1.5inch OLED Module User Manual

OVERVIEW

This is a general OLED display module, 1.5inch diagonal, 128*128 pixels, 16-bit grey level, with embedded controller, communicating via SPI or I2C interface.

FEATURES

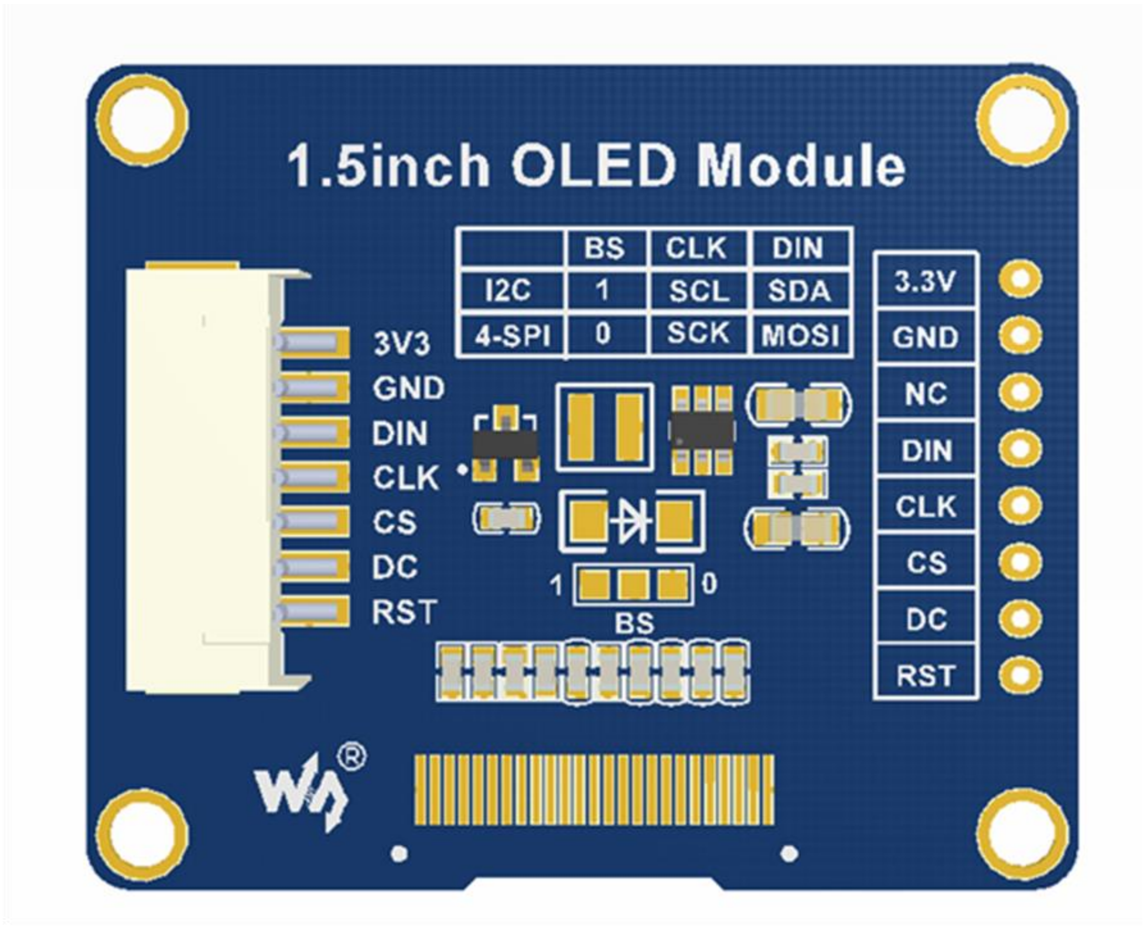
Driver:	SSD1327
Interface:	4-wire SPI/I2C
Pixels:	128*128
Display area:	1.5inch (diagonal)
Dimension:	44.5mm*37mm
Display color:	White (16-bit grey level)
Operating voltage:	3.3V/5V

INTERFACES

PIN	Description
VCC	3.3V/5V
GND	Ground
DIN	Data Input
CLK	Clock
CS	Chip Selection
DC	Data/Command Selection
RST	Reset

HARDWARE CONFIGURATION

This OLED module supports two drive interfaces: 4-wire SPI and I2C interface. On the backside, there is a welding resistor, users can change the communicating interface by change this welding resistor.



