.9.9	R_WINDOW_SURFACES_DoMessageLoop	Enters the message loop.
5.7.9.10	R_WINDOW_SURFACES_AccessLayerAttributes	Accesses attributes of the specified display layer.
5.7.9.11	R_WINDOW_SURFACES_AllocOffscreenStack	Allocates the off-screen buffer from VRAM stack.
5.7.9.12	R_WINDOW_SURFACES_FreeOffscreenStack	Frees the off-screen buffer to VRAM stack.

5.7.9.2 R_WINDOW_SURFACES_InitConst

Outline: Initializes internal variables with constants.

Header: RGA_SampleLib.h

Declaration: void R_WINDOW_SURFACES_InitConst(window_surfaces_t* self);

Description

Argument

window_surfaces_t* self	Frame buffer and screen display

Return value

None

5.7.9.3 R_WINDOW_SURFACES_Initialize

Outline: Initializes the display device or window and starts displaying graphics.

Header: RGA_SampleLib.h

Declaration:
```
errnum_t   R_WINDOW_SURFACES_Initialize(window_surfaces_t* self,
      window_surfaces_config_t* in_out_config );
```

Description: To control display independently, directly use the frame_buffer_t structure instead of the window_surfaces_t class.

Initializes internal variables.

The entire screen becomes black after initialization.

After calling "R_WINDOW_SURFACES_SwapBuffers" function, to show is started.

Argument

window_surfaces_t* self	Frame buffer and screen display
window_surfaces_config_t* in_out_config	See (5.4.5.6).

Return value

Error code. If there is no error, the return value is 0.

5.7.9.4 R_WINDOW_SURFACES_Finalize

Outline: Finalizes the display device.

Header: RGA_SampleLib.h

Declaration errnum_t R_WINDOW_SURFACES_Finalize (window_surfaces_t* self, errnum_t e);

Description

Argument

window_surfaces_t* self	Frame buffer and screen display
errnum_t e	Errors that have occurred. No error = 0

Return value

Error code or e, 0 = successful and e = 0

5.7.9.5 R_WINDOW_SURFACES_GetLayerFrameBuffer

Outline Acquires the pointer to the frame buffer structure of the specified layer.

Header RGA_SampleLib.h

Declaration errnum_t R_WINDOW_SURFACES_GetLayerFrameBuffer(window_surfaces_t* self, int_t layer_num, frame_buffer_t** out_frame_buffer);

Description Reference: (5.11.5)Sample Screen Control Layer Configuration

When the attribute of frame buffer is changed, call "R_WINDOW_SURFACES_AccessLayerAttributes" function.

Argument

window_surfaces_t* self	Frame buffer and screen display
int_t layer_num	Layer number 0: Innermost, +1: Next to the innermost layer
frame_buffer_t** out_frame_buffer	(Output) Frame buffer structure

Return value

Error code. If there is no error, the return value is 0.

5.7.9.6 R_WINDOW_SURFACES_GetLayerCount

Outline Acquires the number of layers.

Header RGA_SampleLib.h

Declaration errnum_t R_WINDOW_SURFACES_GetLayerCount(window_surfaces_t* self, int_t* out_layer_count);

Description

Argument

window_surfaces_t* self	Frame buffer and screen display
int_t* out_layer_count	(Output) Number of layers

Return value

Error code. If there is no error, the return value is 0.

5.7.9.7 R_WINDOW_SURFACES_SwapBuffers

Outline Swaps the buffer of the specified layer and displays the drawn content.

Header RGA_SampleLib.h

Declaration errnum_t R_WINDOW_SURFACES_SwapBuffers(window_surfaces_t* self, int_t layer_num, graphics_t graphics);

Description No single buffer is swapped. The drawn content is displayed without calling this function, but the progress of the drawing is displayed instead. When Graphics = NULL is specified, completion of drawing is not waited before the buffer is swapped.

Argument

window_surfaces_t* self	Frame buffer and screen display
int_t layer_num	Layer number 0: Innermost, +1: Next to the innermost layer
graphics_t graphics	Drawn graphics context, NULL enabled

Return value

Error code. If there is no error, the return value is 0.

5.7.9.8 R_WINDOW_SURFACES_WaitForVSync

Outline Waits for V-Sync signal of the screen.

Header RGA.h, window_surfaces.h

Declaration errnum_t R_WINDOW_SURFACES_WaitForVSync(window_surfaces_t* self, int_fast32_t swap_interval, bool_t is_1_v_sync_at_minimum);

Description Waits until the V-Sync interrupt enters for the number of times specified by "swap_interval" from the previous swap.

In the case of "is_1_v_sync_at_minimum = false", when the V-Sync interrupt has already entered for the number of times specified by SwapInterval, the processing immediately returns from this function.

Argument	window_surfaces_t* self	Frame buffers and screen display
	int_fast32_t swap_interval	Number of V-Sync interrupts until the frame buffer is swapped. 0 or more than 0.
	bool_t is_1_v_sync_at_minimum	Information on whether at least one V-Sync is waited. false=never wait. true=wait 1 times or more than 1.
Return value	Error code. If there is no error, the return value is 0. See section 6.2.	

5.7.9.9 R_WINDOW_SURFACES_DoMessageLoop

Outline	Enters the message loop.	
Header	RGA_SampleLib.h	
Declaration	errnum_t R_WINDOW_SURFACES_DoMessageLoop(window_surfaces_t* self);	
Description	Upon completion of the application, the processing returns from this function. For the terminating method, see the sub-class specifications.	
Argument	window_surfaces_t* self	Frame buffer and screen display
Return value	Error code. If there is no error, the return value is 0.	

5.7.9.10 R_WINDOW_SURFACES_AccessLayerAttributes

Outline	Accesses attributes of the specified display layer.	
Header	RGA_SampleLib.h	
Declaration	errnum_t R_WINDOW_SURFACES_AccessLayerAttributes(window_surfaces_t* self, layer_attributes_t* in_out_attributes);	
Description	Not all attributes are available. It depends on the device and support status.	
Argument	window_surfaces_t* self	Frame buffer and screen display
	layer_attributes_t* in_out_attributes	(Input/output) Attributes of layer. See 5.4.5.7. Set read or write to "access" member variable.
Return value	Error code. If there is no error, the return value is 0.	

5.7.9.11 R_WINDOW_SURFACES_AllocOffscreenStack

Outline	Allocates the off-screen buffer from VRAM stack.	
Header	RGA.h, window_surfaces.h	
Declaration	errnum_t R_WINDOW_SURFACES_AllocOffscreenStack(window_surfaces_t* self, frame_bufer_t* in_out_frame_buffer);	
Description	Input member variable in "frame_buffer_t" is "stride", "height", "buffer_count". Output member variable in "frame_buffer_t" is all element of "buffer_address" array. If the memory was few, E_FEW_ARRAY error is returned. Allocated off-screen buffer is freed by calling "R_WINDOW_SURFACES_Finalize" function.	
Argument	window_surfaces_t* self	Frame buffers and screen display
	frame_bufer_t* in_out_frame_buffer	(Input/output) The off-screen buffer
Return value	Error code. If there is no error, the return value is 0.	

5.7.9.12 R_WINDOW_SURFACES_FreeOffscreenStack

Outline	Frees the off-screen buffer to VRAM stack.
Header	RGA.h, window_surfaces.h
Declaration	errnum_t R_WINDOW_SURFACES_FreeOffscreenStack(window_surfaces_t* self, frame_bufer_t* frame_buffer);
Description	Input member variable in "frame_buffer_t" is "buffer_count", "buffer_address". If freeing order is not reverse of allocating order, E_ACCESS_DENIED error is returned.

Argument	window_surfaces_t* self	Frame buffers and screen display
	frame_bufer_t* in_out_frame_buffer	(Input/output) The freeing off-screen buffer
Return value	Error code. If there is no error, the return value is 0.	

5.7.10 Functions Related to byte_per_pixel_t Class

5.7.10.1 List of Functions

Section	Function Name	Description
5.7.10.2	R_RGA_BitPerPixelType_To_BytePerPixelType	Converts the number of bits per pixel to the number of bytes per pixel (with decimal part).
5.7.10.3	R_RGA_BytePerPixelType_To_BitPerPixelType	Converts the number of bytes per pixel (with decimal part) to the number of bits per pixel.
5.7.10.4	R_BYTE_PER_PIXEL_IsInteger	Returns information on whether the number of bytes per pixel is an integer.

5.7.10.2 R_RGA_BitPerPixelType_To_BytePerPixelType

Outline	Converts the number of bits per pixel to the number of bytes per pixel (with decimal part).	
Header	RGA.h	
Declaration	byte_per_pixel_t R_RGA_BitPerPixelType_To_BytePerPixelType(int_t bit_per_pixel);	
Description		
Argument	int_t bit_per_pixel	Number of bits per pixel
Return value	Number of bytes per pixel (with decimal part)	

5.7.10.3 R_RGA_BytePerPixelType_To_BitPerPixelType

Outline	Converts the number of bytes per pixel (with decimal part) to the number of bits per pixel.	
Header	RGA.h	
Declaration	int_t R_RGA_BytePerPixelType_To_BitPerPixelType(byte_per_pixel_t byte_per_pixel);	
Description		
Argument	byte_per_pixel_t byte_per_pixel	Number of bytes per pixel (with decimal part)
Return value	Number of bits per pixel	

5.7.10.4 R_BYTE_PER_PIXEL_IsInteger

Outline	Returns information on whether the number of bytes per pixel is an integer.	
Header	RGA.h	
Declaration	bool_t R_BYTE_PER_PIXEL_isInteger(byte_per_pixel_t byte_per_pixel);	
Description		
Argument	byte_per_pixel_t byte_per_pixel	Number of bytes per pixel (with decimal part)
Return value	Information on whether the number of bits per pixel is an integer	

5.7.11 Functions Related to v_sync_t Class

5.7.11.1 List of Functions

Section	Function Name	Description
5.7.11.2	R_V_SYNC_InitConst	Initializes internal variables with constants.
5.7.11.3	R_V_SYNC_Initialize	Attaches to the V-Sync interrupt.
5.7.11.4	R_V_SYNC_Finalize	Detaches from the V-Sync interrupt.
5.7.11.5	R_V_SYNC_WaitForInterrupt	Waits until the V-Sync interrupt enters.

5.7.11.2 R_V_SYNC_InitConst

Outline Initializes internal variables with constants.

Header RGA_SampleLib.h

Declaration void R_V_SYNC_InitConst(v_sync_t* self);

Description

Argument

v_sync_t* self	Context waiting for the V-Sync interrupt

Return value None

5.7.11.3 R_V_SYNC_Initialize

Outline Attaches to the V-Sync interrupt.

Header RGA_SampleLib.h

Declaration errnum_t R_V_SYNC_Initialize(v_sync_t* self);

Description Calls back the user-defined function NCGDU_Attach_ISR from inside of this function.

When the V-Sync interrupt has already been attached, an error occurs.

When the V-Sync interrupt is controlled by the application, the v_sync_t class cannot be used.

This function is used in the window_surfaces_t class. For this reason, the v_sync_t class cannot be used when the window_surfaces_t class is used.

Argument

v_sync_t* self	Context waiting for the V-Sync interrupt

Return value Error code. If there is no error, the return value is 0.

5.7.11.4 R_V_SYNC_Finalize

Outline Detaches from the V-Sync interrupt.

