N9H20 Non-OS Library Reference Guide

Document Information

Abstract	Introduce Non-OS Library for the N9H20 series microprocessor (MPU).
Apply to	N9H20 series

For additional information or questions, please contact: Nuvoton Technology Corporation.

www.nuvoton.com

TABLE OF CONTENTS

1 ADC Libary

1.1 Overview

The N9H20 ADC library provides a set of APIs to report the X and Y-axis coordinate, battery voltage and audio recording. With these APIs, user can read the position that was touched in touch panel, or get the current battery voltage, or record mono signed 16 bits PCM data. Please note, position detection on touch panel and voltage detection will be invalid if enable audio recording.

These libraries are created by using Keil uVision IDE. Therefore, they only can be used in Keil environment.

1.1.1 ADC Library APIs Specification

adc_init

Synopsis

void adc_init(void);

Description

This function is used to initialize the ADC library.

Parameter

None

Return Value

None

Example

```
/* Initialize ADC library */
adc_init();
adc_open(ADC_TS_4WIRE, 320, 240);
```

adc_open

Synopsis

int adc_open (unsigned char type, unsigned short hr, unsigned short vr)

Description

This function opens the ADC library and set the panel type.

Parameter

type ADC_TS_4WIRE. N9H20 only support 4-wire touch panel.

hr Touch screen horizontal resolution. It is for future using.

vr Touch screen vertical resolution. . It is for future using.

Return Value

Return 0 on success, -1 for ADC not being initialize, or wrong parameter.

Example

```
/* Initialize ADC library */
adc_init();
adc_open(ADC_TS_4WIRE, 320, 240);
```

adc_close

Synopsis

void adc_close(void)

Description

Close the ADC library.

Parameter

None

Return Value

None

Example

```
/* Close ADC library*/
adc_close();
```

adc_read

Synopsis

int adc_read(unsigned char mode, unsigned short *x, unsigned short *y)

Description

This function is used to read the position that was touched in touch panel.

Parameter

mode ADC_NONBLOCK or ADC_BLOCK

x x-axis coordinate.

y y-axis coordinate.

Table 1-1: ADC read mode

Field name	Value	Description
ADC_NONBLOCK	0	Non-block the program
ADC_BLOCK	1	Block the program until touch panel pressed

Return Value

None

Example

```
/* Read the x and y-axis coordinate */
adc_init();
adc_open(ADC_TS_4WIRE, 320, 240);
while (1)
{
   if(adc_read(ADC_NONBLOCK, &x, &y))
         sysprintf("x = %d, y = %d\n", x, y);
}
```

adc_normalread

Synopsis

UINT32 adc_normalread(UINT32 u32Channel, PUINT16 pu16Data)

Description

This function is used to read the battery voltage

Parameter

u32Channel 2, 3 or 4. It depends on the hardware connects to which channel.

pu16Data 10 bits unsigned integer. It means the battery voltage.

Return Value

Error code or Successful

Example

```
/* Read the battery voltage from channel 2 */
adc_init();
adc_open(ADC_TS_4WIRE, 320, 240);
while(1)
{
   if(adc_normalread(2, &u16Vol)==Successful)
         sysprintf("Battery voltage = %x\n", u16Vol);
}
```

adc_setTouchScreen

Synopsis

VOID_setTouchScreen(E_ADC_TSC_MODE eTscMode, INT32 u32DleayCycle,

BOOL bIsPullup, BOOL bMAVFilter)

Description

This function is used to set some properties about touch screen

Parameter

eTscMode Setup ADC to operation in auto conversion mode or wait for trigger mode.

Field name	Value	Description
eADC_TSCREEN_NORMAL	0	The mode is not supported for touch screen
eADC_TSCREEN_SEMI	1	The mode is not supported now.
eADC_TSCREEN_AUTO	2	ADC works in auto conversion mode
eADC_TSCREEN_TRIG	3	ADC works in waiting for trigger mode

u32DleayCycle The clock count between ADC to converse one sample of X or Y coordinate.

bIsPullup The parameter is used to pull up internal resister or not

bMAVFilter Enable MAV filter or not.

Return Value

None

Example

```
/* Power down wake up by touch panel event */
while(1)
   {
          adc_setTouchScreen(eADC_TSCREEN_TRIG, /*E_DRVADC_TSC_MODE*/
                            180,          /* Delay cycle each conversion
*/
                              TRUE,   /* BOOL bIsPullup */
                              FALSE);    /* Disable bMAVFilter */
          sysDelay(50);
          sysprintf("\n");
          if(Entry_PowerDown()!=Successful)/* system enter standby
mode*/
          {
                sysprintf("Memory copy error \n");
                break;
          }
          outp32(0xb0000030, inp32(0xb0000030)| 0x40000000);

/* Clear ADC wakeup status    */
          sysprintf("Wake up!!! %d \n", u32Count);
          u32Count = u32Count +1;
   }
```

audio_Open

Synopsis

INT32 audio_Open(E_SYS_SRC_CLK eSrcClock, UINT32 u32ConvClock)

Description

Open the Audio record function

Parameter

eSrcClock The source of clock,

u32ConvClock The specified sample rate. It is only support 8000, 11025, 12000 and 16000 sample rate. The frequency of source clock needs to meet the specified sampling rate.

Return Value

Error code or Successful

Example

```
/* Set the sample rate */
U32SampleRate = 16000;
audio_Open(eSYS_APLL, u32SampleRate);
```

adc_enableInt

Synopsis

UINT32 adc_enableInt(E_ADC_INT eIntType)

Description

This function enables ADC interrupt

Parameter

eIntType The ADC interrupt type

Table 1-2: ADC interrupt type

Field name	Value	Description
eADC_ADC_INT	0	ADC interrupt
eADC_AUD_INT	1	Audio interrupt.
eADC_LVD_INT	2	Low voltage detector (LVD) interrupt
eADC_WT_INT	3	Waiting for trigger interrupt

Return Value

Error code or Successful

Example

```
/* Set the sample rate and enable audio interrupt */
```

```
audio_Open(eSYS_APLL, u32SampleRate);
adc_enableInt(eADC_AUD_INT);
```

adc_disableInt

Synopsis

UINT32 adc_disableInt(E_ADC_INT eIntType)

Description

This function disables ADC interrupt

Parameter

eIntType The ADC interrupt type

Table 1-3: ADC interrupt type

Field name	Value	Description
eADC_ADC_INT	0	ADC interrupt
eADC_AUD_INT	1	Audio interrupt.
eADC_LVD_INT	2	Low voltage detector (LVD) interrupt
eADC_WT_INT	3	Waiting for trigger interrupt

Return Value

Error code or Successful

Example

```
/* Set the sample rate and disable audio interrupt */
audio_Open(eSYS_APLL, u32SampleRate);
adc_disableInt(eADC_AUD_INT);
```

adc_installCallback

Synopsis

UINT32 adc_installCallback(E_ADC_INT eIntType, PFN_ADC_CALLBACK pfnCallback, PFN_ADC_CALLBACK* pfnOldCallback)

Description

Set the callback function and store the old callback function.

Parameter

eIntType The ADC interrupt type

pfnCallback Function pointer to the callback function.

pfnOldCallback Function pointer to the old callback function

Return Value

Error code or Successful

Example

```
/* Set the sample rate and disable audio interrupt, set the callback
function for audio interrupt */
audio_Open(eSYS_APLL, u32SampleRate);
adc_disableInt(eADC_AUD_INT);
adc_installCallback(eADC_AUD_INT, pfnRecordCallback, &pfnOldCallback);
```

audio_StartRecord

Synopsis

void audio_StartRecord(void)

Description

Start to record Audio data. This function only can be used in ADC_RECORD mode.

Parameter

None

Return Value

None

Example

```
/* Start record audio data */
adc_StartRecord()
```

audio_StopRecord

Synopsis

void audio_StopRecord(void)

Description

Stop to record Audio data. This function only can be used in ADC_RECORD mode.

Parameter

None

Return Value

None

Example

```
/* Start and stop record audio data */
```

```
audio_StartRecord()
.
.
.
audio_StopRecord()
```

audio_SetAutoGainTiming

Synopsis

void audio_SetAutoGainTiming(UINT32 u32Period, UINT32 u32Attack, UINT32 u32Recovery, UINT32 u32Hold);

Description

Set timings for auto gain control.

Parameter

u32Period The unit for attack, recovery and hold time.

u32Attack The attack time to decrease the gain for output target level

u32Recovery The recovery time to increase the gain for output target level

u32Hold The hold time to keep current gain if current level has meet output target level

Return Value

None

Example

```
UINT32 u32Period, u32Attack, u32Recovery, u32Hold;
   audio_GetAutoGainTiming(&u32Period, &u32Attack, &u32Recovery, &u32Hold);
   if(u32Period<128)
   {
          u32Period = u32Period+16;
          audio_SetAutoGainTiming(u32Period, u32Attack, u32Recovery, u32Hold);
   }
```

audio_GetAutoGainTiming

Synopsis

void audio_GetAutoGainTiming(PUINT32 pu32Period,PUINT32 pu32Attack,PUINT32 pu32Recovery,PUINT32 pu32Hold);

Description

Get current timings for auto gain control.

Parameter

pu32Period The unit for attack, recovery and hold time.

pu32Attack The attack time to decrease the gain for output target level

pu32Recovery The recovery time to increase the gain for output target level

pu32Hold The hold time to keep current gain if current level has meet output target level

Return Value

None

Example

```
UINT32 u32Period, u32Attack, u32Recovery, u32Hold;
   audio_GetAutoGainTiming(&u32Period, &u32Attack, &u32Recovery,
&u32Hold);
   if(u32Period<128)
   {
          u32Period = u32Period+16;
          audio_SetAutoGainTiming(u32Period, u32Attack, u32Recovery,
u32Hold);
   }
```

audio_SetAutoGainControl

Synopsis

void audio_SetAutoGainControl(BOOL bIsEnable, UINT32 u32OutputLevel, E_ADC_UPBAND eAdcUpBand,E_ADC_DOWNBAND eAdcDownBand);

Description

Set audio record output target level, ramp up and ramp down step if enables AGC function.

Parameter

bIsEnable Enable AGC or not.

u32OutputLevel Output target level. The value from 0 ~ 15. Value 0 means -28.5 db with each level 1.5 db. Value 15 means -6 db.

eAdcUpBand Ramp up each step

eAdcDownBand Ramp down each step

Table 1-4 eAdcUpBand - Ramp up

Field name	Value	Description
eADC_BAND_P0P5	0	Increase 0.5db each step
eADC_BAND_P0P75	1	Increase 0.75db each step

Table 1-5 eAdcDownBand - Ramp down

Field name	Value	Description
eADC_BAND_N0P5	0	Decrease 0.5db each step
eADC_BAND_N0P75	1	Decrease 0.75db each step

Return Value

None

Example

```
   audio_SetAutoGainControl(TRUE,   /* AGC enable */
                     13,          /* Output target aszOTLArray[13] = -
9db */
                    eADC_BAND_P0P5,
                     eADC_BAND_N0P5);
```

Error Code Table

Code Name	Value	Description
E_DRVADC_INVALID_INT	0xFFFFB8E0	Invalid interrupt
E_DRVADC_INVALID_CHANNEL	0xFFFFB8E1	Invalid channel
E_DRVADC_INVALID_TIMING	0xFFFFB8E2	ADC is busy. It is only occurrence if ADC works in touch panel mode and battery detection in the same time,

2 AVI Library

2.1 Video render

N9H20 can support JPEG decoder to output decoded packet data in DIRECT_RGB555, DIRECT_RGB565, DIRECT_RGB888 or DIRECT_YUV422 format. User application must initialize VPOST as corresponding format specified in AVI function call aviPlayFile(…). AVI player library will configure JPEG output format as the specified format and use DMA to copy the decoded data to VPOST frame buffer in Vsync period to avoid the tearing issue.

In this way, three frame buffers are required. One is allocated in VPOST initialized function and two buffers are allocated in AVI library.

2.2 How to use AVI player library

The AVI player library has managed the file access, JPEG decode and audio decode. User only gives the AVI file name and the render method to play the movie. The AVI player required user to prepare the following things before playing an AVI movie:

- Initialize system with cache on
- Initialize file system and storage interface (ex. SD card)
- Initialize timer 0
- Initialize VPOST

The VPOST frame buffer format should be consistent with the AVI playback render mode:

- Direct RGB555 – VPOST should select ***DRVVPOST_FRAME_RGB555***
- Direct RGB565 – VPOST should select ***DRVVPOST_FRAME_RGB565***
- Direct RGB888 – VPOST should select DRVVPOST_FRAME_RGBx888 or DRVVPOST_FRAME_RGB888x
- Direct YUV422 – VPOST should select DRVVPOST_FRAME_CBYCRY or DRVVPOST_FRAME_YCBYCR or DRVVPOST_FRAME_CRYCBY or DRVVPOST_FRAME_YCRYCB

The AVI playback function supports (x, y) coordinate that are the second and third argument of ***aviPlayFile()*** used to specify the render location on LCD now. Moreover, decoded image scales by 1/2 in horizontal and vertical direction if the decoded video width is larger than the panel width.

2.3 AVI player user callback

While playing an AVI move, user application may want to draw information on screen or manage user inputs. AVI library provides a callback function to allow user application to grab pieces of CPU time. The callback function pointer was passed to AVI player as the last argument of ***aviPlayFile()***.

Depends on the loading of playing an AVI movie, the user callback will be called several times in each one second. User application should finish the execution of callback function as soon as possible. Otherwise, the AVI playback can be broken because of the insufficience of CPU time.

2.4 AVI playback information

While playing an AVI move, user application can get AVI file information and playback progress information from AVI player. The AVI information will be passed to user application as a parameter of callback function. All information is packed in the AVI_INFO_T structure.

2.5 AVI Library APIs Specification

Enumeration

Name	Value	Description
JV_MODE_E		
DIRECT_RGB555	0x0	Direct RGB555 output format
DIRECT_RGB565	0x1	Direct RGB565 output format
DIRECT_RGB888	0x2	Direct RGB888 output format
DIRECT_YUV422	0x3	Direct YUV422 output format
AU_TYPE_E		
AU_CODEC_UNKNOWN	0x0	Unknown audio format
AU_CODEC_PCM	0x1	PCM audio format
AU_CODEC_IMA_ADPCM	0x2	ADPCM audio format
AU_CODEC_MP3	0x3	MP3 audio format
PLAY_CTRL_E		
PLAY_CTRL_FF	0x0	(Not supported)
PLAY_CTRL_FB	0x1	(Not supported)
PLAY_CTRL_FS	0x2	(Not supported)
PLAY_CTRL_PAUSE	0x3	Pause Playback
PLAY_CTRL_RESUME	0x4	Resume Playback
PLAY_CTRL_STOP	0x5	Stop Playback
PLAY_CTRL_SPEED	0x6	(Not supported)

Structure

Field	Type	Description
uMovieLength	UINT32	The total length of input AVI movie (in 0.01 second unit)
uPlayCurTimePos	UINT32	The current playback position. (in 0.01 second unit)
eAuCodec	AU_TYPE_E	Audio format type
nAuPlayChnNum	INT	Audio channel number. (1: mono, 2: stereo, 0: video-only)
nAuPlaySRate	INT	audio sampling rate
uVideoFrameRate	UINT32	Video frame rate.
usImageWidth	UINT16	Video image width
usImageHeight	UINT16	Video image height
uVidTotalFrames	UINT32	total number of video frames
uVidFramesPlayed	UINT32	Indicate how many video frames have been played
uVidFramesSkipped	UINT32	The number of frames was skipped. Video frames may be skipped due to A/V sync

Table 2-1: AVI_INFO_T structure

2.6 Functions

aviStopPlayFile

Synopsis

int

aviStopPlayFile(void);

Description

Stop current AVI file playback.

Parameter

None

Return Value

Successful: Success

ERRCODE: Error

Example

None.

aviPlayFile

Synopsis

int

aviPlayFile(

char *suFileName,

int x,

int y,

JV_MODE_E mode,

AVI_CB *cb

) ;

Description

Play an AVI file on the specified coordinate.

Parameter

suFileName [in]

The full path file name of input AVI file.

x [in]

The x-coordinate from left-up corner of AVI video render area.

y [in]

The y-coordinate from left-up corner of AVI video render area.

There are 3 cases for the x/y coordinate specified.

Case 1: x=0 and y=0

The AVI display data is aligned to center of panel.

Case 2: x<0 or y<0

The AVI display data is aligned to coordinate (0,0) on the left-up corner

Case 3: others

The AVI display data is aligned to coordinate (x,y).

mode [in]

Video render mode.

cb [in]

User application callback function.

Return Value

Successful: Success

ERRCODE: Error

Example

```
/*-------------------------------------------------------------*/
/*  Direct RGB565 AVI playback !!            */
/*-------------------------------------------------------------*/
lcdformatex.ucVASrcFormat = DRVVPOST_FRAME_RGB565;
vpostLCMInit(&lcdformatex, (UINT32 *)_VpostFrameBuffer);
fsAsciiToUnicode("c:\\Flip-20fps_640x480.avi", suFileName, TRUE);
aviPlayFile(suFileName, 0, 0, DIRECT_RGB565, avi_play_control);
```

aviGetFileInfo

Synopsis

int

aviGetFileInfo (

char *suFileName,

AVI_INFO_T *ptAviInfo

);

Description

Get the AVI file information.

Parameter

suFileName [in]

The full path file name of input AVI file.

ptAviInfo [in]

Return AVI parsing information.

Return Value

Successful: Success

ERRCODE: Error

Example

```
fsAsciiToUnicode("c:\\Flip-20fps.avi", suFileName, TRUE);
aviGetFileInfo(suFileName, &sAVIInfo);
```

aviSetPlayVolume

Synopsis

int

aviSetPlayVolume (

int vol

);

Description

Set the Left channel and Right channel playback audio volume.

Parameter

vol [in]

The audio volume

Return Value

Successful: Success

ERRCODE: Error

Example

```
aviSetPlayVolume(0x1F);
```

aviSetRightChannelVolume

Synopsis

int

aviSetRightChannelVolume (

int vol

);

Description

Set the Right channel audio playback volume only.

Parameter

vol [in]

The audio volume

Return Value

Successful: Success

ERRCODE: Error

Example

```
// Set Right Channel as Mute
aviSetPlayRightChannelVolume(0x0);
```

aviSetLeftChannelVolume

Synopsis

int

aviSetLeftChannelVolume (

int vol

);

Description

Set the Left channel audio playback volume only.

Parameter

vol [in]

The audio volume

Return Value

Successful: Success

ERRCODE: Error

Example

```
// Set Left Channel as Mute
aviSetPlayLeftChannelVolume(0x0);
```

mfl_get_last_buf

Synopsis

char *

mfl_get_last_buf (void);

Description

Get the last JPEG decoded buffer address.

Parameter

None

Return Value

Last JPEG decoded buffer address

Example

```
// Get last Jpeg Decoded buffer address
JpgBuf = mfl_get_last_buf();
```

Error Code Table

Code Name	Value	Description
MFL_ERR_NO_MEMORY	0xFFFF8000	no memory
MFL_ERR_HARDWARE	0xFFFF8002	hardware general error
MFL_ERR_NO_CALLBACK	0xFFFF8004	must provide callback function
MFL_ERR_AU_UNSUPPORT	0xFFFF8006	not supported audio type
MFL_ERR_VID_UNSUPPORT	0xFFFF8008	not supported video type
MFL_ERR_OP_UNSUPPORT	0xFFFF800C	unsupported operation
MFL_ERR_PREV_UNSUPPORT	0xFFFF800E	preview of this media type was not supported or not enabled
MFL_ERR_FUN_USAGE	0xFFFF8010	incorrect function call parameter
MFL_ERR_RESOURCE_MEM	0xFFFF8012	memory is not enough to play/record a media file
MFL_ERR_FILE_OPEN	0xFFFF8020	cannot open file
MFL_ERR_FILE_TEMP	0xFFFF8022	temporary file access failure
MFL_ERR_STREAM_IO	0xFFFF8024	stream access error
MFL_ERR_STREAM_INIT	0xFFFF8026	stream was not opened
MFL_ERR_STREAM_EOF	0xFFFF8028	encounter EOF of file
MFL_ERR_STREAM_SEEK	0xFFFF802A	stream seek error
MFL_ERR_STREAM_TYPE	0xFFFF802C	incorrect stream type
MFL_ERR_STREAM_METHOD	0xFFFF8030	missing stream method
MFL_ERR_STREAM_MEMOUT	0xFFFF8032	recorded data has been over the application provided memory buffer
MFL_INVALID_BITSTREAM	0xFFFF8034	invalid audio/video bitstream forma
MFL_ERR_AVI_FILE	0xFFFF8080	Invalid AVI file format
MFL_ERR_AVI_VID_CODEC	0xFFFF8081	AVI unsupported video codec type

MFL_ERR_AVI_AU_CODEC	0xFFFF8082	AVI unsupported audio codec type
MFL_ERR_AVI_CANNOT_SEEK	0xFFFF8083	The AVI file is not fast-seekable
MFL_ERR_AVI_SIZE	0xFFFF8080	Exceed estimated size
MFL_ERR_MP3_FORMAT	0xFFFF80D0	incorrect MP3 frame format
MFL_ERR_MP3_DECODE	0xFFFF80D2	MP3 decode error
MFL_ERR_HW_NOT_READY	0xFFFF8100	the picture is the same as the last one
MFL_ERR_SHORT_BUFF	0xFFFF8104	buffer size is not enough
MFL_ERR_VID_DEC_ERR	0xFFFF8106	video decode error
MFL_ERR_VID_DEC_BUSY	0xFFFF8108	video decoder is busy
MFL_ERR_VID_ENC_ERR	0xFFFF810A	video encode error
MFL_ERR_UNKNOWN_MEDIA	0xFFFF81E2	unknow media type
MFL_ERR_INFO_NA	0xFFFF81E0	media information is insuficient
MFL_ERR_MOVIE_PLAYING	0xFFFF81E4	movie is still in play
MFL_ERR_ULTRAM_TMPF	0xFFFF81E6	ultra merge file stream must use temp file

2.7 Font Library Overview

The N9H20 font library provides a set of APIs to write character or draw rectangle border to frame buffer. With these APIs, user can quickly show some strings on N9H20 demo board or evaluation board. The library is a software solution. After updating the frame buffer, VPOST controller can show the content of panel or TV.

These libraries are created by using Keil uVision IDE. Therefore, they only can be used in Keil environment.

2.8 Font Library APIs Specification

InitFont

Synopsis

void InitFont(S_DEMO_FONT* ptFont, UINT32 u32FrameBufAddr);

Description

This function is used to initialize the font library, and get some information of font library.

Parameter

ptFont Font library information pointer.

u32FrameBufAddr Frame buffer base address.

Field name	Data Type	Description
u32FontRectWidth	UINT32	Font width. Now it is fixed to 16
u32FontRectHeight	UINT32	Font height. Now it is fixed to 22
u32FontOffset	UINT32	Font Offset. Now it is fixed to 11
u32FontStep	UINT32	Font Step. Now it is fixed to 10

u32FontOutputStride	UINT32	Output Stride. It should same as the panel width
u32FontInitDone	UINT32	1 = Font library initialized done. 0 = Font library not yet initialized done or de-initialized.
u32FontFileSize	UINT32	Reserved
pu32FontFileTmp	UINT32	Reserved
pu32FontFile	UINT32	Pointer of font file
au16FontColor[3]	UINT16	RGB565 color au16FontColor[0]: Font background color au16FontColor[1]: Font color au16FontColor[2]: Border color

Table 2-2:Font Information

Return Value

None

Example

```
/* Initialize font library */
__align(32) static S_DEMO_FONT s_sDemo_Font;
__align(32) UINT16 u16FrameBuffer[_LCM_WIDTH_*_LCM_HEIGHT_];

InitFont(&s_sDemo_Font, u16FrameBufAddr);
```

DemoFont_PaintA

Synopsis

void DemoFont_PaintA(S_DEMO_FONT* ptFont, UINT32 u32x, UINT32 u32y, PCSTR pszString)

Description

This function writes a specified string to frame buffer.

Parameter

ptFont	Font library information pointer. Refer to the Table 2-2:Font Information
u32x	start x position.
u32y	start y position.
pszString	The specified string is written to frame buffer.

Return Value

None

Example

```
/* Draw a string to the position (0, 0) of frame buffer */
__align(32) static S_DEMO_FONT s_sDemo_Font
char szString[64];
sprintf(szString, "N9H20 Font Code");
DemoFont_PaintA(&s_sDemo_Font, 0, 0, szString);
```

UnInitFont

Synopsis

void UnInitFont(S_DEMO_FONT* ptFont)

Description

De-Initialize the font library. .

Parameter

ptFont Font library information pointer. Refer to the Table 2-2:Font Information

Return Value

None

Example

```
/* De-Initialize the font library */
__align(32) static S_DEMO_FONT s_sDemo_Font
UninitFont(&s_sDemo_Font);
```

DemoFont_Rect

Synopsis

void DemoFont_Rect(SDEMO_FONT* ptFont, S_DEMO_RECT* ptRect)

Description

This function draws a solid rectangle to frame buffer.

Parameter

ptFont Font library information pointer. Refer to the Table 2-2:Font Information

ptRect Solid rectangle pointer

Field name	Data Type	Description
u32StartX	UINT32	X position for the upper-left corner
u32StartY	UINT32	Y position for the upper-left corner
u32EndX	UINT32	X position for the lower-right corner

u32EndY	UINT32	Y position for the lower-right corner

Table 2-3: Rectangle Information

Return Value

None

Example

```
/* Draw a solid rectangle with dimension 320x240*/
__align(32) static S_DEMO_FONT s_sDemo_Font;
static S_DEMO_RECT s_sDemo_Rect;
s_sDemo_Rect.u32StartX = 0;
s_sDemo_Rect.u32StartY = 0;
s_sDemo_Rect.u32EndX = 320-1;
s_sDemo_Rect.u32EndY =240-1;
DemoFont_Rect(&ptFont,
          &s_sDemo_Rect);
```

DemoFont_RectClear

Synopsis

void DemoFont_RectClear(SDEMO_FONT* ptFont, S_DEMO_RECT* ptRect)

Description

This function clears a solid rectangle to background color in frame buffer. The background color was fixed as 0. It means the color is black for RGB565 format.

Parameter

ptFont Font library information pointer. Refer to the Table 2-2:Font Information

ptRect Solid rectangle pointer. Refer to the Table 2-3: Rectangle Information

Return Value

None

Example

```
/* Clear a solid rectangle from position (0, 0) to (319, 240) */
__align(32) static S_DEMO_FONT s_sDemo_Font;
static S_DEMO_RECT s_sDemo_Rect;
s_sDemo_Rect.u32StartX = 0;
s_sDemo_Rect.u32StartY = 0;
s_sDemo_Rect.u32EndX = 320-1;
s_sDemo_Rect.u32EndY =240-1;
```

```
DemoFont_RectClear(&ptFont,
          &s_sDemo_Rect);
```

Font_ClrFrameBuffer

Synopsis

void Font_ClrFrameBuffer(UINT32 u32FrameBufAddr)

Description

This function clears the specified frame buffer to fixed background color (black color). The dimension is specified in the header file- _LCM_WIDTH_ and _LCM_HEIGHT_ with 16-bit pixel format.

Parameter

u32FrameBufAddr Frame buffer base address.

Return Value

None

Example

```
__align(32) UINT16 u16FrameBuffer[_LCM_WIDTH_*_LCM_HEIGHT_];

/* Clear frame buffer to background color-black*/
Font_ClrFrameBuffer(u16FrameBuffer);
```

DemoFont_Border

Synopsis

void DemoFont_Border(S_DEMO_FONT* ptFont, S_DEMO_RECT* ptRect, UINT32 u32Width);

Description

This function draws a hollow rectangle with the specified border width.

Parameter

ptFont Font library information pointer. Refer to the Table 2-2:Font Information

ptRect Solid rectangle pointer. Refer to the Table 2-3: Rectangle Information.

u32Width Border width.

Return Value

None

Example

```
__align(32) static S_DEMO_FONT s_sDemo_Font;
```

```
   S_DEMO_RECT s_sDemo_Rect;
__align(32) UINT16 u16FrameBuffer[_LCM_WIDTH_*_LCM_HEIGHT_];

InitFont(&s_sDemo_Font, u16FrameBuffer);
          s_sDemo_Rect.u32StartX =0;
s_sDemo_Rect.u32StartY = 0;
s_sDemo_Rect.u32EndX = _LCM_WIDTH_-1;
s_sDemo_Rect.u32EndY = _LCM_HEIGHT_-1;
/* Draw a hollow rectangle with dimension same as panel and border is 2
pixels width */
DemoFont_Border(&s_sDemoFont,
                &s_sDemo_Rect,
                2);
```

DemoFont_ChangeFontColor

Synopsis

void DemoFont_ChangeFontColor(S_DEMO_FONT* ptFont, UINT16 u16RGB565);

Description

This function sets the font color. The format is RGB565.

Parameter

ptFont Font library information pointer. Refer to the Table 2-2:Font Information

u16RGB565 RGB565 format

Return Value

None

Example

```
__align(32) static S_DEMO_FONT s_sDemo_Font;
/* Set the blue font color */
DemoFont_ChangeFontColor(&s_sDemo_Font, 0x001F);
```

DemoFont_GetFontColor

Synopsis

UINT16 DemoFont_GetFontColor(S_DEMO_FONT* ptFont);

Description

This function gets the current font color. The return value format is RGB565.

Parameter

ptFont Font library information pointer. Refer to the Table 2-2:Font Information

Return Value

RGB565 format

Example

```
__align(32) static S_DEMO_FONT s_sDemo_Font;
UINT16 u16FontColor;
/* Get the blue font color */
u16FontColor = DemoFont_GetFontColor(&s_sDemo_Font);
```

3 BLT Library

3.1 Overview

This document is written for user applications which want to make use of BLT through provided API.

3.2 Feature

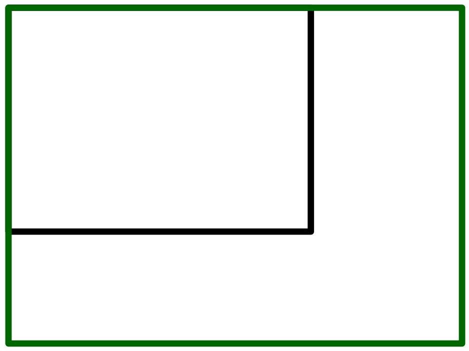
- Fill operation.
  - Fill color with alpha channel
- Blit operation
  - Transformation effects (Scaling, Rotation, Shearing, etc.) through 2x2 inverse transformation matrix.
  - Bitmap smoothing in bi-linear algorithm.
  - Tiling mode (for inversely mapped source pixels lying outside the boundaries of the source image)
    - No drawing
    - Clip to edge (closest edge pixel of the source image)
    - Repeat (source image repeated indefinitely in all directions)
  - Color transformation as defined in Adobe Flash
  - RGB565 color key
- Source format for Blit operation
  - ARGB8888
  - RGB565
  - Palette index with color ARGB8888
    - 1-bit, 2-bit, 4-bit, and 8-bit palette index
    - Endianness of palette index
- Destination format for Fill/Blit operation
  - ARGB8888
  - RGB555
  - RGB565

3.3 Transformation Matrix

In blit operation, transformation effects, such as scaling, rotation, translation, etc. can be achieved through a transformation matrix. These transformations can be combined into one and just one blit operation is needed to finish all the transformations. In the following, common transformations are listed, and user application can combine them to achieve wanted result.

3.3.1 Scaling

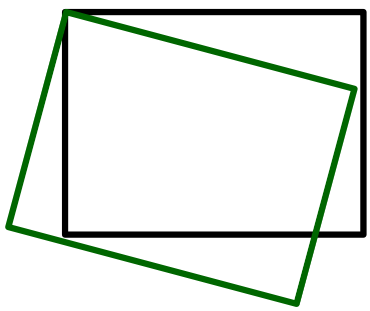
Resize the image by multiplying the location of each pixel by s_x on the x axis and s_y on the y axis.



$$\begin{pmatrix} x_d \\ y_d \\ 1 \end{pmatrix} = \begin{pmatrix} s_x & 0 & 0 \\ 0 & s_y & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_s \\ y_s \\ 1 \end{pmatrix}$$

3.3.2 Rotation

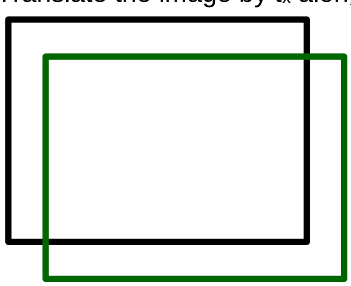
Rotate the image by an angle θclockwise.



$$\begin{pmatrix} x_d \\ y_d \\ 1 \end{pmatrix} = \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & con\theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_s \\ y_s \\ 1 \end{pmatrix}$$

3.3.3 Translation

Translate the image by t_x along the x axis and t_y along the y axis.



$$\begin{pmatrix} x_d \\ y_d \\ 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_s \\ y_s \\ 1 \end{pmatrix}$$

3.4 Amendment to User Transformation Matrix

On mapping back from destination CS[1] to source CS, a mapping point of destination pixel must be taken into consideration. Mapping point can be top-left (Top-left point as mapping point of destination pixel) or center (Center point as mapping point of destination pixel). In the blit implementation, top-left point is chosen and we may encounter an error due to the choice of mapping point. To help explain the issue, an example is given: blit with rotate 180º.

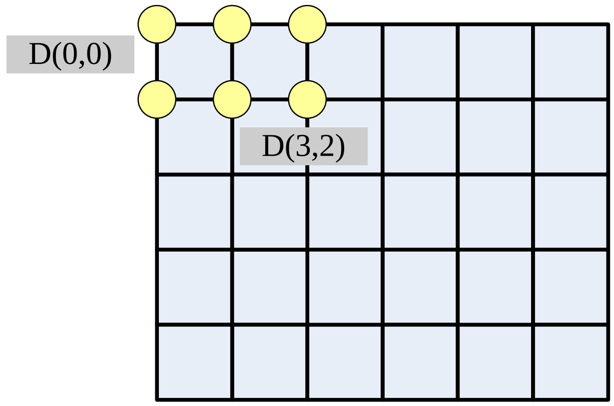


Figure 3-1: Top-left point as mapping point of destination pixel

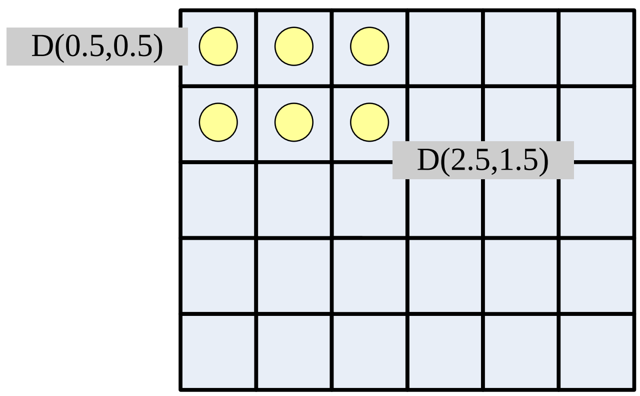


Figure 3-2: Center point as mapping point of destination pixel

1. We want to blit Source image and get Final result, This blit operation involves rotation and translation applied to the source image.

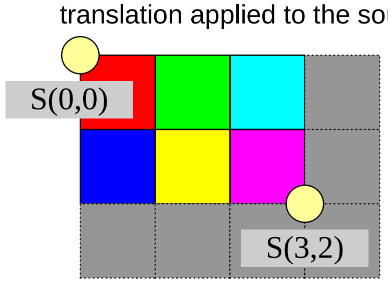


Figure 3-3: Source image

[1] Coordinate system.

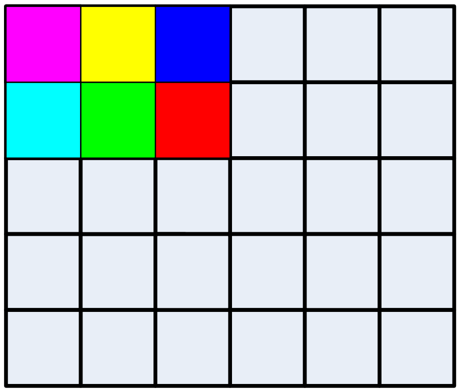


Figure 3-4: Final

2. First, just copy without any transformation effect and get No transform result.

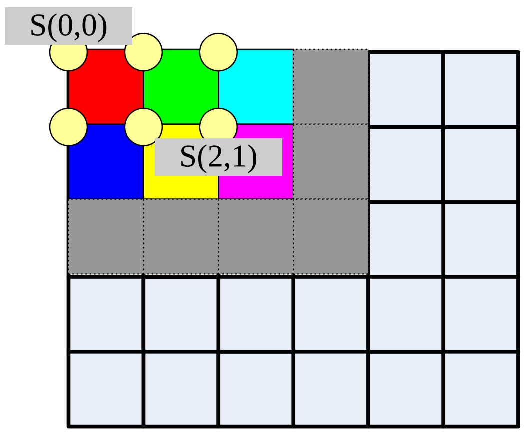


Figure 3-5: No transform

3. Rotate 180º clockwise and get Rotate 180o result.

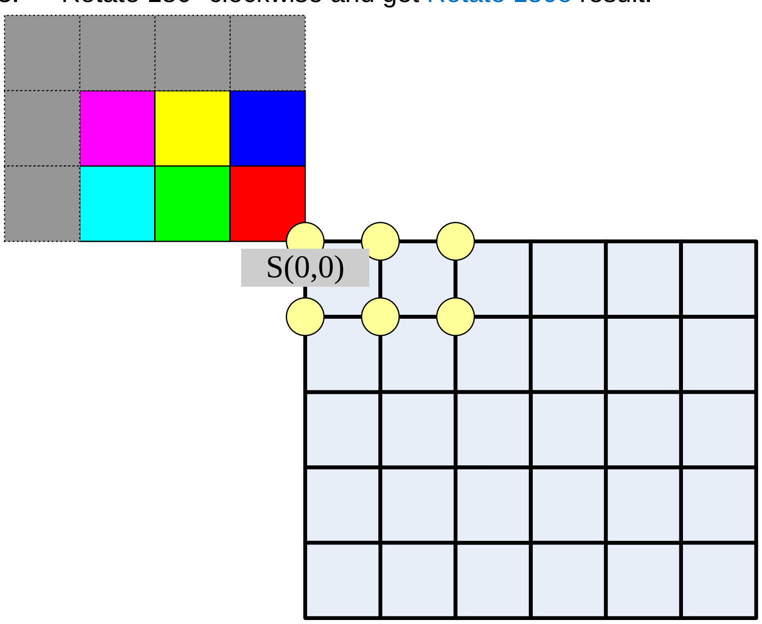


Figure 3-6: Rotate 180º

4. Translate 3 along x-axis and 2 along y-axis and get Rotate 180o + Translate (3, 2) result. But actually, we will get incorrect Rotate 180o + Translate (3, 2) (2) result. It is because in the hardware implementation, the top-left point of a destination pixel is picked as the mapping point. Take D(0, 0) as an example. It will map to S(3, 2) instead of S(2, 1) which is actually what we want.

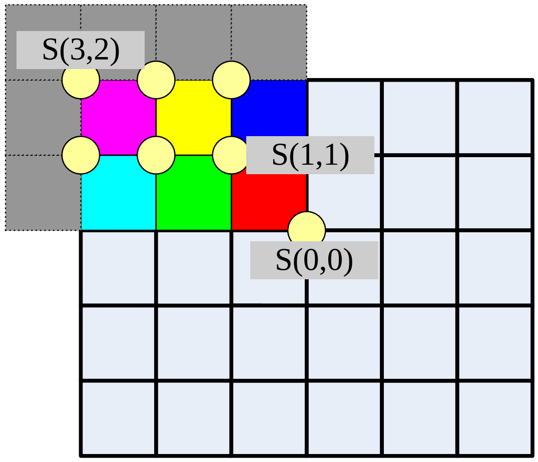


Figure 3-7: Rotate 180º + Translate (3, 2)

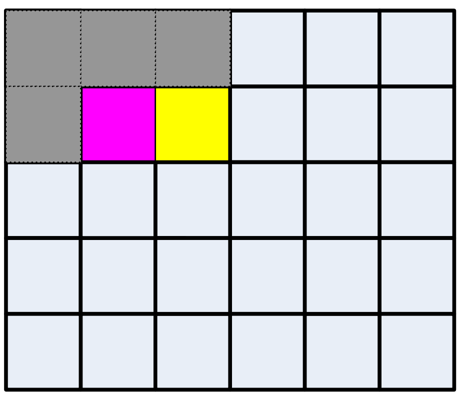


Figure 3-8: Rotate 180º + Translate (3, 2) (2)

5. To fix the issue, translate (-0.5, -0.5) to the end of all above transformations, and get Rotate 180o + Translate (3, 2) + Translate (-0.5, -0.5) result. And we finally get wanted Final result. In this case, D(0, 0) maps to S(2.5, 1.5), and so the source (2, 1) pixel (magenta) is blitted on the destination (0, 0) pixel.

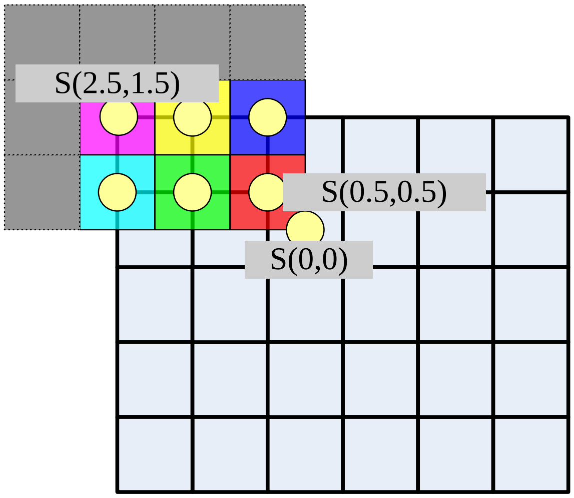


Figure 3-9: Rotate 180o + Translate (3, 2) + Translate (-0.5, -0.5)

3.5 Color Transformation

In Blit operation, user application can decide to apply color transformation or not, which is defined by Adobe Flash and has the following formula. Besides, user application can further decide to apply the alpha channel only.

New alpha value = (old alpha value * alphaMultiplier) + alphaOffset
New red value = (old red value * redMultiplier) + redOffset
New green value = (old green value * greenMultiplier) + greenOffset
New blue value = (old blue value * blueMultiplier) + blueOffset

3.6 Pixel Mapping

To use blit operation, think of pixel mapping in the inverse direction, that is, from destination CS to source CS. Fields associated with transformation matrix include:

- Elements a, b, c, and d in S_DRVBLT_MATRIX.
- i32XOffset and i32YOffset in S_DRVBLT_SRC_IMAGE.

Equations below give how these fields are associated with transformation matrix.

$$\begin{pmatrix} x_d \\ y_d \\ 1 \end{pmatrix} = \begin{pmatrix} s & t & t_x \\ u & v & t_y \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_s \\ y_s \\ 1 \end{pmatrix}$$

$$\begin{pmatrix} s & t & t_x \\ u & v & t_y \\ 0 & 0 & 1 \end{pmatrix}^{-1} \begin{pmatrix} x_d \\ y_d \\ 1 \end{pmatrix} = \begin{pmatrix} x_s \\ y_s \\ 1 \end{pmatrix}$$

$$\begin{vmatrix} a & c & i32XOffset \\ b & d & i32YOffset \\ 0 & 0 & 1 \end{vmatrix} = \begin{vmatrix} s & t & t_x \\ u & v & t_y \\ 0 & 0 & 1 \end{vmatrix}^{-1}$$

When a point is mapped from destination CS to source CS, there are several cases to consider. Below gives an example to help explain:

$$\begin{pmatrix} x_d \\ y_d \\ 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_s \\ y_s \\ 1 \end{pmatrix}$$

1. In M0, D(0, 0) (origin pixel of destination CS) is inversely mapped to S(1, 1), which needn't be the origin pixel of the source image. D(0, 0) is filled with Red color.
2. In M1, D(1, 1) is inversely mapped to S(2, 2), which lies inside the source image. D(1, 1) is filled with Green color.
3. In M2, D(4, 2) is inversely mapped to S(5, 3), which lies outside the source image. Dependent on tiling mode specified in E_DRVBLT_FILL_STYLE, there are 3 different rendering results:
   甲、 No drawing: D(4, 2) is not drawn.
   乙、 Clip to edge: D(4, 2) is inversely mapped to S(3, 3). D(4, 2) is filled with Blue color.
   丙、 Repeat: Think of whole source CS as filled with source images and D(4, 2) is inversely mapped to S(5, 3), and then wraps to S(1, 3). D(4, 2) is filled with Yellow color.

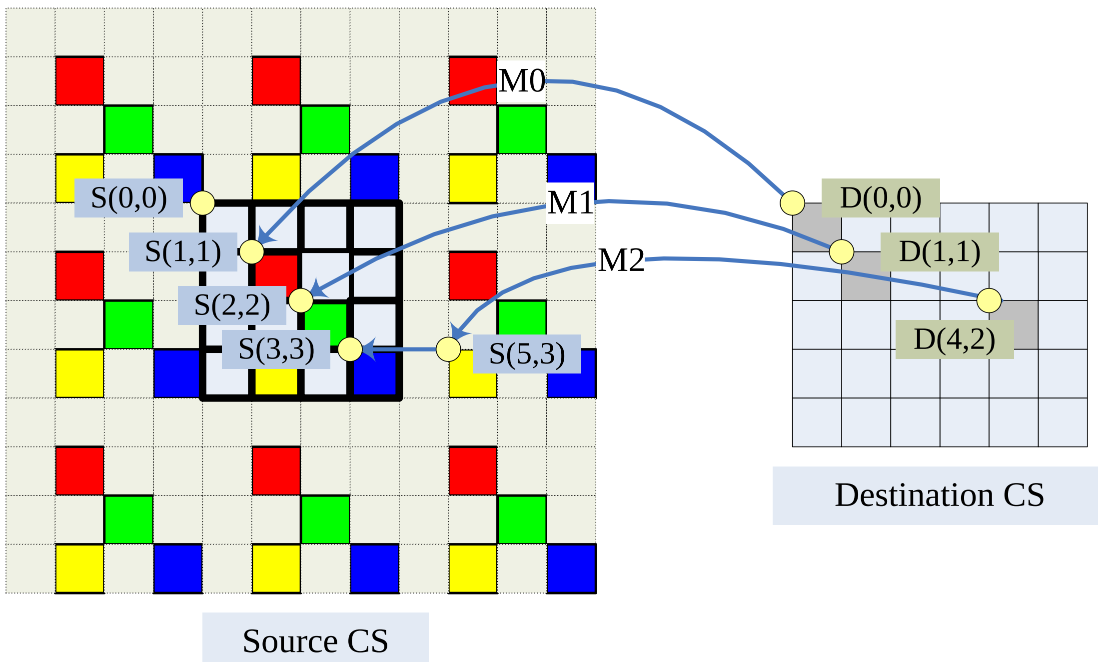


Figure 3-10: Mapping from destination CS to source CS

3.7 Palette

To use BLT palette, user must choose index size first. There are 4 index sizes (SFMT) supported:

- 1-bit index
- 2-bit index
- 4-bit index
- 8-bit index

After determination of index size, user then must set up two parts: palette entries and source image in palette index format, both of which will depend on index size.

3.7.1 Palette entries

Palette ranges from BLT_BA+0x400. Its format is ARGB8888, premultiplied-alpha by default and user can change it by setting up the field SET2DA.S_ALPHA.

For n-bit index size where n can only be 1, 2, 4, or 8, user must prepare 2 to the power of n (2, 4, 16, or 256 respectively) palette entries. Take n=2 for example, user must fill in 4 palette entries in the range, BLT_BA+0x400~BLT_BA+0x400+3 words.

3.7.2 Source image in palette index format

To specify source image in palette index format is the same as in other formats: pixel format (SFMT), start address (SADDR), width (SWIDTH), height (SEIGHT), stride (SSTRIDE). Note stride must be word-aligned. If palette index is not 8-bit, index order in one byte image data must be taken into consideration.

For example,

One byte in image data=b7b6b5b4b3b2b1b0

Index size=2-bit

Index order=big-endian (SET2DA.L_ENDIAN=0) ➔

b7b6=1st pixel, b5b4=2nd pixel, b3b2=3rd pixel, b1b0=4th pixel

Index order=little-endian (SET2DA.L_ENDIAN=1) ➔

b7b6=4th pixel, b5b4=3rd pixel, b3b2=2nd pixel, b1b0=1st pixel

3.8 API Data Structure

E_BLT_INT_TYPE

Interrupt type.

Name	Value	Description
BLT_INT_CMPLT	1	Fill/Blit operation completed

E_DRVBLT_FILLOP

Fill or Blit operation.

Name	Value	Description
eDRVBLT_DISABLE	0	Blit operation
eDRVBLT_ENABLE	1	Fill operation

E_DRVBLT_REVEAL_ALPHA

Premultiplied alpha or not for source format of ARGB8888

Name	Value	Description
eDRVBLT_EFFECTIVE	0	Premultiplied alpha
eDRVBLT_NO_EFFECTIVE	1	Non-premultiplied alpha

E_DRVBLT_TRANSFORM_FLAG

Transform flags for Blit operation.

Color transformation formula applied when eDRVBLT_HASCOLORTRANSFORM specified:
New alpha value = (old alpha value * alphaMultiplier) + alphaOffset
New red value = (old red value * redMultiplier) + redOffset
New green value = (old green value * greenMultiplier) + greenOffset
New blue value = (old blue value * blueMultiplier) + blueOffset

Alpha-only color transformation formula applied when both eDRVBLT_HASCOLORTRANSFORM and eDRVBLT_HASALPHAONLY specified:
New alpha value = (old alpha value * alphaMultiplier) + alphaOffset

Name	Value	Description
eDRVBLT_NONTRANSPARENCYE	0	No per-pixel transparency in the source.
eDRVBLT_HASTRANSPARENCY	1	Has per-pixel transparency in the source.
eDRVBLT_HASCOLORTRANSFORM	2	Apply color transformation formula.
eDRVBLT_HASALPHAONLY	4	If color transformation enabled, just apply the alpha-only formula.

E_DRVBLT_BMPIXEL_FORMAT

Source format for Blit operation.

If eDRVBLT_SRC_ARGB8888/palette index, source/palette color can be RGB888 or ARGB8888 dependent on E_DRVBLT_TRANSFORM_FLAG.

Name	Value	Description
eDRVBLT_SRC_ARGB8888	1	RGB888/ARGB8888
eDRVBLT_SRC_RGB565	2	RGB565
eDRVBLT_SRC_1BPP	4	1-bit palette index
eDRVBLT_SRC_2BPP	8	2-bit palette index
eDRVBLT_SRC_4BPP	16	4-bit palette index
eDRVBLT_SRC_8BPP	32	8-bit palette index

E_DRVBLT_DISPLAY_FORMAT

Destination format for Fill/Blit operation.

Name	Value	Description
eDRVBLT_DEST_ARGB8888	1	ARGB8888
eDRVBLT_DEST_RGB565	2	RGB565
eDRVBLT_DEST_RGB555	4	RGB555

E_DRVBLT_FILL_STYLE

Other flags for Blit operation.

eDRVBLT_CLIP_TO_EDGE/eDRVBLT_NONE_FILL specify how to behave when reverse mapping doesn't fall in the range of source bitmap.

Name	Value	Description
eDRVBLT_CLIP_TO_EDGE	1	The bitmap should be clipped to its edges, otherwise a repeating texture.
eDRVBLT_NOTSMOOTH	2	The bitmap should not be smoothed
eDRVBLT_NONE_FILL	4	Neither clip to edge nor repeating texture

E_DRVBLT_PALETTE_ORDER

Palette index in big-endian or little-endian.

Name	Value	Description
eDRVBLT_BIG_ENDIAN	0	Palette index in big endian
eDRVBLT_LITTLE_ENDIAN	1	Palette index in little endian

S_DRVBLT_MATRIX

Transformation matrix used in inverse mapping.

Name	Type	Description
a	INT32	
b	INT32	
c	INT32	
d	INT32	

S_DRVBLT_ARGB16

Multiplier/offset of A, R, G, and B channels used in color transformation.

Name	Type	Description
i16Blue	INT16	Color multiplier/offset of blue channel
i16Green	INT16	Color multiplier/offset of green channel
i16Red	INT16	Color multiplier/offset of red channel
i16Alpha	INT16	Color multiplier/offset of alpha channel

S_DRVBLT_ARGB8

ARGB8888 color

Name	Type	Description
u8Blue	UINT8	Value of blue channel
u8Green	UINT8	Value of green channel
u8Red	UINT8	Value of red channel
u8Alpha	UINT8	Value of alpha channel

S_DRVBLT_SRC_IMAGE

Source image.

Name	Type	Description
u32SrcImageAddr	UINT32	Source image start address
i32Stride	INT32	Source image's stride in bytes
i32XOffset	INT32	X offset into the source to start rendering from
i32YOffset	INT32	Y offset into the source to start rendering from
i16Width	INT16	Source image's width in pixels
i16Height	INT16	Source image's height in pixels

S_DRVBLT_DEST_FB

Destination buffer.

Name	Type	Description
u32FrameBufAddr	UINT32	Destination buffer address to start rendering to
i32XOffset	INT32	No use
i32YOffset	INT32	No use
i32Stride	INT32	Destination buffer's stride in bytes
i16Width	INT16	Destination buffer's width in pixels
i16Height	INT16	Destination buffer's height in pixels

3.9 API Function

bltOpen

Synopsis

ERRCODE bltOpen(void);

Description

Initialize BLT and install interrupt service routine.

Parameter

None

Return Value

E_SUCCESS Success

bltClose

Synopsis

void bltClose(void);

Description

Tear down BLT.

Parameter

None

Return Value

None

bltSetTransformMatrix

Synopsis

void bltSetTransformMatrix(S_DRVBLT_MATRIX sMatrix);

Description

Set up inverse transformation matrix.

Parameter

sMatrix Transformation matrix as defined in S_DRVBLT_MATRIX.

Return Value

None

bltGetTransformMatrix

Synopsis

void bltGetTransformMatrix(S_DRVBLT_MATRIX *psMatrix);

Description

Retrieve inverse transformation matrix which has set up.

Parameter

psMatrix User-prepared buffer to save read-back transformation matrix as defined in S_DRVBLT_MATRIX.

Return Value

None

bltSetSrcFormat

Synopsis

ERRCODE bltSetSrcFormat (E_DRVBLT_BMPIXEL_FORMAT eSrcFmt);

Description

Set up source format.

