An Area Look-Up-Table based Controller for Improving Performance of Luminance on Lighting Passive Matrix Organic Light Emitting Diodes Panels

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Abstract
This study proposes a controller with the technique of voltage-compensated driver for producing gray-scaled pictures on passive matrix organic light emitting diodes (PMOLEDs) panels; especially, the controller overcomes the problem of luminance non-uniformity on displaying pictures. Because the controller is a voltage type driver, the output impedance of the driver is much less than that of the current-type driver. Hence, the controller provides a better electron-optical response than those of traditional current drivers. An area compensated look-up table (ACLUT) is designed in data feeding paths for removing luminance non-uniformity; thus, the proposed controller provides nearly 95% luminance uniformity.

1. Introduction
Organic light emitting diodes (OLEDs) technology emerged in 1987 [1]. It is becoming a popular research domain 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 listed as follows:

1. Self-emission: An OLEDs panel does not require a backlight module.
2. Quick electron-optical response: An OLEDs panel can display real-time video without residual images.
3. Light: An OLEDs panel weighs only a few grams.
4. Thin: The average thickness of an OLEDs panel is less than 5mm.
5. Wide viewing angle: The viewing angle is nearly 170° without any color distortion.
6. Good contrast: The Contrast ratio is above 400:1.

Based on these superior properties of the OLEDs panels, they can be attached into numerous consumer products such as mobile 'phones, digital cameras, game stations, information displays, PDA. For example, an OLEDs panel as a cellular phone's information display is light, thin, bright, and displays more vivid hues. Display screen of game-stations by an OLEDs panel is attractive because bright, fluent and sharpen pictures are displayed on screen. However, a serious problem, non-uniformity of luminance, will be occurred on FPD; especially, when the size of FPD is large day by day.

OLED pixel is a stack structure so that the emissive light should be pass through several interfaces. The light is influenced by parameters as follows: thickness of the ITO, flatness of the glass, transparency of glass, conductivity of each interface, and reflection of metal cathode. The detailed information are listed as follow:

1. Flatness and thickness of the glass: Glass forms the light output layer of the OLED panel. Therefore, the flatness and thickness of the glass affect the external-coupling coefficients of the light, and hence the brightness uniformity of the OLEDs panel.
2. Transmission rate of the glass: The output intensity of the light is determined by the transmission rate of the glass.
3. Roughness and resistance of the ITO film: Electrical properties of the OLED pixel are influenced by the attributes of the ITO film. Hence, the electron efficient is totally different in each pixel on the OLEDs panel.
4. Organic layers processing techniques: The thickness and conductivity of each organic layer

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affect light emmission.

5. The refraction index of material: The emissive light is influenced by the refractive index of the material.

Considering luminance uniformity problems, we focus not only in electrical path but also in optical emitting path. Electrical resister reduces electron efficiency, and the index of refraction of the substrate decrease optical efficiency [4]-[6]. Therefore, improving luminance uniformity should be concerned of both electrical and optical factors. In this study, an effective method, ACLUT, is proposed to solve all the problems that are caused from the optical path and to achieve luminance uniformity requirement.

The emissive luminance of the active OLED pixel depends on feeding in current. However, focusing on detailed structure of the OLED panel [1], the intensity of the emission light is affected by many parameters, which are listed as follows: flatness and thickness of the glass, transmission rate of the glass, roughness and resistance of the ITO film, techniques of processing organic layers, the refraction index of material Thus, there is no identical pixel in one OLED panel.

The same luminance is expecting when two pixels are lit by the same conductive time; unfortunately, these two pixels display different luminance. Therefore, an adaptive conductive time is applied to the pixel which brightness is low so that the same luminance is emitted from these two pixels. An ACLUT was designed to overcome the non-uniformity of luminance herein. We divide a panel into 64 areas, and each block has its own compensated-LUT. Because ACLUT can be established by an EPROM chip, it is an easy and inexpensive solution for removing luminance non-uniformity problem. The block diagram of the ACLUT architecture is shown in Fig. 1

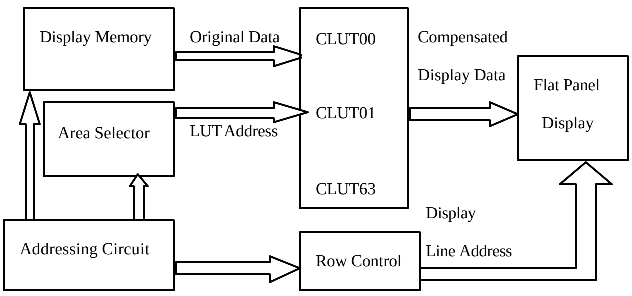

Figure 1 Block diagram of the ACLUT and the displaying system

2. Algorithm of the ACLUT

The uniformity of the luminance compensation algorithm is described as follows:

1. The measured panel is divided into 64 areas and selected pixels are located on [0,0], [0,3], [0,4], [0,7], [3,0], [3,3], [3,4], [3,7]… [7,7]
2. All of pixel on the OLEDs panel is lit on by a precise constant current.
3. Luminance of the selected pixels, which denotes as data [selected], are measured by a luminance meter and the data are stored into measured luminance matrix.
4. MAX_data = max {data [0,0], data [0,3], data [0,4], data [0,7] … data [7,7]}.
5. The same luminance of the selected pixel can be generated by adjusting conductive time. The compensated ratio k is calculated as follows:
   k [selected] = (MAX_data / data [selected]).
   Therefore, the conductive time is modified as:
   $T_{on\_modified}$[selected] = $T_{on\_original}$ [selected] * k [selected].
6. The compensated ratio of selected area can be calculated by step 5, and the compensated ratio of the other 48 areas (64-16 = 48) is computed by using linear interpolation.
7. There are 64 ACLUT in a complete CLUT structure. The data in the CLUT is formed by storing the compensated data, i.e. data*k [select].

3. Experimental Results and Discussion

This section presents the experimental results concerning the performance of the emissive response, the gray-scaling, and uniformity of luminance.

Figure 2 plots the relationship between output gray level of the active pixel and input data for turning on the active pixel Figure 3 presents a timing chart associated with the gray-scaled function with pre-charging. The waveforms in Figure 3 show 63-scaled, 31-scaled, and 1-scaled gray levels. The time required control a 63-scaled gray level is twice that required control a 31-scaled gray level, excluding the pre-charge duration. The NTUST logo in a 16 gray-scaled and a 40 gray-level of luminance are displayed on a PMOLEDs panel of size 48×64 to demonstrate the luminance of the controller. Figures 4.a and 4.b display the pictures

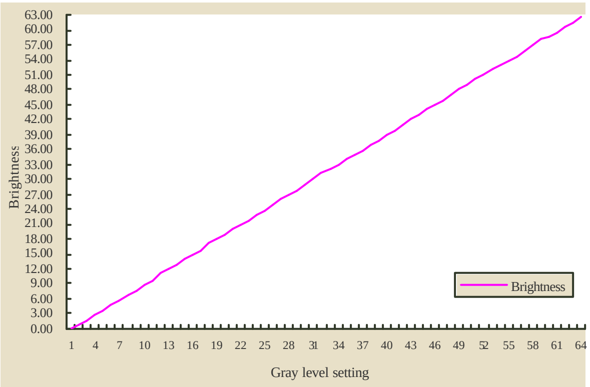

Figure 2 Relationship between gray level setting and brightness

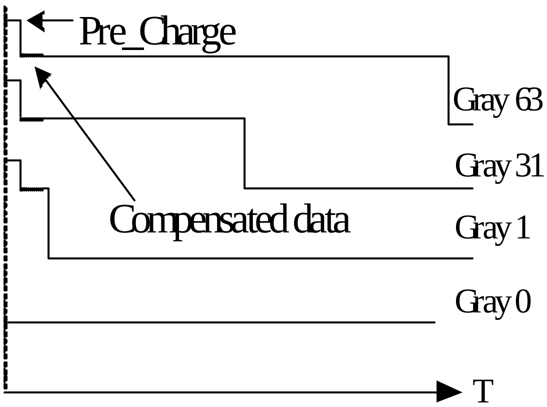

Figure 3 The timing chart of the PWM gray level and compensated data

Figure 4a, 4b The demonstrate picture for verifying the performance of the controller

4 Conclusion

The problem of non-uniformity of luminance is more serious when the size of FPD is increasing day by day. The proposed controller is developed try to resolve this problem by an inexpensive solution. All of the emissive problems, i.e. electrical and optical problem, are compensated by the ACLUT. The luminance uniformity performance of the proposed controller is sufficiently good to replace conventional controllers; in particular, the cost of the proposed controller is reasonable. The aim was to achieve a controller for driving PMOLEDs panels that is competitive in the highly competitive consumer market. Finally, experimental results reveal that the controller meets the requirements of the display market. Thus, the proposed controller can be applied to driving PMOLEDs panels.

6. Acknowledgements

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