Line-flash appearance in PM OLED and Frame part method

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Abstract

PM OLED has the line-disturbance when eyes can detect the driving line status in the shaking situation. It is closely related with the lighting intensity and the lighting time during the line driving. .In this paper we suggest the frame part method for eliminating line-flash appearance. Frame part is a driving method of PM OLED, which divides one frame into several inner-frame parts to reduce the color interference between closely related pixels and to lessen the line-flash appearance which disturbs viewer to perceive the images. Frame part groups one frame into several inner-frame parts and have inner-frame rate higher than the frame rate. Frame part could be used in most of applications in PM OLED systems to enhance the total performance of screen quality.

1. Introduction

It is well known that self-luminous OLED (Organic Light Emitting Diode) is one of the pioneer next-generation FPDs (Flat Panel Displays) due to its superior characteristics such as wider viewing angle, faster response time, wider operating temperature, and lower manufacturing cost.[1] Typically, there are two types of OLED, namely 'active matrix' and 'passive matrix'. The device by low molecule passive matrix has been extensively studied and successfully manufactured by the asian companies due to its simple manufacturing process and mature material technology.[2] These days, PM OLED has been used widely in many applications, like MP3 and personal mobile communication systems. There were several weaknesses in PM OLED - High power consumption of operating module, Not-long life time, line defect from pixel defect and etc. Most of them are overwhelmed and consumer products had begun to adopt PM OLED as a main display. These days line-flash appearance is issued after being used widely. In this paper, we suggest the frame part method to lessen the line-flash and to enhance the screen quality higher.

2. OLED vs. Eye perception

Generally OLED panel is composed of ITO / HIL/HTL/EML/ ETL/ cathode electrode. Figure 1 shows the basic structure and the equivalent circuit of the normal OLED panel. Data and scan electrodes are separately connected to anode and cathode electrode.

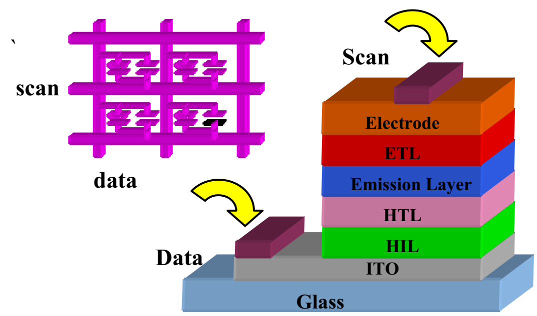


Figure 1 Typical structure of PM OLED

In Figure 1, all data electrodes are connected column by column. All scan electrodes are connected row by row. When a scan line is selected, a pixel is lit in the condition on which data is driven. After one line is selected, the next line is selected step by step. During the overall circulation of all scan lines, the frame image is constructed and is viewed to the viewers. This is called as line-driving and Figure 2 shows the sequencing picture in the line-driving method.

Figure 2 Line-driving in PM OLED

The perceived frame is written as following;

$$P_{frame} = \sum_{i=1}^{N} Li = \sum_{i=1}^{N} (\sum_{j=1}^{M} P_j) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

, where $Li = \sum_{j=1}^{M} P_j$

In addition, we must consider time factor with Eq. (1). The perceived intensity is composed of successive line intensity with driving time. Before mentioned, line intensity is made up of pixel intensity.

$$P_{frame}(W, t) = \sum_{i=1}^{N} L_i(t) * W = \sum_{i=1}^{N} W * \sum_{j=1}^{M} P_j(t) \quad \ldots\ (2)$$

, where W is the intensity of luminance

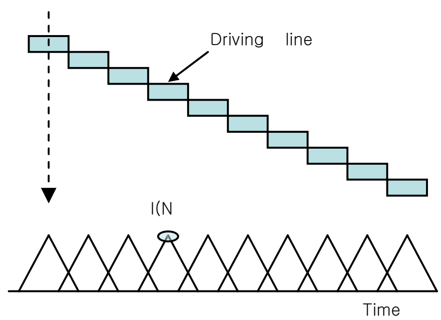


Figure 3 Perceived intensity in driving time

Figure 3 illustrates the intensity status from the line driving. Human eye has the low-pass filter characteristics and there are few problems in perceiving images from line driving in the normal condition. But when the image itself is moved from one point to other and eye tracking is matched with the direction and speed of the image, the driving line is perceived to the viewer within a short duration. The bright line is shown and disturbs the perceiving normal image.

This phenomenon happens frequently in the shaking or moving situations-in a car or while walking.