Parameter

eSrcFmt Source format as defined in E_DRVBLT_BMPIXEL_FORMAT.

Return Value

E_SUCCESS	Success
ERR_BLT_INVALID_SRCFMT	Invalid source format

bltGetSrcFormat

Synopsis

E_DRVBLT_BMPIXEL_FORMAT bltGetSrcFormat(void);

Description

Retrieve source format which has set up.

Parameter

None

Return Value

Source format as defined in E_DRVBLT_BMPIXEL_FORMAT.

bltSetDisplayFormat

Synopsis

ERRCODE bltSetDisplayFormat(E_DRVBLT_DISPLAY_FORMAT eDisplayFmt);

Description

Set up destination format.

Parameter

eDisplayFmt Destination format defined in E_DRVBLT_DISPLAY_FORMAT.

Return Value

E_SUCCESS	Success
ERR_BLT_INVALID_DSTFMT	Invalid destination format

bltGetDisplayFormat

Synopsis

E_DRVBLT_DISPLAY_FORMAT bltGetDisplayFormat(void);

Description

Retrieve destination format which has set up.

Parameter

None

Return Value

Destination format as defined in E_DRVBLT_DISPLAY_FORMAT.

bltEnableInt

Synopsis

void bltEnableInt(E_BLT_INT_TYPE eIntType);

Description

Enable specified interrupt type.

Parameter

eIntType	Interrupt type as defined in E_BLT_INT_TYPE.

Return Value

None

bltDisableInt

Synopsis

void bltDisableInt(E_BLT_INT_TYPE eIntType);

Description

Disable specified interrupt type.

Parameter

eIntType	Interrupt type as defined in E_BLT_INT_TYPE.

Return Value

None

bltIsIntEnabled

Synopsis

BOOL bltIsIntEnabled (E_BLT_INT_TYPE eIntType);

Description

Query if the specified interrupt type is enabled.

Parameter

eIntType	Interrupt type as defined in E_BLT_INT_TYPE.

Return Value

TRUE	Specified interrupt enabled
FALSE	Specified interrupt disabled

bltPollInt

Synopsis

BOOL bltPollInt(E_BLT_INT_TYPE eIntType);

Description

Query interrupt status of the specified interrupt type.

Parameter

eIntType	Interrupt type as defined in E_BLT_INT_TYPE.

Return Value

TRUE	Specified interrupt type active.
FALSE	Specified interrupt type inactive.

bltInstallCallback

Synopsis

void bltInstallCallback (E_BLT_INT_TYPE eIntType, PFN_BLT_CALLBACK pfnCallback, PFN_BLT_CALLBACK* pfnOldCallback);

Description

Install callback function invocated on interrupt generated.

Parameter

eIntType	Interrupt type as defined in E_BLT_INT_TYPE.
pfnCallback	New callback function to install. NULL to uninstall.
pfnOldCallback	User-prepared buffer to save previously installed callback function.

Return Value

None

bltSetColorMultiplier

Synopsis

void bltSetColorMultiplier(S_DRVBLT_ARGB16 sARGB16);

Description

Set up color multipliers of A, R, G, and B channels for color transformation.

Parameter

sARGB16 Color multipliers of A, R, G, and B channels as defined in S_DRVBLT_ARGB16.

Return Value

None

bltGetColorMultiplier

Synopsis

void bltGetColorMultiplier(S_DRVBLT_ARGB16* psARGB16);

Description

Retrieve color multipliers of A, R, G, and B channels which has set up.

Parameter

psARGB16 User-prepared buffer to save color multipliers of A, R, G, and B channels as defined in S_DRVBLT_ARGB16.

Return Value

None

bltSetColorOffset

Synopsis

void bltSetColorOffset(S_DRVBLT_ARGB16 sARGB16);

Description

Set up color offsets of A, R, G, and B channels for color transformation.

Parameter

sARGB16 Color offsets of A, R, G, and B channels as defined in S_DRVBLT_ARGB16.

Return Value

None

bltGetColorOffset

Synopsis

void bltGetColorOffset(S_DRVBLT_ARGB16* psARGB16);

Description

Retrieve color offsets of A, R, G, and B channels which has set up.

Parameter

psARGB16 User-prepared buffer to save color offsets of A, R, G, and B channels as defined in S_DRVBLT_ARGB16.

Return Value

None

bltSetSrcImage

Synopsis

void bltSetSrcImage(S_DRVBLT_SRC_IMAGE sSrcImage);

Description

Set up source image..

Parameter

sSrcImage Source image as defined in S_DRVBLT_SRC_IMAGE.

Return Value

None

bltSetDestFrameBuf

Synopsis

void bltSetDestFrameBuf(S_DRVBLT_DEST_FB sFrameBuf);

Description

Set up destination buffer..

Parameter

sFrameBuf Destination buffer as defined in S_DRVBLT_DEST_FB.

Return Value

None

bltSetARGBFillColor

Synopsis

void bltSetARGBFillColor(S_DRVBLT_ARGB8 sARGB8);

Description

Set up fill color for Fill operatioin, which can be ARGB8888 or RGB888 dependent on bltSetFillAlpha.

Parameter

sARGB8	Fill color as defined in S_DRVBLT_ARGB8.

Return Value

None

Note

If ARGB8888, it must be in non-premultiplied alpha format.

bltGetARGBFillColor

Synopsis

void bltGetARGBFillColor(S_DRVBLT_ARGB8* psARGB8);

Description

Retrieve ARGB8888 color for Fill operation which has set up.

Parameter

psARGB8 User-prepared buffer to save read-back ARGB8888 color for Fill operation.

Return Value

None

bltGetBusyStatus

Synopsis

BOOL bltGetBusyStatus(void);

Description

Query if Fill/Blit operation is busy.

Parameter

None

Return Value

TRUE	Busy
FALSE	Free

bltSetFillAlpha

Synopsis

void bltSetFillAlpha(BOOL bEnable);

Description

Set up whether or not fill color's alpha channel is in effect.

Parameter

bEnable

TRUE	Fill color is ARGB8888
FALSE	Fill color is RGB888

Return Value

None

bltGetFillAlpha

Synopsis

BOOL bltGetFillAlpha(void);

Description

Retrieve whether or not fill color's alpha channel is in effect which has set up.

Parameter

None

Return Value

TRUE	Fill color is ARGB8888.
FALSE	Fill color is RGB888

bltSetTransformFlag

Synopsis

void bltSetTransformFlag(UINT32 u32TransFlag);

Description

Set up transform flag.

Parameter

U32TransFlag Transform flag as defined in E_DRVBLT_TRANSFORM_FLAG.

Return Value

None

bltGetTransformFlag

Synopsis

UINT32 bltGetTransformFlag(void);

Description

Retrieve transform flag which has set up.

Parameter

None.

Return Value

Transform flag as defined in E_DRVBLT_TRANSFORM_FLAG.

bltSetPaletteEndian

Synopsis

void bltSetPaletteEndian(E_DRVBLT_PALETTE_ORDER eEndian);

Description

Set up endianness of palette index..

Parameter

eEndian Endianness of palette index as defined in E_DRVBLT_PALETTE_ORDER.

Return Value

None

bltGetPaletteEndian

Synopsis

E_DRVBLT_PALETTE_ORDER bltGetPaletteEndian(void);

Description

Retrieve endianness of palette index which has set up.

Parameter

None

Return Value

Endianness of palette index as defined in E_DRVBLT_PALETTE_ORDER.

bltSetColorPalette

Synopsis

void bltSetColorPalette(UINT32 u32PaletteInx, UINT32 u32Num, S_DRVBLT_ARGB8 *psARGB);

Description

Set up palette's colors.

Parameter

u32PaletteInx	Index of palette to start to set up
u32Num	Number of colors to set up
psARGB	ARGB8888 colors

Return Value

None

bltSetFillOP

Synopsis

void bltSetFillOP(E_DRVBLT_FILLOP eOP);

Description

Set up operation to be Fill or Blit.

Parameter

eOP	Operation as defined in E_DRVBLT_FILLOP.

Return Value

None

bltGetFillOP

Synopsis

BOOL bltGetFillOP(void);

Description

Retrieve operation which has set up..

Parameter

None

Return Value

TRUE	Fill operation.
FALSE	Blit operation

bltSetFillStyle

Synopsis

void bltSetFillStyle(E_DRVBLT_FILL_STYLE eStyle);

Description

Set up other flags for Blit operation.

Parameter

eStyle Other flags as defined in E_DRVBLT_FILL_STYLE.

Return Value

None

bltGetFillStyle

Synopsis

E_DRVBLT_FILL_STYLE bltGetFillStyle(void);

Description

Retrieve other flags for Blit operatioin which has set up.

Parameter

None

Return Value

Other flags as defined in E_DRVBLT_FILL_STYLE.

bltSetRevealAlpha

Synopsis

void bltSetRevealAlpha(E_DRVBLT_REVEAL_ALPHA eAlpha);

Description

Set up premultiplied alpha or not for source format of ARGB8888

Parameter

eAlpha Premultiplied alpha or not as specified in E_DRVBLT_REVEAL_ALPHA

Return Value

None

bltGetRevealAlpha

Synopsis

BOOL bltGetRevealAlpha(void);

Description

Retrieve premultiplied alpha or not for source format of ARGB8888.

Parameter

None

Return Value

Premultiplied alpha or not as specified in E_DRVBLT_REVEAL_ALPHA

bltTrigger

Synopsis

void bltTrigger(void);

Description

Start Fill/Blit operation..

Parameter

None

Return Value

None

bltSetRGB565TransparentColor

Synopsis

void bltSetRGB565TransparentColor(UINT16 u16RGB565);

Description

Set up transparent color for source format of RGB565 for color key enabled

Parameter

u16RGB565	RGB565 to be transparent color

Return Value

None

bltGetRGB565TransparentColor

Synopsis

UINT16 bltGetRGB565TransparentColor(void);

Description

Retrieve transparent color which has set up..

Parameter

None

Return Value

RGB565 to be transparent color

bltSetRGB565TransparentCtl

Synopsis

void bltSetRGB565TransparentCtl(BOOL bEnable);

Description

Enable color key or not.

Parameter

bEnable

TRUE	Enable color key
FALSE	Disable color key

Return Value

None

bltGetRGB565TransparentCtl

Synopsis

BOOL bltGetRGB565TransparentCtl(void);

Description

Retrieve color key enabled or not.

Parameter

None

Return Value

TRUE	Color key enabled
FALSE	Color key disabled

bltFlush

Synopsis

void bltFlush(void);

Description

Wait for Fill/Blit operation to complete.

Parameter

None

Return Value

None

Error Code Table

Code Name	Value	Description
Successful	0	Success
ERR_BLT_INVALID_INT	BLT_ERR_ID | 0x01	Invalid interrupt type
ERR_BLT_INVALID_SRCFMT	BLT_ERR_ID | 0x02	Invalid source format
ERR_BLT_INVALID_DSTFMT	BLT_ERR_ID | 0x03	Invalid destination format

4 GNAND Library

4.1 overview

N9H20 Non-OS library consists of the sets of libraries. These libraries are built to access those on-chip functions such as VPOST, APU, SIC, USBH, USBD, GPIO, I2C, SPI and UART, as well as File System (NVTFAT), USB MassStorage devices (UMAS) and NAND Flash devices (GNAND). This document describes the provided APIs of GNAND library. With these APIs, user can quickly build a binary target for GNAND library on N9H20 micro processor.

These libraries are created by using Keil uVision IDE. Therefore, they only can be used in Keil environment.

4.2 GNAND Library Introduction

In GNAND library, a NAND is though as a disk. User can access NAND by logical block address and don't worry about the bad block issue. It's possible that a few leading physical blocks were reserved for boot code or information area. GNAND library will not access those reserved blocks.

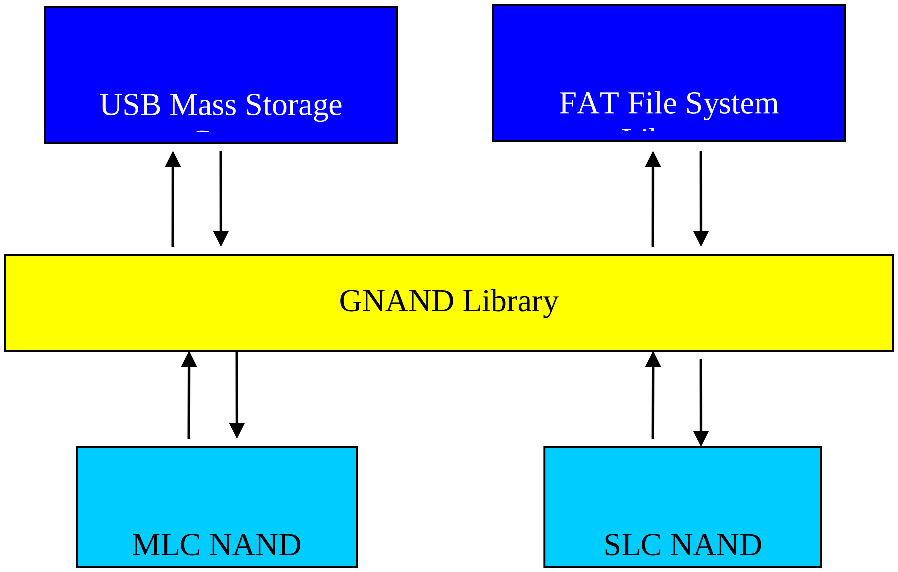
The Generic NAND (GNAND) library has the following features:

- Mapping between logical block and physical block to support bad block management
- Platform independent.
- Support both FAT file system and USB mass storage device
- Support both SLC and MLC NAND
- Able to recover from any power-off exceptions
- High performance, fast startup
- Support multiple NAND disk
- Support two disks in one NAND (reserved NAND partition)
- Dirty page management to support garbage collection feature
- Balanced usage on all physical blocks to support wear-leveling feature (will supported in the future)

4.3 Programming Guide

4.3.1 System Overview

GNAND library works as a hardware independent library. NAND disk access service was provided by NAND driver. File system access service was provided by the upper layer FAT file system library or USB mass storage device driver. The relationship between these component libraries was shown in the following picture:



4.3.2 Initialize GNAND Library

To initialize GNAND library, just invoke **GNAND_InitNAND()**. Application must give corresponding NAND driver as input argument to **GNAND_InitNAND()**, then GNAND library can access NAND disk through NAND driver service.

GNAND library will validate the NAND disk is GNAND format or not. If it is not GNAND format, application can determine to program it as GNAND format or not. It depends on the third argument of **GNAND_InitNAND()**.

4.3.3 GNAND work with Nuvoton FAT Library

If **GNAND_InitNAND()** returns GNAND_OK, application can invoke **GNAND_MountNandDisk()** to mount NAND disk to NVTFAT file system.

4.3.4 NAND driver function set

To work as an underlying driver of GNAND, the NAND driver must provide the following function set and pass it to GNAND library with **GNAND_InitNAND()**.

```
#define NDRV_T struct ndrv_t
struct ndrv_t
{
   INT  (*init)(NDISK_T *NDInfo);
   INT  (*pread)(INT nPBlockAddr, INT nPageNo, UINT8 *buff);
   INT  (*pwrite)(INT nPBlockAddr, INT nPageNo, UINT8 *buff);
   INT  (*is_page_dirty)(INT nPBlockAddr, INT nPageNo);
   INT  (*is_valid_block)(INT nPBlockAddr);
   INT  (*ioctl)(INT param1, INT param2, INT param3, INT param4);
   INT  (*block_erase)(INT nPBlockAddr);
   INT  (*chip_erase)(VOID);
```

```
    VOID *next;
};
```

In **init(NDISK_T *NDInfo)** function, NAND driver should detect NAND disk and fill NAND disk information into <**NDISK_T *NDInfo**>, which was passed as an argument. If success, return 0.

NDISK_T members

Member Name	Return by init()	Comments
vendor_ID	Optional	
device_ID	Optional	
NAND_type	Must	NAND_TYPE_SLC or NAND_TYPE_MLC
nZone	Must	Number of zones
nBlockPerZone	Must	Maximum number of physical blocks per zone
nPagePerBlock	Must	Number of pages per block
nLBPerZone	Must	Maximum number of allowed logical blocks per zone
nPageSize	Must	Page size in bytes
nStartBlock	Must	Reserved number of leading blocks
nBadBlockCount	Optional	Bad block count for all zones
driver	Must	NAND driver function set pointer
nNandNo	Optional	
pDisk	Optional	
write_page_in_seq	Must	Programming pages out of sequence within a block is prohibited or not. NAND_TYPE_PAGE_OUT_SEQ or NAND_TYPE_PAGE_IN_SEQ
reserved[59]	Ignore	
need2P2LN	Optional	Need second P2LN block or not
p2ln_block1	Optional	Physical block address for second P2LN block
p2lm	Ignore	GNAND internal used
l2pm	Ignore	GNAND internal used
dp_tbl	Ignore	GNAND internal used
db_idx[16]	Ignore	GNAND internal used
p2ln_block	Ignore	GNAND internal used
op_block	Ignore	GNAND internal used
op_offset	Ignore	GNAND internal used
last_op[32]	Ignore	GNAND internal used
err_sts	Ignore	GNAND internal used
next	Ignore	GNAND internal used

In **pread(INT nPBlockAddr, INT nPageNo, UINT8 *buff)** function, NAND driver execute a page read operation from physical block <**nPBlockAddr**> page <**nPageNo**>. And <**buff**> was guaranteed to be non-cacheable memory.

In **pwrite(INT nPBlockAddr, INT nPageNo, UINT8 *buff)** function, NAND driver execute a page programming operation to physical block <**nPBlockAddr**> page <**nPageNo**>. And <**buff**> was guaranteed to be non-cacheable memory.

In **is_page_dirty(INT nPBlockAddr, INT nPageNo)** function, NAND driver check the redundant area of physical block <**nPBlockAddr**> page <**nPageNo**>. If this page had ever been written, NAND driver should return 1, otherwise, return 0.

In **is_valid_block(INT nPBlockAddr)** function, NAND driver check if physical block <**nPBlockAddr**> is a valid block or not. If the block is a valid block, NAND driver should return 1, otherwise, return 0.

At current version, **ioctl()** was not used by GNAND library. NAND driver can give it a NULL value.

In **block_erase(INT nPBlockAddr)** function, NAND driver execute a block erase operation on physical block <**nPBlockAddr**>.

In **chip_erase()** function, NAND driver execute a chip erase operation on the NAND disk. Note that the whole GNAND information will lost after chip_erase(). You have to call GNAND_InitNAND() to rebuild GNAND format.

4.3.5 GNAND Library APIs Specification

GNAND_InitNAND

Synopsis

INT GNAND_InitNAND (NDRV_T *ndriver, NDISK_T *ptNDisk, BOOL bEraseIfNotGnandFormat)

Description

Initialize a NAND disk.

Parameter

ndriver NAND driver function sets to hook NAND driver on GNAND library.

ptNDisk NAND disk information that GNAND initiated. You need this pointer to call other GNAND APIs.

bEraseIfNotGnandFormat

If NAND disk was GNAND format, ignore this argument.

If NAND disk was not GNAND format, format it if this argument is 1, otherwise, return a GNERR_GNAND_FORMAT error.

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
NDRV_T _nandDiskDriver0 =
{
nandInit0,
nandpread0,
nandpwrite0,
nand_is_page_dirty0,
nand_is_valid_block0,
nand_ioctl,
nand_block_erase0,
nand_chip_erase0,
0
};
…
NDISK_T *ptNDisk;
int status;

fsInitFileSystem();
```

```
/* Initialize FMI */
sicIoctl(SIC_SET_CLOCK, 192000, 0, 0);
sicOpen();

ptNDisk = (NDISK_T *)malloc(sizeof(NDISK_T));
if (ptNDisk == NULL)
{
printf("malloc error!!\n");
return -1;
}

status = GNAND_InitNAND(&_nandDiskDriver0, ptNDisk, TRUE);
if (status < 0)
{
    printf("NAND disk init failed, status = %x\n", status);
    return status;
}

status = GNAND_MountNandDisk(ptNDisk);
if (status < 0)
{
    printf("Mount NAND disk failed, status = %x\n", status);
    return status;
}
```

GNAND_MountNandDisk

Synopsis

INT GNAND_MountNandDisk (NDISK_T *ptNDisk)

Description

Mount NAND disk to NVTFAT file system.

Parameter

ptNDisk The pointer refers to the NAND disk information that initiated by GNAND_InitNAND().

Return Value

0	– Success
Otherwise	– error code defined in Error Code Table

Example

Refer to the example code of GNAND_InitNAND();

GNAND_read

Synopsis

INT GNAND_read (NDISK_T *ptNDisk, UINT32 nSectorNo, INT nSectorCnt, UINT8 *buff)

Description

Read logical sectors from NAND disk.

Parameter

ptNDisk The pointer refers to the NAND disk information that initiated by GNAND_InitNAND().

nSectorNo Read start sector number.

nSectorCnt Number of sectors to be read.

buff Memory buffer to receive data, which is 32 bytes aligned non-cacheable buffer.

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
/* Read data from NAND disk sector 100 to sector 104 and store data to buff on RAM */
__align (32) UINT8 buff [512*5];
GNAND_read(ptNDISK, 100, 5, buff);
```

GNAND_write

Synopsis

INT GNAND_write (NDISK_T *ptNDisk, UINT32 nSectorNo, INT nSectorCnt, UINT8 *buff)

Description

Write logical sectors to NAND disk

Parameter

ptNDisk The pointer refers to the NAND disk information that initiated by GNAND_InitNAND().

nSectorNo Write the start sector number.

nSectorCnt Number of sectors to be written.

buff Memory buffer for writing data, which is 32 bytes aligned non-cacheable buffer

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
/* Write data from buff to NAND disk sector 100 to sector 104 */
__align (32) UINT8 buff [512*5];
…
GNAND_write(ptNDISK, 100, 5, buff);
```

GNAND_block_erase

Synopsis

INT GNAND_block_erase (NDISK_T *ptNDisk, INT pba)

Description

Erase a physical block.

Parameter

ptNDisk The pointer refers to the NAND disk information that initiated by GNAND_InitNAND().

pba NAND physical block address.

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
int status;

/* erase physical block 10 */
status = GNAND_block_erase(ptNDisk, 10);
if (status != 0)
{
/* handle error status */
}
```

GNAND_chip_erase

Synopsis

INT GNAND_chip_erase (NDISK_T *ptNDisk)

Description

This function erases all blocks in NAND chip. All data in chip will be lost, including information for GNAND library.

Parameter

ptNDisk The pointer refers to the NAND disk information that initiated by GNAND_InitNAND().

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
int status;

/* erase whole NAND chip */
status = GNAND_chip_erase(ptNDisk);
if (status != 0)
{
/* handle error status */
}
```

GNAND_UnMountNandDisk

Synopsis

VOID GNAND_UnMountNandDisk (NDISK_T *ptNDisk)

Description

Unmount NAND disk from NVTFAT file system.

Parameter

ptNDisk The pointer refers to the NAND disk information that initiated by GNAND_InitNAND().

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
int status;

status = GNAND_UnMountNandDisk(ptNDisk);
if (status != 0)
{
/* handle error status */
```

```
}
```

Example code

The example code tests the GNAND library, please refer to the SIC example code of BSP Non-OS.

Error Code Table

CODE NAME	Value	Description
GNAND_OK	0	Success
GNERR_GENERAL	0xFFFFC001	General access error
GNERR_MEMORY_OUT	0xFFFFC005	No available memory
GNERR_GNAND_FORMAT	0xFFFFC010	NAND disk was not GNAND format
GNERR_FAT_FORMAT	0xFFFFC015	NAND disk was unformatted as FAT
GNERR_BLOCK_OUT	0xFFFFC020	There’s no available physical blocks
GNERR_P2LN_SYNC	0xFFFFC025	Internal error for P2LN table sync problem
GNERR_READONLY_NAND	0xFFFFC026	Cannot write data into read only NAND disk
GNERR_IO_ERR	0xFFFFC030	NAND read/write/erase access failed
GNERR_NAND_NOT_FOUND	0xFFFFC040	NAND driver cannot find NAND disk.
GNERR_UNKNOW_ID	0xFFFFC042	Not supported NAND ID

5 GPIO Library

5.1 Overview

The GPIO library provides a set of APIs to control on-chip GPIO pins. This library depends on N9H20 System Library.

5.2 GPIO Library APIs Specification

gpio_open

Synopsis

int gpio_open(unsigned char port)

Description

This function enables GPIO port A, D, and E, which GPIO is not the default pad function. There is no need to call this function for GPIO port B and C.

Parameter

port GPIO_PORTA, GPIO_PORTD, GPIO_PORTE

Return Value

Return 0 on success. -1 for unknown port number

Example

```
/* Open port D*/
gpio_open (GPIO_PORTD);
```

gpio_configure

Synopsis

int gpio_configure (unsigned char port, unsigned short num)

Description

This function configures the specified pin of a port as GPIO.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

num pin number

Return Value

Return 0 on success. -1 for unknown port number

Example

```
/* Configure the pin 0 of port D as GPIO*/
gpio_configure (GPIO_PORTD, 0);
```

gpio_readport

Synopsis

int gpio_readport(unsigned char port, unsigned short *val)

Description

This function reads back all pin value of a GPIO port, ignore the direction of each pin.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

*val Return port value

Return Value

Return 0 on success, -1 for unknown port number

Example

```
/* Read PORT C value*/
unsigned short val;
gpio_readport(GPIO_PORTC, &val);
```

gpio_setportdir

Synopsis

int gpio_setportdir (unsigned char port, unsigned short mask, unsigned short dir)

Description

This function sets the pin direction of GPIO port. It could select the pin(s) to be configured with the second parameter.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

mask pin mask, each bit stands for one pin

dir Direction, each bit configures one pin, 0 means input, 1 means output

Return Value

Return 0 on success, -1 for unknown port number

Example

```
/* Set PORT C pin 1 to output mode, and pin 0 to input mode */
gpio_setportdir (GPIO_PORTC, 0x3, 0x2);
```

gpio_setportval

Synopsis

int gpio_setportval (unsigned char port, unsigned short mask, unsigned short val)

Description

This function sets the output value of GPIO port. It could select the pin(s) to be configured with the second parameter.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

mask pin mask, each bit stands for one pin

val Output value, each bit configures one pin, 0 means low, 1 means high

Return Value

Return 0 on success, -1 for unknown port number

Example

```
/* Set PORT C pin 1 to output high, and pin 0 to low */
gpio_setportval (GPIO_PORTC, 0x3, 0x2);
```

gpio_setportpull

Synopsis

int gpio_setportpull (unsigned char port, unsigned short mask, unsigned short pull)

Description

This function sets the pull up resistor of GPIO port. It could select the pin(s) to be configured with its second parameter.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

mask pin mask, each bit stands for one pin

pull Pull up resister state, each bit configures one pin, 0 means disable, 1 means enable

Return Value

Return 0 one success, -1 for unknown port number

Example

```
/* Enable PORT C pin 1 pull up resistor, and disable pin 0 pull up
resistor */
```

```
gpio_setportpull (GPIO_PORTC, 0x3, 0x2);
```

gpio_setdebounce

Synopsis

int gpio_setdebounce(unsigned int clk, unsigned char src)

Description

This function is used to configure external interrupt de-bounce time.

Parameter

clk Debounce sampling clock, could be 1, 2, 4, 8, 16, 32, 64, 128, 256, 2*256, 4*256, 8*256, 16*256, 32*256, 64*256 and 128*256

src Debounce sampling interrupt source. Valid values are between 0~15. Each bit represents one interrupt source

Return Value

Return 0 on success, -1 on parameter error

Example

```
/* Set nIRQ0 debounce sampling clock to 128 clocks*/
gpio_setdebounce (128, 1);
```

gpio_getdebounce

Synopsis

void gpio_getdebounce(unsigned int *clk, unsigned char *src)

Description

This function gets current external interrupt de-bounce time setting.

Parameter

*clk Debounce sampling clock

*src Debounce sampling interrupt source

Return Value

None

Example

```
unsigned int clk;
unsigned char src;
gpio_getdebounce (&clk, &src);
```

gpio_setsrcgrp

Synopsis

int gpio_setsrcgrp (unsigned char port, unsigned short mask, unsigned char irq)

Description

This function is used to set external interrupt source group.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

mask pin mask, each bit stands for one pin

irq external irq number. Could be 0~3

Return Value

Return 0 on success, -1 on parameter error

Example

```
/* Set GPIO port C pin 0 as source of nIRQ3 */
gpio_setsrcgrp (GPIO_PORTC, 1, 3);
```

gpio_getsrcgrp

Synopsis

int gpio_getsrcgrp (unsigned char port, unsigned int *val)

Description

This function is used to get current external interrupt source setting.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

*val Current source setting. Every two bits stands for the interrupt source each pin triggers

Return Value

Return 0 on success, and -1 for unknown port number

Example

```
/* Read GPIO port C interrupt group status */
unsigned int val;
gpio_setsrcgrp (GPIO_PORTC, &val);
```

gpio_setintmode

Synopsis

int gpio_setintmode (unsigned char port, unsigned short mask, unsigned short falling, unsigned short rising)

Description

This function sets the interrupt trigger mode of GPIO port. It could select the pin(s) to be configured with its second parameter.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

mask Pin mask, each bit stands for one pin

falling Triggers on falling edge, each bit stands for one pin

rising Triggers on rising edge, each bit stands for one pin

Return Value

Return 0 on success, -1 for parameter error

Example

```
/* Set PORT C pin 0 triggers on both falling and rising edge */
gpio_setintmode (GPIO_PORTC, 1, 1, 1);
```

gpio_getintmode

Synopsis

int gpio_getintmode (unsigned char port, unsigned short *falling, unsigned short *rising)

Description

This function is used to get interrupt trigger mode of GPIO port.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

*falling Triggers on falling edge, each bit stands for one pin

*rising Triggers on rising edge, each bit stands for one pin

Return Value

Return 0 on success, -1 for parameter error

Example

```
/* Get PORT C trigger mode */
unsigned short falling;
unsigned short rising;
gpio_getintmode (GPIO_PORTC, &falling, &rising);
```

gpio_setlatchtrigger

Synopsis

int gpio_setlatchtrigger (unsigned char src)

Description

This function used to set latch trigger source.

Parameter

src Latch trigger source. Each bit stands for one external interrupt source. If the value is 1, GPIO port input value will be latched while interrupt triggers

Return Value

Return 0 on success, -1 for parameter error

Example

```
/* Enable latch for nIRQ0 and nIRQ3*/
gpio_setlatchtrigger (9);
```

gpio_getlatchtrigger

Synopsis

void gpio_getlatchtrigger (unsigned char *src)

Description

This function used to get latch trigger source.

Parameter

*src Latch trigger source

Return Value

None

Example

```
/* Get latch trigger source*/
unsigned char src;
gpio_getlatchtrigger (&src);
```

gpio_getlatchval

Synopsis

int gpio_getlatchval (unsigned char port, unsigned short *val)

Description

This function is used to get interrupt latch value.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

*val Variable to store latch value

Return Value

Return 0 on success, -1 for parameter error

Example

```
/* Get port C latch value */
unsigned short val;
gpio_getlatchval (GPIO_PORTC, &val);
```

gpio_gettriggersrc

Synopsis

int gpio_gettriggersrc (unsigned char port, unsigned short *src)

Description

This function is used to get interrupt trigger source.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

*src Variable to store trigger source

Return Value

Return 0 on success, -1 for parameter error

Example

```
/* Get port C interrupt trigger source */
unsigned short src;
gpio_gettriggersrc (GPIO_PORTC, &src);
```

gpio_cleartriggersrc

Synopsis

int gpio_cleartriggersrc(unsigned char port)

Description

This function is used to clear interrupt trigger source.

Parameter

port GPIO_PORTA, GPIO_PORTB, GPIO_PORTC, GPIO_PORTD, and GPIO_PORTE

Return Value

Return 0 on success, -1 for parameter error

Example

```
/* Clear port C interrupt trigger source */
gpio_cleartriggersrc (GPIO_PORTC);
```

6 I2C Library

6.1 Overview

This library provides APIs for programmers to access I2C slaves connecting with N9H20 I2C interfaces. The default clock frequency is configured at 100 kHz after i2cOpen() is called, programmers could use i2cIoctl() function to change the frequency.

The maximum receive/transmit buffer length of this library is 450 bytes, which includes slave address and sub address. Data beyond this range will be ignored.

The I2C library will get the APB clock frequency from system library, application must set the CPU clock before using I2C library.

6.2 I2C Library APIs Specification

i2cInit

Synopsis

INT32 i2cInit(VOID)

Description

This function configures GPIO to I2C mode.

Parameter

None

Return Value

0 Always successes

Example

```
i2cInit();
```

i2cOpen

Synopsis

INT32 i2cOpen(VOID)

Description

This function initializes the software resource and sets the clock frequency to 100 kHz.

Parameter

None

Return Value

0	Successful
I2C_ERR_BUSY	Interface already opened

Example

```
INT32     status;
status = i2cOpen();
```

i2cClose

Synopsis

INT32 i2cClose(VOID)

Description

This function disables I2C engine clock.

Parameter

None

Return Value

0	Successful

Example

```
i2cClose();
```

i2cRead

Synopsis

INT32 i2cRead(PUINT8 buf, UINT32 len)

Description

This function reads data from I2C slave.

Parameter

buf	Receive buffer pointer
len	Receive length

Return Value

> 0	Return read length on success
I2C_ERR_BUSY	Interface busy
I2C_ERR_IO	Interface not opened
I2C_ERR_NACK	Slave returns an erroneous ACK
I2C_ERR_LOSTARBITRATION	Arbitration lost during transmission

Example

```
UCHAR8 buf[8];
INT32 len = 0;
len = i2cRead(buf, 8); // Read 8 bytes from i2c slave
```

i2cRead_OV

Synopsis

INT32 i2cRead_OV(PUINT8 buf, UINT32 len)

Description

This function reads data from OmniVision sensor.

Parameter

buf	Receive buffer pointer
len	Receive length

Return Value

> 0	Return read length on success
I2C_ERR_BUSY	Interface busy
I2C_ERR_IO	Interface not opened
I2C_ERR_NACK	Slave returns an erroneous ACK
I2C_ERR_LOSTARBITRATION	Arbitration lost during transmission

Example

```
UCHAR8 buf[1];
INT32 len = 0;
len = i2cRead_OV(buf, 1); // Read 1 bytes from OmniVision sensor
```

i2cWrite

Synopsis

INT32 i2cWrite(PUINT8 buf, UINT32 len)

Description

This function writes data to I2C slave.

Parameter

buf	Transmit buffer pointer
len	Transmit length

Return Value

> 0	Return writes length on success
I2C_ERR_BUSY	Interface busy
I2C_ERR_IO	Interface not opened
I2C_ERR_NACK	Slave returns an erroneous ACK
I2C_ERR_LOSTARBITRATION	Arbitration lost during transmission

Example

```
UINT8 buf [5] = {0x00, 0x01, 0x02, 0x03, 0x04};
UINT32 len;
len = i2cWrite(buf, 5); // Write 5 bytes to I2C slave
```

i2cIoctl

Synopsis

INT32 i2cIoctl(UINT32 cmd, UINT32 arg0, UINT32 arg1)

Description

This function allows programmers configure I2C interface, the supported command and arguments listed in the table below.

Command	Argument 0	Argument 1	Description
I2C_IOC_SET_DEV_ADDRESS	Unsigned integer stores the slave address	Not used	This command sets the slave address
I2C_IOC_SET_SPEED	Unsigned integer stores the new frequency	Not used	This command sets the clock frequency
I2C_IOC_SET_SUB_ADDRESS	Unsigned integer stores the sub address	Sub-address length	This command sets the sub-address and its length

Parameter

cmd	Command
arg0	First argument of the command
arg1	Second argument of the command

Return Value

0	On Success
I2C_ERR_IO	Interface not activated
I2C_ERR_NOTTY	Command not support, or parameter error

Example

```
/* Set clock frequency to 400 kHz */
i2cIoctl(I2C_IOC_SET_SPEED, 400, 0);
```

i2cExit

Synopsis

INT32 i2cExit(VOID)

Description

This function does nothing.

Parameter

None

Return Value

0 Always successful

Example

```
i2cExit();
```

Error Code Table

Code Name	Value	Description
I2C_ERR_LOSTARBITRATION	0xFFFF1101	Arbitration lost during transmission
I2C_ERR_BUSBUSY	0xFFFF1102	I2C bus is busy
I2C_ERR_NACK	0xFFFF1103	Slave returns an erroneous ACK
I2C_ERR_SLAVENACK	0xFFFF1104	slave not respond after address
I2C_ERR_NODEV	0xFFFF1105	Interface number out of range
I2C_ERR_BUSY	0xFFFF1106	Interface busy
I2C_ERR_IO	0xFFFF1107	Interface not activated
I2C_ERR_NOTTY	0xFFFF1108	Command not support, or parameter error

7 JPEG Library

7.1 Overview

N9H20 Non-OS library consists of a set of libraries. These libraries are built to access those on-chip functions such as VPOST, APU, SIC, USBH, USBD, GPIO, I2C, SPI and UART, as well as File System (NVTFAT), USB Mass Storage devices (UMAS) and NAND Flash devices (GNAND). This document describes the provided APIs of JPEG library. With these APIs, user can quickly build a binary target for JPEG library on N9H20 micro-processor.

These libraries are created by using ARM Development Suite 1.2. Therefore, they only can be used in ADS environment.

7.2 JPEG Library Overview

This library is designed to make user application to use N9H20 JPEG more easily.

The JPEG library has the following features:

- JPEG Normal / Encode function
- JPEG Encode Upscale function
- JPEG Decode Downscale function
- JPEG Window Decode function
- JPEG Decode Input Wait function

7.3 Programming Guide

7.3.1 System Overview

The JPEG Codec supports Baseline Sequential Mode JPEG still image compression and decompression that is fully compliant with ISO/IEC International Standard 10918-1 (T.81). The features and capability of the JPEG codec are listed below.

7.3.2 JPEG Features

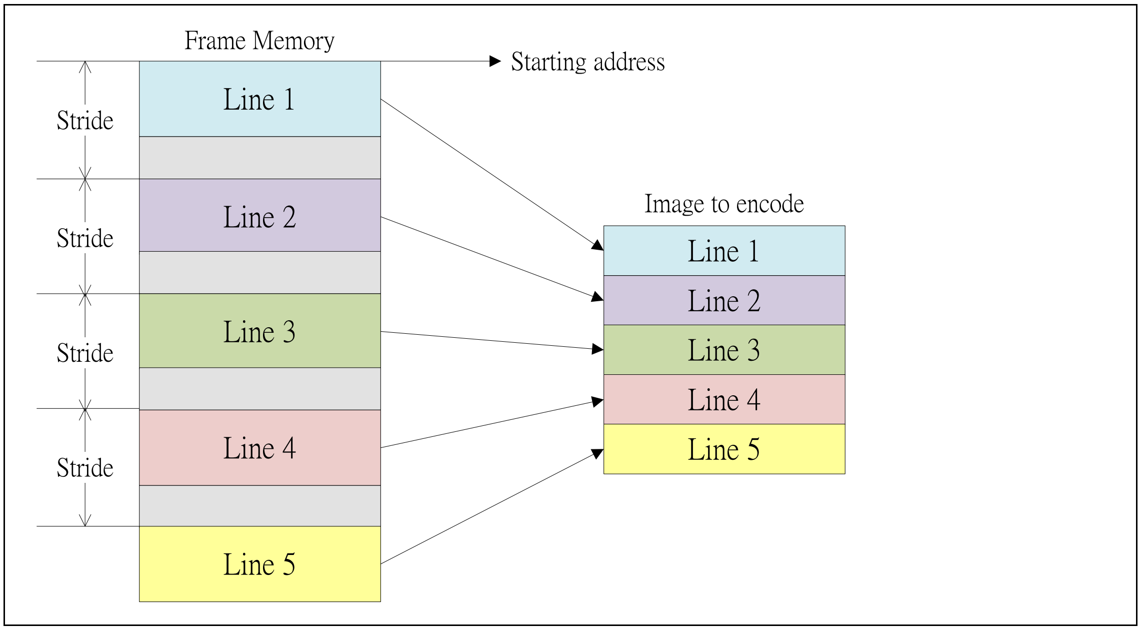
- Support to encode interleaved YCbCr 4:2:2/4:2:0 and gray-level (Y only) format image
- Support to decode interleaved YCbCr 4:4:4/4:2:2/4:2:0/4:1:1 and gray-level (Y only) format image
- Support to decode YCbCr 4:2:2 transpose format
- The encoded JPEG bit-stream format is fully compatible with JFIF and EXIF standards
- Support Capture and JPEG hardware on-the-fly access mode for encode
- Support JPEG and Playback hardware on-the-fly access mode for decode
- Support software input/output on-the-fly access mode for both encode and decode
- Support arbitrary width and height image encode and decode
- Support three programmable quantization-tables
- Support standard default Huffman-table and programmable Huffman-table for decode
- Support arbitrarily 1X~8X image up-scaling function for encode mode
- Support down-scaling function for encode and decode modes
- Support specified window decode mode
- Support quantization-table adjustment for bit-rate and quality control in encode mode

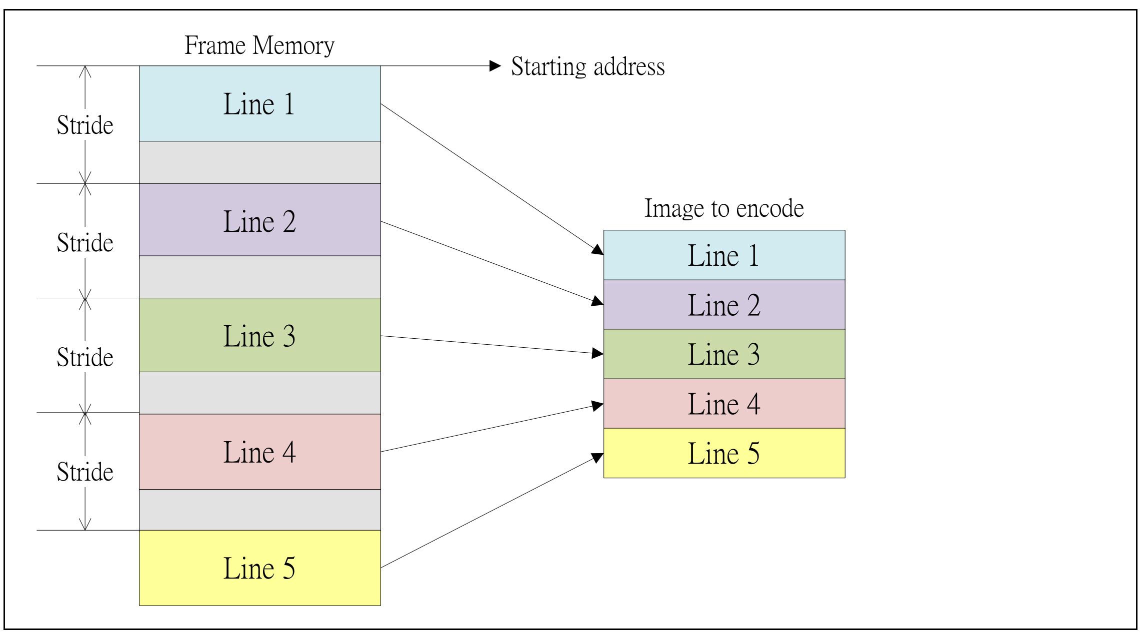
- Support rotate function in encode mode

7.3.3 JPEG Operation Control

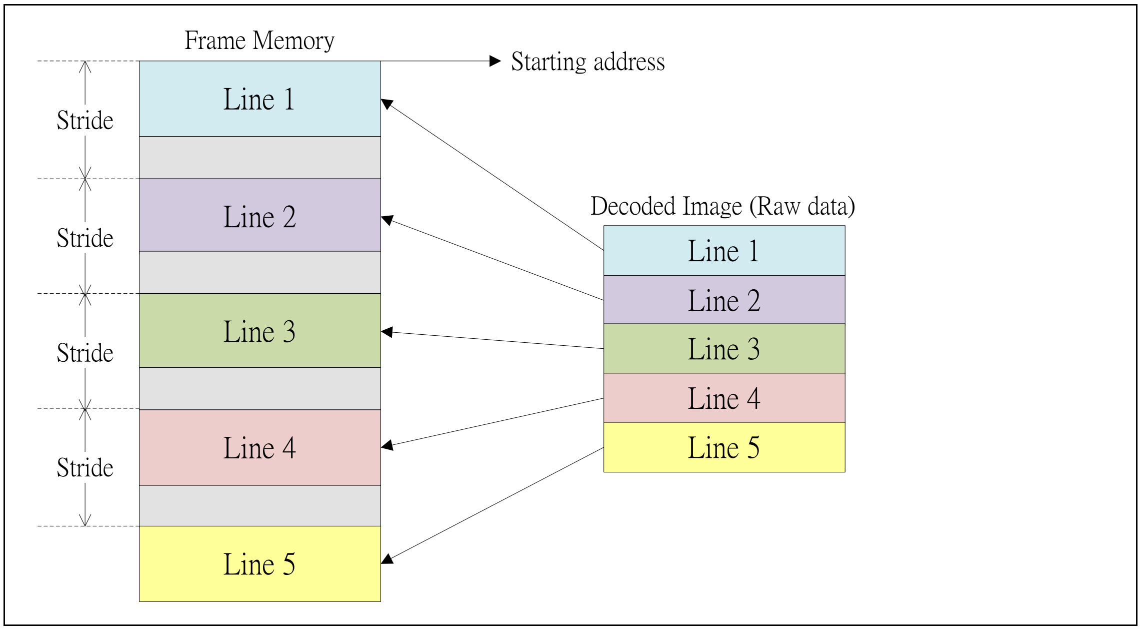
7.3.3.1 Memory access

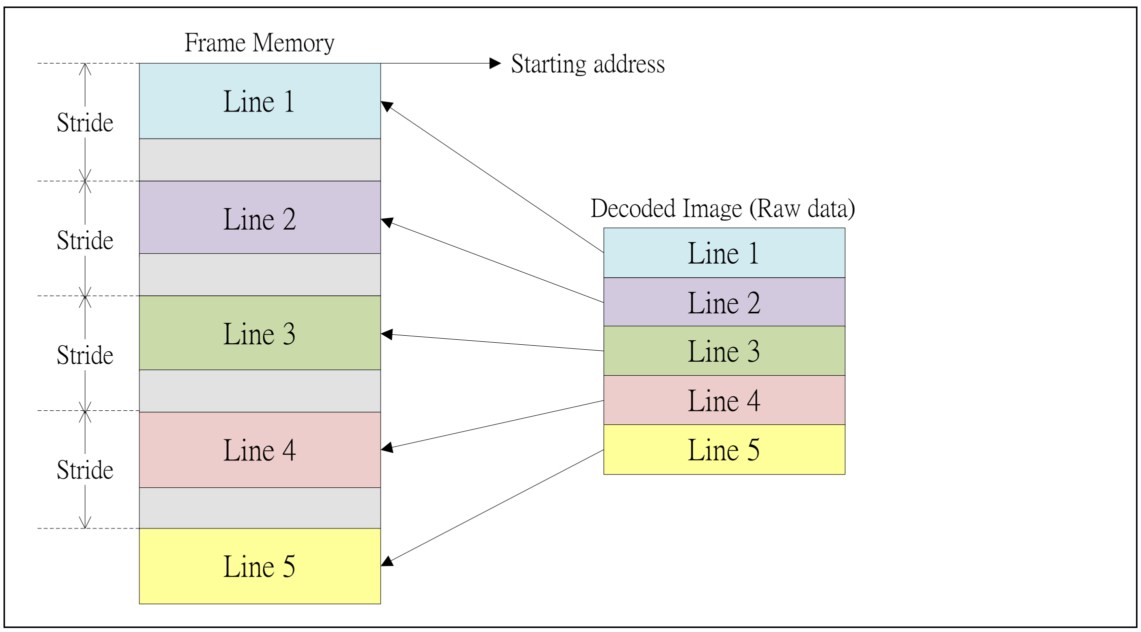
The following figure shows the encode mode to access the source data which are from sensor normally and stored on the SDRAM.



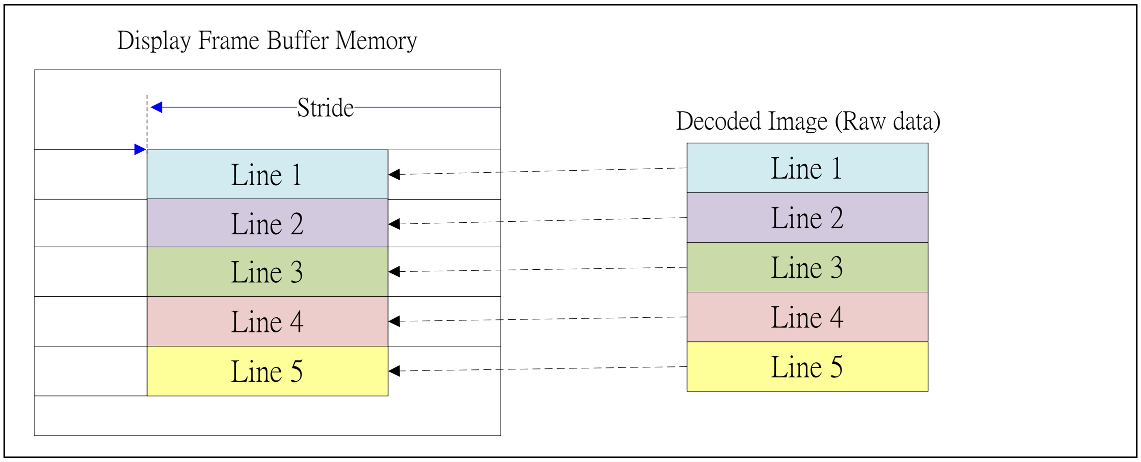


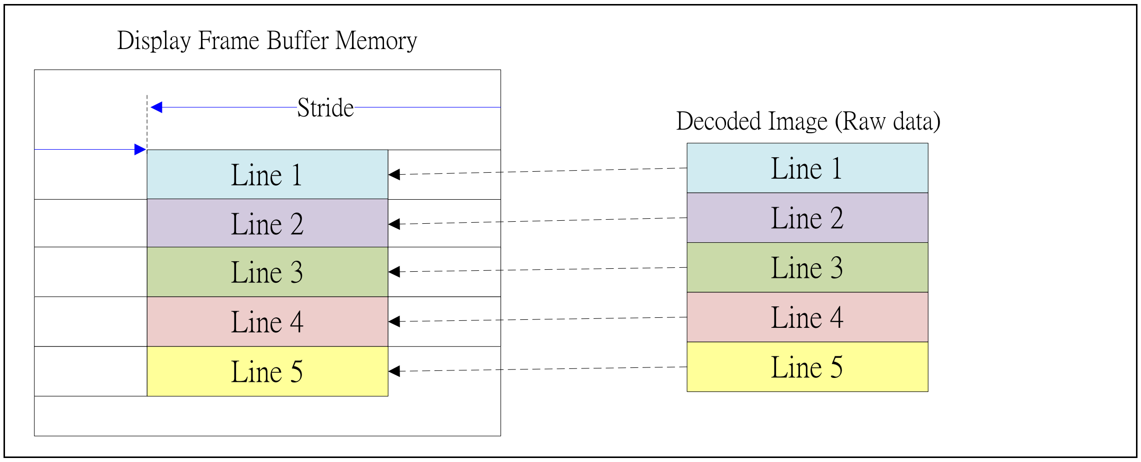
The following figure shows the decode mode to output the decoded raw data on the SDRAM.


Frame Memory
Starting address
Stride
Stride
Stride
Stride
Line 1
Line 2
Line 3
Line 4
Line 5
Decoded Image (Raw data)
Line 1
Line 2
Line 3
Line 4
Line 5

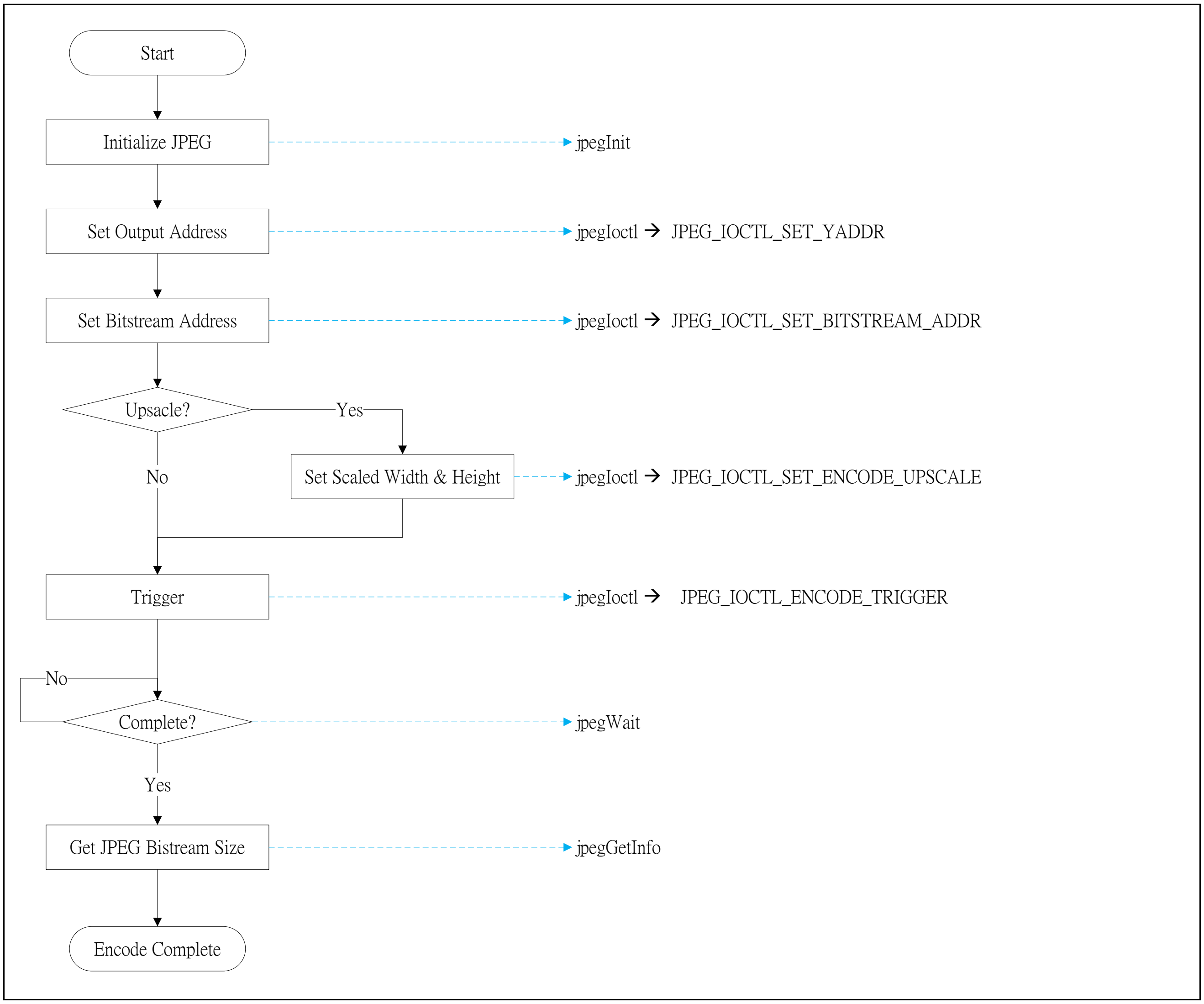

Frame Memory
Starting address
Stride
Stride
Stride
Stride
Line 1
Line 2
Line 3
Line 4
Line 5
Decoded Image (Raw data)
Line 1
Line 2
Line 3
Line 4
Line 5

User can use stride function to output decoded image to any position on the Display Frame Buffer for Display. Following figure shows the decode mode with stride to output the decoded raw data on the Display Frame Buffer.

