

15. LCD

15.1 LCD

15.2.1 LCD

image-20220112144941418

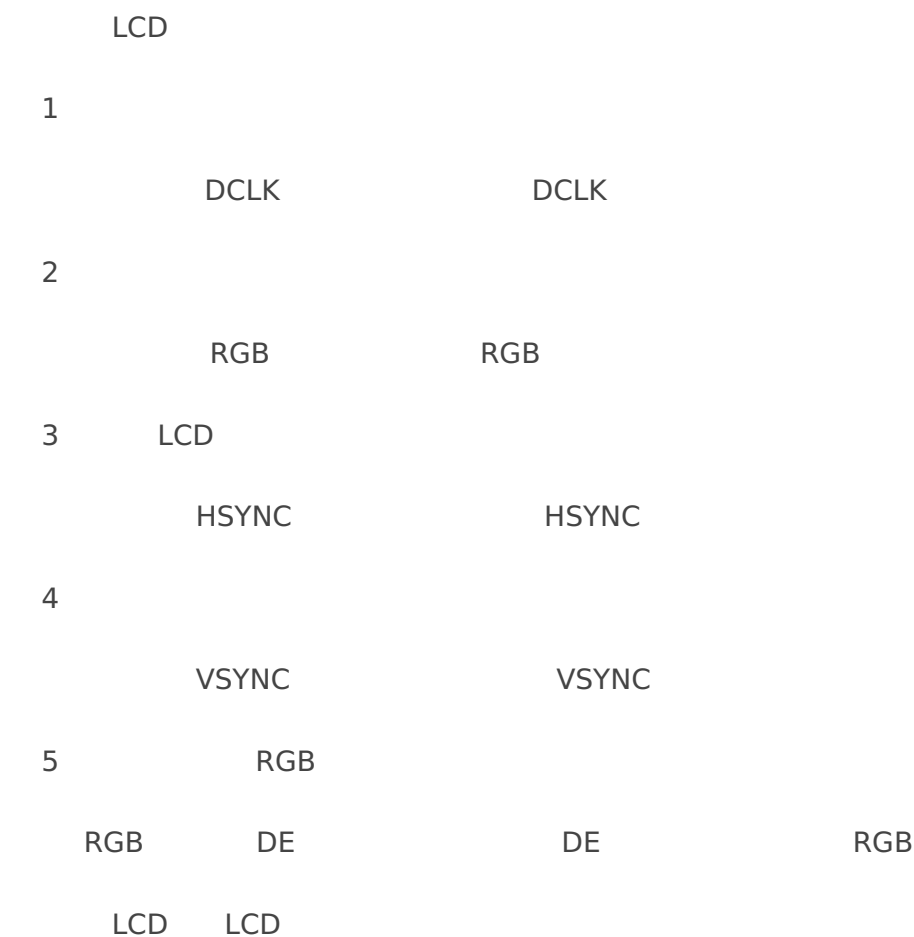


image-20220112145025755

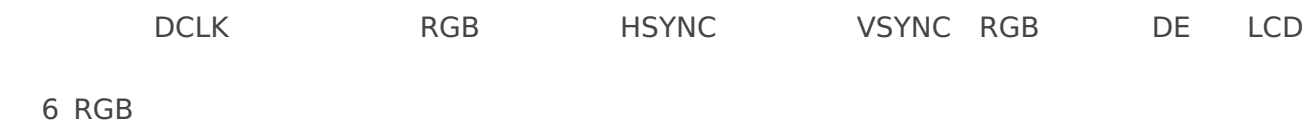


image-20220112145046895

RGB Framebuffer Framebuffer Framebuffer LC
LCD Framebuffer DCLK VSYNC HSYNC DE

15.2.2 RGB LCD

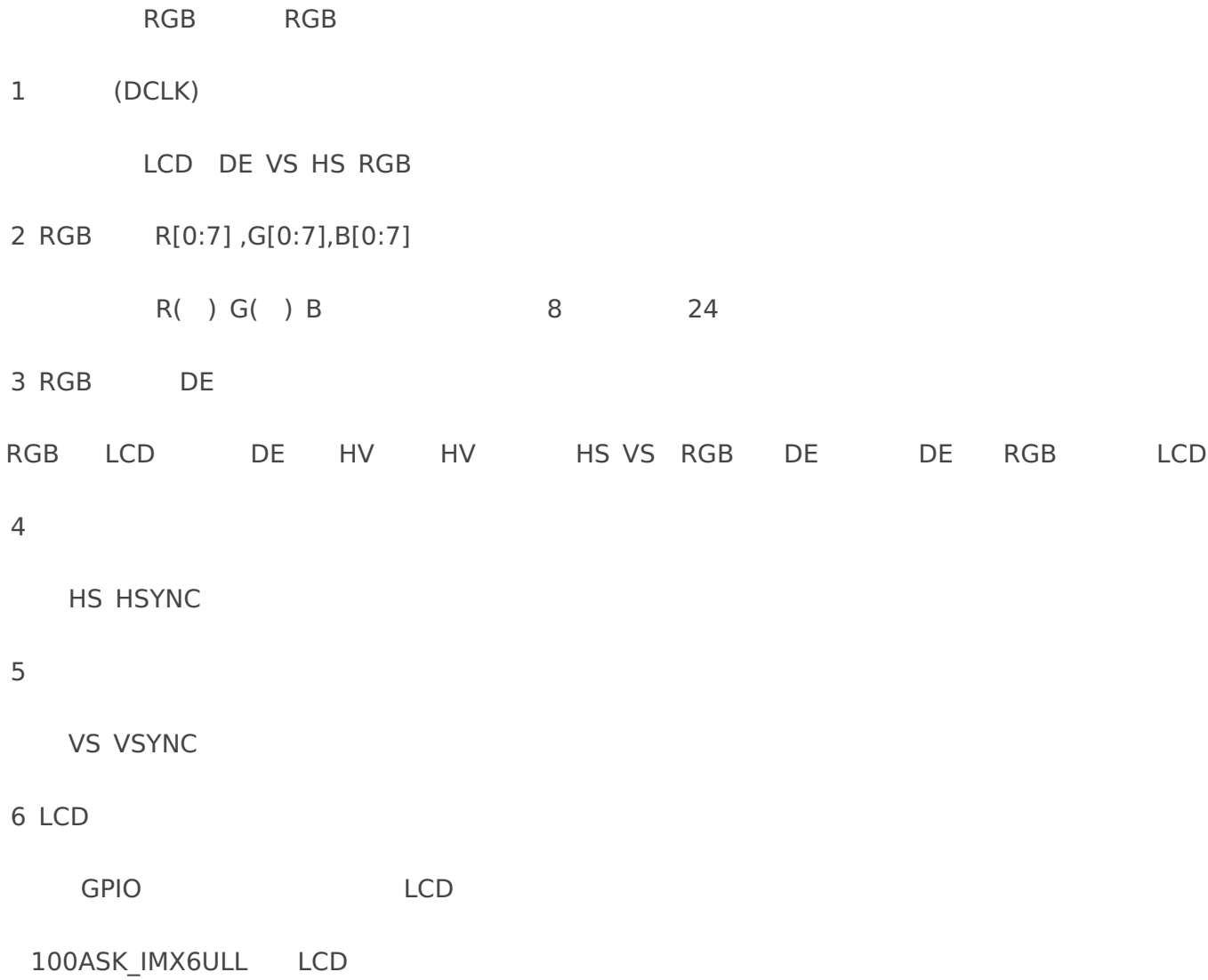


image-20220112145210913

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15.2.3 TFT (7 1024600TN-RGB)

TFT 7 1024600TN-RGB

image-20220112145308136

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15.2.4 LCD

①

100ASK_7.0 LCD

image-20220112145317135

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CLK	LCD	Dn0-Dn7
Hsync	LCD HSD	HSD
		thp thb thd thf thg

image-20220112145335485

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VSD	LCD VSD	VSD	tvpw	tvb	tv
-----	---------	-----	------	-----	----

image-20220112145341913

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RGB DEN

image-20220112145347564

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51.2Mhz

②RGB

LCD	R0-R7	G0-G7	B0-B7	3*8=24	LCD BPP
	ARGB888	ARGB555			
ARGB888	32	A	RGB	8+8+8=24BPP	
ARGB555	16	A	RGB	5+5+5=15BPP	

15.2 IMX6ULL LCD

15.2.1 LCD

IMX6ULL LCD elcdif(LCD)