Header RGA_SampleLib.h

Declaration errnum_t R_V_SYNC_Finalize(v_sync_t* self, errnum_t e);

Description

Argument

v_sync_t* self	Context waiting for the V-Sync interrupt

Return value Error code or e, 0 = successful and e = 0

5.7.11.5 R_V_SYNC_WaitForInterrupt

Outline Waits until the V-Sync interrupt enters.

Header RGA_SampleLib.h

Declaration errnum_t R_V_SYNC_WaitForInterrupt(v_sync_t* self, int_t swap_interval, bool_t is_1_v_sync_at_minimum);

Description Waits until the V-Sync interrupt enters for the number of times specified by swap_interval from the previous swap.

In the case of is_1_v_sync_at_minimum = false, when the V-Sync interrupt has already entered for the number of times specified by swap_interval, the processing immediately returns from this function.

Argument

v_sync_t* self	Context waiting for the V-Sync interrupt
int_t swap_interval	Number of V-Sync interrupts until the frame buffer is swapped

	bool_t is_1_v_sync_at_minimum	Information on whether at least one V-Sync is waited
Return value	Error code. If there is no error, the return value is 0.	

5.7.12 Functions Related to vram_ex_stack_t class

5.7.12.1 List of Functions

Section	Function Name	Description
5.7.12.2	R_VRAM_EX_STACK_Initialize	Initialize the stack in the external RAM.
5.7.12.3	R_VRAM_EX_STACK_Alloc	Allocates the off-screen buffer from the external RAM.
5.7.12.4	R_VRAM_EX_STACK_Free	Frees the off-screen buffer to the external RAM.

5.7.12.2 R_VRAM_EX_STACK_Initialize

Outline	Initialize the stack in the external RAM.	
Header	RGA_SampleLib.h	
Declaration	errnum_t R_VRAM_EX_STACK_Initialize(vram_ex_stack_t* self, void* null_config);	
Description	If to re-initialize was done, all allocated off-screen buffer is freed.	
Argument	vram_ex_stack_t* self	The stack in the external RAM
	void* null_config	The reserved variable. Pass NULL
Return value	Error code. If there is no error, the return value is 0.	

5.7.12.3 R_VRAM_EX_STACK_Alloc

Outline	Allocates the off-screen buffer from the external RAM.	
Header	RGA_SampleLib.h	
Declaration	errnum_t R_VRAM_EX_STACK_Alloc(vram_ex_stack_t* self, frame_bufer_t* in_out_frame_buffer);	
Description	Input member variable in "frame_buffer_t" is "stride", "height", "buffer_count". Output member variable in "frame_buffer_t" is all element of "buffer_address" array. If the memory was few, E_FEW_ARRAY error is returned. Allocated off-screen buffer is freed by calling "R_VRAM_EX_STACK_Initialize" function.	
Argument	vram_ex_stack_t* self	The stack in the external RAM
	frame_bufer_t* in_out_frame_buffer	(Input/output) The off-screen buffer
Return value	Error code. If there is no error, the return value is 0.	

5.7.12.4 R_VRAM_EX_STACK_Free

Outline	Frees the off-screen buffer to the external RAM.	
Header	RGA_SampleLib.h	
Declaration	errnum_t R_VRAM_EX_STACK_Free(vram_ex_stack_t* self, frame_bufer_t* frame_buffer);	
Description	Input member variable in "frame_buffer_t" is "buffer_count", "buffer_address". If freeing order is not reverse of allocating order, E_ACCESS_DENIED error is returned.	
Argument	vram_ex_stack_t* self	The stack in the external RAM
	frame_bufer_t* in_out_frame_buffer	(Input/output) The freeing off-screen buffer
Return value	Error code. If there is no error, the return value is 0.	

5.7.13 Functions Related to animation_timing_function_t class

5.7.13.1 List of Functions

Section	Function Name	Description
5.7.13.2	R_Get_AnimationTimingFunction	Gets defined animation timing.
5.7.13.3	R_ANIMATION_TIMING_FUNCTION_GetValue	Calculates an attribute value at the specified elapsed time from the time starting animation.

5.7.13.2 R_Get_AnimationTimingFunction

Outline	Gets defined animation timing.	
Header	RGA.h	
Declaration	errnum_t R_Get_AnimationTimingFunction(char* timing_name, animation_timing_function_t** out_timing);	
Description		
Argument	char* timing_name	The name of animation timing. The following name can be passed: "ease", "linear", "ease_in", "ease_out", "ease_in_out"
	animation_timing_function_t** out_timing	(Output) The address of animation timing object
Return value	Error code. If there is no error, the return value is 0.	

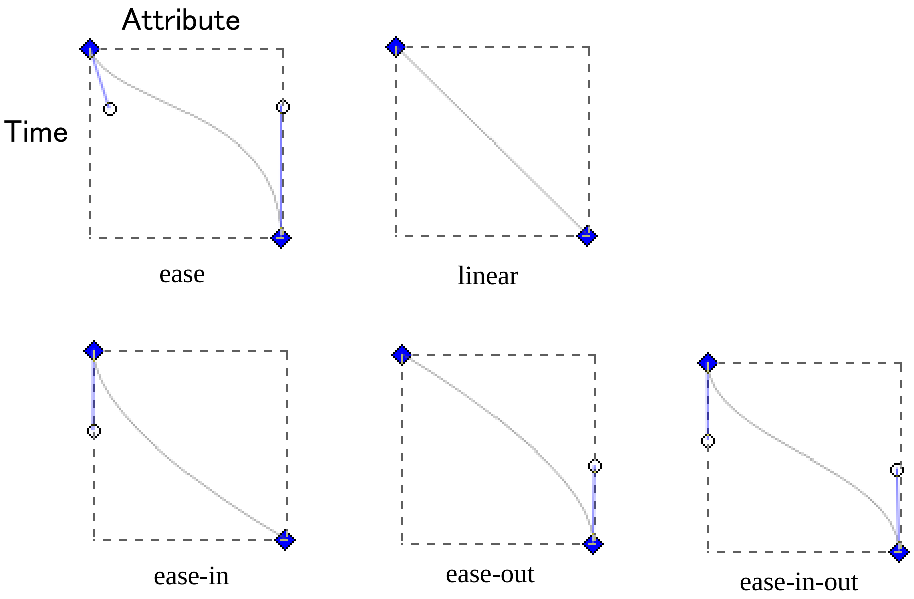
5.7.13.3 R_ANIMATION_TIMING_FUNCTION_GetValue

Outline Calculates an attribute value at the specified elapsed time from the time starting animation.

Header RGA.h

Declaration float32_t R_ANIMATION_TIMING_FUNCTION_GetValue(animation_timing_function_t* self, float32_t clamp_time, float32_t value_of_previous_keyframe, float32_t value_of_next_keyframe);

Description Attribute value is user defined position value, color value or other value changed by time



ease

linear

ease-in

ease-out

ease-in-out

Example:

```
timing_name="linear", value_of_previous_keyframe=10,
value_of_next_keyframe=20, clamp_time=0.5
```

This case returns 15.

Argument	animation_timing_function_t* self	The animation timing object
	float32_t　clamp_time	The percentage of time from previous key frame (clamp_time=0.0) to next key frame (clamp_time=1.0). (decimal from 0.0 to 1.0)
	float32_t value_of_previous_keyframe	The value of attribute at the previous key frame
	float32_t value_of_next_keyframe	The value of attribute at the next key frame
Return value	The value of attribute at the time of "clamp_time" argument	

5.7.14 Other Functions

5.7.14.1 List of Functions

Section	Function Name	Description
5.7.14.2	R_RGA_Get_R8G8B8A8	Returns the R8G8B8A8 color value.
5.7.14.3	R_RGA_CalcWorkBufferSize	Calculates the size required for the work buffer.
5.7.14.4	R_RGA_CalcWorkBufferB_Size	Calculates the size required for the work buffer B.

5.7.14.2 R_RGA_Get_R8G8B8A8

Outline	Returns the R8G8B8A8 color value.	
Header	RGA.h	
Declaration	r8g8b8a8_t R_RGA_Get_R8G8B8A8(int_t red, int_t green, int_t blue, int_t alpha);	
Description		
Argument	int_t red, int_t green, int_t blue, int_t alpha	Each color component 0 to 255
Return value	R8G8B8A8 color value	

5.7.14.3 R_RGA_CalcWorkBufferSize

Outline	Calculates the size required for the work buffer.	
Header	RGA.h	
Declaration	size_t R_RGA_CalcWorkBufferSize(int_t MaxHeightOfFrameBuffer);	
Description	Parameters may change in the future. R_RGA_CalcWorkBufferSize is the #define macro. Size of workBuf: Maximum length of display list + 64 * (Maximum height of the frame buffer (multiple of 8)) *4*2 [Bytes] Maximum length of display list = 128 See 5.4.5.3. graphics_config_t	
Argument	int_t MaxHeightOfFrameBuffer	Maximum height of the frame buffer to be a drawing destination
Return value	Size (bytes) required for the work buffer	

5.7.14.4 R_RGA_CalcWorkBufferB_Size

Outline: Calculates the size required for the work buffer B.

Header: RGA.h

Declaration: size_t R_RGA_CalcWorkBufferB_Size(int_t MaxWidthOfJPEG, int_t MaxHeightOfJPEG, int_t MaxBytePerPixelOfFrameBuffer);

Description: Parameters may change in the future.

R_RGA_CalcWorkBufferB_Size is the #define macro.

Requested size for work buffer B:

ceil_16(MaxWidthOfJPEG) * ceil_16(MaxHeightOfJPEG) * MaxBytePerPixelOfFrameBuffer [Bytes]

ceil_16: round up to multiples of 16

The work buffer B is not requested, if all following condition were fulfilled (JPEG Codec Unit (JCU) can draw directly) or any JPEG images are not drawn.

- The drawing target address of left up of JPEG image can be divided by 8.
- The size of JPEG image is multiples of MCU (Minimum Coded Unit). The size is depending on the pixel format of the JPEG data.
  - 16pixels x 8lines (JPEG image is YCbCr422 format)
  - 16pixels x 16lines (JPEG image is YCbCr420 format)

- The matrix is unit matrix or translation only.

The return value is set in "graphics_config_t" type. See 5.4.5.3. graphics_config_t

Argument	int_t MaxWidthOfJPEG	The maximum width of JPEG image
	int_t MaxHeightOfJPEG	The maximum height of JPEG image
	int_t MaxBytePerPixelOfFrameBuffer	The maximum bytes of the drawing target frame buffer. If the matrix is not unit matrix and not translation only, this argument is 4
Return value	Size (bytes) required for the work buffer B	

5.7.15 Functions in strings

5.7.15.1 List of Functions

Section	Function Name	Description
5.7.15.2	rgb	Returns the value of color from CSS Color format
5.7.15.3	rgba	Returns the value of color from CSS Color format with alpha

5.7.15.2 rgb

Outline	Returns the value of color from CSS Color format	
Header	RGA.h	
Declaration	r8g8b8a8_t rgb(int_t red_max255, int_t green_max255, int_t blue_max255);	
Description	Example: "rgb(255, 255, 0)" Target: fillStyle (5.6.1.3) The value of alpha component is maximum value (=1.0).	
Argument	int_t red_max255	The value of red component (0-255)
	int_t green_max255	The value of green component (0-255)
	int_t blue_max255	The value of blue component (0-255)
Return value	The value of R8G8B8A8 color.	