By default, the module is in 4-wire SPI communication mode, that is the BS is connected to 0. Not all the 0 and 1 stands for level, it just stands for the connecting options of the resister. The actual hardware connection for different communication mode is as below:

	BS	CS	D/C	DIN	CLK
4-wire SPI	0	Chip Selection	D/C	MOSI	SCK
I2C	1	NC	0/1	SDA	SCL

Description:

4-wires SPI (factory setting): BS (0) is connected to ground. In this mode, DIN is connected to MOSI and the CLK is connected to SCK.

I2C: BS (1) is connected to VCC. In this mode, DIN is connected to SDA and the CLK is connected to SCL. The CS pin can be dangling. The pin DC must be connected to 0 or 1, it is used to configure the slave address of I2C device, 1 (High) configures the address of OLED to 0x3D and 0 set it as 0x3C.

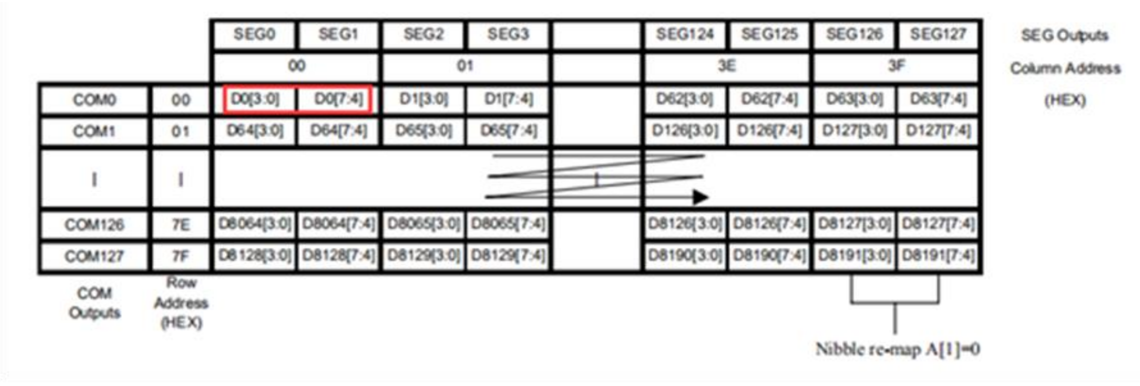
WORDING PRINCIPLE

1. Working principle

SSD1327 is a controller for 128*128 OLED display, and the module embeds this controller. The controller supports 16-bit grey level picture display as well.

The OLED supports 8-bit 8080 and 8-bit 6800 parallel control, it also supports 3-wire SPI, 4-wires SPI and I2C control. Parallel interface requires too much IO pin and the 3-wire is less used, so this module we use 4-wires SPI and I2C interface for communication.

