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Application Note FAN4217

10.4" Bar Shaped TFT LCD

This application note will review the setup and features of Focus LCDs' 10.4-inch TFT.





10.4-inch Bar Shaped TFT LCD

This display is unique because it is in the shape of a thin bar. This means that most of the pixels are distributed in the horizontal direction. The applications for this display are largely focused on the unique resolution and aspect ratio of this display. This note will highlight the features, review the required hardware connections, and cover the necessary software commands to setup this display.



This TFT has a 10.4" diagonal with a resolution of 1024 x 100-pixels. The connection interface of this display is a 24-bit RGB parallel FPC cable connection. This display has a low input voltage of 3.3 V and an anti-glare polarizer. Additional features are described in the following table:

Feature	Specification	Unit
Focus LCDs Part Number	<u>E104RB-FW450-N</u>	
Size	10.4	inch
Display type	TFT Active Matrix	
Display Area	264.192 x 35.8	mm
Resolution	1024 x 100	pixels
Pixel Arrangement	RGB Vertical Stripe	
TFT Controller	HX8678C	
Display Mode	Transmissive, Normally White	
Polarizer	Anti-Glare	

For more information on the technical specifications of this display, please visit <u>www.FocusLCDs.com</u>.



Hardware Connection

This display offers a full range of 24-bit RGB color and is capable of displaying up to 16.7 million unique variations of red, green, and blue color data. The setup for this display requires an external graphics controller to time the signals of the RGB video interface. The pins of the FPC cable are described in the table below.

NO.	PIN	Description	I/O
1-2	VDD	Input power supply for digital interface (3.3V)	Р
3	VSS	Supply power Ground	Р
4-11	B0-B7	RGB interface 8-bit blue data pins	I/O
12	VSS	Ground	Р
13-20	G0-G7	RGB interface 8-bit green data pins	I/O
21	VSS	Ground	Р
22-29	R0-R7	RGB interface 8-bit red data pins	I/O
30	VSS	Ground	Р
31	DCLK	Dot/Pixel clock signal of the RGB interface	I
32	VSS	Ground	Р
33	HSYNC	Horizontal synchronization signal used to frame RGB data in the the horizontal direction. The sync occurs for every line in the horizontal direction.	I
34	VSS	Ground	Р
35	VSYNC	Vertical synchronization signal used to frame the RGB data in the vertical direction. Sync occurs once every full frame of data.	I
36	VSS	Ground	Р
37	DE	Data enable signal of the RGB interface. Active high for the valid data.	I
38	ורסע	Cathada ains of the backlight LEDs	
39			F
40		Anodo pipe of the headlight LEDe	
41	LEDA	Anode pins of the backlight LEDS	P

I: Input, O: Output, P: Power

The graphics controller used in this application note is specifically designed to manage RGB display timings. This makes processing the display data much easier to manage. The controller used in this application is SSD1963. This controller functions as a signal clock generator, a signal controller, and SRAM for display data. The display controller has 1,215kB of internal SRAM for the RGB pixel data available.







SSD1963 Block Diagram

The microcontroller used in this application is a 32-bit ARM core processor which is available on the Arduino Due development board. This development board was chosen for the availability of the digital I/O pins that are required for the 16-bit 8080 parallel interface of the graphics controller. This processor is capable of interfacing the 8080 parallel graphics cards but is not suitable for controlling the display timing and signals alone.





The connection between the display <u>E104RB-FW450-N</u> and the SSD1963 graphics controller is described in the table below. Each pin of the display corresponds to a dedicated pin on the graphics controller.

NO.	SSD1963	E104RB-FW450-N	I/O
1-2	3.3V	VDD	Р
3	GND	VSS	Р
4	DBO	BO	I/O
5	DB1	B1	I/O
6	DB2	B2	I/O
7	DB3	B3	I/O
8	DB4	B4	I/O
9	DB5	B5	I/O
10	DB6	B6	I/O
11	DB7	B7	I/O
12	GND	VSS	Р
13	DB8	G0	I/O
14	DB9	G1	I/O
15	DB10	G2	I/O
16	DB11	G3	I/O
17	DB12	G4	I/O
18	DB13	G5	I/O
19	DB14	G6	I/O
20	DB15	G7	I/O
21	GND	VSS	Р
22	DB16	RO	I/O
23	DB17	R1	I/O
24	DB18	R2	I/O
25	DB19	R3	I/O
26	DB20	R4	I/O
27	DB21	R5	I/O
28	DB22	R6	I/O
29	DB23	R7	I/O
30	GND	VSS	Р
31	LSHIFT	DCLK	I
32	GND	VSS	Р
33	LLINE	HSYNC	I
34	GND	VSS	Р
35	LFRAME	VSYNC	I
36	GND	VSS	Р
37	LDEN	DE	I
38-39	External bkl supply voltage	LEDK	Р
40-41	External bkl supply ground	LEDA	Р

