Waveshare Dust Sensor

Waveshare Dust Sensor Detector Module User Manual

Model: Dust Sensor

1. Introduction

This manual provides detailed instructions for the Waveshare Dust Sensor Detector Module, featuring the Sharp GP2Y1010AU0F sensor. This module is designed for accurate detection of fine particles, including those found in cigarette smoke, with a diameter larger than 0.8µm. It outputs an analog voltage directly proportional to the dust density, making it an essential component for various air quality monitoring and control systems.

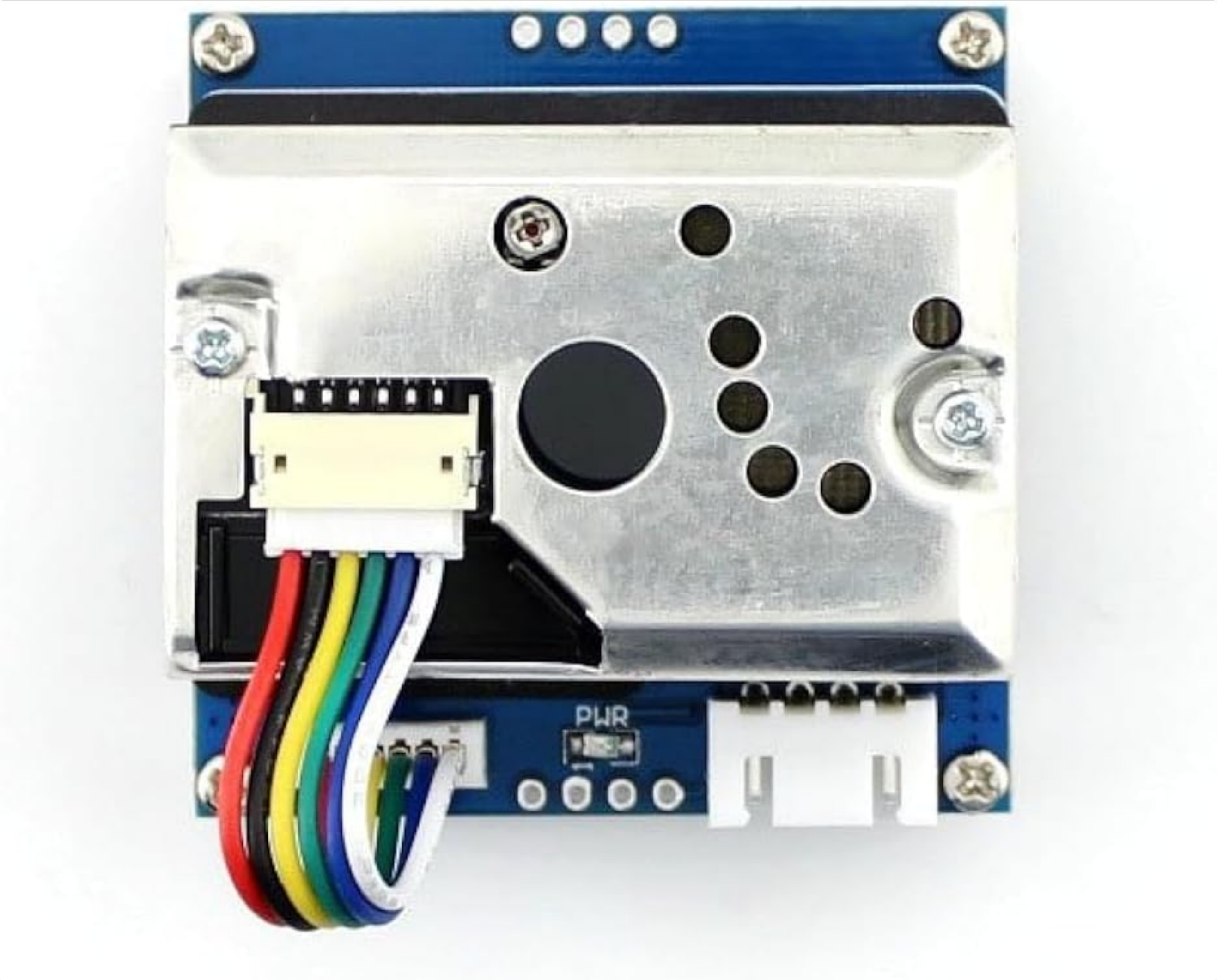


Figure 1: Waveshare Dust Sensor Detector Module.

2. Key Features

- **Sharp GP2Y1010AU0F Onboard:** Detects fine particles larger than 0.8µm in diameter, including cigarette smoke.
- **Low Power Consumption:** Efficient operation for extended use.
- **Analog Voltage Output:** Provides an output level that is linear with dust density, simplifying data interpretation.
- **Embedded Voltage Boost Circuit:** Supports a wide range of power supply inputs (2.5V to 5.5V).

3. Technical Specifications

Parameter	Value
Sensitivity	0.5V/(100µg/m³)
Measurement Range	500µg/m³
Power Supply	2.5V ~ 5.5V
Operating Current	20mA (max)

Operating Temperature	-10°C ~ 65°C
Storage Temperature	-20°C ~ 80°C
Life Time	5 years
Dimensions (L×W×H)	63.2mm × 41.3mm × 21.1mm
Mounting Hole Size	2.0mm
Air Hole Size	9.0mm

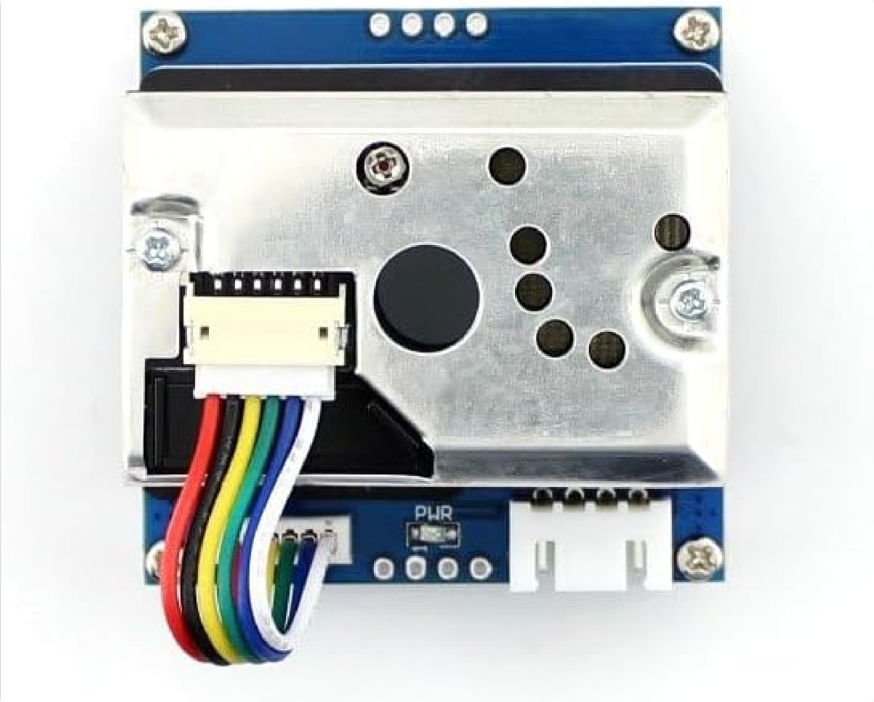


Figure 2: Overview diagram showing key specifications and connection details.

4. Package Contents

The Waveshare Dust Sensor Detector Module package typically includes:

- 1x Waveshare Dust Sensor Detector Module (with Sharp GP2Y1010AU0F)
- 1x 6-pin connection cable

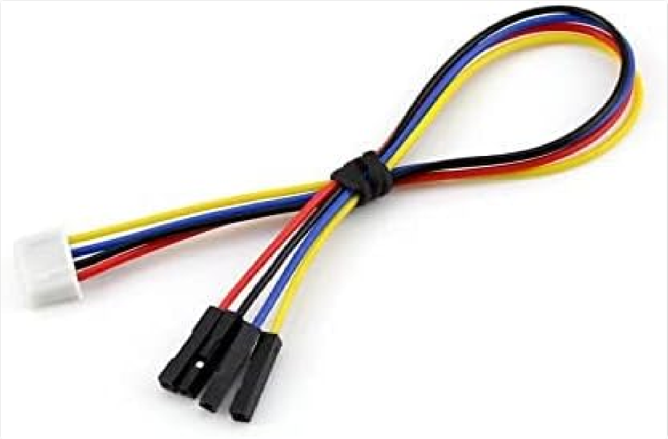
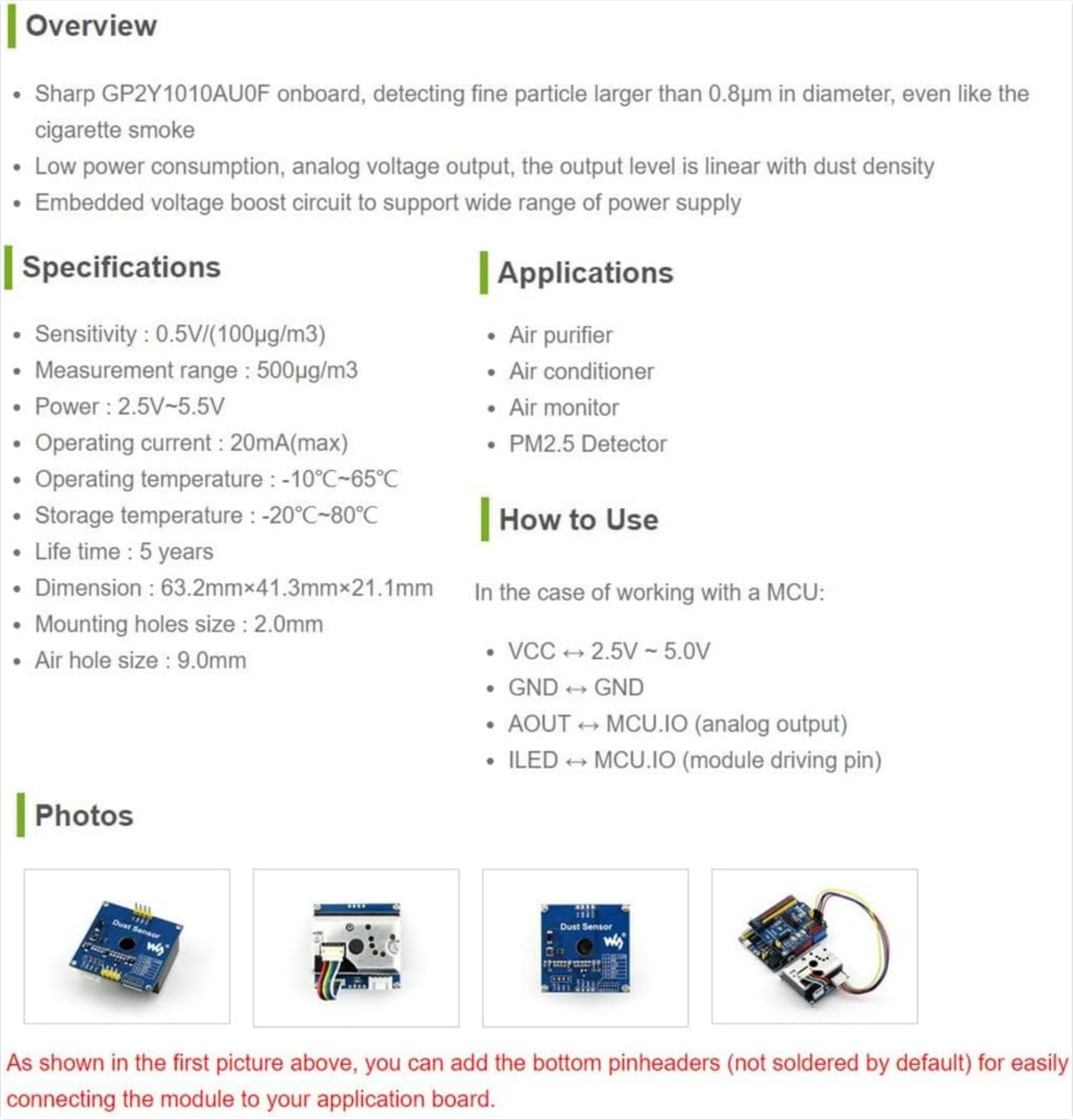


Figure 3: Included 6-pin connection cable.

5. Setup and Connection

To integrate the Waveshare Dust Sensor Detector Module with a microcontroller unit (MCU), follow these connection guidelines:

1. **VCC:** Connect to the power supply of your MCU. The module supports a voltage range of 2.5V to 5.5V. Ensure your power supply is within this range to prevent damage.
2. **GND:** Connect to the ground (GND) of your MCU.
3. **AOUT:** Connect to an analog input pin on your MCU. This pin provides the analog voltage output, which is proportional to the dust density.
4. **ILED:** Connect to a digital I/O pin on your MCU. This pin is used to drive the internal infrared LED of the sensor. Refer to the sensor's datasheet or Waveshare's documentation for specific timing requirements for pulsing this pin to take readings.