5.7.15.3 rgba

Outline	Returns the value of color from CSS Color format with alpha	
Header	RGA.h	
Declaration	r8g8b8a8_t rgba(int_t red_max255, int_t green_max255, int_t blue_max255, float32_t alpha_max1);	
Description	Example: "rgba(255, 255, 0, 0.5)" Target: fillStyle (5.6.1.3)	
Argument	int_t red_max255	The value of red component (0-255)
	int_t green_max255	The value of green component (0-255)
	int_t blue_max255	The value of blue component (0-255)
	float32_t alpha_max1	The value of alpha component (0.0-1.0)
Return value	The value of R8G8B8A8 color.	

5.8 Porting Layer Functions

This section describes porting layer functions called back from this module for other OS and board. The package contains a sample which can be modified by the user.

5.8.1 Functions on Default Settings of RGA

Section	Function Name	Description
5.8.1.1	R_GRAPHICS_STATIC_OnInitializeDefault	Default of the callback function that sets the default graphics_config_t value
5.8.1.2	R_GRAPHICS_OnInitialize_FuncType	Type of the callback function that sets the default graphics_config_t value
5.8.1.3	R_GRAPHICS_STATIC_OnFinalizeDefault	Default of the function that releases memory allocated in the R_GRAPHICS_OnInitialize_FuncType function
5.8.1.4	R_GRAPHICS_OnFinalize_FuncType	Type of the function that releases memory allocated in the R_GRAPHICS_OnInitialize_FuncType function

5.8.1.1 R_GRAPHICS_STATIC_OnInitializeDefault

Outline Default of the callback function that sets the default graphics_config_t value

Header RGA.h

Declaration errnum_t R_GRAPHICS_STATIC_OnInitializeDefault(graphics_t* self,
graphics_config_t* in_out_config, void** out_default_object);

Description Default of the R_GRAPHICS_OnInitialize_FuncType function type.
See 5.8.1.2. R_GRAPHICS_OnInitialize_FuncType

Argument	graphics_t* self	Address of the object (non-initialized) at which initialization starts
	graphics_config_t* in_out_config	See section 5.4.5.3.
	void** out_default_object	(Output) Memory allocated in this function
Return value	Error code. If there is no error, the return value is 0.	

5.8.1.2 R_GRAPHICS_OnInitialize_FuncType

Outline Type of the callback function that sets the default graphics_config_t value

Header RGA.h

Declaration errnum_t R_GRAPHICS_OnInitialize_FuncType(graphics_t* self,
graphics_config_t* in_out_config, void** out_default_object);

Description Use R_GRAPHICS_STATIC_SetOnInitialize() to register callback functions of this function type.

Callback functions of this function type are called back from inside of R_GRAPHICS_Initialize() function.

*out_default_object is used only to be released in inter R_GRAPHICS_OnInitialize_FuncType(). When R_GRAPHICS_OnInitialize_FuncType() is not called back, it is not necessary to set *out_default_object.

Argument	graphics_t* self	Address of the object (non-initialized) at which initialization starts
	graphics_config_t* in_out_config	See section 5.4.5.3.
	void** out_default_object	(Output) Memory allocated in this function
Return value	Error code. If there is no error, the return value is 0.	

5.8.1.3 R_GRAPHICS_STATIC_OnFinalizeDefault

Outline Default of the function that releases memory allocated in the R_GRAPHICS_OnInitialize_FuncType function

Header RGA.h

Declaration errnum_t R_GRAPHICS_STATIC_OnFinalizeDefault(graphics_t* self,
void* default_object, errnum_t e);

Description: Default of the R_GRAPHICS_OnFinalize_FuncType function type.
See. 5.8.1.4. R_GRAPHICS_OnFinalize_FuncType

Argument

graphics_t* self	Address of the object that has been finalized
void* default_object	(Output) Memory allocated in this function
errnum_t e	Errors that have occurred. No error = 0

Return value

Error code or e, 0 = successful and e = 0

5.8.1.4 R_GRAPHICS_OnFinalize_FuncType

Outline: Type of the function that releases memory allocated in the R_GRAPHICS_OnInitialize_FuncType function

Header RGA.h

Declaration:

```
errnum_t   R_GRAPHICS_OnFinalize_FuncType( graphics_t* self,
       void* default_object, errnum_t e );
```

Description: Use R_GRAPHICS_STATIC_SetOnFinalize() to register callback functions of this function type.

Callback functions of this function type are called back from the end of the R_GRAPHICS_Finalize() function.

The output default_object value is contained in *out_default_object of the R_GRAPHICS_OnInitialize_FuncType() function.

Argument

graphics_t* self	Address of the object that has been finalized
void* default_object	(Output) Memory allocated in this function
errnum_t e	Errors that have occurred. No error = 0

Return value

Error code or e, 0 = successful and e = 0

5.8.2 Functions on Cache

Section	Function Name	Description
5.8.2.1	NCGSYS_WriteBackAndInvalidate	Writes back data stored in the cache and invalidates.

5.8.2.1 NCGSYS_WriteBackAndInvalidate

Outline	Writes back data stored in the cache to the RAM and invalidates it.	
Header	RGA_Callback.h	
Declaration	errnum_t NCGSYS_WriteBackAndInvalidate(void* start, void* end);	
Description		
Argument	void* start	Virtual starting address
	void* end	Virtual end address (not next to end)
Return value	Error code. If there is no error, the return value is 0.	

5.8.3 Functions on the Display Controller Interrupt

Section	Function Name	Description
5.8.3.1	NCGDU_Attach_ISR	Attaches the display controller interrupt to the interrupt function.
5.8.3.2	NCGDU_Detach_ISR	Detaches the interrupt function from the display controller interrupt.

5.8.3.1 NCGDU_Attach_ISR

Outline	Attaches the display controller interrupt to the interrupt processing function.	
Header	ncg_du_isr.h	
Declaration	NCGint32 NCGDU_Attach_ISR(NCGISRfp pfnInterrupt);	
Description	The interrupt processing function transferred to the argument when called back from the RGA can be transferred directly to the VDC4_RegistCallbackFunc function of the Video Display Controller 4 (VDC4) driver. Independently of attaching the interrupt processing function transferred to the argument, register the interrupt handler of the Video Display Controller 4 (VDC4) driver in this function or before using a device. (See section 5.9.2.)	
Argument	NCGISRfp pfnInterrupt	Interrupt processing function to be attached
Return value	Error code: Normal = NCG_no_err Example of error code: NCG_err_isr_management_failed	

5.8.3.2 NCGDU_Detach_ISR

Outline	Detaches the interrupt processing function from the display controller interrupt.	
Header	ncg_du_isr.h	
Declaration	NCGint32 NCGDU_Detach_ISR(NCGISRfp pfnInterrupt);	
Description		
Argument	NCGISRfp pfnInterrupt	Interrupt processing function to be detached
Return value	Error code: Normal = NCG_no_err Example of error code: NCG_err_isr_management_failed	

5.8.4 Porting layer functions of OSPL

RGA uses following functions of OSPL API. If the memory map or OS was changed, change define of OSPL API functions or replace to functions already changed. More information is in the document of SH7268/SH7269 group OS Porting Layer "OSPL" Sample Program (R01AN2339EJ).

- Functions depended on the memory map
  - R_OSPL_ToCachedAddress
  - R_OSPL_ToUncachedAddress
  - R_OSPL_ToPhysicalAddress
- Functions depended on OS
  - R_OSPL_THREAD_GetCurrentId
  - R_OSPL_EVENT_Set
  - R_OSPL_EVENT_Clear
  - R_OSPL_EVENT_Wait
  - R_OSPL_MEMORY_Flush
  - R_OSPL_Delay
- Functions depended on the compiler or OS
  - INLINE
  - STATIC_INLINE
  - R_OSPL_SECTION
  - R_OSPL_ALIGNMENT
  - R_OSPL_EnableAllInterrupt
  - R_OSPL_DisableAllInterrupt
  - R_OSPL_MEMORY_Barrier
- Functions depended on hardware
  - R_OSPL_FTIMER_InitializeIfNot
  - R_OSPL_FTIMER_Get
- Functions no depended on
  - (some functions)

5.8.5 Porting layer functions of RGPNCG

RGA uses following functions of RGPNCG. If the OS was changed, change define of RGPNCG functions or replace functions to functions already changed.

If NCGSYS_*State functions use event flags of OSPL, it is necessary to port NCGSYS_*State functions.

- Functions depended on OS

Section	Function Name	Description
5.8.5.1	NCGSYS_CreateState	Creates an event flags of NCG.
5.8.5.2	NCGSYS_DestroyState	Destroys the event flags of NCG.
5.8.5.3	NCGSYS_SetState	Changes the value of the event flags of NCG.
5.8.5.4	NCGSYS_GetState	Gets the value of the event flags of NCG.
5.8.5.5	NCGSYS_WaitState	Waits for the value of the event flags of NCG until specified value.
5.8.5.6	NCGSYS_SetStateEventValue	Sets using value of OS event flags
5.8.5.7	NCGSYS_GetLastCreatedState	Returns last created event flags
5.8.5.8	NCGSYS_SetNextStateEventValue	Sets value of next creating event flags
5.8.5.9	NCGVG_Attach_ISR	Registers the interrupt callback function for R-GPVG.
5.8.5.10	NCGVG_Detach_ISR	Unregisters the interrupt callback function for R-GPVG.
5.8.5.11	NCGVGISRfp	Type of the interrupt callback function for R-GPVG.

- Functions depended on the policy of Power-Down Modes

Section	Function Name	Description
5.8.5.12	NCGVG_Init	Starts to use R-GPVG
5.8.5.13	NCGVG_DeInit	Ends to use R-GPVG

- Functions no depended on
  - NCGSYS_Abort
  - NCGSYS_CPUVAddrToSysPAddr
  - NCGSYS_ReadReg
  - NCGSYS_WriteReg

5.8.5.1 NCGSYS_CreateState

Outline	Creates an event flags of NCG.	
Header	ncg_state.h	
Declaration	NCGint32 NCGSYS_CreateState(NCGvoid** ppObj, NCGuint32 ui32StateID);	
Description	Change define of this function for the target OS. If thread attached event of OSPL was called, it does not have to change define.	
Argument	NCGvoid** ppObj	(Output) A event flags object
	NCGuint32 ui32StateID	Not used
Return value	Error code. If there is no error, the return value is NCG_no_err.	

5.8.5.2 NCGSYS_DestroyState

Outline	Destroys the event flags of NCG.
Header	ncg_state.h

Declaration	NCGint32 NCGSYS_DestroyState(NCGvoid *pObj);	
	If thread attached event of OSPL was called, it does not have to change define.	
Description	Change define of this function for the target OS.	
Argument	NCGvoid* pObj	The event flags object
Return value	Error code. If there is no error, the return value is NCG_no_err.	

5.8.5.3 NCGSYS_SetState

Outline	Changes the value of the event flags of NCG.	
Header	ncg_state.h	
Declaration	NCGint32 NCGSYS_SetState(NCGvoid* pObj, NCGuint32 ui32State, NCGuint32 ui32Flags);	
Description	Change define of this function for the target OS. If thread attached event of OSPL was called, it does not have to change define.	
Argument	NCGvoid* pObj	The event flags object
	NCGuint32 ui32State	See the description of ui32Flags argument
	NCGuint32 ui32Flags	Case of NCGSYS_STATE_SET_SET: Changes all bits of the event flags to the value of ui32State argument Case of NCGSYS_STATE_SET_OR: Does the OR operation with the event flags. Sets 1 to the event flags' bits of the column set 1 in ui32State argument. Case of NCGSYS_STATE_SET_AND: Does the AND operation with the event flags. Sets 0 to the event flags' bits of the column set 0 in ui32State argument.
Return value	Error code. If there is no error, the return value is NCG_no_err.	

