OLED Solution for Mobile Phone Subdisplay

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INTRODUCTION

At 1987, a group of Kodak scientists developed a new luminous material. It is a thin organic layer, which emits bright fluorescence light with DC electric field applied. It is well known as Organic Light Emitting Diode (OLED) nowadays.

More than 10 years R&D effort in laboratories, the OLED becomes a very competitive display technology.

Solomon Systech Limited, one of the world's premier OLED driver suppliers, leveraging its extensive experience and technical knowhow on display driver ICs and mobile phones application, has developed OLED drivers exploiting the superior features of OLED displays - contrast, thinness, lightness, power consumption, response speed and viewing angle

In this article, we'll discuss how the driver IC matches the OLED display technology to form an outstanding mobile phone subdisplay.

Keywords: OLED, display driver, subdisplay

An integrated OLED driver/controller IC family, SSD13xx, is introduced to resolve the mechanical design limitation.

SSD13xx is a family of highly integrated single chip ICs with OLED Common/Segment driver; display RAM, controller, DC/DC booster and oscillator (See Fig. 1).

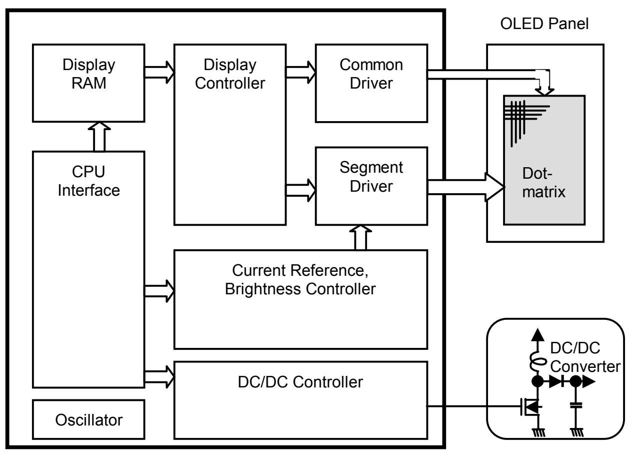


Fig.1 Functional Block Diagram of an Integrated OLED Driver

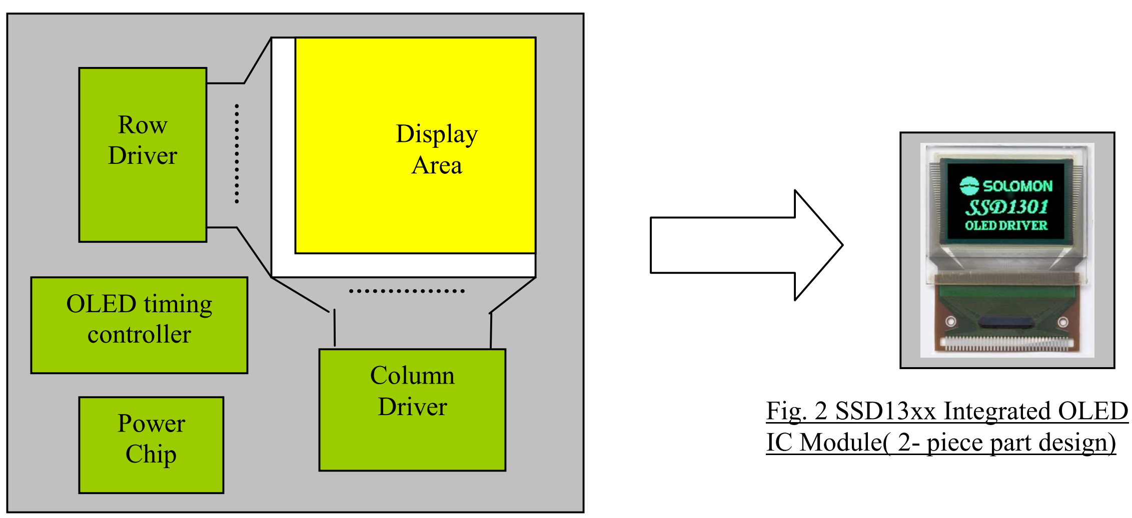
OLED MODULE MECHANICAL DESIGN

First of all, mobile phone is a handheld device. Therefore, compact size and lightweight are the primary consideration in the mechanical design. Although the OLED driver IC is an electronic component, it plays an important role to the mechanical design.