Overview

- Sharp GP2Y1010AU0F onboard, detecting fine particle larger than 0.8μm in diameter, even like the cigarette smoke
- Low power consumption, analog voltage output, the output level is linear with dust density
- Embedded voltage boost circuit to support wide range of power supply

Specifications

- Sensitivity : 0.5V/(100μg/m3)
- Measurement range : 500μg/m3
- Power : 2.5V~5.5V
- Operating current : 20mA(max)
- Operating temperature : -10℃~65℃
- Storage temperature : -20℃~80℃
- Life time : 5 years
- Dimension : 63.2mm×41.3mm×21.1mm
- Mounting holes size : 2.0mm
- Air hole size : 9.0mm

Applications

- Air purifier
- Air conditioner
- Air monitor
- PM2.5 Detector

How to Use

In the case of working with a MCU:

- VCC ↔ 2.5V ~ 5.0V
- GND ↔ GND
- AOUT ↔ MCU.IO (analog output)
- ILED ↔ MCU.IO (module driving pin)

Photos

As shown in the first picture above, you can add the bottom pinheaders (not soldered by default) for easily connecting the module to your application board.

Figure 4: Dust Sensor Module with connection cable.

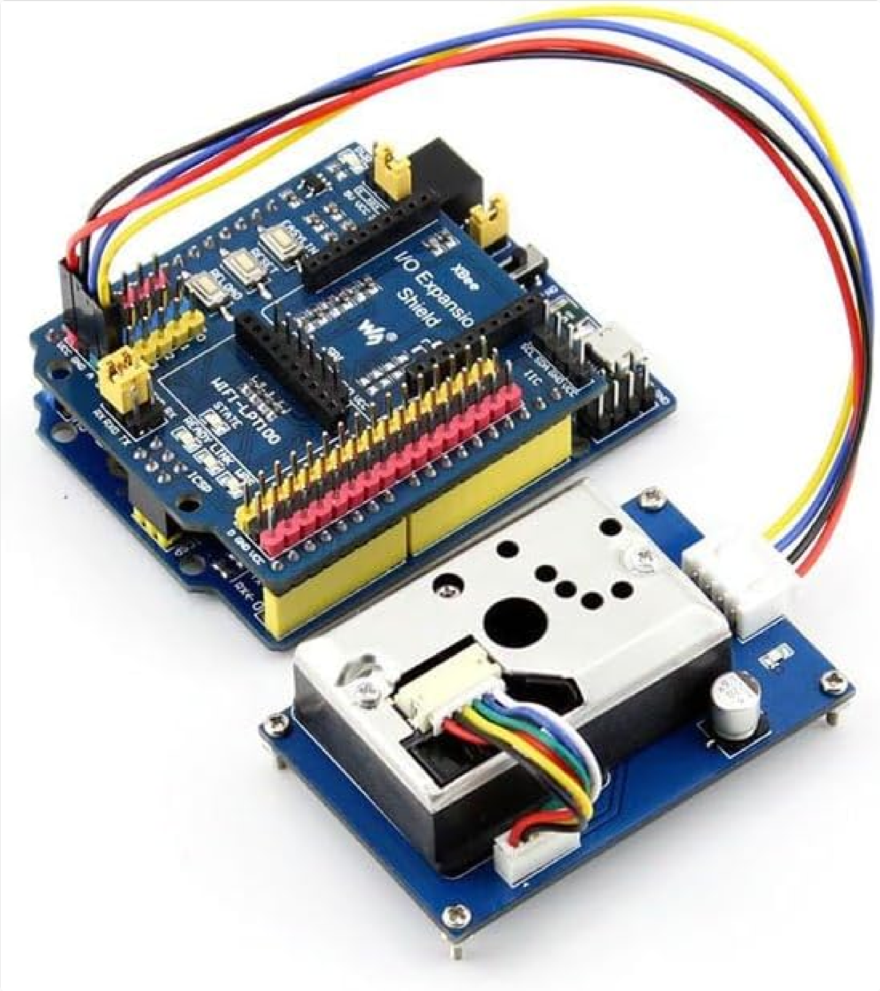


Figure 5: Example connection of the Dust Sensor Module to an Arduino expansion shield.

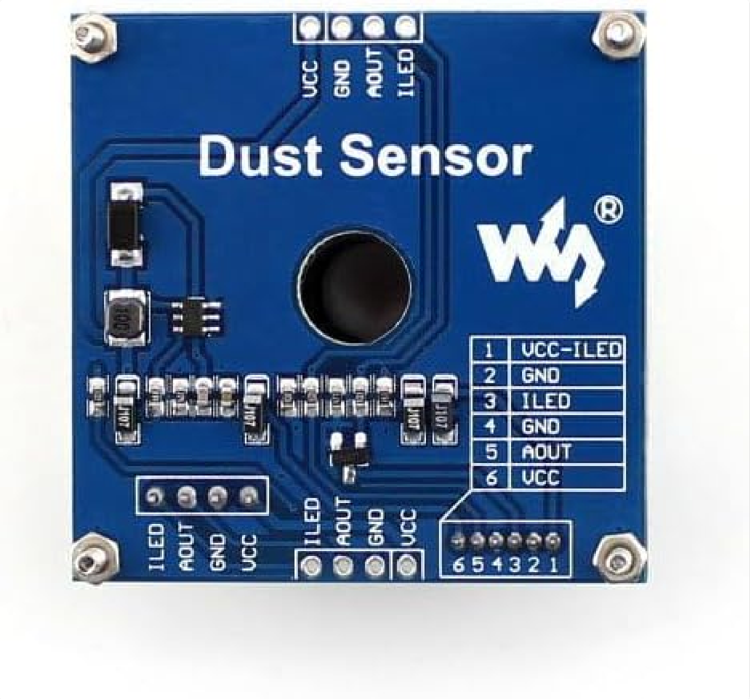


Figure 6: Pinout diagram on the bottom of the module for reference.

6. Operation Principles

The Sharp GP2Y1010AU0F sensor operates by detecting scattered light from dust particles. An infrared emitting diode (ILED) periodically pulses light into a detection area. If dust particles are present, they scatter this light, which is then detected by a phototransistor. The amount of scattered light is converted into an analog voltage output (AOUT).

The output voltage is directly proportional to the concentration of dust in the air. Higher dust concentrations result in a higher analog output voltage. To obtain accurate readings, it is crucial to pulse the ILED pin according to the sensor's specifications (e.g., a 0.32ms pulse width within a 10ms cycle, with sampling at 0.28ms into the pulse).

7. Maintenance

To ensure optimal performance and longevity of your dust sensor module, consider the following maintenance tips:

- **Keep Clean:** Periodically inspect the sensor's air intake and optical path for dust accumulation. Gently blow dust away using compressed air. Avoid using liquids or abrasive materials.
- **Avoid Physical Contact:** Do not touch the internal components of the sensor, especially the optical elements.
- **No Adjustments:** The potentiometer on the module is factory-calibrated. Do not attempt to adjust it, as this can negatively impact sensor accuracy.

8. Troubleshooting

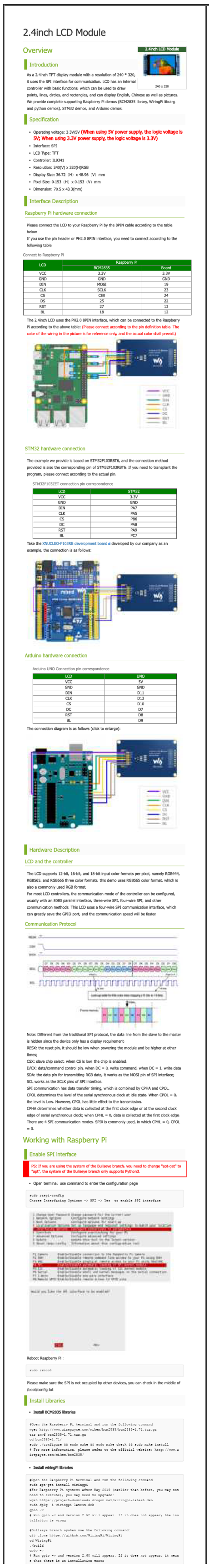
If you encounter issues with your Waveshare Dust Sensor Detector Module, refer to the following common problems and solutions:

- **No Output or Erratic Readings:**
  - Verify all connections (VCC, GND, AOUT, ILED) are secure and correctly wired to your MCU.
  - Ensure the power supply voltage is within the specified range of 2.5V to 5.5V. Supplying higher voltages can damage the module.
  - Check your microcontroller code for correct timing and analog reading procedures for the ILED and AOUT pins. Refer to Waveshare's official documentation for example code.
- **Inconsistent or Fluctuating Readings:**
  - Ensure the sensor is placed in an area with stable airflow, free from direct drafts or stagnant air pockets. Consider adding a small fan to ensure consistent air sampling if needed.
  - Environmental factors such as humidity and temperature can influence readings. Ensure the operating environment is within the specified temperature range.
- **Module Not Powering On / Damaged:**
  - Reconfirm that the input voltage does not exceed 5.5V. Overvoltage is a common cause of damage.
  - Inspect the module for any visible physical damage or loose solder joints.

9. Warranty and Support

For technical support, additional documentation, and software examples, please visit the official Waveshare website. Information regarding product warranty and return policies can typically be found on the product page where the item was purchased or on the Waveshare support portal.

Related Documents - Dust Sensor



2.4inch LCD Module

Overview

Introduction

As a 2.4inch TFT display module with a resolution of 240 * 320, it uses the SPI interface for communication. LCD has an internal controller with basic functions, which can be used to draw points, lines, circles, and rectangles, and can display English, Chinese as well as pictures. We provide complete supporting Raspberry Pi demos (BCM2835 library, WiringPi library, and python demos), STM32 demos, and Arduino demos.

Specification

- Operating voltage: 3.3V/5V (When using 5V power supply, the logic voltage is 5V; When using 3.3V power supply, the logic voltage is 3.3V)
- Interface: SPI
- LCD Type: TFT
- Controller: IL9341
- Resolution: 240(V) x 320(H)RGB
- Display Size: 36.72（H）x 48.96（V）mm
- Pixel Size: 0.153（H）x 0.153（V）mm
- Dimension: 70.5 x 43.3(mm)

Interface Description

Raspberry Pi hardware connection

Please connect the LCD to your Raspberry Pi by the 8PIN cable according to the table below
If you use the pin header or PH2.0 8PIN interface, you need to connect according to the following table

Connect to Raspberry Pi

LCD	Raspberry Pi	
	BCM2835	Board
VCC	3.3V	3.3V
GND	GND	GND
DIN	MOSI	19
CLK	SCLK	23
CS	CE0	24
DS	25	22
RST	27	13
BL	18	12

The 2.4inch LCD uses the PH2.0 8PIN interface, which can be connected to the Raspberry Pi according to the above table: (Please connect according to the pin definition table. The color of the wiring in the picture is for reference only, and the actual color shall prevail.)

STM32 hardware connection

The example we provide is based on STM32F103RBT6, and the connection method provided is also the corresponding pin of STM32F103RBT6. If you need to transplant the program, please connect according to the actual pin.

STM32F103ZET connection pin correspondence

LCD	STM32
VCC	3.3V
GND	GND
DIN	PA7
CLK	PA5
CS	PB6
DC	PA8
RST	PA9
BL	PC7

Take the XNUCLEO-F103RB development board developed by our company as an example, the connection is as follows:

Arduino hardware connection

Arduino UNO Connection pin correspondence

LCD	UNO
VCC	5V
GND	GND
DIN	D11
CLK	D13
CS	D10
DC	D7
RST	D8
BL	D9

The connection diagram is as follows (click to enlarge):

Hardware Description

LCD and the controller

The LCD supports 12-bit, 16-bit, and 18-bit input color formats per pixel, namely RGB444, RGB565, and RGB666 three color formats, this demo uses RGB565 color format, which is also a commonly used RGB format.
For most LCD controllers, the communication mode of the controller can be configured, usually with an 8080 parallel interface, three-wire SPI, four-wire SPI, and other communication methods. This LCD uses a four-wire SPI communication interface, which can greatly save the GPIO port, and the communication speed will be faster.

Communication Protocol

Note: Different from the traditional SPI protocol, the data line from the slave to the master is hidden since the device only has a display requirement.
RESX: the reset pin, it should be low when powering the module and be higher at other times;
CSX: slave chip select, when CS is low, the chip is enabled.
D/CX: data/command control pin, when DC = 0, write command, when DC = 1, write data
SDA: the data pin for transmitting RGB data, it works as the MOSI pin of SPI interface;
SCL works as the SCLK pins of SPI interface.
SPI communication has data transfer timing, which is combined by CPHA and CPOL.
CPOL determines the level of the serial synchronous clock at idle state. When CPOL = 0, the level is Low. However, CPOL has little effect to the transmission.
CPHA determines whether data is collected at the first clock edge or at the second clock edge of serial synchronous clock; when CPHL = 0, data is collected at the first clock edge.
There are 4 SPI communication modes. SPI0 is commonly used, in which CPHL = 0, CPOL = 0.

Working with Raspberry Pi

Enable SPI interface

PS: If you are using the system of the Bullseye branch, you need to change "apt-get" to "apt", the system of the Bullseye branch only supports Python3.