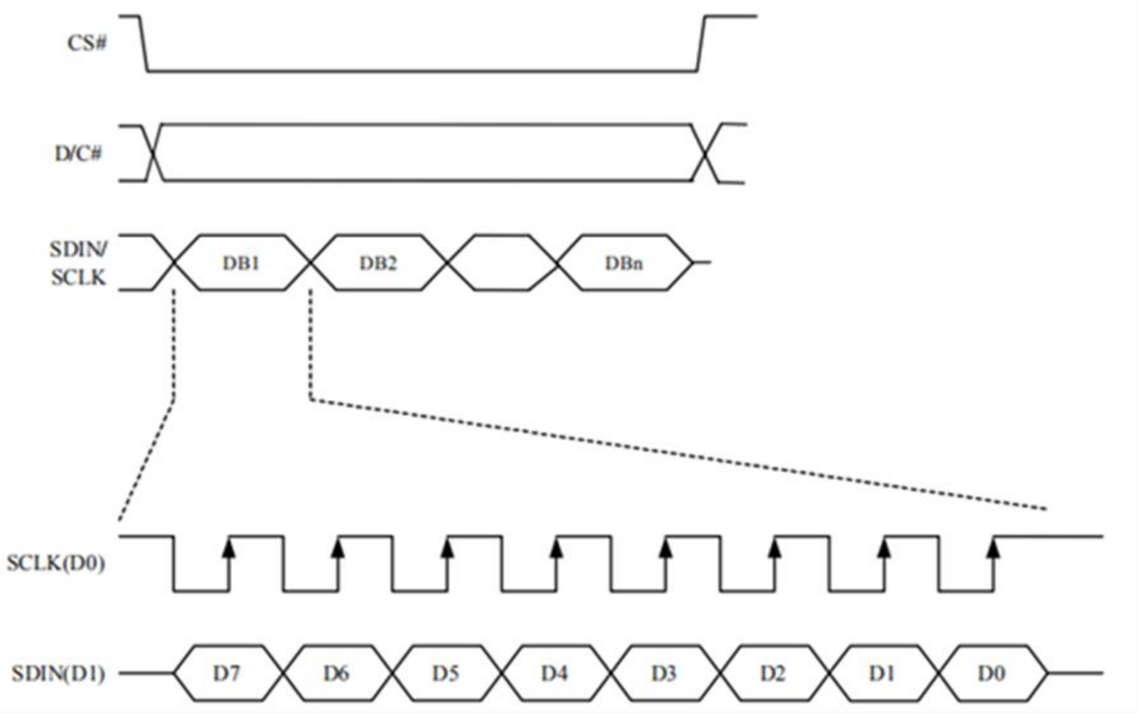
The drive controller support 16-bit grey level display. 16-bit grey level is controlled by 4 bits. In hardware, two pixels controlled by one byte, so it will be most simple that the controller scans pixels horizontally. (For detailed information please visit the datasheet: Page30)



		SEG0	SEG1	SEG2	SEG3		SEG124	SEG125	SEG126	SEG127	SEG Outputs
		00		01			3E		3F		Column Address (HEX)
COM0	00	D0[3:0]	D0[7:4]	D1[3:0]	D1[7:4]		D62[3:0]	D62[7:4]	D63[3:0]	D63[7:4]	
COM1	01	D64[3:0]	D64[7:4]	D65[3:0]	D65[7:4]		D126[3:0]	D126[7:4]	D127[3:0]	D127[7:4]	
I	I										
COM126	7E	D8064[3:0]	D8064[7:4]	D8065[3:0]	D8065[7:4]		D8126[3:0]	D8126[7:4]	D8127[3:0]	D8127[7:4]	
COM127	7F	D8128[3:0]	D8128[7:4]	D8129[3:0]	D8129[7:4]		D8190[3:0]	D8190[7:4]	D8191[3:0]	D8191[7:4]	
COM Outputs	Row Address (HEX)										

Nibble re-map A[1]=0

2. SPI Communication Protocol



Note: The difference between the traditional is that: the OLED only supports display, so we only require the data input (MCU to module) and hide the data line that sends data from slave device to master (MISO). The table can be get at Datasheet Page 21.

CS# Chip selection. The chip only be enable when the CS is Low.

D/C# Data/Command control pin. DC=0: commands is sent; DC=1: data is sent.