5.8.5.4 NCGSYS_GetState

Outline	Gets the value of the event flags of NCG.	
Header	ncg_state.h	
Declaration	NCGuint32 NCGSYS_GetState(NCGvoid* pObj, NCGuint32 ui32Flags);	
Description	Change define of this function for the target OS. If thread attached event of OSPL was called, it does not have to change define.	
Argument	NCGvoid* pObj	The event flags object
	NCGuint32 ui32Flags	Not used
Return value	The value of the event flags.	

5.8.5.5 NCGSYS_WaitState

Outline	Waits for the value of the event flags of NCG until specified value.	
Header	ncg_state.h	
Declaration	NCGint32 NCGSYS_WaitState(NCGvoid* pObj, NCGuint32 ui32State, NCGuint32 ui32Flags, NCGuint32 ui32Timeout);	
Description	Change define of this function for the target OS. If thread attached event of OSPL was called, it does not have to change define. Status are not cleared. When 2 bits are set, this function can be called to waiting one bit after calling it to waiting another bit. This function can be called to waiting one bit many times after the bit was set 1 time.	
Argument	NCGvoid* pObj	The event flags object
	NCGuint32 ui32State	The value of bits set to 1 waiting for bits that become to 1

	NCGuint32 ui32Flags	Case of NCGSYS_STATE_WAIT_AND: Waits for all bits are 1 that bits are 1 in the specified ui32State argument. Case of NCGSYS_STATE_WAIT_OR: Waits for any bits are 1 that bits are 1 in the specified ui32State argument.
	NCGuint32 ui32Timeout	NCG_TIMEOUT_INFINITE is passed.
Return value	Error code. If there is no error, the return value is NCG_no_err.	

5.8.5.6 NCGSYS_SetStateEventValue

Outline Sets using value of OS event flags

Header ncg_state.h

Declaration NCGvoid NCGSYS_SetStateEventValue (NCGvoid* pObj, NCGuint32 ui32EventValue);

Description Define this function, if not defined.

If thread attached event of OSPL was called, it does not have to change define.

Thread attached event flags specified with "NCGSYS_SetState" function is set to variables in NCG.

Thread attached event flags specified with "NCGSYS_SetStateEventValue" function is set to OS objects.

Argument	NCGvoid* pObj	An event flag of NCG
	NCGuint32 ui32EventValue	Value setting to thread attached event flags
Return value	None	

5.8.5.7 NCGSYS_GetLastCreatedState

Outline Returns last created event flags

Header ncg_state.h

Declaration NCGvoid* NCGSYS_GetLastCreatedState(void);

Description Define this function, if not defined.

If thread attached event of OSPL was called, it does not have to change define.

This function returns an event flags created by "NCGSYS_CreateState" function.

Thread preemption does not occur from calling "NCGSYS_CreateState" function to calling "NCGSYS_GetLastCreatedState" function in RGA.

Argument	None	
Return value	Last created event flags	

5.8.5.8 NCGSYS_SetNextStateEventValue

Outline Sets value of next creating event flags

Header ncg_state.h

Declaration NCGvoid NCGSYS_SetNextStateEventValue (NCGuint32 ui32EventValue);

Description Define this function, if not defined.

If thread attached event of OSPL was called, it does not have to change define.

This function registers the value of thread attached event of created thread by "NCGSYS_CreateState" function after this function called.

R_OSPL_UNUSED_FLAG can be specified. Notification target thread is a thread called "R_GRAPHICS_Initialize". "graphics_config_t::internal_event_value" is specified with this function in RGA. Thread preemption does not occur from calling "NCGSYS_CreateState" function to calling "NCGSYS_GetLastCreatedState" function in RGA.

Argument	NCGuint32 ui32EventValue	Value setting to thread attached event flags
Return value	Error code. If there is no error, the return value is NCG_no_err.	

5.8.5.9 NCGVG_Attach_ISR

Outline	Registers the interrupt callback function for OpenVG™-Compliant Renesas Graphics Processor (R-GPVG).	
Header	ncg_vg_isr.h	
Declaration	NCGint32 NCGVG_Attach_ISR(NCGVGISRfp pfnInterrupt);	
Description	Change define of this function for the target OS.	
Argument	NCGVGISRfp pfnInterrupt	The interrupt callback function
Return value	Error code. If there is no error, the return value is NCG_no_err.	

5.8.5.10 NCGVG_Detach_ISR

Outline	Unregisters the interrupt callback function for OpenVG™-Compliant Renesas Graphics Processor (R-GPVG).	
Header	ncg_vg_isr.h	
Declaration	NCGint32 NCGVG_Detach_ISR(NCGVGISRfp pfnInterrupt);	
Description	Change define of this function for the target OS.	
Argument	NCGVGISRfp pfnInterrupt	The interrupt callback function
Return value	Error code. If there is no error, the return value is NCG_no_err.	

5.8.5.11 NCGVGISRfp

Outline	Type of the interrupt callback function for OpenVG™-Compliant Renesas Graphics Processor (R-GPVG).	
Header	ncg_defs.h	
Declaration	NCGuint32 (*NCGVGISRfp)(void);	
Description	Call "R_GRAPHICS_OnInterrupting" function from the last of this callback function. In attached "RGPNCG", "NCGVGISRfp" type function is "NCGVG_RGPVG_ISR".	
Argument	None	
Return value	None	

5.8.5.12 NCGVG_Init

Outline	Starts to use OpenVG™-Compliant Renesas Graphics Processor (R-GPVG)	
Header	ncg_vg.h	
Declaration	NCGvoid NCGVG_Init(PNCGVGINFO pVGInfo);	
Description	If the Power-Down Mode of OpenVG™-Compliant Renesas Graphics Processor (R-GPVG) was the halted state, change to the running state in this function.	
Argument	PNCGVGINFO pVGInfo	Not used
Return value	None	

5.8.5.13 NCGVG_DeInit

Outline	Ends to use OpenVG™-Compliant Renesas Graphics Processor (R-GPVG)	
Header	ncg_vg.h	
Declaration	NCGvoid NCGVG_DeInit(PNCGVGINFO pVGInfo);	
Description	If necessary, change the Power-Down Mode of OpenVG™-Compliant Renesas Graphics Processor (R-GPVG) to the halted state in this function.	
Argument	PNCGVGINFO pVGInfo	Not used
Return value	None	

5.9 Interrupt Handler

Statically register the interrupt handler in the interrupt vector for compilation or dynamically register the interrupt handler before calling a function of this library.

5.9.1 OpenVG™-Compliant Renesas Graphics Processor (R-GPVG) Interrupt

5.9.1.1 NCGVG_RGPVG_ISR

Outline	Interrupt handler of OpenVG™-Compliant Renesas Graphics Processor (R-GPVG)	
Header	(None)	
Declaration	void NCGVG_RGPVG_ISR(void);	
Description	Call this function from all interrupts INT3 (184), INT2 (185), INT1 (186), and INT0 (187) of the OpenVG™-Compliant Renesas Graphics Processor (R-GPVG).	
Argument	None	
Return value	None	

5.9.2 Video Display Controller 4 (VDC4) Interrupt

Register the interrupt handler according to the Video Display Controller 4 (VDC4).

See section 5.8.3.1, NCGDU_Attach_ISR.

5.9.3 JPEG Codec Unit (JCU) Interrupt

Register the interrupt handler according to the JPEG Codec Unit Driver User's Manual.

See section 5.8.3.1, NCGDU_Attach_ISR.

5.10 Sections

Register the following sections in the memory map section information. The following error is raised, if they are not registered.

```
      L1120 (W) Section address is not assigned to "P_RGA"
```

Add to setting of linker option of "Mapping sections from ROM to RAM".

Add initialization codes of each RAM section to the initial setting program.

Location	Section Name
ROM	P_RGA, C_RGA, D_RGA P_RGAH, C_RGAH, D_RGAH P_JCU, C_JCU, D_JCU P_VDC, C_VDC, D_VDC P_OSPL, C_OSPL, D_OSPL
RAM Cached Area	B_RGA, R_RGA (Section in which D_RGA is the initial value) B_RGAH, R_RGAH (Section in which D_RGAH is the initial value) B_JCU, R_JCU (Section in which D_JCU is the initial value) B_VDC, R_VDC (Section in which D_VDC is the initial value) B_OSPL, R_OSPL (Section in which D_OSPL is the initial value)
RAM Uncached Area	B_RGAH_Work

5.11 Supplementary Explanation

5.11.1 Correspondence to Canvas 2D and Correspondence to Hardware Acceleration

In the hardware column, ✓: Hardware is used, x: No hardware is used, —: Not applicable

Canvas2D API	RGA - C++ API	RGA - C language API	Hard ware
1 Conformance requirements			
CanvasRenderingContext2D interface.	Canvas2D_ContextClass	graphics_t	—
getContext()	R_RGA_New_Canvas2D_ContextClass	R_GRAPHICS_Initialize	—
context.canvas	-		
CSS currentColor	-		
2 The canvas state			
.save ()	.save()	R_GRAPHICS_Save	—
.restore()	.restore()	R_GRAPHICS_Restore	—
3 Transformations			
.scale(x, y)	.scale(x, y)	R_GRAPHICS_ScaleMatrix	✓
.rotate(angle)	.rotate(angle)	R_GRAPHICS_RotateMatrixRadian	✓
.translate(x, y)	.translate(x, y)	R_GRAPHICS_TranslateMatrix	✓
.transform(a, b, c, d, e, f)	.transform(a, b, c, d, e, f)	R_GRAPHICS_TransformMatrix	✓
.setTransform(a, b, c, d, e, f)	.setTransform(a, b, c, d, e, f)	R_GRAPHICS_SetMatrix_2x3	✓
4 Line styles			
.lineWidth	-		
.lineCap, .lineJoin, .miterLimit	-		
5 Text styles			
	-		
6 Building paths			
.moveTo()	-		
.closePath()	-		
.lineTo()	-		
.quadraticCurveTo()	-		
.bezierCurveTo()	-		
.arcTo()	-		
.arc()	-		
.rect()	.rect()	R_GRAPHICS_Rect	✓
7 Fill and stroke styles			
.fillStyle single-color	.fillStyle	R_GRAPHICS_SetFillColor	✓
.fillStyle gradation	-		
.fillStyle pattern	.fillStyle	R_GRAPHICS_SetFillPattern	✓
.strokeStyle single-color	-		

.strokeStyle gradation	-		
.strokeStyle pattern	-		
.createLinearGradient()	-		
.createRadialGradient()	-		
CanvasGradient.addColorStop()	-		
.createPattern()	.createPattern()	R_GRAPHICS_PATTERN_Initialize	—
8 The current default path			
.beginPath()	.beginPath()	R_GRAPHICS_BeginPath	—
.fill()	-		
.stroke()	-		
.drawSystemFocusRing()	-		
.drawCustomFocusRing()	-		
.scrollPathIntoView()	-		
.clip()	.clip() (Only a single rectangle)	R_GRAPHICS_Clip (Only a single rectangle)	✓
.isPointInPath()	-		
9 Drawing rectangles to the canvas			
.clearRect()	.clearRect()	R_GRAPHICS_Clear	✓
.fillRect()	.fillRect()	R_GRAPHICS_FillRect	✓
.strokeRect()	-		
10 Drawing text to the canvas			
	-		
11 Drawing images to the canvas			
.drawImage(dx, dy)	.drawImage()	R_GRAPHICS_DrawImage	✓
.drawImage(dx, dy, dw, dh)	.drawImage()	R_GRAPHICS_DrawImageResized	✓
.drawImage(sx, sy, sw, sh, dx, dy, dw, dh)	.drawImage()	R_GRAPHICS_DrawImageChild	✓
12 Pixel manipulation			
.createImageData(Width, Height)	.createImageData()	R_GRAPHICS_IMAGE_-InitR8G8B8A8	—
.createImageData(ImageData)	.createImageData()	R_GRAPHICS_IMAGE_-InitSameSizeR8G8B8A8	—
ImageData.width	ImageData.width	R_GRAPHICS_IMAGE_GetProperties	—
ImageData.height	ImageData.height	R_GRAPHICS_IMAGE_GetProperties	—
ImageData.data	ImageData.data	R_GRAPHICS_IMAGE_GetProperties	—
.getImageData()	.getImageData()	R_GRAPHICS_IMAGE_-InitCopyFrameBufferR8G8B8A8	x
.putImageData()	.putImageData()	R_GRAPHICS_DrawImage	x

