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From Monochrome to Color LCD Display in Cellular Phones

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Introduction

From the old day's analog cellular phone till today's digital cellular phone, the technology migrates from AMPS to GSM, CDMA…etc and then GPRS and 3G. Although the technology changes, one trend has always been true is that the physical size of cellular phones becomes smaller and smaller while the information to be displayed keeps increasing. If the same physical LCD glass size is to be retained while the display information has to be increased, there are two ways:

1. Increase the number of pixels by reducing the pixel size;
2. Use the same number of pixels but each pixel displays gray scale or color.

The former solution is first limited by the minimum pixel gap that can be fabricated by the LCD maker. Secondly, when the multiplex ratio is increased with higher display resolution, the LCD driving voltage required is higher. The system ends up with a larger module display current. This solution may also require additional LCD drivers for the extra segment and common pins.

For the later solution, the LCD driving voltage will be the same as mono display solution. The LCD driver can be designed in such a way that same LCD glass and interface can be used in TAB or COF applications. The only changes required to upgrade from mono to gray scale is to use a gray scale LCD driver and have a minor modification on the software. In case of COG applications, the LCD glass will have to be modified, as the IC die dimension may not be the same for mono and gray scale display.
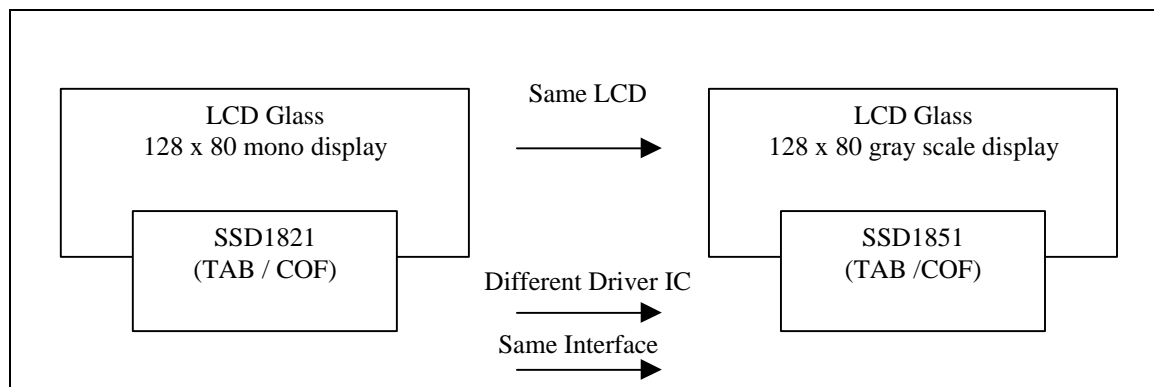
When gray scale driver is used, additional features can also be implemented on top of the mono display such as watermark, page swapping, image display, as well as color STN display.

Watermark

With innovative design on the IC hardware, the memory of a gray scale LCD driver can be configured into two different groups, foreground and background, when gray scale display is not in used. An image / watermark (for example logo) can be loaded into the background memory while the mono information to be displayed can be loaded into the foreground memory.

Background data

Foreground data

Combined display

The watermark can be turned on/off by programming the gray scale mapping.

For example, the gray scale information of each pixel is represented by two RAM bits, namely 00, 01, 10 and 11. The first bit represents the foreground data and the second bit represents the background data. Each of the four scales can be programmed into one of 64 contrast levels. If only the foreground data is to be displayed, then gray scales 00 and 01 can be programmed to the white level, while gray scales 10 and 11 can be programmed to the same black level. In the contrary, if only the background data is to be displayed, then gray scales 00 and 01 can be programmed to the black level, while gray scales 10 and 11 can be programmed to the white level. To make the watermark, the gray scale of 00 will be programmed to the white level, scale 01 to a light gray level, scale 10 to white level and 11 to dark level.

In order to make programming easier, a specific command is made on the LCD driver IC such that odd RAM bits (foreground data) and even RAM bits (background data) will be accessed separately.

