Controller with Voltage-Compensated Driver for Lighting Passive Matrix Organic Light Emitting Diodes Panels

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Abstract

This study proposes controller with voltage-compensated drivers for producing gray-scaled pictures on passive matrix organic light emitting diodes (PMOLEDs) panels. The controller includes voltage type drivers so the output impedance of the driver is far less than that of the current-type driver. Its low output impedance provides better electron-optical properties than those of traditional current drivers. A free running clock and a group of counters are applied to the gray-scaled function so that phase lock loop (PLL) circuit can be reduced in the controller. A pre-charge function is used to enhance performance of the luminance of an active OLED pixel. As a result, distribution of the low gray level portion is achieved linear relationship with input data.

*In this work, the digital part of the proposed controller is implemented using FPGA chips, and analog parts are combined with a digital-analog converter (DAC) and analog switches. A still image is displayed on a 48*64 PMOLEDs panel to assess the luminance performance of the controller. Based on its cost requirement and luminance performance, the controller is qualified to join the market for driving PMOLEDs panels.*

1. Background

Organic light emitting diodes (OLEDs) technology emerged in 1987 [1]. It is becoming a popular field of research in the field of flat panel displays (FPD). Several investigations have presented the advantages of OLEDs panels [2], [3]. Here, the most important characteristics of the OLEDs panels are the following: Self-emission, Quick electron-optical response, Light, Thin, Wide viewing angle, Good contrast. Based on these superior properties of the OLEDs panels, they can be used into numerous consumer products. For example, a mobile 'phone with an OLEDs panel is light, thin, bright, and displays more vivid hues.

With respect to driving, several studies have addressed the use of a current mode driver to display gray-scaled pictures on a PMOLEDs panel [4-5]. The brightness of an OLEDs pixel is directly controlled by the current fed into the OLEDs pixel [6]. The most researchers believe that controlling the current that passes through an OLED pixel can feasibly drive it. Accordingly, controlling the driving current of the each OLED pixel is one way of displaying a gray-scaled picture on an OLEDs panel. However, current modulation is too expensive to implement in a competitive consumer market. Thus, many drivers with gray-scaled capability use pulse width modulation (PWM) [7-8]. PWM is based on time-sharing theory, and it provides good gray level distribution performance in high gray value portion. The PLL circuit implements the PWM technique, which generates a pulse train to perform the gray level function. The PLL circuit incorporates an analog filter, a voltage-controlled oscillation circuit and digital counters; thus, controllers with PLL include a complex analog circuit. However, such kind of the controller is expensive. Eliminating the PLL circuit facilitate the design and fabrication of the circuit. The price of a PLL-less controller that meets the gray-scaled performance of the marketplace should be cheaper than a one that uses traditional techniques. A simplified digital circuit is designed herein to replace PLL; the proposed controller can vie with rivals in the display driver market.

A voltage driver for lighting a PMOLEDs panel has some advantages, such as low output impedance, the absence of feedback-loop circuitry and ease of fabrication. In 2003, our research team developed a voltage-compensated driver for lighting a PMOLEDs panel [9-10]. The luminance uniformity performance of the proposed driver is similar to that of current-type drivers. In particular, the proposed driver had a better electron-optical efficiency than the conventional driver's, when driving a PMOLEDs panel. Therefore, a voltage-compensated skill is applied to the controller proposed herein work.

Capacitor exists in OLED pixel [11]; therefore, the driving current is charging the capacitor before lighting the pixel. The charging action introduces a time delay in the emission of light. Using pre-charge skill can reduce the delay time. Hence, the pre-charge circuit in the proposed controller is designed to yield an effective electron-optical response.

2. Results:

Figure 1 illustrates the time response of the emission from an OLED pixel. The sharper curve is obtained when the OLED pixel is driven at a constant voltage with pre-charge, and the other curve in Fig. 1 is obtained at a driving voltage without pre-charge. The sharper curve corresponds to a more efficient generation of brightness than the smooth curve. In short, the brightness

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performance of the driver with pre-charge is better than that of the driver without pre-charge. Furthermore, the pre-charge function provides the advantage of improving the rendering of the luminance at low gray levels because the driving time of the low luminance is insufficient to charging the capacitor of the OLED pixel.

Figure 2 plots the relationship between output gray level of the active pixel and input data for turning on the active pixel. The use of the pre-charge function makes the low gray level remain linear with the input data. Of course, the voltage and duration of the pre-charge are factors to affect the linear relationship between input data and intensity of the output light, and the factors depend on the material used and the structural designed of the OLED pixels.