- Open terminal, use command to enter the configuration page

```
sudo raspi-config
Choose Interfacing Options -> SPI -> Yes  to enable SPI interface
```

Reboot Raspberry Pi :

```
sudo reboot
```

Please make sure the SPI is not occupied by other devices, you can check in the middle of /boot/config.txt

Install Libraries

- Install BCM2835 libraries

```
#Open the Raspberry Pi terminal and run the following command
wget http://www.airspayce.com/mikem/bcm2835/bcm2835-1.71.tar.gz
tar zxvf bcm2835-1.71.tar.gz
cd bcm2835-1.71/
sudo ./configure && sudo make && sudo make check && sudo make install
# For more information, please refer to the official website: http://www.a
irspayce.com/mikem/bcm2835/
```

- Install wiringPI libraries

```
#Open the Raspberry Pi terminal and run the following command
sudo apt-get install wiringpi
#For Raspberry Pi systems after May 2019 (earlier than before, you may not
need to execute), you may need to upgrade:
wget https://project-downloads.drogon.net/wiringpi-latest.deb
sudo dpkg -i wiringpi-latest.deb
gpio -v
# Run gpio -v and version 2.52 will appear. If it does not appear, the ins
tallation is wrong

#Bullseye branch system use the following command:
git clone https://github.com/WiringPi/WiringPi
cd WiringPi
./build
gpio -v
# Run gpio -v and version 2.60 will appear. If it does not appear, it mean
s that there is an installation error
```

- Install Python libraries

```
#python2
sudo apt-get update
sudo apt-get install python-pip
sudo apt-get install python-pil
sudo apt-get install python-numpy
sudo pip install RPi.GPIO
sudo pip install spidev
#python3
sudo apt-get update
sudo apt-get install python3-pip
sudo apt-get install python3-pil
sudo apt-get install python3-numpy
sudo pip3 install RPi.GPIO
sudo pip3 install spidev
```

Download Examples

Open Raspberry Pi terminal and run the following command

```
sudo apt-get install unzip -y
sudo wget https://www.waveshare.com/w/upload/8/8d/LCD_Module_RPI_code.zip
sudo unzip ./LCD_Module_RPI_code.zip
cd LCD_Module_RPI_code/RaspberryPi/
```

Run the demo codes

Please go into the RaspberryPi directory (demo codes) first and run the commands in terminal

C codes

- Re-compile the demo codes

```
cd c
sudo make clean
sudo make -j 8
```

- The test program of all screens can be called directly by entering the corresponding size

```
sudo ./main Screen Size
```

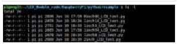
Depending on the LCD, one of the following commands should be entered:

```
#0.96inch LCD Module
sudo ./main 0.96
#1.14inch LCD Module
sudo ./main 1.14
#1.28inch LCD Module
sudo ./main 1.28
#1.3inch LCD Module
sudo ./main 1.3
#1.47inch LCD Module
sudo ./main 1.47
#1.54inch LCD Module
sudo ./main 1.54
#1.8inch LCD Module
sudo ./main 1.8
#2inch LCD Module
sudo ./main 2
#2.4inch LCD Module
sudo ./main 2.4
```

python

- Enter the python program directory and run the command ls -l

```
cd python/examples
ls -l
```



```
[illegible]:~/LCD_Module_code/RaspberryPi/python/example $ ls -l
total 24
-rw-r--r-- 1 pi pi [illegible] 0inch96_LCD_test.py
-rw-r--r-- 1 pi pi [illegible] 1inch14_LCD_test.py
-rw-r--r-- 1 pi pi [illegible] 1inch3_LCD_test.py
-rw-r--r-- 1 pi pi [illegible] 1inch54_LCD_test.py
-rw-r--r-- 1 pi pi [illegible] 1inch8_LCD_test.py
-rw-r--r-- 1 pi pi [illegible] 2inch_LCD_test.py
```

Test programs for all screens can be viewed, sorted by size:
0inch96_LCD_test.py: 0.96inch LCD test program
1inch14_LCD_test.py: 1.14inch LCD test program
1inch28_LCD_test.py: 1.28inch LCD test program
1inch3_LCD_test.py: 1.3inch LCD test program
1inch47_LCD_test.py: 1.47inch LCD test program
1inch54_LCD_test.py: 1.54inchLCD test program
1inch8_LCD_test.py: 1.8inch LCD test program
2inch_LCD_test.py: 2inch LCD test program
2inch4_LCD_test.py: 2inch4 LCD test program

- Just run the program corresponding to the screen, the program supports python2/3

```
# python2
sudo python 0inch96_LCD_test.py
sudo python 1inch14_LCD_test.py
sudo python 1inch28_LCD_test.py
sudo python 1inch3_LCD_test.py
sudo python 1inch47_LCD_test.py
sudo python 1inch54_LCD_test.py
sudo python 1inch8_LCD_test.py
sudo python 2inch_LCD_test.py
sudo python 2inch4_LCD_test.py
# python3
sudo python3 0inch96_LCD_test.py
sudo python3 1inch14_LCD_test.py
sudo python3 1inch28_LCD_test.py
sudo python3 1inch3_LCD_test.py
sudo python3 1inch47_LCD_test.py
sudo python3 1inch54_LCD_test.py
sudo python3 1inch8_LCD_test.py
sudo python3 2inch_LCD_test.py
sudo python3 2inch4_LCD_test.py
```

FBCP Porting

PS: FBCP is currently not compatible with 64-bit Raspberry Pi system, it is recommended to use 32-bit system.

Framebuffer uses a video output device to drive a video display device from a memory buffer containing complete frame data. Simply put, a memory area is used to store the display content, and the display content can be changed by changing the data in the memory.
There is an open source project on github: fbcp-ili9341. Compared with other fbcp projects, this project uses partial refresh and DMA to achieve a speed of up to 60fps

Download Drivers

```
sudo apt-get install cmake -y
cd ~
wget https://www.waveshare.com/w/upload/1/18/Waveshare_fbcp.zip
unzip Waveshare_fbcp.zip
cd Waveshare_fbcp/
sudo chmod +x ./shell/*
```

Method 1: Use a script (recommended)

Here we have written several scripts that allow users to quickly use fbcp and run corresponding commands according to their own screen
If you use a script and do not need to modify it, you can ignore the second method below.
Note: The script will replace the corresponding /boot/config.txt and /etc/rc.local and restart, if the user needs, please back up the relevant files in advance.

```
#0.96inch LCD Module
sudo ./shell/waveshare-0inch96
#1.14inch LCD Module
sudo ./shell/waveshare-1inch14
#1.3inch LCD Module
sudo ./shell/waveshare-1inch3
#1.44inch LCD Module
sudo ./shell/waveshare-1inch44
#1.54inch LCD Module
sudo ./shell/waveshare-1inch54
#1.8inch LCD Module
sudo ./shell/waveshare-1inch8
#2inch LCD Module
sudo ./shell/waveshare-2inch
#2.4inch LCD Module
sudo ./shell/waveshare-2inch4
```

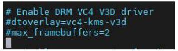
Method 2: Manual Configuration

Environment Configuration

Raspberry Pi's vc4-kms-v3d will cause fbcp to fail, so we need to close vc4-kms-v3d before installing it in fbcp.

```
sudo nano /boot/config.txt
```

Just block the statement corresponding to the picture below.



```
# Enable DRM VC4 V3D driver
#dtoverlay=vc4-kms-v3d
#max_framebuffers=2
```

A reboot is then required.

```
sudo reboot
```

Compile and run

```
mkdir build
cd build
cmake [options] ..
sudo make -j
sudo ./fbcp
```

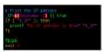
Replace it by yourself according to the LCD Module you use, above cmake [options] ..

```
#0.96inch LCD Module
sudo cmake -DSPI_BUS_CLOCK_DIVISOR=20 -DWAVESHARE_0INCH96_LCD=ON -DBACKLIG
HT_CONTROL=ON -DSTATISTICS=0 ..
#1.14inch LCD Module
sudo cmake -DSPI_BUS_CLOCK_DIVISOR=20 -DWAVESHARE_1INCH14_LCD=ON -DBACKLIG
HT_CONTROL=ON -DSTATISTICS=0 ..
#1.3inch LCD Module
sudo cmake -DSPI_BUS_CLOCK_DIVISOR=20 -DWAVESHARE_1INCH3_LCD=ON -DBACKLIGH
T_CONTROL=ON -DSTATISTICS=0 ..
#1.54inch LCD Module
sudo cmake -DSPI_BUS_CLOCK_DIVISOR=20 -DWAVESHARE_1INCH54_LCD=ON -DBACKLIG
HT_CONTROL=ON -DSTATISTICS=0 ..
#1.8inch LCD Module
sudo cmake -DSPI_BUS_CLOCK_DIVISOR=20 -DWAVESHARE_1INCH8_LCD=ON -DBACKLIGH
T_CONTROL=ON -DSTATISTICS=0 ..
#2inch LCD Module
sudo cmake -DSPI_BUS_CLOCK_DIVISOR=20 -DWAVESHARE_2INCH_LCD=ON -DBACKLIGHT
_CONTROL=ON -DSTATISTICS=0 ..
#2.4inch LCD Module
sudo cmake -DSPI_BUS_CLOCK_DIVISOR=20 -DWAVESHARE_2INCH4_LCD=ON -DBACKLIGH
T_CONTROL=ON -DSTATISTICS=0 ..
```

Set up to start automatically

```
sudo cp ~/Waveshare_fbcp/buil
d/fbcp /usr/local/bin/fbcp
sudo nano /etc/rc.local
```

Add fbcp& before exit 0. Note that you must add "&" to run in the background, otherwise the system may not be able to start.



```
# Print the IP address
_IP=$(hostname -I) || true
if [ "$_IP" ]; then
  printf "My IP address is %s\n" "$_IP"
fi

fbcp&
exit 0
```

Set the Display Resolution

Set the user interface display size in the /boot/config.txt file.

```
sudo nano /boot/config.txt
```

Then add the following lines at the end of the config.txt.

```
hdmi_force_hotplug=1
hdmi_cvt=[options]
hdmi_group=2
hdmi_mode=1
hdmi_mode=87
display_rotate=0
```

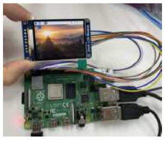
Replace the above hdmi_cvt=[options] according to the LCD Module you are using.

```
#2.4inchinch LCD Module & 2inchinch LCD Module
hdmi_cvt=640 480 60 1 0 0 0

#1.8inch LCD Module
hdmi_cvt=400 300 60 1 0 0 0

#1.3inch LCD Module & 1.54inch LCD Module
hdmi_cvt=300 300 60 1 0 0 0

#1.14inch LCD Module
hdmi_cvt=300 170 60 1 0 0 0

#0.96inch LCD Module
hdmi_cvt=300 150 60 1 0 0 0
```

And then reboot the system

```
sudo reboot
```

After rebooting the system, the Raspberry Pi OS user interface will be displayed.



API Description

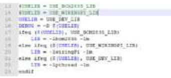
The RaspberryPi series can share a set of programs, because they are all embedded systems, and the compatibility is relatively strong.
The program is divided into bottom-layer hardware interface, middle-layer LCD screen driver, and upper-layer application;

C

Hardware Interface

We have carried out the low-level encapsulation, if you need to know the internal implementation can go to the corresponding directory to check, for the reason the hardware platform and the internal implementation are different.
You can open DEV_Config.c(.h) to see definitions,which in the directory RaspberryPi\c\lib\Config.

```
1. There are three ways for C to drive: BCM2835 library, WiringPi library,
and Dev library respectively
2. We use Dev libraries by default. If you need to change to BCM2835 or Wi
ringPi libraries, please open RaspberryPi\c\Makefile and modify lines 13-1
5 as follows:
```



```
13  #USELIB = USE_BCM2835_LIB
14  #USELIB = USE_WIRINGPI_LIB
15  USELIB = USE_DEV_LIB
16  DEBUG = -D $(USELIB)
17  ifeq ($(USELIB), USE_BCM2835_LIB)
18      LIB = -lbcm2835 -lm
19  else ifeq ($(USELIB), USE_WIRINGPI_LIB)
20      LIB = -lwiringPi -lm
21  else ifeq ($(USELIB), USE_DEV_LIB)
22      LIB = -lpthread -lm
23  endif
```

- Data type:

```
#define UBYTE      uint8_t
#define UWORD      uint16_t
#define UDOUBLE    uint32_t
```

- Module initialization and exit processing.

```
void DEV_Module_Init(void);
void DEV_Module_Exit(void);
Note:
  Here is some GPIO processing before and after using the LCD screen.
```

- GPIO read and write:

```
void    DEV_Digital_Write(UWORD Pin, UBYTE Value);
UBYTE   DEV_Digital_Read(UWORD Pin);
```

- SPI write data:

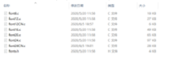
```
void DEV_SPI_WriteByte(UBYTE Value);
```

Upper application

If you need to draw pictures or display Chinese and English characters, we provide some basic functions here about some graphics processing in the directory RaspberryPi\c\lib\GUI\GUI_Paint.c(.h).