- a. MPU
- b. DOTCLK RGB
- c.VSYNC
- d. 8/16/18/24/32 bit bpp IO
- e.MPU VSYNC DOTCLK

image-20220112145424746

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IMX6ULL LCD AXI RGB FIFO FIFO LCD LCD

IMX6ull Chapter 34

Enhanced LCD Interface (eLCDIF)

15.2.2 LCD

image-20220112145449271

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LCD

15.2.2.1 ①LCDIF_CTRL

image-20220112145500174

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SFTRST

BYPASS_COUNT DOTCLK DVI modes 1

DOTCLK_MODE 1 DOTCLK

LCD_DATABUS_WIDTH RGB

WORD_LENGTH RBG

MASTER LCD

DATA_FORMAT_16_BIT 16BPP

15.2.2.2 ②LCDIF_CTRL1

image-20220112145520234

Image not found or type unknown

BYTE_PACKING_FORMAT 4 RGB A()

15.2.2.3 ③LCDIF_TRANSFER_COUNT

image-20220112145543927

Image not found or type unknown

V_COUNT x

H_COUNT y

15.2.2.4 ④LCDIF_VDCTRL0

image-20220112145551594

Image not found or type unknown

VSYNC_PULSE_WIDTH

VSYNC_PULSE_WIDTH_UNIT

VSYNC_PERIOD_UNIT

ENABLE_POL DE

DOTCLK_POL

HSYNC_POL

VSYNC_POL

ENABLE_PRESENT	DOTCLK	ENABLE
----------------	--------	--------

VSYNC_OEB VSYNC

15.2.2.5 ⑤LCDIF_VDCTRL1

image-20220112145558654

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VSYNC_PERIOD

15.2.2.6 ⑥LCDIF_VDCTRL2

image-20220112145602359

Image not found or type unknown

HSYNC_PULSE_WIDTH

HSYNC_PERIOD

15.2.2.7 ⑦LCDIF_VDCTRL3

image-20220112145625980

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HRIZONTAL_WAIT_CNT

VERTICAL_WAIT_CNT

15.2.2.8 ⑧LCDIF_VDCTRL4

image-20220112145632883

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SYNC_SIGNALS_ON	DOTCLK	1
-----------------	--------	---

DOTCLK H VALID DATA CNT DOTCLK y

15.2.2.9 ⑨LCDIF_CUR_BUF

image-20220112145636601

Image not found or type unknown

ADDR LCD

15.2.2.10 ⑩LCDIF_NEXT_BUF

image-20220112145651586

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ADDR LCD

15.3 —

003 _LCD _ _P

15.3.3

LCD

LCD

15.3.4

① LCD lcd

② CPU LCD cpu

“ ”

LCD

LCD

LCD

LCD

CPU LCD

LCD

LCD

LCD

LCD

LCD “ ”

image-20220112145758887

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LCD

LCD

imx6ull_con.c

LCD

xxx_con

LCD

LCD

lcd_7_0.c

LCD

lcd_xxx.c

15.4

Git NoosProgramProject/(15_LCD /01_simple_test/lcd_manager.h)Git
NoosProgramProject/(15_LCD /01_simple_test/lcd_controller_manager.h)**

004_LC

15.4.1 LCD

lcd_manager.h

LCD

bpp

lcd_manager.h

```
enum {
    NORMAL = 0,
    INVERT = 1,
};

/* NORMAL :
 * INVERT :
 */

typedef struct pins_polarity {
    int de; /* normal: */
    int vclk; /* normal: */
    int hsync; /* normal: */
    int vsync; /* normal: */
    pins_polarity, *p_pins_polarity;

    typedef struct time_sequence {
        /*
        int tvp; /* vsync
        int tvb; /* , Vertical Back porch */
        int tvf; /* , Vertical Front porch */

        /*
        int thp; /* hsync
        int thb; /* , Horizontal Back porch */
        int thf; /* , Horizontal Front porch */

        int vclk;
        time_sequence, *p_time_sequence;
```



```

typedef struct lcd_params {

    char *name;

    /* */
    pins_polarity pins_pol;

    /* */
    time_sequence time_seq;

    /* */
    int xres;
    int yres;
    int bpp;

    /* */
    unsigned int fb_base;

    lcd_params, *p_lcd_params;