3. Line-flash appearance

As mentioned, it is named as line-flash appearance to perceive the line status in the image. The line-flash appearance is caused from the characteristics of the line driving. Driving method is classified upon the characteristics of display. PM OLED has the line driving characteristics to drive line by line. CRT has the pixel driving characteristics. TFT LCD and PDP have the full screen driving characteristics on the contrary. Figure 4 illustrates various driving methods following display types.

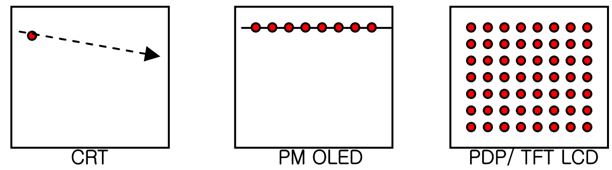


Figure 4 Various driving methods

In the normal situation, eyes can not detect the driving status because human eyes have the characteristics of low pass filter. In the moving or shaking situations, the viewer can see one line in the screen and it gives disturbances to perceive the screen.

Generally, the line-flash appearance could be relieved from making the frame rate higher. However, higher frame rate makes other problems to happen – for example, the coarse grayscale representation from the shortage of driving time for a line, the limitation of the response time from capacitive loads of panel, the high power consumption increasing from higher operation clock.

4. Frame part method

Frame part methods are the driving way which divides one frame into several inner-frames. [3] Figure 4 illustrates the frame part method. Frame part increases the inner-frame rates higher and maintains the frame rate same. It separates grayscales into several groups and represents entire grayscale from summing all inner-frame part in one frame.

$$P_{frame}(W, t) = \sum_{i=1}^{N} W * \sum_{j=1}^{M} P_i(t) = W * \sum_{i=1}^{N} \sum_{j=1}^{M} P_j(t)$$

$$= \sum_{p=1}^{K} W \sum_{i=1}^{N} \sum_{j=1}^{M} P_{j,\,p}(t) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

, where $P_{pixel}(W, t) = \sum_{p=1}^{K} W * P_{pixel,\,p}(t)$

W indicates the luminance intensity. In PWM driving method, W is constant. On the contrary, W is changed $W_{j,p}$ in PAM driving. As Eq. (3), the total driving time is not changed when frame part is applied. Instead of that, the frame is composed of various inner-frame parts.

Fig 4 shows an example of frame part in 64 grayscales.

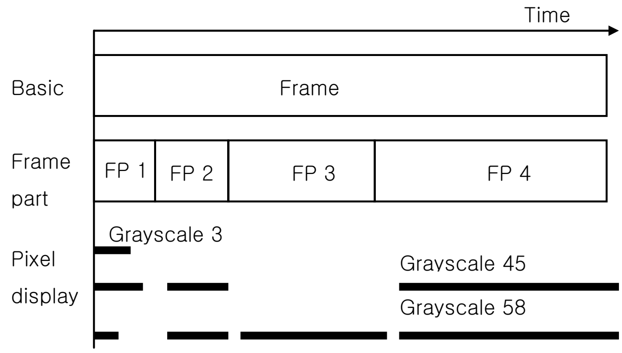


Figure 4 Frame part sequence in 1 frame

Grayscale 3 is displayed in frame part 1 region. As the same, grayscale 45 is displayed in frame part 1, 2, 3.

Grayscale 3 = Fp1(3)

Grayscale 45 = Fp1(5) + Fp2(8) + Fp3(0) + Fp4(32)

Grayscale 58 = Fp(2) + Fp2(8) + Fp3(16) + Fp4(32)

Frame part 1 has the 7/63 duration and frame part 2 has the 8/63 duration. Frame part 3 has the 16/63 duration and frame part 4 has the 32/63 duration. In the result the sum of frame parts is the 63/63 duration.

Frame part could be applied in various ways in the combination and positioning of frame part. But, there are some constraints in frame part method.

(i) address time constraints

In the line driving, data latch process is needed for the preparation of the next line. One data latch operation consumes one latch clock and One line latch operation must have the $M*T_{clock}$ time maximally. Therefore, the line driving time of the minimum frame part must be bigger than one line latch operation time.

$$Min(P_j(t)) \geq M * T_{clock} \quad \text{.....................} \ (4)$$

(ii) grayscale combination constraints

Frame part method makes one frame into several inner-frame parts. Each inner-frame has the different weight. The combination of inner-frame part could be adapted from the grayscale. The combination of the inner-frame part could result the non-uniform grayscale representation. The proper combination must be applied for the best quality through experiments.