An OLED display module consists of OLED panel, row driver, column driver, power chip, timing controller and interconnection cables. It is impossible to put such bulky module of discrete components into today's mobile phone.

With the integrated driver IC/controller IC, a compact OLED module can be realized by simply connecting the OLED panel and driver IC (see Fig. 2).

Compared to LCD module, emissive OLED displays do not require backlight and LED driving circuit. A typical OLED module is only around 1~1.5mm thick, while the thickness of a LCD module is at least 3mm. Hence, an OLED module can perfectly fit into the ultra thin flip cover of a clamshell type mobile phone.



Discrete OLED Display System

Fig. 2 SSD13xx Integrated OLED IC Module(2- piece part design)

BUILD IN OLED DRIVING SIGNAL CONTROL

Passive OLED display requires a more sophisticated driving scheme and signal interchange system. The SSD13xx drivers adopt multiplex addressing driving algorithm for dot-matrix monochrome or gray-scale OLED displays. Each driving cycle composes of discharge, voltage pre-charge, and current drive phase.

The grey-scale display driver, SSD1328, supports 4-bit 16 gray scale levels display. It makes use of pulse width modulation (PWM) of the current drive time to set different gray levels. There is also an internal look-up table acting as an 8-bit color palette, which provides gamma correction capability.

The OLED driving circuit of SSD13xx has been pre-set to an optimum setting. Auto run is possible with a simple “Display On” command. In addition, fine adjustment per user preference is still available.

Therefore, no additional software routine is required from the mobile phone baseband MCU. Software engineers can concentrate their efforts on creating phone features rather than the complicated OLED driving signals.

** More discussion related to OLED driving scheme can refer another SSL article “OLED Driver IC Optimizes Display Performance”, which is published in http://www.solomon-systech.com/products/app_tech_art.htm.

DYNAMIC POWER MANAGEMENT

A Mobile phone has two operating modes - active mode (dialing, receiving call) and standby mode (idle, standby for use).

For LCD display, it has no difference between the active mode and idle mode. Only the backlight is turned off in standby mode for power saving purpose.

OLED has a unique characteristic, which is self-emissive where no backlight is required. OLED panel power consumption is directly proportional to the panel brightness and the number of pixels turned on. Moreover, panel lifetime depends on the panel on-time and pixel voltage (brightness).

And we know that for more than 95% of usage time, the phone is in standby mode. A dynamic power management is essential to maintain low power consumption and extend panel lifetime.

In standby mode, the main display is off and the sub-display should be kept in a very low power condition. The subdisplay function is to display the information like clock, battery and reception power. It requires a few icons and several characters, as shown in figure 3 below.

Let’s discus how to handle the subdisplay between active mode and standby mode in two aspects - Partial display and Built in DC/DC generator.

Fig. 3 SSD1301 OLED Driver IC Implemented in a Clamshell Phone

1. Partial Display

The SSD13xx series OLED drivers have programmable multiplexing ratio capability. This feature enables power reduction by lowering the multiplexing ratio if less display rows are required in standby mode. In low multiplexing ratio operation, the magnitude of the current pulses is reduced, and hence the required supply voltage is lowered. On the other hand, the non-display region keeps in completely “OFF” state.

When the display area is reduced to a quarter size in standby mode (see Fig. 3 and Fig. 4) The dark region is completely shut down with zero current consumption (see table 2 below for the power saving of an OLED module with partial display function). LCD display does not have this flexibility. At least, the LCD backlight cannot be partially turned off and the non-display LCD COM lines are still running with non-selection voltage pulse scanning.

Fig. 4 Active Mode (Full display)

Fig. 5 Standby Mode (Partial display)

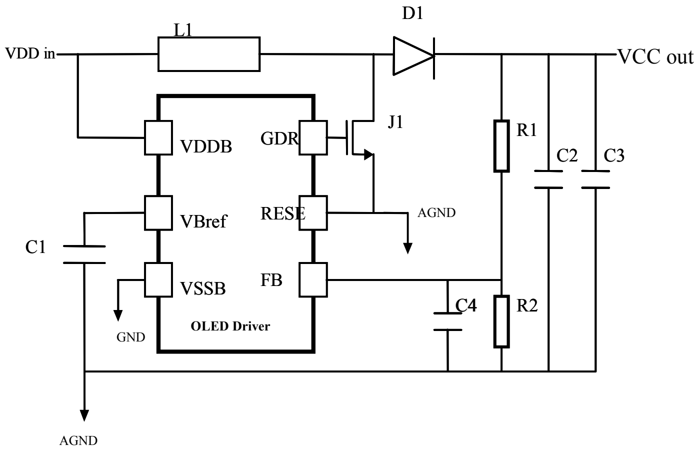
Table 2: Comparison of Active Mode and Standby Mode

