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Application Note FAN3203

Using External Power Supply for Graphic LCDs

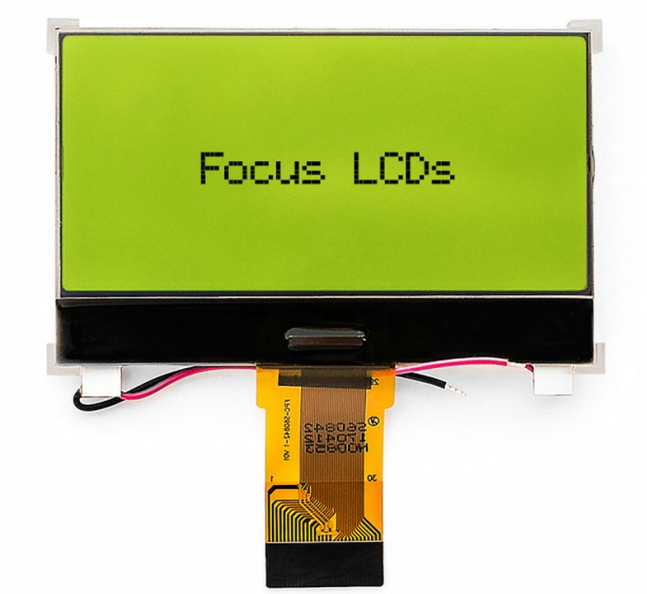
This application note will discuss how to connect an external power source to drive the Liquid Crystal segments on the display. This will forgo the use of the internal voltage boosting circuits. Many graphic LCD's will offer embedded analog power supply circuits to regulate the Liquid Crystal driving parameters. The display in this application G126GLGFYSY6WT is a 128x64 pixel graphic LCD.

Using External Power Supply for Graphic LCDs

Many graphic LCD's will offer embedded analog power supply circuits to regulate the Liquid Crystal driving parameters. The standard power circuits found in these LCD drivers are Booster, Regulator and Follower. It is often recommended to use an external power supply instead of the voltage boosting circuit for larger displays.

This application note will discuss how to connect an external power source to drive the Liquid Crystal segments on the display. This will forgo the use of the internal voltage boosting circuits. It is recommended that the voltage regulator and voltage following circuits be used in conjunction with the external power source.

The display in this application G126GLGFYSY6WT is a 128x64 pixel graphic LCD. The details of this display are as follows: (data sheet)



- 30 pins, 72x46x4.2mm
- 128x64 pixels, FSTN
- LCD Driver: ST7565P
- Yellow/Green Backlight
- Transflective (Positive)
- Serial and Parallel interfaces
- Viewing Angle: 6:00

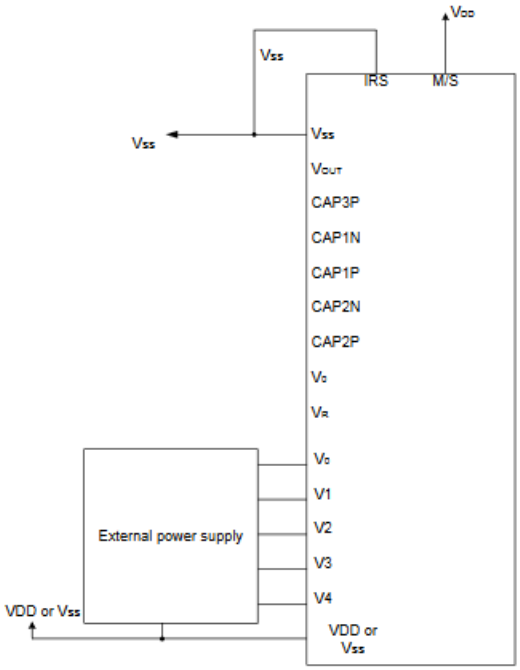


Figure 1: External Power without use of Embedded Power Circuits

It is necessary to provide the LCD driver 9.60 V to operate. This can be done with the voltage boosting circuit or by providing 9.60 V directly to the V0-V4 inputs (*Figure 1*). This approach excludes the booster, regulator and follower circuits. The voltage boosting circuit and the capacitors C1-C3 (positive and negative) can be removed and left open. It is important to note that the voltages V0-V4 must maintain the relative magnitudes as shown below:

$$V0 \geq V1 \geq V2 \geq V3 \geq V4 \geq Vss$$

While these conditions can be met by applying different voltages to each of the (V0-V4) terminals, as seen in *Figure 1*, it is recommended to use the on-chip voltage follower circuit to change the impedance to provide these voltages (V1-V4) internally. The voltage V0 is produced by a resistive voltage divider which can be applied internally or externally. (*Figure 2 & Figure 3*)

When the internal power circuit is used, the voltages will be generated according to the following table.