GUI_BMP.c
GUI_BMP.h
GUI_Paint.c
GUI_Paint.h

The fonts can be found in RaspberryPi\c\lib\Fonts directory.



font8.c
font12.c
font12CN.c
font16.c
font20.c
font24.c
font24CN.c
fonts.h

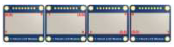
- New Image Properties: Create a new image buffer, this property includes the image buffer name, width, height, flip Angle, and color.

```
void Paint_NewImage(UBYTE *image, UWORD Width, UWORD Height, UWORD Rotate, UWORD Color)
Parameters:
      Image: the name of the image buffer, which is actually a pointer to the first address of the image buffer;
      Width: image buffer Width;
      Height: the Height of the image buffer;
      Rotate: Indicates the rotation Angle of an image
      Color: the initial Color of the image;
```

- Select image buffer: The purpose of the selection is that you can create multiple image attributes, there can be multiple images buffer, you can select each image you create.

```
void Paint_SelectImage(UBYTE *image)
Parameters:
       Image: the name of the image buffer, which is actually a pointer to the first address of the image buffer;
```

- Image Rotation: Set the rotation Angle of the selected image, preferably after Paint_SelectImage(), you can choose to rotate 0, 90, 180, 270.



```
void Paint_SetRotate(UWORD Rotate)
Parameters:
        Rotate: ROTATE_0, ROTATE_90, ROTATE_180, and ROTATE_270 correspond to 0, 90, 180, and 270 degrees.
```

- Image mirror flip: Set the mirror flip of the selected image. You can choose no mirror, horizontal mirror, vertical mirror, or image center mirror.

```
void Paint_SetMirroring(UBYTE mirror)
Parameters:
        Mirror: indicates the image mirroring mode. MIRROR_NONE, MIRROR_HORIZONTAL, MIRROR_VERTICAL, MIRROR_ORIGIN correspond to no mirror, horizontal mirror, vertical mirror, and image center mirror respectively.
```

- Set points of the display position and color in the buffer: here is the core GUI function, processing points display position and color in the buffer.

```
void Paint_SetPixel(UWORD Xpoint, UWORD Ypoint, UWORD Color)
Parameters:
        Xpoint: the X position of a point in the image buffer
        Ypoint: Y position of a point in the image buffer
        Color: indicates the Color of the dot
```

- Image buffer fill color: Fills the image buffer with a color, usually used to flash the screen into blank.

```
void Paint_Clear(UWORD Color)
Parameters:
        Color: fill Color
```

- The fill color of a certain window in the image buffer: the image buffer part of the window filled with a certain color, usually used to fresh the screen into blank, often used for time display, fresh the last second of the screen.

```
void Paint_ClearWindows(UWORD Xstart, UWORD Ystart, UWORD Xend, UWORD Yend, UWORD Color)
Parameters:
        Xstart: the x-starting coordinate of the window
        Ystart: the y-starting coordinate of the window
        Xend: the x-end coordinate of the window
        Yend: the y-end coordinate of the window
        Color: fill Color
```

- Draw point: In the image buffer, draw points on (Xpoint, Ypoint), you can choose the color, the size of the point, the style of the point.

```
void Paint_DrawPoint(UWORD Xpoint, UWORD Ypoint, UWORD Color, DOT_PIXEL Dot_Pixel, DOT_STYLE Dot_Style)
Parameters:
        Xpoint: indicates the X coordinate of a point.
        Ypoint: indicates the Y coordinate of a point.
        Color: fill Color
        Dot_Pixel: The size of the dot, the demo provides 8 size pointss by default.
              typedef enum {
                 DOT_PIXEL_1X1  = 1,    // 1 x 1
                 DOT_PIXEL_2X2  ,              // 2 X 2
                 DOT_PIXEL_3X3  ,              // 3 X 3
                 DOT_PIXEL_4X4  ,              // 4 X 4
                 DOT_PIXEL_5X5  ,              // 5 X 5
                 DOT_PIXEL_6X6  ,              // 6 X 6
                 DOT_PIXEL_7X7  ,              // 7 X 7
                 DOT_PIXEL_8X8  ,              // 8 X 8
               } DOT_PIXEL;
        Dot_Style: the size of a point that expands from the center of the point or from the bottom left corner of the point to the right and up.
                 typedef enum {
                    DOT_FILL_AROUND  = 1,
                    DOT_FILL_RIGHTUP,
                  } DOT_STYLE;
```

- Draw line: In the image buffer, draw line from (Xstart, Ystart) to (Xend, Yend), you can choose the color, the width and the style of the line.

```
void Paint_DrawLine(UWORD Xstart, UWORD Ystart, UWORD Xend, UWORD Yend, UWORD Color, LINE_STYLE Line_Style ,  LINE_STYLE Line_Style)
Parameters:
        Xstart: the x-starting coordinate of a line
        Ystart: the y-starting coordinate of the a line
        Xend: the x-end coordinate of a line
        Yend: the y-end coordinate of a line
        Color: fill Color
        Line_width: The width of the line, the demo provides 8 sizes of width by default.
              typedef enum {
                 DOT_PIXEL_1X1  = 1,    // 1 x 1
                 DOT_PIXEL_2X2  ,              // 2 X 2
                 DOT_PIXEL_3X3  ,              // 3 X 3
                 DOT_PIXEL_4X4  ,              // 4 X 4
                 DOT_PIXEL_5X5  ,              // 5 X 5
                 DOT_PIXEL_6X6  ,              // 6 X 6
                 DOT_PIXEL_7X7  ,              // 7 X 7
                 DOT_PIXEL_8X8  ,              // 8 X 8
              } DOT_PIXEL;
        Line_Style: line style. Select whether the lines are joined in a straight or dashed way.
              typedef enum {
                 LINE_STYLE_SOLID = 0,
                 LINE_STYLE_DOTTED,
              } LINE_STYLE;
```

- Draw rectangle: In the image buffer, draw a rectangle from (Xstart, Ystart) to (Xend, Yend), you can choose the color, the width of the line, whether to fill the inside of the rectangle.

```
void Paint_DrawRectangle(UWORD Xstart, UWORD Ystart, UWORD Xend, UWORD Yend, UWORD Color, DOT_PIXEL Line_width,  DRAW_FILL Draw_Fill)
Parameters:
        Xstart: the starting X coordinate of the rectangle
        Ystart: the starting Y coordinate of the rectangle
        Xend: the x-end coordinate of the rectangle
        Yend: the y-end coordinate of the rectangle
        Color: fill Color
        Line_width: The width of the four sides of a rectangle. And the demo provides 8 sizes of width by default.
                typedef enum {
                        DOT_PIXEL_1X1  = 1,     // 1 x 1
                        DOT_PIXEL_2X2  ,               // 2 X 2
                        DOT_PIXEL_3X3  ,               // 3 X 3
                        DOT_PIXEL_4X4  ,               // 4 X 4
                        DOT_PIXEL_5X5  ,               // 5 X 5
                        DOT_PIXEL_6X6  ,               // 6 X 6
                        DOT_PIXEL_7X7  ,               // 7 X 7
                        DOT_PIXEL_8X8  ,               // 8 X 8
                 } DOT_PIXEL;
         Draw_Fill: Fill, whether to fill the inside of the rectangle
              typedef enum {
                        DRAW_FILL_EMPTY = 0,
                        DRAW_FILL_FULL,
              } DRAW_FILL;
```

- Draw circle: In the image buffer, draw a circle of Radius with (X_Center Y_Center) as the center. You can choose the color, the width of the line, and whether to fill the inside of the circle.

```
void Paint_DrawCircle(UWORD X_Center, UWORD Y_Center, UWORD Radius, UWORD Color, DOT_PIXEL Line_width,  DRAW_FILL Draw_Fill)
Parameters:
        X_Center: the x-coordinate of the center of the circle
        Y_Center: the y-coordinate of the center of the circle
        Radius: indicates the Radius of a circle
        Color: fill Color
        Line_width: The width of the arc, with a default of 8 widths
                typedef enum {
                        DOT_PIXEL_1X1  = 1,     // 1 x 1
                        DOT_PIXEL_2X2  ,               // 2 X 2
                        DOT_PIXEL_3X3  ,               // 3 X 3
                        DOT_PIXEL_4X4  ,               // 4 X 4
                        DOT_PIXEL_5X5  ,               // 5 X 5
                        DOT_PIXEL_6X6  ,               // 6 X 6
                        DOT_PIXEL_7X7  ,               // 7 X 7
                        DOT_PIXEL_8X8  ,               // 8 X 8
                } DOT_PIXEL;
        Draw_Fill: fill, whether to fill the inside of the circle
              typedef enum {
                        DRAW_FILL_EMPTY = 0,
                        DRAW_FILL_FULL,
              } DRAW_FILL;
```

- Write Ascii character: In the image buffer, use (Xstart Ystart) as the left vertex, write an Ascii character, you can select Ascii visual character library, font foreground color, font background color.

```
void Paint_DrawChar(UWORD Xstart, UWORD Ystart, const char Ascii_Char, sFONT* Font, UWORD Color_Foreground,  UWORD Color_Background)
Parameters:
        Xstart: the x-coordinate of the left vertex of a character
        Ystart: the Y-coordinate of the left vertex of a character
        Ascii_Char: indicates the Ascii character
        Font: Ascii visual character library, in the Fonts folder the demo provides the following Fonts:
                Font8: 5*8 font
                Font12: 7*12 font
                Font16: 11*16 font
                Font20: 14*20 font
                Font24: 17*24 font
        Color_Foreground: Font color
        Color_Background: indicates the background color
```

- Write English string: In the image buffer, use (Xstart Ystart) as the left vertex, write a string of English characters, you can choose Ascii visual character library, font foreground color, font background color.

```
void Paint_DrawString_EN(UWORD Xstart, UWORD Ystart, const char * pString, sFONT* Font, UWORD Color_Foreground,  UWORD Color_Background)
Parameters:
        Xstart: the x-coordinate of the left vertex of a character
        Ystart: the Y coordinate of the font's left vertex
        PString: string, string is a pointer
        Font: Ascii visual character library, in the Fonts folder the demo provides the following Fonts:
                Font8: 5*8 font
                Font12: 7*12 font
                Font16: 11*16 font
                Font20: 14*20 font
                Font24: 17*24 font
        Color_Foreground: Font color
        Color_Background: indicates the background color
```

- Write Chinese string: in the image buffer, use (Xstart Ystart) as the left vertex, write a string of Chinese characters, you can choose character font, font foreground color, and font background color of the GB2312 encoding.

```
void Paint_DrawString_CN(UWORD Xstart, UWORD Ystart, const char * pString, cFONT* font, UWORD Color_Foreground,  UWORD Color_Background)
Parameters:
        Xstart: the x-coordinate of the left vertex of a character
        Ystart: the Y coordinate of the font's left vertex
        PString: string, string is a pointer
        Font: GB2312 encoding character Font library, in the Fonts folder the demo provides the following Fonts:
                Font12CN: ASCII font 11*21, Chinese font 16*21
                Font24CN: ASCII font24 *41, Chinese font 32*41
        Color_Foreground: Font color
        Color_Background: indicates the background color
```

- Write numbers: In the image buffer,use (Xstart Ystart) as the left vertex, write a string of numbers, you can choose Ascii visual character library, font foreground color, font background color.

```
void Paint_DrawNum(UWORD Xpoint, UWORD Ypoint, double Nummber, sFONT* Font, UWORD Digit, UWORD Color_Foreground,   UWORD Color_Background)
Parameters:
        Xpoint: the x-coordinate of the left vertex of a character
        Ypoint: the Y coordinate of the left vertex of the font
        Nummber: indicates the number displayed, which can be a decimal
        Digit: It's a decimal number
        Font: Ascii visual character library, in the Fonts folder the demo provides the following Fonts:
                Font8: 5*8 font
                Font12: 7*12 font
                Font16: 11*16 font
                Font20: 14*20 font
                Font24: 17*24 font
        Color_Foreground: Font color
        Color_Background: indicates the background color
```

- Display time: in the image buffer,use (Xstart Ystart) as the left vertex, display time,you can choose Ascii visual character font, font foreground color, font background color.

```
void Paint_DrawTime(UWORD Xstart, UWORD Ystart, PAINT_TIME *pTime, sFONT* Font, UWORD Color_Background,  UWORD Color_Foreground)
Parameters:
        Xstart: the x-coordinate of the left vertex of a character
        Ystart: the Y coordinate of the font's left vertex
        PTime: display time, A time structure is defined here, as long as the hours, minutes, and seconds are passed to the parameters;
        Font: Ascii visual character library, in the Fonts folder the demo provides the following Fonts:
                Font8: 5*8 font
                Font12: 7*12 font
                Font16: 11*16 font
                Font20: 14*20 font
                Font24: 17*24 font
        Color_Foreground: Font color
        Color_Background: indicates the background color
```

- Read the local bmp image and write it to the cache.

For Linux operating systems such as Raspberry Pi, you can read and write pictures. For Raspberry Pi, in the directory: RaspberryPi\c\lib\GUI\GUI_BMPfile.c(.h).