SDIN: The data transmitted (image data)

SCLK: SPI clock

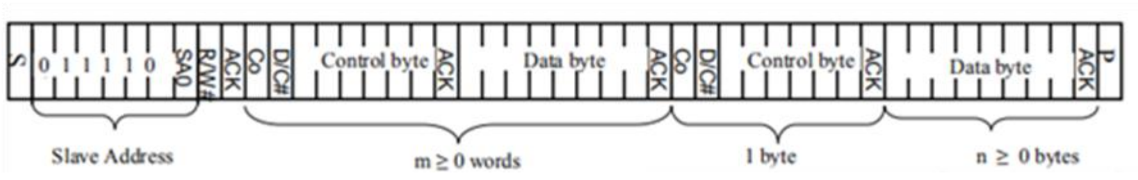
The timing of SPI is composed of CPHA and CPOL. The timing controls the data transmission of SPI communication.

CPOL (Clock polarity): Controls the steady state value of the clock when no data is transferred. CPOL=0, SCK pin is low at idle state.

CPHA (Clock phase): Control when the first data is captured, at the first edge or the second edge. CPHA=0, data is captured at the first edge.

The combination of CPOL and CPHA are the four communication modes of SPI. We generally use SPI0, that is CPHA=0, CPOL=0.

3. I2C Communication Protocol



For detailed information, please visit Datasheet Page 23

First, transfer 7-bits address of slave device plus 1-bit read/write bit. Then waiting for response from slave device. It is similar to most of I2C communication. Users can control the DC pin to change the address of slave device.

Second, transfer 1-bit data bit plus 1-bit command control bit plus 6-bits control byte. The most important is the command control bit. If the bit is set 0, it means the data transferred is command, and if it is set 1, data will be transmitted.

Finally, 8-bits data is transferred.

Note: OLED data cannot be read when the controller communicating via serial port for.

HOW TO USE

We provide STM32, Arduino and Raspberry Pi (BCM2835, WiringPi and Python) demo code. The OLED can be used to:

1. Drawing point, line, figures and circles. And can set their size, solid/dashed, linewidth, full or nor, etc.
2. Supports English characters display and provide five common fonts
3. Support display Bitmap and 16-bit grey level images.

STM32

1. Hardware connection (Based on XNUCLEO-F103RB)

PIN	XNUCLEO-F103RB
VCC	3V3/5V
GND	GND
DIN	PA7
CLK	PA5
CS	PB6
DC	PA8
RST	PA9

2. Files description

Under the folder /User/Fonts of project, there are five fonts provided

Under the folder /User/OLED of project, there are:

DEV_Config.c: Define the GPIOs used and the communication type.
OLED_Driver.c: Drive code of OLED.
OLED_GUI.c: Provide drawing functions and display functions.

3. Using

It defines two macros in DEV_Config.h: USE_SPI_4W and USE_IIC. If use I2C interface, you need to set USE_IIC as 1 and USE_SPI_4W as 0; Otherwise, set USE_IIC as 0 and USE_SPI_4W as 1.

4. Expected result

Download the code and reset board, relative information are printed via UART interface, and the OLED will display figures for 2s after a full refresh. Then display bitmap, 16-bits grayscale and finally display time.

ARDUINO

1. Hardware connection (Based on UNO PLUS)

PIN	UNO PLUS
VCC	3V3/5V
GND	GND
DIN	11
CLK	13
CS	10
DC	7
RST	8

2. Files description

Two kinds of examples are provided: EXT_RAM and INI_RAM. In INI_RAM project, it use internal RAM of Arduino and the EXT_RAM project use external SRAM (23K256).

Note: If you EXT_RAM, you need to buy an SRAM module and connect to Arduino separately. SRAM module is not included in our product.

/Fonts: Provide five common fonts. You need to copy this folder to the libraries directory of Arduino IDE.

/OLED:

DEV_Config.cpp: Defines the GPIOs and communication type.
OLED_Driver.cpp: Drive code of OLED
OLED_GUI.cpp: Functions for GUI drawing and displaying.
SPI_RAM.cpp: Because of the little flash of Arduino, we use an external SRAM as buffer.