Figure 3 presents a timing chart associated with the gray-scaled function with pre-charge. These waveforms in Fig. 3 illustrate the gray level on a 63-scaled, a 31-scaled, and a 1-scaled. The time for required by the gray level to be controlled on the 63-scaled is twice that the required to be controlled on the 31-scaled, excluding the pre-charge duration. The picture of the NTUST logo in a 16 gray-scaled is displayed on a PMOLEDs panel of size 48*64 to demonstrate the performance of the luminance of the controller. Figure 4 shows the picture.

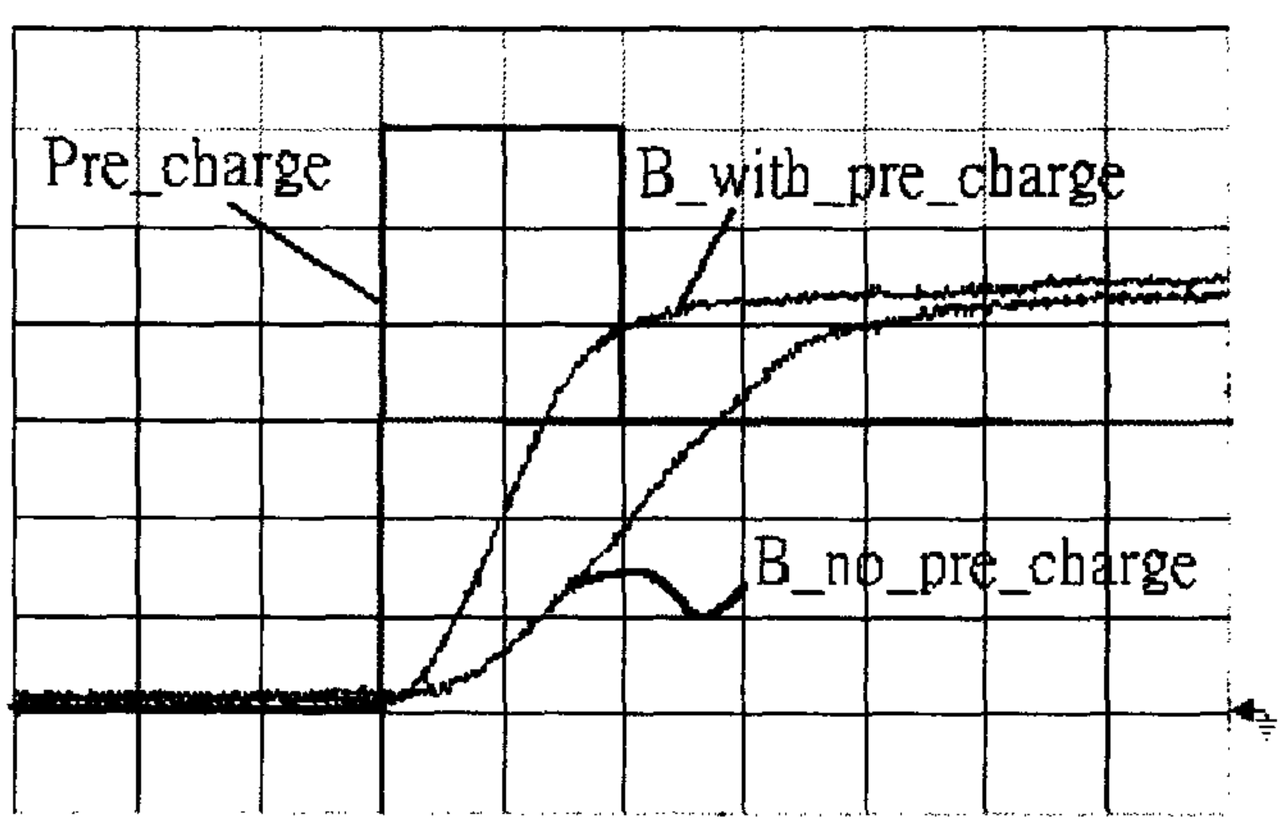