```

lcd_params

lcd

register_lcd

LCD

lcd_params

select_lcd

lcd_pa

15.4.2 LCD

lcd_controller_manager.h LCD

lcd_controller_ma

```

typedef struct lcd_controller{
    char* name;
    void (*init)(p_lcd_params plcdparams);
    void (*enable)(void);
    void (*disable)(void);
}lcd_controller, *p_lcd_controller;

```

lcd_controller

lcd

lcd_controller_manager.c
ller LCD

LCD
LCD

register_lcd_controller
lcd_controller

LCD
LCD

lcd_c

15.5 LCD

** Git NoosProgramProject/(15_LCD /01_simple_test/imx6ull_con.c)**

005

15.5.1 LCD

image-20220112145945035

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15.1.3

30

0

15.5.2 LCD

IMX6ULL

Chapter 18 Clock Controller Module (CCM)

51.2Mhz

15.5.2.1 ① PLL

image-20220112150005692

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LCD

PLL5(video pll)

image-20220112150039275

Image not found or type unknown

VIDEO pll

Video PLL output frequency(PLL5)= Fref * (DIV_SELECT +

15.5.2.2 ② PLL

image-20220112150053310

Image not found or type unknown

PLL5

PLL5_MAIN_CLK = PLL5 / POST_DIV_SELECT / VIDEO_DIV

15.5.2.3 ③PLL LCDIF

image-20220112150121312

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PLL5 LCDIF LCDIF1_CLK_ROOT = PLL5_MAIN_CLK /LCDIF1_PRED / LCDIF1_PODF
= 32 NUM = 0 DENOM = 0 POST_DIV_SELECT = 1 VIDEO_DIV = 1LCDIF1_PRED = 3 LCDIF1_PODF :

 $24 \times (32 + 0) / 1 / 1 / 3 / 5 \approx 51.2\text{Mhz}$:

15.5.3 LCD

15.5.3.1 ①

```
CCM_ANALOG->PLL_VIDEO_NUM    = 0;   
CCM_ANALOG->PLL_VIDEO_DENOM = 0;
```

15.5.3.2 ② CCM_ANALOG_PLL_VIDEO_n

image-20220112150211473

Image not found or type unknown

```
CCM_ANALOG->PLL_VIDEO = ( 2 << 19) | ( 1 << 13) | ( 32<< 0);
```

PLL5 32 1 24M PLL5 24 * 32 / 1

15.5.3.3 ③ CCM_ANALOG_MISC2_n

image-20220112150247815

Image not found or type unknown

1 PLL5 24 * 32 / 1 / 1 = 768Mhz

15.5.3.4 ④ CCM_CSCDR2

image-20220112150300024

Image not found or type unknown

3 768 / 3 = 256Mhz

```

CCM->CSCDR2 &= ~( 7 << 15);
CCM->CSCDR2 |= ( 2 << 15);
CCM->CSCDR2 &= ~( 7 << 12);
CCM->CSCDR2 |= ( 2 << 12);
CCM->CSCDR2 &= ~( 7 << 9);

```

15.5.3.5 ⑤ CCM_CBCMR

image-20220112150322222

Image not found or type unknown

```

CCM->CBCMR &= ~( 7 << 23);
CCM->CBCMR |= 4 << 23; /*[ 25: 23] : 4 : 5 */

```

5 51.2Mhz

15.5.3.6 ⑥

image-20220112150341565

Image not found or type unknown

```

/* LCD LCD */
LCDIF->CTRL = 1<<31;

/* */
delay(100);

/* */
LCDIF->CTRL = 0<<31; /* */

```

15.5.4 LCD

15.5.4.1 ① LCDIF_CTRLn

image-20220112150402916

Image not found or type unknown

```
LCDIF->CTRL |= (1 << 19) | (1 << 17) | (3 << 10) | (bpp_mode << 8) | (1 << 5) ;
```

```
/* [ 3] bpp 16      ARGB555*/  
if(plcdparams->bpp == 16)  
{  
    LCDIF->CTRL |= 1<<3;  
}
```

