Life time extension method for simultaneous emission driving AMOLED displays

N.-H. Keum, H.-J. In, K.W. Oh and O.-K. Kwon

A life time extension method for simultaneous emission driving active matrix organic light emitting diode (AMOLED) displays is proposed. The proposed driving method extends emission time by driving even and odd row lines separately. The extended emission time reduces organic light emitting diode (OLED) degradation because the current density of the OLED decreases as emission time increases. The proposed driving method increases the emission time by 50% compared with the conventional simultaneous emission driving method. Measurement results show the proposed driving method increases the OLED life time by 70.07% when the target luminance of the OLED is 100 cd/m² and the life time is assumed that the time until the lifetime is assumed that the time until the second emission phase is 10 years. The extended emission time reduces the OLED degradation because the current density of the OLED decreases. To reduce the number of TFTs, simultaneous emission with the active voltage control (SEAV) driving method was proposed in [5]. However, the flicker is caused by the short emission time of the SEAV driving method for a frame time when the frame frequency is lower than the critical flicker frequency [6]. To reduce flicker, the frame frequency should increase [7]. When the frame frequency increases, the emission time of OLED decreases because a frame time reduces and the programming time is fixed in the SEAV driving method. Furthermore, the SEAV driving method requires pixel power supply voltage swing, which induces additional power consumption and noise due to the coupling through the large parasitic capacitance between power lines and signal lines. In this Letter, a new high-frequency driving method and a pixel structure of the AMOLED for extending emission time and removing flicker are proposed. In addition, the proposed pixel does not require the swing of the pixel power supply voltage and achieves uniform luminance of the OLED by compensating the electrical characteristic variations of driving TFTs on the poly-Si backplane.

Fig. 1 Schematic diagram of proposed pixel structure

Pixel structure and driving method: Fig. 1 shows the schematic diagram of the proposed pixel structure located at the kth row line, where k varies from 1 to the number of row lines of the panel. T₁ is the driving TFT to generate current flowing through the OLED. T₂, T₃, and T₄ are switching TFTs, and Cₛ is the storage capacitor. Fig. 2 shows the timing diagram of the proposed driving method. The proposed driving method is divided into the odd-pixel-programming phase, the first emission phase, the even-pixel-programming phase, and the second emission phase during a frame time as shown in Fig. 2 where m means the number of row lines of the panel. The scan[−1] and scan[0] signals in Fig. 2 are dummy signals for scan[−2] of the pixels located at the first and second row lines, respectively. In the odd-pixel-programming phase, T₁ in every pixel is turned off by the em signal. T₄ turns on when the scan[k − 2] signal becomes low voltage row line by row line, and T₂ turns on when the scan[k] signal becomes low voltage row line by row line, when k is an odd number. When T₄ turns on, the gate voltage of T₁ (Vₛ(T₁)) becomes Vₛ(0), which is low voltage to turn on T₁. When T₂ turns on, Vₛ(T₂) becomes ELVDD−Vₛ(0), where Vₛ(0) is the threshold voltage of T₁. At the same time, the data voltage (Vₛ(d)) is programmed to the data line.

Fig. 2 Timing diagram of proposed driving method

Therefore, the voltage applied to data line-to-node A is Vₛ(d) − ELVDD − Vₛ(0). The voltage applied to data line-to-node A in the pixels located at even lines is held by Cₛ during this phase. In the first emission phase, data becomes the reference voltage (Vₛ(ref)), so Vₛ(T₁) becomes ELVDD − Vₛ(ref) by the coupling through Cₛ. The em signal becomes low voltage to turn on T₁, so T₁ generates emission current which flows through the OLED. The emission current of each pixel is determined by Vₛ(T₁) and can be expressed by

\[ I_{OLED} = \frac{1}{2} \mu_p C_{ox} W L (V_{gs} - V_{th})^2 \]

where \( I_{OLED} \), \( \mu_p \), \( C_{ox} \), and \( W/L \) are the emission current of the OLED, mobility, gate capacitance per unit area, and the ratio of channel width and length of T₁, respectively. As shown in (1), the emission current is independent from Vₛ(0).

In the even-pixel-programming phase, T₂ and T₄ turn on when the scan[k − 2] and scan[k] signals become low voltage, respectively, when k is an even number. In this phase, the em signal becomes high voltage to turn off T₁. The operation of the pixels in the even lines in the even-pixel-programming phase is the same as that of the pixels in the odd lines during the odd-pixel-programming phase. The voltage applied to data line-to-node A in the pixels located at odd lines is held by Cₛ during this phase.

In the second emission phase, em becomes low voltage to turn on T₁. So, T₁ generates emission current with Vₛ(T₁). The emission current is expressed by (1).

As shown in the above explanation, the emission frequency of the OLED is increased because the OLED emits two times during one frame time when the proposed driving method is used. So, the proposed driving method reduces flicker successfully.

The proposed driving method requires half programming time because only half of the pixels on the panel are programmed during the odd-pixel-programming phase or the even-pixel-programming phase. Therefore, emission time increases as the programming time decreases.

Experimental results: The luminance uniformity of OLEDs using the proposed method is verified by the fabricated 3.8-inch AMOLED panel with 8-bit greyscale green mono-colour. Fig. 3 shows the photograph of the 3.8-inch panel using the proposed driving method. The photograph of the demonstration is taken by a CMOS image sensor.
(CIS) camera. Figs. 4a–c show the measured luminance results of the panel luminance using a charge-coupled device (CCD) camera pixel by pixel when all pixels display same the grey level of 255, 150, and 50, respectively. The target luminance of the 255 grey level is 300 cd/m². For describing the uniformity of the panel, long range uniformity (LRU) as the luminance error between the luminance of each pixel and the average luminance of the panel and short range uniformity (SRU) as the luminance error between two adjacent pixels are defined. The measured results show that the range of LRU is $-3.17$ to $3.16\%$ and the maximum SRU is $0.26\%$.

![Figure 3](image-url) **Fig. 3** Demonstration of 3.8-inch panel using proposed pixel structure

![Figure 4](image-url) **Fig. 4** Measured luminance of panel when all pixels display same grey level of 255, 150, 50

a 255  
b 150  
c 50

The proposed driving method increases emission time by 50% compared with the conventional simultaneous emission driving method. Assuming that the OLED life time is the time until the OLED luminance becomes 75% of the initial luminance, which is 300 cd/m², the measurement results show the OLED life time increases by 70.07% when the emission time increases by 50%.

**Conclusion:** A new driving method for extending the life time of AMOLED displays by driving even and odd lines separately is proposed. The emission time of the proposed driving method increases by 50% compared with that of the conventional simultaneous driving method. The measurement results show the OLED life time increases by 70.07% when the emission time increases by 50%. In addition, the proposed driving method does not have additional power consumption and coupling noise due to pixel power supply voltage swing. The proposed driving method is demonstrated using a 3.8-inch panel. The experimental results show that the range of LRU is $-3.17$ to $3.16\%$ and the maximum SRU is $0.26\%$, which is the excellent uniformity of luminance. Therefore, high image quality, low flicker, and extended life time can be achieved using the proposed AMOLED driving method.

© The Institution of Engineering and Technology 2012
30 July 2012
doi: 10.1049/el.2012.2728
One or more of the Figures in this Letter are available in colour online.
E-mail: okwon@hanyang.ac.kr

**References**