3. Using

Configure the communication type:

It defines two macros in DEV_Config.h: USE_SPI_4W and USE_IIC. If use I2C interface, you need to set USE_IIC as 1 and USE_SPI_4W as 0; Otherwise, set USE_IIC as 0 and USE_SPI_4W as 1.

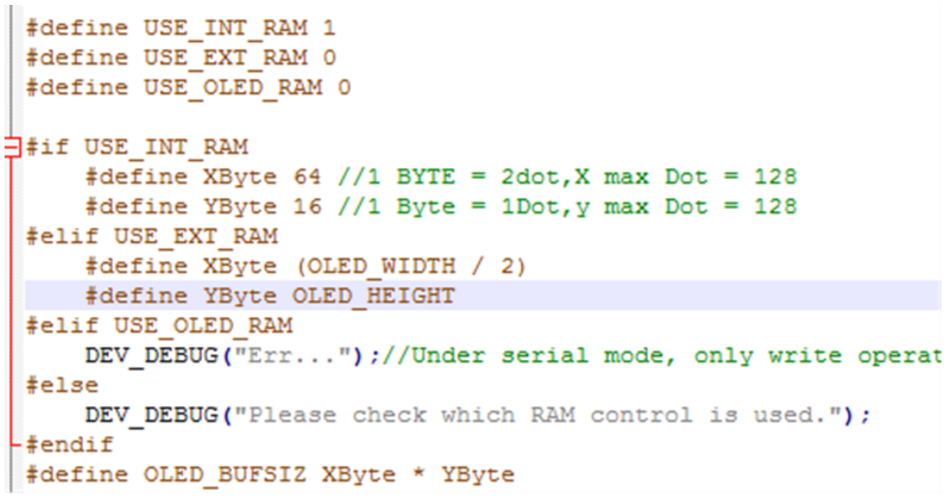
Configure RAM:

Three macros are used to configure the control type, they are separately set for use internal RAM of MCU, use external RAM and use the RAM of OLED:

#define USE_INT_RAM 1

#define USE_EXT_RAM 0

#define USE_OLED_RAM 0



```
#define USE_INT_RAM 1
#define USE_EXT_RAM 0
#define USE_OLED_RAM 0

#if USE_INT_RAM
    #define XByte 64 //1 BYTE = 2dot,X max Dot = 128
    #define YByte 16 //1 Byte = 1Dot,y max Dot = 128
#elif USE_EXT_RAM
    #define XByte (OLED_WIDTH / 2)
    #define YByte OLED_HEIGHT
#elif USE_OLED_RAM
    DEV_DEBUG("Err...");//Under serial mode, only write operat
#else
    DEV_DEBUG("Please check which RAM control is used.");
#endif
#define OLED_BUFSIZ XByte * YByte
```

The sizes of internal RAM are different among different Arduino board:

The sample code we provided is based on UNO, so the OLED_BUFSIZ is only 64*16 bytes, about 1K. However, if you want to full display, it requires about 8K OLED_BUFSIZ.

If use external RAM, you just need to set USE_EXT_RAM as 1 and others as 0.

The OLED RAM is unavailable for this module. Because that when the OLED use serial communication, data on its buffer cannot be read. It is defined here to compatible with other OLED.

4. Expected result

Download the code and reset board, relative information are printed via UART interface, and the OLED will display figures for 2s after a full refresh. Then display bitmap, 16-bits grayscale and finally display time.

RAPSBERRY PI

1. Hardware Connection

1.5inch OLED	Raspberry Pi
VCC	3.3V/5V
GND	GND
DIN	MOSI
CLK	SCK
CS	CE0
DC	24 (BCM)

RST	25 (BCM)

2. Enable communication interfaces of Pi

sudo raspi-config

If you use SPI interface (by default):
Choose Interface Options -> SPI -> yes to enable the SPI

If you use I2C interfae:
Choose Interface Options -> I2C -> yes to enable I2C

3. Libraries installation

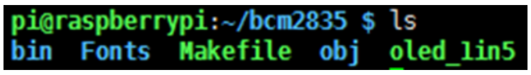
About how to install libraries for Raspberry Pi code, please visit this page: Libraries_Installation_for_RPi. The wiki page describe about how to install libraries for BCM2835, WiringPi and Python.