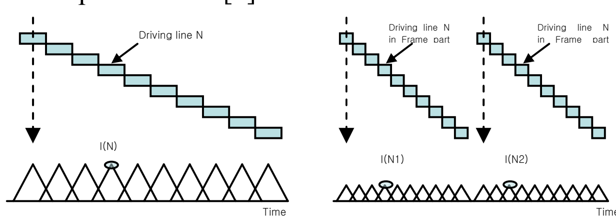
(iii) flicker-free frame time constraints

The flicker could be caused from the low frame rate. Frame part must keep the restriction which the total driving time of all inner-frame parts must be higher than the flicker-free frequency (F_{frame}) in Eq. (5).

$$P_{frame}(W,t) = \sum_{p=1}^{K}\sum_{i=1}^{N} L_i(t) \geq F_{frame} \quad \text{..............} \ (5)$$

5. Application

In the conventional PM OLED panel, all grayscales in a line are addressed simultaneously within one line period. Figure 5 (a) illustrates the line driving diagram and pixel intensity. A complete picture is realized through the line driving. However, it makes the line-flash appearance to happen in the shaking or moving situation from the characteristics of eye perception. The line-flash appearance could be shown easily when the grayscale is high in a line. The frame part method is applied for eliminating line-flash appearance. Each sub-frame part consists of the similar grayscale level and Figure 5 (b) shows that typical example for divided 2 inner-frame part using frame part method [5].



(a) (b)

Figure 5 Perceived intensity in driving time

Expanding Figure 5, the third-frame part is applied for the test environment. The system is based on the dual driving with the resolution of QVGA. The frame rate is set to 90 Hz preventing flicker effects.

Category	Item	Value	Unit
Frame	Freq	90	Hz
	Time	11.11	msec
Resolution	Horizon	320	Dot
	Vertical	240	Line
Dual	Dual	O	O=dual/x=single
Line	Freq	11.52	kHz
	Tune	86.80	usec
Effective	Duty	90	%
	Line time	78.125	usec

Table 1 system specification

Frame part	Number	6	EA
	Gray	64	Grayscale
Frame part	1	1.24	usec
	2	2.48	usec
	3	4.96	usec
	4	9.92	usec
	5	19.84	usec
	6	39.68	usec

Table 2 Violated frame part specification

Basically Table 2 is presented. However, frame part 1, 2, 3, 4 violated the address time constraints. The data latch time for the next line is not enough. It makes the normal line driving difficult. High internal clock is required for satisfying the fast data latch timing. The frame part 1 through 4 is grouped together for satisfying the condition which frame part method suggests having the similar grayscale groups instead of high clock requirement. The new organized frame part is suggested in Table 3. The grayscale from 1 to 15 is displayed in frame part 1. Grayscale level 16 is displayed in frame part 2. Grayscale level 32 is displayed in frame part 3.

Frame part	Number	4	EA
	Gray	64	Grayscale
Frame part	1	18.3	usec
	2	19.84	usec
	3	39.68	usec

Table 3 Optimum frame part specification

5. Results

From the limitation of the observation environment for measuring the line-flash appearance, the test is based on the human test which determines whether the line-flash appearance is shown or not. The experiment was done in 64 grayscale picture with PWM data drivers and scan drivers. The line-flash appearance is dramatically lessened in the condition which frame part method is applied. The system shows the same image compared with the normal system.

Figure 6 320x240 demonstration of the still picture

6. Conclusion

The line-flash appearance is an issue in the application of PM OLED. It gives a viewer disturbance for perceiving an image. Frame part method is applied for eliminating the line-flash appearance. It separates one frame into several inner-frame parts for spreading the intensity of the grayscale while preserving the total frame time and having same image quality. The tested system shows the superior performance in lessening the line-flash appearance.

6. Acknowledge

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References

[1] Mike Hack, J.J. Brown, J.K. Mahon, R.Kwong and R. Hewitt, IDMC 2000, 435P "Performance of High Efficiency AMOLED Displays"

[2] Teruo Thoma, EL'00 "Development of Organic EL Display using small molecule material"

[3] Giljae Lee, Jin Doo Noh, Jin Kim, Jonghak Baek and YoungWook Ko, IMID 2001, "New OLED Drive Using Frame Part and Continuous Scanning with Frame Reset Method"

[4] Kazutaka Inukai, Hajime Kimura, Mayumi Mizukami SID Digest 924P "Late News Paper: 4.0-in TFT OLED Displays and a novel digital Driving method"

[5] Mayumi Mizukami, Kazutaka Inukai and Hirokazu Ymagata SID Digest 912P "6 Bit Digital VGA OLED"