Operation mode	Active model	Standby Mode	Standby Mode (Partial display)
Multiplex ratio	1:64	1:64	1:16
Number of lit pixels	768	192	192
Segment current source	88uA	88uA	40uA
Supply voltage	11.7V	11.7V	8.7V
Power	23mW	9.6mW	4.4mW

2. Build in DCDC Voltage Generator

It is a switching voltage generator circuit, designed for handheld applications. An internal DC-DC voltage converter accompanying with a few external components (shown in Fig. 6) can generate a high voltage supply V_{CC} from a low voltage supply input V_{DD}. V_{CC} is the voltage supply to the OLED driver block. The booster is optimized to generate Vcc of 12V @20mA ~ 30mA application, which is the most common setting for the subdisplay applications.

Moreover, the voltage generator can be turned on /off by software command.



$$VCC = 1.2 \times (R1+R2) / R2$$

Fig.6 DCDC Voltage Generator Application Circuit

VALUE ADDED FEATURES (GREY SCALE / AREA COLOR)

With the special panel fabrication and IC driving functions, a passive OLED display can have "Grey Scale" and "Area Color" features.

SSD1328 has 16-grey scale (current pulse width modification) driving capability. It turns a normal mono OLED panel into a grey scale module. See figure 7 below:

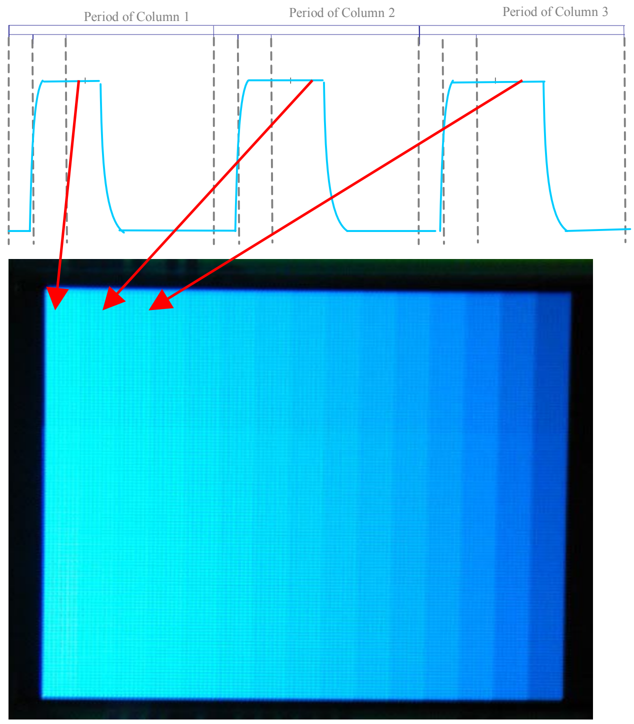


Fig. 7 SSD1328 Grey Scale Display

Another SSD1303 OLED driver IC is equipped with an area color driving circuit. It is very useful for mobile phone display with color icons. An OLED module with area color icon bars is shown in figure 8 below:

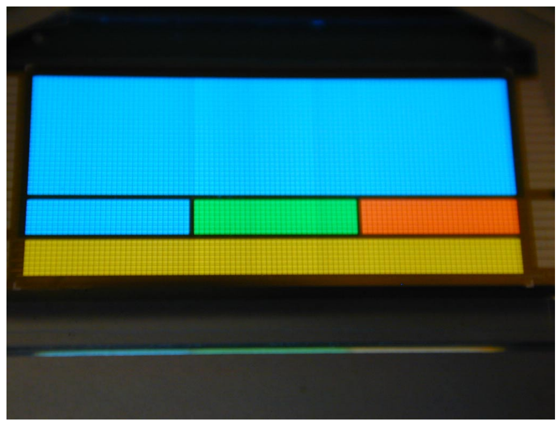


Fig: 8 SSD1303 Area Color Display

IC PACKAGE DESIGN

Beside the slim die for COG application, a T3 series TAB package (SSD1300T3, SSD1303T3 and SSD1328T3) is designed for subdisplay application. T3 series TAB is a folding TAB design with outline dimension of 25.6x16.5mm and OLB bonding pitch of 0.13mm. It is very suitable for tiny subdisplay module applications (See table 3 below for the T3 package information).

