

Design of TFT Driver for Mobile Devices

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According to DisplaySearch's data in the year of 2004, total number of modules for mobile and PDA is forecast as 669 million units in 2004. The penetration of TFT module in the mobile and PDA market will increase from 18% in 2003 to 28% in 2004.

a-TFT displays were initially dominated by large area displays applications such as notebook, monitor and TV before. Until 2003, the demand of medium and small a-TFT modules increase sharply because of the reduced price gap between a-TFT and CSTN modules. The requirements for large and small area display modules are very different and therefore new design techniques are required.

For large area displays, they are usually powered by large batteries (eg. notebook) or even connected to the AC main supply (eg. monitor and TV). As a result, power consumption and size are not very critical for the display drivers. However, in medium and small size displays, they are usually portable and power by light-weighted batteries such as cellular phones and digital cameras. Power consumption and size are very critical for these handheld applications. Following paragraphs outline the details of the differences and proposed the solutions for solving them.

1. Reducing power consumption

Two methods will be discussed below to reduce the power consumption in medium and small size displays.

i) Inversion method

In large area displays, dot (or pixel) inversion is used to reduce flicker. However, dot inversion requires much higher power consumption and therefore it cannot be used in medium or small size displays. Line inversion or column inversion are normally used in medium and small size displays. For smaller displays such as 1.9" to 2.2" displays, frame inversion can be consider for even lower power consumption. However, when frame inversion is used, the frame frequency may need to be increased to reduce the flicker effect. Even with the increased power consumption due to the increased frequency, the total power consumption will still be lower than using line inversion.

In an actual measurement of a 1.9", 176x220 QCIF+ display module using Solomon Systech's TFT driver SSD1278, the module power consumption at 262k color, 60Hz frame frequency and line inversion is 8mW, while the power consumption at frame inversion is 7mW only. (Figure 1)

Figure 1 - 1.9" QCIF+ module using Solomon Systech's TFT driver SSD1278.



ii) Partial display mode

In cellular phone operation, over 90% of time is in standby mode, where the phone is used to display information like day, time, network condition and battery signals only. The power consumption of the standby mode is therefore an important factor to cellular phone design too.

In flip phone configuration, the main display is faced inside. When the phone is in stand by condition, the flip is closed and therefore the main display can be turned off to reduce power consumption. In candy bar phone, the main display is always faced outside and therefore it cannot be turned off. In this case, the panel needs to be configured to show the information as mentioned in previous paragraph. Since the information does not require high color depth and will not occupy the whole display, an 8-color partial display mode was provided by SSD1278. During this partial display mode, frame inversion or frame frequency can be reduced to lower the power consumption. Figure 2 shows the SSD1278 display module at 32 lines, 8-color mode, 60Hz frame frequency and frame inversion. The power measured is 1.2mW only.

Figure 2 - 32 rows 8-color display mode.



2. Reducing display module size

For medium and small size panels, they are usually for handheld products and the end product size is usually small. For a typical cellular phone, the dimension is around 90mm x 45mm x 23mm only. The thickness and size of the display module is very critical. Different techniques are designed into the driver ICs to reduce the module size.

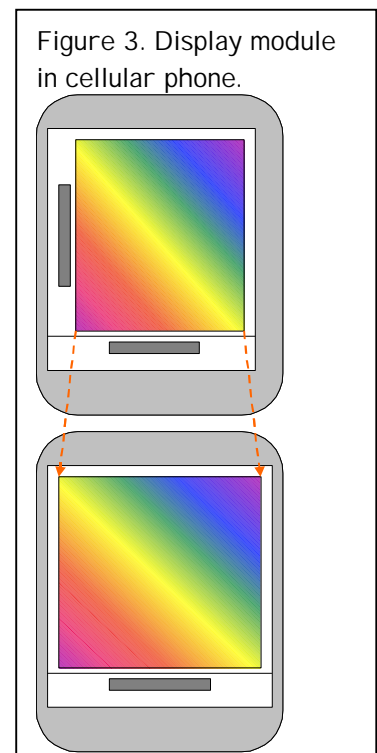
i) Single Chip

Tradition TFT panels have two ledges, one for source driver and one for gate driver. For cellular displays, we want to maximize the active viewing area by reducing the ledges size. From two chips to single chip solution, the active viewing area can be enlarged and is more suitable for high-resolution displays (Figure 3).

