Driver electronics for commercialization of emerging display technologies

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Abstract — *Driver electronics for emerging display technologies are presented for OLED's, microdisplays, electrophoretic displays & bi-stable LCD's. Key factors for commercialization of these technologies are derived from the experience of the LCD's, including driver IC designs, wafer and assembly processes & applications.*

Index Terms — LCD, microdisplays, electrophoretic displays, bi-stable LCD, OLED, driver electronics

I. Introduction

The electronic display is a key component in any electronic appliance to provide the man-machine visual interface. The LCD is the dominant flat panel display technology and is finding and creating display applications in a very large range of products from portable, desk top, to large wall sizes. In many ways, the success of the LCD has spurred inventions and commercial developments of many new display technologies.

The electronics required to drive the electronic display plays a key role in any display technology. Graphics and timing controllers, MCU interfaces, field memory, common and segment drivers, DCDC converter, back light driver and power converter are typical components found in display driver electronics systems.

This paper is an overview of our work in driver electronics for new emerging display technologies, including microdisplays, electrophoretic displays, bi-stable LCD's, and OLED's.

II. LCD Enhancements

To provide the basis of driver electronics for new display technologies, this section summarizes the present status for the LCD and the enhancements coming in the near future. Figure 1 shows block diagrams of the general driver electronics used for the CSTN and the TFT-LCD in mobile applications.

For the CSTN, enhancement push is mainly towards cost reduction by improved integrated circuit design, wafer technology scaling, reduced pad pitch, and reduced external component count, as well as power reduction. These advancements coupled with maturity of the technology have contributed to the success of the CSTN technology in small displays, in keeping off competitions from the emerging display technologies.

Applications are migrating to video with increased data rate, display resolution and image quality requirements. Driver electronics need fast speed processor interface, high resolution and high speed DAC, color management, and picture motion driving scheme. The TFT-LCD is undoubtedly the dominant flat panel display technology at present and for many years to come. Advancements are being pushed in the areas summarized below in Table 1. The challenge is to implement these advancements under very tight cost, power, and mechanical budgets, requiring migration to higher integration provided by 0.18u wafer technology and beyond.

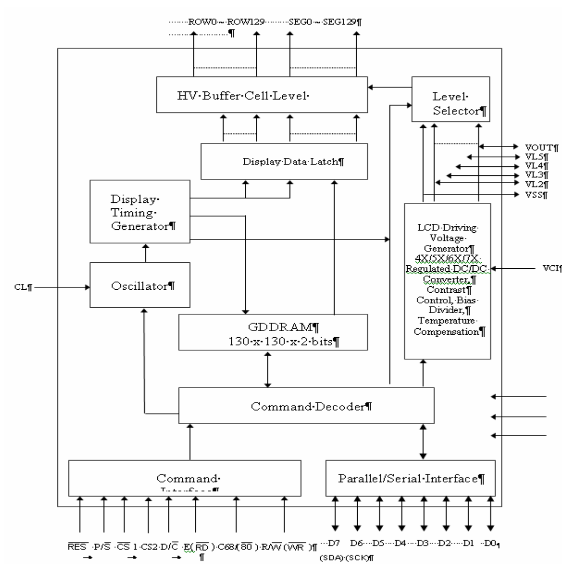

Figure 1a. CSTN Driver IC Block Diagram.