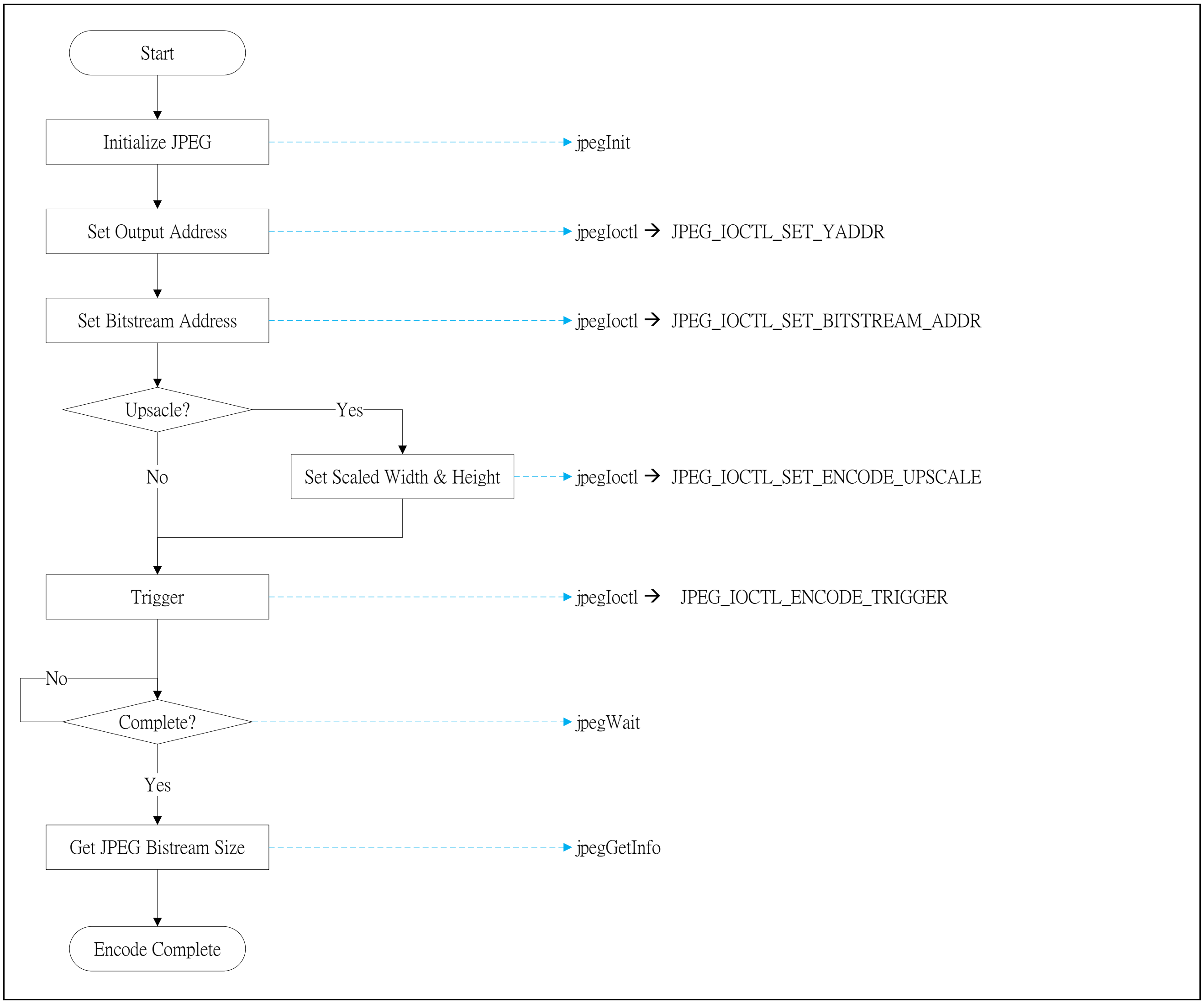


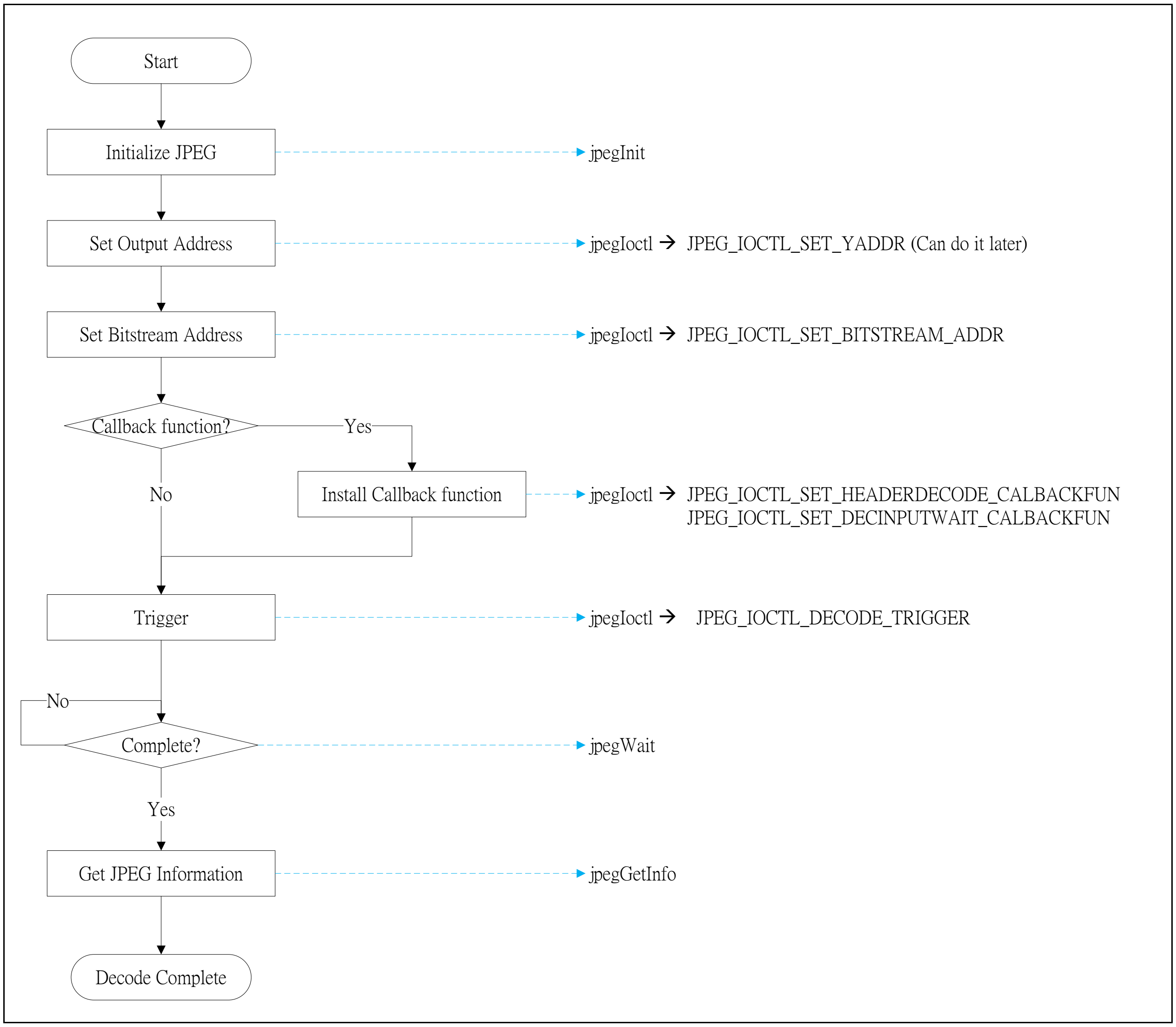


7.3.3.2 Encode operation flow



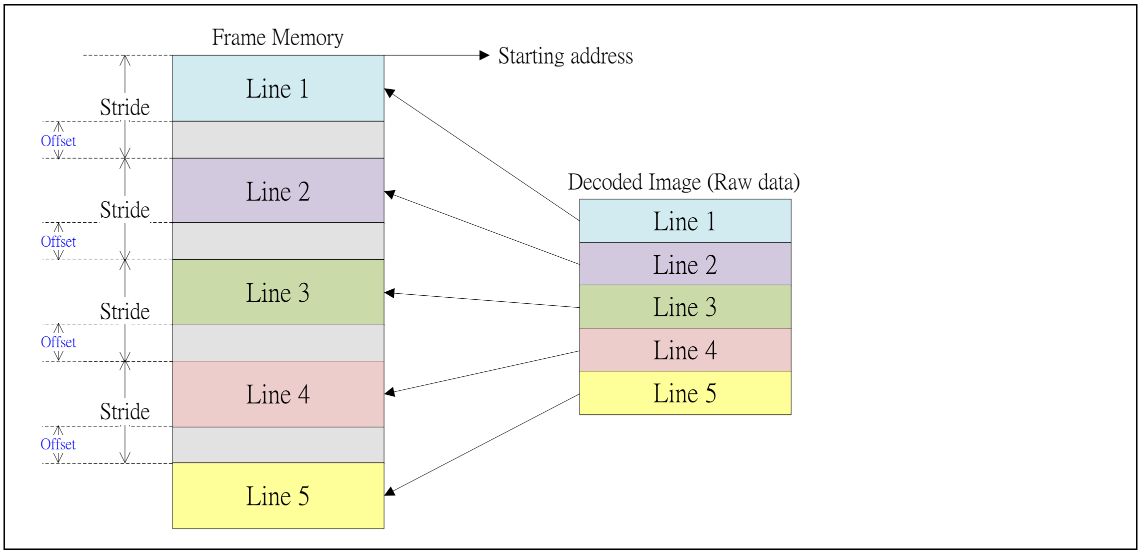
7.3.3.3 Decode operation flow

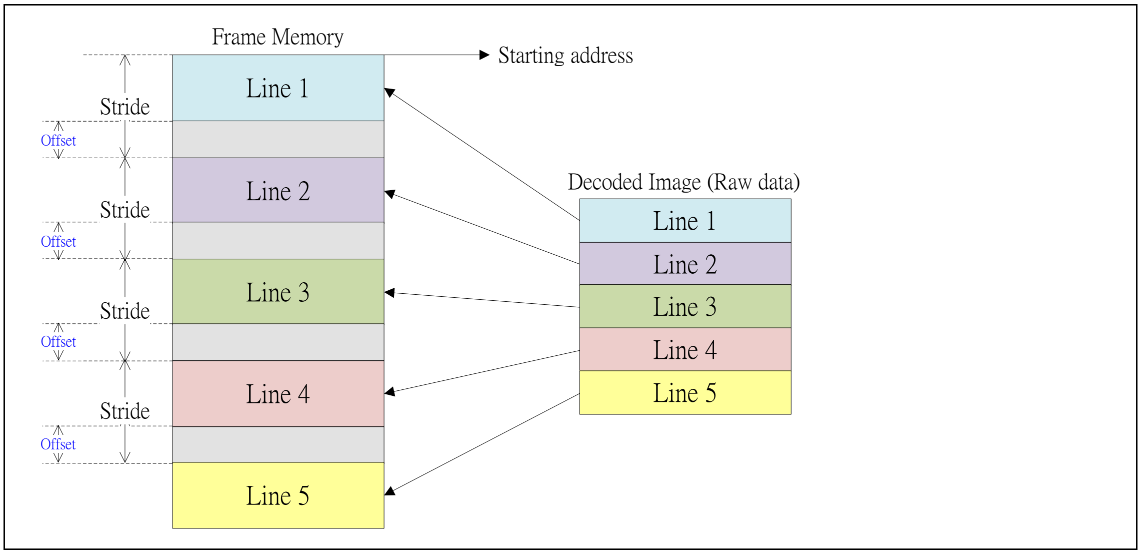



Start
Initialize JPEG
jpegInit
Set Output Address
jpegIoctl → JPEG_IOCTL_SET_YADDR (Can do it later)
Set Bitstream Address
jpegIoctl → JPEG_IOCTL_SET_BITSTREAM_ADDR
Callback function?
Yes
No
Install Callback function
jpegIoctl → JPEG_IOCTL_SET_HEADERDECODE_CALBACKFUN
JPEG_IOCTL_SET_DECINPUTWAIT_CALBACKFUN
Trigger
jpegIoctl → JPEG_IOCTL_DECODE_TRIGGER
No
Complete?
jpegWait
Yes
Get JPEG Information
jpegGetInfo
Decode Complete

7.3.3.4 Decode stride

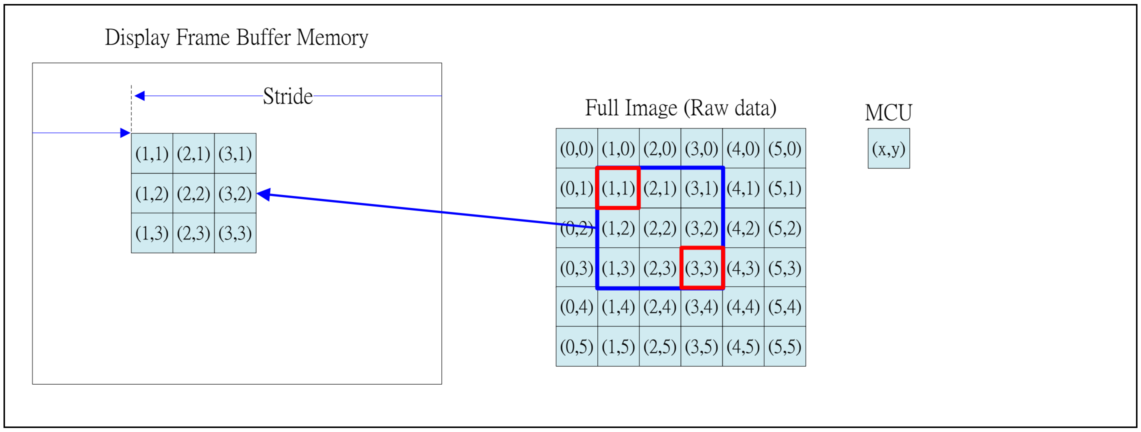
Before clearing Header Decode End interrupt, the value of stride must be set to stride value instead of original width. Offset is the difference between Stride and Image width. If Offset is 0, the decoded raw data is continuous.

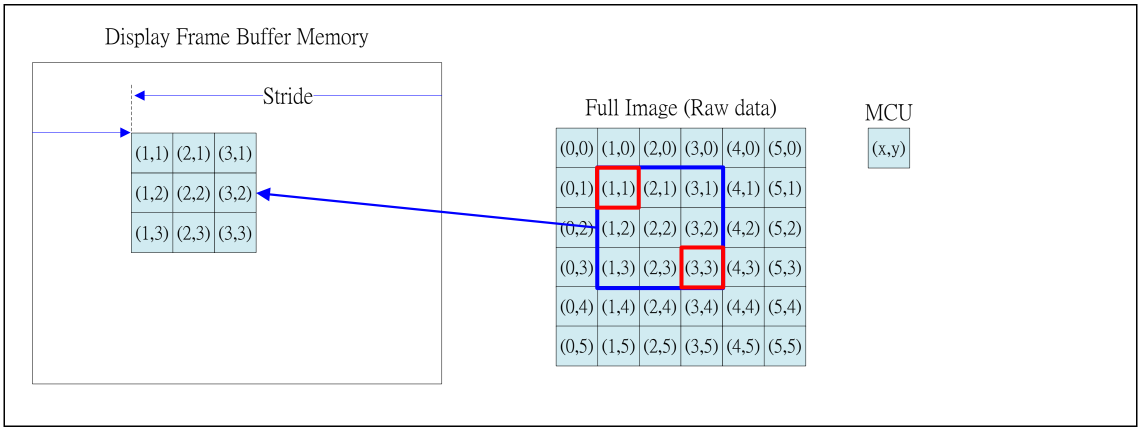




7.3.3.5 Window Decode

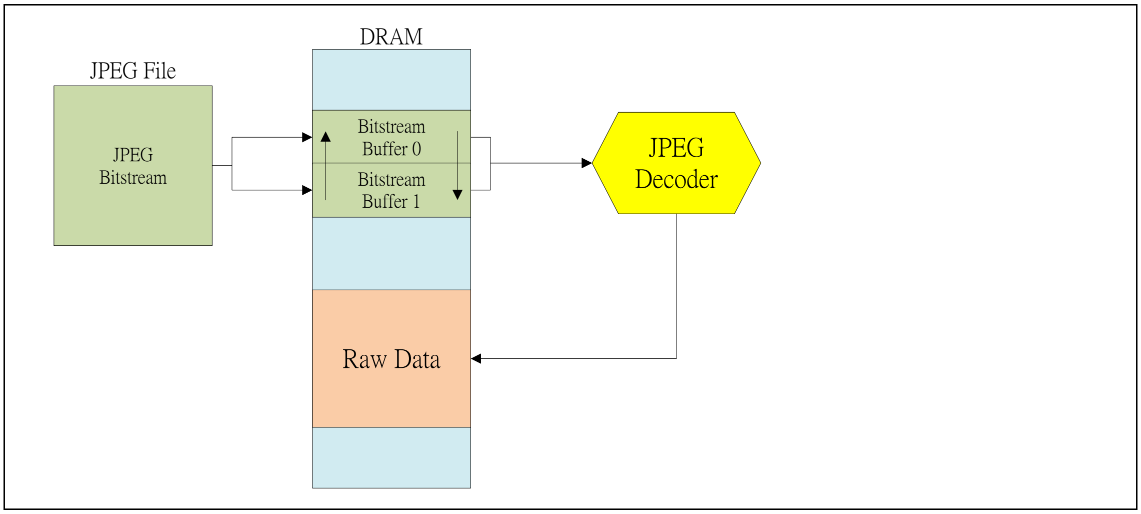
The JPEG decoder supports specified window decode mode. This function allows user to specify a sub-window region within the whole image to be decoded as shown in the following figure. Only the specified window region image will be decoded and stored to frame memory.

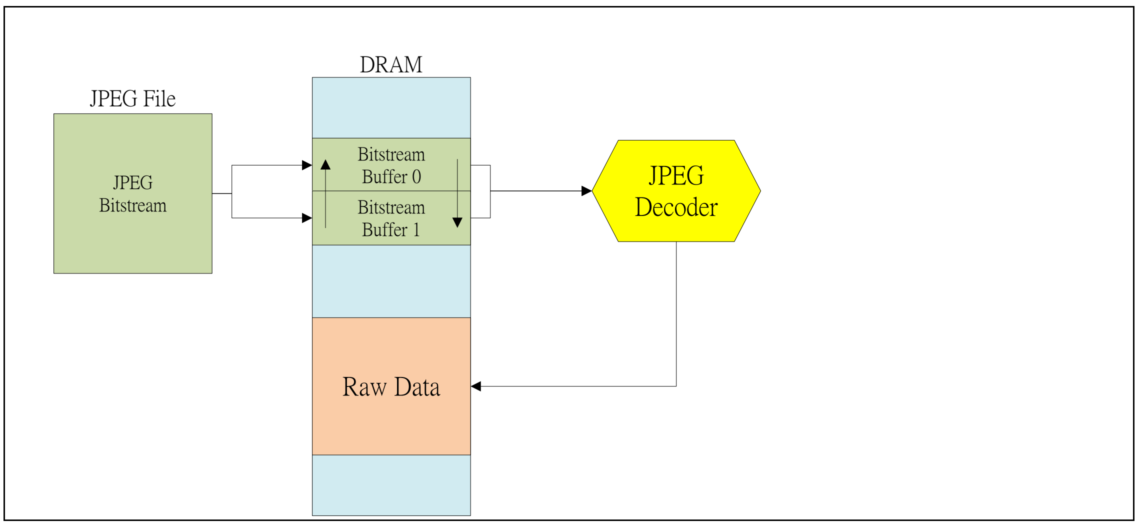




7.3.3.6 Decode Input Wait

When the JPEG is in decoding mode, the input source is the JPEG bit-stream written by host. The bit-stream buffer size is in 2K unit dual-buffer manner. If the buffer-size is 2KB, host need to fill 1KB bit-stream into one of the half buffer region before resuming JPEG operation when an input-wait interrupt is generated.





7.3.3.7 Header Decode Complete

In the callback function, user can get JPEG image width and height by calling jpegGetInfo(). After getting the information, user can use jpegIoctl to

- Allocate and set output buffer → JPEG_IOCTL_SET_YADDR
- Change output buffer address → JPEG_IOCTL_SET_YADDR
- Set Downscale → JPEG_IOCTL_SET_DECODE_DOWNSCALE
- Set Decode output Stride → JPEG_IOCTL_SET_DECODE_STRIDE
- Set windows decode → JPEG_IOCTL_SET_WINDOW_DECODE

7.3.4 JPEG Library Constant Definition

Error Code

Name	Value	Description
E_FAIL	0	Fail
E_SUCCESS	1	Success
E_JPEG_INVALID_PARAM	2	Invalid parameter
E_JPEG_TIMEOUT	3	Time out

Encode operation

Name	Value	Description
Encode format		
JPEG_ENC_PRIMARY	0	Encode operation : Primary JPEG
JPEG_ENC_THUMBNAIL	1	Encode operation : Thumbnail JPEG
JPEG_ENC_SOURCE_PLANAR	0	Encode source : planar format
JPEG_ENC_SOURCE_PACKET	1	Primary Encode source : packet format
JPEG_ENC_PRIMARY_YUV420	0xA0	Primary Encode image format : YUV 4:2:0
JPEG_ENC_PRIMARY_YUV422	0xA8	Primary Encode image format : YUV 4:2:2
JPEG_ENC_PRIMARY_GRAY	0xA1	Primary Encode image format : GRAY
JPEG_ENC_THUMBNAIL_YUV420	0x90	Thumbnail Encode image format : YUV 4:2:0
JPEG_ENC_THUMBNAIL_YUV422	0x98	Thumbnail Encode image format : YUV 4:2:2
JPEG_ENC_THUMBNAIL_GRAY	0x91	Thumbnail Encode image format : GRAY
Encode Header control		
JPEG_ENC_PRIMARY_DRI	0x10	Restart Interval in Primary JPEG Header
JPEG_ENC_PRIMARY_QTAB	0x20	Quantization-Table in Primary JPEG Header
JPEG_ENC_PRIMARY_HTAB	0x40	Huffman-Table in Primary JPEG Header
JPEG_ENC_PRIMARY_JFIF	0x80	JFIF Header in Primary JPEG Header
JPEG_ENC_THUMBNAIL_DRI	0x1	Restart Interval in Thumbnail JPEG Header
JPEG_ENC_THUMBNAIL_QTAB	0x2	Quantization-Table in Thumbnail JPEG Header
JPEG_ENC_THUMBNAIL_HTAB	0x4	Huffman-Table in Thumbnail JPEG Header
JPEG_ENC_THUMBNAIL_JFIF	0x8	JFIF Header in Thumbnail JPEG Header

Decode operation

Name	Value	Description
Decode output format		
JPEG_DEC_PRIMARY_PLANAR_YUV	0x08021	Primary Decode output format : planar format
JPEG_DEC_PRIMARY_PACKET_YUV422	0x00021	Primary Decode output format : planar YUV422
JPEG_DEC_PRIMARY_PACKET_RGB555	0x04021	Primary Decode output format : packet RGB555
JPEG_DEC_PRIMARY_PACKET_RGB565	0x06021	Primary Decode output format : packet RGB565
JPEG_DEC_PRIMARY_PACKET_RGB888	0x14021	Primary Decode output format : packet RGB888
JPEG_DEC_THUMBNAIL_PLANAR_YUV	0x08011	Thumbnail Decode output format : planar YUV
JPEG_DEC_THUMBNAIL_PACKET_YUV422	0x00031	Thumbnail Decode output format : packet RGB555
JPEG_DEC_THUMBNAIL_PACKET_RGB555	0x40031	Thumbnail Decode output format : packet RGB565
JPEG format		
JPEG_DEC_YUV420	0x000	JPEG format is YUV420
JPEG_DEC_YUV422	0x100	JPEG format is YUV422
JPEG_DEC_YUV444	0x200	JPEG format is YUV444
JPEG_DEC_YUV411	0x300	JPEG format is YUV411
JPEG_DEC_GRAY	0x400	JPEG format is Gray
JPEG_DEC_YUV422T	0x500	JPEG format is YUV422 Transport

7.3.5 JPEG Library Property Definition

The JPEG library provides the property structure to set JPEG property.

JPEG_INFO_T;

Name	Value	Description
yuvformat	JPEG_DEC_YUV420 JPEG_DEC_YUV422 JPEG_DEC_YUV444 JPEG_DEC_YUV411 JPEG_DEC_GRAY JPEG_DEC_YUV422T	JPEG format (Decode only)
width	< 8192	Decode Output width (Decode only)
height	< 8192	Decode Output height (Decode only)
jpeg_width	< 65535	JPEG width (Decode only)
jpeg_height	< 65535	JPEG height (Decode only)
stride	< 8192	Decode output Stride (Decode only)
bufferend	Reserved	Reserved

image_size[2]	< 2^{24} -1	Encode Bitstream Size (Encode Only)

The JPEG library provides window decode function, user can partially decode the JPEG image by MCU unit (16 pixels *16 pixels).

JPEG_WINDOW_DECODE_T

Name	Value	Description
u16StartMCUX	0~511	Decode MCU Horizontal Start index
u16StartMCUY	0~511	Decode MCU Vertical Start index
u16EndMCUX	0~511	Decode MCU Horizontal End index
u16EndMCUY	0~511	Decode MCU Vertical End index
u32Stride	< 8192	Decode output Stride

7.3.6 JPEG Library APIs Specification

jpegOpen

Synopsis

INT jpegOpen(VOID)

Description

This function initializes the software resource, sets the engine clock and enables its interrupt

Parameter

None

Return Value

E_SUCCESS - Always successes

Example

```
jpegOpen();
```

jpegClose

Synopsis

VOID jpegClose(VOID)

Description

Disable clock of JPEG engine and disable its interrupt

Parameter

None

Return Value

None

Example

```
jpegClose();
```

jpegInit

Synopsis

VOID jpegInit(VOID)

Description

Reset JPEG engine and set default value to its registers

Parameter

None

Return Value

None

Example

```
jpegInit();
```

jpegGetInfo

Synopsis

VOID jpegGetInfo(JPEG_INFO_T *info)

Description

This function can get JPEG width and height after header decode completes and get JPEG bit stream size after encode completes.

Parameter

info JPEG Data type pointer stores the returned JPEG header information

Return Value

None

Example

```
JPEG_INFO_T jpegInfo;
/* Get JPEG Header information */
jpegGetInfo(&jpegInfo);
```

jpegWait

Synopsis

INT jpegWait(VOID)

Description

After triggers JPEG engine, application needs to wait the completion flag while JPEG engine completes its job.

Parameter

None

Return Value

E_FAIL	Error happens
E_SUCCESS	Action is done

Example

```
jpegWait();
```

jpegIsReady

Synopsis

BOOL jpegIsReady(VOID)

Description

The function can get the JPEG engine status.

Parameter

None

Return Value

TRUE	Engine is ready
FALSE	Engine is busy

Example

```
jpegIsReady ();
```

jpegSetQTAB

Synopsis

```
INT jpegSetQTAB(
    PUINT8      puQTable0,
    PUINT8      puQTable1,
    PUINT8      puQTable2,
    UINT8       u8num
);
```

Description

The function can specify the Quantization table

Parameter

puQTable0 Specify the address of Quantization table 0

puQTable1 Specify the address of Quantization table 1

puQTable2 Specify the address of Quantization table 2

u8num Specify the number of Quantization table

Return Value

E_SUCCESS : Success

E_JPEG_TIMEOUT : Set Quantization table timeout

Example

```
jpegSetQTAB(g_au8QTable0,g_au8QTable1, 0, 2);
```

jpegIoctl

Synopsis

VOID jpegIoctl(UINT32 cmd, UINT32 arg0, UINT32 arg1)

Description

This function allows programmers configure JPEG engine, the supported command and arguments listed in the table below.

Command	Argument 0	Argument 1	comment
JPEG_IOCTL_SET_YADDR	JPEG Y component frame buffer address		Specify the JPEG Y component frame buffer address.
JPEG_IOCTL_SET_YSTRIDE	JPEG Y component frame buffer stride		Specify the JPEG Y component frame buffer stride
JPEG_IOCTL_SET_USTRIDE	JPEG U component frame buffer stride		Specify the JPEG U component frame buffer stride
JPEG_IOCTL_SET_VSTRIDE	JPEG V component frame buffer stride		Specify the JPEG V component frame buffer stride
JPEG_IOCTL_SET_BITSTREAM_ADDR	JPEG bit stream buffer starting address		Specify the bit stream frame buffer starting address
JPEG_IOCTL_SET_SOURCE_IMAGE_HEIGHT	The encode source image height in pixel		Specify the encode source image height in pixel
JPEG_IOCTL_ENC_SET_HEADER_CONTROL	JPEG_ENC_PRIMARY_DRI JPEG_ENC_PRIMARY_QTAB JPEG_ENC_PRIMARY_HTAB JPEG_ENC_PRIMARY_JFIF		Specify the header information includes in the encoding bit stream
JPEG_IOCTL_SET_DEFAULT_QTAB			Specify the Quantization table
JPEG_IOCTL_SET_DECODE_MODE	JPEG_DEC_PRIMARY_PLANAR_YUV JPEG_DEC_PRIMARY_PACKET_YUV422 JPEG_DEC_PRIMARY_PACKET_RGB555 JPEG_DEC_PRIMARY_PACKET_RGB565		Specify the decoded image output format

	JPEG_DEC_PRIMARY_PACKET_RGB888 JPEG_DEC_THUMBNAIL_PLANAR_YUV JPEG_DEC_THUMBNAIL_PACKET_YUV422 JPEG_DEC_THUMBNAIL_PACKET_RGB555		
JPEG_IOCTL_SET_ENCODE_MODE	JPEG_ENC_SOURCE_PLANAR JPEG_ENC_SOURCE_PACKET	JPEG_ENC_PRIMARY_YUV420 JPEG_ENC_PRIMARY_YUV422	Specify the encode source format and encoding image format
JPEG_IOCTL_SET_DIMENSION	Image height	Image width	Set the encode image dimension or decode output image dimension
JPEG_IOCTL_ENCODE_TRIGGER			Trigger the JPEG operation for encoding
JPEG_IOCTL_DECODE_TRIGGER			Trigger the JPEG operation for decoding
JPEG_IOCTL_WINDOW_DECODE	JPEG_WINDOW_DECODE_T		Enable window decode mode and set the decode window region
JPEG_IOCTL_SET_DECODE_STRIDE	Decode Output Stride (in pixel)		Specify the decode output stride
JPEG_IOCTL_SET_DECODE_DOWNSCALE	Scaled Height	Scaled Width	Set Decode downscale function
JPEG_IOCTL_SET_ENCODE_UPSCALE	Scaled Height	Scaled Width	Set Encode Upscale function
JPEG_IOCTL_SET_HEADERDECODE_CALBACKFUN	Header Decode Complete Call Back function pointer		Set Header Decode Complete Call Back function pointer
JPEG_IOCTL_SET_DECINPUTWAIT_CALBACKFUN	Decode Input Wait Call Back function pointer		Set Decode Input Wait Call Back function pointer
JPEG_IOCTL_ADJUST_QTAB	JPEG_ENC_PRIMARY JPEG_ENC_THUMBNAIL	Quantization-Table Adjustment and control values[0]	Set Quantization-Table Adjustment and control
JPEG_IOCTL_ENC_RESERVED_FOR_SOFTWARE	Reserved size		Reserve memory space for user application
JPEG_IOCTL_SET_UADDR	Address for U Component		Set address for U Component
JPEG_IOCTL_SET_VADDR	Address for V Component		Set address for V Component
JPEG_IOCTL_SET_ENCODE_PRIMARY_RESTART_INTERVAL	Primary Restart interval		Set Primary Restart interval size
JPEG_IOCTL_SET_ENCODE_THUMBNAIL_RESTART_INTERVAL	Thumbnail Restart interval		Set Thumbnail Restart interval size
JPEG_IOCTL_GET_ENCODE_PRIMARY_RESTART_INTERVAL	The pointer to store Primary Restart interval size		Get Primary Restart interval size
JPEG_IOCTL_GET_ENCODE_THUMBNAIL_RESTART_INTERVAL	The pointer to store Thumbnail Restart interval size		Get Thumbnail Restart interval size
JPEG_IOCTL_SET_THUMBNAIL_DIMENSION	Thumbnail Height	Thumbnail Width	Set Thumbnail Dimension
JPEG_IOCTL_SET_ENCODE_SW_OFFSET	Offset		Set Software Encode Offset

JPEG_IOCTL_GET_THUMBNAIL_DIMENSION	The pointer to store Thumbnail Height	The pointer to store Thumbnail Width	Get Thumbnail Dimension
JPEG_IOCTL_GET_ENCODE_SW_OFFSET	The pointer to store Encode Offset		Get Software Encode Offset
JPEG_IOCTL_SET_ENCODE_PRIMARY_DOWNSCALE	Primary Downscaled Height	Primary Downscaled Width	Set Primary Encode downscale Size (Planar format only)
JPEG_IOCTL_SET_ENCODE_THUMBNAIL_DOWNSCALE	Thumbnail Downscaled Height	Thumbnail Downscaled Width	Set Thumbnail Encode downscale Size (Planar format only)
JPEG_IOCTL_SET_ENCODE_PRIMARY_ROTATE_RIGHT			Encode rotate right (Planar format only)
JPEG_IOCTL_SET_ENCODE_PRIMARY_ROTATE_LEFT			Encode rotate left (Planar format only)
JPEG_IOCTL_SET_ENCODE_PRIMARY_ROTATE_NORMAL			Encode no rotate (Planar format only)

Parameter

cmd	Command
arg0	The first argument of the command
arg1	The second argument of the command

Return Value

None

Example

```
/* Set Downscale to QVGA */
jpegIoctl(JPEG_IOCTL_SET_DECODE_DOWNSCALE, 240, 320);

/* Set Decode Stride to Panel width (480 pixels) */
jpegIoctl(JPEG_IOCTL_SET_DECODE_STRIDE, 480, 0);

/* Set Decoded Image Address */
jpegIoctl(JPEG_IOCTL_SET_YADDR, u32FrameBuffer, 0);

/* Set Bit stream Address */
 jpegIoctl(JPEG_IOCTL_SET_BITSTREAM_ADDR, u32BitStream, 0);

/* Set Decode Input Wait mode (Input wait buffer is 8192) */
jpegIoctl(JPEG_IOCTL_SET_DECINPUTWAIT_CALBACKFUN, (UINT32) JpegDecInputWait, 8192);

 /* Decode mode */
jpegIoctl(JPEG_IOCTL_SET_DECODE_MODE, JPEG_DEC_PRIMARY_PACKET_YUV422, 0);
```

```
/* Set JPEG Header Decode End Call Back Function */
jpegIoctl(JPEG_IOCTL_SET_HEADERDECODE_CALBACKFUN, (UINT32) JpegDecHeaderComplete, 0);

/* Trigger JPEG decoder */
jpegIoctl(JPEG_IOCTL_DECODE_TRIGGER, 0, 0);

/* Set Source Y/U/V Stride */
jpegIoctl(JPEG_IOCTL_SET_YSTRIDE, u16Width, 0);
jpegIoctl(JPEG_IOCTL_SET_USTRIDE, u16Width/2, 0);
jpegIoctl(JPEG_IOCTL_SET_VSTRIDE, u16Width/2, 0);

/* Primary Encode Image Width / Height */
jpegIoctl(JPEG_IOCTL_SET_DIMENSION, u16Height, u16Width);

/* Encode upscale 2x */
jpegIoctl(JPEG_IOCTL_SET_ENCODE_UPSCALE, u16Height * 2, u16Width * 2);

/* Set Encode Source Image Height */
jpegIoctl(JPEG_IOCTL_SET_SOURCE_IMAGE_HEIGHT, u16Height, 0);

/* Include Quantization-Table and Huffman-Table */
jpegIoctl(JPEG_IOCTL_ENC_SET_HEADER_CONTROL, JPEG_ENC_PRIMARY_QTAB |
JPEG_ENC_PRIMARY_HTAB, 0);

/* Use the default Quantization-table 0, Quantization-table 1 */
jpegIoctl(JPEG_IOCTL_SET_DEFAULT_QTAB, 0, 0);

Note [0]
8 bits Quantization-Table Adjustment and control value
```

7	6	5	4	3	2	1	0
P_QADJUST				P_QVS			

Bits	Descriptions	
[7:4]	P_QADJUST	Primary Quantization-Table Adjustment If the sum of the position (x, y) of quantization-table is greater than P_QADJUST, the quantization value will be set to 127. Otherwise the value will keep as the original. 8x8 DCT block: x = 0~7, y = 0~7 if ((x+y) > P_QADJUST) => Q' = 127

		else => Q' = Q
[3:0]	P_QVS	Primary Quantization-Table Scaling Control Q' = (P_QVS[3]*2*Q)+(P_QVS[2]*Q)+(P_QVS[1]*Q/2)+(P_QVS[0]*Q/4)

7.4 Example code

This demo code has sample code for “Normal Encode”, “Encode Upscale”, “Normal Decode”, “Decode Downscale”, “Decode Input”, and “Stride” (write/read from SD Card).

Please refer to the JPEG sample code of BSP Non-OS.

8 KPI Library

8.1 Overview

The GPIO library provides a set of APIs to control keypad interface. This library depends on both N9H20 System Library and N9H20 GPIO Library.

8.2 KPI Library APIs Specification Functions

kpi_init

Synopsis

void kpi_init (void)

Description

This function initialized the keypad interface.

Parameter

None

Return Value

None

Example

```
kpi_init();
```

kpi_open

Synopsis

int kpi_open (unsigned int src)

Description

This function is used to open keypad interface. kpi_init() should be called before this function.

Parameter

src External interrupt source for KPI to use

Return Value

Return 0 on success, -1 for parameter error, or duplicate open call

Example

```
/* Assign nIRQ3 for KPI */
kpi_open (3);
```

kpi_close

Synopsis

void kpi_close (void)

Description

This function is used to close keypad interface.

Parameter

None

Return Value

None

Example

```
kpi_close ();
```

kpi_read

Synopsis

int kpi_read (unsigned char mode)

Description

This function is used to read keypad input. It supports both blocking and non-clocking mode.

Parameter

mode	Read mode, KPI_NONBLOCK or KPI_BLOCK

Return Value

Return -1 for unknown read mode or un-opened interface. Return 0 for no key in non-blocking mode. Return key value in other situation.

Example

```
/* Read in blocking mode*/
kpi_read (KPI_BLOCK);
```

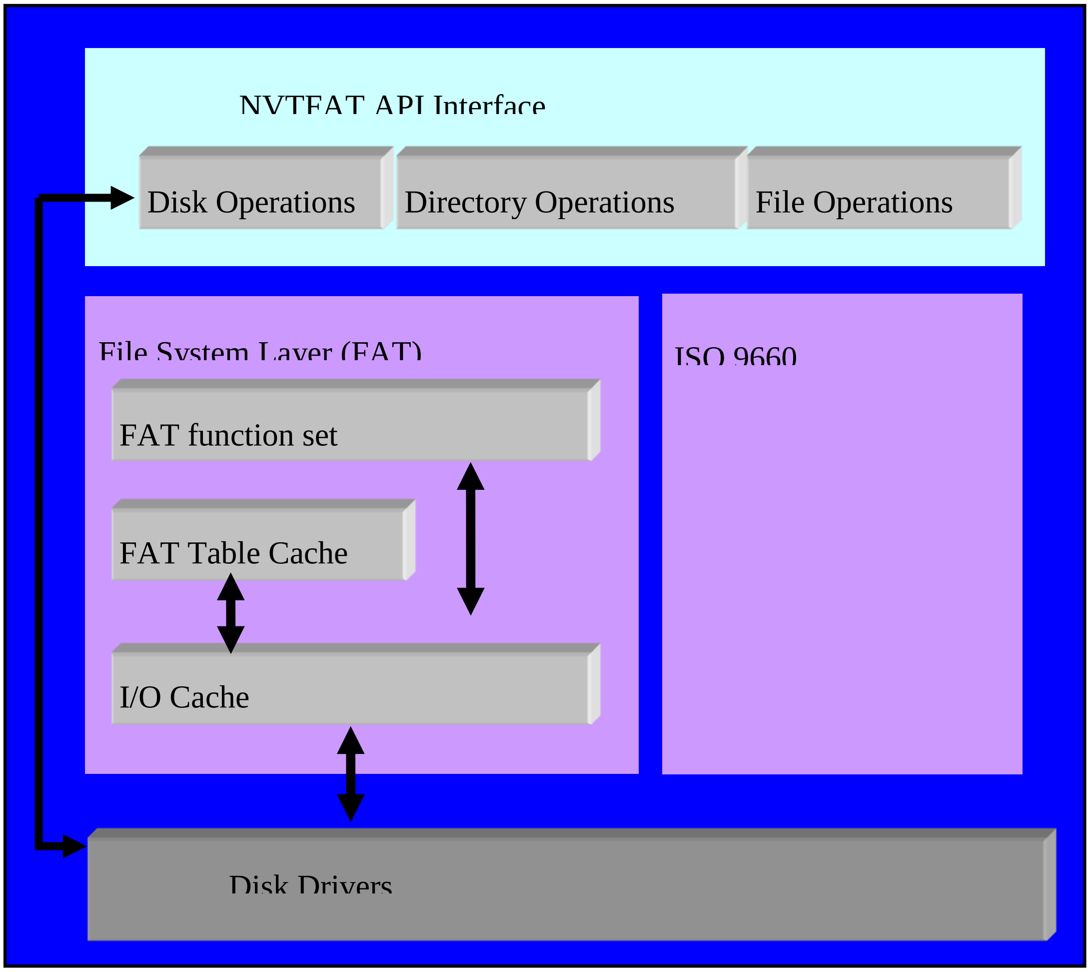
9 NVTFAT Library

9.1 Features

The NVTFAT File System Library has the following features:

- Support FAT12/FAT16/FAT32
- Support multiple disks and multiple partitions
- Dynamically mount and un-mount disk
- Support sub-directory
- Support long file name. The length of file name can be up to 514 characters. The length of file path, including the file name, can be up to 520 characters.
- Can format flash memory cards
- Get disk physical size and free space
- Can open at most 12 files at the same time
- Open files with create, truncate, append
- Create, delete, rename, move, copy, seek, read, and write files
- Enumerate files under a directory
- Get file position and get file status
- Set file size and set file attributes
- Create, rename, remove, and move directories

9.2 General Description



9.3 Initialize File System

To initialize this file system, just invoke *fsInitFileSystem()*. The underlying disk driver should be initialized followed the file system initialization.

9.4 Error Code

Because the file operation may fail due to the various reasons, it's strongly recommended that application should check the return value of each file system API call. The File System Library provides the very detailed error code to indicate the error reasons.

9.5 File Handle

File handle is a handle obtained by opening a file. Application should check the return value of *fsOpenFile()*. If the return value > 0, it's a valid handle. Otherwise, some errors happened for the file open operation. A file handle is valid until the file was closed by *fsCloseFile()*.

9.6 Format Flash Memory Card

The File System Library provides *fsFormatFlashMemoryCard()* to format flash memory card, such as SD, MMC, CF, or Smart Media. This function requires caller to pass a physical disk pointer as parameter, which can be obtained by *fsGetFullDiskInfomation()*.

The format of File System Library was fully compliant to Smart Media disk format standard. The rules of disk formatting are defined in table 2-1.

Disk Size	FAT Type	Cluster Size	Capacity
1 MB	FAT12	4 KB	984 KB
2 MB	FAT12	4 KB	1984 KB
4 MB	FAT12	8 KB	3976 KB
8 MB	FAT12	8 KB	7976 KB
16 MB	FAT12	16 KB	15968 KB
32 MB	FAT12	16 KB	31968 KB
64 MB	FAT12	16 KB	63952 KB
128 MB	FAT16	16 KB	127936 KB
256 MB	FAT16	32 KB	255744 KB
512 MB	FAT16	32 KB	511744 KB
1024 MB	FAT16	32 KB	1023616 KB
2048 MB	FAT16	32 KB	2047288 KB

Table 9-1 Disk Format

9.7 File Operations

Many of the file operations can be done only if the file has been opened. These file operations determine the target by file handle. In this section, all file operations based on file handle will be introduced.

9.7.1 Open File

To read or write a file, applications must first open the file and obtain a file handle, which is an integer. Function *fsOpenFile()* is used to open a file. If the opening file operation succeed, the caller will obtain a file handle, whose value is >= 3000. Otherwise, the call will receive a negative value, which represented an error code (refer to *Error Code Table*).

Function *fsOpenFile()* receives two parameters. The first parameter is the full path file name of the file to be opened. Both long file name or short file name are acceptable and are non-case-sensitive. The full path file name must also include disk number. For example, the full path file name is “C:\\OpenATestFile.txt” or “C:\\OpenAT~1.txt”. The second parameter is combination of control flags. It uses bit-OR to represent various control flags. The control flags and their effectives are listed in Table 2-2.

Flag	Description
O_RDONLY	Open with read capability. In addition, O_DIR and O_APPEND have implicit read capability.
O_WRONLY	Open with write capability. In addition, O_APPEND, O_CREATE, and O_TRUNC have implicit write capability.
O_RDWR	Open with read and write capabilities
O_APPEND	Open an exist file and set the file access position to end of file. O_APPEND has implicit read and write capabilities.

O_CREATE	Open or create a file. If the file did not exist, File System Library would create it. Otherwise, if the file existed, File System Library would just open it and set file access position to start of file. O_CREATE has implicit write capability.
O_TRUNC	Open an existed file and truncate it. If the file did not exist, return an error code. If the file existed, open it. O_TRUNC has implicit write capability.
O_FSEEK	File system will create cluster chain for this file to speed up file seeking operation. It will allocate 1KB extra memory.

Table 9-2 File open control flags

9.7.2 File Access Position

Each opened file has one and only one access position. Subsequent *fsReadFile()* and *fsWriteFile()* operations are started from the file access position. File access position can be obtained by *fsGetFilePosition()* and can be changed by *fsFileSeek().*

When a file was opened, the file access position was initially set as 0, that is, start of file. The only exception is a file opened with O_APPEND flag. In this case, the file access position will be set as end of file.

When file access position is at the end of file, *fsReadFile()* will result in EOF error, while *fsWriteFile()* will extend the file size.

9.7.3 Read File

A file can be read after it was opened. *fsReadFile()* was used to read data from a file. It receives a file handle as the first parameter, which was previously obtained by *fsOpenFile()*. The general scenario of reading files is:

fsOpenFile() → fsReadFile() → fsCloseFile()

9.7.4 Write File

A file can be written after it was opened with write capability. *fsWriteFile()* was used to write data to a file. It receives a file handle as the first parameter, which was previously obtained by *fsOpenFile()*. The general scenario of writing files is:

fsOpenFile() → fsWriteFile() → fsCloseFile()

9.7.5 Directory Operations

File System Library supports sub-directory and provides supporting routines to manage directories. It supports directory creation, remove, rename, and move.

9.7.6 Create/Remove Directorys

fsMakeDirectory() can be used to create a new directory. Directory name can be long file name, and the name must not be conflicted with any existed files or sub-directories under the same directory.

fsRemoveDirectory() can be used to remove an empty directory. If there are some files or sub-directories under the directory to be removed, an error will be received. Root directory cannot be removed.

9.7.7 Move/Rename Directories

A directory can be completely moved from a directory to another directory. *fsMoveFile()* can be used to move directory. All files and sub-directories under that directory will be completely moved at the same time. If the target directory contained a file or directory whose name was conflicted with the directory to be moved, the operation will be canceled.

A directory can be renamed with *fsRenameFile()*. If the new name will be conflicted with any existed files or directories under the same directory, the operation will be canceled.

9.7.8 Delete/Rename/Move Files

A file can be deleted with *fsDeleteFile()*. All disk space occupied by this file will be released immediately and can be used by other files.

A file can be moved from a directory to another directory with *fsMoveFile()*. If the target directory contained a file or directory whose name was conflicted with the file to be moved, the operation will be canceled.

A file can be renamed with *fsRenameFile()*. If the name will be conflicted with any existed files or directories under the same directory, the operation will be canceled.

9.7.9 Enumerate Files In a Directory

File System Library provides a set of functions to support the enumerating files under a specific directory. These functions are ***FSFINDFIRST()***, ***FSFINDNEXT()***, and ***FSFINDCLOSE()***.

Firstly user uses ***FSFINDFIRST()*** to specify the directory to be searched, and specify search conditions. If there is any file or sub-directory to match the search conditions, ***FSFINDFIRST()*** will return 0 and user can obtain a file-find object (FILE_FIND_T) . The file-find object contains the information of the first found file, including the file name and attributes. User can use the same file-find object to do the subsequent searches by calling ***FSFINDNEXT().*** Each call to ***FSFINDNEXT()*** will obtain a newly found file or sub-directory, if it returns 0. ***FSFINDNEXT()*** returns non-zero value means that there is no any other file or sub-directory to match the search conditions and the file enumeration should be terminated. User should call ***FSFINDCLOSE()*** to terminate a search series.

9.8 File System Library APIs Specification

9.8.1 Disk Operations

fsPhysicalDiskConnected

Synopsis

INT fsPhysicalDiskConnected(PDISK_T *ptPDisk)

Description

Register and parsing a newly detected disk.

Parameter

ptPDisk	The pointer refers to the physical disk descriptor

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
STORAGE_DRIVER_T SD0DiskDriver =
{/* SD driver low level operation API */
    sd_disk_init0,
    sd_disk_read0,
    sd_disk_write0,
    sd_disk_ioctl0
};
/* Reference SIC driver */
```

```
pDisk->szManufacture[0] = '\0';
strcpy(pDisk->szProduct, (char *)pSDDisk->product);
strcpy(pDisk->szSerialNo, (char *)pSDDisk->serial);
pDisk->nDiskType = DISK_TYPE_SD_MMC;
pDisk->nPartitionN = 0;
pDisk->ptPartList = NULL;
pDisk->nSectorSize = 512;
pDisk->uTotalSectorN = pSDDisk->totalSectorN;
pDisk->uDiskSize = pSDDisk->diskSize;

pDisk->ptDriver = &_SD0DiskDriver; /* register low level operation API
*/
fsPhysicalDiskConnected(pDisk);
…
```

fsPhysicalDiskDisconnected

Synopsis

INT fsPhysicalDiskDisconnected(PDISK_T *ptPDisk)

Description

Flush I/O cache and unlink logical disk as remove physical disk

Parameter

ptPDisk	The pointer refers to the physical disk descriptor

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
static INT  ram_disk_init(PDISK_T *ptPDisk)
{
   return 0;
}
static INT  ram_disk_ioctl(PDISK_T *ptPDisk, INT control, VOID *param)
{
   return 0;
}
static INT  ram_disk_read(PDISK_T *ptPDisk, UINT32 uSecNo,
                                                  INT nSecCnt, UINT8
*pucBuff)
```

```
{
   memcpy(pucBuff, (UINT8 *)(_RAMDiskBase + uSecNo * 512), nSecCnt * 512);
   return FS_OK;
}
static INT  ram_disk_write(PDISK_T *ptPDisk, UINT32 uSecNo,
                                                INT nSecCnt, UINT8 *pucBuff, BOOL bWait)
{
   memcpy((UINT8 *)(_RAMDiskBase + uSecNo * 512), pucBuff, nSecCnt * 512);
   return FS_OK;
}
STORAGE_DRIVER_T  _RAMDiskDriver =
{
   ram_disk_init,
   ram_disk_read,
   ram_disk_write,
   ram_disk_ioctl,
};
static PDISK_T         *ptRAMDisk;
INT32 RemoveRAMDisk(void)
{
   fsPhysicalDiskDisconnected(ptRAMDisk);
   return 0;
}
```

fsUnmountPhysicalDisk

Synopsis

INT fsUnmountPhysicalDisk(PDISK_T *ptPDisk)

Description

Flush I/O cache and unlink logical disk as remove physical disk. The function is almost same as function-fsPhysicalDiskDisconnected

Parameter

ptPDisk The pointer refers to the physical disk descriptor

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
PDISK_T *pDisk_SD0 = NULL;
/* Reference SIC driver */
/* Detect Card insert */
…
pDisk_SD0 = pDisk;
fsPhysicalDiskConnected(pDisk);
…
…
/* Detect Card remove */
fsUnmountPhysicalDisk(pDisk_SD0);
free(pDisk_SD0);
pDisk_SD0 = NULL;
```

fsDiskFreeSpace

Synopsis

INT fsDiskFreeSpace(INT nDriveNo, UINT32 *puBlockSize,
UINT32 *puFreeSize, INT32 *puDiskSize);

Description

Format a flash memory card by FAT12/FAT16/FAT32 format. NVTFAT will first create a MBR for this disk and configure it to be the single partition. Then NVTFAT will format it to be FAT12/FAT16 format.

Parameter

ptPDisk Get free space of disk <driveNo>

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
UINT32 uBlockSize, uFreeSize, uDiskSize;
...
if (fsDiskFreeSpace (‘C’, &blockSize, &freeSize,
&diskSize) == FS_OK)
    sysprintf(“Disk C block size=%d, free space=%d MB,
   disk size=%d MB\n”, blockSize, (INT)freeSize/1024,
   (INT)diskSize/1024;
```

fsFormatFlashMemoryCard

Synopsis

INT fsFormatFlashMemoryCard(PDISK_T *ptPDisk);

Description

Format a flash memory card by FAT12/FAT16/FAT32 format. NVTFAT will first create a MBR for this disk and configure it to be the single partition. Then NVTFAT will format it to be FAT12/FAT16 format.