LCD Bias	V1	V2	V3	V4
1/N bias	(N-1)/NxV0	(N-2)/NxV0	(2/N)xV0	(1/N)xV0

Note: N = 5 to 12

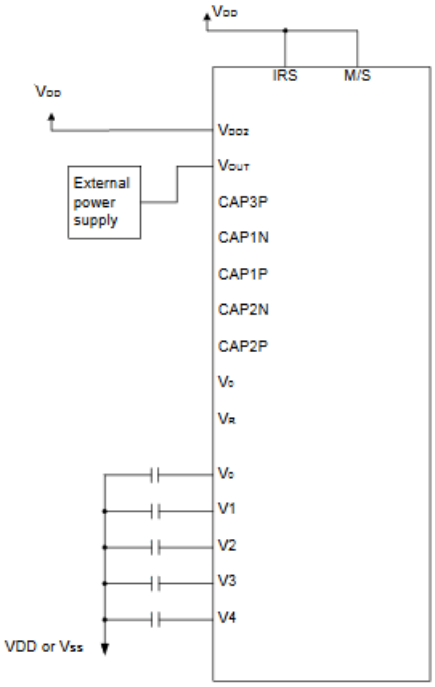


Figure 2: External Power with built in VF/VR

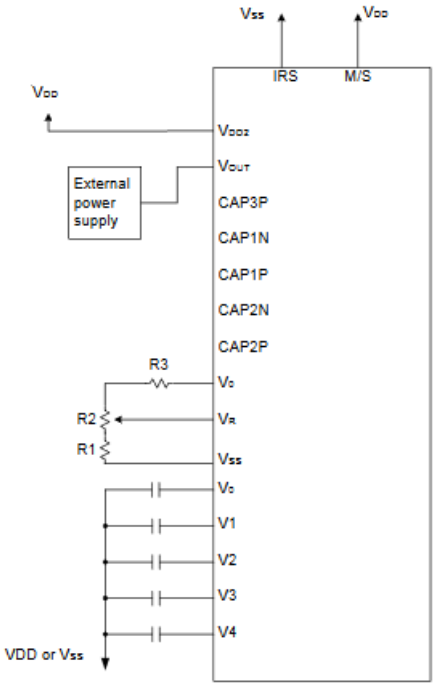


Figure 3: External Power/VR with internal VF

It is important to note that the capacitors (1µF-4.4µF) are connected to the V0-V4 terminals for the voltage following circuit to be active. The voltage regulator (either internal or external) is composed of a voltage divider and is combined with an op-amp for the voltage follower circuit. The following relationship is maintained between V0 and Vout as it applies to the voltage divider.

$$| V0 | \leq | Vout |$$

When the internal voltage regulator is used the resistance values and thus V0 can be adjusted through commands to the resistor ratio and electronic volume registers. The electronic volume and resistor ratio act as a digital potentiometer that is controlled by changing the register values in software. The electronic volume register has 64 levels to adjust the contrast of V0. The resistor ratio can be set to 8 different levels. The relationship between V0, electronic volume and resistor ratio is seen in *Figure 4*.

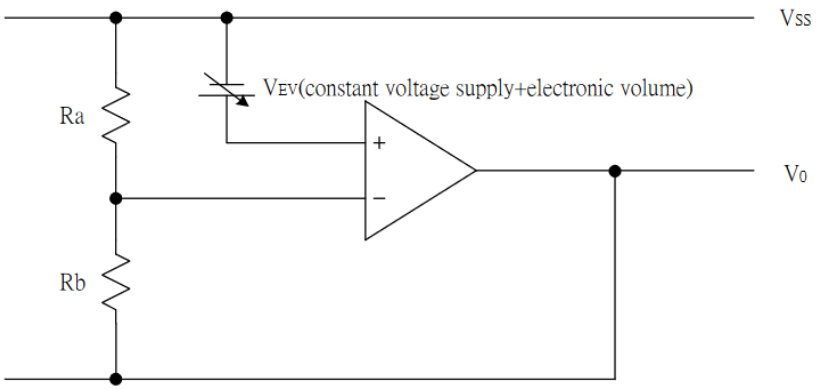


Figure 4: Voltage Regulator Circuit

To calculate the values needed for the resistor ratio the following equation can be used, where Vreg for the IC ST7565 is 2.1V and α is a level between 0-63.