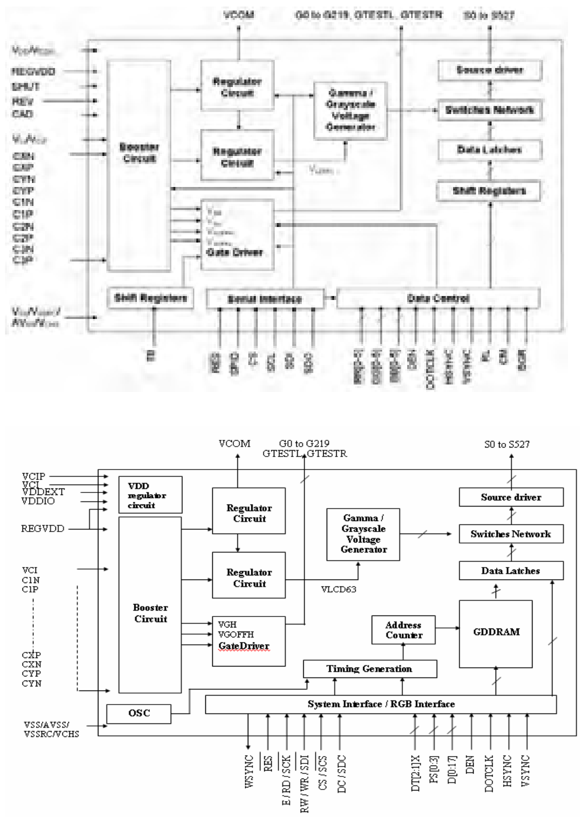

Figure 1b. TFT-LCD Controller/Driver IC Block Diagrams for aTFT and LTPS panels.

Features	Present Status	Coming Advancements
1. Resolutions	QVGA	VGA
2. DAC	6-bits grey scale or colored presence	8-bit
3. Colors	Mostly single gamma	Multiple gamma
4. Motion	LCD Overdrive	Overdrive with frame insertion
5. Interface	Parallel and SPI	Custom parallel and high speed serial
6. Backlight	No control	LED backlight control
7. Ambient	No adjustment according to ambient	Adjustment according to ambient
8. Touch panel	High end feature	Popular feature

Table 1. Portable TFT-LCD Driver Electronics Functions showing present status and coming advancements.

A. High Speed Interfaces

Video streaming in mobile phones requires a high speed interface between the display driver electronics and the base processor. A serial type interface has advantages of small number of connections and low EMI. Two industrial standards have emerged, namely the MDDI (Mobile Display Digital Interface) and the MIPI (Mobile Industry Processor Interface).

Figure 2 shows the driver electronics system configuration for the MDDI and block diagram of key functions in the transceiver controller. Figure 3 shows the system configuration for the MIPI and the interface signal levels. Before these interfaces are embedded into the processor and the display driver IC's, bridge transceiver IC's can be used.

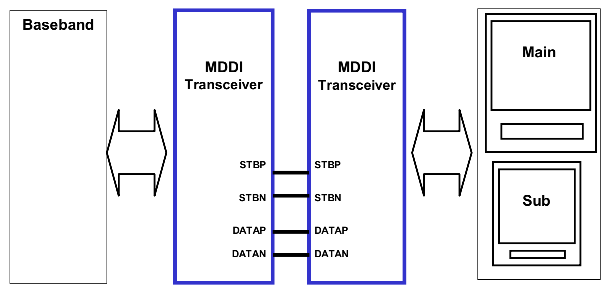

Figure 2a. MDDI System Configuration Diagram where the main display can either be a smart or a dumb panel.

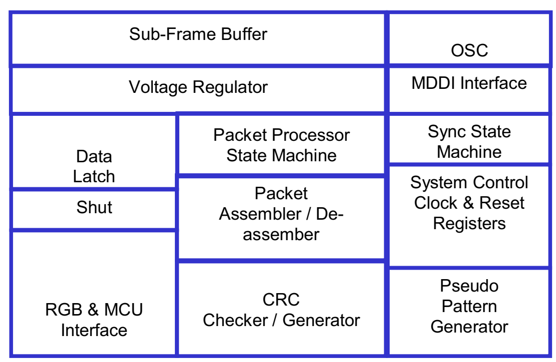

Figure 2b. MDDI Transceiver/Controller IC Block Diagram.