Table 3: T3 Series OLED IC Package

	Mono Small	Mono Big	Grey Scale	Color (COF)
Part Number	SSD1300T3	SSD1303T3	SSD1328T3	TBD
Resolution	96x39	96x64	96x64	96RGBx64
Function	Area Color	Area Color	16 GS	Full Color
OLB Pitch	P0.13x99.8%	P0.13x99.8%	P0.13x99.8%	60u Seg/ 90u Com
Input Pins	31 x 0.7mm	31 x 0.7mm	31 x 0.7mm	31 x 0.7mm

All the SSD13xxT3 series TAB packages have the same mechanical outline and input pin assignment for easy interchange. Please refer to figure 9 and figure 10 for the detail TAB drawing and pin assignment.

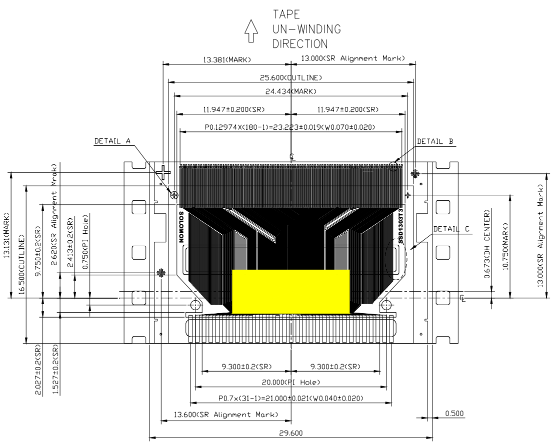


Fig. 9 T3 TAB Package Design

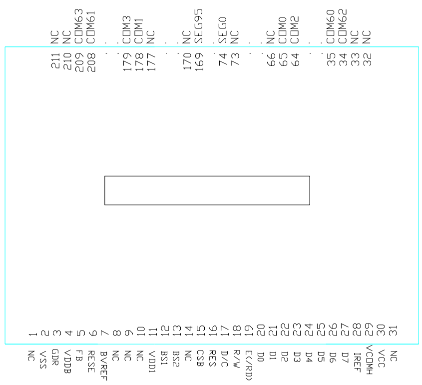


Fig. 10 T3 Pin Assignment

Moreover, SSD13xx series ICs are using standard command/instruction set and MCU interface. Therefore, user can have single module design for different kinds of subdisplay modules - mono small size (96x48), mono big size(96x64), grey scale(96x64) and the coming color subdisplay. They are easy for change over and software code is highly compatible. The product development time and tooling cost can be minimized.

CONCLUSION

The trends of mobile phones go towards multimedia applications, such as in 3G phones and smartphones. An active TFT main display is needed to handle the high quality graphic display. A low power subdisplay is needed to take care the general information. Other than LCD, OLED display is a promising choice with its wide viewing angle and brilliant outlook.

Carried from our successful experience and knowhow of SSD181x LCD driver/controller in mobile phone industry, a new SSD13xx series OLED driver/controller is launched to support the OLED application in mobile phone.

Meanwhile, Solomon Systech is developing a full color OLED driver/controller IC family to support this emerging OLED industry.

REFERENCES

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APPENDIX – Features of SSD13xx series IC

Features	SSD1301	SSD1300	SSD1303	SSD1328
Max display size	132x65	104x48	132x64	128x128
Display color	Mono	Area Color	Area Color	Mono 16 G/S
Logic voltage	2.4V – 3.5V	2.4V – 3.5V	2.4V – 3.5V	2.4V – 3.5V
OLED driving voltage	7.0V to 16.5V	+7.0V to +16.0V	+7.0V to +16.0V	+7.0V to +16.0V
DC/DC booster	No	Yes	Yes	Yes
Max seg output current	300uA	300uA	300uA	300uA
Max com output current	40mA	35mA	40mA	40mA
MCU interface	6800/8080/SPI/I2C	6800/8080/SPI	6800/8080/SPI	6800/8080/SPI
On-chip RAM	132x65	104x48	132x64	128x128x4