15.5.4.2 ② LCDIF_CTRL1n

image-20220112150501256

Image not found or type unknown

```
if(plcdparams->bpp == 24 || plcdparams->bpp == 32)  
{  
    LCDIF->CTRL1 &= ~(0xf << 16);  
    LCDIF->CTRL1 |= (0x7 << 16);  
}
```

ARGB 24 A 16bpp ARGB555

15.5.5 LCD

15.5.5.1 ① LCDIF_TRANSFER_COUNT

image-20220112150610501

Image not found or type unknown

```
```c
```

```
LCDIF->TRANSFER_COUNT = (plcdparams->yres << 16) | (plcdparams->xres << 0); ``
```

### 15.5.5.2 ② LCDIF\_VDCTRL0n

image-20220112150638122

Image not found or type unknown

```

LCDIF->VDCTRL0 = (1 << 28) | (plcdparams->pins_pol. vsync << 27)
[18:17] (plcdparams->pins_pol. hsync << 26)
[16:15] (plcdparams->pins_pol. vclk << 25)
[14:13] (plcdparams->pins_pol. de << 24)
[12:11] (1 << 21) | (1 << 20) | (plcdparams->time_seq. tvp << 0);

```

### 15.5.5.3 ③ LCDIF\_VDCTRL1

image-20220112150655412

Image not found or type unknown

```

LCDIF->VDCTRL1 = plcdparams->time_seq. tvb + plcdparams->time_seq. tvp + plcdparams->yres +
plcdparams->time_seq. tvf;

```

: tvb+ tvp+ yres+ tvf

### 15.5.5.4 ④ LCDIF\_VDCTRL2

image-20220112150744101

Image not found or type unknown

```

LCDIF->VDCTRL2 = (plcdparams->time_seq. thp << 18) | (plcdparams->time_seq. thb + plcdparams-
>time_seq. thp + plcdparams->xres + plcdparams->time_seq. thf);

```

[18:31]:

[17: 0]:

: thb+ thp+ xres+ thf

### 15.5.5.5 ⑤ LCDIF\_VDCTRL3

image-20220112150809660

Image not found or type unknown

```

LCDIF->VDCTRL3 = ((plcdparams->time_seq. thb + plcdparams->time_seq. thp) << 16) | (plcdparams-
>time_seq. tvb + plcdparams->time_seq. tvp);

```

ELCDIF VDCTRL3

[27:16]                   =thb + thp

[15:0] :                   = tvb + tvp

## 15.5.5.6 ⑥ LCDIF\_VDCTRL4

image-20220112150833971

Image not found or type unknown

```
LCDIF->VDCTRL4 = (1<<18) | (plcdparams->xres);
```

ELCDIF VDCTRL4

[18] : VSHYNC HSYNC DOTCLK      1

17:0:

## 15.5.6

image-20220112150949262

Image not found or type unknown

```
LCDIF->CUR_BUF = plcdparams->fb_base;
LCDIF->NEXT_BUF = plcdparams->fb_base;
```

CUR\_BUF :

NEXT\_BUF :

## 15.5.7 \_LCD

\*\* Git   NoosProgramProject/(15\_LCD /01\_simple\_test/lcd\_7\_0.c)\*\*

006 \_LC

## 15.5.8 LCD

```
.name = "lcd_7.0",
```

LCD

LCD

## 15.5.9

LCDIF\_VDCTRL0n

image-20220112151048189

Image not found or type unknown

VSYNC\_POL HSYNC\_POL 0 1

DOTCLK\_POL 0 1

ENABLE\_POL 0 1

15 1.4

DCLK

HSD

VSD

DEN

```
enum {
 [NORMAL = 0,
 [INVERT = 1,
};
```

```
.pins_pol = {
 [de = INVERT, /* normal: */
 [vclk = INVERT, /* normal: */
 [hsync = NORMAL, /* normal: */
 [vsync = NORMAL, /* normal: */
},
```

## 15.5.10

image-20220112151141164

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lcd\_7\_0.c lcd\_7\_0\_params

1 Thpw tvb = 20



2 Thb      thb = 140

3 Thfp      thf = 160

4 THA      tvp = 1024

5 Tvpw      tvp = 3

6 Tvb      thp = 20

7 Tvfp      tvf = 12

8 Tvd      yres = 600

```
.time_seq = {
 /* */
 tvp=13, /* vsync */
 tvb=20, /* , Vertical Back porch */
 tvf=12, /* , Vertical Front porch */

