Fast Measurement Approach for Examining Electrical Characteristics of Passive Matrix Organic Light Emitting Diodes panels

Chang-Jung Juan[1,2], *Ming-Jong Tsai*[1]

[1]Automation and Control School, National Taiwan University of Science and Technology, Taipei, Taiwan

[2]Department of Electronic Engineering, Haw-Hsia College of Technology and Commerce, No. 111, Hwa-Shin Street, Jong-He city, Taipei County, Taiwan, ROC

Abstract

The approach is based on a phenomenon of lighting on electronic transient response of a PMOLED pixel. It achieves a speedy measurement because of using a compact algorithm; therefore, the method is suitable applied to production lines for examining quality of PMOLEDs panels

1. Introduction

After improving many characteristics of the OLEDs panels, OLEDs panels could play a major role in information display field in the next decade. However, the quality requirement is becoming a barrier of mass production for the OLEDs panels. Providing a perfect OLEDs panels to customers is a basic requirement for producers; unfortunately, there is no standard inspection system for examining quality in an OLEDs panels' production line. The best solution for quality consideration is a quality design-in methodology, but it depends on well knowledge of a designer. Thus, checking the quality of products after production is a compromise.

A fast measurement approach is proposed in this paper. The measurement method is based on transient response of an OLED pixel when it was lighted on. An equivalent circuit of the OLED pixel is similar to paralleled a resister and a capacitor; hence, an across voltage transient response of the OLED pixel should be responded to its electrical properties. Based on the phenomenon, the approach is applied to measure electrical characteristics of each pixel on a panel to judge the quality of the panel. Because no complex algorithm is applied to the approach, the time for checking a panel is short, and almost no delay time is generated due to inserting the measurement procedure. The most important requirement for a mass production line is productivity so that the proposed approach could be useful in production lines.

2. Background

The technologies of flat panel display (FPD) are listed as follows: organic light emitting diodes (OLEDs), liquid crystal display (LCD), plasma display panel (PDP), and field emission display (FED) [1]. There are some special properties of each technology; therefore, these technologies are applied to different FPD products. For example, the LCD can be used in a median monitor whose size range is below 30 inches, and the PDP is usually applied to a TV set; especially, the size range is from 40 inches to 60 inches. Characteristics of the OLEDs panel are written below: self-emission, thinness, wide view angle, quick electronic response, and lightness [2-4]. However, the OLED technology is still under development. Some barriers such as lifetime, material, oxidation, moisture, and driving-voltage problem are waiting for improving. Many researchers believe when the most barriers are removed, the OLEDs panels could be joined a mainstream of the small FPD in the next generation [5-6].

Consumers cannot accept an information display with some defects, e.g., bright pixels, dark pixels, and non-uniform problems. Therefore, producers have to consider how to provide perfect products for customers. One of the compensation skills is setting an inspection station into producing procedure. Under a producing inspection process, a product should be maintained its quality standard. The common inspection methodologies for quality performance is described as follows: Operators light on the under testing PMOLEDs panel, and check the performance of the panel by their eyes.

Here, the drawbacks of the inspection by operators' eyes will be discussed in detailed. The easiest checking method is lighting on a pixel only if the pixel under checking, and operators inspect status of the pixel, which is under checking, by their eyes. Because intelligent and smart humankind join the inspection procedure, a complex and difficult inspection system can be accomplished. In short, a system with cheap in cost is obtained. However, a serious problem will be induced because the quality control depends on operators' ability, i.e., different operators will vibrate the quality of products. The skill, mood, and stability of the operators are variations of such kind a human dependence system. A product with stable quality could be expected only if precise inspection instruments are used in assembly lines.