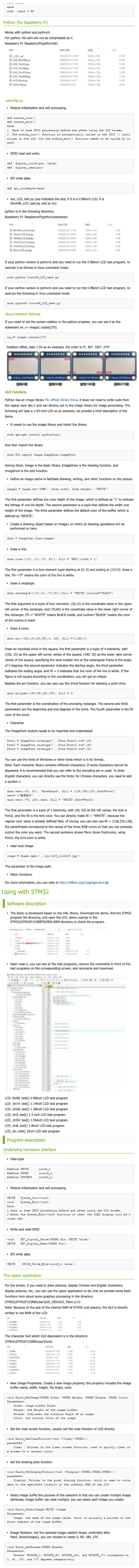
```
UBYTE GUI_ReadBmp(const char *path, UWORD Xstart, UWORD Ystart)
parameter:
       path: the relative path of the BMP image
       Xstart: The X coordinate of the left vertex of the image, generally 0 is passed by default
       Ystart: The Y coordinate of the left vertex of the picture, generally 0 by default
```

Testing Code for Users

For Raspberry Pi, in the directory: RaspberryPi\c\examples, for all the test code;

If you need to run the 0.96-inch LCD test program, you need to add 0.96 as a parameter when running the main demo.
Re-execute in Linux command mode as follows:

```
make clean
```



```
make
sudo ./main 0.96
```

Python (for Raspberry Pi)

Works with python and python3.
For python, his calls are not as complicated as C.
Raspberry Pi: RaspberryPi\python\lib\

lcdconfig.py

- Module initialization and exit processing.

```
def module_init()
def module_exit()
Note:
1. Here is some GPIO processing before and after using the LCD screen.
2. The module_init() function is automatically called in the INIT () initi
alizer on the LCD, but the module_exit() function needs to be called by it
self.
```

- GPIO read and write:

```
def  digital_write(pin, value)
def  digital_read(pin)
```

- SPI write data.

```
def spi_writebyte(data)
```

- xxx_LCD_test.py (xxx indicates the size, if it is a 0.96inch LCD, it is 0inch96_LCD_test.py, and so on)

python is in the following directory:
Raspberry Pi: RaspberryPi\python\examples\

If your python version is python2 and you need to run the 0.96inch LCD test program, re-execute it as follows in linux command mode:

```
sudo python 0inch96_LCD_test.py
```

If your python version is python3 and you need to run the 0.96inch LCD test program, re-execute the following in linux command mode:

```
sudo python3 0inch96_LCD_test.py
```

About Rotation Settings

If you need to set the screen rotation in the python program, you can set it by the statement im_r= image1.rotate(270).

```
im_r= image1.rotate(270)
```

Rotation effect, take 1.54 as an example, the order is 0°, 90°, 180°, 270°

GUI Functions

Python has an image library PIL official library link, it does not need to write code from the logical layer like C and can directly call to the image library for image processing. The following will take a 1.54-inch LCD as an example, we provide a brief description of the demo.

- It needs to use the image library and install the library.

```
sudo apt-get install python3-pil
```

And then import the library

```
from PIL import Image,ImageDraw,ImageFont.
```

Among them, Image is the basic library, ImageDraw is the drawing function, and ImageFont is the text function.

- Define an image cache to facilitate drawing, writing, and other functions on the picture.

```
image1 = Image.new("RGB", (disp.width, disp.height), "WHITE")
```

The first parameter defines the color depth of the image, which is defined as "1" to indicate the bitmap of one-bit depth. The second parameter is a tuple that defines the width and height of the image. The third parameter defines the default color of the buffer, which is defined as "WHITE".

- Create a drawing object based on Image1 on which all drawing operations will be performed on here.

```
draw = ImageDraw.Draw(image1)
```

- Draw a line.

```
draw.line([(20, 10),(70, 60)], fill = "RED",width = 1)
```

The first parameter is a four-element tuple starting at (0, 0) and ending at (127,0). Draw a line. Fill ="0" means the color of the line is white.

- Draw a rectangle.

```
draw.rectangle([(20,10),(70,60)],fill = "WHITE",outline="BLACK")
```

The first argument is a tuple of four elements. (20,10) is the coordinate value in the upper left corner of the rectangle, and (70,60) is the coordinate value in the lower right corner of the rectangle. Fill =" WHITE" means BLACK inside, and outline="BLACK" means the color of the outline is black.

- Draw a circle.

```
draw.arc((150,15,190,55),0, 360, fill =(0,255,0)
```

Draw an inscribed circle in the square, the first parameter is a tuple of 4 elements, with (150, 15) as the upper left corner vertex of the square, (190, 55) as the lower right corner vertex of the square, specifying the level median line of the rectangular frame is the angle of 0 degrees, the second parameter indicates the starting angle, the third parameter indicates the ending angle, and fill = 0 indicates that the color of the line is white. If the figure is not square according to the coordination, you will get an ellipse.

Besides the arc function, you can also use the chord function for drawing a solid circle.

```
draw.ellipse((150,65,190,105), fill = 0)
```

The first parameter is the coordination of the enclosing rectangle. The second and third parameters are the beginning and end degrees of the circle. The fourth parameter is the fill color of the circle.

- Character.

The ImageFont module needs to be imported and instantiated:

```
Font1 = ImageFont.truetype("../Font/Font01.ttf",25)
Font2 = ImageFont.truetype("../Font/Font01.ttf",35)
Font3 = ImageFont.truetype("../Font/Font02.ttf",32)
```

You can use the fonts of Windows or other fonts which is in ttc format..
Note: Each character library contains different characters; If some characters cannot be displayed, it is recommended that you can refer to the encoding set ro used. To draw English characters, you can directly use the fonts; for Chinese characters, you need to add a symbol u:

```
draw.text((40, 50), 'WaveShare', fill = (128,255,128),font=Font2)
text= u"微雪电子"
draw.text((74, 150),text, fill = "WHITE",font=Font3)
```

The first parameter is a tuple of 2 elements, with (40, 50) as the left vertex, the font is Font2, and the fill is the font color. You can directly make fill = "WHITE", because the regular color value is already defined Well, of course, you can also use fill = (128,255,128), the parentheses correspond to the values of the three RGB colors so that you can precisely control the color you want. The second sentence shows Micro Snow Electronics, using Font3, the font color is white.

- read local image

```
image = Image.open('../pic/LCD_1inch28.jpg')
```

The parameter is the image path.

- Other functions.

For more information, you can refer to http://effbot.org/imagingbook pil

Using with STM32

Software description

- The demo is developed based on the HAL library. Download the demo, find the STM32 program file directory, and open the LCD_demo.uvprojx in the STM32\STM32F103RBT6\MDK-ARM directory to check the program.
- Open main.c, you can see all the test programs, remove the comments in front of the test programs on the corresponding screen, and recompile and download.

LCD_0in96_test() 0.96inch LCD test program
LCD_1in14_test() 1.14inch LCD test program
LCD_1in28_test() 1.28inch LCD test program
LCD_1in3_test() 1.3 inch LCD test program
LCD_1in54_test() 1.54inch LCD test program
LCD_1in8_test() 1.8inch LCD test program
LCD_2in_test() 2inch LCD test program

Program description

Underlying hardware interface

- Data type

```
#define UBYTE      uint8_t
#define UWORD      uint16_t
#define UDOUBLE    uint32_t
```

- Module initialization and exit processing

```
UBYTE   System_Init(void);
void    System_Exit(void);
Note:
1.here is some GPIO processing before and after using the LCD screen.
2.After the System_Exit(void) function is used, the OLED display will be t
urned off;
```

- Write and read GPIO

```
void    DEV_Digital_Write(UWORD Pin, UBYTE Value);
UBYTE   DEV_Digital_Read(UWORD Pin);
```

- SPI write data

```
UBYTE    SPI4W_Write_Byte(uint8_t value);
```

The upper application

For the screen, if you need to draw pictures, display Chinese and English characters, display pictures, etc., you can use the upper application to do, and we provide some basic functions here about some graphics processing in the directory STM32\STM32F103RB\User\GUI_DEV\GUI_Paint.c(.h)
Note: Because of the size of the internal RAM of STM32 and arduino, the GUI is directly written to the RAM of the LCD.

The character font which GUI dependent is in the directory STM32\STM32F103RB\User\Fonts

- New Image Properties: Create a new image property, this property includes the image buffer name, width, height, flip Angle, color.

```
void Paint_NewImage(UWORD Width, UWORD Height, UWORD Rotate, UWORD Color)
Parameters:
    Width: image buffer Width;
    Height: the Height of the image buffer;
    Rotate: Indicates the rotation Angle of an image
    Color: the initial Color of the image;
```

- Set the clear screen function, usually call the clear function of LCD directly.

```
void Paint_SetClearFuntion(void (*Clear)(UWORD));
parameter:
    Clear : Pointer to the clear screen function, used to quickly clear th
e screen to a certain color;
```

- Set the drawing pixel function

```
void Paint_SetDisplayFuntion(void (*Display)(UWORD,UWORD,UWORD));
parameter:
    Display: Pointer to the pixel drawing function, which is used to write
data to the specified location in the internal RAM of the LCD;
```

- Select image buffer:the purpose of the selection is that you can create multiple image attributes, image buffer can exist multiple, you can select each image you create.

```
void Paint_SelectImage(UBYTE *image)
Parameters:
    Image: the name of the image cache, which is actually a pointer to the
first address of the image buffer
```

- Image Rotation: Set the selected image rotation Angle, preferably after Paint_SelectImage(), you can choose to rotate 0, 90, 180, 270.

```
void Paint_SetRotate(UWORD Rotate)
Parameters:
    Rotate: ROTATE_0, ROTATE_90, ROTATE_180, and ROTATE_270 correspond to
0, 90, 180, and 270 degrees respectively;
```

Waveshare 2.4-inch LCD Module User Manual

A comprehensive guide to the Waveshare 2.4-inch LCD TFT display module, detailing its features, specifications, and usage with Raspberry Pi, STM32, and Arduino. Learn about SPI interface, IL9341 controller, hardware connections, and software examples for integrating this 240x320 resolution display into your projects.

- Image mirror flip: Set the mirror flip of the selected image. You can choose no mirror, horizontal mirror, vertical mirror, or image center mirror.

```
void Paint_SetMirroring(UBYTE mirror)
Parameters:
    Mirror: indicates the image mirroring mode. MIRROR_NONE, MIRROR_HORIZO
NTAL, MIRROR_VERTICAL, MIRROR_ORIGIN correspond to no mirror, horizontal m
irror, vertical mirror, and about image center mirror respectively.
```

- Set points of display position and color in the buffer: here is the core GUI function, processing points display position and color in the buffer.

```
void Paint_SetPixel(UWORD Xpoint, UWORD Ypoint, UWORD Color)
Parameters:
    Xpoint: the X position of a point in the image buffer
    Ypoint: Y position of a point in the image buffer
    Color: indicates the Color of the dot
```

- Image buffer fill color: Fills the image buffer with a color, usually used to flash the screen into blank.

```
void Paint_Clear(UWORD Color)
Parameters:
    Color: fill Color
```

- Image buffer part of the window filling color: the image buffer part of the window filled with a certain color, generally as a window whitewashing function, often used for time display, whitewashing on a second

```
void Paint_ClearWindows(UWORD Xstart, UWORD Ystart, UWORD Xend, UWORD Yen
d, UWORD Color)
Parameters:
    Xstart: the x-starting coordinate of the window
    Ystart: indicates the Y starting point of the window
    Xend: the x-end coordinate of the window
    Yend: indicates the y-end coordinate of the window
    Color: fill Color
```

- Draw points: In the image buffer, draw points on (Xpoint, Ypoint), you can choose the color, the size of the point, the style of the point.

```
void Paint_DrawPoint(UWORD Xpoint, UWORD Ypoint, UWORD Color, DOT_PIXEL Do
t_Pixel, DOT_STYLE Dot_Style)
Parameters:
    Xpoint: indicates the X coordinate of a point
    Ypoint: indicates the Y coordinate of a point
    Color: fill Color
    Dot_Pixel: The size of the dot, providing a default of eight size poin
ts
        typedef enum {
            DOT_PIXEL_1X1   = 1,        // 1 x 1
            DOT_PIXEL_2X2  ,            // 2 X 2
            DOT_PIXEL_3X3  ,            // 3 X 3
            DOT_PIXEL_4X4  ,            // 4 X 4
            DOT_PIXEL_5X5  ,            // 5 X 5
            DOT_PIXEL_6X6  ,            // 6 X 6
            DOT_PIXEL_7X7  ,            // 7 X 7
            DOT_PIXEL_8X8  ,            // 8 X 8
        } DOT_PIXEL;
    Dot_Style: the size of a point that expands from the center of the poi
nt or from the bottom left corner of the point to the right and up
        typedef enum {
            DOT_FILL_AROUND  = 1,
            DOT_FILL_RIGHTUP,
        } DOT_STYLE;
```

- Line drawing: In the image buffer, line from (Xstart, Ystart) to (Xend, Yend), you can choose the color, line width, line style.

```
void Paint_DrawLine(UWORD Xstart, UWORD Ystart, UWORD Xend, UWORD Yend, UW
ORD Color, LINE_STYLE Line_Style ,  LINE_STYLE Line_Style)
Parameters:
    Xstart: the x-starting coordinate of a line
    Ystart: indicates the Y starting point of a line
    Xend: x-terminus of a line
    Yend: the y-end coordinate of a line
    Color: fill Color
    Line_width: The width of the line, which provides a default of eight w
idths
        typedef enum {
            DOT_PIXEL_1X1   = 1,        // 1 x 1
            DOT_PIXEL_2X2  ,            // 2 X 2
            DOT_PIXEL_3X3  ,            // 3 X 3
            DOT_PIXEL_4X4  ,            // 4 X 4
            DOT_PIXEL_5X5  ,            // 5 X 5
            DOT_PIXEL_6X6  ,            // 6 X 6
            DOT_PIXEL_7X7  ,            // 7 X 7
            DOT_PIXEL_8X8  ,            // 8 X 8
        } DOT_PIXEL;
    Line_Style: line style. Select whether the lines are joined in a strai
ght or dashed way
        typedef enum {
            LINE_STYLE_SOLID = 0,
            LINE_STYLE_DOTTED,
        } LINE_STYLE;
```