4. Using

Copy the Raspberry Pi sample codes to your Raspberry Pi (you can use samba or directly copy to the boot folder of SD card). The codes we describe below are all be copy to the user directory of pi.

4.1 BM2835

Execute command ls:



```
pi@raspberrypi:~/bcm2835 $ ls
bin  Fonts  Makefile  obj  oled_1in5
```

bin: Include the .o files
Fonts: Include five fonts files
Obj: Object files are contained

main.c: main functions file

DEV_Config.c: defines the GPIOs of Pi and the communication type. If you have changed the communication mode followed the Hardware Configuration above, you just need to modify the USE_SPI_4W and USE_IIC macros in the header file.

OLED_Driver.c: drive codes of OLED

OLED_GUI.c: functions of drawing and displaying.

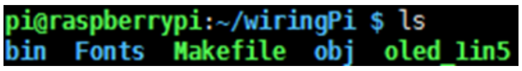
Makefile: make file of project. If you have changed the codes, you need to execute command **make clear** to delete the dependent files and executable files which generated before. Then execute **make** to generate new files.

oled_1in5: Executable file, generated by command **make**.

You can run the sample code by command: **sudo ./oled_1in5**

4.2 WiringPi

Execute command ls:



```
pi@raspberrypi:~/wiringPi $ ls
bin  Fonts  Makefile  obj  oled_1in5
```

The folder catalog of WiringPi is same as BCM2835. Their difference are that:

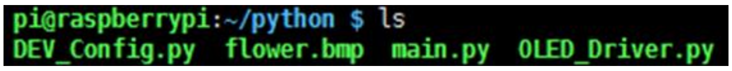
1. WiringPi oprates by read/write the device files of Linux OS. and the bcm2835 is library function of Raspberry Pi's CPU, it operates registers directly. Thus, if you have used bcm2835 libraries firstly, the usage of WiringPi code will be failed. In this case, you just need to reboot the system and try again.

2. Due to the first difference, they underlying configuration are different. In DEV_Config.c, use wiringpiPi and the corresponding wiringPiSPI to provide underlay interfaces.

User command **sudo ./oled_1in5** to run the code.

4.3 Python

Execute command ls:



```
pi@raspberrypi:~/python $ ls
DEV_Config.py  flower.bmp  main.py  OLED_Driver.py
```

DEV.Config.py: Hardware pin defined here, change USE_SPI_4W and USE_I2C to switch the communication mode.

OLED.Driver.py: Drive code of OLED

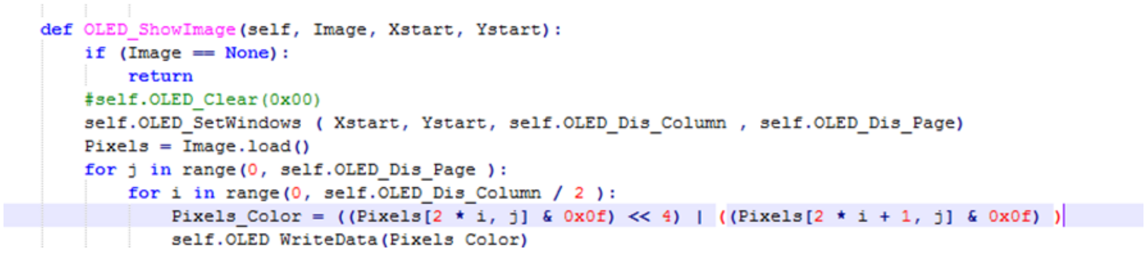
main.py: main function, use Image libraries.