Lifetime, photoelectrical response, and defectives pixel are the basic terms for examining of the OLEDs panels. In the OLEDs field, lifetime and photoelectrical response can be found in theoretical papers [7-8]; however, not any academic paper is

Chang-Jung Juan: ericjuan@cc.hwh.edu.tw
Ming-Jong Tsai: mjtsai@mail.ntust.edu.tw

focused on checking pixel defects and decreasing production time. Therefore, an intelligent technique; especially for assembly lines, is presented in this paper. A personal computer (PC) combines with a data acquisition card to form the approach, and it runs under a simple algorithm without complex image calculation. The proposed scheme is relied on a phenomenon of lighting on the voltage transient response of OLED pixel. In addition, a database matching skill is applied to the system so that to shorten the inspection time is achieved. The block diagram of the proposed approach is shown in Fig. 1.

An electrical equivalent circuit is shown in Fig. 2. In electrical point of view, a capacitor, a resister, and a LED are paralleled to form a PMOLED pixel. The resister is from the conductivity of each layer and transparency conductor, i.e., ITO. The capacitance of the PMOLED pixel is proportional to the area, thickness, and dielectric constant of the each material. Focused on electrical phenomenon only, an impedance Z can be represented the PMOLED pixel.

Assume a constant current, *I*, is fed into a PMOLED pixel. An across voltage transient response can be written as Equation (1):

$$V(t) = i(t) * (R // C) = i(t) * R * (1 - e^{-1/RC}) = i(t) * Z = I * Z \big|_{\text{I-constant}} \quad (1)$$

The across voltage transient response of each pixel on a PMOLEDs panel is different because the impedance of the pixel, Z, is not a constant value. Indeed, there are no two pixels with the same impedance on a PMOLEDs panel. The impedance of pixels is depending on material, number of layers, display area, and conductivity status of pixel. The conductivity status problems are focused in this research. Due to components of the Z, waveforms of the *V(t)* can be expressed by a first order function. Therefore, the transient response of the across voltage on the OLED pixel can be applied to judge the quality of the OLED pixel. Fig. 3 shows a standard waveform of the Equation (1) with an upper bound and lower bound limitation.

A judgment algorithm is listed as follows:

1. The driving current is set for inspection process.
2. Measuring some chosen pixels' transient response to produce a standard waveform.
3. The waveform is expressed as data style, (value, time), and the data save in a standard matrix.
4. Setting a lower bound and upper bound into the standard matrix.
5. Capturing data from an inspected pixel, and comparing with the standard matrix. The data should be set in the accepted range, i.e., the sampled data is between the lower bound and the upper bound.
6. If the data of measurement transient response is passed the rule of the step 5, the pixel can be marked as an OK pixel; otherwise, marked it as a NG pixel.
7. Repeat the step 5 and step 6 until the entire pixel in the panel is checked.
8. Count the NG pixel number; if the number is less than quality control minimum requirement, the panel is passed the inspection procedure.

3. Results and discussion

Measurement performance of the approach is verified by an OLEDs panel with 2*2 pixels. The measurement time for each pixel is set 1ms, and captured data number for checking is 1000. Therefore, the time of capturing is 100μS, and rest 900μS for the system to compare and decide the status of the pixel. The pixel size is 2mm * 2mm, and driving current is set 100μA. The standard waveform is shown in Fig. 4a and transient waveforms of defective pixels are shown in Fig. 4b, 4c and 4d. The quality judgment algorithm of the scheme is made decisions from comparing these waveforms. Because capturing and comparing data of a pixel is finished in one millisecond, the system is achieved a fast measurement requirement. Based on the short checking time, the approach is suitable used in mass production lines for examining quality.

4. Impact

A fast measurement approach for checking quality of the PMOLEDs panel is presented in this paper. The paper states the algorithm for the measurement and a complete technique of the approach. Based on a simple hardware architecture and software structure, the approach is cheap in cost and efficient in checking performance. The measurement time for checking PMOLEDs panels is shortened; therefore, it could be used in the PMOLEDs panel production lines for a real-time quality control and mass production purpose.