		R_GRAPHICS_DrawImageChild	
13 Compositing			
.globalAlpha	.globalAlpha	R_GRAPHICS_SetGlobalAlpha	✓
.globalCompositeOperation	.globalCompositeOperation	R_GRAPHICS_-SetGlobalCompositeOperation	✓
14 Shadows			
	-		

5.11.2 Internal operation in initialize function

Take care by referring the following call tree and comment, if RGA initialize was failed, please.

```
R_GRAPHICS_Initialize
    A function registered by "R_GRAPHICS_STATIC_OnInitializeDefault" or
"R_GRAPHICS_STATIC_SetOnInitialize"
        // Sets default value of "graphics_config_t" and work buffer
    R_OSPL_ToUncachedAddress
        // Change the address of work buffer to the address in uncached area or
        // check the address
    R_OSPL_ToPhysicalAddress
        // Change the address of work buffer to physical address or check the address
    NCGSYS_WriteReg (This function will be called many times from here.)
        // An exception is raised, if R-GPVG was not supplied clock
        // It is supplied by setting bit 4 of STBCR8 register to 0
    NCGSYS_CreateState
    NCGSYS_SetState( 0x33, NCGSYS_STATE_SET_OR )
        R_OSPL_EVENT_Set
    NCGVG_Attach_ISR
    NCGSYS_SetState( ~0x02, NCGSYS_STATE_SET_AND )
        R_OSPL_EVENT_Clear
    // Interrupt RGPVG INT1  (186).
    // It is sometimes signaled before or after "NCGSYS_WaitState".
        NCGVG_RGPVG_ISR
            A function specified with "NCGVG_Attach_ISR".
                NCGSYS_SetState( 0x02, NCGSYS_STATE_WAIT_OR |
                                       NCGSYS_STATE_CALL_INTERRUPT )
                    R_OSPL_EVENT_Set
        // If the interrupt was not signaled, there is a possiblity that the interrupt
        // was masked or work buffer is not set in uncached area or the address is
        // not changed to uncached area by "R_OSPL_ToUncachedAddress".
    NCGSYS_WaitState( 0x02, NCGSYS_STATE_WAIT_OR )
        R_OSPL_EVENT_Wait  // Waiting "R_OSPL_EVENT_Set" called from interrupt
    NCGSYS_SetState( ~0x02, NCGSYS_STATE_SET_AND )
        R_OSPL_EVENT_Clear
    NCGSYS_WaitState( 0x02, NCGSYS_STATE_WAIT_OR )
        R_OSPL_EVENT_Wait  // Waiting "R_OSPL_EVENT_Set" called from interrupt
    // Interrupt RGPVG INT1  (186).
    // It is sometimes signaled before or after "NCGSYS_WaitState".
    // If 2nd interrupt was not signaled, in the case of OS less environment,
    // there is a possibility to not correct whether "#pragma interrupt" is specified
    // or not with function specified with "R_BSP_InterruptWrite" function.
    // See the section of "R_BSP_InterruptWrite" in "OSPL" document.
        NCGVG_RGPVG_ISR
            A function specified with "NCGVG_Attach_ISR".
                NCGSYS_SetState( 0x02, NCGSYS_STATE_WAIT_OR |
                                       NCGSYS_STATE_CALL_INTERRUPT )
                    R_OSPL_EVENT_Set
    NCGSYS_GetLastCreatedState
```

5.11.3 Identifying Image Format

The first few bytes of the graphics_image_t-type structure to be specified for the argument of the R_GRAPHICS_DrawImage (section 5.7.1.26), R_GRAPHICS_DrawImageResized (section 5.7.1.27), or R_GRAPHICS_DrawImageChild (section 5.7.1.28) function are used to identify image formats. Therefore, JPEG file data can be specified directly for the graphics_image_t-type argument of the R_GRAPHICS_DrawImage function.

Image Format	First Few Bytes	Note
JPEG	0xFF 0xD8	SOI segment
Raw	Others	graphics_image_t-type structure + Raw data

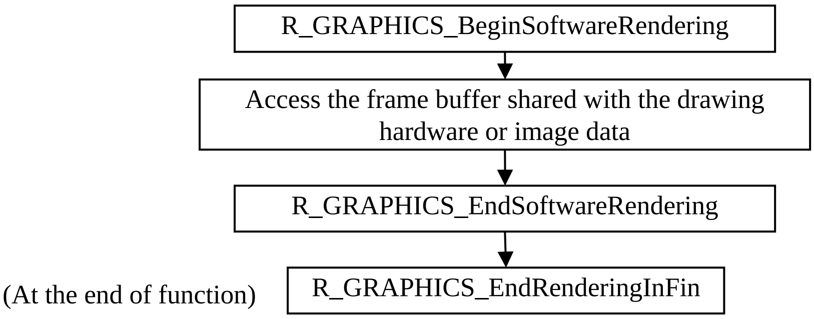
5.11.4 Flush Mode

In auto-flush mode, drawn content can be displayed only by calling R_GRAPHICS_Finish or R_WINDOW_SURFACES_SwapBuffers. In fast manual flush mode, however, cache flush operation is required.

Auto-flush mode is enabled by default. In this mode, you need not pay attention to the description of this section.

To enable fast manual flush mode, set graphics_config_t::is_fast_manual_flush to "true." Since unnecessary flush operation is not performed in the graphics library in this mode, the processing may be performed quickly.

To perform the flush operation efficiently, enclose the processing that accesses the frame buffer shared with the drawing hardware or image data by R_GRAPHICS_BeginSoftwareRendering (section 0) to R_GRAPPHICS_EndSoftwareRendering (section 5.7.1.46).


R_GRAPHICS_BeginSoftwareRendering
Access the frame buffer shared with the drawing hardware or image data
R_GRAPHICS_EndSoftwareRendering
(At the end of function)
R_GRAPHICS_EndRenderingInFin

The following describes specific examples of processing that must be enclosed.

- When directly reading or writing the frame buffer from outside the graphics library. However, enclosing this processing is not necessary when accessing the frame buffer from a non-cache area.
- When reading or writing image data specified for R_GRAPHICS_DrawImage or image data obtained from R_GRAPHICS_IMAGE_GetAddress. However, enclosing this processing is not necessary when reading or writing image data provided in the ROM.
- When this read or write operation is performed in the API that reads and writes files

When these functions are called, frame buffer data or image data is flushed from the CPU cache to the physical memory or hardware drawing is completed as needed.

If you do not want to use these functions, call R_GRAPHICS_Finish before accessing the frame buffer shared with the drawing hardware or image data. After the frame buffer or the image data is accessed, write back the CPU cache.

Sample:

```
  e= R_GRAPHICS_BeginSoftwareRendering( graphics ); IF(e){goto fin;}

  /* Access to frame buffer directly */
  IF ( error ) { e=ERROR_CODE; goto fin; }

  e= R_GRAPHICS_EndSoftwareRendering( graphics ); IF(e){goto fin;}

fin:
  e= R_GRAPHICS_EndRenderingInFin( graphics, e );
```

5.11.5 Sample Screen Control Layer Configuration

The following table shows correspondence between layer configuration supported by window_surfaces_t (section 5.4.5.5) and planes of Video Display Controller 4 (VDC4).

ID of section 5.4.5.7, layer_attributes_t	Plane Name of Video Display Controller 4 (VDC4)
(Not used)	Graphics (3)
0	Other than YUV422: Graphics (2) YUV422: Graphics (1)
-1 (only for background color)	Graphics (1)

5.11.6 Flagged Structure Parameters

Flags member variables in the structure are used as a bit field. When the bit is 1, the corresponding member variable is enabled in this coding pattern. When the bit is 0, it is treated that the default value is set or not change for the member variable as omitted. Updating the version allows binary compatibility even when structure members increase.

```
FuncA_ConfigClass  config;

config.Flags  = F_FuncA_Param1 | F_FuncA_Param2;
config.Param1 = 10;
config.Param2 = 2;
FuncA( &config );
```

The default value is config.Param3 because "Flags |= F_FuncA_Param3" does not exist.

5.11.7 Defaultable Flags

Defaultable flags are the type that can select three options: setting to ON, setting to OFF, and no setting (unchanged) for each array element when setting logic-type array variables. Symbols for setting to ON and setting to OFF are defined. When these symbols are not used, settings remain unchanged.

The variable type that stores defaultable flags is a 32-bit integer type. These flags are defined as a flag that sets the lower 16 bits to ON and a flag that sets the upper 16 bits to OFF. Components of the upper 16 bits are the same as those of the lower 16 bits.

Flag to be set to OFF (upper 16 bits)	Flag to be set to ON (lower 16 bits)

```
typedef BitField  DefaultableFlagsType;  /* Flags of DefaultableFlagType */
enum DefaultableFlagType {
    /* Set to "ON" */
    ENABLE_SAMPLE_FLAG_A     = 0x0001,
    ENABLE_SAMPLE_FLAG_B     = 0x0002,
    ENABLE_SAMPLE_FLAG_C     = 0x0004,

    /* Set to "OFF" */
    DISABLE_SAMPLE_FLAG_A    = ENABLE_SAMPLE_FLAG_A << 16,
    DISABLE_SAMPLE_FLAG_B    = ENABLE_SAMPLE_FLAG_B << 16,
    DISABLE_SAMPLE_FLAG_C    = ENABLE_SAMPLE_FLAG_C << 16,
};
```

When the argument of the function to set flags (SampleClass_setDefaultableFlags below) is a defaultable flag, only flags to be set to "ON" or "OFF" are connected by "|". Settings remain unchanged for flags that are not set to "ON" or "OFF." For initialization functions, default values are used.

```
errnum_t  main()
{
    DefaultableFlagsType  flags;

    e= SampleClass_setDefaultableFlags( object,
        ENABLE_SAMPLE_FLAG_A | DISABLE_SAMPLE_FLAG_B ); IF(e)goto fin;
        /* SAMPLE_FLAG_C is not modified. */

    e= SampleClass_getDefaultableFlags( object, &flags ); IF(e)goto fin;
    if ( flags & ENABLE_SAMPLE_FLAG_A ) { ... }
    if ( flags & DISABLE_SAMPLE_FLAG_B ) { ... }
    if ( flags & ENABLE_SAMPLE_FLAG_C ) { ... }
}

errnum_t  SampleClass_setDefaultableFlags( SampleClass* self,
DefaultableFlagsType Flags )
{
    self->Flags = self->Flags | ( Flags & 0x0000FFFF );
    self->Flags = self->Flags & ~( Flags >> 16 );
}

errnum_t  SampleClass_getDefaultableFlags( SampleClass* self,
DefaultableFlagsType* out_Flags )
{
    BitField  flags = ( self->Flags & 0x0000FFFF );
    *out_Flags = flags | ~( flags << 16 );
}
```

When the argument of the function to acquire the current flag (SampleClass_getDefaultableFlags above) is a defaultable flag, the upper 16 bits of an acquirable value are an inverted value of the lower 16 bits. For this reason, both symbols for setting to ON and symbols for setting to OFF can be used for decision statements. Since the internal variable that retains the current flag is the internal specification, there is no problem with specifications in which upper 16 bits are disabled.