I: Input, O: Output, P: Power



The data pins for the RGB interface must be connected to the correct 24-bit digital output pins as described in the table above. The order of the RGB pins is set to be used for the RGB-888 interface where each red, green, and blue pixels contain 8-bits of color data. The pixel data format can be changed in the configuration settings of the graphics controller.

Different pixel data formats require different pin mappings of the 24-bit RGB data. These pin connections must be consistent between the display and the graphics controller. This should be verified in the datasheet of the controller and the display.

Interface	Cycle	D[23]	D[22]	D[21]	D[20]	D[19]	D[18]	D[17	D[16]	D[15]	D[14]	D[13]	D[12]	D[11]	D[10]	D[9]	D[8]	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
24 bits	1 st	R7	R6	R5	R4	R3	R2	R1	R0	G7	G6	G5	G4	G3	G2	G1	G0	B7	B6	B5	B4	B3	B2	B1	B0
18 bits	1 st							R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B 3	B2	B1	B0
16 bits (565 format)	1 st									R5	R4	R3	R2	R1	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1
	1 st									R7	R6	R5	R4	R3	R2	R1	R0	G7	G6	G5	G4	G3	G2	G1	G0
16 bits	2 nd									B7	B6	B5	B4	B3	B2	B1	B0	R7	R6	R5	R4	R3	R2	R1	R0
	3 rd									G7	G6	G5	G4	G3	G2	G1	G0	B7	B6	B5	B4	B3	B2	B1	B0
12 bits	1 st													R7	R6	R5	R4	R3	R2	R1	R0	G7	G6	G5	G4
	2 nd													G3	G2	G1	G0	B7	B6	B5	B4	B3	B2	B1	B0
0 bite	1 st																R5	R4	R3	R2	R1	R0	G5	G4	G3
9 Dits	2 nd																G2	G1	G0	B5	B4	B3	B2	B1	B0
8 bits	1 st																	R7	R6	R5	R4	R3	R2	R1	R0
	2 nd																	G7	G6	G5	G4	G3	G2	G1	G0
	3 rd																	B7	B6	B5	B4	B3	B2	B1	B0

Pixel Data Format

The MCU is connected to the graphics controller to indicate the desired RGB signal timings, clock PLL settings and display configurations. This is done through the 16-bit parallel 8080 interface through 20 interface pins.

This interface is used to send initialization commands to the display control registers. The power of these pins is supplied by the 3.3V on the Arduino Due and is also the supply for the display's digital logic voltage and ground.

A wide variety of microcontrollers can be used for this application because a majority of the processing and data storage is left to the graphics controller. The minimal 8-bit commands to initialize the graphics controller can be done with minimal functions provided by the microcontroller. This is a good option for applications where the microcontroller has many peripheral functions and GPU is limited.

The pixel clock that is required for the RGB interface is generated by an internal phase locked loop by the graphic controller. This clock generation is done through software commands during the initialization sequence.

The Arduino Due and the graphics controller are connected by the following interface and power pins. The interface used is a 16-bit 8080 parallel connection, operating at 3.3V. These pins are the minimum requirements for interfacing the GFX card with the microcontroller. The GFX chip offers additional features such as tearing and backlight control.



Signal	Description	MCU	Graphics Controller	I/O
VDD	Digital Power Supply (3.3V)	3.3V	VDD	Р
IOVCC	Power supply for I/O pins (3.3V)	3.3V	VDDIO	Р
GND	Ground	GND	GND	Р
DBO	Data pin 0	D37	D0	I/O
DB1	Data pin 1	D36	D1	I/O
DB2	Data pin 2	D35	D2	I/O
DB3	Data pin 3	D34	D3	I/O
DB4	Data pin 4	D33	D4	I/O
DB5	Data pin 5	D32	D5	I/O
DB6	Data pin 6	D31	D6	I/O
DB7	Data pin 7	D30	D7	I/O
DB8	Data pin 8	D22	D8	I/O
DB9	Data pin 9	D23	D9	I/O
DB10	Data pin 10	D24	D10	I/O
DB11	Data pin 11	D25	D11	I/O
DB12	Data pin 12	D26	D12	I/O
DB13	Data pin 13	D27	D13	I/O
DB14	Data pin 14	D28	D14	I/O
DB15	Data pin 15	D29	D15	I/O
RS	Register select signal (D/C, A0)	D52	D/C	I
WR	Write signal	D53	R/W (WR)	I
RD	Read signal	D51	E (RD)	I
CS	Chip select signal	D50	CS	Ι
RESET	Reset signal	D48	RESET	Ι