Parameter

ptPDisk The pointer refers to the physical disk descriptor.

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
PDISK_T      *ptPDiskList, *ptPDisk;
PARTITION_T  *ptPartition;

/* Get complete disk information */
ptPDiskList = fsGetFullDiskInfomation();

/* Format the first physical disk */
ptPartition = ptPDiskList;
ptPDisk = ptPDiskList;     /* format the first physical disk */
fsFormatDiskPartition(ptPDisk);
/* Release allocated memory */
fsReleaseDiskInformation(pDiskList);
```

fsTwoPartAndFormatAll

Synopsis

INT fsTwoPartAndFormatAll(PDISK_T *ptPDisk,
INT firstPartSize,
INT secondPartSize);

Description

Configure the disk to be two partitions and format these two partitions as FAT32 format. If the total sizes of these two partitions are larger than disk size, NVTFAT will automatically shrink the size of the second partition to fit disk size.

Parameter

ptPDisk The pointer refers to the physical disk descriptor.

firstPartSize The size (in KBs) of the first partition

secondPartSize The size (in KBs) of the second partition.

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
PDISK_T      *ptPDiskList, *ptPDisk;
PARTITION_T  *ptPartition;

/* Get complete disk information */
ptPDiskList = fsGetFullDiskInfomation();

/* Format the first physical disk */
ptPartition = ptPDiskList;
ptPDisk = ptPDiskList;      /* format the first physical disk */
fsTwoPartAndFormatAll(ptPDisk, 2048, 10240);

/* Release allocated memory */
fsReleaseDiskInformation(pDiskList);
```

fsAssignDriveNumber

Synopsis

```
INT   fsAssignDriveNumber (INT nDriveNo,
                           INT disk_type,
                           INT instance,
                           INT partition)
```

Description

Claim the drive number assignment. This API must be called prior to fsInitFileSystem().

Parameter

nDriveNo The drive number. Valid number is ‘A’ ~ ‘Z’.

disk_type Disk type defines in nvtfat.h. Prefixed with “DISK_TYPE_”.

For example, NAND disk type is DISK_TYPE_SMART_MEDIA

instance The disk instance of specified <disk_type>, start from 0.

For example, the first NAND disk is instance 0, the second NAND is instance 1

Partition Which partition of the specified <disk_type><instance>.

The first partition is 1, the second partition is 2, and so on.

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
// SD0 first partition => C
fsAssignDriveNumber('C', DISK_TYPE_SD_MMC, 0, 1);

// NAND0 first partition => E
fsAssignDriveNumber('E', DISK_TYPE_SMART_MEDIA, 0, 1);

// NAND1 first partition => H
fsAssignDriveNumber('H', DISK_TYPE_SMART_MEDIA, 1, 1);

// NAND1 second partition => I
fsAssignDriveNumber('I', DISK_TYPE_SMART_MEDIA, 1, 2);
```

fsFormatFixedDrive

Synopsis

INT fsFormatFixedDrive (INT nDriveNo)

Description

Format the specified drive. The drive number must be have been successfully assigned by fsAssignDriveNumber().

Parameter

nDriveNo The drive number. Valid number is 'A' ~ 'Z'.

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
#define DISK_TYPE_SMART_MEDIA  0x00000008 // defined in nvtfat.h
#define DISK_TYPE_SD_MMC       0x00000020 // defined in nvtfat.h

fsAssignDriveNumber('C', DISK_TYPE_SD_MMC, 0, 1);
fsAssignDriveNumber('E', DISK_TYPE_SMART_MEDIA, 0, 1);

fsFormatFixedDrive('C');
fsFormatFixedDrive('E');
```

fsGetFullDiskInfomation

Synopsis

PDISK_T   *fsGetFullDiskInfomation(VOID)

Description

Get the complete information list of physical disk, disk partitions, and logical disk information. The returned PDISK_T pointer was referred to a dynamically allocated memory, which contains the complete disk information list. Note that caller is responsible to deallocate it by calling fsReleaseDiskInformation().

Parameter

None

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

```
PDISK_T       *pDiskList, *ptPDiskPtr;
PARTITION_T   *ptPartition;
INT           nDiskIdx = 0;
INT           nPartIdx;
ptPDiskPtr = pDiskList = fsGetFullDiskInfomation();
while (ptPDiskPtr != NULL)
{
   sysprintf("\n\n=== Disk %d (%s) ======================\n",
         nDiskIdx++, (ptPDiskPtr->nDiskType &
         DISK_TYPE_USB_DEVICE) ? "USB" : "IDE");
   sysprintf("    name:     [%s%s]\n", ptPDiskPtr->szManufacture,
         ptPDiskPtr->szProduct);
   sysprintf("    head:     [%d]\n", ptPDiskPtr->nHeadNum);
   sysprintf("    sector:   [%d]\n", ptPDiskPtr->nSectorNum);
   sysprintf("    cylinder: [%d]\n", ptPDiskPtr->nCylinderNum);
   sysprintf("    size:     [%d MB]\n", ptPDiskPtr->uDiskSize / 1024);

ptPartition = ptPDiskPtr->ptPartList;
   nPartIdx = 1;
   while (ptPartition != NULL)
   {
         sysprintf("\n    --- Partition %d --------------------\n",
               nPartIdx++);
         sysprintf ("       active: [%s]\n",
```

```
            (ptPartition->ucState & 0x80) ? "Yes" : "No");
sysprintf("       size:   [%d MB]\n",
            (ptPartition->uTotalSecN / 1024) / 2);
sysprintf("       start:  [%d]\n", ptPartition->uStartSecN);
sysprintf("       type:   ");
ptPartition = ptPartition->ptNextPart;
   }
   ptPDiskPtr = ptPDiskPtr->ptPDiskAllLink;
}
fsReleaseDiskInformation(pDiskList);
```

fsReleaseDiskInformation

Synopsis

VOID fsReleaseDiskInformation(PDISK_T *ptPDiskList)

Description

Release the memory allocated by fsGetFullDiskInfomation().

Parameter

ptPDiskList	The PDISK_T pointer returned by the previous call to fsGetFullDiskInfomation()

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

See example code of fsGetFullDiskInfomation()

fsReleaseDiskInformation

Synopsis

VOID fsReleaseDiskInformation(PDISK_T *ptPDiskList)

Description

Release the memory allocated by fsGetFullDiskInfomation().

Parameter

ptPDiskList	The PDISK_T pointer returned by the previous call to fsGetFullDiskInfomation()

Return Value

0 – Success

Otherwise – error code defined in Error Code Table

Example

See example code of fsGetFullDiskInfomation()

fsInitFileSystem

Synopsis

VOID fsInitFileSystem(VOID)

Description

Initialize file system.

Parameter

None

Return Value

None

Example

```
sysEnableCache(CACHE_WRITE_THROUGH);
fsInitFileSystem();
fmiInitDevice();
fmiInitSDDevice();
```

fsFixDriveNumber

Synopsis

INT fsFixDriveNumber(CHAR sd_drive,
CHAR sm_drive,
CHAR cf_drive)

Description

Specify the fixed driver number of SD card, SM/NAND, and CF. If the specified drive number was used, NVTFAT will find other driver number for it. This API must be called prior to fsInitFileSystem().

Parameter

sd_drive	'A' ~ 'Z'
sm_drive	'A' ~ 'Z'
cf_drive	'A' ~ 'Z'

Return Value

0	Success

ERR_DRIVE_INVALID_NUMBER invalid drive number one

Example

```
fsFixDriveNumber('D', 'C', 'F');
fsInitFileSystem();
```

fsSetReservedArea

Synopsis

INT fsSetReservedArea(UINT32 u32StartSector)

Description

Specify the start sector in file system.

Parameter

u32StartSector Start sector of file system. To set the start sector is only for special application. The reserved space may store some binary image or data for booting. The function should be called before format disk.

Return Value

Success

Example

```
#define RESERVED_SIZE  (1024*1024)

fsSetReservedArea(RESERVED_SIZE/512);/* Start sector from 2048 sector */
pDiskList = fsGetFullDiskInfomation();
fsFormatFlashMemoryCard(pDiskList);
```

9.9 File/Directory Operations

fsCloseFile

Synopsis

INT fsCloseFile(INT hFile)

Description

Close a file, that was previously opened by fsOpenFile().

Parameter

hFile The file handle of the file to be closed.

Return Value

FS_OK – Success

Otherwise – error code defined in Error Code Table

Example

Refer to the example of fsOpenFile().

fsDeleteFile

Synopsis

INT fsDeleteFile(CHAR *suFileName, CHAR *szAsciiName)

Description

Delete a file.

Parameter

suFileName The Unicode full path of file name for the file to be opened.

The file name must include its absolute full path with drive number specified. The full path file name must be ended with two 0x00 character.

szAsciiName The ASCII version name of <suFileName> excluding the file path. This parameter is optional. Caller must set this parameter as NULL if it was not used. If caller did not give the ASCII name, NVTFAT will generate the ASCII version name from the <suFileName>. Note that if two-bytes code language was used in <suFileName>, NVTFAT generated ASCII version name will be incorrect. It was suggested to set this parameter if two-bytes code language contained in <suFileName>

Return Value

FS_OK – Success

Otherwise – error code defined in Error Code Table

Example

```
CHAR  suFileName[] = { ‘C’, 0, ‘:’, 0, ‘\\’, 0, ‘l’, 0, ‘o’, 0,
             ‘g’, 0, ‘.’, 0, ‘t’, 0, ‘x’, 0, ‘t’, 0, 0, 0};
INT  nStatus;
/* Delete file C:\log.txt */
nStatus = fsDeleteFile(suFileName, NULL);
if (nStatus < 0)
   sysprintf(“Cannot delete file log.txt!\n”);
```

fsFileSeek

Synopsis

INT64 fsFileSeek(INT64 hFile, INT n64Offset, INT16 usWhence)

Description

Set the current read/write position of an opened file.

Parameter

hFile The file handle of the file to be closed.

n64Offset Byte offset from the position indicated by <usWhence>

usWhence Seek position base

Table 9-3: Seek Position Base

usWhence	Description
SEEK_SET	"file offset 0" + <n64Offset>
SEEK_CUR	file current position" + <n64Offset>
SEEK_END	"end of file position"+ <n64Offset>

Return Value

0 Success

Otherwise error code defined in Error Code Table

Example

```
INT    hFile, nReadLen;
CHAR  suFileName[] = { 'C', 0, ':', 0, '\\', 0, 'l', 0, 'o', 0,
             'g', 0, '.', 0, 't', 0, 'x', 0, 't', 0, 0, 0};
UINT8  pucBuff[64];

if ((hFile = fsOpenFile(suFileName, NULL, O_RDONLY) < 0)
   return hFile;
/* read 10 bytes from file offset 1000 */
fsFileSeek(hFile, 1000, SEEK_SET);
fsReadFile(hFile, pucBuff, 10, &nReadLen)
fsCloseFile(hFile);
```

fsIsEOF

Synopsis

BOOL fsIsEOF(INT hFile)

Description

Check whether the file pointer has reached the end of file or not.

Parameter

hFile The file handle of the file.

Return Value

TRUE It's end of file.

FALSE It's not end of file.

Example

Refer to the example of fsFindFirst().

fsFindClose

Synopsis

INT fsFindClose(FILE_FIND_T *ptFindObj)

Description

Close a search series.

Parameter

ptFindObj The file-search object obtained by previous fsFindFirst() call.

Return Value

FS_OK Success.

Otherwise Error code defined in Error Code Table

Example

Refer to the example of fsFindFirst().

fsFindFirst

Synopsis

```
INT fsFindFirst (CHAR *suDirName,
                 CHAR *szAsciiName,
                 FILE_FIND_T *ptFindObj)
```

Description

Start a file search and get the first file/directory entry found.

Parameter

suDirName The Unicode full path name of the directory to be searched. The name must include its absolute full path with drive number specified. The full path name must be ended with two 0x00 characters.

szAsciiName The ASCII version name of <suDirName> excluding the path part. This parameter is optional. Caller must set this parameter as NULL if it was not used. If caller did not give the ASCII name, NVTFAT will generate the ASCII version name from the <suDirName>. Note that if two-bytes code language was used in <suDirName>, NVTFAT generated ASCII version name will be incorrect. It was suggested to set this parameter if two-bytes code language contained in <suDirName>.

ptFindObj caller prepares file/directory entry container.

Return Value

0 Success

Otherwise error code defined in Error Code Table

Example

```
INT  ListDir(CHAR *szPath)
{
    INT           nIdx, nStatus;
    CHAR          szMainName[12], szExtName[8], *pcPtr;
    FILE_FIND_T   tFileInfo;
    nStatus = fsFindFirst(szPath, NULL, &tFileInfo);
    if (nStatus < 0)
            return nStatus;
    do
    {
    pcPtr = tFileInfo.szShortName;
    if ((tFileInfo.ucAttrib & A_DIR) &&
    (!strcmp(pcPtr, ".") || !strcmp(pcPtr, "..")))
    strcat(tFileInfo.szShortName, ".");
    memset(szMainName, 0x20, 9);
    szMainName[8] = 0;
    memset(szExtName, 0x20, 4);
    szExtName[3] = 0;
    i = 0;
    while (*pcPtr && (*pcPtr != '.'))
    szMainName[i++] = *pcPtr++;
    if (*pcPtr++)
    {
            nIdx = 0;
            while (*pcPtr)
```

```
            szExtName[nIdx++] = *pcPtr++;
    }
            if (tFileInfo.ucAttrib & A_DIR)
sysprintf("%s %s     <DIR>  %02d-%02d-%04d  %02d:%02d  %s\n",
szMainName, szExtName, tFileInfo.ucWDateMonth,
                  tFileInfo.ucWDateDay, tFileInfo.ucWDateYear+80)%100 ,
                  tFileInfo.ucWTimeHour, tFileInfo.ucWTimeMin,
                  tFileInfo.szLongName);
            else
                  sysprintf("%s %s %10d  %02d-%02d-
%04d  %02d:%02d  %s\n",
                  szMainName, szExtName, (UINT32)tFileInfo.nFileSize,
                  tFileInfo.ucWDateMonth, tFileInfo.ucWDateDay,
                  (tFileInfo.ucWDateYear+80)%100, tFileInfo.ucWTimeHour,
                  tFileInfo.ucWTimeMin, tFileInfo.szLongName);
    } while (!fsFindNext(&tFileInfo));
    fsFindClose(&tFileInfo);
}
```

fsFindNext

Synopsis

INT fsFindNext(FILE_FIND_T *ptFindObj)

Description

Continue the previous fsFindFirst() file search and get the next matched file. If there's no more match found, the search series will be closed automatically.

Parameter

ptFindObj The file-search object used in the previous fsFindFirst() call.

Return Value

FS_OK – Success

Otherwise – error code defined in Error Code Table

Example

Refer to the example of fsFindFirst().

fsGetFilePosition

Synopsis

INT fsGetFilePosition(INT hFile, UINT32 *puPos)

Description

Get the current read/write position of an opened file.

Parameter

hFile The file handle of the opened file to get file read/write position.

puPos The current read/write position.

Return Value

FS_OK – Success

Otherwise – error code defined in Error Code Table

Example

```
INT     hFile, nStatus;
UINT32  uFilePos;
/* Open a read-only file */
hFile = fsOpenFile(file, O_RDONLY);
fsFileSeek(hFile, 1000, SEEK_SET);
fsGetFilePosition(hFile, &uFilePos);
sysprintf("Current file position is: %d\n", uFilePos);
fsCloseFile(hFile);
```

fsGetFileSize

Synopsis

INT fsGetFileSize(INT hFile)

Description

Get the current size of an opened file.

Parameter

hFile The file handle of the opened file to get size.

Return Value

FS_OK – Success

Otherwise – error code defined in Error Code Table

Example

```
INT     hFile, nStatus;
UINT32  uFilePos;
/* Open a read-only file */
hFile = fsOpenFile(file, O_RDONLY);
sysprintf("The size of %s is %d\n", file, fsGetFileSize(hFile));
fsCloseFile(hFile);
```

fsGetFileStatus

Synopsis

INT fsGetFileStatus(INT hFile,
CHAR *suFileName,
CHAR *szAsciiName,
FILE_STAT_T *ptFileStat)

Description

Get the file status of a specific file or directory.

Parameter

hFile The file handle of the opened file.

suFileName The Unicode full path of file name for the file to be opened. It was used only if <hFile> is < 0.

szAsciiName The ASCII version name of <suFileName> excluding the file path.

ptFileStat Caller prepares the container to receive status of this file.

Return Value

FS_OK – Success

Otherwise – error code defined in Error Code Table

Example

```
          CHAR  suFileName[] = { ‘C’, 0, ‘:’, 0, ‘\\’, 0, ‘l’, 0, ‘o’, 0,
             ‘g’, 0, ‘.’, 0, ‘t’, 0, ‘x’, 0, ‘t’, 0, 0, 0};
FILE_STAT_T  tFileStat;
INT          nStatus
if ((nStatus = fsGetFileStatus(-1, suFileName, NULL , &stat)) < 0)
{
       sysprintf("fsGetFileStatus failed\n”);
          fsGetErrorDescription(nStatus, NULL, 1);
       return nStatus;
}
```

fsMakeDirectory

Synopsis

INT fsMakeDirectory(CHAR *suDirName, CHAR *szAsciiName)

Description

Create a new directory if not exists.

Parameter

suDirName The Unicode full path name of the directory to be created.

szAsciiName The ASCII version name of <suDirName> excluding the path part.

Return Value

FS_OK – Success

Otherwise – error code defined in Error Code Table

Example

```
        CHAR  suDirName[] = { 'C', 0, ':', 0, '\\', 0, 't', 0, 'e', 0,
           'm', 0, 'p', 0, 0, 0};
        /* Create a new directory "temp" under "C:\" */
        fsMakeDirectory(suDirName, NULL);
```

fsMoveFile

Synopsis

```
INT   fsMoveFile(CHAR *suOldName,
                 CHAR *szOldAsciiName,
                 CHAR *suNewName,
                 CHAR *szNewAsciiName,
                 INT bIsDirectory)
```

Description

Move a file or a whole directory.

Parameter

suOldName The Unicode full path name of the file/directory to be moved.

szOldAsciiName The ASCII version name of < suOldName > excluding the path part.

suNewName The Unicode full path name of the old file/directory to be moved to.

szNewAsciiName The ASCII version name of < suNewName > excluding the path part.

bIsDirectory TRUE: is moving a directory; FALSE: is moving a file

Return Value

FS_OK – Success

Otherwise – error code defined in Error Code Table

Example

```
        CHAR  szOldFile[] = "C:\log.txt"
CHAR  szNewFile[] = "C:\temp\log,txt"
CHAR  suOldFile[128], suNewFile[128];

fsAsciiToUnicode(szOldFile, suOldFile, TRUE);
fsAsciiToUnicode(szNewFile, suNewFile, TRUE);
fsMoveFile(suOldFile, NULL, suNewFile, "log.txt", FALSE);
```

fsCopyFile

Synopsis

INT fsCopyFile(CHAR *suSrcName,
CHAR *szSrcAsciiName,
CHAR *suDstName,
CHAR *szDstAsciiName)

Description

Copy a file. (Copy directory was not allowed.)

Parameter

suSrcName	The Unicode full path name of the file to be copied.
szSrcAsciiName	The ASCII version name of < suSrcName > excluding the path part.
suDstName	The Unicode full path name of the file/directory to be generated.
szDstAsciiName	The ASCII version name of < suDsrName > excluding the path part.

Return Value

FS_OK	Success
Otherwise	error code defined in Error Code Table

Example

Refer to the example of fsOpenFile().

fsCloseFile

Synopsis

INT fsCloseFile(INT hFile)

Description

Close a file, that was previously opened by fsOpenFile().

Parameter

hFile The file handle of the file to be closed.

Return Value

FS_OK – Success

Otherwise – error code defined in Error Code Table

Example

None.

fsOpenFile

Synopsis

INT fsOpenFile(CHAR *suFileName, CHAR *szAsciiName,UINT32 uFlag)

Description

Open/Create a file.

Parameter

suFileName The Unicode full path file name of the file to be opened. The file name must include its absolute full path with drive number specified. The full path file name must be ended with two 0x00 character.

szAsciiName The ASCII version name of <suFileName> excluding the file path. This parameter is optional. Caller must set this parameter as NULL if it was not used. If caller did not give the ASCII name, NVTFAT will generate the ASCII version name from the <suFileName>. Note that if two-bytes code language was used in <suFileName>, NVTFAT generated ASCII version name will be incorrect. It was suggested to set this parameter if two-bytes code language contained in <suFileName>.

uFlag

Table 9-4: Open File capability

uFlag	Description
O_ RDONLY	open file with read capability

O_ WRONLY	open file with write capability
O_APPEND	open file with write-append operation, the file position was set to end of file on open
O_CREATE	If the file exists, open it. If the file is not exists, create it.
O_TRUC	Open a file and truncate it, file size becomes 0
O_DIR	open a directory file

Return Value

< 0 error code defined in Error Code Table

Otherwise file handle

Example

```
        INT   hFile;
    CHAR  suFileName[] = { 'C', 0, ':', 0, '\\', 0, 'l', 0, 'o', 0,
                'g', 0, '.', 0, 't', 0, 'x', 0, 't', 0, 0, 0};
    CHAR  szAsciiName[] = "log.txt";
    /* Open a read-only file */
    hFile = fsOpenFile(suFileName, szAsciiName, O_RDONLY);
    if (hFile < 0)
        return hFile;
fsCloseFile(hFile);
```

fsReadFile

Synopsis

INT fsReadFile(INT hFile, UINT8 *pucBuff, INT nBytes, INT *pnReadCnt)

Description

Read <nBytes> of octets from an opened file

Parameter

hFile The file handle of an opened file.

pucBuff Refer to the buffer to receive data read from the specified file

nBytes Number of bytes to read

pnReadCnt Number of bytes actually read.

Return Value

FS_OK Success

Otherwise error code defined in Error Code Table

Example

```
UINT8   pucBuff[4096];
INT     hFileSrc, hFileOut;
INT     nReadLen, nWriteLen, nStatus;
if ((hFileSrc = fsOpenFile("C:\\log.txt", O_RDONLY) < 0)
return hFileSrc;
if ((hFileOut = fsOpenFile("C:\\logcopy.txt", O_CREATE) < 0)
return hFileOut;
while (1)
{
      if ((nStatus = fsReadFile(hFileSrc, pucBuff, 4096,
    &nReadLen) < 0)
                break;
    if ((nStatus = fsWriteFile(hFileOut, pucBuff, nReadLen,
   &nWriteLen);
         break;
   if ((nReadLen < 4096) || (nWriteLen != nReadLen)
         break;
}
fsCloseFile(hFileSrc);
fsCloseFile(hFileOut);
```

fsRemoveDirectory

Synopsis

INT fsRemoveDirectory(CHAR *suDirName, CHAR *szAsciiName)

Description

Remove an empty directory. If the directory is not empty, an ERR_DIR_REMOVE_NOT_EMPTY error will be returned.

Parameter

suDirName The Unicode full path name of the directory to be removed.

szAsciiName The ASCII version name of <suDirName> excluding the path part.

Return Value

FS_OK Success

Otherwise error code defined in Error Code Table

Example

```
CHAR  szDirName[] = "C:\temp"
CHAR  suDirName[128];
```

```
fsAsciiToUnicode(szDirName, suDirName, TRUE);
/* Remove directory “C:\temp” */
nStatus = fsRemoveDirectory(suDirName, “temp”);
```

fsRenameFile

Synopsis

```
INT   fsRenameFile(CHAR *suOldName,
                   CHAR *szOldAsciiName,
                   CHAR *suNewName,
                   CHAR *szNewAsciiName,
                   BOOL bIsDirectory)
```

Description

Rename a file or directory.

Parameter

suOldName The Unicode full path name of the file/directory to be renamed.

szOldAsciiName The ASCII version name of < suOldName > excluding the path part.

suNewName Rename into the Unicode full path name of the file/directory

szNewAsciiName The ASCII version name of < suNewName > excluding the path part.

bIsDirectory TRUE: is renaming a directory; FALSE: is renaming a file.

Return Value

FS_OK Success

Otherwise error code defined in Error Code Table

Example

```
CHAR  szOldFile[] = “C:\log.txt”
CHAR  szNewFile[] = “C:\log2.txt”
CHAR  suOldFile[128], suNewFile[128];

fsAsciiToUnicode(szOldFile, suOldFile, TRUE);
fsAsciiToUnicode(szNewFile, suNewFile, TRUE);
fsRenameFile(suOldFile, NULL, suNewFile, “log2.txt”, FALSE);
```

fsSetFileAttribut

Synopsis

INT fsSetFileAttribute(INT hFile,
CHAR *suFileName,
CHAR *szAsciiName,
UINT8 ucAttrib,
FILE_STAT_T *ptFileStat);

Description

Modify file attribute of a specific file or directory..

Parameter

hFile The file handle of the opened file to be set attribute,

suFileName The Unicode full path of file name for the file to be set attribute.

It was used only if <hFile> is < 0.

szAsciiName The ASCII version name of <suFileName> excluding the file path.

ptFileStat The specified file attribute.

Return Value

FS_OK Success

Otherwise error code defined in Error Code Table

Example

```
CHAR  szFileName[] = “C:\temp”
CHAR  suFileName[128];
FILE_STAT_T  tFileStat;
fsGetFileStatus(-1, suFileName, NULL, &fFileStat)
/* force changing file to be hidden */
tFileStat.ucAttrib |= FA_HIDDEN;
fsSetFileAttribute(-1, suFileName, NULL, &tFileStat);
```

fsSetFileSize

Synopsis

INT fsSetFileSize(INT hFile,
CHAR *suFileName,
CHAR *szAsciiName,
UINT32 nNewSize)

Description

Resize the file size. If specified new size is larger than the current size, NVTFAT will allocate disk space and extend this file. On the other hand, if specified new size is smaller than the current size, this file will be truncated.

Parameter

hFile The file handle of the opened file.

suFileName The Unicode full path of file name for the file to be set size. It was used only if <hFile> is < 0..

szAsciiName The ASCII version name of <suFileName> excluding the file path.

newSize Set the file size to be extended to or truncated.

Return Value

FS_OK Success

Otherwise error code defined in Error Code Table

Example

```
int  ChangeFileSize(INT hFile, INT32 uLen)
{
    if (fsSetFileSize(hFile, NULL, NULL, uLen) < 0)
        sysprintf("fsSetFileSize error!!\n");
}
```

fsSetFileTime

Synopsis

INT fsSetFileTime(INT hFile,
CHAR *suFileName,
CHAR *szAsciiName,
UINT8 ucYear,
UINT8 ucMonth,
UINT8 ucDay,
UINT8 ucHour,
UINT8 ucMin,
UINT8 ucSec);

Description

Set the date/time attribute of a file/directory. Note that fsSetFileTime() will set the last access date and modify date/time, but the create date/time was left unchanged.

Parameter

hFile The file handle of the opened file.

suFileName The Unicode full path of file name for the file to be set time. It was used only if <hFile> is < 0..

szAsciiName The ASCII version name of <suFileName> excluding the file path.

ucYear Years from 1980. For example, for 2003, <year> is equal to 23.

ucMonth 1 <= month <= 12

ucHour 0 <= hour <= 23

ucMin 0 <= min <= 59

unSec 0 <= sec <= 59

Return Value

0 Success

Otherwise error code defined in Error Code Table

Example

None

fsWriteFile

Synopsis

INT fsWriteFile(INT hFile, UINT8 *pucBuff, INT nBytes, INT *pnWriteCnt)

Description

Write <nBytes> bytes data to an opened file

Parameter

hFile The file handle of an opened file.

pucBuff The buffer contains the data to be written

nBytes Number of bytes to written

pnWriteCnt Number of bytes actually written

Return Value

FS_OK Success

Otherwise error code defined in Error Code Table

Example

```
int  CopyFile(int hFileSrc, int hFileOut)
{

   UINT8   pucBuff[4096];
   INT     nReadLen, nWriteLen, nStatus;
```

```
    while (1)
    {
           if (fsReadFile(hFileSrc, pucBuff, 4096, &nReadLen) < 0)
           break;
           fsWriteFile(hFileOut, pucBuff, nReadLen, &nWriteLen);
           if ((nReadLen < 4096) || (nWriteLen != nReadLen)
            break;
    }
}
```

9.10 Language Support

fsUnicodeToAscii

Synopsis

INT fsUnicodeToAscii(VOID *pvUniStr,
VOID *pvASCII,
BOOL bIsNullTerm)

Description

Translate a Unicode string into an ASCII string. This function can only translate single byte language (for example, English). If the Unicode string contained two-bytes code language (for example, BIG5 or GB), the translation result will be wrong, because NVTFAT has no built-in Unicode-ASCII translation table.

Parameter

pvUniStr	The Unicode string to be translated. It must be ended with two 0x0 characters.
pvASCII	Caller prepares the container to accommodate the translation result.
bIsNullTerm	Add a NULL character (0x0) to the end of pvASCII

Return Value

FS_OK	Success
Otherwise	error code defined in Error Code Table

Example

```
CHAR  suRoot[] = { ‘C’, 0, ‘:’, 0, ‘\\’, 0, 0, 0 };
CHAR      szLongName[MAX_FILE_NAME_LEN/2];
FILE_FIND_T  tFileInfo;
fsFindFirst(suRoot, NULL, &tFileInfo);  /* C:\ */
do
{
```

```
   fsUnicodeToAscii(tFileInfo.suLongName, szLongName, TRUE);
   sysprintf("%s\n  szLongName);
} while (!fsFindNext(&tFileInfo));
fsFindClose(&tFileInfo);
```

fsAsciiToUnicode

Synopsis

INT fsAsciiToUnicode(VOID *pvASCII,
VOID *pvUniStr,
BOOL bIsNullTerm)

Description

Translate an ASCII string into a Unicode string. This function can only translate single byte language (for example, English). If the ASCII string contained two-bytes code language (for example, BIG5 or GB), the translation result will be wrong, because NVTFAT has no built-in ASCII-Unicode translation table.

Parameter.

pvASCII The ASCII string to be translated. It must be NULL-terminated.

pvUniStr Caller prepares the container to accommodate the translation result.

bIsNullTerm Add two 0x0 characters to the end of pvUniStr

Return Value

FS_OK Success

Otherwise error code defined in Error Code Table

Example

```
CHAR  szDirName[] = “C:\temp”
CHAR  suDirName[128];
fsAsciiToUnicode(szDirName, suDirName, TRUE);
/* Remove directory “C:\temp” */
nStatus = fsRemoveDirectory(suDirName, “temp”);
```

fsUnicodeNonCaseCompare

Synopsis

INT fsUnicodeNonCaseCompare(VOID *pvUnicode1,
VOID *pvUnicode2)

Description

Compare two Unicode strings by case non-sensitive. The Unicode strings must be ended with two 0x0 characters.

Parameter.

pvUnicode1 The source (0x0,0x0)-ended Unicode string to compared.

pvUnicode2 The target (0x0,0x0)-ended Unicode string to compared.

Return Value

0 The two Unicode strings are treated to be equal

Otherwise The two Unicode strings are treated to be unequal

Example

```
CHAR  szName1[] = "log.txt"
CHAR  szName2[] = "Log.TXT";
CHAR  suName1[32], suName2[32];
fsAsciiToUnicode(szName1, suName1, TRUE);
fsAsciiToUnicode(szName2, suName2, TRUE);
if (fsUnicodeNonCaseCompare(suName1, suName2) == 0)
    sysprintf("Equal!\n");
else
    sysprintf("Non-equal!");
```

fsUnicodeCopyStr

Synopsis

INT fsUnicodeCopyStr(VOID *pvStr1,
VOID *pvStr2)

Description

Copy a Unicode string

Parameter.

pvStr1 The Unicode string to be copied to.

pvStr2 The source Unicode string. It must be (0x0,0x0)-ended.

Return Value

0 The two Unicode strings are treated to be equal

Otherwise The two Unicode strings are treated to be unequal

Example

```
CHAR  szName1[] = "log.txt"
CHAR  szName2[] = "Log.TXT";
```

```
CHAR  suName1[32], suName2[32];
fsAsciiToUnicode(szName1, suName1, TRUE);
fsAsciiToUnicode(szName2, suName2, TRUE);
if (fsUnicodeNonCaseCompare(suName1, suName2) == 0)
    sysprintf("Equal!\n");
else
    sysprintf("Non-equal!");
```

fsUnicodeNonCaseCompare

Synopsis

INT fsUnicodeNonCaseCompare(VOID *pvUnicode1,
VOID *pvUnicode2)

Description

Compare two Unicode strings by case non-sensitive. The Unicode strings must be ended with two 0x0 characters.

Parameter.

pvUnicode1 The source (0x0,0x0)-ended Unicode string to compared.

pvUnicode2 The target (0x0,0x0)-ended Unicode string to compared.

Return Value

0 The two Unicode strings are treated to be equal

Otherwise The two Unicode strings are treated to be unequal

Example

```
CHAR  szName1[] = "log.txt"
CHAR  szName2[] = "Log.TXT";
CHAR  suName1[32], suName2[32];
fsAsciiToUnicode(szName1, suName1, TRUE);
fsAsciiToUnicode(szName2, suName2, TRUE);
if (fsUnicodeNonCaseCompare(suName1, suName2) == 0)
    sysprintf("Equal!\n");
else
    sysprintf("Non-equal!");
```

fsUnicodeCopyStr

Synopsis

INT fsUnicodeCopyStr(VOID *pvStr1,

VOID *pvStr2)

Description

Copy a Unicode string

Parameter.

pvStr1	The Unicode string to be copied to.
pvStr2	The source Unicode string. It must be (0x0,0x0)-ended.

Return Value

FS_OK	Success
Otherwise	error code defined in Error Code Table.

Example

```
FILE_FIND_T tFileInfo;
CHAR      suSlash[] = { '\\', 0x00, 0x00, 0x00 };
CHAR      suFullName[MAX_PATH_LEN];
INT nLen, nStatus;
fsFindFirst(suDirName, NULL, &tFileInfo);
do
{
   fsUnicodeCopyStr(suFullName, suDirName);
   fsUnicodeStrCat(suFullName, suSlash);
   fsUnicodeStrCat(suFullName, tFileInfo.suLongName);
   fsDeleteFile(suFullName, NULL);
} while (!fsFindNext(&tFileInfo));
fsFindClose(&tFileInfo);
```

fsUnicodeStrCat

Synopsis

INT fsUnicodeStrCat(VOID *pvUniStr1,
VOID *pvUniStr2)

Description

Concatenate two (0x0,0x0)-ended Unicode strings.

Parameter.

pvUniStr1	The Unicode string to be concatenated to.
pvUniStr2	The Unicode to be concatenated to the end of < pvUniStr1>.

Return Value

FS_OK	Success

Otherwise error code defined in Error Code Table.

Example

Refer to the example of fsUnicodeCopyStr();

Error Code Table

Code Name	Value	Description
ERR_FILE_EOF	0xFFFF8200	End of file
ERR_GENERAL_FILE_ERROR	0xFFFF8202	General file error
ERR_NO_FREE_MEMORY	0xFFFF8204	No available memory
ERR_NO_FREE_BUFFER	0xFFFF8206	No available sector buffer
ERR_NOT_SUPPORTED	0xFFFF8208	Operation was not supported
ERR_UNKNOWN_OP_CODE	0xFFFF820A	Unrecognized operation code
ERR_INTERNAL_ERROR	0xFFFF820C	File system internal error
ERR_FILE_NOT_FOUND	0xFFFF8220	File not found
ERR_FILE_INVALID_NAME	0xFFFF8222	Invalid file name
ERR_FILE_INVLAID_HANDLE	0xFFFF8224	Invalid file handle
ERR_FILE_IS_DIRECTORY	0xFFFF8226	The file to be opened is a directory
ERR_FILE_IS_NOT_DIRECTORY	0xFFFF8228	The directory to be opened is a file
ERR_FILE_CREATE_NEW	0xFFFF822A	Cannot create new directory entry
ERR_FILE_OPEN_MAX_LIMIT	0xFFFF822C	Number of opened files has reached limitation
ERR_FILE_RENAME_EXIST	0xFFFF822E	Rename file conflict with an existent file
ERR_FILE_INVALID_OP	0xFFFF8230	Invalid file operation
ERR_FILE_INVALID_ATTR	0xFFFF8232	Invalid file attribute
ERR_FILE_INVALID_TIME	0xFFFF8234	Invalid time specified
ERR_FILE_TRUNC_UNDER	0xFFFF8236	Truncate file underflow, size < pos
ERR_FILE_NO_MORE	0xFFFF8238	Actually not an error, used to identify end of file in the enumeration of a directory
ERR_FILE_IS_CORRUPT	0xFFFF823A	File is corrupt
ERR_PATH_INVALID	0xFFFF8260	Invalid path name
ERR_PATH_TOO_LONG	0xFFFF8262	Path too long
ERR_PATH_NOT_FOUND	0xFFFF8264	Path not found
ERR_DRIVE_NOT_FOUND	0xFFFF8270	Drive not found, the disk may have been unmounted
ERR_DRIVE_INVALID_NUMBER	0xFFFF8272	Invalid drive number
ERR_DRIVE_NO_FREE_SLOT	0xFFFF8274	Cannot mount more drive
ERR_DIR_BUILD_EXIST	0xFFFF8290	Try to build an existent directory
ERR_DIR_REMOVE_MISS	0xFFFF8292	Try to remove a nonexistent directory
ERR_DIR_REMOVE_ROOT	0xFFFF8294	Try to remove root directory
ERR_DIR_REMOVE_NOT_EMPTY	0xFFFF8296	Try to remove a non-empty directory
ERR_DIR_DIFFERENT_DRIVE	0xFFFF8298	Specified files on different drive
ERR_DIR_ROOT_FULL	0xFFFF829A	FAT12/FAT16 root directory full

ERR_DIR_SET_SIZE	0xFFFF829C	Try to set file size of a directory
ERR_READ_VIOLATE	0xFFFF82C0	User has no read privilege
ERR_WRITE_VIOLATE	0xFFFF82C2	User has no write privilege
ERR_ACCESS_VIOLATE	0xFFFF82C4	Cannot access
ERR_READ_ONLY	0xFFFF82C6	Try to write a read-only file
ERR_WRITE_CAP	0xFFFF82C8	Try to write file/directory which was opened with read-only
ERR_NO_DISK_MOUNT	0xFFFF8300	There's no any disk mounted
ERR_DISK_CHANGE_DIRTY	0xFFFF8302	Disk change, buffer is dirty
ERR_DISK_REMOVED	0xFFFF8304	Portable disk has been removed
ERR_DISK_WRITE_PROTECT	0xFFFF8306	Disk is write-protected
ERR_DISK_FULL	0xFFFF8308	Disk full
ERR_DISK_BAD_PARTITION	0xFFFF830A	Bad partition
ERR_DISK_UNKNOWN_PARTITION	0xFFFF830C	Unknown or not supported partition type
ERR_DISK_UNFORMAT	0xFFFF830E	Disk partition was not formatted
ERR_DISK_UNKNOWN_FORMAT	0xFFFF8310	Unknown disk format
ERR_DISK_BAD_BPB	0xFFFF8312	Bad BPB, disk may not be formatted
ERR_DISK_IO	0xFFFF8314	Disk I/O failure
ERR_DISK_IO_TIMEOUT	0xFFFF8316	Disk I/O time-out
ERR_DISK_FAT_BAD_CLUS	0xFFFF8318	Bad cluster number in FAT table
ERR_DISK_IO_BUSY	0xFFFF831A	I/O device is busy writing, must retry. direct-write mode only
ERR_DISK_INVALID_PARM	0xFFFF831C	Invalid parameter
ERR_DISK_CANNOT_LOCK	0xFFFF831E	Cannot lock disk, the disk was in-use or locked by other one
ERR_SEEK_SET_EXCEED	0xFFFF8350	File seek set exceed end-of-file
ERR_ACCESS_SEEK_WRITE	0xFFFF8352	Try to seek a file which was opened for written
ERR_FILE_SYSTEM_NOT_INIT	0xFFFF83A0	File system was not initialized
ERR_ILLEGAL_ATTR_CHANGE	0xFFFF83A2	Illegal file attribute change

10 PWM Library

10.1 Overview

This library is designed to make user application to set N9H20 PWM more easily.

The PWM library has the following features:

- PWM signal frequency and duty setting
- PWM Capture function

10.2 Programming Guide

10.2.1 System Overview

The N9H20 have 4 channels pwm-timers. The 4 channels pwm-timers has 2 prescalers, 2 clock dividers, 4 clock selectors, 4 16-bit counters, 4 16-bit comparators, 2 Dead-Zone generators. They are all driven by system clock. Each channel can be used as a timer and issue interrupt independently.

Each two channels pwm-timers share the same prescaler(channel0-1 share prescalar0 and channel2-3 share prescalar1). Clock divider provides each channel with 5 clock sources (1, 1/2, 1/4, 1/8, 1/16). Each channel receives its own clock signal from clock divider which receives clock from 8-bit prescaler. The 16-bit counter in each channel receives clock signal from clock selector and can be used to handle one pwm period. The 16-bit comparator compares number in counter with threshold number in register loaded previously to generate pwm duty cycle.

The N9H20 has 4 channels pwm-timers and each pwm-timer includes a capture channel. The Capture 0 and PWM 0 share a timer that included in PWM 0; and the Capture 1 and PWM 1 share another timer, and etc. Therefore user must setup the PWM-timer before turn on Capture feature. After enabling capture feature, the capture always latched PWM-counter to CRLR when input channel has a rising transition and latched PWM-counter to CFLR when input channel has a falling transition. Capture channel 0 interrupt is programmable by setting CCR0[1] (Rising latch Interrupt enable) and CCR0[2] (Falling latch Interrupt enable) to decide the condition of interrupt occur. Capture channel 1 has the same feature by setting CCR0[17] and CCR0[18]. And capture channel 2 & 3 have the same feature by setting CCR1[1],CCR1[2] and CCR1[17], CCR1[18] respectively. Whenever Capture issues Interrupt 0/1/2/3, the PWM counter 0/1/2/3 will be reload at this moment.

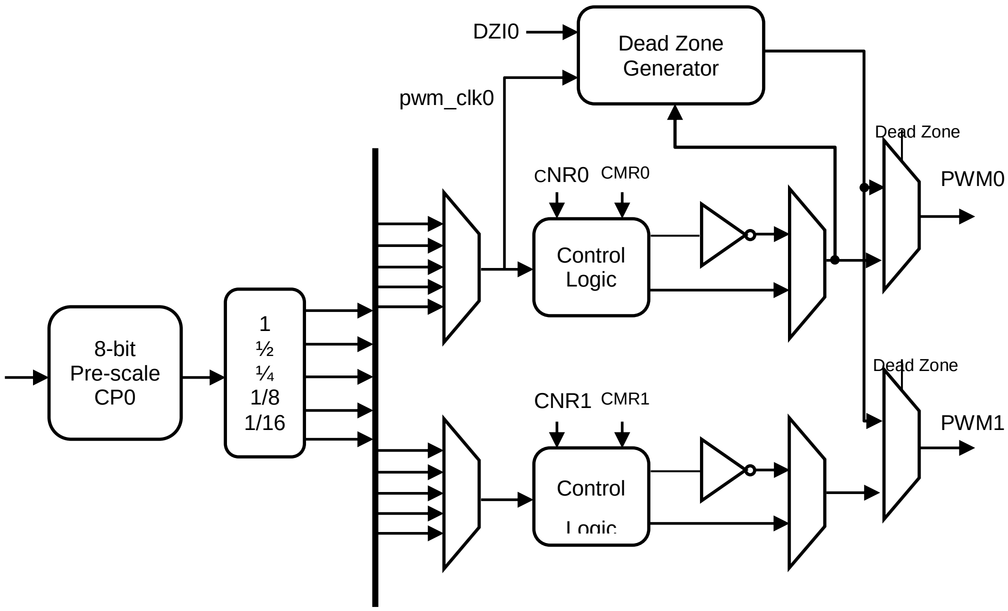
There are only four interrupts from PWM to advanced interrupt controller (AIC). PWM 0 and Capture 0 share the same interrupt channel, PWM1 and Capture 1 share the same interrupt and so on. Therefore, PWM function and Capture function in the same channel cannot be used at the same time.

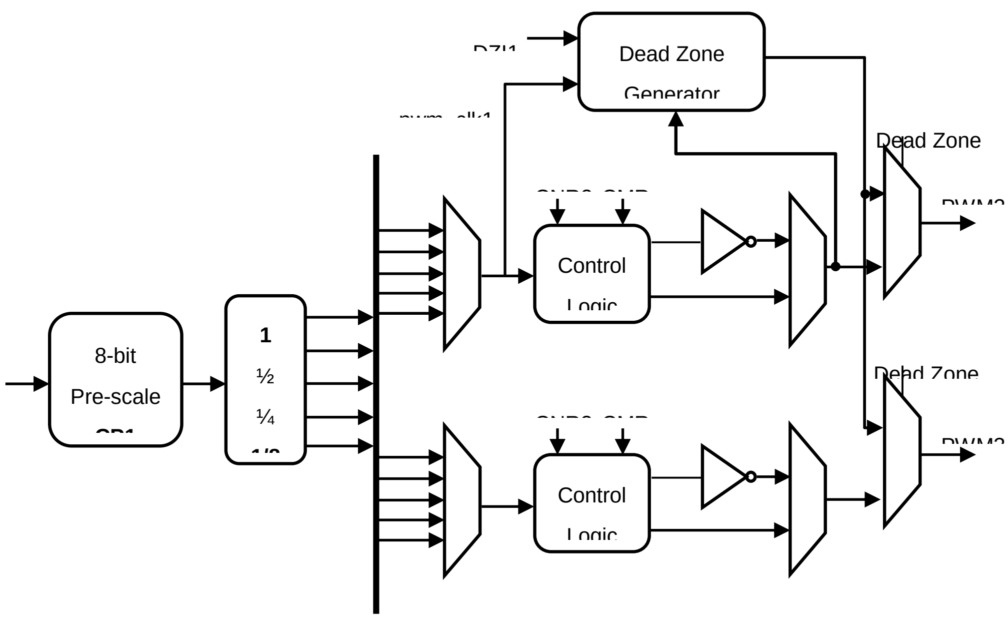
PWM Features

- Two 8-bit prescalers and Two clock dividers
- Four clock selectors
- Four 16-bit counters and four 16-bit comparators
- Two Dead-Zone generators
- Capture function

10.2.2 Block Diagram

The following figure describes the architecture of pwm in one group. (channel0&1 are in one group and channel2&3 are in another group)





10.2.3 PWM Timer Control

Prescaler and clock selector

The PWM has two groups (two channels in each group) of timers. The clock input of the group is according to the PWM Prescaler Register (**PPR**) value. The PWM prescaler divided the clock input by PPR+1 before it is fed to the counter. Please notice that when the PPR value equals zero, the prescaler output clock will stop. Furthermore, according to the PWM Clock Select Register (**CSR**) value, the clock input of PWM timer channel can be divided by 1,2,4,8 and 16.

Consider following examples, which explain the PWM timer period (Duty).

$$\text{period} = \frac{1}{(PCLK) \div (PPR+1) \div CSR}$$

When the PCLK = 60 MHz, the maximum and minimum PWM timer counting period is described as follows.

Maximum period: PPR = 255 (since the length of PPR is 8bit) and CSR = 16

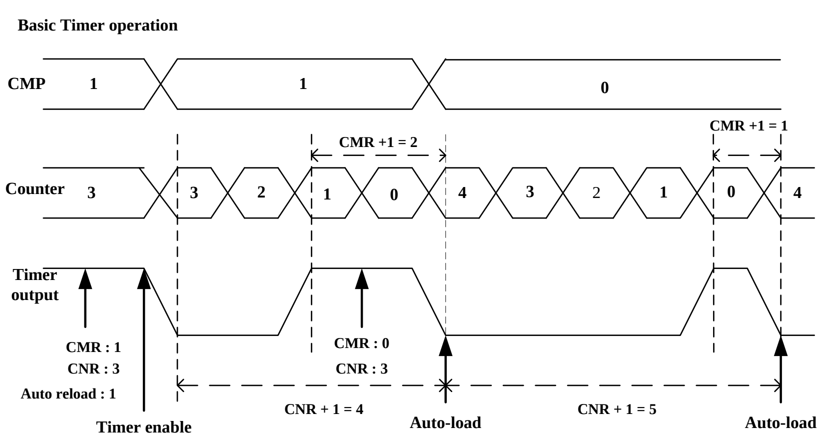
$$\text{period}_{\max} = \frac{1}{(60Mhz) \div (255+1) \div 16} = 68.266us$$

Minimum period: PCLK = 60 MHz, PPR=1 and CSR=1

$$\text{period}_{\min} = \frac{1}{(60Mhz) \div (1+1) \div 1} = 0.0333us$$

The maximum and minimum intervals between two interrupts depend on the *period*$_{max}$, *period*$_{min}$ and PWM Counter Register(**CNRx**) length. The maximum interval between two interrupts is (65535+1)*(68.266us) since the length of CNR is 16bit. Please notice that the above calculation is based on the PCLK = 60MHz. Therefore, all of the values need to be recalculated when the PCLK is not equal to 60Mhz.

Basic Timer Operation



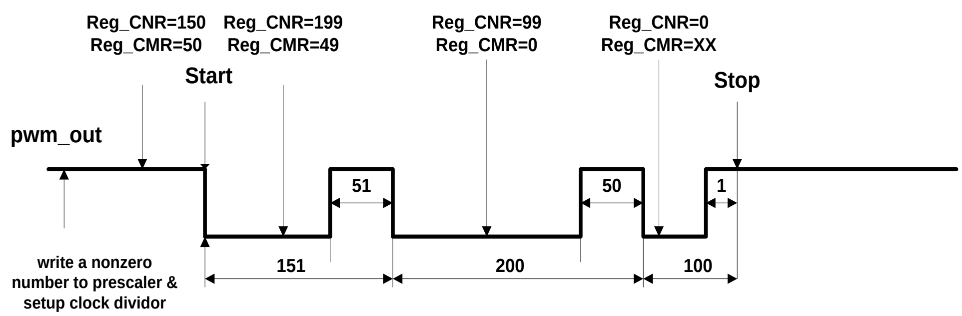
PWM Double Buffering and Automatic Reload

N9H20 PWM Timers have a double buffering function, enabling the reload value changed for next timer operation without stopping current timer operation. Although new timer value is set, current timer operation still operate successfully.

The counter value can be written into CNR0~3 and current counter value can be read from PDR0~3.

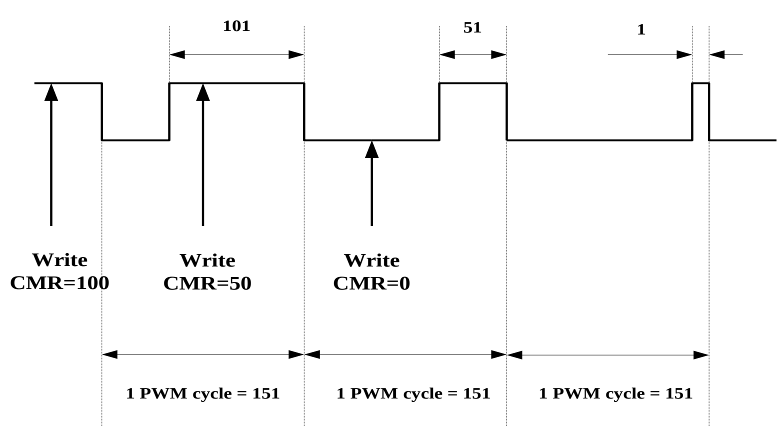
The auto-reload operation copies from CNR0~3 to down-counter when down-counter reaches zero. If CNR0~3 are set as zero, counter will be halt when counter count to zero. If auto-reload bit is set as zero, counter will be stopped immediately

PWM double buffering



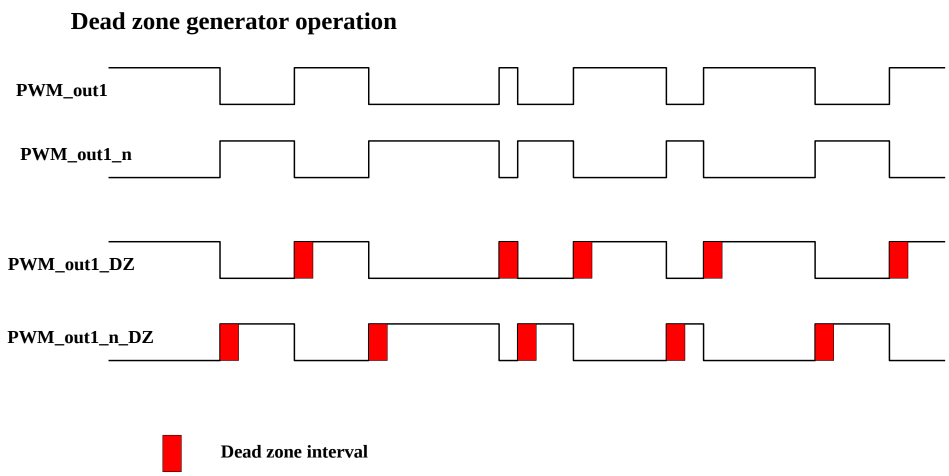
The double buffering function allows CMR written at any point in current cycle. The loaded value will take effect from next cycle.

Modulate PWM controller ouput duty ratio(CNR = 150)

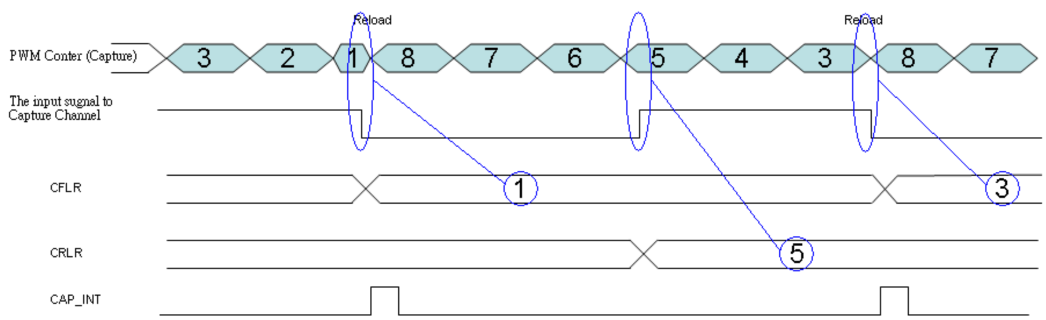


Dead-Zone Generator

N9H20 PWM is implemented with Dead Zone generator. They are built for power device protection. This function enables generation of a programmable time gap at the rising of PWM output waveform. User can program PPR [31:24] and PPR [23:16] to determine the two Dead Zone interval respectively.