Inverted value of lower 16 bits (upper 16 bits)	Current flag (lower 16 bits)

5.11.8 Function to Initialize Internal Variables with Constants (*_initConst Function)

In the C language class that includes the finalizing function (*_finalize function), the *_initConst function must be called first (before calling the *_initialize function). This is to prevent any exception from occurring even if the *_finalize function is called when an error occurs from another object before initialization. Before calling the function that may cause an error first among functions, call the *_initConst function first at a time for all objects that only exist in functions (i.e. created and deleted in functions).

Even if the *_initConst function is called, many functions (methods) are not made available until the *_initialize function is called.

In the case of the C++ language API of this library, the *_initConst function responds to the constructor. The *_initialize function responds to object creation functions (such as R_RGA_New_Canvas2D_ContextClass function). The *_finalize function responds to the destroy member function. For example, when an error occurs before an object creation function is called after the constructor was called by the variable declaration, no exception occurs even when the destroy member function is called.

5.11.9 Compatibility between C++ Language and JavaScript Object

JavaScript codes using the Canvas 2D object can be operated as they are by using the C++ language class provided by this library. The following shows codes using variables of the class provided by this library, which are the same description of codes using variables that reference the JavaScript object.

- When assignment operation is performed, one object can be accessed from two variables. Therefore, an operation is performed as if the value of the pointer that indicates the C++ language object is copied.

```
object_1_reference = object_1;
```

- When accessing a member, describe a period instead of the "->" operator (hyphen + inequality sign).

```
object_1.attr = 1;
```

- Since the destructor is not automatically activated as in the case of JavaScript, explicitly call the destroy member function to delete objects. This corresponds delete operator of C++ language.

```
object_1.destroy();
```

The compatibility between the C++ language provided by this library and JavaScript applies only to codes for objects. In the C++ language, not all JavaScript codes operate as they are (such as required variable declaration).

When an error occurs, the return value of "R_OSPL_GetErrNum" function is not 0. No exception occurs. Call the R_OSPL_CLEAR_ERROR function when returning from the error. Even if a method of an error object is called, no internal processing is performed. However, "save" and "restore" methods do operations in the error state.

Sample code of error check code:

```
if ( R_OSPL_GetErrNum() != 0 ) { ... }
```

Sample code of error clear code:

```
R_OSPL_CLEAR_ERROR();
```

If an error was raised in the function creating an object, "R_OSPL_GetErrNum" function returns not 0 and undefined object is returned from the creating function. Whether the return value is the undefined object or not can be determined by == operator of the object handle variable.

6. Tools

6.1 Image Format Conversion by ImagePackager

The ImagePackager packs multiple image files into a single binary file (for the target board) or a source file (for the target board and PC). When image files are packed, they can also be converted to the raw format of any pixel formats. In an XML file, specify image files to be packed. File names and extension name are not ignored case-insensitive comparison in XML file.

ImagePackager is one of commands in "RGA_Tools.vbs". It calls vbs files and exe files internally.

6.1.1 Operational Procedure

1. Make .image.xml file ().
2. Double click RGA_Tools.vbs file at armcc\common\src\samples\RGA, select "ImagePackager" command in opened window, specify .image.xml file. This makes header file and binary file or C language data source.

```
---------------------------------------------------------------------------
RGA Tools - Copyright(c) 2012-2016 Renesas Electronics Corporation
 1. Convert image format [RunImagePackager]
 2. Search error information [SearchErrorInformation]
Number or command >1
---------------------------------------------------------------------------
((( [RunImagePackager_sth] )))
Renesas Image Packager - Copyright(c) 2012-2016 Renesas Electronics
Corporation
Make one binary file from many image files and other files.
Enter only : Open sample folder.
Setting file(ImagePackagerConfig.xml) >
```

3. Write #include directive with a generated header file and pass a symbol of image defined in the header file to "R_GRAPHICS_DrawImage" function or other functions.
4. If binary file was generated, write it at the address written in .image.xml file and start drawing operations. The address is written at /ImagePackager/OutputBinary/OutputHeader/@address in .image.xml file or generated header file.

ImagePackager can be started by the following command in the command prompt.

```
>cd  armcc\common\src\samples\RGA\Sample_Common\Images
>cscript  //nologo  ..\..\RGA_Tools.vbs  RunImagePackager
BinaryImageConfig.image.xml
```

6.1.2 List of files

File	Description
RGA_Tools.vbs	Script file which contains ImagePackager
*.image.xml	Setting file of ImagePackager
(*.bmp, *.jpg, *.png)	Input image file
(Output: binary file)	A file which contains images and files to download to the target board
(Output: source file)	A source file which contains image data and file data to put in the program

6.1.3 Sample

BinaryImageConfig.image.xml

```xml
<?xml version="1.0" encoding="UTF-8"?>
<ImagePackager>

<OutputBinary path="BinaryImage_SH7269.c" language="C"
symbol="g_RGA_Sample_BinaryImage"
   source_template="${ImagePackagerLib}\SourceTemplate.xml#default"
   super_class="${ImagePackagerLib}\SuperClass.xml#default">
<OutputHeader path="BinaryImage_SH7269.h"
include_define="BINARYIMAGE_SH7269_H"/>
</OutputBinary>

<InputFiles>
<File path="BinaryHeader.txt" type="char[]" symbol="g_BinaryHeader"/>
<Image path="picture.bmp" type="graphics_image_t*" symbol="g_Picture_bmp"
output_format="RGB565"/>
<Image path="smile32.bmp" type="graphics_image_t*" symbol="g_Smile_bmp"
output_format="ARGB4444"/>
<File path="JPEG.jpg" type="graphics_image_t*" symbol="g_JPEG_jpg"/>
</InputFiles>

</ImagePackager>
```

Refer 6.1.8 regarding the basic forms of writing XML and XPath.

The folder that contains the XML file is the reference of relative paths.

A folder path or wild card can be specified for Image/@path.

Providing a fixed-value header at the top allows checking whether binary data is contained or not.

6.1.4 Types of Output Binary File (Language)

- Binary format (external reference symbol of C language) + C language header
- Binary format or S-record format (direct addressing such as in flush) + C language header
- C language source + C language header

Specified for /ImagePackager/OutputBinary/@language and /ImagePackager/OutputHeader/@address

6.1.5 File Formats in the Output Binary File

Format	Description
Offset table	The array of 4byte integer type in the first of the binary file that indicates the offset value to image data and binary data.
Raw-format image	Specified for /ImagePackager/InputFiles/Image/@output_format "ARGB8888", "XRGB8888"(X component is 0x00), "RGB565", "ARGB1555", "ARGB4444", "YUV422", "CLUT8","CLUT4","CLUT1","A8","A4","A1" See following "The format of Raw-format image"
Binary format	When expanding JPEG data on the target board, the file is stored as it is. Specified for /ImagePackager/InputFiles/File

The format of Raw-format image:

Offset	Size	Description
0x00	4byte	The bit flags described the type of image [bit0] 1fixed

<table>
<tr><td></td><td></td><td>[bit1] (reserved)
[bit2] 1=Premultiplied alpha, 0=not Premultiplied alpha
[bit3-bit15] (reserved) [bit16-bit31] 0
This endian is depended on the setting of "@endian".</td></tr>
<tr><td>0x04</td><td>4byte</td><td>The offset value to the image data from the first of Raw-format image.
This endian is depended on the setting of "@endian".</td></tr>
<tr><td>0x08</td><td>4byte</td><td>(reserved)</td></tr>
<tr><td>0x0C</td><td>2byte</td><td>The image width (pixels)
This endian is depended on the setting of "@endian".</td></tr>
<tr><td>0x0E</td><td>2byte</td><td>The image height (pixels)
This endian is depended on the setting of "@endian".</td></tr>
<tr><td>0x10</td><td>1byte</td><td>The pixel format
0=RGB565, 2=ARGB1555, 3=ARGB4444, 6=CLUT8, 7=CLUT4, 8=CLUT1, 9=XRGB8888, 10=ARGB8888, 11=YUV422, 20=A8, 21=A4, 22=A1</td></tr>
<tr><td>0x11</td><td>7byte</td><td>(reserved)</td></tr>
<tr><td>*</td><td></td><td>Image data
If the pixel format was RGB components, this endian is depended on the setting of "@endian". If the pixel format was YUV components, this endian is not depended on.
The offset value of this image data is depended on the setting of "@raw_image_alignment".
The byte count par one line (stride) is depended on the setting of "@raw_stride_alignment" and so on.
If this image data had CLUT (Color Look Up Table, Palette), there are image data after CLUT. The elements of CLUT are ARGB8888 format depended on the endian by "@endian" setting. The count of elements is 256 (CLUT8), 16 (CLUT4) or 2(CLUT1).

Limitation for RGA:
It is necessary that start address and byte count as 1 line of image data drawing by RGA is aligned to following values.
<table>
<tr><th colspan="3">Alignment of start address for the image (byte)</th><th colspan="3">Alignment of byte count for the image (byte)</th></tr>
<tr><td>RGB</td><td>YCbCr</td><td>CLUT</td><td>RGB</td><td>YCbCr</td><td>CLUT</td></tr>
<tr><td>32</td><td>4</td><td>1</td><td>32</td><td>4</td><td>1</td></tr>
</table></td></tr>
</table>

6.1.6 Input Formats

- BMP format: 32 bits or 24 bits (256, 16, or 2 colors for CLUT)
- PNG format: Supports data with alpha
- JPEG format

See the description on @path of "/ImagePackager/InputFiles/Image".

6.1.7 Parameters That Can Be Described in BinaryImageConfig.image.xml

6.1.7.1 /ImagePackager/OutputBinary

One or more parameters (Two or more parameters are used to output both "Binary" @language and "C" @language.)

@path	Path of the binary file output destination (Essential)
@symbol	C language's external reference symbol (global variable name) that supports all binary files (Essential)

When outputting multiple binary files, do not change this parameter in each binary file. When /ImagePackager/OutputHeader/@address is set, this parameter is a macro name having the address value.

@language

Programming language of output binary data (Optional)
"Binary" and "C", "SRec"(S-record) can be set. "Binary" is set by default.

@section

Specified section is embedded in the output source.
Example: section = "_BinaryImage" --- C_BinaryImage section is created. This is filled at ${Section} in /ImagePackager/SourceTemplate.

@endian

Endian (Optional)
"LittleEndian" or "BigEndian" can be selected. @endian pointed from @super_class is set by default.

@raw_image_alignment

Alignment (bytes) of the starting address of raw-format image data (Optional)
Only 2^n can be set. @raw_image_alignment pointed from @super_class is set by default. When outputting multiple binary files, do not change this parameter in each binary file.
The raw-format header is not aligned by this setting.