- Draw rectangle: In the image buffer, draw a rectangle from (Xstart, Ystart) to (Xend, Yend), you can choose the color, the width of the line, whether to fill the inside of the rectangle.

```
void Paint_DrawRectangle(UWORD Xstart, UWORD Ystart, UWORD Xend, UWORD Yen
d, UWORD Color, DOT_PIXEL Line_width,  DRAW_FILL Draw_Fill)
Parameters:
        Xstart: the starting X coordinate of the rectangle
        Ystart: indicates the Y starting point of the rectangle
        Xend: X terminus of the rectangle
        Yend: specifies the y-end coordinate of the rectangle
        Color: fill Color
        Line_width: The width of the four sides of a rectangle. Default ei
ght widths are provided
            typedef enum {
                DOT_PIXEL_1X1   = 1,    // 1 x 1
                DOT_PIXEL_2X2  ,                // 2 X 2
                DOT_PIXEL_3X3  ,                // 3 X 3
                DOT_PIXEL_4X4  ,                // 4 X 4
                DOT_PIXEL_5X5  ,                // 5 X 5
                DOT_PIXEL_6X6  ,                // 6 X 6
                DOT_PIXEL_7X7  ,                // 7 X 7
                DOT_PIXEL_8X8  ,                // 8 X 8
            } DOT_PIXEL;
        Draw_Fill: Fill, whether to fill the inside of the rectangle
            typedef enum {
                DRAW_FILL_EMPTY = 0,
                DRAW_FILL_FULL,
            } DRAW_FILL;
```

- Draw circle: In the image buffer, draw a circle of Radius with (X_Center Y_Center) as the center. You can choose the color, the width of the line, and whether to fill the inside of the circle.

```
void Paint_DrawCircle(UWORD X_Center, UWORD Y_Center, UWORD Radius, UWORD
Color, DOT_PIXEL Line_width,  DRAW_FILL Draw_Fill)
Parameters:
    X_Center: the x-coordinate of the center of a circle
    Y_Center: Y coordinate of the center of a circle
    Radius: indicates the Radius of a circle
    Color: fill Color
    Line_width: The width of the arc, with a default of 8 widths
        typedef enum {
            DOT_PIXEL_1X1  = 1,         // 1 x 1
            DOT_PIXEL_2X2  ,            // 2 X 2
            DOT_PIXEL_3X3  ,            // 3 X 3
            DOT_PIXEL_4X4  ,            // 4 X 4
            DOT_PIXEL_5X5  ,            // 5 X 5
            DOT_PIXEL_6X6  ,            // 6 X 6
            DOT_PIXEL_7X7  ,            // 7 X 7
            DOT_PIXEL_8X8  ,            // 8 X 8
        } DOT_PIXEL;
    Draw_Fill: fill, whether to fill the inside of the circle
        typedef enum {
            DRAW_FILL_EMPTY = 0,
            DRAW_FILL_FULL,
        } DRAW_FILL;
```

- Write Ascii character: In the image buffer, at (Xstart Ystart) as the left vertex, write an Ascii character, you can select Ascii visual character library, font foreground color, font background color.

```
void Paint_DrawChar(UWORD Xstart, UWORD Ystart, const char Ascii_Char, sFO
NT* Font, UWORD Color_Foreground,  UWORD Color_Background)
Parameters:
    Xstart: the x-coordinate of the left vertex of a character
    Ystart: the Y coordinate of the font's left vertex
    Ascii_Char: indicates the Ascii character
    Font: Ascii visual character library, in the Fonts folder provides the
following Fonts:
        Font8: 5*8 font
        Font12: 7*12 font
        Font16: 11*16 font
        Font20: 14*20 font
        Font24: 17*24 font
    Color_Foreground: Font color
    Color_Background: indicates the background color
```

- Write English string: In the image buffer, use (Xstart Ystart) as the left vertex, write a string of English characters, can choose Ascii visual character library, font foreground color, font background color.

```
void Paint_DrawString_EN(UWORD Xstart, UWORD Ystart, const char * pString,
sFONT* Font, UWORD Color_Foreground,  UWORD Color_Background)
Parameters:
    Xstart: the x-coordinate of the left vertex of a character
    Ystart: the Y coordinate of the font's left vertex
    PString: string, string is a pointer
    Font: Ascii visual character library, in the Fonts folder provides the
following Fonts:
        Font8: 5*8 font
        Font12: 7*12 font
        Font16: 11*16 font
        Font20: 14*20 font
        Font24: 17*24 font
     Color_Foreground: Font color
     Color_Background: indicates the background color
```

- Write Chinese string: in the image buffer, use (Xstart Ystart) as the left vertex, write a string of Chinese characters, you can choose GB2312 encoding character font, font foreground color, font background color.

```
void Paint_DrawString_CN(UWORD Xstart, UWORD Ystart, const char * pString,
cFONT* font, UWORD Color_Foreground,  UWORD Color_Background)
Parameters:
    Xstart: the x-coordinate of the left vertex of a character
    Ystart: the Y coordinate of the font's left vertex
    PString: string, string is a pointer
    Font: GB2312 encoding character Font library, in the Fonts folder prov
ides the following Fonts:
        Font12CN: ASCII font 11*21, Chinese font 16*21
        Font24CN: ASCII font24 *41, Chinese font 32*41
    Color_Foreground: Font color
    Color_Background: indicates the background color
```

- Write numbers: In the image buffer,use (Xstart Ystart) as the left vertex, write a string of numbers, you can choose Ascii visual character library, font foreground color, font background color.

```
void Paint_DrawNum(UWORD Xpoint, UWORD Ypoint, double Nummber, sFONT* Fon
t, UWORD Digit, UWORD Color_Foreground,   UWORD Color_Background)
Parameters:
    Xpoint: the x-coordinate of the left vertex of a character
    Ypoint: the Y coordinate of the left vertex of the font
    Nummber: indicates the number displayed, which can be a decimal
    Digit: It's a decimal number
    Font: Ascii visual character library, in the Fonts folder provides the
following Fonts:
        Font8: 5*8 font
        Font12: 7*12 font
        Font16: 11*16 font
        Font20: 14*20 font
        Font24: 17*24 font
    Color_Foreground: Font color
    Color_Background: indicates the background color
```

- Display time: in the image buffer,use (Xstart Ystart) as the left vertex, display time,you can choose Ascii visual character font, font foreground color, font background color.

```
void Paint_DrawTime(UWORD Xstart, UWORD Ystart, PAINT_TIME *pTime, sFONT*
Font, UWORD Color_Background,  UWORD Color_Foreground)
Parameters:
    Xstart: the x-coordinate of the left vertex of a character
    Ystart: the Y coordinate of the font's left vertex
    PTime: display time, here defined a good time structure, as long as th
e hour, minute and second bits of data to the parameter;
    Font: Ascii visual character library, in the Fonts folder provides the
following Fonts:
        Font8: 5*8 font
        Font12: 7*12 font
        Font16: 11*16 font
        Font20: 14*20 font
        Font24: 17*24 font
    Color_Foreground: Font color
    Color_Background: indicates the background color
```

Arduino software description

Note: The demos are all tested on Arduino uno. If you need other types of Arduino, you need to determine whether the connected pins are correct.

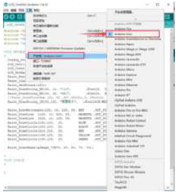
Run program

In the product encyclopedia interface download the program, and then unzip it. The Arduino program is located at ~/Arduino/...

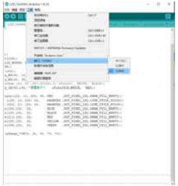
Please select the corresponding program according to the LCD screen model to open.

You can view test programs for all screen sizes, sorted by size:

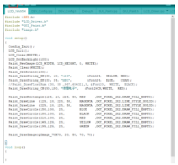
For example, 1.54inch LCD Module. Open the LCD_1inch54 folder and run the LCD_1inch54.ino file.
Open the program, select the development board model Arduino UNO.



Select the corresponding COM port



Then click to compile and download

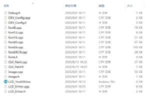


```
#include <SPI.h>
#include "LCD_Driver.h"
#include "GUI_Paint.h"
#include "image.h"

void setup()
{
  Config_Init();
  LCD_Init();
  LCD_Clear(WHITE);
  LCD_SetBacklight(100);
  Paint_NewImage(LCD_WIDTH, LCD_HEIGHT, 0, WHITE);
  Paint_Clear(WHITE);
  Paint_SetRotate(180);
  Paint_DrawString_EN(30, 10, "123",        &Font24,  YELLOW, RED);
  Paint_DrawString_EN(30, 34, "ABC",        &Font24,  BLUE,   CYAN);
  //Paint_DrawFloatNum (30, 58 ,987.654321,3, &Font20,  WHITE,  BLACK);
  Paint_DrawString_CN(50,180, "微雪电子",   &Font24CN,WHITE,  RED);

  Paint_DrawRectangle(125, 10, 225, 58, RED     ,DOT_PIXEL_2X2,DRAW_FILL_EMPTY);
  Paint_DrawLine  (125, 10, 225, 58,    MAGENTA ,DOT_PIXEL_2X2,LINE_STYLE_SOLID);
  Paint_DrawLine  (225, 10, 125, 58,    MAGENTA ,DOT_PIXEL_2X2,LINE_STYLE_SOLID);
  Paint_DrawCircle(150,100,  25,        BLUE    ,DOT_PIXEL_2X2,DRAW_FILL_EMPTY);
  Paint_DrawCircle(180,100,  25,        BLACK   ,DOT_PIXEL_2X2,DRAW_FILL_EMPTY);
  Paint_DrawCircle(210,100,  25,        RED     ,DOT_PIXEL_2X2,DRAW_FILL_EMPTY);
  Paint_DrawCircle(165,125,  25,        YELLOW  ,DOT_PIXEL_2X2,DRAW_FILL_EMPTY);
  Paint_DrawCircle(195,125,  25,        GREEN   ,DOT_PIXEL_2X2,DRAW_FILL_EMPTY);

  Paint_DrawImage(gImage_70X70, 20, 80, 70, 70);

}
void loop()
{

}
```

Program Description

Document Introduction

Take Arduino UNO controlling a 1.54-inch LCD as an example, open the Arduino\LCD_1inch54 directory:



名称	修改日期	类型	大小
Debug.h	2020/6/9 18:11	H 文件	1 KB
DEV_Config.cpp	2020/6/9 18:11	CPP 文件	2 KB
DEV_Config.h	2020/6/9 18:11	H 文件	3 KB
font8.cpp	2020/6/9 18:11	CPP 文件	18 KB
font12.cpp	2020/6/9 18:11	CPP 文件	6 KB
font16.cpp	2020/6/9 18:11	CPP 文件	51 KB
font20.cpp	2020/6/9 18:11	CPP 文件	67 KB
font24.cpp	2020/6/9 18:11	CPP 文件	100 KB
font24CN.cpp	2020/6/9 18:11	CPP 文件	28 KB
fonts.h	2020/6/9 18:11	H 文件	4 KB
GUI_Paint.cpp	2020/6/11 16:32	CPP 文件	27 KB
GUI_Paint.h	2020/6/10 14:25	H 文件	7 KB
image.cpp	2020/6/9 18:11	CPP 文件	50 KB
image.h	2020/6/9 18:11	H 文件	1 KB
LCD_1inch54.ino	2020/6/9 18:12	Arduino file	2 KB
LCD_Driver.cpp	2020/6/9 18:20	CPP 文件	8 KB
LCD_Driver.h	2020/6/9 18:11	H 文件	2 KB

Of which:
LCD_1inch54.ino: open with Arduino IDE;
LCD_Driver.cpp(.h): is the driver of the LCD screen;
DEV_Config.cpp(.h): It is the hardware interface definition, which encapsulates the read and writes pin levels, SPI transmission data, and pin initialization;
font8.cpp, font12.cpp, font16.cpp, font20.cpp, font24.cpp, font24CN.cpp, fonts.h: fonts for characters of different sizes;
image.cpp(.h): is the image data, which can convert any BMP image into a 16-bit true color image array through Img2Lcd (downloadable in the development data).
The program is divided into bottom-layer hardware interface, middle-layer LCD screen driver, and upper-layer application;

Underlying hardware interface

The hardware interface is defined in the two files DEV_Config.cpp(.h), and functions such as read and write pin level, delay, and SPI transmission are encapsulated.

- write pin level

```
void DEV_Digital_Write(int pin, int value)
```

The first parameter is the pin, and the second is the high and low levels.

- Read pin level

```
int DEV_Digital_Read(int pin)
```

The parameter is the pin, and the return value is the level of the read pin.

- Delay

```
DEV_Delay_ms(unsigned int delaytime)
```

millisecond level delay.