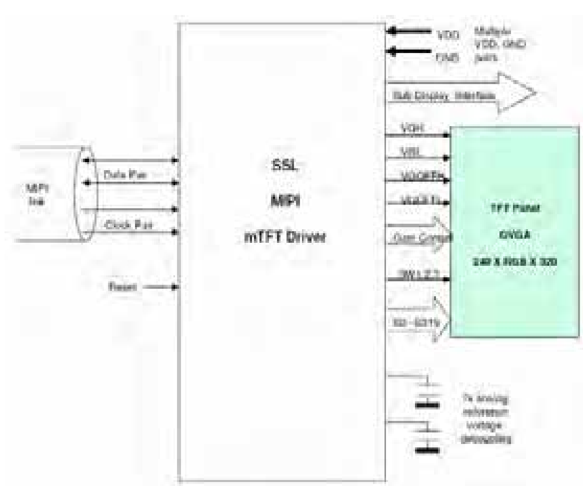

Figure 3a. MIPI System Configuration Diagram showing signal connections when the main display is a smart panel.

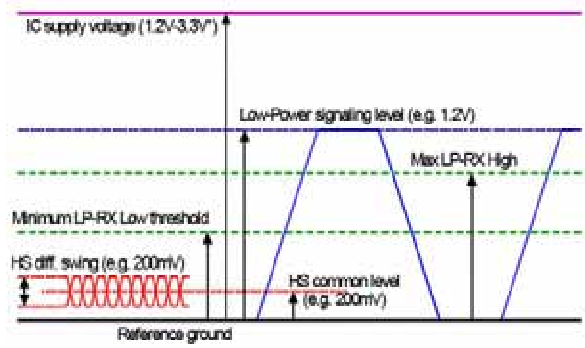

Figure 3b. MIPI D-PHY Signal Levels Diagram.

B. *LED Backlight Control*

The LED has become a likely replacement for the CCFL as backlight for the TFT-LCD. Recent advancement has improve the LED efficiency and the LED cost to a competitive level. Figure 4 shows the block diagram of a driver electronics system that supports both dynamic backlight control according to image data and ambient light sensing backlight control. Aside from the key purpose of power saving, there is also the benefit for color enhancement.

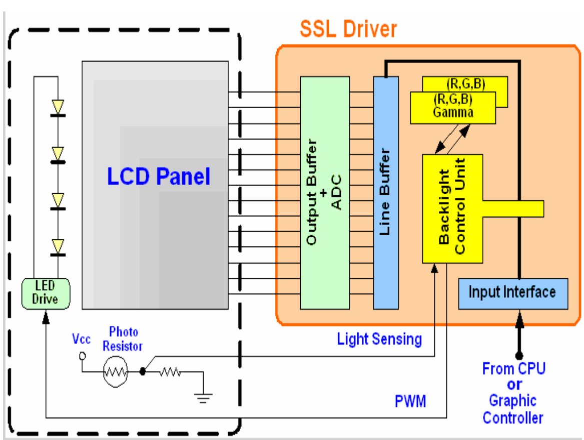

Figure 4. Block Diagram of a Display Driver Electronics System Incorporating LED Backlight Control.

The TFT-LCD for TV market has taken up a surprisingly fast pace and created additional requirements over those for the traditional notebook and monitor products, because of large panel size, emphasis on motion images and image perception, subjective color perception, and desirable large viewing angle. Many advancements are similar to those for mobile applications mentioned above, except that more resources are available to achieve higher performance levels than for portable electronics. Large external frame memory and powerful processors embedded in the TCON will perform advanced temperature compensation, dynamic gamma color management, and extensive image processing. Figure 5 shows the system configuration for the TFT-LCD TV application.

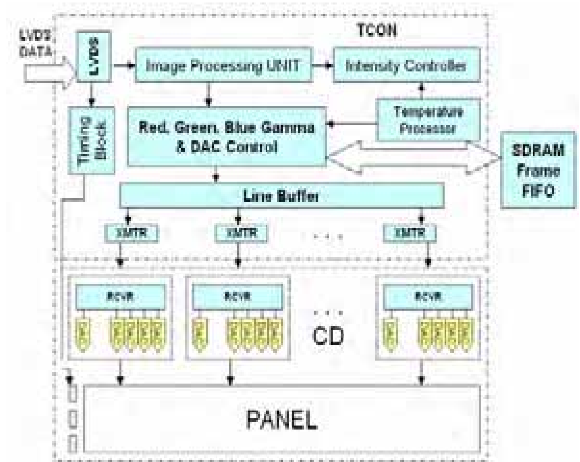

Figure 5. TFT-LCD TV System Configuration Diagram showing TCON with embedded video processor and multiple gamma control for image and color enhancement.