Figure1 The transient response of the brightness from different driving skill

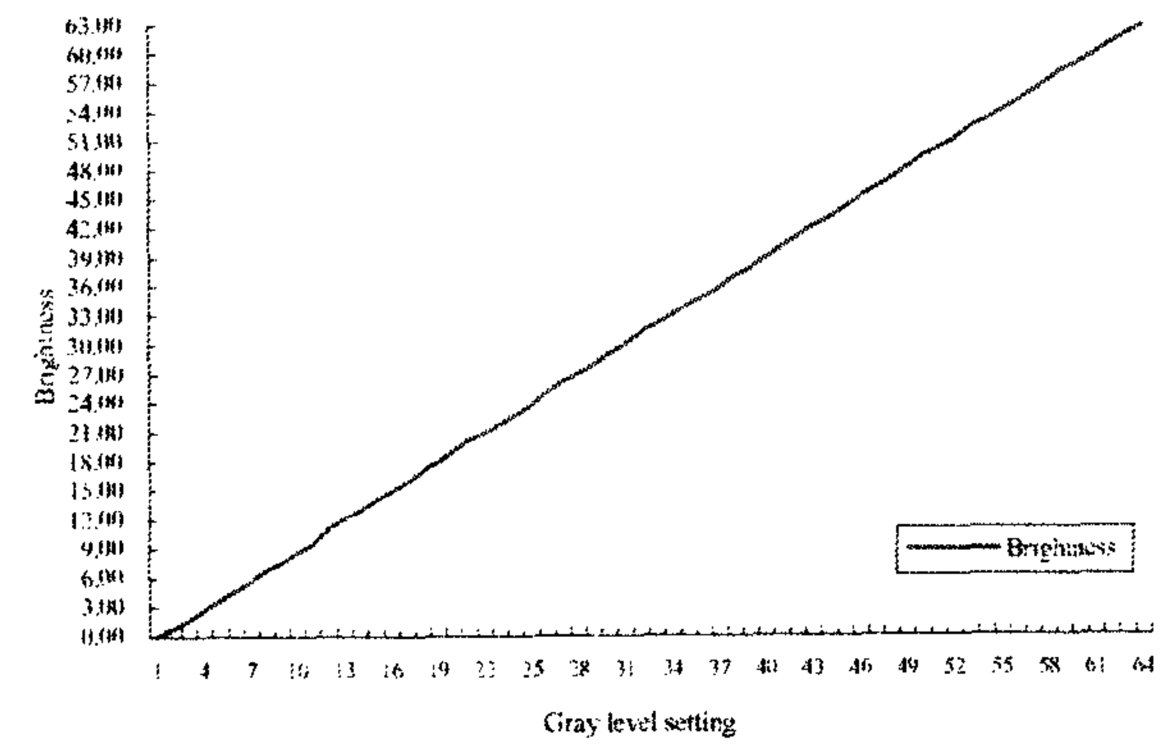

Figure 2 Relationship between gray level setting and brightness

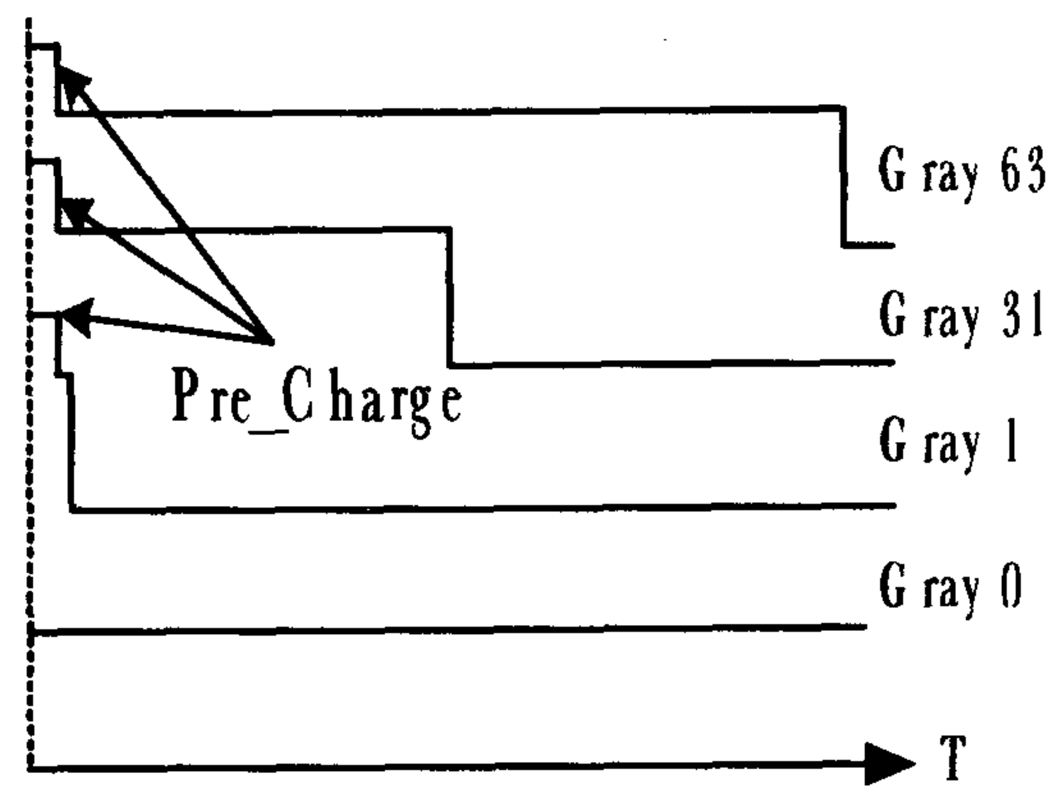

Figure 3 The timing chart of the PWM gray level

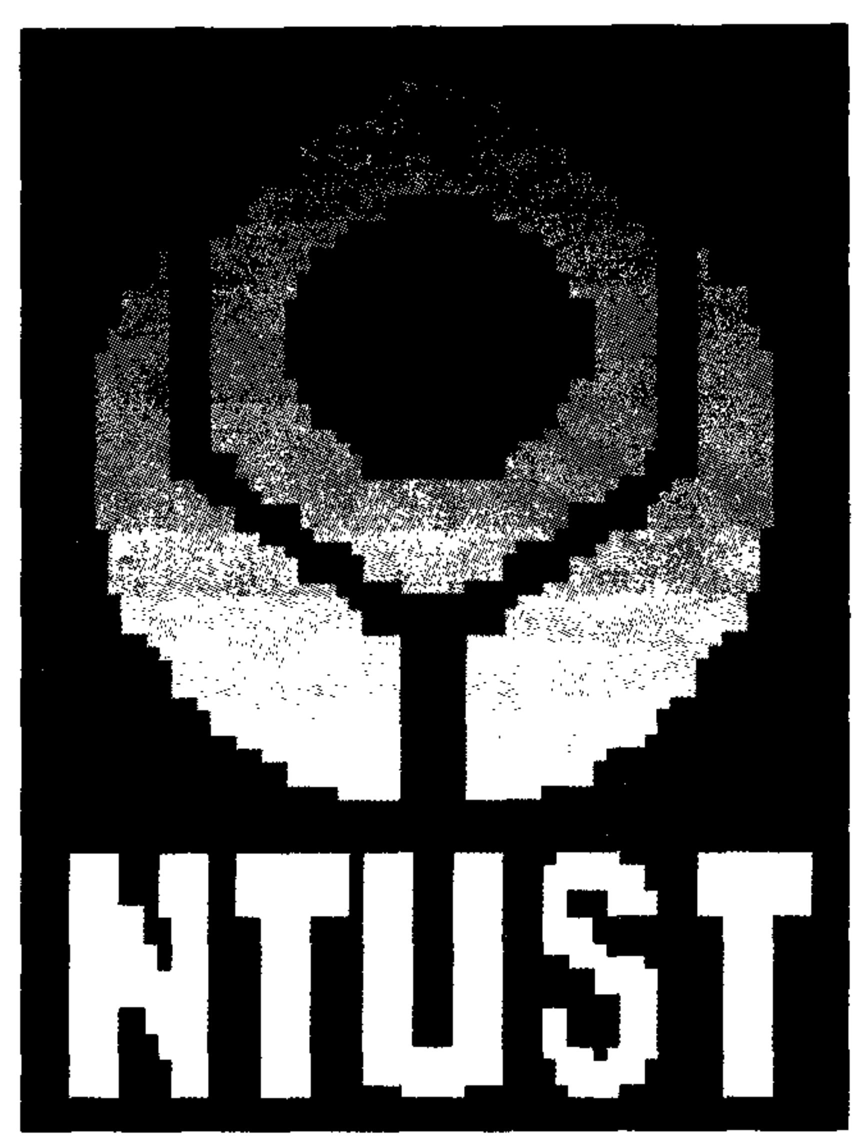

Figure 4 The demonstrate picture to verify the performance of the controller

3. IMPACT

The proposed controller is developed from FPGA chips, DAC chips, and analog switches. The capabilities of the controller differ completely from those of traditional controllers, and the unique technologies used, such as the compensated-voltage driver, the pre-charge function and PLL-less PWM are discussed herein. The performance of the proposed controller in terms of brightness, gray-scaling, and driving voltage is sufficiently good to replace conventional controllers; in particular, the cost of the proposed controller is inexpensive. The aim was to achieve a controller for driving PMOLEDs panels that is competitive in the highly vying consumer market. Finally, experimental results indicate that the controller meets the requirements of the display market. Hence, the proposed controller could be applied to driving PMOLEDs panels.

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