@raw_image_alignment_symbol

The #define symbol name containing the @raw_image_alignment value (Optional)
The #define symbol name is output to the header file to be generated. Compile the program using binary files by using the header.

```
Example: raw_image_alignment_symbol=
"GRAPHICS_RAW_IMAGE_ALIGNMENT"
```

The code filled in the header file:

```
#define  RAW_IMAGE_ALIGNMENT  32
```

The #define sentence of the symbol name is not output by default.
When outputting multiple binary files, do not change this parameter in each binary file.

@raw_stride_alignment

Alignment of the number of bytes up to the line immediately below in an image to be output (Optional). The number of bytes is carried to a multiple of the value specified for (value).
@raw_stride_alignment pointed from @super_class is set by default.

```
Example: raw_stride_alignment = 32
```

@raw_stride_alignment_4

Pixel format of output image in which the number of bytes up to the line immediately below is 4. Two or more CSV formats can be specified. (Optional)
This setting takes precedence over the @raw_stride_alignment setting. @raw_stride_alignment_4 pointed from @super_class is set by default.

```
Example: raw_stride_alignment_4 = YUV422
```

@table_format

The format of the table. (Optional)

- "Offset": Fills not only the body but also the offset to the body in the binary file, because re-compile does not have to be done, even if the size of the image or the file was changed.
- "Embed": Fills images and files normally.

Default value is the following value.

- If @language="Binary", @table_format="Offset"
- If @language="C", @table_format="Embed"

@source_template

ID of the template of the output source file in the case of @language="C". (Optional)
Set the value of "/ImagePackager/SourceTemplate/@id".
It is able to set the reference to the other XML file.
${ImagePackagerLib} is replaced to the folder path containing ImagePackagerLib.vbs

```
Example:
source_template="${ImagePackagerLib}\SourceTemp
late.xml#default"
```

@super_class

ID of the super class attached to the binary file. (Optional)
Set the value of "/ImagePackager/SuperClass/@id".
It is able to set the reference to the other XML file.
${ImagePackagerLib} is replaced to the folder path containing ImagePackagerLib.vbs

```
Example:
super_class="${ImagePackagerLib}\SuperClass.xml
#default"
```

6.1.7.2 /ImagePackager/OutputBinary/OutputHeader: One or more elements

Same as /ImagePackager/OutputHeader.

6.1.7.3 /ImagePackager/OutputHeader: Zero or one element

@path

Path of the header file output destination (Essential)

@include_define

The #define symbol name to prevent the header file from being included twice (Optional)
Default name: "__BINARY_IMAGE__"

@address

Memory address to allocate binary files (Optional)
Specify the memory address in the 0x00000000 format. This parameter is used when allocating addresses directly in the flash memory in addition to the program image to be linked. Since the set address is output to the header file to be created, compile the program that references binary data by using the header. If this parameter is omitted, the C language's external reference symbol (global variable name) specified for /ImagePackager/OutputBinary/@symbol is used.

6.1.7.4 /ImagePackager/InputFiles: Only one element

@base_folder

A path to be the reference of /ImagePackager/InputFiles/Image/@path (Optional)
The reference of relative paths is the folder that contains the BinaryImageConfig.image.xml file. Default path: "."

6.1.7.5 /ImagePackager/InputFiles/Image: Zero, one or more elements

The data converted to Raw-format are embedded in the binary file.

@path

Path of image files to be input (Essential)
As the reference of relative paths, the path of the /ImagePackager/InputFiles/@base_folder folder and the sub-folder are also input when a wild card is specified. In the case of "png" or "jpg" extension, incompressibly expanded files are output to binary files. When expanding a file on the target board, specify JPEG file for /ImagePackager/InputFiles/File. For images with no alpha channel or images whose all alpha values are 0xFF, information that shows that alpha blending is not required is embedded in the output data. This information may allow fast drawing.

@type

Type of symbols described in the header file (Essential)
@symbol type. Specify graphics_image_t*.

@symbol

A symbol described in the header file (Essential)
The #define symbol in the global scope. @type type
When "${...}" is used, the symbol is replaced with a file name.

```
    Example: g_${BaseName}_${Extension}_${Format}
    -> g_Sample_jpg_ARGB8888
```

@output_format

Format of files to be output (Essential)
If input file was 24bit/32bit Window bitmap file, JPEG file, PNG file (with alpha/without alpha), values "ARGB8888", "XRGB8888"(X component is 0x00), "RGB565", "ARGB1555", "ARGB4444", "YUV422", "A8", "A4" and "A1" can be specified.
When "CLUT8" is specified, input a 256-color Windows bitmap file.
When "CLUT4" is specified, input a 16-color Windows bitmap file.
When "CLUT1" is specified, input a monochrome Windows bitmap file.
The following table describes alpha component of output image. If input image was 256, 16 colors or monochrome Windows bitmap file, see the input color as CLUT referenced color at the following table. Notice: PNG format created by Paint Brush for Windows 7 always has alpha component.

Input Image	Output Image	Alpha component of output
With A	Every format	A component of the input image
Without A	ARGB	0xFF
	A component only	Y component (luminance) converted input image from RGB to YCbCr

Two or more values can be specified in the CSV format. In that case, however, include "${Format}" in @symbol. "${Format}" will be replaced to the name of pixel format.

@premultiplied_alpha

This parameter shows whether to multiply RGB components by the alpha component. (Optional)

- "no": Not multiplied (default)
- "yes": RGB components are converted to multiplied values before they are output. This choice is available only when the alpha component is not contained in the drawing destination.

- "already_yes": The input image has already been multiplied. This choice is available only when the alpha component is not contained in the drawing destination.

6.1.7.6 /ImagePackager/InputFiles/File: Zero, one or more elements

Not converted data are embedded in the binary file.

@path	Path of files to be input (Essential) Reference of relative paths: /ImagePackager/InputFiles/@base_folder Files in sub folder are input, if the value had wildcard.
@type	Type of symbols described in the header file (Optional) @symbol type. When the file content is an array, attach [] to the end of the type name. uint8_t[] is set by default.
@symbol	A symbol described in the header file (Essential) The #define symbol in the global scope. uint8_t[] type.
@alignment	The address alignment of the file. (Optional) @alignment pointed from /ImagePackager/OutputBinary/@super_class is set by default.

6.1.7.7 /ImagePackager/InputFiles/Var: Zero, one or more elements

The values written in XML file are embedded in the binary file.

@type	Type of the symbol written in the header file. (Essential) int32_t, uint32_t, int16_t, uint16_t, int8_t, uint8_t can be specified.
@symbol	The symbol name written in the header file. (Essential) This name is a name of global variable initialized the value embedded in the binary file.
@value	The value embedded in the binary file. (Essential) Integer or the following special format can be specified. ● Example of integer: "10", "-10", "0xFF" ● Special format "(new Image('file_path')).width" : Width of image named by file_path ● Special format "(new Image('file_path')).height" : Height of image named by file_path "file_path" is the path of image file.

6.1.7.8 /ImagePackager/SourceTemplate/ : Zero, one or more elements

@id	ID of SourceTemplate tag. (Essential) This value is referred from /ImagePackager/OutputBinary/@source_template.
Source/text()	Template of source file. (Essential) The following tags can be filled in the template.

- ${Section} : Section name. The value of /ImagePackager/OutputBinary/@section
- ${Symbol} : Variable name. The value of /ImagePackager/OutputBinary/@symbol
- ${Size} : Size of the binary file (bytes)
- ${BinaryData} : Binary data

SourceWithSection/text()

Template of source file, if a section was specified. (Optional)
If SourceWithSection tag was not specified, the content specified by Source tag is used, even if a section was specified.

Header/text()

Template of header file. (Essential)
The following tags can be filled in the template.

- ${include_define} : Macro name avoiding double include. The value of /ImagePackager/OutputBinary/OutputHeader/@include_define
- ${DeclareBinaryImageSymbol} : Declares of symbols in the binary data. The content of DeclareVariable/text() or DeclareAddress/text() and #define by @raw_image_alignment_symbol
- ${Variables} : #define list as variables
- ${Section} : Section name. The value of /ImagePackager/OutputBinary/@section
- ${Symbol} : Variable name. The value of /ImagePackager/OutputBinary/@symbol
- ${Size} : Size of the binary file (bytes)
- ${StartAddress} : Start address of the binary data
- ${LastAddress} : Last address of the binary data

HeaderWithSection/text()

Template of header file, if a section was specified. (Optional)
If HeaderWithSection tag was not specified, the content specified by Header tag is used, even if a section was specified.

DeclareVariable/text()

If @language="C", template filled at ${DeclareBinaryImageSymbol}.
The following tags can be filled in the template.

- ${Section} : Section name. The value of /ImagePackager/OutputBinary/@section
- ${Symbol} : Variable name. The value of /ImagePackager/OutputBinary/@symbol
- ${Size} : Size of the binary file (bytes)

DeclareAddress/text()

If @language="Binary", template filled at ${DeclareBinaryImageSymbol}.
The following tags can be filled in the template.

- ${Section} : Section name. The value of /ImagePackager/OutputBinary/@section
- ${Symbol} : Variable name. The value of /ImagePackager/OutputBinary/@symbol
- ${StartAddress} : Start address of the binary data
- ${LastAddress} : Last address of the binary data

6.1.7.9 /ImagePackager/SuperClass: Zero, one or more elements

@id	ID of SuperClass tag. (Essential) This value is referred from /ImagePackager/OutputBinary/@super_class.

6.1.7.10 /ImagePackager/SuperClass/OutputBinary : Zero or one

@endian	Default value of /ImagePackager/OutputBinary/@endian. This default value is "LittleEndian".
@raw_image_alignment	Default value of /ImagePackager/OutputBinary/@raw_image_alignment. This default value is 4.
@raw_stride_alignment	Default value of /ImagePackager/OutputBinary/@raw_stride_alignment. This default value is 1.
@raw_stride_alignment_4	Default value of /ImagePackager/OutputBinary/@raw_stride_alignment_4. This default value is "".

6.1.7.11 /ImagePackager/SuperClass/InputFiles/File : Zero, one or more elements

@path	Path of target file attached with SuperClass. Wildcard can be specified. (Essential) Example: path="*.jpg"
@alignment	Default value of /ImagePackager/InputFiles/File/@alignment. This default value is 4.

6.1.8 Basic forms of writing XML

This section describes basic forms of writing XML, XPath and # fragment that is data format specified with tools.

6.1.8.1 XML

XML file is one of text file. You can edit it by text editor. This section describes basic forms of writing XML only.

XML declaration is written at the head of XML file like the following text. Character code set is generally encoding="UTF-8", if XML declaration was omitted. The following text is an example.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
```

A markup construct that begins with < and ends with >. Start-tags must be paired with end-tags. End-tag is appended with slash at head of start-tag's name. Target program ignores not supported tags and does not warn spelling mistakes. Difference between upper case and lower case is treated as different name.

```
<Root>

</Root>
```

XML tags must have tree structure. Also, there must be one root end tag. Data passing to target program are not changed, even if return character was replaced space or tab character or deleted between tags.

```
<Root>
        <LeafA></LeafA>
        <LeafB></LeafB>
</Root>
```

Start-tag and end-tag can be replaced to one tag that has a name appended slash at the tail of tag name. Data passing to target program are not changed, even if they were replaced like it.

```
<Root>
        <LeafA/>
        <LeafB/>
</Root>
```

Text can be written between start-tag and end-tag. The text is specified value depending on tag specification defined by target program. It is depended on tag specification whether different text between upper case and lower case is treated as same data or not same data.