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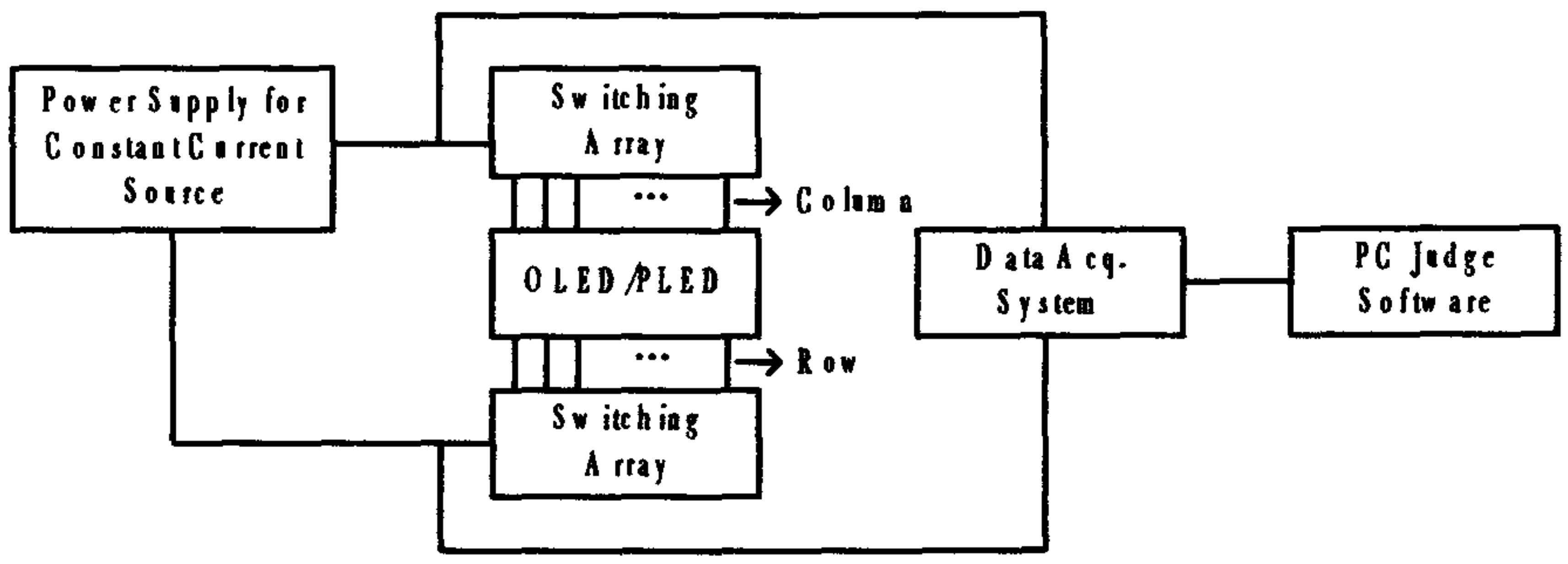