Capture Basic Timer Operation



At this case, the CNR is 8:

When set falling interrupt enable, the pwm counter will be reload at time of interrupt occur.

The channel low pulse width is (CNR – CRLR).

The channel high pulse width is (CRLR - CFLR).

The channel cycle time is (CNR – CFLR).

10.2.4 PWM Library Constant Definition

Name	Value	Description
PWM_TIMER0	0x0	PWM Timer 0
PWM_TIMER1	0x1	PWM Timer 1
PWM_TIMER2	0x2	PWM Timer 2
PWM_TIMER3	0x3	PWM Timer 3
PWM_CAP0	0x10	PWM Capture 0
PWM_CAP1	0x11	PWM Capture 1
PWM_CAP2	0x12	PWM Capture 2
PWM_CAP3	0x13	PWM Capture 3

PWM_CAP_ALL_INT	0	PWM Capture All Interrupt
PWM_CAP_RISING_INT	1	PWM Capture Rising Interrupt
PWM_CAP_FALLING_INT	2	PWM Capture Falling Interrupt
PWM_CAP_RISING_FLAG	6	Capture rising interrupt flag
PWM_CAP_FALLING_FLAG	7	Capture falling interrupt flag
PWM_CLOCK_DIV_1	1	Input clock divided by 1
PWM_CLOCK_DIV_2	2	Input clock divided by 2
PWM_CLOCK_DIV_4	4	Input clock divided by 4
PWM_CLOCK_DIV_8	8	Input clock divided by 8
PWM_CLOCK_DIV_16	16	Input clock divided by 16
PWM_TOGGLE_MODE	TRUE	PWM Timer Toggle mode
PWM_ONE_SHOT_MODE	FALSE	PWM Timer One-shot mode

10.2.5 PWM Library Property Definition

The PWM library provides property structure to set PWM timer property.

Name	Value	Description
fFrequency	>= 0	The timer/capture frequency[0]
u8HighPulseRatio	1~100	High pulse ratio
u8Mode	PWM_ONE_SHOT_MODE / PWM_TOGGLE_MODE	PWM Timer Trigger mode
bInverter	TRUE / FALSE	Inverter Enable / Inverter Disable
u8ClockSelector	PWM_CLOCK_DIV_1/ PWM_CLOCK_DIV_2/ PWM_CLOCK_DIV_4/ PWM_CLOCK_DIV_8/ PWM_CLOCK_DIV_16	Clock Selector [1]
u16PreScale	2 ~ 256	Clock Prescale [1]
u32Duty	0~65535	Pulse duty [2]

[0] PWM provides two timer setting mode: Frequency-setting and Property-setting modes.

- Frequency-setting mode (***fFrequency*** > 0)

  User doesn't need to set ***u8ClockSelector*** / ***u16PreScale*** / ***u32Duty*** fields. PWM library will set the proper values according to current APB clock automatically.

- Property-setting mode (***fFrequency*** = 0)

- User must set ***u8ClockSelector*** / ***u16PreScale*** / ***u32Duty*** fields by himself. Please refer to the previous section “Prescaler and clock selector.

[1] The value take effect only when Property-setting mode.

[2] The value takes effect when Property-setting mode or the Capture functions. It is the capture monitor period.

10.3 PWM Library APIs Specification

PWM_Open

Synopsis

VOID PWM_Open (VOID)

Description

Enable PWM engine clock and reset PWM

Parameter

None

Return Value

None

Example

```
/* Enable PWM clock */
PWM_Open();
```

PWM_Close

Synopsis

VOID PWM_Close (VOID)

Description

Disable PWM engine clock and the I/O enable

Parameter

None

Return Value

None

Example

```
PWM_Close();
```

PWM_SetTimerClk

Synopsis

FLOAT PWM_SetTimerClk (UINT8 u8Timer, PWM_TIME_DATA_T *sPt)

Description

This function is used to configure the frequency/pulse/mode/inverter function

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

sPt PWM property information

Return Value

= 0 - Setting Fail.

> 0 - Success. The actual frequency is set by PWM timer.

Note

1. The function will set the frequency property automatically (It will change the parameters to the values that it sets to hardware) when user set a nonzero frequency value
2. The function can set the proper frequency property (Clock selector/Prescale) for capture function and user needs to set the proper pulse duty himself.

Example

```
//* Set PWM Timer 0 Configuration */
PWM_SetTimerClk(PWM_TIMER0,&sPt);
```

PWM_SetTimerIO

Synopsis

VOID PWM_SetTimerIO (UINT8 u8Timer, BOOL bEnable)

Description

This function is used to enable/disable PWM timer/capture I/O function

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

bEnable Enable (TRUE) / Disable (FALSE)

Return Value

None

Example

```
/* Enable Output for PWM Timer 0 */
```

```
PWM_SetTimerIO(PWM_TIMER0,TRUE);
```

PWM_Enable

Synopsis

VOID PWM_Enable (UINT8 u8Timer, BOOL bEnable)

Description

This function is used to enable PWM timer / capture function

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

bEnable Enable (TRUE) / Disable (FALSE)

Return Value

None

Example

```
/* Enable PWM Timer 0 */
PWM_Enable(PWM_TIMER0,TRUE);
```

PWM_IsTimerEnabled

Synopsis

BOOL PWM_IsTimerEnabled (UINT8 u8Timer)

Description

This function is used to get PWM specified timer enable/disable state

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

Return Value

TURE - The specified timer is enabled.

FALSE - The specified timer is disabled.

Example

```
/*  Check PWM Timer0 is enabled or not */
If (PWM_IsTimerEnabled(PWM_TIMER0))
    sysprintf("PWM Timer 0 is enabled\n");
else
```

```
    sysprintf("PWM Timer 0 isn't enabled\n");
```

PWM_SetTimerCounter

Synopsis

VOID PWM_SetTimerCounter (UINT8 u8Timer, UINT16 u16Counter)

Description

This function is used to set the PWM specified timer counter

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

u16Counter The timer value. (0~65535)

Return Value

None

Note

If the counter is set to 0, the timer will stop.

Example

```
/* Set PWM Timer 0 counter as 0 */
PWM_SetTimerCounter(PWM_TIMER0,0);
```

PWM_GetTimerCounter

Synopsis

UINT32 PWM_GetTimerCounter (UINT8 u8Timer)

Description

This function is used to get the PWM specified timer counter value

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

Return Value

The specified timer-counter value

Example

```
/* Loop when Counter of PWM Timer0 isn't 0 */

while(PWM_GetTimerCounter(PWM_TIMER0));
```

PWM_EnableDeadZone

Synopsis

VOID PWM_EnableDeadZone (UINT8 u8Timer, UINT8 u8Length, BOOL bEnableDeadZone)

Description

This function is used to set the dead zone length and enable/disable Dead Zone function

Parameter

u8Timer	The function to be set
	PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3
u8Length	Dead Zone Length : 0~255
bEnableDeadZone	Enable DeadZone (TRUE) / Disable DeadZone (FALSE)

Return Value

None

Note

1. If Deadzone for PWM_TIMER0 or PWM_TIMER1 is enabled, the output of PWM_TIMER1 is inverse waveform of PWM_TIMER0.
2. If Deadzone for PWM_TIMER2 or PWM_TIMER3 is enabled, the output of PWM_TIMER3 is inverse waveform of PWM_TIMER2.

Example

```
/* Enable Deadzone of PWM Timer 0 and set it to 100 units*/
PWM_EnableDeadZone(PWM_TIMER0, 100, TRUE)
```

PWM_EnableInt

Synopsis

VOID PWM_EnableInt (UINT8 u8Timer, UINT8 u8Int)

Description

This function is used to enable the PWM timer/capture interrupt

Parameter

u8Timer	The function to be set
	PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3
	PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3
u8Int	Capture interrupt type (The parameter is valid only when capture function)
	PWM_CAP_RISING_INT: The capture rising interrupt.
	PWM_CAP_FALLING_INT: The capture falling interrupt.

PWM_CAP_ALL_INT: All capture interrupt.

Return Value

None

Example

```
/* Enable Interrupt Sources of PWM Timer 0 */
PWM_EnableInt(PWM_TIMER0,0);
/* Enable Interrupt Sources of PWM Capture3 */
PWM_EnableInt(PWM_CAP3, PWM_CAP_FALLING_INT);
```

PWM_DisableInt

Synopsis

VOID PWM_DisableInt (UINT8 u8Timer, UINT8 u8Int)

Description

This function is used to disable the PWM timer/capture interrupt

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

u8Int Capture interrupt type (The parameter is valid only when capture function)

PWM_CAP_RISING_INT: The capture rising interrupt.

PWM_CAP_FALLING_INT: The capture falling interrupt.

PWM_CAP_ALL_INT: All capture interrupt.

Return Value

None

Example

```
/* Disable Capture Interrupt */
PWM_DisableInt(PWM_CAP3,PWM_CAP_ALL_INT);
```

PWM_InstallCallBack

Synopsis

VOID PWM_InstallCallBack (UINT8 u8Timer, PFN_PWM_CALLBACK pfncallback, PFN_PWM_CALLBACK *pfnOldcallback)

Description

This function is used to install the specified PWM timer/capture interrupt call back function

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

pfncallback The callback function pointer for specified timer / capture.

pfnOldcallback The previous callback function pointer for specified timer / capture.

Return Value

None

Example

```
/* Install Callback function */
PWM_InstallCallBack(PWM_TIMER0, PWM_PwmIRQHandler, &pfnOldcallback);
```

PWM_ClearInt

Synopsis

VOID PWM_ClearInt (UINT8 u8Timer)

Description

This function is used to clear the PWM timer/capture interrupt.

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

Return Value

None

Example

```
/* Clear the PWM Capture 3 Interrupt */
PWM_ClearInt(PWM_CAP3);
```

PWM_GetIntFlag

Synopsis

BOOL PWM_GetIntFlag (UINT8 u8Timer)

Description

This function is used to get the PWM timer/capture interrupt flag

Parameter

u8Timer The function to be set

PWM_TIMER0 ~ PWM_TIMER3: PWM timer 0 ~ 3

PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

Return Value

TRUE - The specified interrupt occurs.

FALSE - The specified interrupt doesn't occur.

Example

```
/* Get PWM Timer 0 Interrupt flag*/
PWM_GetIntFlag(PWM_TIMER0);
```

PWM_GetCaptureIntStatus

Synopsis

BOOL PWM_GetCaptureIntStatus (UINT8 u8Capture, UINT8 u8IntType)

Description

Check if there's a rising / falling transition

Parameter

u8Timer The function to be set

PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

u8Int capture Capture interrupt type (The parameter is valid only when function)

PWM_CAP_RISING_INT: The capture rising interrupt.

PWM_CAP_FALLING_INT: The capture falling interrupt.

Return Value

TRUE - The specified interrupt occurs.

FALSE - The specified interrupt doesn't occur.

Example

```
/* Wait for Interrupt Flag (Falling) */
while(PWM_GetCaptureIntStatus(PWM_CAP0, PWM_CAP_FALLING_FLAG)!=TRUE);
```

PWM_ClearCaptureIntStatus

Synopsis

VOID PWM_ClearCaptureIntStatus (UINT8 u8Capture, UINT8 u8IntType)

Description

Clear the rising / falling transition interrupt flag

Parameter

u8Timer	The function to be set	
		PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3
u8Int capture		Capture interrupt type (The parameter is valid only when function)
		PWM_CAP_RISING_INT: The capture rising interrupt.
		PWM_CAP_FALLING_INT: The capture falling interrupt.

Return Value

None

Example

```
/* Clear the Capture Interrupt Flag */
PWM_ClearCaptureIntStatus(PWM_CAP0, PWM_CAP_FALLING_FLAG);
```

PWM_GetRisingCounter

Synopsis

UINT16 PWM_GetRisingCounter (UINT8 u8Capture)

Description

This function is used to get value which latches the counter when there’s a rising transition

Parameter

u8Timer	The function to be set	
		PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

Return Value

The value which latches the counter when there’s a rising transition

Example

```
/* Get the Rising Counter Data */
u32Count[u32i++] = PWM_GetRisingCounter(PWM_CAP0);
```

PWM_GetFallingCounter

Synopsis

UINT16 PWM_GetFallingCounter (UINT8 u8Capture)

Description

This function is used to get value which latches the counter when there's a falling transition

Parameter

u8Timer The function to be set

PWM_CAP0 ~ PWM_CAP3: PWM capture 0 ~ 3

Return Value

The value which latches the counter when there's a falling transition

Example

```
/* Get the Falling Counter Data */
u32Count[u32i++] = PWM_GetFallingCounter(PWM_CAP0);
```

11 RTC Library

11.1 Overview

This library is designed to make user application access N9H20 RTC more easily.

The RTC library has the following features:

- Support RTC Current/Alarm time access.
- Support System Power Off Control

11.2 Programming Guide

11.2.1 System Overview

Real Time Clock (RTC) block can be operated by independent power supply while the system power is off. The RTC uses a 32.768 KHz external crystal. It can transmit data to CPU with BCD values. The data includes the time by (second, minute and hour), the day by (day, month and year). In addition, to achieve better frequency accuracy, the RTC counter can be adjusted by software.

The built in RTC is designed to generate the alarm interrupt and periodic interrupt signals. The period interrupt can be 1/128, 1/64, 1/32, 1/16, 1/8, 1/4, 1/2 and 1 second. The alarm interrupt indicates that time counter and calendar counter have counted to a specified time recorded in TAR and CAR.

The wakeup signal is used to wake the system up from sleep mode.

RTC Features

- There is a time counter (second, minute, hour) and calendar counter (day, month, year) for user to check the time.
- Alarm register (second, minute, hour, day, month, year).
- 12-hour or 24-hour mode is selectable.
- Recognize leap year automatically.
- The day of week counter.
- Frequency compensate register (FCR).
- Beside FCR, all clock and alarm data expressed in BCD code.
- Support time tick interrupt.
- Support wake up function.
- System Power off Control function

11.2.2 System Power Control Flow

Normal system Power Control Flow

The control steps are as follows

User presses the power key, RPWR, to makes the power control signal, PWRCE pin, to high. If the PWR_ON bit, PWRON[0], be set, the power key can be released and the PWRCE will keep on. If the PWR_ON bit, PWRON [0], doesn't be set as 1, the PWRCE will back to low when the power key is released.

If there is another pulse on power key when the PWR_ON bit is set, the system will get an interrupt signal (PSWI). User can decide to clear the PWR_ON or not. If this bit is clear, the PWRCE will go to low to turn off the core power. If the PWRON bit is also kept high, the PWRCE pin will keep in high level. If there is no any pulse on the power key and the PWR_ON bit is clear by user, the PWRCE pin is also set to low at this time.

The following table is the system power control flow table.

Input		Output	Note
PWRKey	PWR_ON	PWCE	
X1	X2	Y	
1	0	0	RTC powered only (Default state)
0	0	1	Press key, Power On
0	1	1	keep key & S/W Set X2, Power On
1	1	1	Left key, Power keep On
0	1	1	Press key, get INT, intend to power Off
1	0	0	Left key & S/W clean X2, power Off Or S/W clean X2 , don't need press key, power off
X	1	1	RST_ active, still keep power whenX2=1
PWCE is open drain output X1, internal pull-up X2, it is R/W able There is Interrupt from key be pressed			

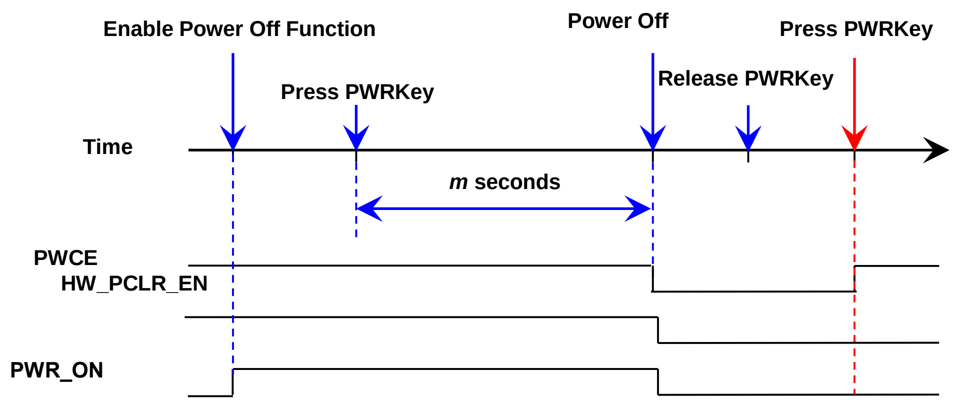
Force system Power Off Control Flow

The RTC supports a hardware automatic power off function and a software power off function like notebook. For hardware power off function, it can be enable and disable in HW_PCLR_EN bit and the user presses the power button for a few seconds to power off system. The time for pressing the power button to power off is configured in PCLR_TIME.

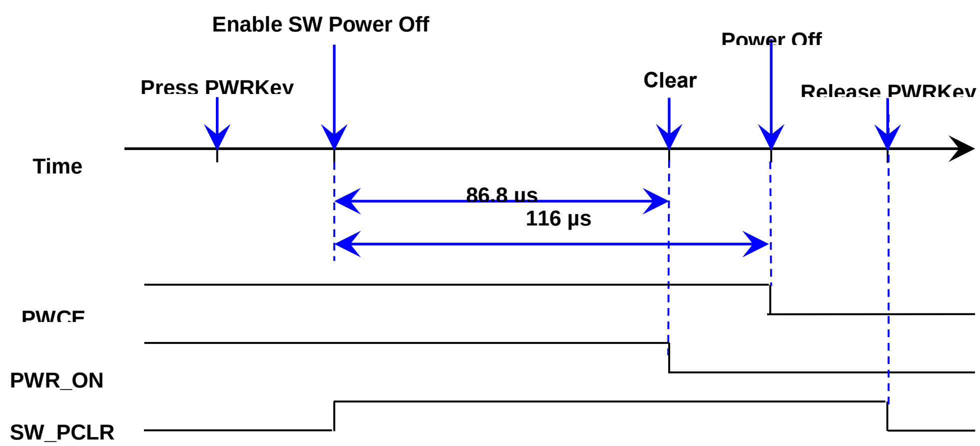
PCLR_TIME Setting	Pressed time to power off	PCLR_TIME Setting	Pressed time to power off
0	Power off right away	8	7~9 seconds
1	0~1 second	9	8~9 seconds
2	1~2 seconds	10	9~10 seconds
3	2~3 seconds	11	10~11 seconds
4	3~4 seconds	12	11~12 seconds
5	4~5 seconds	13	12~13 seconds
6	5~6 seconds	14	13~14 seconds
7	6~7 seconds	15	14~15 seconds

The RTC supports a hardware power off function to provide the power off flow like Notebook. The user presses the power button for a few seconds to power off the system. The time to press power key to power off is counted by hardware. After the time, hardware will set the PWCE to low and clear the PWR_ON and HW_PCLR_EN. After power off, user can decide to set the PWR_ON bit to power on system or not when the PWRKey is pressed.

The timing of the hardware power off function is following



The RTC also supports a software power off function. The user presses the power button for a few seconds to power off the system. The time to press power key to power off is counted by user. When the PWR_ON bit is cleared by user, the PWRCE outputs low after 116us and the SW_PCLR bit is cleared when the power key is released. See the timing Figure as following.



RTC Library Constant Definition

Name	Value	Description
RTC_CLOCK_12	0	12-Hour mode
RTC_CLOCK_24	1	24-Hour mode
RTC_AM	1	a.m.
RTC_PM	2	p.m.
RTC_LEAP_YEAR	1	Leap year
RTC_TICK_1_SEC	0	1 tick per second
RTC_TICK_1_2_SEC	1	2 tick per second
RTC_TICK_1_4_SEC	2	4 tick per second
RTC_TICK_1_8_SEC	3	8 tick per second
RTC_TICK_1_16_SEC	4	16 tick per second
RTC_TICK_1_32_SEC	5	32 tick per second
RTC_TICK_1_64_SEC	6	64 tick per second
RTC_TICK_1_128_SEC	7	128 tick per second
RTC_SUNDAY	0	Day of Week: Sunday
RTC_MONDAY	1	Day of Week: Monday
RTC_TUESDAY	2	Day of Week: Tuesday
RTC_WEDNESDAY	3	Day of Week: Wednesday
RTC_THURSDAY	4	Day of Week: Thursday
RTC_FRIDAY	5	Day of Week: Friday
RTC_SATURDAY	6	Day of Week: Saturday
RTC_ALARM_INT	0x01	Alarm Interrupt
RTC_TICK_INT	0x02	Tick Interrupt
RTC_PSWI_INT	0x04	Power Switch Interrupt
RTC_ALL_INT	0x07	All Interrupt
RTC_IOC_IDENTIFY_LEAP_YEAR	0	Identify the leap year command
RTC_IOC_SET_TICK_MODE	1	Set tick mode command
RTC_IOC_GET_TICK	2	Get tick command
RTC_IOC_RESTORE_TICK	3	Restore tick command
RTC_IOC_ENABLE_INT	4	Enable interrupt command
RTC_IOC_DISABLE_INT	5	Disable interrupt command
RTC_IOC_SET_CURRENT_TIME	6	Set Current time command
RTC_IOC_SET_ALAMRM_TIME	7	Set Alarm time command
RTC_IOC_SET_FREQUENCY	8	Set Frequency command
RTC_IOC_SET_POWER_ON	9	Set Power On (Set PWR_ON to 1)

RTC_IOC_SET_POWER_OFF	10	Set Power Off (Set PWR_ON to 0)
RTC_IOC_SET_POWER_OFF_PERIOD	11	Set Power Off Period (PCLR_TIME)
RTC_IOC_ENABLE_HW_POWEROFF	12	Enable H/W Power Off
RTC_IOC_DISABLE_HW_POWEROFF	13	Disable H/W Power Off
RTC_IOC_GET_POWERKEY_STATUS	14	Get Power Key Status
RTC_IOC_SET_PSWI_CALLBACK	15	Set Power Switch Interrupt Callback function
RTC_CURRENT_TIME	0	Current time
RTC_ALARM_TIME	1	Alarm time
RTC_WAIT_COUNT	10000	RTC Initial Time out Value
RTC_YEAR2000	2000	RTC Year Reference Value
RTC_FCR_REFERENCE	32761	RTC FRC Reference Value

11.2.3 RTC Library Time and Date Definition

The RTC library provides time structure to access RTC time property.

Name	Value	Description
u8cClockDisplay	RTC_CLOCK_12 / RTC_CLOCK_24	12 Hour Clock / 24 Hour Clock
u8cAmPm	RTC_AM / RTC_PM	the AM hours / the PM hours
u32cSecond	0~59	Second value
u32cMinute	0~59	Minute value
u32cHour	1~11 / 0~23	Hour value
u32cDayOfWeek	RTC_SUNDAY~ RTC_SATURDAY	Day of week
u32cDay	1~31	Day value
u32cMonth	1~12	Month value
u32Year	0~99	Year value

11.3 RTC Library APIs Specification

RTC_Init

Synopsis

UINT32 RTC_Init (VOID)

Description

This function is to initialize RTC and install Interrupt service routine

Parameter

None

Return Value

E_SUCCESS - Success

E_RTC_ERR_EIO - Access RTC Failed.

Example

```
/* RTC Initialize */
RTC_Init();
```

RTC_Open

Synopsis

UINT32 RTC_Open (RTC_TIME_DATA_T *sPt)

Description

This function configures RTC current time.

Parameter

sPt RTC time property and current time information

Return Value

E_SUCCESS - Success

E_RTC_ERR_EIO - Access RTC Failed.

E_RTC_ERR_CALENDAR_VALUE - Wrong Calendar Value

E_RTC_ERR_TIMESACLE_VALUE - Wrong Time Scale Value

E_RTC_ERR_TIME_VALUE - Wrong Time Value

E_RTC_ERR_DWR_VALUE - Wrong Day Value

E_RTC_ERR_FCR_VALUE - Wrong Compensation value

Example

```
/* Initialization the RTC timer */
if(RTC_Open(&sInitTime) !=E_RTC_SUCCESS)
   sysprintf("Open Fail!!\n");
```

RTC_Close

Synopsis

UINT32 RTC_Close (VOID)

Description

Disable AIC channel of RTC, tick and alarm interrupt

Parameter

None

Return Value

E_SUCCESS - Success

Example

```
/* Disable RTC */
RTC_Close();
```

RTC_Read

Synopsis

UINT32 RTC_Read (E_RTC_TIME_SELECT eTime, RTC_TIME_DATA_T *sPt)

Description

Read current date/time or alarm date/time from RTC

Parameter

eTime	The current/alarm time to be read
	RTC_CURRENT_TIME - Current time
	RTC_ALARM_TIME - Alarm time
sPt	RTC time property and current time information

Return Value

E_SUCCESS	- Success
E_RTC_ERR_EIO	- Access RTC Failed.
E_RTC_ERR_ENOTTY	- Command not support, or incorrect. parameters

Example

```
/* Get the current time */
RTC_Read(RTC_CURRENT_TIME, &sCurTime);
```

RTC_Write

Synopsis

UINT32 RTC_Write (E_RTC_TIME_SELECT eTime, RTC_TIME_DATA_T *sPt)

Description

Write current date/time or alarm date/time from RTC

Parameter

eTime	The current/alarm time to be read
	RTC_CURRENT_TIME - Current time
	RTC_ALARM_TIME - Alarm time
sPt	RTC time property and current time information

Return Value

E_SUCCESS	- Success
E_RTC_ERR_EIO	- Access RTC Failed.
E_RTC_ERR_ENOTTY	- Command not support, or incorrect. parameters

Example

```
/* Set the current time */
RTC_Write(RTC_CURRENT_TIME, &sCurTime);
```

RTC_WriteEnable

Synopsis

UITN32 RTC_WriteEnable (VOID)

Description

Access PW to AER to make access other register enable

Parameter

None

Return Value

E_SUCCESS	- Success
E_RTC_ERR_EIO	- Access RTC Failed.

Example

```
RTC_WriteEnable();
```

RTC_SetFrequencyCompensation

Synopsis

UINT32 RTC_SetFrequencyCompensation (FLOAT fnumber)

Description

Set Frequency Compensation Data if RTC crystal frequency isn't accurate.

Parameter

fnumber	The actual RTC crystal frequency

Return Value

E_SUCCESS	- Success
E_RTC_ERR_FCR_VALUE	- Wrong Compensation value

Example

```
/*  If actual RTC crystal is 32773.65Hz */
```

```
RTC_SetFrequencyCompensation(32773.65)
```

RTC_Ioctl

Synopsis

UINT32 RTC_Ioctl (INT32 i32Num, E_RTC_CMD eCmd, UINT32 u32Arg0, UINT32 u32Arg1)

Description

This function allows user to set some commands for application, the supported commands and arguments listed in the table below (Argument 1 is reserved for feature use).

Command	Argument 0	Comment
RTC_IOC_IDENTIFY_LEAP_YEAR	Unsigned integer pointer to store the return leap year value	Get the leap year
RTC_IOC_SET_TICK_MODE	Unsigned integer stores the tick mode data	Set Tick mode
RTC_IOC_GET_TICK	Unsigned integer pointer to store the return tick number	Get the tick counter
RTC_IOC_RESTORE_TICK	None	Restore the tick counter
RTC_IOC_ENABLE_INT	interrupt type	Enable interrupt
RTC_IOC_DISABLE_INT	interrupt type	Disable interrupt
RTC_IOC_SET_CURRENT_TIME	None	Set current time
RTC_IOC_SET_ALAMRM_TIME	None	Set alarm time
RTC_IOC_SET_FREQUENCY	Unsigned integer stores the Frequency Compensation value	Set Frequency Compensation Data
RTC_IOC_SET_PWRON	None	Set Power on
RTC_IOC_SET_PWROFF	None	Set Power off
RTC_IOC_SET_POWER_OFF_PERIOD	Unsigned integer stores the power off period value : 0~15	Set Power Off Period
RTC_IOC_ENABLE_HW_POWEROFF	None	Enable H/W Power Off
RTC_IOC_DISABLE_HW_POWEROF	None	Disable H/W Power Off
RTC_IOC_GET_POWERKEY_STATUS	Unsigned integer pointer to store the return Power Key status	Get Power Key Status
RTC_IOC_SET_PSWI_CALLBACK	The call back function pointer for Power Switch Interrupts	Set Power Switch Interrupt Callback function

Parameter

u32Arg0 Depend on feature setting

u32Arg1 Depend on feature setting

Return Value

None

Example

```
/* Set Tick setting */
```

```
RTC_Ioctl(0,RTC_IOC_SET_TICK_MODE, (UINT32)&sTick,0);

* Enable RTC Tick Interrupt and install tick call back function */
RTC_Ioctl(0,RTC_IOC_ENABLE_INT, (UINT32)RTC_TICK_INT,0);

/* Press Power Key during 6 sec to Power off */
RTC_Ioctl(0, RTC_IOC_SET_POWER_OFF_PERIOD, 6, 0);

/* Install the callback function for Power Key Press */
RTC_Ioctl(0, RTC_IOC_SET_PSWI_CALLBACK, (UINT32)PowerKeyPress, 0);

/* Enable Hardware Power off */
RTC_Ioctl(0, RTC_IOC_ENABLE_HW_POWEROFF, 0, 0);

/* Query Power Key Status */
RTC_Ioctl(0, RTC_IOC_GET_POWERKEY_STATUS, (UINT32)&u32PowerKeyStatus,
0);

/* Power Off - S/W can call the API to power off any time he wants*/
RTC_Ioctl(0, RTC_IOC_SET_POWER_OFF, 0, 0);
```

Example code

The demo code tests “Time display”, “Alarm” , “Power down Wakeup”, “Software Power Off (Normal Case) Control Flow”, “Hardware Power Off (System Crash) Control Flow”, and “Software Force to Power Off”. Please refer to the RTC sample code of BSP Non-OS.

Error Code Table

Code Name	Value	Description
E_RTC_SUCCESS	0	Operation success
E_RTC_ERR_CALENDAR_VALUE	1	Wrong Calendar Value
E_RTC_ERR_TIMESACLE_VALUE	2	Wrong Time Scale Value
E_RTC_ERR_TIME_VALUE	3	Wrong Time Value
E_RTC_ERR_DWR_VALUE	4	Wrong Day Value
E_RTC_ERR_FCR_VALUE	5	Wrong Compensation value
E_RTC_ERR_EIO	6	Access RTC Failed.
E_RTC_ERR_ENOTTY	7	Command not support, or parameter incorrect.
E_RTC_ERR_ENODEV	8	Interface number incorrect.

12 SIC Library

12.1 Overview

N9H20 Non-OS library consists of some sets of libraries. These libraries are built to access those on-chip functions such as VPOST, APU, SIC, USBH, USBD, GPIO, I2C, SPI and UART, as well as File System (NVTFAT), USB MassStorage devices (UMAS) and NAND Flash devices (GNAND). This document describes the provided APIs of SIC library. With these APIs, user can quickly build a binary target for SIC library on N9H20 micro processor.

These libraries are created by using Keil uVision IDE. Therefore, they only can be used in Keil environment.

12.2 Storage Interface Controller Library

This library is designed to make user application access N9H20 Storage Interface Controller (SIC) more easily. This interface can directly connect to SD card and NAND Flash.

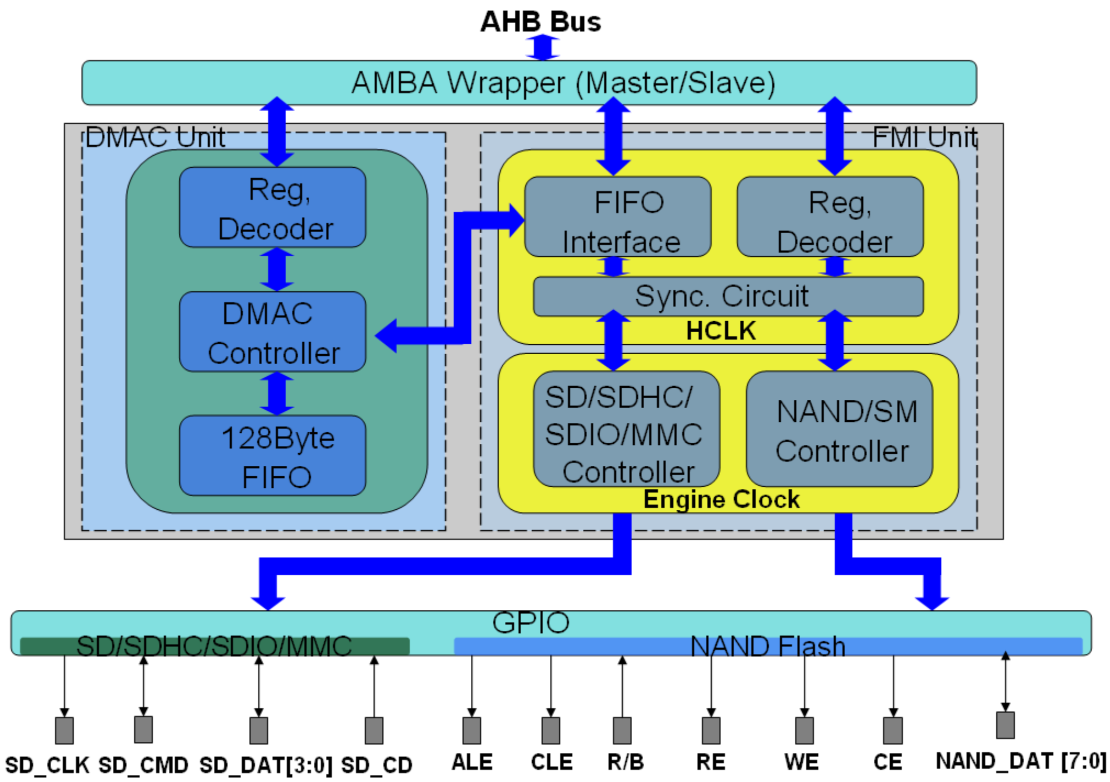
The SIC library has the following features:

- Support single DMA channel and address in non-word boundary.
- Support SD/SDHC/SDIO/MMC card.
- Support SLC and MLC NAND type Flash.
- Adjustable NAND page sizes. (512 / 2048 / 4096 / 8192 bytes + spare area)
- Support up to 4bit/8bit/12bit/15bit hardware ECC calculation circuit to protect data communication.
- Programmable NAND/SM timing cycle.

12.3 Programming Guide

12.3.1 System Overview

The Storage Interface Controller (SIC) of N9H20 chip has SIC_DMAC unit and SIC_FMI unit. The SIC_DMAC unit provides a DMA (Direct Memory Access) function for FMI to exchange data between system memory (ex. SDRAM) and shared buffer (128 bytes), and the SIC_FMI unit control the interface of SD/SDHC/SDIO/MMC or NAND/SM. The serial interface controller can support SD/SDHC/SDIO/MMC card and NAND-type flash and the FMI is cooperated with DMAC to provide a fast data transfer between system memory and cards. The block diagram of SIC controller is shown as following:



12.3.2 NAND Driver and GNAND Library

The SIC library provides NAND driver API to access NAND chip directly. However, the NAND driver doesn't support management features for NAND chip that doesn't guarantee all blocks are valid. The management features include bad block management, garbage collection, and wear-leveling. We provide GNAND library to support these management features and suggest use GNAND library before using SIC NAND driver.

12.4 SIC APIs Specification

sicOpen

Synopsis

void sicOpen (VOID)

Description

sicOpen() will initialize the SIC and DMAC interface hardware. It configures GPIO to FMI mode, and installs ISR. This function is board dependent. It probably needs some modifications before it can work properly on your target board.

Parameter

None

Return Value

None

Example

```
/* initialize SIC to FMI (Flash Memory Interface controller) mode */
sicIoctl(SIC_SET_CLOCK, 192000, 0, 0);  /* clock from PLL */
sicOpen();
```

sicClose

Synopsis

void sicClose (VOID)

Description

sicClose() will close the SIC and DMAC interface hardware. It configures GPIO to close DMAC and disable ISR for SIC.

Parameter

None

Return Value

None

Example

```
sicClose();
```

sicIoctl

Synopsis

VOID sicIoctl (INT32 sicFeature, INT32 sicArg0, INT32 sicArg1, INT32 sicArg2)

Description

sicIoctl() allows user set engine clock and callback functions, the supported features and arguments listed in the table below.

Feature	Argument 0	Argument 1	Argument 2
SIC_SET_CLOCK	AHB clock by KHz	None	None
SIC_SET_CALLBACK	Card type (FMI_SD_CARD)	SD card remove callback function	SD card insert callback function
SIC_GET_CARD_STATUS	Pointer to return value of SD card status.	None	None
SIC_SET_CARD_DETECT	TRUE to enable SD card detect feature; FALSE to disable it.	None	None

Parameter

sicFeature SIC_SET_CLOCK, SIC_SET_CALLBACK, SIC_GET_CARD_STATUS, SIC_SET_CARD_DETECT

sicArg0	Depend on feature setting
sicArg1	Depend on feature setting
sicArg2	Depend on feature setting

Return Value

For SIC_GET_CARD_STATUS, return TRUE means SD card inserted; return FALSE means SD card removed.

Example

Refer to the example code of sicOpen().

12.5 SIC / SD APIs Specification

sicSdOpen

Synopsis

INT sicSdOpen (void)	open SD card 0
INT sicSdOpen0 (void)	open SD card 0
INT sicSdOpen1 (void)	open SD card 1
INT sicSdOpen2 (void)	open SD card 2

Description

This function initializes the SD host interface and programs the SD card from identify mode to stand-by mode.

Parameter

None

Return Value

>0	– Total sector number of SD card
Otherwise	– Refer to the error code defined in Error Code Table

Example

```
if (sicSdOpen0() <= 0) // Open SD port 0
{
printf("Error in initializing SD card !! \n");
sicSdClose0();
/* handle error status */
}
```

sicSdClose

Synopsis

void sicSdClose (void)	close SD card 0
void sicSdClose0 (void)	close SD card 0
void sicSdClose1 (void)	close SD card 1
void sicSdClose2 (void)	close SD card 2

Description

This function closes the SD host interface.

Parameter

None

Return Value

None

Example

```
sicSdClose();            // Close SD port 0
```

sicSdRead

Synopsis

INT sicSdRead (INT32 sdSectorNo, INT32 sdSectorCount, INT32 sdTargetAddr)
for SD card 0

INT sicSdRead0 (INT32 sdSectorNo, INT32 sdSectorCount, INT32 sdTargetAddr)
for SD card 0

INT sicSdRead1 (INT32 sdSectorNo, INT32 sdSectorCount, INT32 sdTargetAddr)
for SD card 1

INT sicSdRead2 (INT32 sdSectorNo, INT32 sdSectorCount, INT32 sdTargetAddr)
for SD card 2

Description

This function will read the data from SD card.

Parameter

sdSectorNo	Sector number which the data is from the address
sdSectorCount	Sector count of this access
sdTargetAddr	The address which data uploads to SDRAM

Return Value

0	- On success
FMI_TIMEOUT	- Access timeout
FMI_NO_SD_CARD	- Card removed

FMI_SD_CRC7_ERROR - Command/Response error

FMI_SD_CRC16_ERROR - Data transfer error

Example

```
#define FMI_TEST_SIZE  (512*128)
__align(4096) UINT8 fmiReadBackBuffer[FMI_TEST_SIZE];
status = sicSdRead(3000, FMI_TEST_SIZE/512, (UINT32)
fmiReadBackBuffer);
```

sicSdWrite

Synopsis

INT sicSdWrite (INT32 sdSectorNo, INT32 sdSectorCount, INT32 sdSourceAddr)
for SD card 0

INT sicSdWrite0 (INT32 sdSectorNo, INT32 sdSectorCount, INT32 sdSourceAddr)
for SD card 0

INT sicSdWrite1 (INT32 sdSectorNo, INT32 sdSectorCount, INT32 sdSourceAddr)
for SD card 1

INT sicSdWrite2 (INT32 sdSectorNo, INT32 sdSectorCount, INT32 sdSourceAddr)
for SD card 2

Description

This function writes the data into SD card.

Parameter

sdSectorNo	Sector number which the data puts the address
sdSectorCount	Sector count of this access
sdSourcetAddr	The address which downloads data from SDRAM

Return Value

0	- On success
FMI_TIMEOUT	- Access timeout
FMI_NO_SD_CARD	- Card removed
FMI_SD_CRC7_ERROR	- Command/Response error
FMI_SD_CRC_ERROR	- Data transfer error

Example

```
#define FMI_TEST_SIZE  (512*128)
__align(4096) UINT8 fmiFlash_Buf[FMI_TEST_SIZE];
status = sicSdWrite(3000, FMI_TEST_SIZE/512, (UINT32)fmiFlash_Buf);
```

12.6 SIC / NAND APIs Specification

nandInit0

Synopsis

INT nandInit0 (NDISK_T *NDISK_info) for NAND chip 0

INT nandInit1 (NDISK_T *NDISK_info) for NAND chip 1

Description

This function configures SIC register to initialize DMAC and FMI to NAND mode. It also initializes the internal data structure for the future use. Since the different NAND chips need different parameters, nandInit0() also reads the product ID from NAND chip to try to configure correct parameters for it. This function is dependent on NAND chip. It probably needs some modifications before it can work properly on your target NAND chip.

Parameter

NDISK_info The internal data for NAND disk information. nandInit0() will initialize it and return to caller.

Return Value

0	- Success
Otherwise	- Refer to the error code defined in Error Code Table

Example

```
NDISK_T *ptMassNDisk;
NDISK_T MassNDisk;
ptMassNDisk = (NDISK_T *)&MassNDisk;
sicOpen();
if (nandInit0(ptMassNDisk) < 0)
{
    printf("NAND initial fail !!\n");
    /* handle error status */
}
```

nand_ioctl

Synopsis

INT nand_ioctl (INT param1, INT param2, INT param3, INT param4)

Description

nand_ioctl() is reserved for I/O control utility for NAND. It is empty now and could support new functions in the future.

Parameter

param1	Depend on feature setting
param2	Depend on feature setting
param3	Depend on feature setting
param4	Depend on feature setting

Return Value

0	- Success
Otherwise	- Refer error code defined in Error Code Table

Example

None

nandpread0

Synopsis

INT nandpread0 (INT PBA, INT page, UINT8 *buff) for NAND chip 0

INT nandpread1 (INT PBA, INT page, UINT8 *buff) for NAND chip 1

Description

This function reads a page of data from NAND.

Parameter

PBA	physical block address of NAND which data is from
page	page number in PBA block that read data from.
buff	the RAM address to store the reading data.

Return Value

0	- Success
Otherwise	- Refer to the error code defined in Error Code Table

Example

```
__align(32) UINT8 fmiFlash_Buf[PAGE_SIZE];
/* read a page of data from NAND block 5 page 10 and store at
fmiFlash_Buf */
status = nandpread0(5, 10, fmiFlash_Buf);
if (status < 0)
{
/* handle error status */
}
```

nandpwrite0

Synopsis

INT nandpwrite0 (INT PBA, INT page, UINT8 *buff) for NAND chip 0

INT nandpwrite1 (INT PBA, INT page, UINT8 *buff) for NAND chip 1

Description

This function writes a page of data to NAND.

Parameter

PBA	physical block address of NAND which the data is written to
page	page number in PBA block to write data.
buff	the RAM address to get the writing data.

Return Value

0	- Success
Otherwise	- Refer to the error code defined in Error Code Table

Example

```
__align(32) UINT8 fmiFlash_Buf[PAGE_SIZE];
/* write a page of data from fmiFlash_Buf to NAND block 5 page 10 */
status = nandpwrite0(5, 10, fmiFlash_Buf);
if (status < 0)
{
/* handle error status */
}
```

nand_is_page_dirty0

Synopsis

INT nand_is_page_dirty0 (INT PBA, INT page) for NAND chip 0

INT nand_is_page_dirty1 (INT PBA, INT page) for NAND chip 1

Description

This function checks the redundancy area of the NAND page and return the dirty status to indicate whether a page to be dirty or not. Dirty page means you cannot write data to it directly. You have to erase this block first to clean it.

Parameter

PBA	physical block address of NAND
page	page number in PBA block which checks the dirty status.

Return Value

0	- Clean page that can write data directly
1	- Dirty page that cannot write data directly

Example

```
/* check dirty status for NAND block 5 page 10 */
status = nand_is_page_dirty0(5, 10);
if (status == 0)
{
printf("This page is clean !! You can write data to it directly.\n");
}
else
{
    printf("This page is dirty !! You cannot write data to it directly.\n");
}
```

nand_is_valid_block0

Synopsis

INT nand_is_valid_block0 (INT PBA) for NAND chip 0

INT nand_is_valid_block1 (INT PBA) for NAND chip 1

Description

This function checks the redundancy area of the NAND block and return the valid status to indicate whether a block to be valid or not. Valid block page means you can write data to it directly or indirectly (maybe need to erase block first). You cannot write data into an invalid block always since it could be a bad block.

Parameter

PBA physical block address of NAND which checks the valid status

Return Value

0 - Invalid block that cannot write data into it

1 - Valid block that can write data into it directly or indirectly

Example

```
/* check valid status for NAND block 5 */
status = nand_is_valid_block0(5);
if (status == 1)
{
printf("This block is valid !! You can write data to it directly or indirectly.\n");
}
else
{
    printf("This block is invalid !! You cannot write data to it always.\n");
```

```
}
```

nand_block_erase0

Synopsis

INT nand_block_erase0 (INT PBA)	for NAND chip 0
INT nand_block_erase1 (INT PBA)	for NAND chip 1

Description

This function erases a block. You should call this API first if you want to write data into a dirty page.

Parameter

PBA	physical block address of NAND which is erased

Return Value

0	- Erase block successfully
Otherwise	- Refer to the error code defined in Error Code Table

Example

```
/* erase NAND block 5 */
status = nand_block_erase0(5);
if (status == 0)
{
printf("This block is erased !!\n");
}
else
{
    printf("This block erase fail !!\n");
}
```

nand_chip_erase0

Synopsis

INT nand_chip_erase0 (VOID)	for NAND chip 0
INT nand_chip_erase1 (VOID)	for NAND chip 1

Description

This function erases all blocks in NAND chip. All data in chip will be lost.

Parameter

None

Return Value

0	- Erase chip successfully
Otherwise	- Refer to the error code defined in Error Code Table

Example

```
/* erase whole NAND chip */
status = nand_chip_erase0();
if (status == 0)
{
printf("This chip is erased !!\n");
}
else
{
    printf("This chip erase fail !!\n");
}
```

12.6.1 Example code

The example code tests the NAND flash and SD card by using the read/write/compare, please refer to the SIC example code of BSP Non-OS.

12.6.2 Error Code Table

Code Name	Value	Description
FMI_TIMEOUT	0xFFFF0101	Access timeout
FMI_NO_MEMORY	0xFFFF0102	No available memory
Error Code for SD Card		
FMI_NO_SD_CARD	0xFFFF0110	No SD card insert
FMI_ERR_DEVICE	0xFFFF0111	Unknown device type
FMI_SD_INIT_TIMEOUT	0xFFFF0112	SD command/response timeout
FMI_SD_SELECT_ERROR	0xFFFF0113	Select card from identify mode to stand-by mode error
FMI_SD_INIT_ERROR	0xFFFF0115	SD card initial and identify error
FMI_SD_CRC7_ERROR	0xFFFF0116	SD command/response error
FMI_SD_CRC16_ERROR	0xFFFF0117	Data transfer error
FMI_SD_CRC_ERROR	0xFFFF0118	Data transfer error
FMI_SD_CMD8_ERROR	0xFFFF0119	SD command 8 response error
Error Code for NAND Flash		
FMI_SM_INIT_ERROR	0xFFFF0120	NAND/SM card initial error
FMI_SM_RB_ERR	0xFFFF0121	NAND don't become ready from busy status

FMI_SM_STATE_ERROR	0xFFFF0122	NAND return fail for write command
FMI_SM_ECC_ERROR	0xFFFF0123	Read data error and uncorrectable by ECC
FMI_SM_STATUS_ERR	0xFFFF0124	NAND return fail for erase command
FMI_SM_ID_ERR	0xFFFF0125	NAND chip ID don't supported
FMI_SM_INVALID_BLOCK	0xFFFF0126	NAND block is invalid to erase or write
FMI_SM_MARK_BAD_BLOCK_ERR	0xFFFF0127	Fail to mark a block to bad

13 SPI Library

13.1 Overview

This library provides APIs for programmers to access SPI device connecting with N9H20 SPI interfaces. The SPI library will get the APB clock frequency from system library; application must set the CPU clock before using SPI library.

13.2 SPI Library APIs Specification

spiOpen

Synopsis

int spiOpen(SPI_INFO_T *pInfo)

Description

This function initializes the SPI interface.

Parameter

typedef struct _spi_info_t

{

INT32 nPort; /* select SPI0 (0) or SPI1 (1) */

BOOL bIsSlaveMode; /* set the interface mode - master mode or slave mode */

BOOL bIsClockIdleHigh; /* set the clock idle state – high or low */

BOOL bIsLSBFirst; /* set LSB transfer first or MSB first */

BOOL bIsAutoSelect; /* set automatically active / inactive CS pin */

BOOL bIsActiveLow; /* define the active level of device select signal */

BOOL bIsTxNegative; /* set the Tx signal changed on rising edge or falling edge */

BOOL bIsLevelTrigger; /* set slave select signal is edge-trigger or level-trigger */

} SPI_INFO_T;

Return Value

= 0	Success
< 0	Fail

Example

```
/* Set SPI0 as master mode, clock idle low, MSB transfer first, not
auto CS, receive on negative edge, slave select signal is active Low
and edge-trigger */
```

```
SPI_INFO_T spi0;
spi0.nPort = 0;
spi0.bIsSlaveMode = FALSE;
spi0.bIsClockIdleHigh = FALSE;
spi0.bIsLSBFirst = FALSE;
spi0.bIsAutoSelect = FALSE;
spi0.bIsActiveLow = TRUE;
spi0.bIsTxNegative = FALSE;
spi0.bIsLevelTrigger = FALSE;
spiOpen(&spi0);
```

spiClose

Synopsis

INT32 spiClose(UINT8 u8Port)

Description

This function disable SPI engine clock.

Parameter

u8Port	Select SPI0 (0) or SPI1 (1)

Return Value

= 0	Success
< 0	Fail

Example

```
spiClose(0);
```

spiIoctl

Synopsis

VOID spiIoctl(INT32 spiPort, INT32 spiFeature, INT32 spiArg0, INT32 spiArg1)

Description

This function allows programmers configure SPI interface.

Parameter

spiPort	Select SPI0 (0) or SPI1 (1)
spiFeature	SPI_SET_CLOCK
spiArg0	APB clock by MHz
spiArg1	Device output clock by kHz

Return Value

None

Example

```
/* apb clock is 48MHz, output clock is 10MHz */
spiIoctl(0, SPI_SET_CLOCK, 48, 10000);
```

spiEnable

Synopsis

INT spiEnable(INT32 spiPort)

Description

The function will be active the SPI interface to access device (active CS#).

Parameter

spiPort Select SPI0 (0) or SPI1 (1)

Return Value

0 success

Example

```
spiEnable(0);
```

spiDisable

Synopsis

INT spiDisable(INT32 spiPort)

Description

This function will be inactive the SPI interface (inactive CS#).

Parameter

spiPort Select SPI0 (0) or SPI1 (1)

Return Value

0 success

Example

```
spiDisable(0);
```

spiRead

Synopsis

INT spiRead(INT port, INT RxBitLen, INT len, CHAR *pDst)

Description

This function is used to read the data back from the SPI interface and store it into the buffer pDst.

Parameter

port select SPI0 (0) or SPI1 (1)

RxBitLen set the receive bit length. *SPI_8BIT, SPI_16BIT, SPI_32BIT*

len data count. SPI_8BIT is byte count; SPI_16BIT is half-word count;

SPI_32BIT is word count.

pDst The buffer stores the read back data.

Return Value

0 Success

Example

```
/* read 1 byte data from SPI device */
spiRead(0, SPI_8BIT, 1, (CHAR *)&rdata);
```

spiWrite

Synopsis

INT spiWrite(INT port, INT TxBitLen, INT len, CHAR *pSrc)

Description

This function is used to write the data to the SPI interface.

Parameter

port select SPI0 (0) or SPI1 (1)

TxBitLen set the transmit bit length. *SPI_8BIT, SPI_16BIT, SPI_32BIT*

len data count. SPI_8BIT is byte count; SPI_16BIT is half-word count;

SPI_32BIT is word count

pSrc The buffer stores the data that is written into SPI interface.

Return Value

0 Success

Example

```
/* write 1 half-word to SPI device */
wdata = 0x80ff;
spiWrite(0, SPI_16BIT, 1, (CHAR *)&wdata);
```

spiTransfer

Synopsis

INT spiTransfer(UINT32 port, UINT32 TxBitLen, UINT32 len, PUINT8 RxBuf , PUINT8 TxBuf)

Description

This function is used to read/write the data from/to the SPI interface.

Parameter

port select SPI0 (0) or SPI1 (1)

TxBitLen set the transmit bit length. *SPI_8BIT, SPI_16BIT, SPI_32BIT*

len data count. SPI_8BIT is byte count; SPI_16BIT is half-word count;

SPI_32BIT is word count.

RxBuf The buffer stores the read back data.

TxBuf The buffer stores the data that is written into SPI interface.

Return Value

0 Success

Example

```
/* write 1 byte to SPI device and read 1 byte data from SPI device */
spiRead(0, SPI_8BIT, 1, (PUINT8)&rdata, (PUINT8)& wdata);
```

spiSSEnable

Synopsis

INT spiSSEnable(UINT32 spiPort, UINT32 SSPin, UINT32 ClockMode)

Description

The function will be set specified SS pin of the SPI interface to active state and set transfer timing.

Parameter

spiPort select SPI0 (0) or SPI1 (1)

SSPin select SS0 (0) or SS1 (1)

ClockMode Decides the transfer timing. (SPI_CLOCK_MODE 0~3)

Return Value

0 Success

Example

```
/* Set SS0 pin of SPI0 to active state and transfer timing as SPI mode
3 */
#define SPI_CLOCK_MODE 3
```

```
spiSSEnable(0, 0, SPI_CLOCK_MODE);
```

spiSSDisable

Synopsis

INT spiSSDisable(UINT32 spiPort, UINT32 SSPin)

Description

The function will be set specified SS pin of the SPI interface to inactive state.

