P-66: Personal Communication System Hand-set with Organic Light Emitting Diode Display

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Abstract
In this paper, new driving methods such as PWM and LUT have been studied and a highly integrated CMOS current driver IC was designed and fabricated for 1.8-inch 128 ´ 128 dot passive matrix Organic Light Emitting Diodes (OLED) display panel. As a result, OLEDs technology was applied to a display for a PCS phone successfully.

1. Introduction
The increasing demand for portable applications has caused a significant growth of display devices that are small, thin, and easy to operate. In such a situation, there is increasing interest in the potential application of organic light-emitting diodes (OLEDs) [1]. It is well known that OLED is one of the pioneer next generation flat panel display application with good contrast, low operation voltage, short response time, wide view angle, and low manufacturing cost [2].

Researches and developments have been focused on optimizing materials and device structures [3]. A generalized driver with good performance is needed for these display device studies [4].

Currently, mobile applications include passive monochrome and multicolor displays, and there have been many intensive works to apply the innovative technology to portable devices such as cellular phones, IMT 2000 mobile handsets, CNS (car navigation system), PDA (personal digital assistants), camcorder, and palm PC, etc. The development of portable consumer electronic applications has been grown rapidly in the past few years over the world. The portability of the terminals and associated demands to power consumption impose stringent requirement for any applicable display. With caution, OLED is believed that one of the best candidates for most of these devices.

2. What's OLED?
For the first time, OLED was observed by Bernanose, French, and co-workers in 1950 and then wide and many intensive works were achieved in both industrial and university laboratories. OLED is one of the self-luminous flat panel displays by the phenomenon of the emission of electromagnetic radiation by the recombination of a pair of electron and hole in organic materials subjected to an external electric field and has excellent characteristics such as low power consumption, high brightness, fast response time, and light weight with low production cost.

A passive matrix OLED display (Figure 1.) is made of a transparent glass or plastic substrate on which are patterned columns of transparent conduction anode contacts. And the recombination of electrons and holes injected from anode and cathode makes OLED pixels radiate. To address a particular OLED pixel, common line is activated sequentially and segment line flows appropriate currents. As a LCD, a full image is produced by rapidly scanning the full display area.

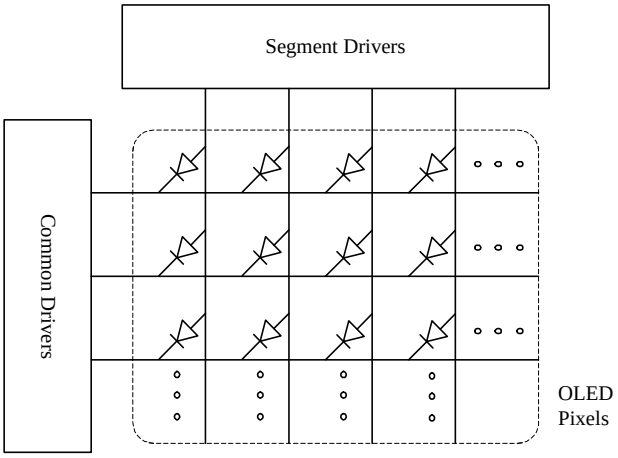

Figure 1. Block diagram of passive matrix OLED

Required features for portable devices

- Fast response time for processing real time motion images.
- High resolution and wide view angle.
- Lighter and thinner thickness.
- High quality, low power consumption and low cost.

From above mentioned requirements, OLED will completely replace LCDs in the future flat panel display applications since it consists of self-luminous pixels, which eliminates the need for back-light and TFT(thin film transistor) required by LCDs and can be manufactured by the lower cost than LCDs.

3. Controller and driver
The driver in this works was designed for OLED displays in 128 × 128 dot passive matrix. The full circuit configuration of the OLED display driver IC is presented in Figure 2.

For the OLED driver, we proposed new driving methods for designing a driver independent of the current property of OLED displays. The proposed methods are the Look-Up Table (LUT) and the Pulse Width Modulation (PWM). The LUT is used to handle the amount of the current for driving the OLED display panel and the PWM is applied to represent the gray scale on the

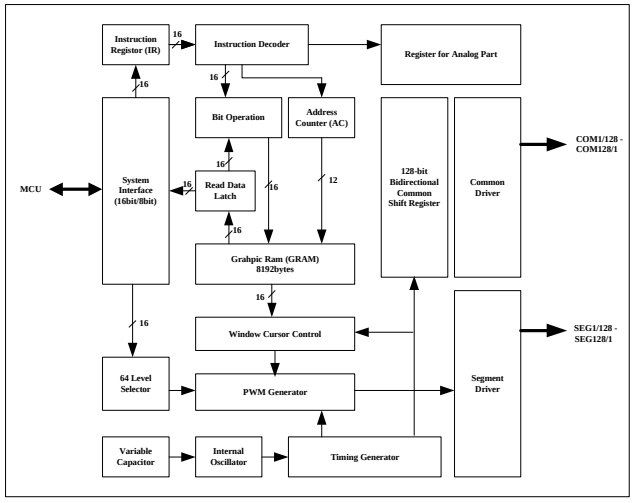

Figure 2. Block diagram of drivers and control circuits for OLED display panel

OLED display panel. Functional description of each block is as follows.