For this application, the backlight features of the GFX card are not used and the backlight of the display is powered externally from the logic devices. The backlight should be powered by a constant current source which can be implemented by a variety of backlight LED driver chips.

The connection between the GFX chip and the microcontroller is described in the diagram below. These connections represent the minimum digital interface pin requirements to interface and initialize the GFX card for the display.





The graphics controller offers optional interfaces that can be used to interface with the microcontroller. The interface used in this application is the 8080 parallel interface. The other option is to use the 6800 parallel interface. The interface pins have multiple functions that are named according to which interface is being used. Below is a review of the interface pin names for the 8080 and 6800 interfaces.

Interface	Pin	Description	I/O	Alt. Names				
8080	WR							
6800	W/R	/R Write/Read Input/Output						
8080	RS	Register Select	Input	40				
6800	D/C	AU						
8080	RD	Read	Output					
6800	E	Input						
8080	<u> </u>	Chin solast	Input					
6800			input					

Software Initialization

The display in this application does not require SPI initialization. The only device that needs to be initialized is the graphics controller to set the parameters that control the signals to the display. After the graphics controller is initialized, the microcontroller can store display data off chip and in the SRAM provided by the GFX chip.

The graphics controller should be initialized with the following parameters. These commands and values set the resolution, the interface, and the color depth of the display. The color used in this example is the RGB 888 format which is integrated into the hardware and software selection.

The first set of commands to initialize the graphics controller are to setup and enable the clock used for the RGB interface. This is determined by the oscillator crystal on the microcontroller and the resolution





of the display. The oscillator from the microcontroller is input into the graphics controllers PLL which can boost the clock to the desired frequency.

The command to set the PLL and enable the clock is reviewed below.

```
write_command(0xE2); //PLL multiplier, set PLL clock to 120M
write_data(0x1E); //N=0x36 for 6.5M, 0x23 for 10M crystal
write_data(0x54);
write_data(0x54); // PLL enable
write_data(0x01);
delay(10);
write_data(0xE6);
write_data(0xF5);
write_data(0xF5);
```

The other aspect to define is the LCD resolution and pixel format. This is set by the following:

<pre>write_command(0xB0); write_data(0x24); write_data(0x00); write_data(0x03); write_data(0xFF); write_data(0x00); write_data(0x63); write_data(0x00); write_data(0x00);</pre>	//24-bit //1024 pixels horizontal //100 pixels vertical
<pre>write_command(0xB4); write_data(0x04); write_data(0x09); write_data(0x00); write_data(0x00); write_data(0x0a); write_data(0x00); write_data(0x00); write_data(0x00);</pre>	<pre>// Horizontal timings //Horizontal Total //Horizontal back porch //Horizontal Pulse width //Horizontal front porch</pre>
<pre>write_command(0xB4); write_data(0x04); write_data(0x09); write_data(0x00); write_data(0x00); write_data(0x00); write_data(0x00); write_data(0x00); write_data(0x00);</pre>	<pre>// Vertical timings //Vertical Total //Vertical back porch //Vertical pulse width //Vertical front porch</pre>





The last section to initialize are the GPIO pins, the rotation of the display, the pixel interface and the column and page addresses.

```
write_command(0xBA);
                              // GPIO output
write_data(0x0F);
write command(0xB8);
write_data(0x0F);
write_data(0x01);
write_command(0x36);
                              // MADCTL
write_data(0x01);
write command(0xF0);
                              // 888 pixel data
write_data(0x03);
write_command(0x2A);
                              // Column address set
write data(0x00);
write_data(0x00);
write_data(0x03);
write_data(0xff);
write command(0x2B);
                              // Page address set
write_data(0x00);
write_data(0x00);
write data(0x00);
write_data(0x63);
write_command(0x29);
                             // Display on
```

This display can be used for a variety of applications that pertain to the unique bar shape of the TFT. The high resolution of 1024x100 pixels provides quality graphics for any display image. The RGB 24-bit interface provides the speed for high level graphics that can support a number of display applications.







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