Parameter

spiPort	select SPI0 (0) or SPI1 (1)
SSPin	select SS0 (0) or SS1 (1)

Return Value

0 Success

Example

```
/* Set SS0 pin of SPI0 to inactive state */
spiSSDisable(0, 0);
```

spiInstallCallBack

Synopsis

INT32 spiInstallCallBack(UINT8 u8Port, PFN_DRVSPI_CALLBACK pfncallback, PFN_DRVSPI_CALLBACK *pfnOldcallback)

Description

This function is used to install the specified SPI port interrupt call back function.

Parameter

u8Port	select SPI0 (0) or SPI1 (1)
pfncallback	The callback function pointer for specified SPI port.
pfnOldcallback	The previous callback function pointer for specified SPI port.

Return Value

0 Success

Example

```
/* Install Callback function */
spiInstallCallBack (0, SPI0_Handler, &pfnOldcallback);
```

spiIsBusy

Synopsis

BOOL spiIsBusy(UINT8 u8Port)

Description

This function is used to get the SPI busy state.

Parameter

u8Port	select SPI0 (0) or SPI1 (1)

Return Value

TURE	- The specified SPI is busy.
FALSE	- The specified SPI is not busy.

Example

```
/* Wait for SPI0 transfer finish */
while(spiIsBusy(0)!= FALSE);
```

spiEnableInt

Synopsis

VOID spiEnableInt(UINT8 u8Port)

Description

This function is used to enable the SPI interrupt.

Parameter

u8Port	select SPI0 (0) or SPI1 (1)

Return Value

None

Example

```
/* Enable Interrupt Sources of SPI0 */
spiEnableInt (0);
```

spiDisableInt

Synopsis

VOID spiDisableInt(UINT8 u8Port)

Description

This function is used to disable the SPI interrupt.

Parameter

u8Port	select SPI0 (0) or SPI1 (1)

Return Value

None

Example

```
/* Disable Interrupt Sources of SPI0 */
spiDisableInt(0);
```

spiSetGo

Synopsis

VOID spiSetGo(UINT8 u8Port)

Description

This function is used to set SPI starts to transfer data.

Parameter

u8Port	select SPI0 (0) or SPI1 (1)

Return Value

None

Example

```
/* Set SPI0 starts to transfer data */
spiSetGo(0);
```

spiSetByteEndin

Synopsis

VOID spiSetByteEndin(UINT8 u8Port, E_DRVSPI_OPERATION eOP)

Description

This function is used to enable or disable byte endin.

Parameter

u8Port	Select SPI0 (0) or SPI1 (1)
eOP	Select enable or disable the byte endin

Return Value

None

Example

```
/* Set SPI0 disable byte endin */
spiSetByteEndin(0, eDRVSPI_DISABLE);
```

14 SPI_SecureIC Library

14.1 Overview

This library provides APIs for programmers to access Winbond SPI Flash (Only for W74M) connecting with N9H26 SPI interfaces. The SPI library will get the APB clock frequency from system library, application must set the CPU clock before using SPI library.

14.2 API Functions

RPMC_ReadJEDECID

Synopsis

INT32 RPMC_ReadJEDECID(PUINT8 data)

Description

This function reads JEDEC ID.

Parameter

data	the JEDEC ID pointer

Return Value

= 0	Success
< 0	Fail

Example

```
if ((RPMC_ReadJEDECID(u8JID)) == -1)
{
    sysprintf("read id error !!\n");
    return -1;
}
```

RPMC_ReadUID

Synopsis

INT16 RPMC_ReadUID (PUINT8 data)

Description

This function reads Unique ID.

Parameter

data	the Unique ID pointer

Return Value

= 0	Success
< 0	Fail

Example

```
    if ((RPMC_ReadUID(u8UID)) == -1)
    {
        sysprintf("read id error !!\n");
        return -1;
    }
```

RPMC_ReadCounterData

Synopsis

unsigned int RPMC_ReadCounterData(void)

Description

This function read counter data in stoage in public array counter[], data is available if RPMC_IncCounter() operation successed

Parameter

None

Return Value

Counter data

Example

```
    /* counter data in stoage in public array counter[], data is 
available if RPMC_IncCounter() operation successed */
    RPMC_counter = RPMC_ReadCounterData();
```

RPMC_WrRootKey

Synopsis

unsigned int RPMC_WrRootKey(unsigned int cadr,unsigned char *rootkey)

Description

This function writes root key to W74M.

Parameter

cadr	Key index (0~3)
rootkey	Root key poiner

Return Value

0x80	Success
Other	Fail

Example

```
RPMCStatus = RPMC_WrRootKey(KEY_INDEX, ROOTKey);         /* initial Rootkey, use first rootkey/counter pair */
    if(RPMCStatus == 0x80)
    {
        /* Write rootkey success */
        sysprintf("RPMC_WrRootKey Success - 0x%02X!!\n",RPMCStatus );
    }
    else
    {
        /* write rootkey fail, check datasheet for the error bit */
        sysprintf("RPMC_WrRootKey Fail - 0x%02X!!\n",RPMCStatus );
    }
```

RPMC_UpHMACkey

Synopsis

unsigned int RPMC_UpHMACkey(unsigned int cadr,unsigned char *rootkey,unsigned char *hmac4,unsigned char *hmackey);

Description

This function updates HMAC Key

Parameter

cadr	Key index (0~3)
rootkey	Root key poiner
hmac4	HMAC Key message pointer
hmackey	HMAC Key pointer (generated by Rootkey and hmac4)

Return Value

0x80	Success
Other	Fail

Example

```
    RPMCStatus = RPMC_UpHMACkey(KEY_INDEX, ROOTKey, HMACMessage, HMACKey);
    if(RPMCStatus == 0x80)
    {
        /* update HMACkey success */
        sysprintf("RPMC_UpHMACkey Success - 0x%02X!!\n",RPMCStatus );
    }
    else
```

```
{
    /* write HMACkey fail, check datasheet for the error bit */
    sysprintf("RPMC_UpHMACkey Fail - 0x%02X!!\n",RPMCStatus );
}
```

RPMC_IncCounter

Synopsis

unsigned int RPMC_IncCounter(unsigned int cadr,unsigned char *hmackey,unsigned char *input_tag);

Description

This function is used to increase counter data

Parameter

cadr	Key index (0~3)
hmackey	HMAC Key pointer (generated by Rootkey and input_tag)
input_tag	Message for increase counter

Return Value

0x80	Success
Other	Fail

Example

```
RPMCStatus = RPMC_IncCounter(KEY_INDEX, HMACKey, Input_tag);
if(RPMCStatus == 0x80)
{
    /* increase counter success */
    sysprintf("RPMC_IncCounter Success - 0x%02X!!\n",RPMCStatus );
}
else
{
    /* increase counter fail, check datasheet for the error bit */
    sysprintf("RPMC_IncCounter Fail - 0x%02X!!\n",RPMCStatus );
}
```

RPMC_Challenge

Synopsis

unsigned char RPMC_Challenge(unsigned int cadr,unsigned char *hmackey,unsigned char *input_tag);

Description

This function is used to do authentication check.

Parameter

cadr	Key index (0~3)
hmackey	HMAC Key pointer (generated by Rootkey and input_tag)
input_tag	Message for authentication

Return Value

0x80	Success
Other	Fail

Example

```
    /* Main security operation call challenge*/
    while(1)
    {
        if(RPMC_Challenge(KEY_INDEX, HMACKey, Input_tag)!=0)
        {
            sysprintf("RPMC_Challenge Fail!!\n" );
            /* return signature miss-match */
            return 0;
        }
        else
        {
            if(count > 500)
            {
                sysprintf("\n" );
                RPMCStatus = RPMC_IncCounter(KEY_INDEX, HMACKey,
Input_tag);
                if(RPMCStatus == 0x80)
                {
                    /* increase counter success */
                    sysprintf("RPMC_IncCounter Success -
0x%02X!!\n",RPMCStatus );
                }
                else
                {
                    /* increase counter fail, check datasheet for the
error bit */
                    sysprintf("RPMC_IncCounter Fail -
0x%02X!!\n",RPMCStatus );
                    while(1);
                }
```

```
                /* counter data in stoage in public array counter[], 
data is available if RPMC_IncCounter() operation successed */
                RPMC_counter = RPMC_ReadCounterData();

                /* increase RPMC counter done*/
                sysprintf("RPMC_counter 0x%X\n",RPMC_counter);
                count = 0;
            }
            else
                count++;
            sysprintf("." );
        }
    }
```

15 SPU Library

15.1 Overview

This library provides APIs for programmers to play PCM audio data from SPU engine. Except playing audio this library also provides 10-band equalizer APIs. SPU engine only plays audio, no record function is included.

15.2 SPU Library APIs Specification

spuOpen

Synopsis

VOID spuOpen(UINT32 u32SampleRate)

Description

This function will set the audio clock, play buffer address and install its interrupt.

Parameter

u32SampleRate Specific sampling rate

Return Value

None

Example

spuOpen();

spuStartPlay

Synopsis

VOID spuStartPlay(PFN_DRVSPU_CB_FUNC *fnCallBack, UINT8 *data)

Description

After setting IO control to engine, this function will trigger SPU engine to start playing.

Parameter

fnCallBackThe pointer for Call back function

data The pointer for Source PCM audio data

Return Value

None

Example

```
int playCallBack(UINT8 * pu8Buffer)
{
…
```

```
}
spuStartPlay((PFN_DRVSPU_CB_FUNC *) playCallBack, (UINT8 *)SPU_SOURCE);
```

spuStopPlay

Synopsis

VOID spuStopPlay (VOID)

Description

Stop play.

Parameter

None

Return Value

None

Example

```
spuStopPlay ();
```

spuClose

Synopsis

VOID spuClose(VOID)

Description

This function disables SPU engine.

Parameter

None

Return Value

None

Example

spuClose ();

spuIoctl

Synopsis

VOID spuIoctl(UINT32 cmd, UINT32 arg0, UINT32 arg1)

Description

This function allows programmers configure SPU engine, the supported command and arguments listed in the table below.

Command	Argument 0	Argument 1	Description
SPU_IOCTL_SET_VOLUME	Specifies left channel volume ranging from 0 (min.) to 0x3F (max.)	Specifies right channel volume ranging from 0 (min.) to 0x3F (max.)	Set SPU volume
SPU_IOCTL_SET_MONO	Not used	Not used	Set SPU to the mono mode
SPU_IOCTL_SET_STEREO	Not used	Not used	Set SPU to the stereo mode
SPU_IOCTL_GET_FRAG_SIZE	Fragment size	Not used	Get the fragment size from library

Parameter

Cmd	Command
arg0	The first argument of the command
arg1	The second argument of the command

Return Value

None

Example

```
spuIoctl(SPU_IOCTL_SET_VOLUME, 0x3f, 0x3f);
```

spuDacOn

Synopsis

VOID spuDacOn(UINT8 level)

Description

This function is used to enable DAC interface and must used before calling spuStartPlay().

Parameter

level	delay time for de-pop noise

Return Value

None

Example

```
spuDacOn (1);
```

spuDacOff

Synopsis

VOID spuDacOff(VOID)

Description

This function is used to disable DAC interface and must used after calling spuStopPlay().

Parameter

None

Return Value

None

Example

```
spuDacOff ();
```

spuEqOpen

Synopsis

VOID spuEqOpen (E_DRVSPU_EQ_BAND eEqBand, E_DRVSPU_EQ_GAIN eEqGain)

Description

Open 10-band equalizer.

Parameter

eEqBand	Equalizer band setting
eEqGain	Equalizer gain setting for each band

Return Value

None

Example

```
spuEqOpen(eDRVSPU_EQBAND_2, eDRVSPU_EQGAIN_P7DB);
```

spuEqClose

Synopsis

VOID spuEqClose (VOID)

Description

Close Equalizer function.

Parameter

None

Return Value

None

Example

```
spuEqClose ();
```

16 I2S Library

16.1 overview

This library provides APIs for programmers to play/record PCM audio data from I2S engine.

16.2 APIs Specification

16.3 Functions

DrvI2S_Open

Synopsis

VOID DrvI2S_Open(VOID)

Description

This function will open I2S pins and engine clock.

Parameter

None

Return Value

None

Example

```
DrvI2S_Open();
```

DrvI2S_Close

Synopsis

VOID DrvI2S_Close(VOID)

Description

This function will close I2S pins and engine clock.

Parameter

None

Return Value

None

Example

```
DrvI2S_Close();
VOID DrvI2S_StartPlay (
    S_DRVI2S_PLAY* psPlayStruct
)
```

DrvI2S_EnableInt

Synopsis

VOID DrvI2S_EnableInt (UINT32 u32InterruptFlag, PFN_DRVI2S_CB_FUNC* pfnCallBack)

Description

Enable the selected interrupt and setup the callback function, respectively.

Parameter

u32InterruptFlag	selected interrupt
pfnCallBack	callback function

Return Value

None

Example

```
DrvI2S_EnableInt (DRVI2S_IRQ_PLAYBACK, audio_PlayCallBack);
```

DrvI2S_DisableInt

Synopsis

VOID DrvI2S_DisableInt (UINT32 u32InterruptFlag)

Description

Disable the related interrupt

Parameter

u32InterruptFlag selected interrupt

Return Value

None

Example

```
DrvI2S_DisableInt (DRVI2S_IRQ_PLAYBACK);
```

DrvI2S_ClearInt

Synopsis

VOID DrvI2S_ClearInt (UINT32 u32InterruptFlag)

Description

Clear the related interrupt flag

Parameter

u32InterruptFlag interrupt flag

Return Value

None

Example

```
DrvI2S_ClearInt (DRVI2S_IRQ_RECORD);
```

DrvI2S_PollInt

Synopsis

VOID DrvI2S_PollInt (UINT32 u32InterruptFlag)

Description

Get the status of related interrupt flag

Parameter

u32InterruptFlag   selected interrupt flag

Return Value

Current status of selected interrupt flag

Example

```
IntStatus = DrvI2S_PollInt (DRVI2S_IRQ_RECORD);
```

DrvI2S_StartPlay

Synopsis

VOID DrvI2S_StartPlay(S_DRVI2S_PLAY* psPlayStruct)

Description

After opening I2S pins and engine clock, this function will trigger I2S engine to start playing.

Parameter

psPlayStruct   Structure pointer for Play related parameters

Return Value

None

Example

```
DrvI2S_StartPlay((S_DRVI2S_PLAY*) &g_sPlay);
```

DrvI2S_StopPlay

Synopsis

VOID DrvI2S_StopPlay (VOID)

Description

Stop playing.

Parameter

None

Return Value

None

Example

```
DrvI2S_StopPlay();
```

DrvI2S_StartRecord

Synopsis

VOID DrvI2S_StartRecord(S_DRVI2S_RECORD* psRecordStruct)

Description

After opening I2S pins and engine clock, this function will trigger I2S engine to start recording.

Parameter

psRecordStruct Structure pointer for Record related parameters

Return Value

None

Example

```
DrvI2S_StartRecord((S_DRVI2S_RECORD*) &g_sRecord);
```

DrvI2S_StopRecord

Synopsis

VOID DrvI2S_StopRecord (VOID)

Description

Stop recording.

Parameter

None

Return Value

None

Example

```
DrvI2S_StopRecord();
```

DrvI2S_SetSampleRate

Synopsis

VOID DrvI2S_SetSampleRate(E_DRVI2S_SAMPLING eSamplaerate)

Description

Set Play/Record sampling rate.

Parameter

eSampleRate	Given sampling rate.

Return Value

E_SUCCESS	set up the sampling rate successfully
E_FAIL	fail in setting up the sampling rate

Example

DrvI2S_SetSampleRate((E_DRVI2S_SAMPLING) eDRVI2S_FREQ_44100

17 System Library

17.1 Overview

The N9H20 System library provides a set of APIs to control on-chip functions such as Timers, UARTs, AIC, Cache and power management. With these APIs, user can quickly create a test program to run on N9H20 demo board or evaluation board.

This library is created by using Keil uVision IDE. Therefore, it only can be used in Keil environment.

17.2 System Library APIs Specification

17.3 Timer Functions

sysClearTimerEvent

Synopsis

VOID sysClearTimerEvent(UINT32 nTimeNo, UINT32 uTimeEventNo);

Description

This function is used to clear the event of selected timer. *nTimeNo* is used to select timer 0 or timer 1. The event function which indicated by *uTimeEventNo* shall be cleared.

Parameter

nTimeNo TIMER0, TIMER1

uTimeEventNo Event number which want to clear

Return value

None

Example

```
/* clear event NO 5*/
sysClearTimerEvent (TIMER0, 5);
```

sysClearWatchDogTimerCount

Synopsis

VOID sysClearWatchDogTimerCount(VOID);

Description

This function is used to clear watch dog timer reset count. When interrupt occurred, the system will reset after 1024 clock cycles. Clear the reset counter, the system will not be reset.

Parameter

None

Return value

None

Example

```
sysClearWatchDogTimerCount();
```

sysClearWatchDogTimerInterruptStatus

Synopsis

VOID sysClearWatchDogTimerInterruptStatus(VOID);

Description

This function is used to clear watch dog timer interrupt status. When interrupt occurred, the watch dog timer interrupt flag will be set. Clear this flag, the interrupt will occur again.

Parameter

None

Return value

None

Example

```
sysClearWatchDogTimerInterruptStatus();
```

sysDelay

Synopsis

VOID sysDelay(UINT32 uTicks);

Description

This function is used to delay a specific period. *uTicks* is the length of delay time which unit is ten milliseconds. Please notice that the delay period has an extent of error which is less than ten milliseconds.

Parameter

uTicks delay period which unit is ten milliseconds

Return value

None

Example

```
/* delay 1s*/
sysDelay(100);
```

sysDisableWatchDogTimer

Synopsis

VOID sysDisableWatchDogTimer(VOID);

Description

This function is used to disable watch dog timer.

Parameter

None

Return value

None

Example

```
sysDisableWatchDogTimer();
```

sysDisableWatchDogTimerReset

Synopsis

VOID sysDisableWatchDogTimerReset(VOID);

Description

This function is used to disable watch dog timer reset function.

Parameter

None

Return value

None

Example

```
sysDisableWatchDogTimerReset();
```

sysEnableWatchDogTimer

Synopsis

VOID sysEnableWatchDogTimer(VOID);

Description

This function is used to enable watch dog timer.

Parameter

None

Return value

None

Example

```
sysEnableWatchDogTimer();
```

sysEnableWatchDogTimerReset

Synopsis

VOID sysEnableWatchDogTimerReset(VOID);

Description

This function is used to enable watch dog timer reset function. The system will be reset when this function is enabled.

Parameter

None

Return value

None

Example

```
sysEnableWatchDogTimerReset();
```

sysGetCurrentTime

Synopsis

VOID sysGetCurrentTime(DateTime_T *curTime);

Description

This function is used to get local time. *curTime* is a structure pointer which contains year, month, day, hour, minute, and second information.

Parameter

*curTime   structure pointer which contains the following information

```
typedef struct datetime_t
{
        UINT32 year;
        UINT32 mon;
        UINT32 day;
        UINT32 hour;
        UINT32 min;
        UINT32 sec;
} DateTime_T;
```

Return value

None

Example

```
/* set local time*/
DateTime_T       TimeInfo;
sysGetCurrentTime(TimeInfo);
```

sysGetTicks

Synopsis

UINT32 sysGetTicks(INT32 nTimeNo);

Description

This function gets the Timer 0 or Timer 1's current tick count.

Parameter

nTimeNo TIMER0, TIMER1

Return value

The current selected timer tick count.

Example

```
/* Get current timer 0 tick count */
UINT32 btime;
btime = sysGetTicks(TIMER0);
```

sysInstallWatchDogTimerISR

Synopsis

PVOID sysInstallWatchDogTimerISR(INT32 nIntTypeLevel, PVOID pvNewISR);

Description

This function is used to set up own watch dog timer interrupt service routine. *nIntTypeLevel* is the selected interrupt to be FIQ or IRQ, and level group 0 ~ 7. *pvNewISR* is the pointer of own interrupt service routine.

Parameter

nIntTypeLevel FIQ_LEVEL_0, IRQ_LEVEL_1 ~ IRQ_LEVEL_7

pvNewISR The pointer of watch dog timer interrupt service routine

Return value

The pointer which points to old ISR

Example

```
/* Set watch dog timer interrupt to be IRQ and group level 1 */
PVOID oldVect;
```

```
oldVect = sysInstallWatchDogTimerISR(IRQ_LEVEL_1, myWatchDogISR);
```

sysResetTicks

Synopsis

INT32 sysResetTicks(INT32 nTimeNo);

Description

This function used to reset Timer 0 or Timer 1's global tick counter.

Parameter

nTimeNo TIMER0, TIMER1

Return value

Successful

Example

```
/* Reset timer 0 tick count */
INT32 status;
status = sysResetTicks(TIMER0);
```

sysSetLocalTime

Synopsis

VOID sysSetLocalTime(DateTime_T ltime);

Description

This function is used to set local time. *ltime* is a structure which contains year, month, day, hour, minute, and second information.

Parameter

ltime structure which contains the following information

```
typedef struct datetime_t
{
        UINT32 year;
        UINT32 mon;
        UINT32 day;
        UINT32 hour;
        UINT32 min;
        UINT32 sec;
} DateTime_T;
```

Return value

None

Example

```
/* set local time*/
DateTime_T      TimeInfo;
TimeInfo.year = 2006;
TimeInfo.mon = 6;
TimeInfo.day = 12
TimeInfo.hour = 9;
TimeInfo.min = 0;
TimeInfo.sec = 30;
sysSetLocalTime(TimeInfo);
```

sysSetTimerEvent

Synopsis

INT32 sysSetTimerEvent(UINT32 nTimeNo, UINT32 nTimeTick, PVOID pvFun);

Description

This function is used to set the event of selected timer. *nTimeNo* is used to select timer 0 or timer 1. The event function which pointed by *pvFun* shall be executed after *nTimeTick* system timer tick.

Parameter

nTimeNo	TIMER0, TIMER1
nTimeTick	Tick count before event executed
pvFun	Event function pointer

Return Value

event number

Example

```
/* Set event function “hello” after 100 tick */
INT nEventNo;
VOID hello(VOID)
{
   sysPrintf(“Hello World!\n”);
}
nEventNo = sysSetTimerEvent (TIMER0, 100, (PVOID)hello);
```

sysSetTimerReferenceClock

Synopsis

INT32 sysSetTimerReferenceClock(UINT32 nTimeNo, UINT32 uClockRate);

Description

This function used to set the reference clock of timer. The default reference clock is system clock (15MHz).

Parameter

nTimeNo TIMER0, TIMER1

uClockRate Reference clock

Return Value

Successful

Example

```
/* Set 20MHz to be timer 0's reference clock */
INT32 status;
status = sysSetTimerReferenceClock(TIMER0, 20000000);
```

sysSetWatchDogTimerInterval

Synopsis

INT32 sysSetWatchDogTimerInterval(INT32 nWdtInterval);

Description

This function is used to set the watch dog timer interval. The default is 0.5 minutes. You can select interval to be 0.5, 1, 2, and 4 minutes.

Parameter

nWdtInterval WDT_INTERVAL_0, WDT_INTERVAL_1, WDT_INTERVAL_2, WDT_INTERVAL_3.

The watch dog timer interval is shown as follows.

nWdtInterval	Interrupt Timeout	Reset Timeout	Real Time Interval
WDT_INTERVAL_0	2^{14} clocks	2^{14} + 1024 clocks	0.28 sec.
WDT_INTERVAL_1	2^{16} clocks	2^{16} + 1024 clocks	1.12 sec.
WDT_INTERVAL_2	2^{18} clocks	2^{18} + 1024 clocks	4.47 sec.
WDT_INTERVAL_3	2^{20} clocks	2^{20} + 1024 clocks	17.9 sec.

Return value

Successful

Example

```
/* Set watch dog timer interval to WDT_INTERVAL_0 */
INT32 status;
status = sysSetWatchDogTimerInterval(WDT_INTERVAL_0);
```

sysStartTimer

Synopsis

INT32 sysStartTimer(INT32 nTimeNo, UINT32 uTicksPerSecond, INT32 nOpMode);

Description

sysStartTimer will start Timer 0 or Timer 1. *nTimeNo* is used to select timer 0 or timer 1. Because W90P710 timer has three operation modes, the *nOpMode* is used to set the operation mode. *uTicksPerSecond* indicates that how many ticks per second.

Parameter

nTimeNo TIMER0, TIMER1

nTickPerSecond Tick numbers per second

nOpMode ONE_SHOT_MODE, PERIODIC_MODE, TOGGLE_MODE

Return Value

Successful

Example

```
/* Start the timer 1, and set it to periodic mode and 100 ticks per second */
INT32 status;
status = sysStartTimer(TIMER1, 100, PERIODIC_MODE);
```

sysStopTimer

Synopsis

INT32 sysStopTimer(INT32 nTimeNo);

Description

sysStopTimer will stop Timer 0 or Timer 1. *nTimeNo* is used to select timer 0 or timer 1. After disabling timer, this function will restore the interrupt service routine.

Parameter

nTimeNo TIMER0, TIMER1

Return Value

Successful

Example

```
/* Stop the timer 1 */
INT32 status;
```

```
status = sysStopTimer(TIMER1);
```

sysUpdateTickCount

Synopsis

INT32 sysUpdateTickCount(INT32 nTimeNo, UINT32 uCount);

Description

This function used to update Timer 0 or Timer 1's global tick counter.

Parameter

nTimeNo	TIMER0, TIMER1
uCount	The value of tick counter

Return Value

Successful

Example

```
/* update  timer 0's tick counter as 3000 */
sysUpdateTickCount (TIMER0, 3000);
```

17.4 UART Function

sysGetChar

Synopsis

CHAR sysGetChar(VOID);

Description

This function is used to obtain the next available character from the UART. Nothing is echoed. When no any available character is found, the function waits until a character is found from UART.

Parameter

None

Return Value

Character from UART

Example

```
/* get user's input*/
CHAR cUserInput;
cUserInput = sysGetChar();
```

sysInitializeUART

Synopsis

INT32 sysInitializeUART(WB_UART *uart);

Description

WB_UART is the device initialization structure. The definition is as follows:

```
typedef struct UART_INIT_STRUCT
{
    UINT32 freq;
    UINT32 baud_rate;
    UINT32 data_bits;
    UINT32 stop_bits;
    UINT32 parity;
    UINT32 rx_trigger_level;
} WB_UART;
```

uart->freq is UART reference clock. Default is 15MHz. If user sets the different reference clock, use this parameter to change it.

uart->baud_rate is used to set the baudrate of COM port. The range is from 9600 to 230400.

The UART data bit can be 5, 6, 7, or 8. Use *uart->data_bits* to set the suitable data bits.

The UART stop bit can be 1, or 2. Use *uart->stop_bits* to set the suitable stop bits.

uart->parity is used to set the suitable parity check.

uart->rx_trigger_level is used to set the suitable trigger level.

Parameter

uart->data_bits WB_DATA_BITS_5 ~ WB_DATA_BITS_8

uart->stop_bits WB_STOP_BITS_1, WB_STOP_BITS_2

uart->parity WB_PARITY_NONE, WB_PARITY_ODD, WB_PARITY_EVEN

uart->rx_trigger_level LEVEL_1_BYTE, LEVEL_4_BYTES, LEVEL_8_BYTES, LEVEL_14_BYTES

Return Value

Successful/ WB_INVALID_PARITY/ WB_INVALID_DATA_BITS/ WB_INVALID_STOP_BITS/ WB_INVALID_BAUD

Example

```
    WB_UART_T uart;
    uart.uiFreq = APB_SYSTEM_CLOCK;
    uart.uiBaudrate = 115200;
    uart.uiDataBits = WB_DATA_BITS_8;
```

```
    uart.uiStopBits = WB_STOP_BITS_1;
    uart.uiParity = WB_PARITY_NONE;
    uart.uiRxTriggerLevel = LEVEL_1_BYTE;
    sysInitializeUART(&uart);    WB_UART_T uart;
```

sysPrintf

Synopsis

VOID sysPrintf(PCHAR pcStr, …);

Description

The function sends the specified *str* to the terminal through the RS-232 interface by interrupt mode.

Parameter

pcStr   Pointer of string which want to display

Return Value

None

Example

```
sysPrintf("Hello World!\n");
```

sysprintf

Synopsis

VOID sysPrintf(PCHAR pcStr, …);

Description

The function sends the specified *str* to the terminal through the RS-232 interface by polling mode.

Parameter

pcStr   Pointer of string which wants to display

Return Value

None

Example

```
sysprintf("Hello World!\n");
```

sysPutChar

Name

sysPutChar – put a character out to UART

Synopsis

VOID sysPutChar(UCHAR ch);

Description

The function sends the specified *ch* to the UART.

Parameter

ch character which wants to display

Return Value

None

Example

```
sysPutChar("A");
```

sysUartEnableInt

Name

sysUartEnableInt– Enable high speed UART time out or data ready interrupt.

Synopsis

VOID sysUartEnableInt (INT32 eIntType);

Description

The function enables the specified UART interrupt.

Parameter

eIntType:

Table 17-1 UART Interrupt Type

u32IntType	Value	Meaning
UART_INT_RDA	1	Data has ready in buffer.
UART_INT_RDTO	2	A moment that over the time of time out after receive UART data
UART_INT_NONE	255	Disable UART interrupt

Return Value

None

Example

```
sysUartEnableInt(UART_INT_RDA);
/* Enable receive data ready interrupt */
sysUartEnableInt(UART_INT_RDTO);
/* Enable receive time out interrupt */
```

sysUartInstallcallback

Name

sysUartInstallcallback – install callback function for upper to process UART events.

Synopsis

VOID sysUartInstallcallback (UINT32 u32IntType,
PFN_SYS_UART_CALLBACK fnCallback);

Description

Generally, the function is used for upper layer to processing the UART events.

Parameter

u32IntType UART interrupt type. Please reference Table 17-1 UART Interrupt Type

Return value

None

Return Value

None

Example

```
void UartDataValid_Handler(UINT8* buf, UINT32 u32Len)
{
    UINT32 u32Idx = 0;
    g_u32Len = u32Len;
    g_u32Valid = g_u32Valid+1;
    memcpy(&(pi8UartBuf[g_u32Idx]), buf, u32Len);
    g_u32Idx = g_u32Idx+u32Len;
    while(u32Idx++<u32Len)
    {
            if(*buf++ =='q')
            {
                    bIsTimeOut = 1;
                    break;
            }
    }
}
void UartDataTimeOut_Handler(UINT8* buf, UINT32 u32Len)
{
```

```
    UINT32 u32Idx = 0;
    g_u32Timeout = g_u32Timeout+1;
    memcpy(&(pi8UartBuf[g_u32Idx]), buf, u32Len);
    g_u32Idx = g_u32Idx+u32Len;

    while(u32Idx++<u32Len)
    {
            if(*buf++ =='q')
            {
                    bIsTimeOut = 1;
                    break;
            }
    }
}
int DemoAPI_HUART(void)
{
…
    sysUartInstallcallback(0, UartDataValid_Handler);
    sysUartInstallcallback(1, UartDataTimeOut_Handler);
…
}
```

sysUartTransfer

Name

sysUartTransfer – Transfer mass data through UART.

Synopsis

VOID sysUartTransfer (char* pu8buf, UINT32 u32Len);

Description

Transfer mass data through UART port.

Parameter

pu8bufBuffer	Pointer for transferring data.
u32Len	Length for transferring data. Unit: Byte.

Return value

None

Example

```
int DemoAPI_HUART(void)
```

```
{
…
   sysUartTransfer(pi8UartBuf,  u32Count);
   /* Transfer out u32Count byte in i8UartBuf */
…
}
```

register_uart_device

Name

register_uart_device – Register UART device

Synopsis

INT32 register_uart_device(UINT32 u32port, UARTDEV_T* pUartDev);

Description

Registered an UART device through the API. Programmer could use same API interface to operation both UART devices in the same time.

Parameter

u32port Specified UART port number for registering.

pUartDev A pointer for registering UART port. The pointer points to the APIs interface

Return value

None

Example

```
UARTDEV_T UART0; /*High speed */
UARTDEV_T* pUART0;
int DemoAPI_HUART(void)
{
…
   register_uart_device(0, &UART0);
 pUART0 = &UART0;
 pUART0->UartPort(0);
   uart.uiFreq = u32ExtFreq*1000;
   uart.uiBaudrate = 115200;
   uart.uiDataBits = WB_DATA_BITS_8;
   uart.uiStopBits = WB_STOP_BITS_1;
   uart.uiParity = WB_PARITY_NONE;
   uart.uiRxTriggerLevel = LEVEL_1_BYTE;
```

```
pUART0->UartInitialize(&uart);
pUART0->UartEnableInt(UART_INT_NONE);
pUART0->UartInstallcallback(0, UartDataValid_Handler);
pUART0->UartInstallcallback(1, UartDataTimeOut_Handler);
…
}
```

17.5 AIC Functions

sysDisableInterrupt

Name

sysDisableInterrupt – disable interrupt source

Synopsis

INT32 sysDisableInterrupt(UINT32 intNo);

Description

This function is used to disable interrupt source.

Parameter

intNo	Interrupt source number

Return Value

Successful or Fail.

Example

```
/* Disable timer 0 interrupt (source number is 7) */
INT32 status;
status = sysDisableInterrupt(7);
```

sysEnableInterrupt

Synopsis

INT32 sysEnableInterrupt(UINT32 intNo);

Description

This function is used to enable interrupt source.

Parameter

intNo	Interrupt source number

Return Value

Successful or Fail.

Example

```
/* Enable timer 0 interrupt (source number is 7) */
INT32 status;
status = sysEnableInterrupt(7);
```

sysGetIBitState

Synopsis

BOOL sysGetIBitState (VOID);

Description

This function is used to get the status of interrupt disable bit, I-bit, of CPSR register.

Parameter

None

Return Value

TRUE – I-bit is clear, FALSE – I-bit is set.

Example

```
BOOL int_status;
Int_status = sysGetIBitState();
```

sysGetInterruptEnableStatus

Synopsis

UINT32 sysGetInterruptEnableStatus(VOID);

Description

This function is used to get the enable/disable status of interrupt which saves in AIC_IMR register.

Parameter

None

Return Value

value of AIC_IMR register

Example

```
/* Set AIC as software mode */
UINT32 uIMRValue;
uIMRValue = sysGetInterruptEnableStatus();
```

sysInstallExceptionHandler

Synopsis

PVOID sysInstallExceptionHandler(INT32 exceptType, PVOID pNewHandler);

Description

This function is used to install *pNewHandler* into *exceptType* exception.

Parameter

exceptType	WB_SWI, WB_D_ABORT, WB_I_ABORT, WB_UNDEFINE
pNewHandler	Pointer of the new handler

Return Value

a pointer which points to old handler

Example

```
/* Setup own software interrupt handler */
PVOID oldVect;
oldVect = sysInstallExceptionHandler(WB_SWI, pNewSWIHandler);
```

sysInstallFiqHandler

Synopsis

PVOID sysInstallFiqHandler(PVOID pNewISR);

Description

Use this function to install FIQ handler into interrupt vector table.

Parameter

pNewISR Pointer of the new ISR handler

Return Value

a pointer which point to old ISR

Example

```
/* Setup own FIQ handler */
PVOID oldVect;
oldVect = sysInstallFiqHandler(pNewFiqISR);
```

sysInstallIrqHandler

Synopsis

PVOID sysInstallIrqHandler(PVOID pNewISR);

Description

Use this function to install FIQ handler into interrupt vector table.

Parameter

pNewISR Pointer of the new ISR handler

Return Value

a pointer which points to old ISR

Example

```
/* Setup own IRQ handler */
PVOID oldVect;
oldVect = sysInstallIrqHandler(pNewIrqISR);
```

sysInstallISR

Synopsis

PVOID sysInstallISR(INT32 intTypeLevel, INT32 intNo, PVOID pNewISR, PVOID pParam);

Description

W90P710 interrupt group level is 0 ~ 7. Level 0 is FIQ, and level 1 ~ 7 are IRQ. The highest priority is 0, and the lowest priority is 7. Use this function to set up interrupt source (*intNo*) *pNewISR* handler to AIC interrupt vector table.

Parameter

intTypeLevel	FIQ_LEVEL_0, IRQ_LEVEL_1 ~ IRQ_LEVEL_7
intNo	Interrupt source number
pNewISR	Function pointer of new ISR
pParam	Parameter for ISR

Return Value

a pointer which point to old ISR

Example

```
/* Setup timer 0 handler */
PVOID oldVect;
oldVect = sysInstallISR(IRQ_LEVEL_1, 7, pTimerISR, param);
```

sysSetAIC2SWMode

Synopsis

INT32 sysSetAIC2SWMode(VOID);

Description

This function is used to set AIC as software mode. When the system AIC in software mode, the priority of each interrupt source shall be handled by software.

Parameter

intState ENABLE_IRQ, ENABLE_FIQ, ENABLE_FIQ_IRQ, DISABLE_IRQ, DISABLE_FIQ, DISABLE_FIQ_IRQ

Return Value

Successful

Example

```
/* Set AIC as software mode */
sysSetAIC2SWMode();
```

sysSetGlobalInterrupt

Synopsis

INT32 sysSetGlobalInterrupt(INT32 intState);

Description

Enable / disable all interrupt sources.

Parameter

intState ENABLE_ALL_INTERRUPTS, DISABLE_ALL_INTERRUPTS

Return Value

Successful

Example

```
/* Disable all interrupt */
INT32 status;
status = sysSetGlobalInterrupt(DISABLE_ALL_INTERRUPTS);
```

sysSetInterruptPriorityLevel

Synopsis

INT32 sysSetInterruptPriorityLevel(UINT32 intNo, UINT32 intLevel);

Description

W90P710 interrupt has 8 group levels. The highest is 0, and the lowest is 7. Use this function can change the priority level after installing the ISR.

Parameter

intNo Interrupt source number

intLevel FIQ_LEVEL_0, IRQ_LEVEL_1 ~ IRQ_LEVEL_7

Return Value

Successful or Fail.

Example

```
/* Change timer 0 priority to level 4 */
INT32 status;
status = sysSetInterruptPriorityLevel(7, 4);
```

sysSetInterruptType

Synopsis

INT32 sysSetInterruptType(UINT32 intNo, UINT32 intSourceType);

Description

W90P710 has four kinds of interrupt source types. They are low level sensitive, high level sensitive, negative edge trigger, and positive edge trigger. The default is high level sensitive. This function is used to change the interrupt source type.

Parameter

intNo Interrupt source number

intSourceType LOW_LEVEL_SENSITIVE, HIGH_LEVEL_SENSITIVE, NEGATIVE_EDGE_TRIGGER, POSITIVE_EDGE_TRIGGER

Return Value

Successful or Fail.

Example

```
/* Change timer 0 source type to be positive edge trigger */
INT32 status;
status = sysSetInterruptType(7, POSITIVE_EDGE_TRIGGER);
```

sysSetLocalInterrupt

Synopsis

INT32 sysSetLocalInterrupt(INT32 intState);

Description

When using interrupt, the CPSR I bit and F bit need to be enabled or disabled. This function is used to enable / disable I bit and F bit.

Parameter

intState ENABLE_IRQ, ENABLE_FIQ, ENABLE_FIQ_IRQ, DISABLE_IRQ, DISABLE_FIQ, DISABLE_FIQ_IRQ

Return Value

Successful

Example

```
/* Enable I bit of CPSR */
INT32 state;
state = sysSetLocalInterrupt(ENABLE_IRQ);
```

17.6 Cache Function

sysDisableCache

Synopsis

VOID sysDisableCache(VOID);

Description

This function is used to disable cache.

Parameter

None

Return Value

None

Example

```
/* disabled cache */
sysDisableCache();
```

sysEnableCache

Synopsis

VOID sysEnableCache(UINT32 uCacheOpMode);

Description

This function is used to enable cache.

Parameter

uCacheOpMode	CACHE_WRITE_BACK, CACHE_WRITE_THROUGH

Return Value

None

Example

```
/* enable cache */
sysEnableCache();
```

sysFlushCache

Synopsis

VOID sysFlushCache(INT32 cacheType);

Description

This function is used to flush system cache. The parameter, cacheType is used to select cache which needs to be flushed.

Parameter

cacheType	I_CACHE, D_CACHE, I_D_CACHE

Return Value

None

Example

```
/* flush cache */
sysFlushCache(I_D_CACHE);
```

sysGetCacheState

Synopsis

VOID sysGetCacheState (VOID);

Description

This function is used to get the enable/disable status of cache.

Parameter

None

Return Value

None

Example

```
/* Read cache status */
BOOL status;
status = sysGetCacheState();
```

sysGetSdramSizebyMB

Synopsis

INT32 sysGetSdramSizebyMB(VOID);

Description

This function returns the size (in Mbytes) of total memory.

Parameter

None

Return Value

Memory size or Fail

Example

```
/* Get the memory size */
INT32 memsize;
memsize = sysGetSdramSizebyMB();
sysprintf("The total memory size is %dMbytes\n", memsize);
```

sysInvalidCache

Synopsis

VOID sysInvalidCache (VOID);

Description

This function is used to invalid both Instruction and Data cache contents.

Parameter

None

Return Value

None

Example

```
/* Invalid cache */
sysInvalidCache();
```

sysSetCachePages

Synopsis

INT32 sysSetCachePages(UINT32 addr, INT32 size, INT32 cache_mode);

Description

This function is used to change the cache mode of a memory area. Note that the starting address and the size must be 4Kbytes boundary.

Parameter

addr The memory starting address.

size The memory size.

cache_mode CACHE_WRITE_BACK / CACHE_WRITE_THROUGH / CACHE_DISABLE.

Return Value

Successful or Fail

Example

```
/* enable cache to write-back mode */
sysEnableCache(CACHE_WRITE_BACK);
…
sysFlushCache();
/* Change the memory region 0x1000000 ~ 0x1001000 to be non-cachebale
*/
sysSetCachePages(0x1000000, 4096, CACHE_DISABLE);
```

17.7 Clock Control Function

sysGetExternalClock

Synopsis

UINT32 sysGetExternalClock(void);

Description

This function is used to get external clock setting. N9H20 IBR only supports 2 kinds of external clock frequency. 12MHz or 27MHz. So external clock will be 12MHz or 27MHz.

Parameter

None

Return Value

External clock. Unit : KHz.

Example

```
/* Read system clock setting */
UINT32 u32ExtFreq;

u32ExtFreq = sysGetExternalClock();
```

sysSetSystemClock

Synopsis

```
UINT32 sysSetSystemClock(E_SYS_SRC_CLK eSrcClk,
                         UINT32 u32PllKHz,
                         UINT32 u32SysKHz,
                         UINT32 u32CpuKHz,
                         UINT32 u32HclkKHz,
                         UINT32 u32ApbKHz);
```

Description

This function is used to write system clock setting includes PLL output frequency, System, CPU, AHB and APB clock.

Parameter

eSrcClk Sytem clock source.

It could be eSYS_EXT, eSYS_APLL and eSYS_UPLL. They mean the system clock source comes from external clock, APLL and UPLL respectively.

u32PllKHz Set the APLL or UPLL output frequency. Unit: KHz.

u32SysKHz Set the system clock output frequency.

Unit: KHz. The system clock source can be external, APLL or UPLL.

u32CpuKHz Set the CPU working frequency.

Unit: KHz.

u32HclkKHz Set the DDR/SDRAM working frequency.

Unit: KHz. It is always equal to u32SysClk/2

u32ApbKHz Set the APB output frequency.

Unit: KHz.

There are some limitations in the clock function due to hardware's limitation.

1. These clocks exist multiplication factor. It means PLL >= n*SYS. SYS>=m*CPU. SYS=2*HCLK. SYS>=x*APB. Where n, m, x are all integer.
2. PLL clock must under or equal to 240MHz.
3. System clock must under or equal to the source clock.
4. CPU clock source is system clock. It can only be equal to system clock or half of system clock.
5. HCLK clock can only be half of system clock.

APB clock source comes from system clock. It is can only smaller than system clock.

Return Value

Successful or Error code.

Example

```
/* Write system clock setting */
sysSetSystemClock(eSYS_UPLL,        // system clock come from UPLL
                240000,      // UPLL = 240MHz
                240000,      // SYS = 240MHz
                120000,      // CPU = 120MHz
                120000,      // HCLK = 120MHz,
                60000);            // APB = 60MHz
```

sysGetSystemClock

Synopsis

void sysGetSystemClock(E_SYS_SRC_CLK* peSrcClk,
PUINT32 pu32PllKHz,
PUINT32 pu32SysKHz,
PUINT32 pu32CpuKHz,
PUINT32 pu32HclkKHz,
PUINT32 pu32ApbKHz);

Description

This function is used to read system clock setting including PLL output frequency, System, CPU, AHB and APB clock. The function must be called after function-sysSetSystemClock. The clocks are just only a record after function- sysGetSystemClock.

Parameter

peSrcClk Sytem clock source.

It could be eSYS_EXT=0, eSYS_APLL= 2 and eSYS_UPLL = 3.

pu32PllKHz : APLL or UPLL output frequency.

Unit: KHz.

pu32SysKHz System clock output frequency.

Unit: KHz. The system clock source can be external, APLL or UPLL.

pu32CpuKHz CPU working frequency.

Unit: KHz.

pu32HclkKHz DDR/SDRAM working frequency.

Unit: KHz.

pu32ApbKHz APB output frequency.

Unit: KHz.

Return Value

None.

Example

```
/* Write system clock setting */
E_SYS_SRC_CLK eSrcClk;
UINT32 u32PllKHz, u32SysKHz, u32CpuKHz, u32HclkKHz, u32ApbKHz;
sysSetSystemClock(eSYS_UPLL, // system clock come from UPLL
                       240000,      // UPLL = 240MHz
                       240000,      // SYS = 240MHz
                       120000,      // CPU = 120MHz
                       120000,      // HCLK = 120MHz,
                       60000);      // APB = 60MHz
   /* Read system clock setting */
```

```
    sysGetSystemClock(&eSrcClk,
                        &u32PllKHz,
                        &u32SysKHz,
                        &u32CpuKHz,
                        &u32HclkKHz,
                        &u32ApbKHz);
```

sysSetPllClock

Synopsis

UINT32 sysSetPllClock(E_SYS_SRC_CLK eSrcClk,

UINT32 u32TargetKHz) ;

Description

There are two PLLs in N9H20. User can assign one PLL as system clock source. The other PLL can be assigned the output frequency through the function.

Parameter

eSrcClk: eSYS_APLL = 2 or eSYS_UPLL = 3.

u32TargetKHz: Target PLL output frequency. Unit : KHz.

Return Value

Specified PLL output frequency. Unit : KHz. The return value may not be the same as the specified value due to hardware's limitation. If it could not meet the hardware SPEC, library will automatically search the nearest frequency.

Example

```
/* Write system clock setting */
E_SYS_SRC_CLK eSrcClk;
sysSetSystemClock(eSYS_UPLL,        // system clock come from UPLL
                240000,      // UPLL = 240MHz
                240000,      // SYS = 240MHz
                120000,      // CPU = 120MHz
                120000,      // HCLK = 120MHz,
                60000);      // APB = 60MHz

/*Specified APLL clock */
sysSetPllClock(eSYS_APLL,
         192000);
```

sysClockDivSwitchStart

Synopsis

INT32 sysClockDivSwitchStart(UINT32 u32SysDiv);,

Description

The function is used to set system divider quickly. It doesn't change PLL clock. If the system divider is not zero after the function was called. User need to calculate the u32SysDiv by himself after call function-sysSetSystemClock().

Parameter

U32SysDiv System divider. The value is from 0 ~ 7.

Return Value

Sussessful.

Example

```
/* Write system clock setting */
E_SYS_SRC_CLK eSrcClk;
sysSetSystemClock(eSYS_UPLL,        // system clock come from UPLL
                240000,      // UPLL = 240MHz
                240000,      // SYS = 240MHz
                120000,      // CPU = 120MHz
                120000,      // HCLK = 120MHz,
                60000);      // APB = 60MHz

/* Specified APLL clock */
sysSetPllClock(eSYS_APLL,
                192000);
sysClockDivSwitchStart(240000/48000-1); /* Change system clock to 48MHz
*/
```

sysCheckPllConstraint

Synopsis

VOID sysCheckPllConstraint (BOOL bIsCheck);

Description

There are some constraints in PLL formula. The function is used to enable or disable these constraints.

Parameter

bIsCheck TRUE:

Check PLL constraints as call function-sysSetSystemClock or sysSetPllClock.

FALSE:

Not to check PLL constraints as call function-sysSetSystemClock or sysSetPllClock.

Return Value

None.

Example

```
sysCheckPllConstraint(FALSE); // Not to check PLL constraint
sysSetPllClock(eSYS_APLL,           // APLL for audio recording,
                153600);             // UINT32 u32PllKHz,
sysCheckPllConstraint(TRUE);  // Check PLL constraint
```

sysSetCPUClock

Synopsis

UINT32 sysSetCPUClock(UINT32 u32CPUClockKHz);

Description

This function is used to set CPU clock.

Parameter

u32CPUClockKHz Specified CPU clock

Return Value

The CPU clock after setting. Due to some constraints of clock tree, the finally CPU clock may not equal to the specified CPU clock.

Example

```
UINT32 u32CPUClock;
u32CPUClock = sysSetCPUClock (96000);
```

sysGetCPUClock

Synopsis

UINT32 sysGetCPUClock(VOID);

Description

This function is used to get CPU clock.

Parameter

None

Return Value

The CPU clock

Example

```
UINT32 u32CPUClock;
u32CPUClock = sysGetCPUClock ();
```

sysSetAPBClock

Synopsis

UINT32 sysSetAPBClock(UINT32 u32APBlockKHz);

Description

This function is used to set APB clock.

Parameter

u32APBClockKHz Specified APB clock

Return Value

The APB clock after setting. Due to some constraints of clock tree, the finally APB clock may not equal to the specified APB clock.

Example

```
UINT32 u32APBClock;
u32APBClock = sysSetAPBClock (48000);
```

sysGetAPBClock

Synopsis

UINT32 sysGetAPBClock(VOID);

Description

This function is used to get APB clock.

Parameter

None

Return Value

The APB clock

Example

```
UINT32 u32APBClock;
u32APBClock = sysGetAPBClock ();
```

17.8 Power management Function

sysPowerDown

Synopsis

INT32 sysPowerDown(WAKEUP_SOURCE_E eWakeUpSrc);;

Description

This function forces system to enter standby mode. All of IP clock were turned off except RTC and DDR enter self-refresh mode.

Parameter

eWakeUpSrc: Specified the wake up source.

eWakeUpSrc	Value	Meaning
WE_GPIO	0x1	Wake up from GPIO
WE_RTC	0x2	Wake up from RTC
WE_SDH	0x4	Wake up from SD Host
WE_UART	0x8	Wake up from UART (UART high speed CTS pin)
WE_UDC	0x10	Wake up from USB device (Host issue resume command)
WE_UHC	0x20	Wake up from USB host (USB device remote wake up)
WE_ADC	0x40	Wake up from ADC (Touch panel)
WE_KPI	0x80	Wake up from KPI.

Return Value

None

Example

```
/* Reset PM IRQ status*/
…
/* Configuration GPIO for wake up */
sysPowerDown(WE_GPIO);
/* Force system enter power down. Wake up source from GPIO */
```

sysPowerDownPLLDuringSysPowerDown

Synopsis

void sysPowerDownPLLDuringSysPowerDown(BOOL bIsPowerDownPLL)

Description

Calling this function will disable or enable PLL clock as system enter power down mode. It is used to save more power if disable PLL under power down mode. However, it will take more than 25ms for system wake up. If enable PLL as power down mode, the wake up time will be shrunk to 3ms

Parameter

bIsPowerDownPLL 1: Power down PLL as power down mode

0: Keep to enable PLL as power down mode

Return Value

None

Example

```
…
/* enable power down as enter power mode */
sysPowerDownPLLDuringSysPowerDown (1);
/* Configuration GPIO for wake up. PLLs will be disable as power down mode */
sysPowerDown(WE_GPIO);
```

17.9 Error Code Table

Code Name	Value	Description
Successful	0	Successful
Fail	-1	Fail
WB_INVALID_PARITY	-1	Invalid parity
WB_INVALID_DATA_BITS	-2	Invalid data bits
WB_INVALID_STOP_BITS	-3	Invalid stop bits
WB_INVALID_BAUD	-4	Invalid baud rate
WB_PM_PD_IRQ_Fail	-1	Invalid power down IRQ
WB_PM_Type_Fail	-2	Invalid power manager type
WB_PM_INVALID_IRQ_NUM	-3	Invalid IRQ number
E_ERR_CLK	0xB0000001	Wrong clock setting

18 UDC Library

18.1 overview

This library is designed to make user application to use N9H20 UDC more easily.

The UDC library has the following features:

- Support all basic USB operations.
- Pass USB-IF Chapter 9 test.

BSP Non-OS provide two USB class libraries for the USB class reference sample. User can refer to the libraries to develop him own class libraries.

- Mass Storage Class device: mscd library.
- Pass the USB-IF Mass Storage Class Test
- Provide flash options to build MSC device as a Composite device with RAM disk, NAND Disk, and SD card reader.
- Pass the USB-IF Video Class Test
- Provide a video cam sample to send two test patterns to PC.

User can use UDC library to implement all USB basic operations (Send descriptors, Reset command and etc.), and a USB class library (like MSCD) to provide USB class functions.

<table>
<tr><td>MSC Device</td><td>UVC Device</td><td>Other Devices</td></tr>
<tr><td>MSC Library</td><td>UVC Library</td><td>Other Libraries</td></tr>
<tr><td colspan="3">UDC Library</td></tr>
</table>

<table>
<tr><td>MSC Device</td><td>UVC Device</td><td>Other Devices</td></tr>
<tr><td>MSC Library</td><td>UVC Library</td><td>Other Libraries</td></tr>
<tr><td colspan="3">UDC Library</td></tr>
</table>

18.2 Programming Guide

18.2.1 System Overview

The USB device controller interfaces the AHB bus and the UTMI bus. The USB controller contains both the AHB master interface and AHB slave interface. CPU programs the USB controller registers through the AHB slave interface. For IN or OUT transfer, the USB device controller needs to write data to memory or read data from memory through the AHB master interface. The USB device controller is complaint with USB 2.0 specification and it contains four configurable endpoints in addition to control endpoint. These endpoints could be configured to BULK, INTERRUPT or ISO. The USB device controller has a built-in DMA to relieve the load of CPU.