Figure 1 The Block Diagram of the proposed Approach

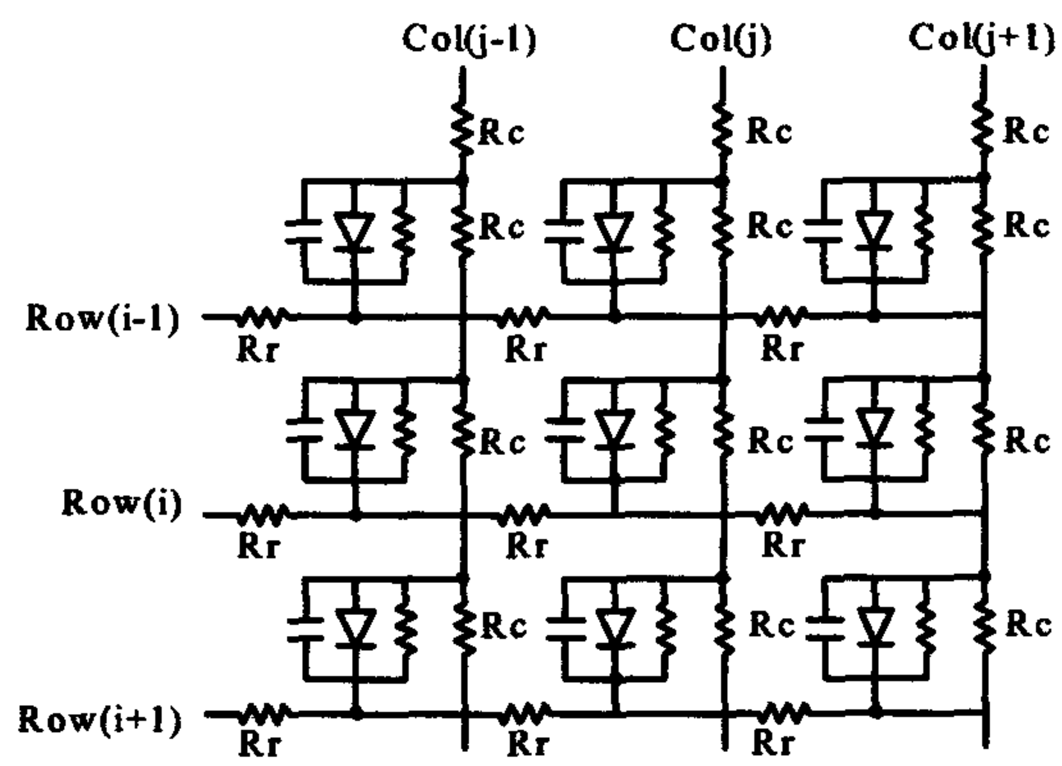

Figure 2 the electrical equivalent circuit of the OLED pixel

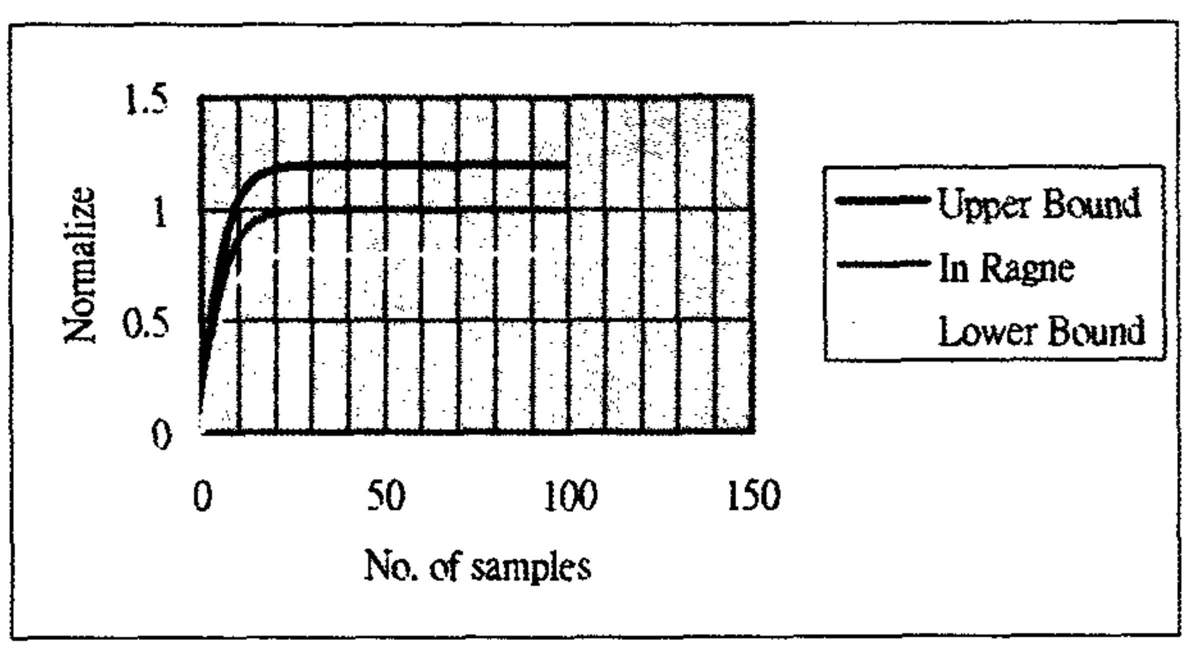

Figure 3 The Transient response of the inspected pixel
1: Upper bound for the limitation
3: Lower bound for the limitation