 /* */
 thp=20, /* hsync */
 thb=140, /* , Horizontal Back porch */
 thf=160, /* , Horizontal Front porch */

 vclk=51.2, /* MHz */
},
.xres = 1024,
.yres = 600
```

## 15.5.11

image-20220112151220548

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imx_6ull	2GB	100ask_imx_6ull	512M	0x80000000~0xaC
xa0000000	6004=2467400≈2.4MB			
0x81000000~0xa0000000	2.4MB			

0x99000000

# 15.6 \_

LCD

\*\* Git NoosProgramProject/(15\_LCD /01\_simple\_test)\*\*

007 \_LCD \_

## 15.6.1 LCD

```
/* LCD */
lcd_7_0_add();
/* LCD */
lcd_controller_add();
```

lcd\_manager.c lcd\_controller\_manager.c LCD LCD

```
/* Imx6ull LCD */
select_lcd_controller("Imx6ull");
/* LCD */
select_lcd("lcd_7.0");
```

lcd\_manager.c lcd\_controller\_manager.c LCD LCD

```
lcd_controller_init(g_p_lcd_selected);
```

lcd\_controller\_init LCD LCD

## 15.6.2 LCD

g\_p\_lcd\_controller\_selected LCD

```
void lcd_controller_enable(void)
{
 if (g_p_lcd_controller_selected)
 {
 g_p_lcd_controller_selected->enable();
 }
}
```



g\_p\_lcd\_controller\_selected      LCD      LCD      lcd\_controller\_enable

```
static void Imx6ull_lcd_controller_enable(void)
{
 LCDIF->CTRL |= 1<<0; /* 6ULL LCD */
}
```

imx6ull LCD      g\_p\_lcd\_controller\_selected->enable()      Imx6ull\_lcd\_controller\_ena

## 15.6.3 LCD

lcd

```
void get_lcd_params(unsigned int *fb_base, int *xres, int *yres, int *bpp)
{
 *fb_base = g_p_lcd_selected->fb_base;
 *xres = g_p_lcd_selected->xres;
 *yres = g_p_lcd_selected->yres;
 *bpp = g_p_lcd_selected->bpp;
}
```

fb\_base      xres yres      bpp

## 15.6.4 framebuffer

16bpp 32bpp      framebuffer

```
*p = (unsigned short *)fb_base;
for (x = 0; x < xres; x++)
 for (y = 0; y < yres; y++)
 *p++ = 0x7c00;

/* green */
*p = (unsigned short *)fb_base;
for (x = 0; x < xres; x++)
 for (y = 0; y < yres; y++)
 *p++ = 0x3E0;
```

```

// *blue*/
p = (unsigned short *)fb_base;
for (x = 0; x < xres; x++)
 for (y = 0; y < yres; y++)
 *p++ = 0x1f;

```

lcd bpp 16

bpp 16    lcd            ARGB555    ARRRRRGGGGGBBBBB    5

```

p2 = (unsigned int *)fb_base;
for (x = 0; x < xres; x++)
 for (y = 0; y < yres; y++)
 *p2++ = 0xff0000;

```

```

// *green*/
p2 = (unsigned int *)fb_base;
for (x = 0; x < xres; x++)
 for (y = 0; y < yres; y++)
 *p2++ = 0x00ff00;

```

```

// *blue*/
p2 = (unsigned int *)fb_base;
for (x = 0; x < xres; x++)
 for (y = 0; y < yres; y++)
 *p2++ = 0x0000ff;

```

lcd bpp 32            bpp 32    lcd            ARGB888    AAAAAAARRRRRRRRRGGGGGGGGBE

# 15.7

\*\* Git    NoosProgramProject/(15\_LCD   /02\_dot\_line\_circle)\*\*

008 \_LCD \_

## 15.7.1

①    (x y) FB

image-20220112151751170

Image not found or type unknown

```
(x y) =fb_base+(bpp/8
```

② frambuffer.c frambuffer.c LCD

```
void fb_get_lcd_params(void)
{
 get_lcd_params(&fb_base, &xres, &yres, &bpp);
}
```

③ LCD          bpp 32                          bpp 16                          32                          16                          16bpp