```
<Root>
        <LeafA>ABC</LeafA>
        <LeafB>DEF</LeafB>
</Root>
```

Specified value can be written as attribute's value in start-tag. The attribute's value (right of equal) must be enclosed between " " or ' '. It is no different between " " and ' '. Specified value cannot be written in end-tag. Target program ignores not supported attributes and does not warn spelling mistakes. Difference between upper case and lower case is treated as different attribute's name. It is depended on target program whether different attribute's value between upper case and lower case is treated as same data or not same data.

```
<Root>
        <Leaf  attribute="1"  other="no"/>
</Root>
```

Same name tags can be written depended on tag's specification. 2nd tag and more tags are ignored, if specification of the tag can be allowed one tag only. It is depended on target program whether only one tag was allowed or not.

```
<Root>
        <Leaf  attribute="1"  other="no"/>
        <Leaf  attribute="2"  other="no"/>
        <Leaf  attribute="3"  other="yes"/>
</Root>
```

6.1.8.2 XPath

XPath is one of address that can point to a part of XML text. XPath is written by the forms like file path. This section describes basic forms only.

When there was XML text like the following text:

```
<Root>
       <LeafA>ABC</LeafA>
       <LeafB  attribute="1"  other="no"/>
</Root>
```

The following text is an XPath that points to the position at the text value "ABC". Between XML nodes are split by slash character. "text()" points a text between tags. It is necessary to write "()" at the tail of "text". Difference between upper case and lower case is treated as different name. The following text is an example.

```
/Root/LeafA/text()
```

The following text is an XPath that points to the position at the attribute's value "1". It is necessary to write slash and "@" at the head of attribute's name.

```
/Root/LeafA/@attribute
```

It is step path that the head of XPath is not slash.

```
LeafB/@attribute
```

```
@attribute
```

6.1.8.3 # fragment

# and ID (fragment) can be written after specified file name or path depended on the specification of target program. The following text is an example.

```
Folder\File.xml#Leaf1
```

Fragment is compared with id attributes from all XML tags in the specified file. Difference between upper case and lower case is treated as different name. Path attached fragment points an XML tag that has matched id attribute's value. For example, "Folder\File.xml#Leaf1" points following "LeafA" tag in "Folder\File.xml" file.

```
<Root>
       <LeafA  id="Leaf1">ABC</LeafA>
       <LeafB  id="Leaf2">ABC</LeafB>
</Root>
```

6.2 Searching for Error Information by SearchErrorInformation

When an error occurs in the debug-version library, the R_DEBUG_BREAK_IF_ERROR function shows the location raising an error. For SH7269, it output the following message to serial output. If target board did not have serial port, there is the way of getting error information by using LED and so on. (See following sentence).

printf output:

```
R_RGA_DebugBreak at C:\folder\Library.c(2095)
```

If you want to change to debug configuration, change the linking library from "lib\RGA\For<SubModule>\Release\RGA.a" to "lib\RGA\For<SubModule>\Debug\RGA.a", delete "R_OSPL_NDEBUG=1" in #define of the project settings.

When the SearchErrorInformation command is executed by double-clicking RGA_Tools.vbs, more advanced error information than the error code can be obtained from the file name and the line number in the library.

Window after RGA_Tools.vbs is double-clicked:

```
RGA Tools - Copyright(c) 2012-2016 Renesas Electronics Corporation
1. Image format conversion [RunImagePackager]
2. Error information search [SearchErrorInformation]
Number or command >2
----------------------------------------------------------------
  ((( [SearchErrorInformation_sth] )))
Path or file name of error source file >Library.c
Error line number >2095
SoftFillRectangle_YUV422(): Rectangle.Left must be even
SoftFillRectangle_YUV422(): Rectangle.Left must be an even number.
```

If you want to break the location raising the error, call "R_OSPL_SET_BREAK_ERROR_ID" function at the first of the program. The argument is "error_ID" attribute of the above "ERROR" tag.

```
R_OSPL_SET_BREAK_ERROR_ID( 1 );
```

In SH7269, drag and drop RGA\Sample_SH7269\src\driver\ospl\porting\DebugBreak.c file to HEW, set a hardware breakpoint by double click at the row of E (Event).

When the program was re-started, CPU breaks at the location raising the error. In HEW, caller function is shown in [View > Code > Stack Trace]. If the menu item was grayed, Stack Trace is already shown in some place.

Even if the target board did not have serial port, you can get information from LED or GPIO connected with oscilloscope. The operational procedure is to call LED control function and waiting function (e.g. R_OSPL_Delay) from R_DebugBreak function and display the argument of R_DebugBreak function like Morse code.

Example:

- At start, turn on for 1 second and turn off for 1 second
- If bit was 1, turn on for 0.5 second and turn off for 0.5 second
- If bit was 0, turn on for 0.2 second and turn off for 0.8 second
- Display next binary digit by shift operation

6.3 Converting binary by ConvertBin

ConvertBin converts from binary file to C language array or S-record format (Motorola S-record).

Command	Description
BinToC	Converts from binary file to C language array. Variable name can be specified.
BinToSRec	Converts from binary file to S-record format. Comment, load address and execute address can be specified. Execute address is usually 0 for data binary.
SRecToBin	Converts from S-record format to binary file.

Window after RGA_Tools.vbs is double-clicked:

```
RGA Tools - Copyright(c) 2012-2016 Renesas Electronics Corporation
 1. Convert image format [RunImagePackager]
 2. Search error information [SearchErrorInformation]
 3. Convert to binary [ConvertBin]
Number or command >3
--------------------------------------------------------------------------
  ((( [ConvertBin] )))
1. Binary to C language [BinToC]
2. Binary to S-record format [BinToSRec]
3. S-record format to binary [SRecToBin]
Number or command >
```

6.4 Creating image file by RawToBmp

RawToBmp creates a BMP image file from Raw data in frame buffer.

Window after RGA_Tools.vbs is double-clicked:

```
RGA Tools - Copyright(c) 2012-2015 Renesas Electronics Corporation
 1. Convert image format [RunImagePackager]
 2. Search error information [SearchErrorInformation]
 3. Convert to binary [ConvertBin]
 4. Convert to BMP file [RawToBmp]
Number or command >4
---------------------------------------------------------------------------
Path of setting file >C:\Folder\RawToBmp.ini
```

Example of setting file:

```
RawPath = Image.bin
OutBmpPath = Image.bmp
Stride = 1600
Format = RGB565
```

Description of setting file:

Attribute Name	Description
RawPath	File path saved Raw data loaded from frame buffer
OutBmpPath	File path of output BMP file
Stride	Number of bytes of pixels having the same x coordinate in the previously below line.
Format	Pixel format. Any one of ARGB8888, RGB565, ARGB1555, ARGB4444, YCbCr422, A8, A4, A1. See Table 1-3.
ReadOffset	List of offsets that means byte order of reading 8 bytes. e.g.) 01234567(Little endian), 76543210(Big endian) "ReadOffset" cannot specify with YCbCr422 format.

7. Contents of Software Update

The main revision contents are shown in this chapter. For all revisions, please refer to the section of Revision Record.

7.1 Improved phenomenon that cannot be drawn immediately after power on

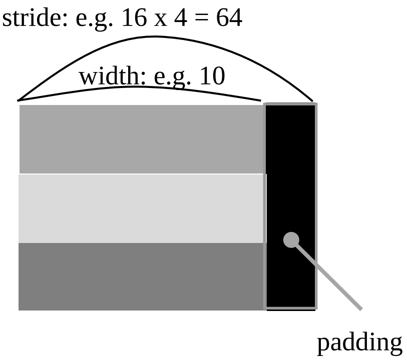
Some chip sometimes not be able to draw immediately after the power is turned on, if the system used RGA 2.10 or lower. RGA 2.12 improves the phenomenon.

7.2 The restriction of drawing an image with zooming

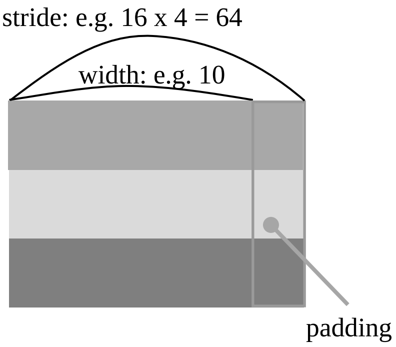
When it meets the following condition, you should not use in all versions of RGA.

When the following 4 conditions are satisfied at the same time:

- Setting GRAPHICS_IMAGE_QUALITY_ANTIALIASED at graphics_quality_flags_t
- The byte width of source image (i.e. pixels of width times color depth) is not multiples of 32
  Example: In the case of width:100, color format is ARGB4444, the byte width is 200 bytes (= 2 x 100)
  It meets the condition, because it is not multiples of 32
- Drawing source image with zooming
  Example: In case, source image is width=1 and height=128, destination size is width=256 and height=128.
  It meets the condition
- Each line in a padding area is not filled by the color at the right end of image width



Each line is not filled by the color
at the right end of image width



Each line is filled by the color
at the right end of image width

7.3 The restriction of drawing an image that has transparent color

When it meets the following condition, you should not use in all versions of RGA.

The source image is one of the following RGB format:

- ARGB8888 and A=0
- ARGB1555 and A=0
- ARGB4444 and A=0

and the destination is one of the following the RGB format:

- ARGB1555
- ARGB4444
- RGB565

RGA must not be used any above combination of drawing source and drawing destination format.

7.4 The restriction of drawing an image that has not transparent color

When it meets the following condition, you should not use in all versions of RGA.

The source image is one of the following RGB format:

- XRGB8888
- ARGB8888 and A=255
- ARGB1555 and A=1
- ARGB4444 and A=15
- RGB565

and the destination is one of the following the RGB format:

- ARGB1555
- ARGB4444
- RGB565

RGA must not be used any above combination of drawing source and drawing destination format.

8. Sample Codes

Sample codes are contained in the RGA folder.

The HEW project file in RGA\Sample_SH7269 is available to operate sample codes on the SH7269.

The Visual Studio 2008 project file in RGA\Sample_PC is available to operate sample codes on a PC.

9. Reference Documents

User's Manual: Hardware

SH7268/SH7269 Group User's Manual (Hardware) Rev.1.00
(Obtain the latest version from the Renesas Electronics homepage.)

User's Manual: Development Environment

SuperH™ RISC engine C/C++ Compiler, Assembler, Optimizing Linkage Editor Compiler Package V.9.04 User's Manual Rev.1.01
(Obtain the latest version from the Renesas Electronics homepage.)

HTML Canvas 2D Context

W3C Candidate Recommendation 29 March 2012

Website and Support

Renesas Electronics Website

http://www.renesas.com/

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Revision Record

Rev.	Date	Description
2.12	Jan. 27, 2018	● Modify: section 5.11.2: to modify the following function name ➢ wrong: NCGSYS_SetStateEventValue ➢ right: NCGSYS_GetLastCreatedState ● New: section 7: Contents of Software Update The following items are revision record of the code: ● Modify: Improves to resolve some chip that sometimes not be able to draw immediately after the power is turned on if RGA 2.10 or lower (section 7.1) ● Change: bundled JCU version was changed from 1.03 to 1.04 ● Modify: an issue to stop drawing. Fixed by adding an exclusive control to the interrupt in RGPNCG
2.10	Feb. 29, 2016	● First edition issued

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins

   Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.

   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment when power is supplied.

   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.

   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.

   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.

   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

5. Differences between Products

   Before changing from one product to another, i.e. to one with a different type number, confirm that the change will not lead to problems.

   — The characteristics of MPU/MCU in the same group but having different type numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different type numbers, implement a system-evaluation test for each of the products.

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