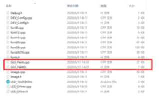
- SPI output data

```
DEV_SPI_WRITE(unsigned char data)
```

The parameter is char type, occupying 8 bits.

The upper application

For the screen, if you need to draw pictures, display Chinese and English characters, display pictures, etc., you can use the upper application to do, and we provide some basic functions here about some graphics processing in the directory GUI_Paint.c(.h)
Note: Because of the size of the internal RAM of STM32 and Arduino, the GUI is directly written to the RAM of the LCD.



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font16.cpp	2020/6/9 18:11	CPP 文件	51 KB
font20.cpp	2020/6/9 18:11	CPP 文件	67 KB
font24.cpp	2020/6/9 18:11	CPP 文件	100 KB
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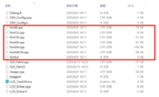
GUI_Paint.cpp	2020/6/11 16:32	CPP 文件	27 KB
GUI_Paint.h	2020/6/10 14:25	H 文件	7 KB
image.cpp	2020/6/9 18:11	CPP 文件	50 KB
image.h	2020/6/9 18:11	H 文件	1 KB
LCD_1inch54.ino	2020/6/9 18:12	Arduino file	2 KB
LCD_Driver.cpp	2020/6/9 18:20	CPP 文件	8 KB
LCD_Driver.h	2020/6/9 18:11	H 文件	2 KB

The fonts used by the GUI all depend on the font*.cpp(h) files under the same file



名称	修改日期	类型	大小
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font8.cpp	2020/6/9 18:11	CPP 文件	18 KB
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font16.cpp	2020/6/9 18:11	CPP 文件	51 KB
font20.cpp	2020/6/9 18:11	CPP 文件	67 KB
font24.cpp	2020/6/9 18:11	CPP 文件	100 KB
font24CN.cpp	2020/6/9 18:11	CPP 文件	28 KB
fonts.h	2020/6/9 18:11	H 文件	4 KB
GUI_Paint.cpp	2020/6/11 16:32	CPP 文件	27 KB
GUI_Paint.h	2020/6/10 14:25	H 文件	7 KB
image.cpp	2020/6/9 18:11	CPP 文件	50 KB
image.h	2020/6/9 18:11	H 文件	1 KB
LCD_1inch54.ino	2020/6/9 18:12	Arduino file	2 KB
LCD_Driver.cpp	2020/6/9 18:20	CPP 文件	8 KB
LCD_Driver.h	2020/6/9 18:11	H 文件	2 KB

- New Image Properties: Create a new image property, this property includes the image buffer name, width, height, flip Angle, and color.

```
void Paint_NewImage(UWORD Width, UWORD Height, UWORD Rotate, UWORD Color)
Parameters:
    Width: image buffer Width;
    Height: the Height of the image buffer;
    Rotate: Indicates the rotation Angle of an image
    Color: the initial Color of the image;
```

- Set the clear screen function, usually call the clear function of LCD directly.

```
void Paint_SetClearFuntion(void (*Clear)(UWORD));
parameter:
    Clear: Pointer to the clear screen function, used to quickly clear the
screen to a certain color;
```

- Set the drawing pixel function.

```
void Paint_SetDisplayFuntion(void (*Display)(UWORD,UWORD,UWORD));
parameter:
    Display: Pointer to the pixel drawing function, which is used to write
data to the specified location in the internal RAM of the LCD;
```

- Select image buffer: the purpose of the selection is that you can create multiple image attributes, image buffer can exist multiple, and you can select each image you create.

```
void Paint_SelectImage(UBYTE *image)
Parameters:
    Image: the name of the image cache, which is actually a pointer to the
first address of the image buffer
```

- Image Rotation: Set the selected image rotation Angle, preferably after Paint_SelectImage(), you can choose to rotate 0, 90, 180, 270.

```
void Paint_SetRotate(UWORD Rotate)
Parameters:
    Rotate: ROTATE_0, ROTATE_90, ROTATE_180, and ROTATE_270 correspond to
0, 90, 180, and 270 degrees respectively;
```

- Image mirror flip: Set the mirror flip of the selected image. You can choose no mirror, horizontal mirror, vertical mirror, or image center mirror.

```
void Paint_SetMirroring(UBYTE mirror)
Parameters:
    Mirror: indicates the image mirroring mode. MIRROR_NONE, MIRROR_HORIZO
NTAL, MIRROR_VERTICAL, MIRROR_ORIGIN correspond to no mirror, horizontal m
irror, vertical mirror, and about image center mirror respectively.
```

- Set points of display position and color in the buffer: here is the core GUI function, processing points display position and color in the buffer.

```
void Paint_SetPixel(UWORD Xpoint, UWORD Ypoint, UWORD Color)
Parameters:
    Xpoint: the X position of a point in the image buffer
    Ypoint: Y position of a point in the image buffer
    Color: indicates the Color of the dot
```

- Image buffer fill color: Fills the image buffer with a color, usually used to flash the screen into blank.

```
void Paint_ClearWindows(UWORD Xstart, UWORD Ystart, UWORD Xend, UWORD Yen
d, UWORD Color)
Parameters:
    Xstart: the x-starting coordinate of the window
    Ystart: indicates the Y starting point of the window
    Xend: the x-end coordinate of the window
    Yend: indicates the y-end coordinate of the window
    Color: fill Color
```

- Draw points: In the image buffer, draw points on (Xpoint, Ypoint), you can choose the color, the size of the point, the style of the point.

```
void Paint_DrawPoint(UWORD Xpoint, UWORD Ypoint, UWORD Color, DOT_PIXEL Do
t_Pixel, DOT_STYLE Dot_Style)
Parameters:
    Xpoint: indicates the X coordinate of a point
    Ypoint: indicates the Y coordinate of a point
    Color: fill Color
    Dot_Pixel: The size of the dot, providing a default of eight size poin
ts
        typedef enum {
                DOT_PIXEL_1X1  = 1,             // 1 x 1
                DOT_PIXEL_2X2  ,                // 2 X 2
                DOT_PIXEL_3X3  ,                // 3 X 3
                DOT_PIXEL_4X4  ,                // 4 X 4
                DOT_PIXEL_5X5  ,                // 5 X 5
                DOT_PIXEL_6X6  ,                // 6 X 6
                DOT_PIXEL_7X7  ,                // 7 X 7
                DOT_PIXEL_8X8  ,                // 8 X 8
        } DOT_PIXEL;
    Dot_Style: the size of a point that expands from the center of the poi
nt or from the bottom left corner of the point to the right and up
        typedef enum {
                DOT_FILL_AROUND  = 1,
                DOT_FILL_RIGHTUP,
        } DOT_STYLE;
```

- Line drawing: In the image buffer, line from (Xstart, Ystart) to (Xend, Yend), you can choose the color, line width, line style.

```
void Paint_DrawLine(UWORD Xstart, UWORD Ystart, UWORD Xend, UWORD Yend, UW
ORD Color, LINE_STYLE Line_Style ,  LINE_STYLE Line_Style)
Parameters:
        Xstart: the x-starting coordinate of a line
        Ystart: indicates the Y starting point of a line
        Xend: x-terminus of a line
        Yend: the y-end coordinate of a line
        Color: fill Color
        Line_width: The width of the line, which provides a default of eig
ht widths
                typedef enum {
                        DOT_PIXEL_1X1  = 1,             // 1 x 1
                        DOT_PIXEL_2X2  ,                // 2 X 2
                        DOT_PIXEL_3X3  ,                // 3 X 3
                        DOT_PIXEL_4X4  ,                // 4 X 4
                        DOT_PIXEL_5X5  ,                // 5 X 5
                        DOT_PIXEL_6X6  ,                // 6 X 6
                        DOT_PIXEL_7X7  ,                // 7 X 7
                        DOT_PIXEL_8X8  ,                // 8 X 8
                    } DOT_PIXEL;
        Line_Style: line style. Select whether the lines are joined in a s
traight or dashed way
                typedef enum {
                        LINE_STYLE_SOLID = 0,
                        LINE_STYLE_DOTTED,
                } LINE_STYLE;
```

- Draw a rectangle: In the image buffer, draw a rectangle from (Xstart, Ystart) to (Xend, Yend), you can choose the color, the width of the line, and whether to fill the inside of the rectangle.

```
void Paint_DrawRectangle(UWORD Xstart, UWORD Ystart, UWORD Xend, UWORD Yen
d, UWORD Color, DOT_PIXEL Line_width,  DRAW_FILL Draw_Fill)
Parameters:
        Xstart: the starting X coordinate of the rectangle
        Ystart: indicates the Y starting point of the rectangle
        Xend: X terminus of the rectangle
        Yend: specifies the y-end coordinate of the rectangle
        Color: fill Color
        Line_width: The width of the four sides of a rectangle. Default ei
ght widths are provided
        typedef enum {
                DOT_PIXEL_1X1  = 1,             // 1 x 1
                DOT_PIXEL_2X2  ,                // 2 X 2
                DOT_PIXEL_3X3  ,                // 3 X 3
                DOT_PIXEL_4X4  ,                // 4 X 4
                DOT_PIXEL_5X5  ,                // 5 X 5
                DOT_PIXEL_6X6  ,                // 6 X 6
                DOT_PIXEL_7X7  ,                // 7 X 7
                DOT_PIXEL_8X8  ,                // 8 X 8
        } DOT_PIXEL;
        Draw_Fill: Fill, whether to fill the inside of the rectangle
        typedef enum {
                DRAW_FILL_EMPTY = 0,
                DRAW_FILL_FULL,
        } DRAW_FILL;
```

- Draw circle: In the image buffer, draw a circle of Radius with (X_Center Y_Center) as the center. You can choose the color, the width of the line, and whether to fill the inside of the circle.

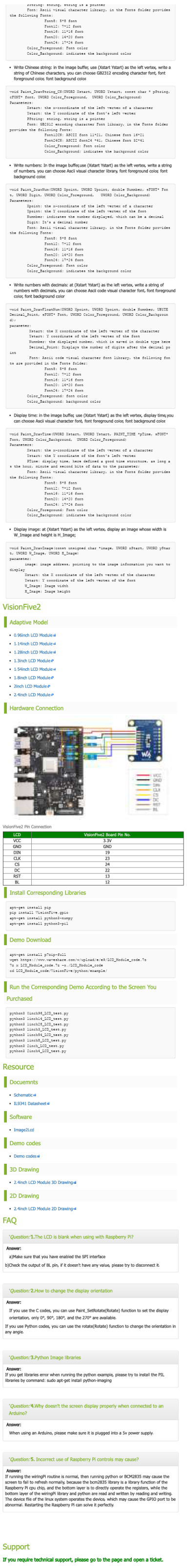
```
void Paint_DrawCircle(UWORD X_Center, UWORD Y_Center, UWORD Radius, UWORD
Color, DOT_PIXEL Line_width,  DRAW_FILL Draw_Fill)
Parameters:
        X_Center: the x-coordinate of the center of a circle
        Y_Center: Y coordinate of the center of a circle
        Radius: indicates the Radius of a circle
        Color: fill Color
        Line_width: The width of the arc, with a default of 8 widths
        typedef enum {
                DOT_PIXEL_1X1  = 1,             // 1 x 1
                DOT_PIXEL_2X2  ,                // 2 X 2
                DOT_PIXEL_3X3  ,                // 3 X 3
                DOT_PIXEL_4X4  ,                // 4 X 4
                DOT_PIXEL_5X5  ,                // 5 X 5
                DOT_PIXEL_6X6  ,                // 6 X 6
                DOT_PIXEL_7X7  ,                // 7 X 7
                DOT_PIXEL_8X8  ,                // 8 X 8
        } DOT_PIXEL;
        Draw_Fill: fill, whether to fill the inside of the circle
        typedef enum {
                DRAW_FILL_EMPTY = 0,
                DRAW_FILL_FULL,
        } DRAW_FILL;
```

- Write Ascii character: In the image buffer, at (Xstart Ystart) as the left vertex, write an Ascii character, you can select Ascii visual character library, font foreground color, font background color.

```
void Paint_DrawChar(UWORD Xstart, UWORD Ystart, const char Ascii_Char, sFO
NT* Font, UWORD Color_Foreground,  UWORD Color_Background)
Parameters:
        Xstart: the x-coordinate of the left vertex of a character
        Ystart: the Y coordinate of the font's left vertex
        Ascii_Char: indicates the Ascii character
        Font: Ascii visual character library, in the Fonts folder provides
the following Fonts:
                Font8: 5*8 font
                Font12: 7*12 font
                Font16: 11*16 font
                Font20: 14*20 font
                Font24: 17*24 font
        Color_Foreground: Font color
        Color_Background: indicates the background color
```

- Write English string: In the image buffer, use (Xstart Ystart) as the left vertex, write a string of English characters, can choose Ascii visual character library, font foreground color, font background color.

```
void Paint_DrawString_EN(UWORD Xstart, UWORD Ystart, const char * pString,
sFONT* Font, UWORD Color_Foreground,  UWORD Color_Background)
Parameters:
        Xstart: the x-coordinate of the left vertex of a character
        Ystart: the Y coordinate of the font's left vertex
        PString: string, string is a pointer
```



```
        PString: string, string is a pointer
        Font: Ascii visual character library, in the Fonts folder provides
the following Fonts:
                Font8: 5*8 font
                Font12: 7*12 font
                Font16: 11*16 font
                Font20: 14*20 font
                Font24: 17*24 font
        Color_Foreground: Font color
        Color_Background: indicates the background color
```