In terms of driver IC design, the wafer process required is different between two solutions. In two chips solution, gate driver requires a high voltage process of 30V or above, and the transistor geometry size is not critical. For source driver, it requires a 5 to 6V process with small transistor geometry. In single chip solution, it requires both high voltage and small transistor geometry and therefore fewer suppliers can provide single chip solution.

By moving from two chips to one chip solution, both number of process and the system cost can be further reduced.

Figure 3. Display module in cellular phone.



ii) Integrated capacitors and Schottky diodes
For older generation single chip TFT drivers, they require 15 to 20 external components including capacitors and Schottky diodes. With advanced design technique and wafer process, the external component count can be reduced down to 10. The display module with Solomon Systech's TFT driver SSD1283 as shown in Figure 4 uses 9 capacitors and one Schottky diode only.

iii) External component size
In addition to smaller number of external components, the mechanical size of the component size is very critical also. As shown in Figure 4, there are only six 0603 and three 0402 capacitors only. For further reduction in module size, array capacitors can be used in some cases.

iv) OTP for panel trimming
For flicker free condition, panel trimming is a tedious work and require mechanical trimming in most of the TFT panels, which require one variable resistor also. By integrating OTP cells into the driver IC, panel trimming can be done by programming in electrical means. This produces more reliable result with fewer components.

Figure 4. Solomon Systech's TFT Driver SSD1283 uses 10 components only in a display module



3. Better performance

Users for mobile devices have much higher expectation than before and expect more information contents from the devices. They expect higher resolution, color depth, faster response time for the display.

i) Resolution
When moving from STN to TFT display modules, some display resolutions becomes the standards because of the higher tooling cost. The common resolutions for cellular phones include 128x160, QCIF (144x176), Symbian (176x208), QCIF+ (176x220), QVGA (240x320), CIF (288x352) and up to VGA (480x640).

As the resolution increased, the number of connection between driver IC and panel increased. For QVGA or below resolution, single chip solution is possible with pad pitch down to 20um using amorphous TFT panel. For higher resolution, two chips solution is required unless Low Temperature Poly Silicon (LTPS) need to be use.

ii) Color depth
The requirement of color depth per pixel has been increased rapidly from 256 to 262k colors in mobile display. Almost all new displays need to support 262k colors already. For drivers with integrated RAM, higher color depth means larger RAM area. Wafer process with smaller geometry size is required such as 0.25um or even 0.18um. The source output driving needs to be increased since the gate selection time is inversely proportional to the number of rows, and the source output must charge the TFT transistors to the required voltage within the gate selection time.

iii) Graphic accelerating features

As the display resolution and color depth growth, the display is capable to display more information. The increased loading for the MCU to update the display slows down the system response. As a result, the display driver needs to have some graphical features to offload the MCU, or an external graphic controller is needed.

For systems with external graphic controller, the display data are kept inside the graphic controller and therefore the display driver do not require any memory, and the interface used between the graphic controller and the display driver will be RGB interface. However, the graphic controller usually consumes much power and they should be shut down at standby mode. As a result, a small portion of can be put into the chip to display some critical information, like time, network and battery status etc in cellular phone. In this case, graphic controller can be shut down unless the display data needs to be update.

In conclusion, the performance of the display module does not depends on the driver IC design only, the TFT panel and module design play a very important role also. The display driver must match with the panel characteristic to reproduce the color. The driver's gamma curve should be programmable such that the module can produce the commonly used 2.2 gamma characteristic. The selection of backlight and aperture ratio of the TFT panel has big impact on the visual performance also. The power consumption of backlight is considerable large when compared with the panel and driver. Transflective TFT is preferred when power consumption is critical.