Instructions and data for display are fetched from a micro-controller unit (MCU). The display instructions are subsequently decoded into the internal register block and the display data are stored into memory. MCU interface unit supports Intel 80x systems and Motorola 68 systems with 8/16 bits general bus width. This MCU interface unit transfers control signals and image data to the internal register unit.

Internal register unit consists of 22 x 16bit register. This unit has parameters for the OLED driver IC. Analog parameters control the power save mode, contrast and brightness. Registers for digital function parts set the flag and the required values. And status register has the current status of the driver IC.

The internal graphic memory block contains 4 two-port random access memories. It contains full graphic image and is accessed via MCU interface unit.

Bit operation unit performs AND, OR XOR operations and bit rotation operation. With this function block, system engineers can implement the background images and animation easily.

Window cursor control unit has many functions related to graphic display. First it accesses graphic ram unit and get the data of next line and performs the digital functions. It contains vertical scroll, partial display, partial vertical scroll, and cursor control.

64-gray level select unit is the early mentioned LUT block. In this unit, we added 6bit adder to implement the bright control.

PWM generator consists of six 128bit shift registers, one 6bit counter and 128 comparators. The comparator output is the segment drive signal.

Timing controller makes required clocks from the internal or external oscillator.

Analog driving circuits composed of 128 common drivers and 128 segment drivers, the latter get the signal form the PWM generator unit. Internal oscillator and DC-DC converter was also designed and integrated.

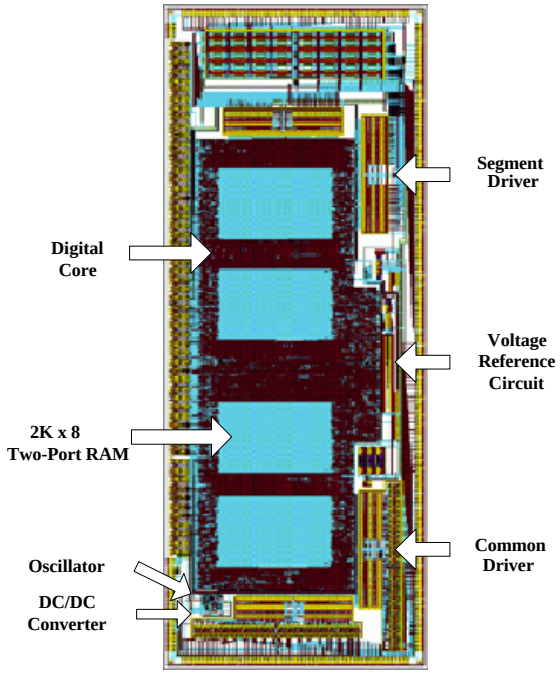

Figure 3 Layout of the OLED driver IC

Driver IC utilized here are fabricated under Hynix 0.6μm 16-volt 2-poly 3-metal CMOS process. Figure 3 shows the layout of the full OLED driver IC.

4. Results

As a result, excellent image uniformity and clear image display were achieved.

Table 1 summarizes the specification of the OLED displays manufactured in this works.

The developed driver IC was adapted to the 1.8'' passive matrix OLED panel, and implemented display module was used for PCS handset (Figure 4).

Display Area	1.8 Inch Diagonal
Pixel Number	128 × 128
Pixel Pitch	260 μm
Gray Scale	64
Clock Freq.	10MHz Internal OSC
Display Freq.	76Hz
Segment Driver	100μA @ 12V
Common Driver	12.8mA @ 12V
Driving Method	Current Driving
Color	Monochrome (Green)
Full CMOS Chip Area	4600 × 13600 μm^2
Number of Pins	411 Pins
OSC, DC/DC Converter, Memory	On Chip

Table 1. Specification of the OLED driver IC

From this result, we showed how OLED display is essential in PCS handset. Figure 5 shows the display image of our OLED panel that was driven by the earlier mentioned driver IC. The color of emission is green. Image with good uniformity and high resolution were acquired.

Figure 4 Photograph of PCS handset using OLED display

Figure 5. Display image of PCS handset display panel

5. Conclusions

In this works, highly integrated CMOS current driver IC was presented applicable for organic light emitting diode (OLED) displays. Developed driver IC contains digital display control unit, internal image memory cells, common and segment driver cells, internal oscillator and DC-DC converter.

In conclusion, the best applicable OLED driver IC was developed and implemented to the PCS handset. From this result, we showed how OLED display devices are appropriate in developing PCS handset.

7. References

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