III. MICRODISPLAY DRIVER ELECTRONICS

A. *Microdisplays Technology and Applications*

The two main types of microdisplays are made by LCOS and active matrix OLED technologies. For LCOS, there are the TFT and the single crystalline backplane kinds. For active matrix OLED, there are the (amorphous) AMOLED and the LTPS_OLED kinds.

One of the first commercial applications for the LCOS microdisplays is as replacement for miniature CRT's in view finders that proved to be very successful, just as TFT-LCD flat panels has taken over CRT monitors. An emerging application for microdisplay is in head mounts with personal convenience and privacy appeal.

B. *Driver Electronics for the Kopin Cyberdisplay®*

To complement the highly compact nature of the Kopin Cyberdisplay® built on single crystalline silicon substrate, a highly integrated electronics system was designed to include video decoder, digital signal processing, video DAC's, backlight control, and stereo video support, Figure 6, reducing the electronic component count to a minimum for a microdisplay system with VGA resolution.

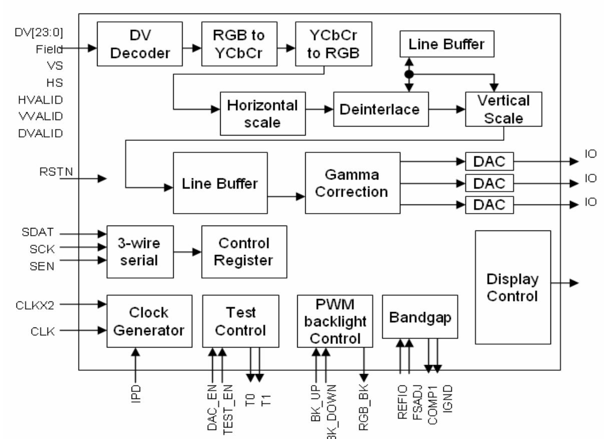

Figure 6. VGA Microdisplay Controller Driver Mixed Signal SoC with support for streaming video, backlight control, video DAC's, and stereo mode.

IV. Electrophoretic and Bistable LCD Display Driver Electronics

A. Electrophoretic and Bi-stable LCD Display Technologies and Applications

The electrophoretic display (EPD) works on the principle of electromechanical manipulation on micron size particles while the bi-stable LCD employs cholesteric liquid crystal or a switchable surface anchoring effect. EPD's are available in segment and active matrix types while bi-stable LCD's are available in both segment as well as passive and active matrix forms. Because of their bi-stable characteristics, they are applicable as electronic labels, electronic signs, clocks and watches, and electronic paper or e-books.

B. Generic EPD and Bi-stable LCD Driver Electronics

In comparison with LCD and OLED, present EPD and some bi-stable LCD require higher drive voltages. Figure 7 shows the block diagram of a generic driver applicable for many types of segment EPD and bi-stable LCD displays. Figure 8 shows a development platform for e-book and system configuration for the display driver electronics.

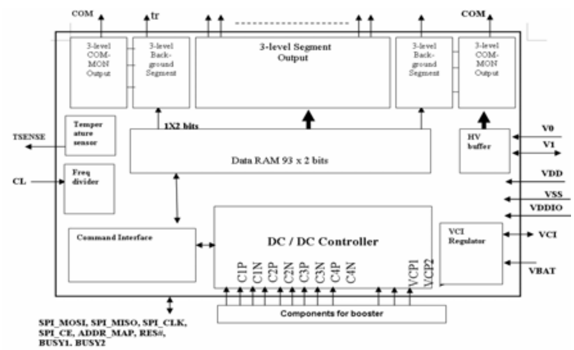

Figure 7. Block Diagram of a Generic 3-Level Driver IC for segment type EPD and bi-stable LCD displays.