18.2.2 Features

- USB Specification version 2.0 compliant.
- Interfaces between USB 2.0 bus and the AHB bus.

- Support 16-bit UTMI Interface to USB2.0 Transceiver.
- Support direct register addressing for all registers from the AHB bus.
- Software control for device remote-wakeup.
- AHB bus facilitates connection to common micro controllers and DMA controllers.
- Support 4 configurable endpoints in addition to Control Endpoint
- Each of these endpoints can be Isochronous, Bulk or Interrupt and they can be either of IN or OUT direction.
- Three different modes of operation of an in-endpoint (Auto validation mode, manual validation mode, Fly mode.)
- DP RAM is used as endpoint buffer.
- DMA operation is carried out by AHB master
- Supports Endpoint Maximum Packet Size up to 1024 bytes.

18.2.3 UDC Library Property Definition

The UDC library provides property structure to set UDC property more easily.

USBD_INFO_T (The fields for internal usage are not in the table)

Name	Description
Descriptor pointer	
pu32DevDescriptor	Device Descriptor pointer
pu32QulDescriptor	Device Qualifier Descriptor pointer
pu32HSConfDescriptor	Standard Configuration Descriptor pointer for High speed
pu32FSConfDescriptor	Standard Configuration Descriptor pointer for Full speed
pu32HOSConfDescriptor	Other Speed Configuration Descriptor pointer for High speed
pu32FOSConfDescriptor	Other Speed Configuration Descriptor pointer for Full speed
pu32HIDDescriptor	HID Device Descriptor pointer
pu32HIDRPTDescriptor	HID Device Report Descriptor pointer
pu32StringDescriptor[5]	String Descriptor pointer
Descriptor length	
u32DevDescriptorLen	Device Descriptor Length
u32QulDescriptorLen	Device Qualifier Descriptor pointer Length
u32HSConfDescriptorLen	Standard Configuration Descriptor Length for High speed
u32FSConfDescriptorLen	Standard Configuration Descriptor Length for Full speed
u32HOSConfDescriptorLen	Other Speed Configuration Descriptor Length for High speed
u32FOSConfDescriptorLen	Other Speed Configuration Descriptor Length for Full speed
u32HIDDescriptorLen	HID Device Descriptor Length
u32HIDRPTDescriptorLen	HID Device Report Descriptor Length
u32StringDescriptorLen[5]	String Descriptor Length
USBD Init	

pfnHighSpeedInit	High speed USB Device Initialization function
pfnFullSpeedInit	Full speed USB Device Initialization function
Endpoint Number	
i32EPA_Num	Endpoint Number for EPA (-1 : Not used)
i32EPB_Num	Endpoint Number for EPB (-1 : Not used)
i32EPC_Num	Endpoint Number for EPC (-1 : Not used)
i32EPD_Num	Endpoint Number for EPD (-1 : Not used)
Endpoint Call Back	
pfnEPACallBack	Callback function pointer for Endpoint A Interrupt
pfnEPBCallBack	Callback function pointer for Endpoint B Interrupt
pfnEPCCallBack	Callback function pointer for Endpoint C Interrupt
pfnEPDCallBack	Callback function pointer for Endpoint D Interrupt
Class Call Back	
pfnClassDataINCallBack	Callback function pointer for Class Data IN
pfnClassDataOUTCallBack	Callback function pointer for Class Data OUT
pfnDMACompletion	Callback function pointer for DMA Complete
pfnReset	Callback function pointer for USB Reset Interrupt
pfnSOF	Callback function pointer for USB SOF Interrupt
pfnPlug	Callback function pointer for USB Plug Interrupt
pfnUnplug	Callback function pointer for USB Un-Plug Interrupt
VBus status	
u32VbusStatus	VBus Status

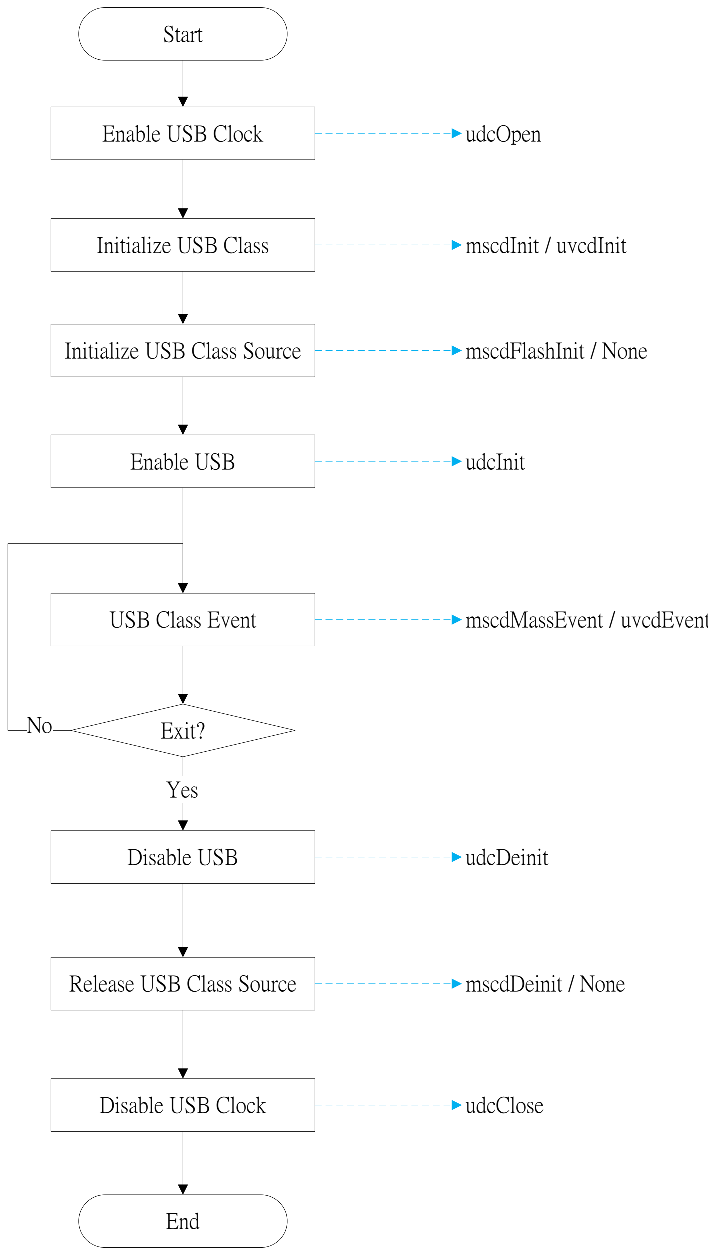
The USB Device initialization function initializes the basic setting of USB device controller including endpoints buffer allocation, endpoint number, endpoint type, speed mode, and interrupt, etc. User can modify the function to change USB speed and endpoint properties.

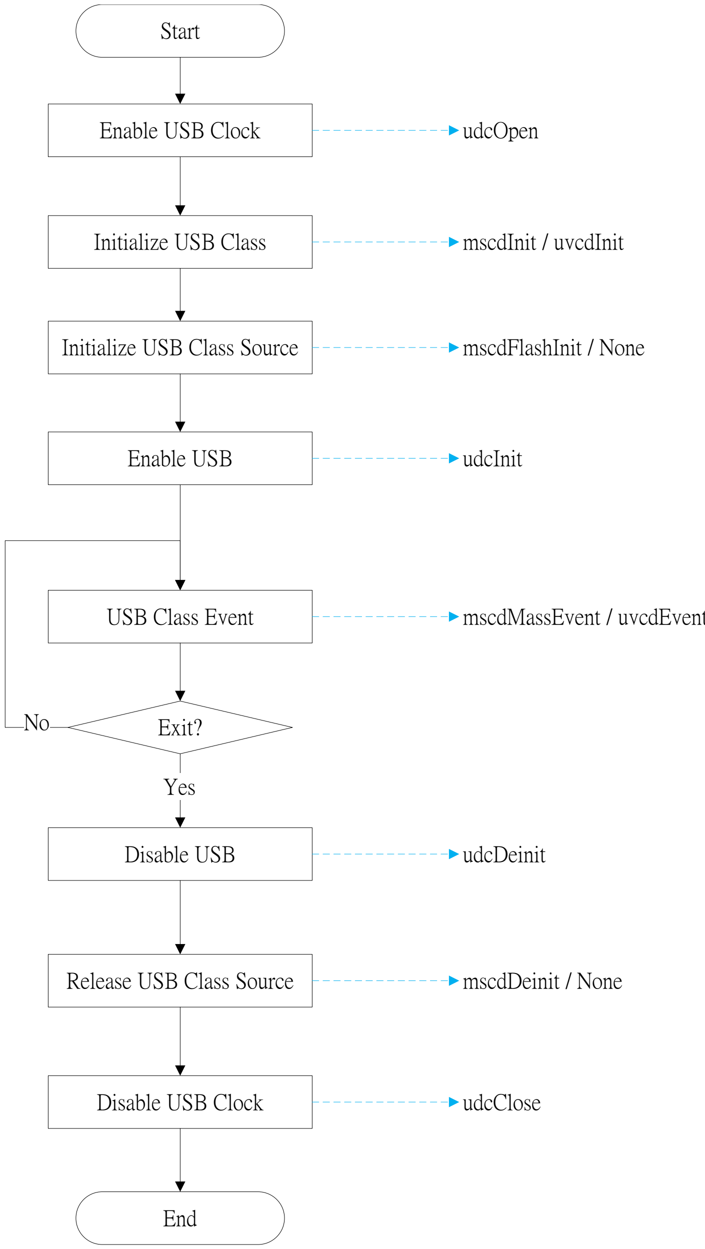
- pfnHighSpeedInit
- mscdHighSpeedInit
- pfnFullSpeedInit
- mscdFullSpeedInit

PC classifies USB derive according to the descriptors. With Non-OS BSP structure, the descriptors are initialized in the class initialize functions. The functions set proper descriptors and the callback functions.

- mscdInit

18.2.4 Programming Flow





18.3 USB Device (UDC) APIs Specification

udcOpen

Synopsis

VOID udcOpen(VOID)

Description

This function enables the engine clock.

Parameter

None

Return Value

None

Example

```
udcOpen ();
```

udcClose

Synopsis

VOID udcClose (VOID)

Description

This function disables the engine clock.

Parameter

None

Return Value

None

Example

```
udcClose ();
```

udcInit

Synopsis

VOID udcInit(VOID)

Description

This function initializes the software resource, enables its interrupt, and set VBus detect function.

Parameter

None

Return Value

None

Example

```
udcInit ();
```

udcDeinit

Synopsis

VOID udcDeinit (VOID)

Description

Disable VBus detect function

Parameter

None

Return Value

None

Example

```
udcDeinit ();
```

udcIsAttached

Synopsis

BOOL udcIsAttached(VOID)

Description

This function can get USB attach status.

Parameter

None

Return Value

TRUE	- USB is attached.
FALSE	- USB isn't attached.

Example

```
/* Check USB attach status */
if(udcIsAttached ())
   sysprintf("USB is attached\n");
else
   sysprintf("USB isn't attached\n");
```

udcIsAttachedToHost

Synopsis

BOOL udcIsAttachedToHost (VOID)

Description

This function can get USB current attach device status.

Parameter

None

Return Value

TRUE	- USB is attached to Host now.
FALSE	- USB doesn't get any command from Host now.

Example

```
/* Check USB HOST attach status */
if(udcIsAttachedToHost ())
   sysprintf("USB is attached to Host now\n");
else
   sysprintf("USB doesn't get any command from Host \n");
```

Note

It takes time for Host to send command to device. So user may set a timeout time to check the status, i.e., user needs to polling the status during the timeout time.

udcSetSupendCallBack

Synopsis

VOID udcSetSupendCallBack (PFN_USBD_CALLBACK pfun)

Description

This function is to install the Suspend call back function

Parameter

pfun	The Suspend Call back function pointer

Return Value

None

Example

```
udcSetSupendCallBack(Demo_PowerDownWakeUp);
```

18.4 Mass Storage Class (MSCD) APIs Specification

mscdInit

Synopsis

VOID mscdInit(VOID)

Description

This function initializes software source (descriptors, callback functions, buffer configuration)

Parameter

None

Return Value

None

Example

```
mscdInit ();
```

mscdDeinit

Synopsis

VOID mscdDeinit (VOID)

Description

This function releases software source (allocated by mscdInit)

Parameter

None

Return Value

None

Example

```
mscdDeinit ();
```

mscdFlashInit

Synopsis

UINT8 mscdFlashInit (char *pDisk, INT SDsector)

Description

Initialize the Flash capacity for usb device controller use.

Parameter

pDisk	The internal data for NAND disk information
SDsector	The total sector number of SD card

Return Value

0	- Fail
1	- Success

Example

```
NDISK_T MassNDisk;
INT32 status;
status = sicSdOpen0();
if(status < 0)
sicSdClose0();
```

```
mscdFlashInit(&MassNDisk,status);
```

Note

1. User can modify the mscd.c and rebuild library to select the flash types you want
   - TEST_RAM: Ram Disk
     - Change RAM_DISK_SIZE to change RAM Disk size
       - RAMDISK_1M / RAMDISK_2M / RAMDISK_4M / RAMDISK_8M/ RAMDISK_16M / RAMDISK_32M
   - TEST_SM: NAND Disk
   - TEST_SD: SD Card Reader
2. The pDisk is used only when TEST_SM is defined.

mscdFlashInitCDROM

Synopsis

UINT8 mscdFlashInitCDROM (

NDISK_T *pDisk,

INT SDsector,

PFN_MSCD_CDROM_CALLBACK pfnCallBack,

INT CdromSizeInByte

)

Description

Initialize the Flash capacity for usb device controller use.

Parameter

pDisk	The internal data for NAND disk information.
SDsector	The total sector number of SD card
pfnCallBack	The callback function for CDROM read function
CdromSizeInByte	The size of CDROM size

Return Value

0	- Fail
1	- Success

Example

```
NDISK_T MassNDisk;
mscdFlashInitCDROM(&MassNDisk,NULL,CDROM_Read,u32CdromSize);
```

Note

3. User can modify the mscd.c and rebuild library to select the flash types you want
   - TEST_RAM: Ram Disk
     - Change RAM_DISK_SIZE to change RAM Disk size
       - RAMDISK_1M / RAMDISK_2M / RAMDISK_4M / RAMDISK_8M/ RAMDISK_16M / RAMDISK_32M
   - TEST_SM: NAND Disk
   - TEST_SD: SD Card Reader
4. The pDisk is used only when TEST_SM is defined.

mscdSdPortSelect

Synopsis

VOID mscdSdPortSelect (UINT32 u32Port)

Description

This function can change the SD port used by MSC library before mscdFlashInit

Parameter

u32Port	SD port index (0/1/2)

Return Value

None

Example

```
mscdSdPortSelect (0);
```

mscdBlcokModeEnable

Synopsis

VOID mscdBlcokModeEnable (BOOL bEnable)

Description

This function can set MSC to Block mode or Non-Block mode.

Parameter

bEnable	TRUE / FALSE

Return Value

None

Example

```
#ifdef NON_BLOCK_MODE
```

```
    mscdBlcokModeEnable(FALSE);    /* Non-Block mode */
    while(1)
    {
        if(!PlugDetection())
            break;
        mscdMassEvent(NULL);
    }
#else
    mscdMassEvent(PlugDetection);  /* Default : Block mode */
#endif
```

19 USB Core Library

19.1 Overview

The USB Core library is composed of four major parts, which are OHCI driver, EHCI driver, USB driver, and USB hub device driver. Each of these four drivers also represents one of the three-layered USB driver layers. Figure 1-1 presents the driver layers of the USB library.

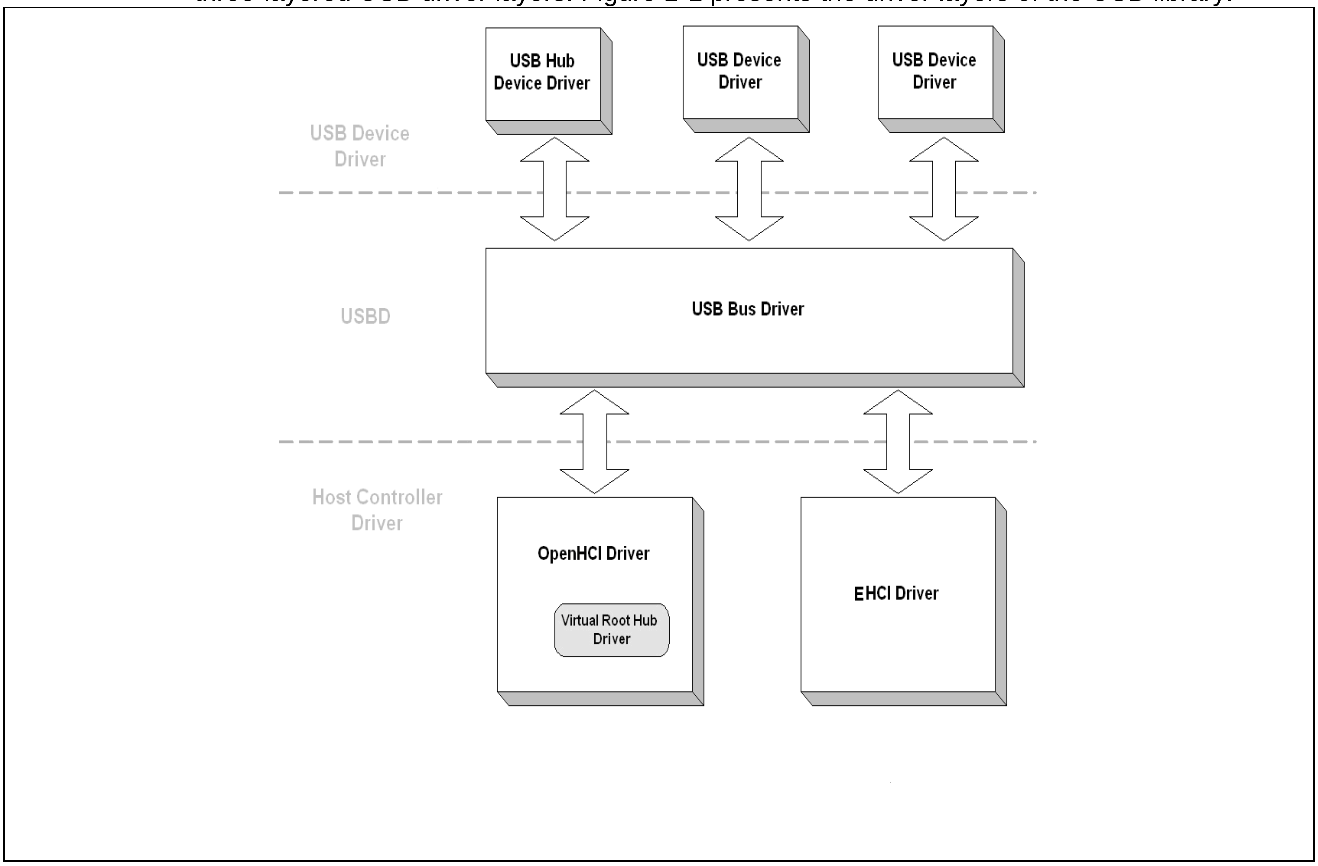


Figure 19-1 USB driver layer of USB library

19.2 Data Structures

The USB Core library includes many complicated data structures to describe a USB bus, a device, a driver, various descriptors, and so on. To realize these data structures may be necessary for a USB device driver designer. In the following sections, we will introduce all data structures which you may need. These data structures are all defined in header file <usb.h>.

19.2.1 USB_DEV_T

USB_DEV_T is the data structure used to represent a device instance. Once the host finds that a device presented on a USB bus, the USB system software is notified. The USB system software resets and enables the hub port to reset the device. It then creates a ***USB_DEV_T*** for the newly detected device. For each USB device presented on the bus, even the same device type, USB system software will create a ***USB_DEV_T*** to represent it as an instance.

The contents of all members of ***USB_DEV_T*** are automatically assigned by USB system software. The USB system software will assign a unique device number, read device descriptor and configuration descriptors, and create parent/child relationships. The definition of USB_DEV_T is listed below, and the detailed descriptions can be found in *Table 19-1: Members of USB_DEV_T*

```
typedef struct usb_device
{
    INT     devnum;
    INT     slow;
    enum
    {
            USB_SPEED_UNKNOWN = ,
            USB_SPEED_LOW,
            USB_SPEED_FULL,
            USB_SPEED_HIGH
    }       speed;
    struct usb_tt  *tt;
    INT     ttport;
    INT     refcnt;
    UINT32  toggle[2];
    UINT32  halted[2];
    INT     epmaxpacketin[16];
    INT     epmaxpacketout[16];
    struct usb_device  *parent;
    INT     hub_port;
    USB_BUS_T *bus;
    USB_DEV_DESC_T  descriptor;
    USB_CONFIG_DESC_T *config;
    USB_CONFIG_DESC_T *actconfig;
    CHAR    **rawdescriptors;
    INT     have_langid;
    INT     string_langid;
    VOID    *hcpriv;
    INT     maxchild;
    struct usb_device  *children[USB_MAXCHILDREN];
} USB_DEV_T;
```

Member	Description
devnum	Device number on USB bus; each device instance has a unique device number
slow	Is low speed device speed? (1: yes; 0: no)
speed	Device speed
refcnt	Reference count (to count the number of users using the device)

toggle[2]	Data toggle; one bit for each endpoint ([0] = IN, [1] = OUT)
halted[2]	Endpoint halts; one bit for each endpoint ([0] = IN, [1] = OUT)
epmaxpacketin[16]	IN endpoints specific maximum packet size (each entry represents for an IN endpoint of this device)
epmaxpacketout[16]	OUT endpoints specific maximum packet size (each entry represents for an OUT endpoint of this device)
parent	Parent device in the bus topology (generally, it should be a hub)
bus	The bus on which this device was presented
descriptor	Device descriptor
config	All of the configuration descriptors
actconfig	The descriptor of the active configuration
rawdescriptors	Raw descriptors for each configuration descriptor (driver can find class specific or vendor specific descriptors from the *rawdescriptors*)
have_langid	Whether string_langid is valid yet
string_langid	Language ID for strings
hcpriv	Host controller private data
maxchild	Number of ports if this is a hub device
children[ ]	Link to the downstream port device if this is a hub device

Table 19-1: Members of USB_DEV_T

19.3 Descriptor Structures

In the USB_DEV_T structure, device descriptor, configuration descriptor and raw descriptor are included. The USB Driver will acquire these descriptors from device automatically while the device is probed. The USB Driver issues GET_DESCRIPTOR standard device request to acquire the configuration descriptors. It also parses the returned descriptors to create configuration-interface-endpoint descriptor links. Client software can obtain any configuration, interface, or endpoint descriptors by tracing the descriptor link started from USB_DEV_T. As USB Driver cannot understand class-specific and vendor-specific descriptors, it does not create link for these descriptors. If the client software wants to obtain any class-specific or vendor-specific descriptors, it can parse the descriptors stored in raw descriptor, which the original descriptors list returned from the device. Table2-2, Table 2-3, Table 2-4, and Table 2-5 describe the structures defined for device descriptor, configuration descriptors, interface descriptors, and endpoint descriptors, respectively.

Figure 2-1 presents an overview on the relationship of these data structures. From USB_DEV_T (device instance structure), USB_DEV_DEC_T (device descriptor structure) and USB_CONFIG_DEC_T (configuration descriptor structure), USB_IF_DESC_T (interface descriptor structure), to USB_EP_DESC_T (endpoint descriptor structure), all structure entries are linked in top-down order.

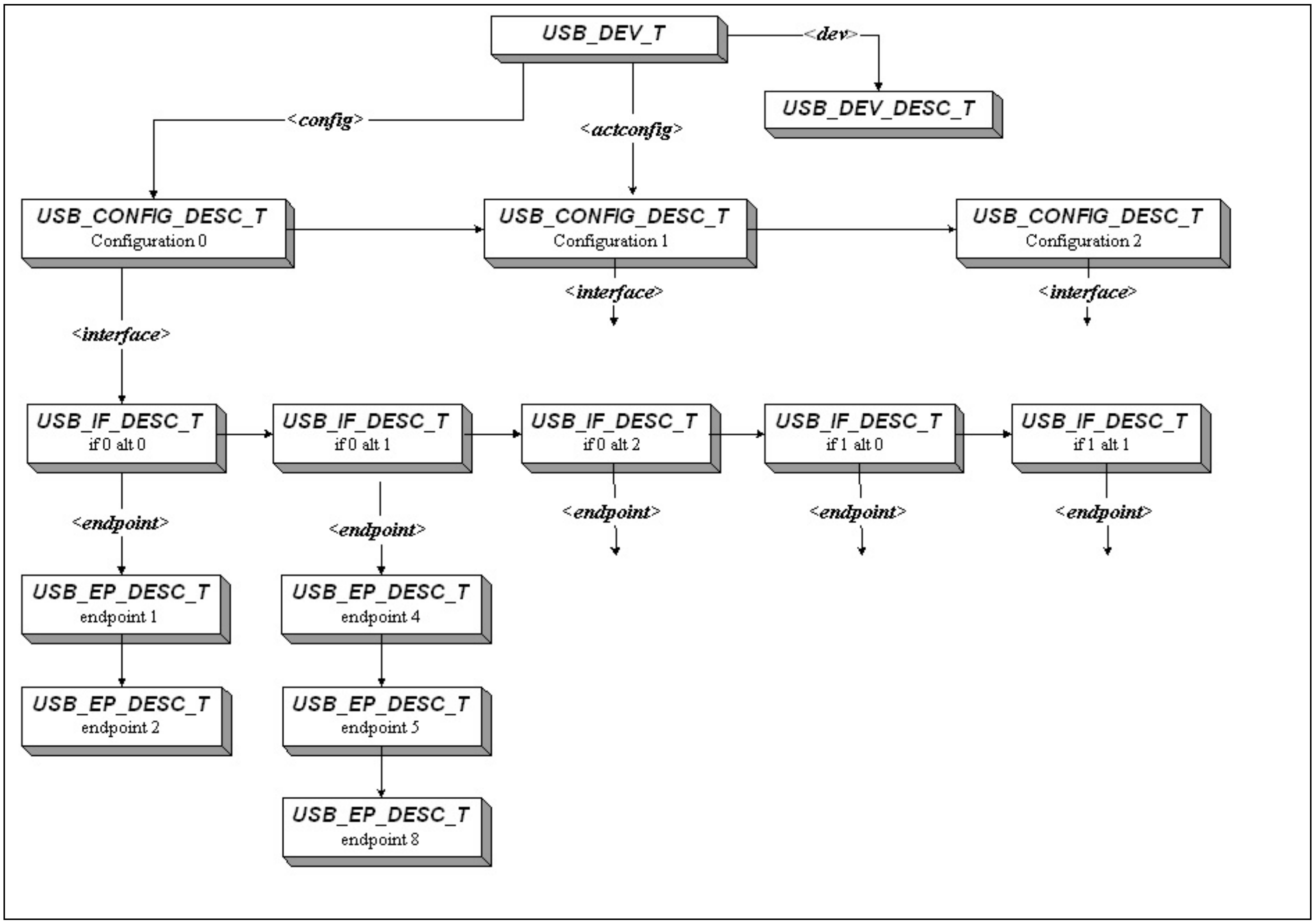


Figure 19-2:Descriptors relationship

```
/* Device descriptor */
typedef struct usb_device_descriptor
{
    __packed UINT8  bLength;
    __packed UINT8  bDescriptorType;
    __packed UINT16 bcdUSB;
    __packed UINT8  bDeviceClass;
    __packed UINT8  bDeviceSubClass;
    __packed UINT8  bDeviceProtocol;
    __packed UINT8  bMaxPacketSize0;
    __packed UINT16 idVendor;
    __packed UINT16 idProduct;
    __packed UINT16 bcdDevice;
    __packed UINT8  iManufacturer;
    __packed UINT8  iProduct;
    __packed UINT8  iSerialNumber;
```

```
    __packed UINT8  bNumConfigurations;
} USB_DEV_DESC_T;
```

Table 19-2: Members of USB_DEV_DESC_T

Member	Description
bLength	Size of the descriptor in bytes
bDescriptorType	DEVICE descriptor type (0x01)
bcdUSB	USB specification release number in BCD format
bDeviceClass	Device class code
bDeviceSubclass	Device subclass code
bDeviceProtocol	Protocol code
bMaxPacketSize0	Maximum packet size for endpoint zero
idVendor	Vendor ID
idProduct	Product ID
iManufacturer	Device release number in BCD format
iProduct	Index of string descriptor describing product
iSerialNumber	Index of string descriptor describing the serial number
bNumConfigurations	Number of possible configurations

You may have found that the definition of ***USB_DEV_DESC_T*** is fully compliant to the definition of device descriptor defined in USB 1.1 specification. In fact, the USB Driver acquires the device descriptor and fills it into this structure without making any modifications.

```
/* Configuration descriptor information */
typedef struct usb_config_descriptor
{
    __packed UINT8   bLength;
    __packed UINT8   bDescriptorType;
    __packed UINT16  wTotalLength;
    __packed UINT8   bNumInterfaces;
    __packed UINT8   bConfigurationValue;
    __packed UINT8   iConfiguration;
    __packed UINT8   bmAttributes;
    __packed UINT8   MaxPower;
    USB_IF_T  *interface;
    UINT8   *extra;
    INT     extralen;
} USB_CONFIG_DESC_T;
```

Table 19-3: Members of USB_CONFIG_DESC_T

Member	Description
bLength	Size of the descriptor in bytes
bDescriptorType	CONFIGURATION descriptor type (0x02)

wTotalLength	The total length of data returned for this descriptor
bNumInterfaces	Number of interface supported by this configuration
bConfigurationValue	Value use as an argument to the SetConfiguration() request to select the active configuration
iConfiguration	Index of string descriptor describing this configuration
bmAttributes	Bitmap describing the configuration characteristics
MaxPower	Maximum power consumption of the USB device from the bus in this specific configuration when the device is fully operational (in mA)
interface	Refer to the interface descriptor list (recorded in USB_IF_DESC_T structure format) returned by this configuration
extra	Refer to the memory buffer to preserve the raw data of this configuration descriptor itself
extralen	The length of the <*extra*> memory buffer

The ***dev***->***config*** refers to a list of configurations supported by this device. Client software can access any configuration by indexing the configuration, for example, dev->config[0] is referred to the first configuration of this device. While <***config***> of ***USB_DEV_T*** refers to the configuration list, <***actconfig***> refers to the currently activated configuration. There is only one configuration activated at the same time.

The structure members from <***bLength***> to <***MaxPower***> are fully compliant to that defined in USB 1.1 specification. The <***interface***> refers to a list of interfaces supported by this configuration. In addition, USB Driver keeps the interface descriptor itself in a dynamically allocated memory buffer, which is referred to by <***extra***>, and the length of this memory buffer is <***extralen***>.

An interface may contain several alternate settings. Each alternate setting has its own set of endpoints. USB Driver creates a single ***USB_IF_DESC_T*** structure for each alternate interface setting and links them in order that they presented in the returned data of a configuration descriptor.

```
/* Interface descriptor */
typedef struct usb_interface_descriptor
{
    __packed UINT8  bLength;
    __packed UINT8  bDescriptorType;
    __packed UINT8  bInterfaceNumber;
    __packed UINT8  bAlternateSetting;
    __packed UINT8  bNumEndpoints;
    __packed UINT8  bInterfaceClass;
    __packed UINT8  bInterfaceSubClass;
    __packed UINT8  bInterfaceProtocol;
    __packed UINT8  iInterface;
    USB_EP_DESC_T *endpoint;
    UINT8  *extra;
    INT    extralen;
} USB_IF_DESC_T;
```

Table 19-4: Members of USB_IF_DESC_T

Member	Description
bLength	Size of the descriptor in bytes
bDescriptorType	INTERFACE descriptor type (0x04)
bInterfaceNumber	Number of interface. Zero-based value identifying the index in the array of concurrent interfaces supported by this configuration.
bAlternateSetting	Value used to select alternate setting for this interface
bNumEndpoints	Number of endpoints used by this interface (excluding endpoint zero)
bInterfaceClass	Class code
bInterfaceSubClass	Subclass code
bInterfaceProtocol	Protocol code
iInterface	Index of string descriptor describing this interface
endpoint	Refer to the endpoint descriptor list (recorded in USB_EP_DESC_T structure format) of this interface returned by this configuration
extra	Refer to the memory buffer preserve the raw data of this interface descriptor itself
extralen	The length of the <*extra*> memory buffer

The ***dev->config[n]->interface*** refers to a list of interfaces supported by configuration n. The structure members from <***bLength***> to <***iInterface***> are fully compliant to that defined in USB 1.1 specification. The <***endpoint***> refers to a list of endpoints supported by this interface. In addition, USB Driver keeps the interface descriptor itself in a dynamically allocated memory buffer, which is referred to by <***extra***>, and the length of this memory buffer is <***extralen***>.

```
/* Endpoint descriptor */
typedef struct usb_endpoint_descriptor
{
    __packed UINT8  bLength;
    __packed UINT8  bDescriptorType;
    __packed UINT8  bEndpointAddress;
    __packed UINT8  bmAttributes;
    __packed UINT16 wMaxPacketSize;
    __packed UINT8  bInterval;
    __packed UINT8  bRefresh;
    __packed UINT8  bSynchAddress;
    UINT8   *extra;
    INT     extralen;
} USB_EP_DESC_T;
```

Table 19-5: Members of USB_EP_DESC_T

Member	Description
bLength	Size of the descriptor in bytes
bDescriptorType	ENDPOINT descriptor type (0x05)
bEndpointAddress	The address of this endpoint

bmAttributes	Transfer type of this endpoint
wMaxPacketSize	The maximum packet size this endpoint is capable of sending or receiving
bInterval	Interval for polling endpoint for data transfers (in milliseconds)
bRefresh	Audio extensions to the endpoint descriptor
bSynchAddress	Audio extensions to the endpoint descriptor
extra	Refer to the memory buffer preserve the raw data of this endpoint descriptor itself
extralen	The length of the <*extra*> memory buffer

DEV_REQ_T

DEV_REQ_T is used to represent the eight-byte device request in a control transfer. All device requests, including standard device requests, class-specific device requests, and vendor-specific device requests, are written in the ***DEV_REQ_T*** structure, which is also a member of a URB, and transferred to device through the control pipe.

```
typedef struct
{
__packed UINT8  requesttype;
__packed UINT8  request;
__packed UINT16 value;
__packed UINT16 index;
__packed UINT16 length;
} DEV_REQ_T;
```

Table 19-6: Members of DEV_REQ_T

Member	Description
requesttype	Characteristics of request
request	Specific request
value	Word-sized field that varies according to request
index	Word-sized field that varies according to request
length	Number of bytes to transfer if there is a DATA stage

USB_DEV_ID_T

When the USB System Software detects a device being attached, it must find out the corresponding device driver for each of its interface from the registered driver list. It can try to invoke the ***probe()*** routine of each registered device driver for each device interface, but this is not efficient and time-consuming. If the USB System Software can make some simple judgment before trying invoking a device driver, it will be better. This is the purpose of ***USB_DEV_ID_T***. The USB Library employs device ID to identify the appropriate device drivers.

When a device driver is registered to USB Driver, it may provide a device ID table, which is structured in ***USB_DEV_ID_T*** format. In the device ID table, driver can specify the characteristics of the USB device interface that the driver would serve. If a driver does not provide a device ID table, then the USB Driver will always try to invoke it when a new device is detected.

The device driver can use device ID table to specify several checks of characteristics, including vendor ID, device ID, release number, device class, device subclass, device protocol, interface class, interface subclass, and interface protocol. The device driver can specify one or more checks. The more checks are specified, the more specific device interface can be identified. Table 2-7 lists the entries of device ID table.

```
typedef struct usb_device_id
{
    UINT16  match_flags;
    UINT16  idVendor;
    UINT16  idProduct;
    UINT16  bcdDevice_lo;
    UINT16  bcdDevice_hi;
    UINT8   bDeviceClass;
    UINT8   bDeviceSubClass;
    UINT8   bDeviceProtocol;
    UINT8   bInterfaceClass;
    UINT8   bInterfaceSubClass;
    UINT8   bInterfaceProtocol;
    UINT32  driver_info;
} USB_DEV_ID_T;
```

Table 19-7: Members of DEV_REQ_T

Member	Description
matchflag	A bitmask of flags, used to determine which of the following items are to be used for matching
idVendor	Used to compare the vendor ID recorded in device descriptor
idProduct	Used to compare the product ID recorded in device descriptor
bcdDevice_lo	Specify the low limit of device release number
bcdDevice_hi	Specify the high limit of device release number
bDeviceClass	Used to compare the class code in device descriptor
bDeviceSubClass	Used to compare the subclass code in device descriptor
bDeviceProtocol	Used to compare the protocol code in device descriptor
bInterfaceClass	Used to compare the class code in interface descriptor
bInterfaceSubClass	Used to compare the subclass code in interface descriptor
bInterfaceProtocol	Used to compare the protocol code in interface descriptor

There are 10 check items can be used to identify a specific type of device. To select which of these check items should be used to identify a device type is controlled by the <***matchflag***> member, which is a 16bits bit-mask flag. Each bit of < ***matchflag*** > is corresponding to one of these check items. The bit-map definition of < ***matchflag*** > is defined as the followings:

```
#define USB_DEVICE_ID_MATCH_VENDOR          0x0001
#define USB_DEVICE_ID_MATCH_PRODUCT         0x0002
#define USB_DEVICE_ID_MATCH_DEV_LO          0x0004
#define USB_DEVICE_ID_MATCH_DEV_HI          0x0008
#define USB_DEVICE_ID_MATCH_DEV_CLASS       0x0010
#define USB_DEVICE_ID_MATCH_DEV_SUBCLASS    0x0020
#define USB_DEVICE_ID_MATCH_DEV_PROTOCOL    0x0040
#define USB_DEVICE_ID_MATCH_INT_CLASS       0x0080
#define USB_DEVICE_ID_MATCH_INT_SUBCLASS    0x0100
```

```
#define USB_DEVICE_ID_MATCH_INT_PROTOCOL    0x0200
```

For convenience of driver implementation, the USB library also provides some useful macros that facilitate the development of device driver. These macros are all listed in the followings, you can also define your own macros:

```
/* Some useful macros */
#define USB_DEVICE(vend,prod) \
       { USB_DEVICE_ID_MATCH_DEVICE, vend, prod, 0, 0,
         0, 0, 0, 0, 0, 0, 0 }

#define USB_DEVICE_VER(vend,prod,lo,hi) \
       { USB_DEVICE_ID_MATCH_DEVICE_AND_VERSION, vend,
         prod, lo, hi, 0, 0, 0, 0, 0, 0, 0 }

#define USB_DEVICE_INFO(cl,sc,pr) \
       { USB_DEVICE_ID_MATCH_DEV_INFO, 0, 0, 0, 0, cl,
         sc, pr, 0, 0, 0, 0 }

#define USB_INTERFACE_INFO(cl,sc,pr) \
       { USB_DEVICE_ID_MATCH_INT_INFO, 0, 0, 0, 0, 0,
         0, 0, cl, sc, pr, 0 }
```

USB_DRIVER_T

The USB library has defined a generalized structure for all USB device drivers. To implement a USB device driver based on this library, you must create such a structure and register it to the USB Driver. Once you have registered your device driver, the USB Driver can determine whether to launch your driver when a new device is attached.

As we will give detail introduction to the implementation of USB device driver, we only briefly describe the members of ***USB_DRIVER_T*** as following:

```
typedef struct usb_device_id
{
    UINT16  match_flags;
    UINT16  idVendor;
    UINT16  idProduct;
    UINT16  bcdDevice_lo;
    UINT16  bcdDevice_hi;
    UINT8   bDeviceClass;
    UINT8   bDeviceSubClass;
    UINT8   bDeviceProtocol;
    UINT8   bInterfaceClass;
    UINT8   bInterfaceSubClass;
```

```
    UINT8   bInterfaceProtocol;
    UINT32  driver_info;
} USB_DEV_ID_T;
```

Table 19-8: Members of DEV_REQ_T

Member	Description
matchflag	A bitmask of flags, used to determine which of the following items are to be used for matching
idVendor	Used to compare the vendor ID recorded in device descriptor
idProduct	Used to compare the product ID recorded in device descriptor
bcdDevice_lo	Specify the low limit of device release number
bcdDevice_hi	Specify the high limit of device release number
bDeviceClass	Used to compare the class code in device descriptor
bDeviceSubClass	Used to compare the subclass code in device descriptor
bDeviceProtocol	Used to compare the protocol code in device descriptor
bInterfaceClass	Used to compare the class code in interface descriptor
bInterfaceSubClass	Used to compare the subclass code in interface descriptor
bInterfaceProtocol	Used to compare the protocol code in interface descriptor

URB_T

USB specification defines four transfer type: control, bulk, interrupt, and isochronous. In the USB library, all these four transfer types are accomplished by URB (USB Request Block). Please refer to Chapter 3 for details about the implementation of each transfer type by using URB.

19.4 Data Transfer

USB specification defines four transfer types, control, bulk, interrupt, and isochronous. The USB device driver performs data transfer by preparing an URB and transfers it to the underlying USB system software. The URBs are designed to be accommodated with all four transfer types. By configuring the URB, USB device driver can specify the destination device interface and endpoint, the data buffer and data length to be transferred, the callback routine on completion, and other detail information. USB device driver passes the URB to the underlying USB system software, which will interpret the URB and accomplish the data transfers by initiating USB transactions between W90X900 Host Controller and the target device endpoint.

URB designes to be accommodated with all four USB data transfer types. Due to the characteristics of different transfer types, various requirements must be satisfied to fulfill the transfer. For example, URB contains <***setup_packet***> for control transfer, <***interval***> for interval transfer, <***start_frame***> and <***number_of_packets***> for isochronous transfer, and <***transfer_buffer***> for all transfers. To implement a USB device driver, the programmers use URBs to accomplish all data transfers to all of the various endpoints.

For a specific endpoint, after delivering a URB to the underlying USB system software, the USB device driver must not deliver another URB to the same endpoint until the current transfer was done by the USB system software. That is, the driver must be blocked in waiting completion of the URB. URB includes a <***complete***> function pointer to solve the block waiting issue. The USB device driver provides a callback function and have <complete> pointer being referred to the callback function. On completion of this URB, the USB system software will invoke the callback function. Thus, the USB device driver was notified with the completion event, and can stop waiting. Note that the callback functions are invoked from an HISR, the execution time must be as short as possible.

Pipe Control

Before delivering a URB, the USB device driver must determine which device and endpoint the URB will operate on. This destination device and endpoint is determined by <***pipe***> of URB. <***pipe***> is actually a 32-bits unsigned integer. The USB library defines pipe structure with a 32-bits unsigned integer. The USB library defines several useful macros for pipe control. The pipe is defined as follows:

31	30	29	28	27	26	25	24
Pipe Type		**Reserved**			**Speed**	**Reserved**	
23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
Reserved				**Data0/1**	**Endpoint**		
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	Device						
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Direction	**Reserved**					**Max Size**	

Member	Description
Max Size [1 .. 0]	The maximum packet size. This field has been obsoleted. Now the maximum packet size is recorded in <*epmaxpacketin*> and <*epmaxpacketout*> fields of *USB_DEV_T*.
Direction[7]	Direction of data transfer. 0 = Host-to-Device [out]; 1 = Device-to-Host [in]
Device[8 .. 14]	Device number. This is the unique device address, which is assigned by Host Controller driver by *SET_ADDRESS* standard request. With this unique device number, the USB device driver can correctly locate the target device.
Endpoint[15 .. 18]	Endpoint number. This is the endpoint number on the target device, that the pipe is created with. By definition, a pipe corresponds to a unique endpoint on a unique device. By determining the device number and endpoint number, USB device driver can uniquely identify a specific endpoint of a specific device.
Data0/1[19]	Data toggle Data0/Data1. This bit is used to record the current data toggle condition.
Speed[26]	Endpoint transfer speed. 1 = Low speed; 0 = Full speed.
Pipe Type[30 .. 31]	Transfer type. 00 = isochronous; 01 = interrupt; 10 = control; 11 = bulk.

Table 19-9: Members of Pipe Control

The USB library provides a lot of macros facilities for USB device driver designer. The device driver can use the facilities to rescuer the trouble of managing bit fields. These macros are listed in the followings:

Transfer Type

```
#define PIPE_ISOCHRONOUS              0
#define PIPE_INTERRUPT                1
#define PIPE_CONTROL                  2
#define PIPE_BULK                     3

#define usb_pipetype(pipe)    (((pipe) >> 30) & 3)
```

```
#define usb_pipecontrol(pipe) (usb_pipetype((pipe)) == PIPE_CONTROL)
#define usb_pipebulk(pipe)    (usb_pipetype((pipe)) == PIPE_BULK)
#define usb_pipeint(pipe)     (usb_pipetype((pipe)) == PIPE_INTERRUPT)\
#define usb_pipeisoc(pipe)    (usb_pipetype((pipe)) == PIPE_ISOCHRONOUS
```

Maximun Packet Size

```
#define usb_maxpacket(dev, pipe, out)   (out                \
        ? (dev)->epmaxpacketout[usb_pipeendpoint(pipe)]   \
: (dev)->epmaxpacketin [usb_pipeendpoint(pipe)] )
```

Direction

```
#define usb_packetid(pipe) (((pipe) & USB_DIR_IN) ?        \
                           USB_PID_IN : USB_PID_OUT)
#define usb_pipeout(pipe)  ((((pipe) >> 7) & 1) ^ 1)
#define usb_pipein(pipe)   (((pipe) >> 7) & 1)
```

Device Number

```
#define usb_pipedevice(pipe)    (((pipe) >> 8) & 0x7f)
#define usb_pipe_endpdev(pipe)  (((pipe) >> 8) & 0x7ff)
```

Endpoint Number

```
#define usb_pipe_endpdev(pipe)  (((pipe) >> 8) & 0x7ff)
#define usb_pipeendpoint(pipe)  (((pipe) >> 15) & 0xf)
```

Data Toggle

```
#define usb_pipedata(pipe)     (((pipe) >> 19) & 1)
#define usb_gettoggle(dev, ep, out)                    \
                  (((dev)->toggle[out] >> ep) & 1)
#define usb_dotoggle(dev, ep, out)                     \
                  ((dev)->toggle[out] ^= (1 << ep))
#define usb_settoggle(dev, ep, out, bit)               \
                 ((dev)->toggle[out] =               \
                 ((dev)->toggle[out] & ~(1 << ep)) | \
                 ((bit) << ep))
```

Speed

```
#define usb_pipeslow(pipe)     (((pipe) >> 26) & 1)
```

Pipe Creation

```
static __inline UINT32 __create_pipe(USB_DEV_T *dev, UINT32 endpoint)
{
    return (dev->devnum << 8) | (endpoint << 15) | (dev->slow << 26);
}

static __inline UINT32 __default_pipe(USB_DEV_T *dev)
{
       return (dev->slow << 26);
}

/* Create various pipes... */
#define usb_sndctrlpipe(dev,endpoint)         \
          (0x80000000 | __create_pipe(dev,endpoint))
#define usb_rcvctrlpipe(dev,endpoint)         \
          (0x80000000 | __create_pipe(dev,endpoint) | USB_DIR_IN)
#define usb_sndisocpipe(dev,endpoint)         \
          (0x00000000 | __create_pipe(dev,endpoint))
#define usb_rcvisocpipe(dev,endpoint)         \
          (0x00000000 | __create_pipe(dev,endpoint) | USB_DIR_IN)
#define usb_sndbulkpipe(dev,endpoint)         \
          (0xC0000000 | __create_pipe(dev,endpoint))
#define usb_rcvbulkpipe(dev,endpoint)         \
          (0xC0000000 | __create_pipe(dev,endpoint) | USB_DIR_IN)
#define usb_sndintpipe(dev,endpoint)          \
          (0x40000000 | __create_pipe(dev,endpoint))
#define usb_rcvintpipe(dev,endpoint)          \
          (0x40000000 | __create_pipe(dev,endpoint) | USB_DIR_IN)
#define usb_snddefctrl(dev)                  \
          (0x80000000 | __default_pipe(dev))
#define usb_rcvdefctrl(dev)                  \
          (0x80000000 | __default_pipe(dev) | USB_DIR_IN)
```

Control Transfer

In this section, we will introduce how to make control transfer by URBs. A control transfer is accomplished by sending a device request to the control endpoint of the target device. Depend on the request sent to device, there may be data stage or not.

The URB provides a <***setup_packet***> field to accommodate the device request command. The USB device driver must have the <***setup_packet***> of its URB being referred to an <unsigned char> array, which contains the device request command to be transferred. Note that <***setup_packet***> is designed to be used with control transfer.

If a device request included data stage, the data to be transferred must be referred to by the

<***transfer_buffer***> pointer of URB. If the device request required data to be sent from Host to Device, the USB device driver must prepare a DMA buffer (non-cacheable) and fill the data to be transferred into this buffer. Then, the USB device driver have <***transfer_buffer***> pointer refer to this buffer, and specify the length of the buffer with <***transfer_buffer_length***> of the URB. If the device request requires data to be sent from Device to Host, the USB device driver must prepare a DMA buffer to receive the data from Device. Again, the USB device driver uses <***transfer_buffer***> and <***Transfer_buffer_length***> to describe its DMA buffer. The <actual_length> is written by USB system software to tell the device driver how many bytes are actually transferred.

The USB device driver also has to prepare a callback function to be invoked by the USB system software. The callback function will be invoked on the completion of URB, in spite of success or fail. Generally, the callback function is responsible for waking up the task that deliveres the URB. The callback function may also check the status of the URB to determine the transfer to be successful or not. The following is an example of control transfer.

```
static VOID  ctrl_callback(URB_T *urb)
{
    PEGASUS_T   *pegasus = urb->context;

    switch ( urb->status )
    {
        case USB_ST_NOERROR:
            if (pegasus->flags & ETH_REGS_CHANGE)
            {
                pegasus->flags &= ~ETH_REGS_CHANGE;
                pegasus->flags |= ETH_REGS_CHANGED;
                update_eth_regs_async(pegasus);
                return;
            }
            break;
        case USB_ST_URB_PENDING:
            return;
        case USB_ST_URB_KILLED:
            break;
        default:
            printf("Warning - status %d\n", urb->status);
    }
    pegasus->flags &= ~ETH_REGS_CHANGED;
    if (pegasus->flags & CTRL_URB_SLEEP)
    {
       pegasus->flags &= ~CTRL_URB_SLEEP;
       NU_Set_Events(&pegasus->events, 1, NU_OR);  /* set event */
    }
}
```

```
static INT  get_registers(PEGASUS_T *pegasus, UINT16 indx, UINT16 size,
VOID *data)
{
    INT    ret;
    UINT8  *dma_data;

    while (pegasus->flags & ETH_REGS_CHANGED)
    {
        pegasus->flags |= CTRL_URB_SLEEP;
        USB_printf("ETH_REGS_CHANGED waiting...\n");
        NU_Retrieve_Events(&pegasus->events, 1, NU_AND,
                           (unsigned long *)&ret, NU_SUSPEND);
    }

    dma_data = (UINT8 *)USB_malloc(size, BOUNDARY_WORD);
    if (!dma_data)
        return -ENOMEM;

    pegasus->dr->requesttype = PEGASUS_REQT_READ;
    pegasus->dr->request = PEGASUS_REQ_GET_REGS;
#ifdef LITTLE_ENDIAN
    pegasus->dr->value = 0;
    pegasus->dr->index = indx;
    pegasus->dr->length = size;
#else
    pegasus->dr->value = USB_SWAP16(0);
    pegasus->dr->index = USB_SWAP16(indx);
    pegasus->dr->length = USB_SWAP16(size);
#endif
    pegasus->ctrl_urb.transfer_buffer_length = size;

    FILL_CONTROL_URB(&pegasus->ctrl_urb, pegasus->usb,
                     usb_rcvctrlpipe(pegasus->usb,0),
                    (UINT8 *)pegasus->dr,
                     dma_data, size, ctrl_callback, pegasus );

    pegasus->flags |= CTRL_URB_SLEEP;
    NU_Set_Events(&pegasus->events, 0, NU_AND);  /* clear event */
    USB_SubmitUrb(&pegasus->ctrl_urb);
    NU_Retrieve_Events(&pegasus->events, 1, NU_AND,
```

```
                      (unsigned long *)&ret, NU_SUSPEND);
    memcpy(data, dma_data, size);
out:
    USB_free(dma_data);
    return  ret;
}
```

In the above example, the device driver first prepares the device request command in <*pegasus->dr*>, which was later referred to by <*urb->setup_packet*>. It requests a buffer for DMA transfer by ***USB_malloc()***. Note that ***USB_malloc()*** will allocate a non-cacheable memory buffer. It then creates a Control-In pipe by using ***usb_rcvctrlpipe*** macro, and the endpoint number is 0. The device driver uses the ***FILL_CONTROL_URB*** macro facility to fill the URB. The callback function is ***ctrl_callback()***, which is provided by the device driver itself. After submitting the URB, the caller task suspends on waiting the <*pegasus->events*> event set. On completion of this URB, the USB system software will invoke ***ctrl_callback()***, and ***ctrl_callback()*** will set the <*pegasus->events*> event to wake up the caller task.

Bulk Transfer

In this section, we will introduce how to make bulk transfers by URBs. The URB provides <***transfer_buffer***> and <***transfer_buffer_length***> to accommodate data to be transferred to or from device. The direction of transfer is determined by the direction bit of bulk pipe. The transfer length is unlimited. If you are familiar with OpenHCI specification, you may understand that the maximum transfer size of a bulk transfer is 4096 bytes. If the transfer length of your URB exceeds 4096 bytes, the USB system software will split it into several transfer units smaller than 4096 bytes. Thus, you can specify unlimited transfer buffer length, only the physical memory can limit the size.

The transfer buffer must be non-cacheable. A designer can use ***USB_malloc()*** to acquire a block of non-cacheable memory.