- Write Chinese string: in the image buffer, use (Xstart Ystart) as the left vertex, write a string of Chinese characters, you can choose GB2312 encoding character font, font foreground color, font background color

```
void Paint_DrawString_CN(UWORD Xstart, UWORD Ystart, const char * pString,
cFONT* font, UWORD Color_Foreground,  UWORD Color_Background)
Parameters:
        Xstart: the x-coordinate of the left vertex of a character
        Ystart: the Y coordinate of the font's left vertex
        PString: string, string is a pointer
        Font: GB2312 encoding character Font library, in the Fonts folder
provides the following Fonts:
                Font12CN: ASCII font 11*21, Chinese font 16*21
                Font24CN: ASCII font24 *41, Chinese font 32*41
                Color_Foreground: Font color
                Color_Background: indicates the background color
```

- Write numbers: In the image buffer,use (Xstart Ystart) as the left vertex, write a string of numbers, you can choose Ascii visual character library, font foreground color, font background color.

```
void Paint_DrawNum(UWORD Xpoint, UWORD Ypoint, double Nummber, sFONT* Fon
t, UWORD Digit, UWORD Color_Foreground,   UWORD Color_Background)
Parameters:
        Xpoint: the x-coordinate of the left vertex of a character
        Ypoint: the Y coordinate of the left vertex of the font
        Nummber: indicates the number displayed, which can be a decimal
        Digit: It's a decimal number
        Font: Ascii visual character library, in the Fonts folder provides
the following Fonts:
                Font8: 5*8 font
                Font12: 7*12 font
                Font16: 11*16 font
                Font20: 14*20 font
                Font24: 17*24 font
        Color_Foreground: Font color
        Color_Background: indicates the background color
```

- Write numbers with decimals: at (Xstart Ystart) as the left vertex, write a string of numbers with decimals, you can choose Ascii code visual character font, font foreground color, font background color

```
void Paint_DrawFloatNum(UWORD Xpoint, UWORD Ypoint, double Nummber, UBYTE
Decimal_Point, sFONT* Font, UWORD Color_Foreground, UWORD Color_Backgroun
d);
parameter:
         Xstart: the X coordinate of the left vertex of the character
         Ystart: Y coordinate of the left vertex of the font
         Nummber: the displayed number, which is saved in double type here
         Decimal_Point: Displays the number of digits after the decimal po
int
         Font: Ascii code visual character font library, the following fon
ts are provided in the Fonts folder:
                Font8: 5*8 font
                Font12: 7*12 font
                Font16: 11*16 font
                Font20: 14*20 font
                Font24: 17*24 font
        Color_Foreground: font color
        Color_Background: background color
```

- Display time: in the image buffer, use (Xstart Ystart) as the left vertex, display time,you can choose Ascii visual character font, font foreground color, font background color.

```
void Paint_DrawTime(UWORD Xstart, UWORD Ystart, PAINT_TIME *pTime, sFONT*
Font, UWORD Color_Background,  UWORD Color_Foreground)
Parameters:
        Xstart: the x-coordinate of the left vertex of a character
        Ystart: the Y coordinate of the font's left vertex
        PTime: display time, here defined a good time structure, as long a
s the hour, minute and second bits of data to the parameter;
        Font: Ascii visual character library, in the Fonts folder provides
the following Fonts:
                Font8: 5*8 font
                Font12: 7*12 font
                Font16: 11*16 font
                Font20: 14*20 font
                Font24: 17*24 font
        Color_Foreground: Font color
        Color_Background: indicates the background color
```

- Display image: at (Xstart Ystart) as the left vertex, display an image whose width is W_Image and height is H_Image;

```
void Paint_DrawImage(const unsigned char *image, UWORD xStart, UWORD yStar
t, UWORD W_Image, UWORD H_Image)
parameter:
       image: image address, pointing to the image information you want to
display
       Xstart: the X coordinate of the left vertex of the character
       Ystart: Y coordinate of the left vertex of the font
       W_Image: Image width
       H_Image: Image height
```

VisionFive2

Adaptive Model

- 0.96inch LCD Module
- 1.14inch LCD Module
- 1.28inch LCD Module
- 1.3inch LCD Module
- 1.54inch LCD Module
- 1.8inch LCD Module
- 2inch LCD Module
- 2.4inch LCD Module

Hardware Connection

VisionFive2 Pin Connection

LCD	VisionFive2 Board Pin No.
VCC	3.3V
GND	GND
DIN	19
CLK	23
CS	24
DC	22
RST	13
BL	12

Install Corresponding Libraries

```
apt-get install pip
pip install VisionFive.gpio
apt-get install python3-numpy
apt-get install python3-pil
```

Demo Download

```
apt-get install p7zip-full
wget https://www.waveshare.com/w/upload/e/e9/LCD_Module_code.7z
7z x LCD_Module_code.7z -o./LCD_Module_code
cd LCD_Module_code/VisionFive/python/example/
```

Run the Corresponding Demo According to the Screen You Purchased

```
python3 0inch96_LCD_test.py
python3 1inch14_LCD_test.py
python3 1inch28_LCD_test.py
python3 1inch3_LCD_test.py
python3 1inch54_LCD_test.py
python3 1inch8_LCD_test.py
python3 2inch_LCD_test.py
python3 2inch4_LCD_test.py
```

Resource

Docuemnts

- Schematic
- IL9341 Datasheet

Software

- Image2Lcd

Demo codes

- Demo codes

3D Drawing

- 2.4inch LCD Module 3D Drawing

2D Drawing

- 2.4inch LCD Module 2D Drawing

FAQ

'*Question:*'1.The LCD is blank when using with Raspberry Pi?

Answer:

a)Make sure that you have enabled the SPI interface

b)Check the output of BL pin, if it doesn't have any value, please try to disconnect it.

'*Question:*'2.How to change the display orientation

Answer:

If you use the C codes, you can use Paint_SetRotate(Rotate) function to set the display orientation, only 0°, 90°, 180°, and the 270° are available.

If you use Python codes, you can use the rotate(Rotate) function to change the orientation in any angle.

'*Question:*'3.Python Image libraries

Answer:

If you get libraries error when running the python example, please try to install the PIL libraries by command: sudo apt-get install python-imaging

'*Question:*'4.Why doesn't the screen display properly when connected to an Arduino?

Answer:

When using an Arduino, please make sure it is plugged into a 5v power supply.

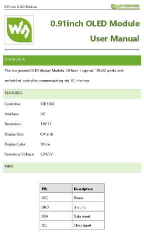
'*Question:*'5. Incorrect use of Raspberry Pi controls may cause?

Answer:

If running the wiringPi routine is normal, then running python or BCM2835 may cause the screen to fail to refresh normally, because the bcm2835 library is a library function of the Raspberry Pi cpu chip, and the bottom layer is to directly operate the registers, while the bottom layer of the wiringPi library and python are read and written by reading and writing. The device file of the linux system operates the device, which may cause the GPIO port to be abnormal. Restarting the Raspberry Pi can solve it perfectly.

Support

If you require technical support, please go to the page and open a ticket.



0.91inch OLED Module

0.91inch OLED Module User Manual

OVERVIEW

This is a general OLED display Module, 0.91inch diagonal, 128x32 pixels, with embedded controller, communicating via I2C interface.

FEATURES

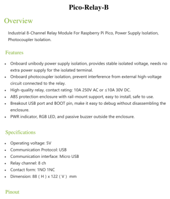
Controller:	SSD1306
Interface:	I2C
Resolution:	128*32
Display Size:	0.91inch
Display Color:	White
Operating Voltage:	2.2V/5V

PINS

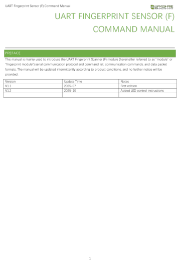
PIN	Description
VCC	Power
GND	Ground
SDA	Data input
SCL	Clock input

0.91inch OLED Module User Manual - Waveshare

User manual for the Waveshare 0.91inch OLED Module (128x32 pixels) with SSD1306 controller. Covers overview, features, pinout, I2C communication, and demo code for STM32, Raspberry Pi (BCM2835, WiringPi, Python), and Arduino.

 Raspberry Pi Industrial 8-Channel Relay Module for Raspberry Pi ico, Multi Protection User Manual Raspberry Pi Pico Header Compatibility: Onboard Female Pin Header for Direct Attaching to Raspberry Pi Pico Enclosure Design: ABS Protection Enclosure with Rail-Mount Support, Easy to Install, Safe to Use	[Waveshare Industrial 8-Channel Relay Module for Raspberry Pi Pico User Manual] User manual for the Waveshare Industrial 8-Channel Relay Module for Raspberry Pi Pico (Pico-Relay-B). Details features, compatibility, enclosure, and pinout for industrial control applications.
 Pico-Relay-B Overview Industrial 8-Channel Relay Module For Raspberry Pi Pico, Power Supply Isolation, Photocoupler Isolation. Features • Onboard unibody power supply isolation, provides stable isolated voltage, needs no extra power supply for the isolated terminal. • Onboard photocoupler isolation, prevent interference from external high-voltage circuit connected to the relay. • High-quality relay, contact rating: 10A 250V AC or ≤10A 30V DC. • ABS protection enclosure with rail-mount support, easy to install, safe to use. • Breakout USB port and BOOT pin, make it easy to debug without disassembling the enclosure. • PWR indicator, RGB LED, and passive buzzer outside the enclosure. Specifications • Operating voltage: 5V • Communication Protocol: USB • Communication interface: Micro USB • Relay channel: 8 ch • Contact form: 1NO 1NC • Dimension: 88 (H) x 122 (V) mm Pinout	[Pico-Relay-B: 8-Channel Relay Module User Guide] User guide for the Waveshare Pico-Relay-B, an industrial 8-channel relay module for Raspberry Pi Pico. Learn about its features, specifications, setup, and programming with detailed instructions and examples.

IMX219-170 Camera
IMX219 Camera, 800 megapixels and 170 FOV. Compatible with Jetson nano. You can also use it with CM3/CM3+ expansion boards like Raspberry Pi Compute Module IO board, Compute Module IO Board Plus, Compute Module POE Board of Waveshare and the StereoPi board.
Test with Jetson Nano
Hardware connection
• Connect the camera to CSI interface of Jetson Nano.Set the metal side of FFC into Heat-sink
• Connect an HDMI LCD to Jetson Nano
Software setting
• Power on Jetson Nano and open the Terminal (Ctrl+ALT+T)
• Test camera with command:
`DISPLAY=:0.0 gst-launch-1.0 nvarguscamerasrc ! 'video/x-raw(memory:NVMM), width=3280, height=2464, format=(string)NV12, framerate=(fraction)20/1' ! nvoverlaysink -e`
• Test dual-camera
• IF you want to test dual cameras with B01 Developer Kit.You can just add sensor-id=x to the pipeline. x can be 0 or 1.
`#test video0`
`DISPLAY=:0.0 gst-launch-1.0 nvarguscamerasrc sensor-id=0 ! 'video/x-raw(memory:NVMM), width=3280, height=2464, format=(string)NV12, framerate=(fraction)20/1' ! nvoverlaysink -e`
`#test video1`
`DISPLAY=:0.0 gst-launch-1.0 nvarguscamerasrc sensor-id=1 ! 'video/x-raw(memory:NVMM), width=3280, height=2464, format=(string)NV12, framerate=(fraction)20/1' ! nvoverlaysink -e`
• If you find that the image captured is reddish. You can try to download .isp file and installed:
`wget https://www.waveshare.com/w/upload/e/eb/Camera_overrides.tar.gz`
`tar zxvf Camera_overrides.tar.gz`
`sudo cp camera_overrides.isp /var/nvidia/nvcam/settings/`
`sudo chmod 664 /var/nvidia/nvcam/settings/camera_overrides.isp`
`sudo chown root:root /var/nvidia/nvcam/settings/camera_overrides.isp`
Test with Compute Module
The IMX219 series can be used with Compute Module series of Raspberry Pi with carriers. And the usage are same as other Raspberry Pi cameras
	[IMX219-170 Camera User Guide for Jetson Nano and Compute Module]
	A guide to using the IMX219-170 camera with Jetson Nano and Raspberry Pi Compute Modules, including hardware connection, software setup, and troubleshooting.

 UART Fingerprint Sensor (F) Command Manual WAVESHARE UART FINGERPRINT SENSOR (F) COMMAND MANUAL PREFACE This manual is mainly used to introduce the UART Fingerprint Scanner (F) module (hereinafter referred to as "module" or "fingerprint module") serial communication protocol and command list, communication commands, and data packet formats. The manual will be updated intermittently according to product conditions, and no further notice will be provided. Version | Update Time | Notes V1.1 | 2025-07 | First edition V1.2 | 2025-10 | Added LED control instructions 1	[WAVESHARE UART Fingerprint Sensor (F) Command Manual: Protocol and Command Reference] This manual details the serial communication protocol, command list, and data packet formats for the WAVESHARE UART Fingerprint Sensor (F) module. It serves as a comprehensive guide for developers integrating fingerprint recognition capabilities into their projects.