```
int r = (rgb >> 16)& 0xff;
int g = (rgb >> 8) & 0xff;
int b = rgb & 0xff;

/* argb555 */
r = r >> 3;
g = g >> 3;
b = b >> 3;
return ((r<<10) | (g<<5) | (b));
```

④          x    y                          16PP                          16 (2 )                          unsigned short                          32PP

```
void fb_put_pixel(int x, int y, unsigned int color)
{
 unsigned short *pw; /* 16bpp */
 unsigned int *pdw; /* 32bpp */

 unsigned int pixel_base = fb_base + (xres * bpp / 8) * y + x * bpp / 8;

 switch (bpp)
 {
 case 16:
 pw = (unsigned short *) pixel_base;
 *pw = convert32bppto16bpp(color);
 break;
 case 32:
```

```

 *pdw = (unsigned int *) pixel_base;
 *pdw = color;
 break;
}
}

```

## 15.7.2

“C LCD ”

<http://blog.csdn.net/p1126500468/article/det>

geometry.c

```

fb_get_lcd_params();

delay(100000);

draw_line(0, 0, xres - 1, 0, 0xff0000);
delay(100000);
draw_line(xres - 1, 0, xres - 1, yres - 1, 0xffff00);
delay(100000);
draw_line(0, yres - 1, xres - 1, yres - 1, 0xff00aa);
delay(100000);
draw_line(0, 0, 0, yres - 1, 0xff00ef);
delay(100000);
draw_line(0, 0, xres - 1, yres - 1, 0xff4500);
delay(100000);
draw_line(xres - 1, 0, 0, yres - 1, 0xff0780);

```

## 15.7.3

“C LCD ”

<http://blog.csdn.net/p1126500468/article/det>

geometry.c

image-20220112151929285

Image not found or type unknown

```
draw_circle(xres/2, yres/2, yres/4, 0xff00);
```

## 15.8

\*\* Git NoosProgramProject/(15\_LCD /03\_font\_test)\*\*

009\_LCD \_ \_

### 15.8.1 LCD

font.c LCD LCD LCD

```
void font_init(void)
{
 get_lcd_params(&fb_base, &xres, &yres, &bpp);
}
```

### 15.8.2

Linux "font" font\_8x16.c A

```
/* 65 0x41 'A' */
0x00, /* 00000000 */
0x00, /* 00000000 */
0x10, /* 00010000 */
0x38, /* 00111000 */
0x6c, /* 01101100 */
0xc6, /* 11000110 */
0xc6, /* 11000110 */
0xfe, /* 11111110 */
0xc6, /* 11000110 */
0xc6, /* 11000110 */
0xc6, /* 11000110 */
0xc6, /* 11000110 */
0x00, /* 00000000 */
0x00, /* 00000000 */
0x00, /* 00000000 */
```

```
0x00, /* 00000000 */
```

8\*16      1      0      "A"      LCD

a.      ascii   fontdata\_8x16

b.

c.

```
void fb_print_char(int x, int y, char c, unsigned int color)
{
 int i, j;

 /* c ascii fontdata_8x16 */
 const unsigned char *dots = &fontdata_8x16[c * 16];

 unsigned char data;
 int bit;

 /* */
 for (j = y; j < y+16; j++)
 {
 data = *dots++;
 bit = 7;
 for (i = x; i < x+8; i++)

 /* */
 if (data & (1<<bit))
 fb_put_pixel(i, j, color);
 bit--;
 }
 }
```

font\_8x16.c      16      ascii      16

1      fb\_put\_pixel()      16

## 15.8.3



x 8

xres

y+16

```
void fb_print_string(int x, int y, char* str, unsigned int color)
{
 int i = 0, j;

 while (str[i])
 {
 if (str[i] == '\n')
 y = y+16;
 else if (str[i] == '\r')
 x = 0;

 else
 {
 fb_print_char(x, y, str[i], color);
 x = x+8;
 if (x >= xres) /* */
 {
 x = 0;
 y = y+16;
 }
 }
 i++;
 }
}
```

```
fb_print_string(10, 10, "www.100ask.net\n\r100ask.taobao.com", 0xff00);
```

## 15.8.4 4-1.4

**Git** NoosProgramProject/(15\_LCD /03\_font\_test)

## 15.8.5 3-1.4

RGB