Run codes: sudo python main.py

<u>**Note**</u>: Some of Raspbian has no image libraries, in this case, you can run this command to install it: sudo apt-get install python-imaging

Image is an image handle library of python, it uses an image object to express an image. Use new to create a blank image, set the size as resolution of OLED, and calling Draw libraries to paint it, finally transmit the image data to OLED to display.

Image.new("L", (OLED.OLED_Dis_Column, OLED.OLED_Dis_Page), 0); "L" is grayscale.



```
def OLED_ShowImage(self, Image, Xstart, Ystart):
    if (Image == None):
        return
    #self.OLED_Clear(0x00)
    self.OLED_SetWindows ( Xstart, Ystart, self.OLED_Dis_Column , self.OLED_Dis_Page)
    Pixels = Image.load()
    for j in range(0, self.OLED_Dis_Page ):
        for i in range(0, self.OLED_Dis_Column / 2 ):
            Pixels_Color = ((Pixels[2 * i, j] & 0x0f) << 4) | ((Pixels[2 * i + 1, j] & 0x0f) )
            self.OLED WriteData(Pixels Color)
```

For python, you can use open function to open an image instead of converting to arrays. Please set the image to 16-bit grayscale and make sure the size of image doesn't larger than the resolution.

4.4 Auto-run after booting.

Initialize auto run in Raspberry Pi by configuring code of /etc/rc.local file:

sudo vim /etc/rc.local

Before exit0 add:

sudo python /home/pi/python/demo.py &

Important: to place the program /home/pi/python/demo.py at the same director, you can input command pwd to get the path. And & character is necessary at the end of command line, otherwise probable need to reinstall the system (impossible terminate the process by pressing ctrl+c, impossible to login with pi user permission).

CONVERT IMAGE TO ARRAYS

1. Convert Image data

Open 16-bit grayscale by Image2Lcd software, and set:

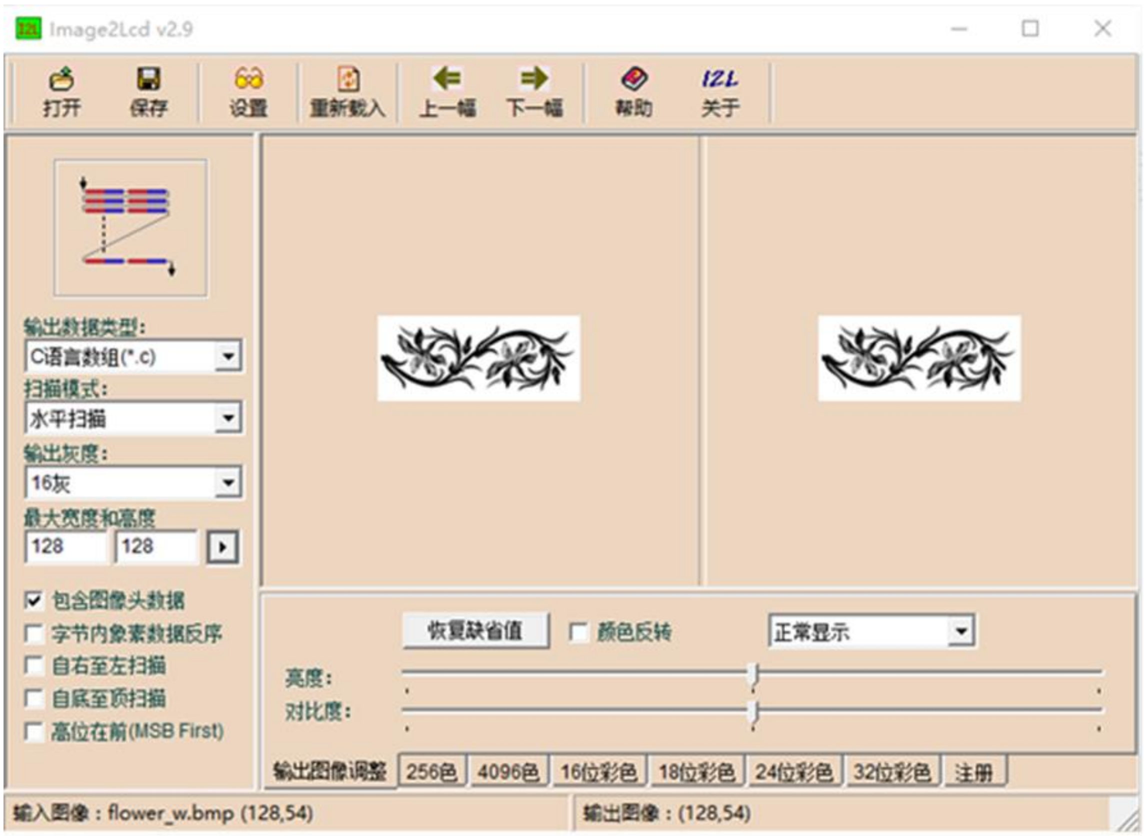
输出数据类型（Output data type）: C 语言数组（*.c）

扫描方式 （Scanning type）: 水平扫描（horizontal scanning）

输出灰度（Output grey level）: 16 灰 (16-bit grey level)

最大宽度和高度（The max width and height）:128 128 （The resolution of OLED）

Then check the option 包含图像头数据（Contain Header）. The header is required while analyze image data.



输出数据类型: C语言数组(*.c)
扫描模式: 水平扫描
输出灰度: 16灰
最大宽度和高度 128 128
[✓] 包含图像头数据
[ ] 字节内象素数据反序
[ ] 自右至左扫描
[ ] 自底至顶扫描
[ ] 高位在前(MSB First)
[ ] 颜色反转
正常显示
输入图像：flower_w.bmp (128,54)
输出图像：(128,54)

2. Analyzing header of image

For 16-bit grayscale image, the header likes that:

```
typedef struct _HEADGRAY
{
    unsigned char scan;
    unsigned char gray;
    unsigned short w;
```

unsigned short h;

}HEADGRAY;

It is totally 6 bytes:

The first byte defines the scanning way:

Bit7: 0: from left to right; 1: from right to left

Bit6: 0: from top to bottom; 1: from bottom to top

Bit5: 0: the pixels in the byte are ordered by DESC; 1: the pixels in the byte are ordered by ASC

Bit4: 0: The byte order of WORD type is same as PC; 1: The byte order of WORD type is contrary to PC

Bit3-2: Reserved

Bit1-0: [00]: Horizontal Scanning; [01]: Vertical Scanning; [10]: Data horizontal and Bytes Vertical; [11]: Data vertical and Bytes horizontal

The second byte is the value of gray level:

1: monochrome

2: 4-bits grayscale

4: 16-bits grayscale

8: 256 color

12: 4096 color

16: 16-bits multicolor

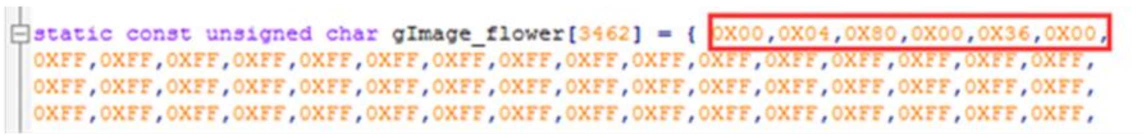
24: 24-bits multicolor

32: 32-bits multicolor

And the rest is the width and height of the image.

For example:

The header we used on the sample code is that:



```
static const unsigned char gImage_flower[3462] = { 0X00,0X04,0X80,0X00,0X36,0X00,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
```

We could get the information: Scanning from left to right, 16-bits grayscale. The width and height of image are 128 and 54 separatelly.