$$V0 = \left(1 + \frac{Rb}{Ra}\right) * Vev \qquad where\ Vev = \left(1 - \frac{\alpha}{162}\right) * Vreg$$

To calculate the specific resistor ratio and electronic volume for this display we can use the following values from the data sheet. VLCD is indicated to be 9.60V (TYP). The following table shows the relationship between V0 and α. First, we will calculate the resistor ratio necessary to produce 9.6V about halfway between the digital potentiometer ($\alpha = 31$)

$$Vev = \left(1 - \frac{31}{162}\right) * 2.1 = 1.7\ \text{V}$$

The resistor ratio at this electronic volume is:

$$9.6V = \left(1 + \frac{Rb}{Ra}\right) * 1.7\ V \qquad \rightarrow \frac{Rb}{Ra} = 4.65 \simeq 5$$

The following table shows the relationship between V0 and α at the resistor ratio 5 using the previous equations.

α	V0 (V)	Vev (V)	Rb/Ra
0	12.6	2.1	5
31	9.6 (TYP)	1.7	5
63	7.8	1.3	5

It is important to note that α at level 0 is essentially the digital potentiometer in the off state. Therefore, the input voltage (connected to Vout) needed to meet the above requirements is 12.6V. This can be supplied using an external battery if you choose not to use the voltage boosting circuit.

These values will be instantiated as hexadecimal or binary values when programming of the display. The electron volume register is 6-bits stored in D0-D5. The electronic volume would be (D5,D4,D3,D2,D1,D0)

= (1,0,0,0,0,0) at α =31. It is important to note that the binary register value does not equal the decimal α value. This is further explained in the following table.

α	V0 (V)	D5	D4	D3	D2	D1	D0	Hex	Decimal
0	12.6	1	1	1	1	1	1	0x3F	63
31	9.6	1	0	0	0	0	0	0x20	32
63	7.8	0	0	0	0	0	0	0x0	0

The resistor ratio is stored in a 3-bit register and can be 8 different values ranging from 3 to 6.5. The resistor ratio set to 5 is represented as (1,0,0).

Rb/Ra	D2	D1	D0	Hex	Decimal
3.0	0	0	0	0	0
5.0	1	0	0	4	4
6.5	1	1	1	7	7

These values can be used when programming the display to adjust the contrast digitally. To use these values when programming we will need to send the following commands to the display.

Power Controller Set → Set Resistor Ratio → Set Electronic Volume

In continuation of the previous example, the following commands will need to be sent to the display.

Power Controller Set (Turn on VR and VF Circuits)							
D7	D6	D5	D4	D3	D2	D1	D0
0	0	1	0	1	0 (VC)	1 (VR)	1 (VF)
Set Resistor Ratio for VR Circuit (Rb/Ra =5)							
0	0	1	0	0	1	0	0
Electronic Volume Mode Set							
1	0	0	0	0	0	0	1
Electronic Volume Register Set (Set α=31)							
0	0	1	0	0	0	0	0

The sequence of commands shown in the table can be seen in the program files for this example. The setup for this example is using the 4-wire serial interface and excludes the additional data commands that would be sent if using a parallel interface. For more information on the use of parallel interface commands refer to the LCD driver data sheet ST7565P.

The commands are instantiated in the program files as follows:

```
//Power Control Set (Generic)
//[0,0,1,0,1,0,0,0]
#define POWER_CONTROL_SET  0x28

//V0 Voltage Regulator Internal Resistor Ratio Set
// [0,0,1,0,0,0,0,0] inital no value for resistor ratio
#define RESISTOR_RATIO_SET  0x20

//The Electronic Volume Mode Set
//[1,0,0,0,0,0,0,1] 81
#define EV_MODE_SET  0x81
```

Above are the generic values without changes to the power supply circuits, resistor ratio or electronic volume. In the .c file we can add the values using the bitwise operator. This can be seen below with the specific values for this example.

```
// turn on voltage follower and voltage regulator (VC=0, VR=1, VF=1)
  st7565_command(POWER_CONTROL_SET | 0x03);
  _delay_ms(10);

// Resistor ratio set, Rb/Ra=5 [1,0,0]
  st7565_command(RESISTOR_RATIO_SET | 0x04);
  _delay_ms(10);
```

Lastly the electronic volume can be controlled through the main file by creating a brightness function.

```
void ST7565::st7565_set_brightness(uint8_t val) {

    //Electronic Volume Mode Set
    st7565_command(EV_MODE_SET);

    //Electronic Volume Register Set
    st7565_command(EV_REG_SET | (val & 0x3f));
}
```

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