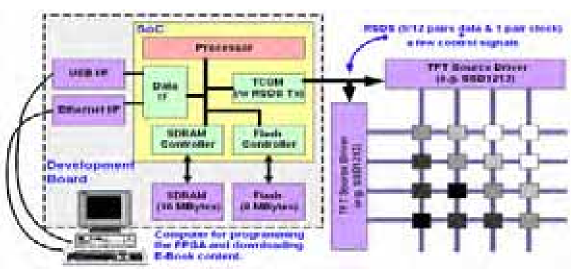

Figure 8. Development Platform and Driver System Configuration for e-book using EPD or Bi-stable LCD.

V. OLED Drive Electronics

A. OLED Technologies and Applications

There are two main classes of OLED materials, small molecules and polymer. Many kinds of both passive and active matrix displays are available of different technologies. Aside from manufacturing challenges, material life time needs improvement. OLED has fast response advantage over LCD and favorable for video applications.

B. OLED Driver Electronics

Current driving instead of voltage driving is the main difference between OLED and LCD driver electronics. Figure 9 shows block diagrams of driver electronics for passive and active OLED's. Driving uniformity and power management are key design areas.

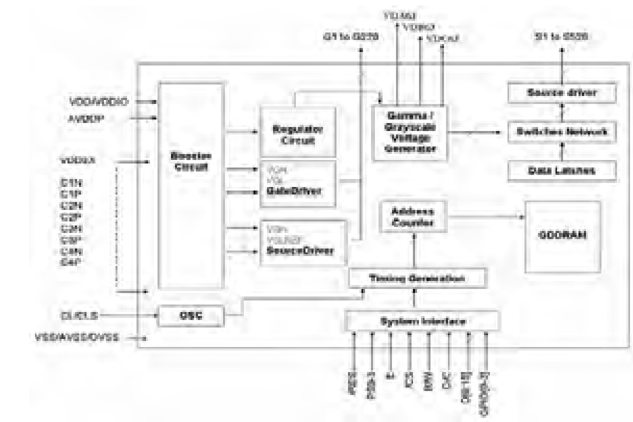

Figure 9a. Block Diagram of Driver IC for Active Matrix OLED.

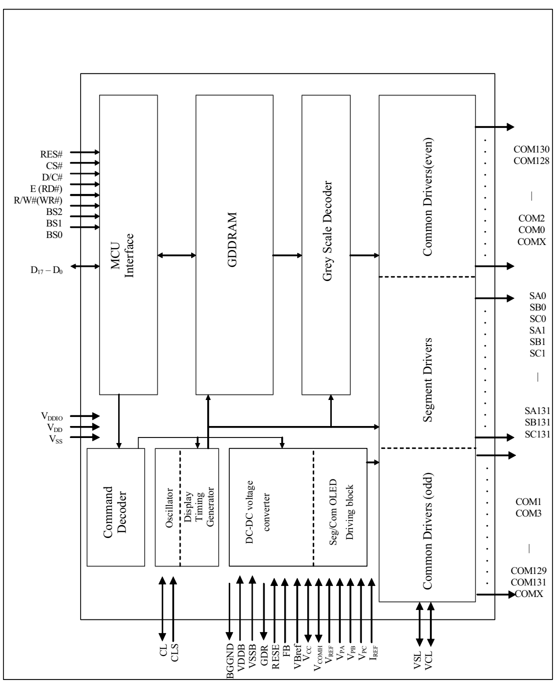

Figure 9b. Block Diagram of Passive OLED Driver IC.

VI. Conclusion

An overview of driver electronics is presented for emerging display technologies. Optimization of the electronics brings out the competitive value of each technology for specific applications. By such optimization, including considerations for manufacturing, existing display applications are improved and emerging display technologies and applications are developed into new markets.

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The author would like to thank my many Solomon Systech colleagues who contributed to the work presented here and Jackie Yu for her expert help in preparation of this article. Solomon Systech Limited is a fabless semiconductor company of display related IC products, headquartered at 6/F., No. 3 Science Park East Avenue, Hong Kong Science Park, Shatin, Hong Kong.