The USB device driver also has to prepare a callback function to be invoked by the USB system software. The callback function will be invoked on the completion of URB, in spite of success or fail. Generally, the callback function is responsible for waking up the task that delivers the URB. The callback function may also check the status of the URB to determine the transfer to be successful or not. The following is an example of bulk transfer

```
/* In Host Controller HISR context */
static VOID write_bulk_callback(URB_T *urb)
{
    PEGASUS_T       *pegasus = urb->context;
    STATUS           previous_int_value;
    DV_DEVICE_ENTRY  *device;

    _PegasusDevice->tx_ready = 1;
    /* Get a pointer to the device. */
    device = DEV_Get_Dev_By_Name("Pegasus");

    /* Lock out interrupts. */
    previous_int_value = NU_Control_Interrupts(NU_DISABLE_INTERRUPTS);
    DEV_Recover_TX_Buffers(device);
```

```
    /* If there is another item on the list, transmit it. */
    if (device->dev_transq.head)
    {
        /* Re-enable interrupts */
        NU_Control_Interrupts(previous_int_value);
        /* Transmit the next packet. */
        PegasusTransmit(device, device->dev_transq.head);
    }
    /* Re-enable interrupts. */
    NU_Control_Interrupts(previous_int_value);
    if (urb->status)
        USB_printf("write_bulk_callback - TX error status: %d\n",
                    urb->status);
}


STATUS  PegasusTransmit(DV_DEVICE_ENTRY *dev, NET_BUFFER *netBuffer)
{
    INT     ret, wait=0;
    UINT8   *buf_ptr;
    INT     totalLength = 0;

    while (!_PegasusDevice->tx_ready)
    {
        NU_Sleep(1);                /* wait on any outgoing Tx */
        if (wait++ > NU_PLUS_Ticks_Per_Second)
        {
            USB_printf("Can't transmit packet!\n");
            return NU_IO_ERROR;
        }
    }

    buf_ptr = _PegasusDevice->tx_buff + 2;
    do
    {
        memcpy(buf_ptr, netBuffer->data_ptr, netBuffer->data_len);
        totalLength += netBuffer->data_len;
        buf_ptr += netBuffer->data_len;

        /* Move on to the next buffer. */
```

```
        netBuffer = netBuffer->next_buffer;
    } while (netBuffer != 0);

    /* The first two bytes record the packet length. */
    buf_ptr = _PegasusDevice->tx_buff;
    buf_ptr[0] = totalLength & 0xff;
    buf_ptr[1] = (totalLength >> 8) & 0xff;

    FILL_BULK_URB(&_PegasusDevice->tx_urb, _PegasusDevice->usb,
                  usb_sndbulkpipe(_PegasusDevice->usb, 2),
                 (CHAR *)buf_ptr, PEGASUS_MAX_MTU,
                  write_bulk_callback, _PegasusDevice);

    _PegasusDevice->tx_urb.transfer_buffer_length =
            ((totalLength+2) & 0x3f) ? totalLength+2 : totalLength+3;
    _PegasusDevice->tx_ready = 0;
    USB_SubmitUrb(&_PegasusDevice->tx_urb);
    return NU_SUCCESS;
}
```

Interrupt Transfer

In this section, we will introduce how to make interrupt transfer by URBs. The URB provids <***transfer_buffer***> and <***transfer_buffer_length***> to accommodate data to be transferred to or from device, and <***interval***> to specify polling interval of the interrupt transfer. The direction of transfer is determined by the direction bit of interrupt pipe. The transfer length is dependent on the endpoint of target interrupt.

The transfer buffer must be non-cacheable. A designer can use ***USB_malloc()*** to acquire a block of non-cacheable memory.

The USB device driver also has to prepare a callback function to be invoked by the USB system software. The callback function will be invoked if there's data received in one of the interrupt interval. In the callback function, USB device driver can read <***transfer_buffer***> to retrieve the received interrupt data. The USB device driver has not to modify URB or resend URB. The USB library will resend the interrupt URB after callback. The interrupt URB will not stop until hardware failure or explicitly deleted by the USB device driver.

```
static VOID  intr_callback(URB_T *urb)
{
    PEGASUS_T *pegasus = urb->context;
    UINT8    *d;

    if (!pegasus)
        return;

    switch (urb->status)
    {
```

```
        case USB_ST_NOERROR:
            break;
        case USB_ST_URB_KILLED:
            return;
        default:
            break;
    }

    d = urb->transfer_buffer;
    if (d[2] & 0x1)
        UART_printf("Rx error - overflow!!\n");
}



    FILL_INT_URB(&_PegasusDevice->intr_urb, _PegasusDevice->usb,
                 usb_rcvintpipe(_PegasusDevice->usb, 3),
                 (CHAR *)&_PegasusDevice->intr_buff[0], 8,
                 intr_callback, _PegasusDevice,
          _PegasusDevice->intr_interval);
    res = USB_SubmitUrb(&_PegasusDevice->intr_urb);
    if (res)
UART_printf("pegasus_open - failed intr_urb %d\n", res);
```

19.5 USB Core Library APIs Specification

USB_PortInit

Synopsis

INT USB_PortInit (UINT32 u32PortType);

Description

The function is used to initialize USB host port type.

Parameter

u32PortType:

Table 19-10: Members of Pipe Control

u32PortType	Description
HOST_LIKE_PORT0	USB host output from GPIOB[1:0]. It is a host like port
HOST_LIKE_PORT1	USB host output from GPIOA[4:3]. It is a host like port
HOST_NORMAL_PORT0_ONLY	USB host output from normal USB transceiver port 0.
HOST_NORMAL_TWO_PORT	USB host output from normal USB transceiver port 0 and port 1.

Return Value

None

Example

```
   /*In/out through host like port 0 */
USB_PortInit(HOST_LIKE_PORT0);
USB_PortDisable(FALSE, TRUE);
InitUsbSystem();
UMAS_InitUmasDriver();
```

USB_PortDisable

Synopsis

VOID USB_PortDisable(BOOL bIsDisPort0, BOOL bIsDisPort1);

Description

The function is used to disable USB host ports if the port is useless.

Parameter

bIsDisPort0	TRUE to disable port 0. FALSE to enable port 0
bIsDisPort1	TRUE to disable port 1. FALSE to enable port 1

Return Value

None

Example

```
/* In/out through host like port 0 and disable port 1 */
USB_PortInit(HOST_LIKE_PORT0);
USB_PortDisable(FALSE, TRUE);
InitUsbSystem();
UMAS_InitUmasDriver();
```

InitUsbSystem

Synopsis

INT   InitUsbSystem (VOID)

Description

Initialize the USB hardware and USB core library. This function must be invoked before any other function execute. The USB library will scan device at this time, but the device will not be activated until the corresponding device driver was registered by USB_RegisterDriver().

Parameter

None

Return Value

0 – Success

Otherwise – Failure

Example

```
/*
Initialize NVTFAT FAT file system, USB core system, and USB mass
storage driver
*/
fsInitFileSystem();
USB_PortInit(HOST_LIKE_PORT0);
USB_PortDisable(FALSE, TRUE);
InitUsbSystem();
UMAS_InitUmasDriver();
```

DeInitUsbSystem

Synopsis

INT DeInitUsbSystem(VOID)

Description

De-Initialize the USB hardware and USB core library.

Parameter

None

Return Value

0 – Success

Example

```
/*
Initialize NVTFAT FAT file system, USB core system, and USB mass
storage driver
*/
fsInitFileSystem();
USB_PortInit(HOST_LIKE_PORT0);
USB_PortDisable(FALSE, TRUE);
InitUsbSystem();
UMAS_InitUmasDriver();
……
/* De-Initialize USB core library */
```

```
DeInitUsbSystem();
```

umass_register_connect

Synopsis

VOID umass_register_connect(PFN_PORT_MS_CALLBACK pfnCallback);

Description

Register connection call back function for mass storage device plug in.

Parameter

pfnCallback	Call back function as mass storage device plug in.

Return Value

None

umass_register_disconnect

Synopsis

VOID umass_register_disconnect(PFN_PORT_MS_CALLBACK pfnCallback);

Description

Register disconnection call back function for mass storage device plug out.

Parameter

pfnCallback	Call back function as mass storage device plug out.

Return Value

None

Example

```
VOID MassStotrageConnection(void* umas)
{
   sysprintf("Umas driver connect  0x%x\n", (UINT32)umas);
   …
}
VOID MassStotrageDisconnection(void* umas)
{
   sysprintf("Umas driver disconnect 0x%x\n", (UINT32)umas);
   …
}
void PenDriverConnectTest(void)
{
umass_register_connect(MassStotrageConnection);
```

```
umass_register_disconnect(MassStotrageDisconnection);
InitUsbSystem();
UMAS_InitUmasDriver();
   …
   while(1);
}
```

UMAS_InitUmasDriver

Synopsis

INT UMAS_InitUmasDriver (VOID)

Description

Initialize the USB mass storage driver. fsInitFileSystem() and InitUsbSystem() must be called prior to this API. Once an USB mass storage device detected, USB core library will initialize it and mount it to NVTFAT file system automatically.

Parameter

None

Return Value

0 – Success

Otherwise – Failure

Example

```
/*
Initialize NVTFAT FAT file system, USB core system, and USB mass
storage driver
*/
fsInitFileSystem();
USB_PortInit(HOST_LIKE_PORT0);
USB_PortDisable(FALSE, TRUE);
InitUsbSystem();
UMAS_InitUmasDriver();
```

UMAS_RemoveUmasDriver

Synopsis

INT UMAS_RemoveUmasDriver (VOID)

Description

Deinitialize the USB mass storage driver.

Parameter

None

Return Value

0 – Success

Otherwise – Failure

Example

```
/*
Initialize NVTFAT FAT file system, USB core system, and USB mass
storage driver
*/
fsInitFileSystem();
USB_PortInit(HOST_LIKE_PORT0);
USB_PortDisable(FALSE, TRUE);
InitUsbSystem();
UMAS_InitUmasDriver();
……
……
UMAS_RemoveUmassDriver();
```

USB_RegisterDriver

Synopsis

INT USB_RegisterDriver (USB_DRIVER_T *driver)

Description

Register a device driver with the USB library. In this function, USB library will also try to associate the newly registered device driver with all connected USB devices that have no device driver associated with it. Note that a connected USB device can be detected by USB library but may not work until it was associated with its corresponding device driver.

Parameter

driver	The USB device driver is registered with USB core library

Return Value

0 – Success

Otherwise – Failure

Example

```
static USB_DRIVER_T  usblp_driver =
{
    "usblp",
    usblp_probe,
```

```
    usblp_disconnect,
    {NULL,NULL},
    {0},
    NULL,
    usblp_ids,
    NULL,
    NULL
};

INT  UsbPrinter_Init() {
   if (USB_RegisterDriver(&usblp_driver)) return -1;
   return 0;
}
```

USB_DeregisterDriver

Synopsis

VOID   USB_DeregisterDriver(USB_DRIVER_T *driver)

Description

Deregister a device driver.

Parameter

driver   The device driver is deregistered

Return Value

0 – Success

Otherwise – Failure

Example

```
VOID  UsbPrinter_Exit()
{
   USB_DeregisterDriver(&usblp_driver);
}
```

USB_AllocateUrb

Synopsis

URB_T   *USB_AllocateUrb(INT iso_packets)

Description

Creates an urb for the USB driver to use and returns a pointer to it. The driver should call USB_FreeUrb() when it is finished with the urb

Parameter

iso_packets The number of isochronous frames within a single URB.

For other transfer types, this value must be zero.

Return Value

NULL - Failure

Otherwise - A pointer to the newly allocated URB

Example

```
_W99683_Camera->sbuf[i].urb = USB_AllocateUrb(FRAMES_PER_DESC);
                       if (_W99683_Camera->sbuf[i].urb == NULL)
  {
          UART_printf("%s - USB_AllocateUrb(%d.) failed.\n", proc,
                 FRAMES_PER_DESC);
          Return -1;
   };
```

USB_FreeUrb

Synopsis

VOID USB_FreeUrb(URB_T *urb)

Description

Free the memory used by a URB.

Parameter

None

Return Value

None

Example

None

USB_SubmitUrb

Synopsis

INT USB_SubmitUrb(URB_T *urb)

Description

Submit a URB for executing data transfer

Parameter

urb Pointer to the URB to be serviced.

Return Value

0 – Success

Otherwise – Failure

Example

```
/* prepare URB */
FILL_BULK_URB(&_PegasusDevice->tx_urb, _PegasusDevice->usb,
           usb_sndbulkpipe(_PegasusDevice->usb, 2), (CHAR *)buf_ptr,
PEGASUS_MAX_MTU,
           write_bulk_callback, _PegasusDevice);

/* set the data length to be transferred */
_PegasusDevice->tx_urb.transfer_buffer_length =
                   ((totalLength+2) & 0x3f) ? totalLength+2 :
totalLength+3;
_PegasusDevice->tx_ready = 0;

/* submit URB */
if (USB_SubmitUrb(&_PegasusDevice->tx_urb) != 0)
{
    UART_printf("Warning - failed tx_urb %d\n", ret);
    return NU_IO_ERROR;
}
```

USB_UnlinkUrb

Synopsis

INT USB_UnlinkUrb(URB_T *urb)

Description

Unlink a URB which has been submitted but not finished

Parameter

urb pointer to the URB to be unlinked

Return Value

0 – Success

Otherwise – Failure

Example

```
   INT  PegasusClose()
{
    _PegasusDevice->flags &= ~PEGASUS_RUNNING;

    if (!(_PegasusDevice->flags & PEGASUS_UNPLUG))
        disable_net_traffic(_PegasusDevice);
```

```
    USB_UnlinkUrb(&_PegasusDevice->rx_urb);
    USB_UnlinkUrb(&_PegasusDevice->tx_urb);
    USB_UnlinkUrb(&_PegasusDevice->ctrl_urb);
#ifdef  PEGASUS_USE_INTR
    USB_UnlinkUrb( &_PegasusDevice->intr_urb );
#endif
    return 0;
}
```

USB_SendBulkMessage

Synopsis

INT USB_SendBulkMessage(USB_DEV_T *dev,
UINT32 pipe,
VOID *data,
INT len,
INT *actual_length,
INT timeout)

Description

Build a bulk URB, send it off and wait for completion. This function sends a simple bulk message to a specified endpoint and waits for the message to complete, or timeout. Don't use this function from within an interrupt context.

Parameter

dev	pointer to the USB device to send the message to
pipe	endpoint "pipe" to send the message to
data	pointer to the data to send
len	length in bytes of the data to send
actual_length	pointer to a location to put the actual length transferred in bytes
timeout	time to wait for the message to complete before timing out (if 0 the wait is forever)

Return Value

0 – Success

Otherwise – Failure

Example

```
        if (!pb->pipe)
                pipe = usb_rcvbulkpipe (s->usbdev, 2);
        else
```

```
                 pipe = usb_sndbulkpipe (s->usbdev, 2);
          ret = USB_SendBulkMessage(s->usbdev, pipe, pb->data, pb-
>size, &actual_length, 100);
          if (ret<0) {
                 err("dabusb: usb_bulk_msg failed(%d)",ret);
                 if (usb_set_interface (s->usbdev, _DABUSB_IF, 1) < 0)
{
                        err("set_interface failed");
                        return -EINVAL;
                 }
          }
```

USB_malloc

Synopsis

VOID *USB_malloc(INT wanted_size,
INT boundary)

Description

Allocate a non-cacheable memory block started from assigned boundary. The total size of the USB library manages memory block is 256KB.

Parameter

wanted_size The wanted size of non-cacheable memory block

boundary The start address boundary of the memory block.

It can be BOUNDARY_BYTE, BOUNDARY_HALF_WORD, BOUNDARY_WORD, BOUNDARY32, BOUNDARY64, BOUNDARY128, BOUNDARY256, BOUNDARY512, BOUNDARY1024, BOUNDARY2048, BOUNDARY4096.

Return Value

NULL Failed, there is not enough memory or USB library is not started

Otherwise pointer to the newly allocated memory block

Example

```
          UINT8  *dma_data;

dma_data = USB_malloc(len, BOUNDARY_WORD);
          if (dma_data == NULL) {
     NU_printf("usblp_ctrl_msg - Memory not enough!\n");
     return -1;
          }
          retval = USB_SendControlMessage(usblp->dev,
```

```
        dir ? usb_rcvctrlpipe(usblp->dev, 0) : usb_sndctrlpipe(usblp->dev, 0),
      request, USB_TYPE_CLASS | dir | recip, value, usblp->ifnum, dma_data,
        len, HZ * 5);
                       memcpy(buf, dma_data, len);
          USB_free(dma_data);
```

USB_free

Synopsis

VOID   USB_free(VOID *alloc_addr)

Description

Free the memory block allocated by USB_malloc().

Parameter

alloc_addr   pointer to the USB_malloc() allocated memory block to be free.

Return Value

None

Example

```
Same as USB_malloc()
```

20 VPOST Library

20.1 Overview

The VPOST consists of LCD and TV encoder controller and is used to display the video/image data to LCD device or to generate the composite signal to the TV system. The LCD timing can be synchronized with TV (NTSC/PAL non-interlace timing) or set by the LCD timing control register. The video/image data source may be come from the frame buffer, color bar or register settings. In general, the frame buffer which is stored in system memory is used as the image source.

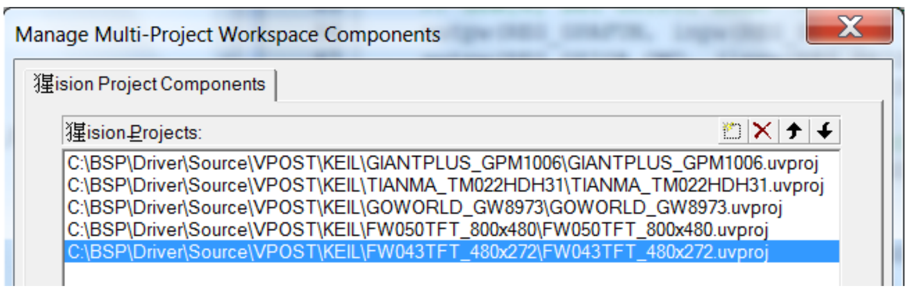
20.1.1 How to build VPOST library

There are several panels can be supported by the VPOST library. If the current driver cannot support the selected panel, the user can add the desired one in the following procedure.

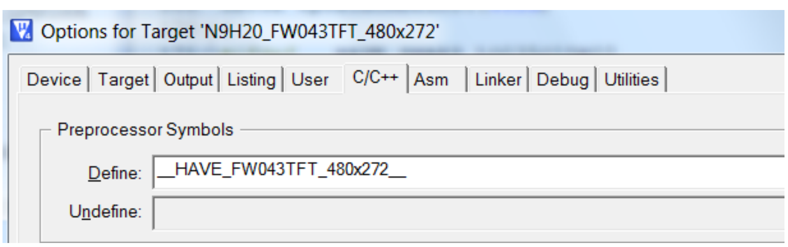
Prepare two functions, i.e., "vpostLCMInit_PanelName()" and "vpostLCMDeInit_PanelName()" in the desired panel driver.

In N9H20_VPOST.c, please add the statement "vpostLCMInit_PanelName();" and "vpostLCMDeInit_PanelName();" to functions of vpostLCMInit () and vpostLCMDeInit(), respectively.

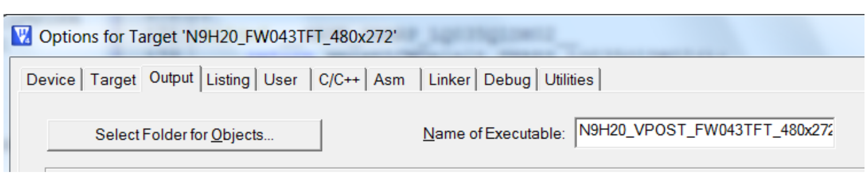
Add the panel project to the VPOST multi-project library.



Add the preprocessor symbol of "__HAVE_PanelName__" in the panel project.



Give the output name for the panel.



According to above procedure, the user can create the desired driver for selected panel.

20.2 VPOST APIs Specification

20.3 Enumeration

Name	Value	Description
E_DRVVPOST_TIMING_TYPE		
eDRVVPOST_SYNC_TV	0x0	LCD timing sync with TV
eDRVVPOST_ASYNC_TV	0x1	LCD timing not sync with TV
E_DRVVPOST_IMAGE_SOURCE		
eDRVVPOST_RESERVED	0x0	Reserved for LC source
eDRVVPOST_FRAME_BUFFER	0x1	LCD source from Frame buffer
eDRVVPOST_REGISTER_SETTING	0x2	LCD source from Register setting color
eDRVVPOST_COLOR_BAR	0x3	LCD source from internal color bar
E_DRVVPOST_IMAGE_SCALING		
eDRVVPOST_DUPLICATED	0x0	Duplicate for TV Line buffer scaling
eDRVVPOST_INTERPOLATION	0x1	Interpolation for TV line buffer scaling
E_DRVVPOST_LCM_TYPE		
eDRVVPOST_HIGH_RESOLUTINO_SYNC	0x0	High resolution LCD device type
eDRVVPOST_SYNC	0x1	Sync-type TFT LCD
eDRVVPOST_MPU	0x3	MPU-type LCD
E_DRVVPOST_MPU_TYPE		
eDRVVPOST_I80	0x0	80-series MPU interface
eDRVVPOST_M68	0x1	68-series MPU interface
E_DRVVPOST_8BIT_SYNCLCM_INTERFACE		
eDRVVPOST_SRGB_YUV422	0x0	YUV422(CCIR601) for 8bit LCD data interface
eDRVVPOST_SRGB_RGBDUMMY	0x1	RGB dummy serial for 8 bit LCD data interface
eDRVVPOST_SRGB_CCIR656	0x2	CCIR656 for 8 bit LCD data interface
eDRVVPOST_SRGB_RGBTHROUGH	0x3	Serial RGB for 8 bit LCD data interface
E_DRVVPOST_CCIR656_MODE		
eDRVVPOST_CCIR656_360	0x0	720Y 360CbCr mode for CCIR656 horizontal active width
eDRVVPOST_CCIR656_320	0x1	640Y 320CbCr mode for CCIR656 horizontal active width
E_DRVVPOST_ENDIAN		
eDRVVPOST_YUV_BIG_ENDIAN	0x0	Big Endian for YCbCr
eDRVVPOST_YUV_LITTLE_ENDIAN	0x1	Little Endian for YCbCr
E_DRVVPOST_SERAIL_SYNCLCM_COLOR_ORDER		
eDRVVPOST_SRGB_RGB	0x0	Data in RGB order
eDRVVPOST_SRGB_BGR	0x1	Data in BGR order
eDRVVPOST_SRGB_GBR	0x2	Data in GBR order
eDRVVPOST_SRGB_RBG	0x3	Data in RBG order

E_DRVVPOST_PARALLEL_SYNCLCM_INTERFACE		
eDRVVPOST_PRGB_16BITS	0x0	16 pin parallel RGB data bus
eDRVVPOST_PRGB_18BITS	0x1	18 pin parallel RGB data bus
eDRVVPOST_PRGB_24BITS	0x2	24 pin parallel RGB data bus
E_DRVVPOST_SYNCLCM_DATABUS		
eDRVVPOST_SYNC_8BITS	0x0	8 bit sync-type LCD
eDRVVPOST_SYNC_9BITS	0x1	9 bit sync-type LCD
eDRVVPOST_SYNC_16BITS	0x2	16 bit sync-type LCD
eDRVVPOST_SYNC_18BITS	0x3	18 bit sync-type LCD
eDRVVPOST_SYNC_24BITS	0x4	24 bit sync-type LCD
E_DRVVPOST_MPULCM_DATABUS		
eDRVVPOST_MPU_8_8	0x0	Transfer in 8-8 format for 16 bit color in 8 bit bus width
eDRVVPOST_MPU_2_8_8	0x1	Transfer in 2-8-8 format for 18 bit color in 8 bit bus width
eDRVVPOST_MPU_6_6_6	0x2	Transfer in 6-6-6 format for 18 bit color in 8 bit bus width
eDRVVPOST_MPU_8_8_8	0x3	Transfer in 8-8-8 format for 24 bit color in 8 bit bus width
eDRVVPOST_MPU_9_9	0x4	Transfer in 9-9 format for 18 bit color in 9 bit bus width
eDRVVPOST_MPU_16	0x5	Transfer in 16 format for 16 bit color in 16 bit bus width
eDRVVPOST_MPU_16_2	0x6	Transfer in 16-2 format for 18 bit color in 16 bit bus width
eDRVVPOST_MPU_2_16	0x7	Transfer in 2-16 format for 18 bit color in 16 bit bus width
eDRVVPOST_MPU_16_8	0x8	Transfer in 16-8 format for 24 bit color in 16 bit bus width
eDRVVPOST_MPU_18	0x9	Transfer in 18 format for 18 bit color in 18 bit bus width
eDRVVPOST_MPU_18_6	0xA	Transfer in 18-6 format for 124 bit color in 18 bit bus width
eDRVVPOST_MPU_24	0xB	Transfer in 24 format for 24 bit color in 24 bit bus width
E_DRVVPOST_FRAME_DATA_TYPE		
eDRVVPOST_FRAME_RGB555	0x0	RGB555 Frame buffer data format
eDRVVPOST_FRAME_RGB565	0x1	RGB565 Frame buffer data format
eDRVVPOST_FRAME_RGBX888	0x2	RGB_Dummy888 Frame buffer data format
eDRVVPOST_FRAME_RGB888X	0x3	RGB888_Dummy Frame buffer data format
eDRVVPOST_FRAME_CBYCRY	0x4	Cb0Y0Cr0Y1 Frame buffer data format
eDRVVPOST_FRAME_YCBYCR	0x5	Y0Cb0Y1Cr0 Frame buffer data format
eDRVVPOST_FRAME_CRYCBY	0x6	Cr0Y0Cb0Y1 Frame buffer data format
eDRVVPOST_FRAME_YCRYCB	0x7	Y0Cr0Y1Cb0 Frame buffer data format

E_DRVVPOST_DATABUS		
eDRVVPOST_DATA_8BITS	0x0	8 bits data bus
eDRVVPOST_DATA_9BITS	0x1	9 bits data bus
eDRVVPOST_DATA_16BITS	0x2	16 bits data bus
eDRVVPOST_DATA_18BITS	0x3	18 bits data bus
eDRVVPOST_DATA_24BITS	0x4	24 bits data bus
E_DRVVPOST_OSD_DATA_TYPE		
eDRVVPOST_OSD_RGB555	0x8	RGB555 OSD data format
eDRVVPOST_OSD_ RGB565	0x9	RGB565 OSD data format
eDRVVPOST_OSD_RGBx888	0xA	RGB_Dummy888 OSD data format
eDRVVPOST_OSD_RGB888x	0xB	RGB_888Dummy OSD data format
eDRVVPOST_OSD_ARGB888	0xC	RGB_Alfa888 OSD data format
eDRVVPOST_OSD_CB0Y0CR0Y1	0x0	CB0Y0CR0Y1 OSD data format
eDRVVPOST_OSD_Y0CB0Y1CR0	0x1	Y0CB0Y1CR0 OSD data format
eDRVVPOST_OSD_CR0Y0CB0Y1	0x2	CR0Y0CB0Y1 OSD data format
eDRVVPOST_OSD_Y0CR0Y1CB0	0x3	Y0CR0Y1CB0 OSD data format
eDRVVPOST_OSD_Y1CR0Y0CB0	0x4	Y1CR0Y0CB0 OSD data format
eDRVVPOST_OSD_CR0Y1CB0Y0	0x5	CR0Y1CB0Y0 OSD data format
eDRVVPOST_OSD_Y1CB0Y0CR0	0x6	Y1CB0Y0CR0 OSD data format
eDRVVPOST_OSD_CB0Y1CR0Y0	0x7	CB0Y1CR0Y0 OSD data format
E_DRVVPOST_OSD_TRANSPARENT_DATA_TYPE		
eDRVVPOST_OSD_ TRANSPARENT_RGB565	0x0	RGB565 transparent color format
eDRVVPOST_OSD_ TRANSPARENT_YUV	0x1	YUV transparent color format
eDRVVPOST_OSD_ TRANSPARENT_RGB888	0x2	RGB888 transparent color format

Structure

Field	Type	Description
ucVASrcFormat	UINT32	User input Display source format
nScreenWidth	UINT32	Driver output LCD width
nScreenHeight	UINT32	Driver output LCD height
nFrameBufferSize	UINT32	Driver output Frame buffer size
ucROT90	UINT8	Rotate 90 degree or not

Table 20-1: LCDFORMATEX structure

Field	Type	Description
u8PulseWidth	UINT8	Horizontal sync pulse width
u8BackPorch	UINT8	Horizontal back porch
u8FrontPorch	UINT8	Horizontal front porch

Table 20-2: S_DRVVPOST_SYNCLCM_HTIMING structure

Field	Type	Description
u8PulseWidth	UINT8	Vertical sync pulse width
u8BackPorch	UINT8	Vertical back porch
u8FrontPorch	UINT8	Vertical front porch

Table 20-3: S_DRVVPOST_SYNCLCM_VTIMING structure

Field	Type	Description
u16ClockPerLine	UINT16	Specify the number of pixel clock in each line or row of screen
u16LinePerPanel	UINT16	Specify the number of active lines per screen
u16PixelPerLine	UINT16	Specify the number of pixel in each line or row of screen

Table 20-4: S_DRVVPOST_SYNCLCM_WINDOW structure

Field	Type	Description
bIsVsyncActiveLow	BOOL	Vsync polarity
bIsHsyncActiveLow	BOOL	Hsync polarity
bIsVDenActiveLow	BOOL	VDEN polarity
bIsDClockRisingEdge	BOOL	Clock polarity

Table 20-5: S_DRVVPOST_SYNCLCM_POLARITY structure

Field	Type	Description
u16LinePerPanel	BOOL	Specify the number of active lines per screen
u16PixelPerLine	BOOL	Specify the number of pixel in each line or row of screen

Table 20-6: S_DRVVPOST_MPULCM_WINDOW structure

Field	Type	Description

u8CSnF2DCt	UINT8	CSn fall edge to Data change clock counter
u8WRnR2CSnRt	UINT8	WRn rising edge to CSn rising clock counter
u8WRnLWt	UINT8	WR Low pulse clock counter
u8CSnF2WRnFt	UINT8	Csn fall edge To WR falling edge clock counter

Table 20-7: S_DRVVPOST_MPULCM_WINDOW structure

Field	Type	Description
bIsSyncWithTV	BOOL	MPU timing sync with TV
bIsVsyncSignalOut	BOOL	Specify MPU FrameMark pin as input or output pin
bIsFrameMarkSignalIn	BOOL	Frame Mark detection disable or enable
eSource	E_DRVVPOST_IMAGE_SOURCE	Specify the image source
eType	E_DRVVPOST_LCM_TYPE	Specify the LCM type
eMPUType	E_DRVVPOST_MPU_TYPE	Specify the MPU type
eBus	E_DRVVPOST_MPULCM_DATABUS	Specify the MPU data bus
psWindow	S_DRVVPOST_MPULCM_WINDOW*	Specify MPU window
psTiming	S_DRVVPOST_MPULCM_TIMING*	Specify MPU timing

Table 20-8: S_DRVVPOST_MPULCM_TIMING structure

Field	Type	Description
u16VSize	UINT16	Specify OSD vertical size
u16HSize	UINT16	Specify OSD horizontal size

Table 20-9: S_DRVVPOST_OSD_SIZE structure

Field	Type	Description
u16VStart_1st	UINT16	Specify 1st OSD bar vertical start position
u16VEnd_1st	UINT16	Specify 1st OSD bar vertical end position
u16VOffset_2nd	UINT16	Specify 2nd OSD bar vertical offset position (2nd_Start – 1st_End)
u16HStart_1st	UINT16	Specify 1st OSD bar horizontal start position
u16HEnd_1st	UINT16	Specify 1st OSD bar horizontal end position
u16HOffset_2nd	UINT16	Specify 2nd OSD bar horizontal offset position (2nd_Start –

		1st_End)

Table 20-10: S_DRVVPOST_OSD_POS structure

Field	Type	Description
bIsOSDEnabled	BOOL	Specify OSD to be enabled or disabled
u32Address	UINT32	Specify the beginning address of OSD buffer
eType	E_DRVVPOST_OSD_DATA_TYPE	Specify OSD data type
psSize	S_DRVVPOST_OSD_SIZE*	Specify the data pointer of OSD size
psPos	S_DRVVPOST_OSD_POS*	Specify the data pointer of OSD position

Table 20-11: S_DRVVPOST_OSD_CTRL structure

20.4 Functions

vpostGetFrameBuffer

Synopsis

void *vpostGetFrameBuffer (void);

Description

Get the display frame buffer address

Parameter

None

Return Value

Display frame buffer address.

Example

vpostSetFrameBuffer

Synopsis

void vpostSetFrameBuffer (

UINT32 pFramebuf

);

Description

Set the display frame buffer address

Parameter

UINT32 pFramebuf

Given frame buffer address

Return Value

None.

Example

None.

vpostLCMInit

Synopsis

INT32

vpostLCMInit (

PLCDFORMATEX plcdformatex,

UINT32 *pFramebuf

);

Description

Initialize the VPOST display device

Parameter

plcdformatex [in]

Input the lcd format information to initialize.

pFramebuf [in]

Input the frame buffer address

Return Value

Successful: Success

ERRCODE: Error

Example

```
__align(32) UINT8 Vpost_Frame[480*272*2];
lcdFormat.ucVASrcFormat = DRVVPOST_FRAME_RGB565;
   lcdFormat.nScreenWidth = 480;
   lcdFormat.nScreenHeight = 272;
   vpostLCMInit(&lcdFormat, (UINT32*)Vpost_Frame);
```

vpostLCMDeinit

Synopsis

INT32

vpostLCMDeinit (void);

Description

The function will stop VPOST operation and turn off VPOST clock.

Parameter

None

Return Value

Successful: Success

ERRCODE: Error

Example

None.

vpostEnaBacklight

Synopsis

void vpostEnaBacklight (void);

Description

The function enables the backlight led.

Parameter

None

Return Value

None

Example

None

vpostSetOSD_Enable

Synopsis

void vpostSetOSD_Enable (void);

Description

The function enables the OSD feature.

Parameter

None

Return Value

None

Example

None

vpostSetOSD_Disable

Synopsis

void vpostSetOSD_Disable (void);

Description

The function disables the OSD feature.

Parameter

None

Return Value

None

Example

None

vpostSetOSD_Size

Synopsis

void vpostSetOSD_Size (

S_DRVVPOST_OSD_SIZE* psSize

);

Description

The function sets the OSD size.

Parameter

psSize [in]

Input the OSD size pointer.

Return Value

None

Example

None

vpostSetOSD_Pos

Synopsis

void vpostSetOSD_Pos (

S_DRVVPOST_OSD_POS* psPos

);

Description

The function sets the OSD position.

Parameter

psPos [in]

Input the OSD position pointer.

Return Value

None

Example

None

vpostSetOSD_DataType

Synopsis

void vpostSetOSD_DataType (

E_DRVVPOST_OSD_DATA_TYPE eType

);

Description

The function sets the OSD data type.

Parameter

eType [in]

Set the OSD data type.

Return Value

None

Example

None

vpostSetOSD_Transparent_Enable

Synopsis

void vpostSetOSD_Transparent _Enable (void);

Description

The function enables the OSD transparent feature.

Parameter

None

Return Value

None

Example

None

vpostSetOSD_Transparent_Disable

Synopsis

void vpostSetOSD_Transparent _Disable (void);

Description

The function disables the OSD transparent feature.

Parameter

None

Return Value

None

Example

None

vpostSetOSD_Transparent

Synopsis

void vpostSetOSD_Transparent (
E_DRVVPOST_OSD_TRANSPARENT_DATA_TYPE eType
UINT32 u32Pattern
);

Description

The function sets the OSD transparent data type and pattern.

Parameter

eType [in]

Set the OSD transparent data type.

u32Pattern [in]

Given the transparent pattern.

Return Value

None

Example

None

vpostSetOSD_BaseAddress

Synopsis

void vpostSetOSD_BaseAddress (

UINT32 u32BaseAddress

);

Description

The function sets the OSD buffer base address.

Parameter

u32BaseAddress [in]

Given the OSD base address.

Return Value

None

Example

None

20.5 Error Code Table

Code Name	Value	Description
ERR_NULL_BUF	0xFFF06004	memory location error
ERR_NO_DEVICE	0xFFF06005	No device error
ERR_BAD_PARAMETER	0xFFF06006	Bad parameter error
ERR_POWER_STATE	0xFFF06007	Power state control error

21 EDMA Library

21.1 Overview

This library is designed to make user application to set N9H20 EDMA more easily.

The EDMA library has the following features:

- Support color space transforms (RGB565, RGB555, RGB888 and YUV422) for VDMA.
- Support transfers data to and from memory or transfer data to and from APB.
- Support hardware Scatter-Gather function.

21.2 Programming Guide

21.2.1 System Overview

The N9H20 contains an enhanced direct memory access (EDMA) controller that transfers data to and from memory or transfers data to and from APB. The EDMA controller has 5-channel DMA that include 1 channel VDMA (Video-DMA, Memory-to-Memory) and four channels PDMA (Peripheral-to-Memory or Memory-to-Peripheral). For channel 0 VDMA mode, it also supports color format transform and stride mode transfer. For PDMA channel (EDMA CH1~CH4), it can transfer data between the Peripherals APB IP (ex: UART, SPI, ADC….) and Memory. The N9H20 also supports hardware scatter-gather function, software can set CSRx [SG_EN] to enable scatter-gather function.

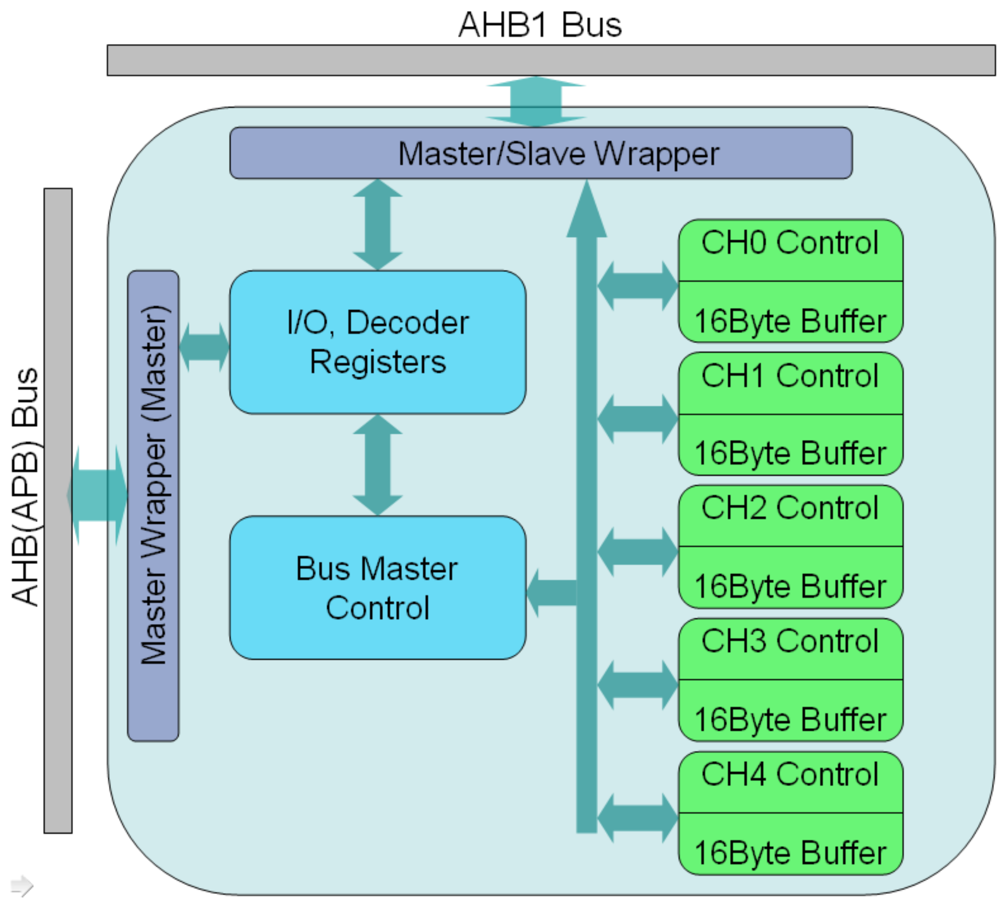
Software can stop the EDMA operation by disable DMA [DMACEN]. The CPU can recognize the completion of an EDMA operation by software polling or when it receives an internal EDMA interrupt. The N9H20 VDMA controller can increment source or destination address, decrement or fixed them as well, and the PDMA can increment source or destination, fixed or wrap around address.

21.2.2 EDMA Features

- AMBA AHB master/slave interface compatible, for data transfer and register read/write.
- Support packaging format color space transforms (RGB565, RGB555, RGB888 and YUV422) for VDMA.
- Support stride mode transfer mode for VDMA.
- VDMA support 32-bit source and destination addressing range, address increment, decrement and fixed.
- PDMA support 32-bit source and destination addressing range address increment, fixed and wrap around.
- Support hardware Scatter-Gather function.

21.2.3 Block Diagram

The following figure describes the architecture of EDMA.



21.2.4 EDMA Control

VDMA Transfer

The main purpose of VDMA channel is to perform a memory-to-memory transfer. Besides the pure memory copy, it also provides the color format transformation in packet during the transfer.

Software must enable DMA channel DMA_CSRx [DMACEN] and then write a valid source address to the DMA_SARx register, a destination address to the DMA_DARx register, and a transfer count to the DMA_BCRx register. Next, trigger the DMA_CSRx [Trig_EN]. If the source address and destination are not in wrap around mode, the transfer will start transfer until DMA_CBCRx reaches zero (in wrap around mode, when DMA_CBCRx equal zero, the DMA will reload DMA_CBCRx and work around until software disable DMA_CSRx [DMACEN]). If an error occurs during the EDMA operation, the channel stops unless software clears the error condition, sets the DMA_CSRx [SW_RST] to reset the EDMA channel and set EDMA_CSRx [DMACEN] and [Trig_EN] bits field to start again.

PDMA Transfer

The PDMA is used to transfer data between SDRAM and APB device. Currently, the APB device only supports UART 0/1, SPIMS 0/1 and ADC audio recording. The data direction can be from APB device or to APB device dependent on the setting of PDMA_CSRx[MODE_SEL]. Hardware IP will do the necessary handshaking signal between PDMA and APB device.

In the PDMA transfer, the APB device data port should be set as the source or destination address dependent on the setting of PDMA_CSRx[MODE_SEL], and the address direction must be set as fixed for APB address. Besides this, the APB device has corresponding register setting to enable PDMA transfer.

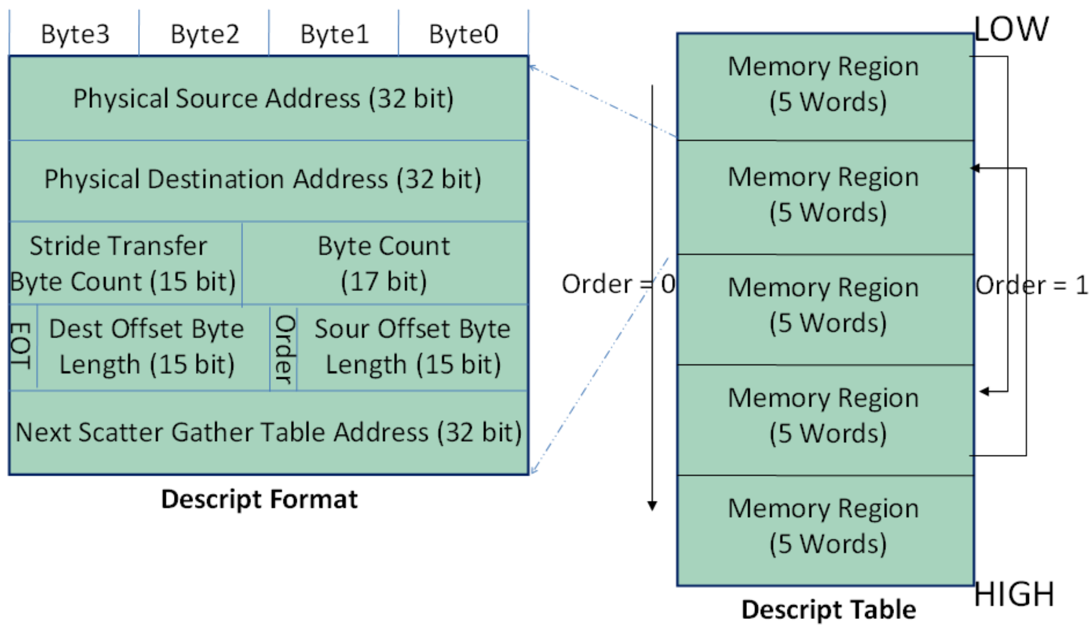
Below table lists the control register and control bit for it.

APB IP	Control Register	Control Bits
Uart 0/1	UA_IER (UA_BA0/1+0x04)	DMA_Tx_En and DMA_Rx_En
SPI0/1	SPI0/1_EDMA	EDMA_RW and EDMA_GO
ADC	AGCP1	EDMA_MODE

Moreover, the EDSSR register in global control is necessary to notice. The PDMA cannot use the same channel selection in it when PDMA is set.

Scatter Gather Transfer

The N9H20 also supports hardware scatter-gather function, software can set DMA_CSRx [SG_EN] to enable scatter-gather function. When in scatter-gather function mode, some register will be automatically updated by descriptor table. The descriptor table format is show as following:



The field definition of scatter table is as below:

- Physical Source Address (32 bits)
- Physical Destination Address (32 bits)
- Byte Count : Transfer Byte Count (17 bits)
- Stride Transfer Byte Count (15 bits)
- EOT : End of Table (1 bit)
- Source Offset Byte Length (15 bits)
- Oder : Scatter Gather table in Link list mode or not (1 bit)
- Destination Offset Byte length (15 bits)
- Next Scatter Gather Table Address (32 bits)

Note : only when in stride transfer mode (CTCSR[Stride_EN]=1), Stride Transfer Byte count, Source Offset Byte length and Destination Offset Byte Length is meaningful

21.3 APIs Specification Functions

EDMA_Init

Synopsis

int EDMA_Init(void)

Description

This function initializes the software resource.

Parameter

None

Return Value

0 Always successes

Example

```
EDMA_Init ();
```

EDMA_Exit

Synopsis

void EDMA_Exit(void)

Description

Disable EDMA engine clock.

Parameter

None

Return Value

None

Example

```
EDMA_Exit ();
```

EDMA_Enable

Synopsis

void EDMA_Enable(int channel)

Description

This function is used to start EDMA channel operation.

Parameter

channel EDMA channel number

Return Value

None

Example

```
EDMA_Enable (0);
```

EDMA_Disable

Synopsis

void EDMA_Disable(int channel)

Description

This function is used to stop EDMA channel operation.

Parameter

channel EDMA channel number

Return Value

None

Example

```
EDMA_Disable (0);
```

EDMA_Request

Synopsis

int EDMA_Request(int channel)

Description

This function is used to allocate specified channel number.

Parameter

channel EDMA channel number

Return Value

SUCCESS Allocation channel is returned.

FAIL < 0 is returned.

EDMA_ERR_BUSY : specified channel is busy.

EDMA_ERR_INVAL : specified channel is greater than the maximum

number of channels.

Example

```
EDMA_Request (0);
```

VDMA_FindandRequest

Synopsis

int VDMA_FindandRequest(void)

Description

This function tries to find a free channel in the specified priority group.

Parameter

None

Return Value

SUCCESS	Allocation channel is returned.
FAIL	EDMA_ERR_NODEV is returned.

Example

```
int g_VdmaCh;
g_VdmaCh = VDMA_FindandRequest ();
```

21.3.1.1 PDMA_FindandRequest

Synopsis

int PDMA_FindandRequest(void)

Description

This function tries to find a free channel in the specified priority group.

Parameter

None

Return Value

SUCCESS	Allocation channel is returned.
FAIL	EDMA_ERR_NODEV is returned.

Example

```
int g_PdmaCh;
g_PdmaCh = PDMA_FindandRequest ();
```

EDMA_SetupHandlers

Synopsis

int EDMA_SetupHandlers(int channel, int interrupt, PFN_DRVEDMA_CALLBACK irq_handler, void *data)

Description

This function is used to setup EDMA channel notification handlers.

Parameter

channel EDMA channel number

interrupt EDMA interrupt enable

irq_handler The callback function pointer for specified EDMA channel .

data User specified value to be passed to the handlers.

Return Value

SUCCESS 0 is returned.

FAIL EDMA_ERR_NODEV is returned.

Example

```
/* Install Callback function */
EDMA_SetupHandlers(0, eDRVEDMA_BLKD_FLAG, EdmaIrqHandler, 0);
```

EDMA_SetupSingle

Synopsis

int EDMA_SetupSingle(int channel, unsigned int src_addr, unsigned int dest_addr, unsigned int dma_length)

Description

This function is used to setup EDMA channel for linear memory to/from device transfer.

Parameter

channel EDMA channel number

src_addr Source address

dest_addr Destination address

dma_length Length of the transfer request in bytes

Return Value

SUCCESS 0 is returned.

FAIL < 0 is returned.

EDMA_ERR_BUSY : specified channel is busy.

EDMA_ERR_INVAL : null address or zero length.

Example

```
EDMA_SetupSingle (0, SRC_ADDR, DEST_ADDR, 0x10000);
```

EDMA_Free

Synopsis

void EDMA_Free(int channel)

Description

This function is used to release previously acquired channel.

Parameter

Channel EDMA channel number

Return Value

None

Example

```
EDMA_Free (0);
```

EDMA_SetupSG

Synopsis

int EDMA_SetupSG(int channel, unsigned int src_addr, unsigned int dest_addr, unsigned int dma_length)

Description

This function is used to setup EDMA channel SG list.

Parameter

channel EDMA channel number

src_addr Source address

dest_addr Destination address

length Total length of the transfer request in bytes

Return Value

SUCCESS 0 is returned.

FAIL < 0 is returned.

EDMA_ERR_BUSY : specified channel is busy.

EDMA_ERR_INVAL : zero length or address is not PAGE_SIZE alignment.

Example

```
EDMA_SetupSG (0, SRC_ADDR, DEST_ADDR, 0x10000);
```

EDMA_FreeSG

Synopsis

void EDMA_FreeSG(int channel)

Description

This function is used to release previously acquired channel SG list.

Parameter

Channel	EDMA channel number

Return Value

None

Example

```
EDMA_FreeSG (0);
```

EDMA_SetupCST

Synopsis

int EDMA_SetupCST(int channel, E_DRVEDMA_COLOR_FORMAT eSrcFormat, E_DRVEDMA_COLOR_FORMAT eDestFormat)

Description

This function is used to setup EDMA channel for color space transform.

Parameter

channel	EDMA channel number
eSrcFormat	The source color format
eDestFormat	The destination color format

Return Value

SUCCESS	0 is returned.
FAIL	EDMA_ERR_BUSY is returned.

Example

```
/* Setup color space transform RGB565 to YCbCr422 */
EDMA_SetupCST(g_VdmaCh, eDRVEDMA_RGB565, eDRVEDMA_YCbCr422);
```

EDMA_ClearCST

Synopsis

int EDMA_ClearCST(int channel)

Description

This function is used to disable EDMA channel color space transform.

Parameter

channel	EDMA channel number

Return Value

SUCCESS 0 is returned.

Example

```
/* Disable EDMA color space transform */
EDMA_ClearCST (g_VdmaCh);
```

EDMA_Trigger

Synopsis

void EDMA_Trigger(int channel)

Description

This function is used to start EDMA channel transfer.

Parameter

channel EDMA channel number

Return Value

None.

Example

```
/* Trigger EDMA channel transfer */
EDMA_Trigger (g_VdmaCh);
```

EDMA_TriggerDone

Synopsis

void EDMA_TriggerDone(int channel)

Description

This function is used to set the variable of EDMA channel transfer done.

Parameter

channel EDMA channel number

Return Value

None

Example

```
EDMA_TriggerDone (g_VdmaCh);
```

EDMA_IsBusy

Synopsis

int EDMA_IsBusy(int channel)

Description

This function is used to query EDMA channel is busy or not.

Parameter

channel	EDMA channel number

Return Value

TRUE	EDMA channel is busy.
FALSE	EDMA channel is ready.

Example

```
EDMA_IsBusy (g_VdmaCh);
```

EDMA_SetAPB

Synopsis

int EDMA_SetAPB(int channel, E_DRVEDMA_APB_DEVICE eDevice, E_DRVEDMA_APB_RW eRWAPB, E_DRVEDMA_TRANSFER_WIDTH eTransferWidth)

Description

This function is used to setup EDMA channel for APB device.

Parameter

channel	EDMA channel number
eDevice	Specify the APB device which will use the EDMA channel
eRWAPB	Indicate that read or write APB device
eTransferWidth	Set the transfer width for specified channel

Return Value

SUCCESS	0 is returned.
FAIL	EDMA_ERR_BUSY is returned.

Example

```
/* Setup ADC use EDMA channel*/
EDMA_SetAPB (g_PdmaCh, eDRVEDMA_ADC, eDRVEDMA_READ_APB,
eDRVEDMA_WIDTH_32BITS);
```

21.3.1.2 EDMA_SetWrapINTType

Synopsis

int EDMA_SetWrapINTType(int channel, int type)

Description

Set the EDMA wrap around interrupt select for specified channel.

Parameter

channel	EDMA channel number
type	Set the wrap around mode for specified channel

Return Value

SUCCESS	0 is returned.
FAIL	EDMA_ERR_BUSY is returned.

Example

```
/* Set wrap around mode with half and empty */
EDMA_SetWrapINTType (g_PdmaCh, eDRVEDMA_WRAPAROUND_EMPTY |
eDRVEDMA_WRAPAROUND_HALF);
```

EDMA_SetDirection

Synopsis

int EDMA_SetDirection(int channel, int src_dir, int dest_dir)

Description

This function is used to set transfer direction for specified channel.

Parameter

channel	EDMA channel number
src_dir	The source transfer direction
dest_dir	The destination transfer direction

Return Value

SUCCESS	0 is returned.
FAIL	EDMA_ERR_BUSY is returned.

Example

```
/* Set source transfer direction fixed and destination wraparound*/
EDMA_SetDirection (g_PdmaCh , eDRVEDMA_DIRECTION_FIXED,
eDRVEDMA_DIRECTION_WRAPAROUND);
```

21.4 Error Code Table

Code Name	Value	Description
EDMA_ERR_NODEV	0xFFFF0401	No device error
EDMA_ERR_INVAL	0xFFFF0402	Invalid parameter error
EDMA_ERR_BUSY	0xFFFF0403	Channel busy error

Revision History

Date	Revision	Description
2021.06.21	1.10	Revision
2018.05.02	1.00	Initially issued.

Important Notice

Nuvoton Products are neither intended nor warranted for usage in systems or equipment, any malfunction or failure of which may cause loss of human life, bodily injury or severe property damage. Such applications are deemed, "Insecure Usage".

Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

All Insecure Usage shall be made at customer's risk, and in the event that third parties lay claims to Nuvoton as a result of customer's Insecure Usage, customer shall indemnify the damages and liabilities thus incurred by Nuvoton.