Page swapping:

For displaying mono moving pictures, all RAM data has to be updated continuously. Depending on the speed of the data write cycle and the display size, human eye may notice the display is being updated from the top to the bottom. This situation is even worst when serial interface is used.

Page swapping function from a gray scale LCD driver will be useful in this case. Similar to the watermark situation, the memory can be visualized as page 1 and page 2. The first bit of the four gray scale combinations represents page 1's data and the second bit represents page 2's data. In order to display the first page, gray scales of 00, 01 and 10 are programmed to the white level, while gray scales of 11 is programmed to the black level. During the first page's data is being displayed, the second page's data can be written into the RAM. When all the data in second page is updated, then the gray scales of 00, 10 and 11 are then programmed to the white level, while gray scales 01 is programmed to the black level. The entire display will therefore change from the first to the second page within two command clock cycles.

Image display:

When displaying an image in mono display, techniques like dithering will be used to make the image looks smooth. Below is an example showing a picture displayed in mono display using dithering and the other displayed in a four gray level display:
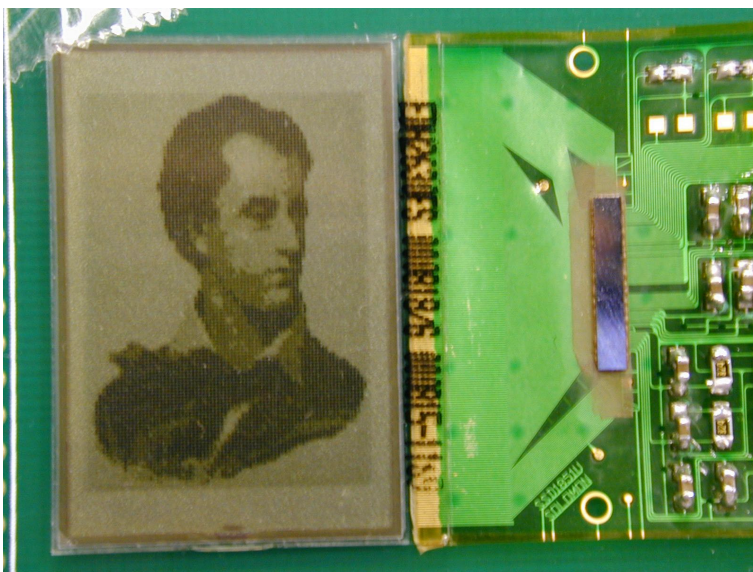
Dithering in mono display

Four gray scales display

The image in mono display could not show all the details within the display window. However, when four gray scales display is used, the image can be displayed more precisely with the same number of pixels.

A four gray scales display of 128 x 80, using SSD1851 in COF applications

Color STN display:

Gray scale driver can also be used to drive a color STN display. If a 128x80 gray scale driver and RGB color filter are used, it can drive a 42x80 RGB display. With two or three gray scale drivers cascaded, a bigger display can be achieved. However, it is suggested not to use COG method in this cascade application because of the LCD ITO resistance loading to the driver IC may cause display contrast differences. TAB or COF method should be used. It is also recommended to use external LCD driving levels and external oscillator:

1. External LCD driving levels: to make sure the drivers will have exactly the same contrast.
2. External Oscillator: to synchronize the cascaded LCD column drivers since the same COM driving signals are support to both drivers.

Following is an example to using two gray scale LCD drivers to display a color STN LCD:

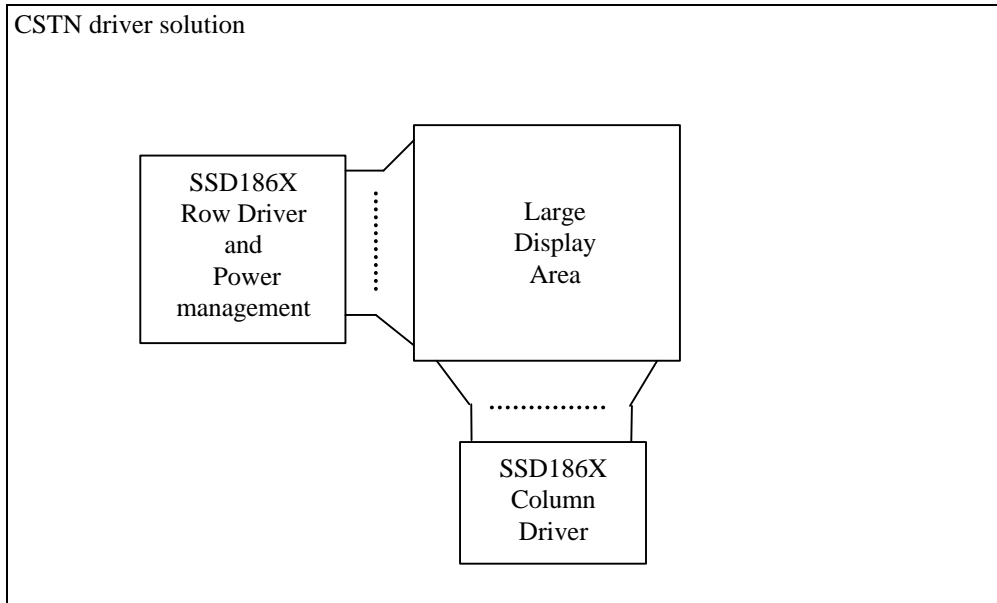
Cascading LCD driver for CSTN display.
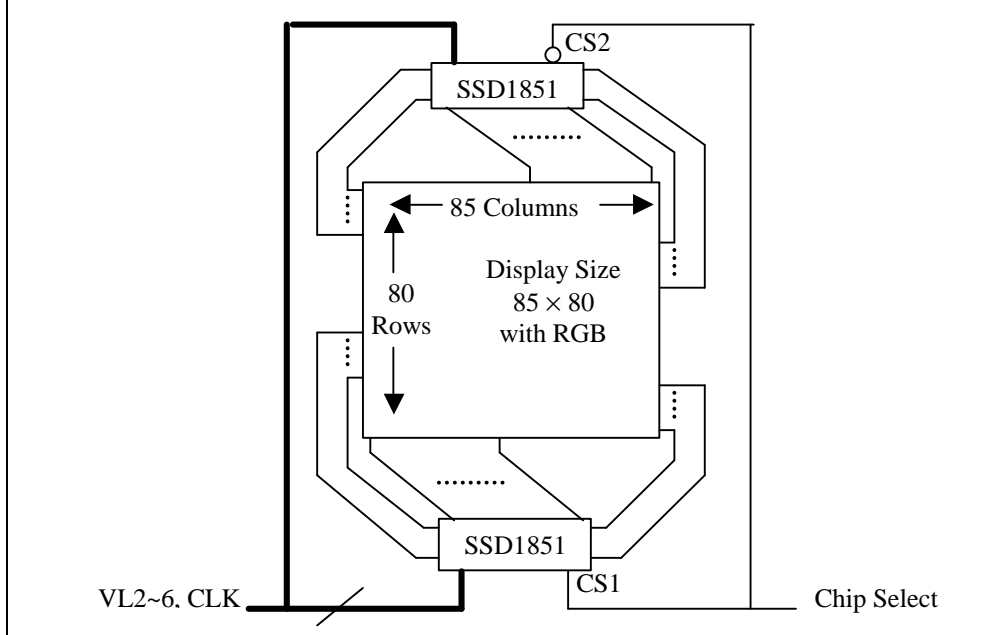
In this configuration, the display size is 85x80 and the color format is 2-bits R, 2-bits G and 2-bits B. It can be used to display up to 64 colors out of 4096 colors at the same time.

Future trend

In addition to the existing cellular phone generation, there is increasing demand on PDA type of display in the handset. The display usually requires 3 bits R, 3 bits G, 2 bits B color format with at least 128x160 RGB display size. It also requires a fast response display with low power consumption.

In order to make the display more compact in this case, two chips solution should be used. The row driver includes the LCD voltage generator and power management function to reduce the power consumption, while the column driver is a high pin count IC (384 output pins) with on-chip RAM for the RGB color.

CSTN driver solution

| SSD186X Row Driver and Power management |
| Large Display Area |
| SSD186X Column Driver |

~ End ~