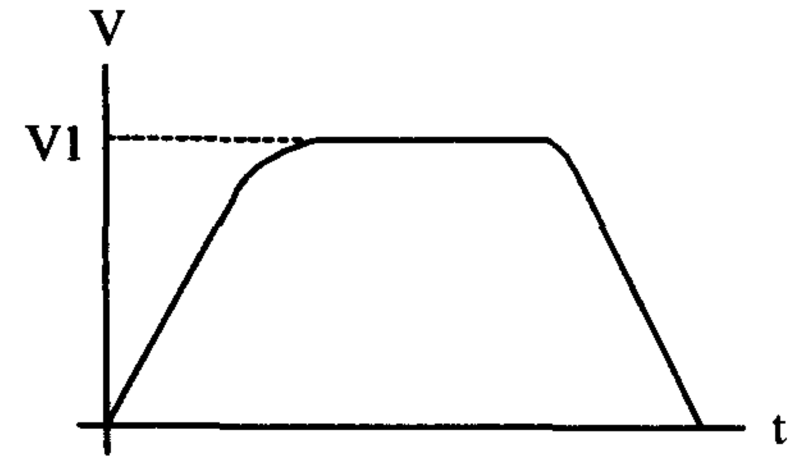

Figure 4a Waveform of the Standard Pixel

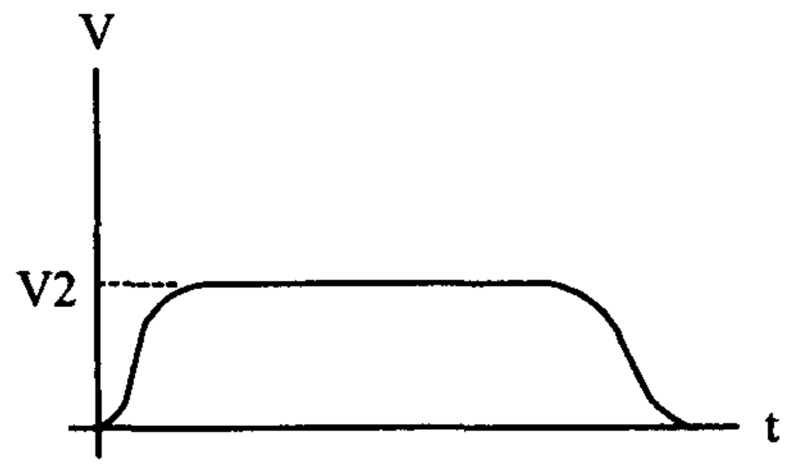

Figure 4b Waveform of the Short situation

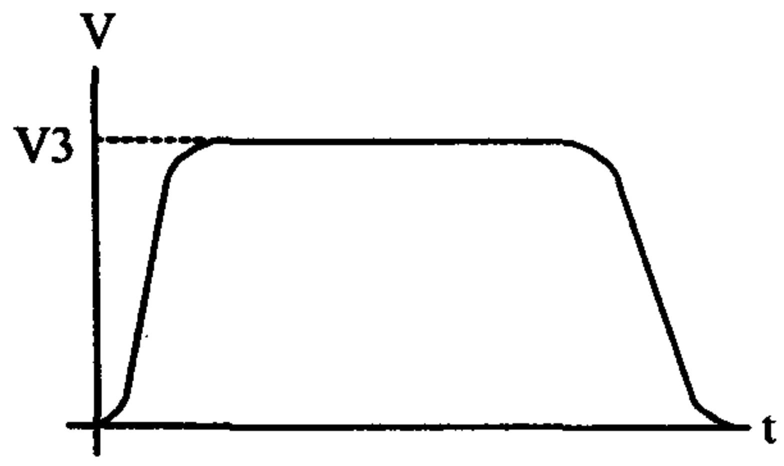

Figure 4c Waveform of the open circuit

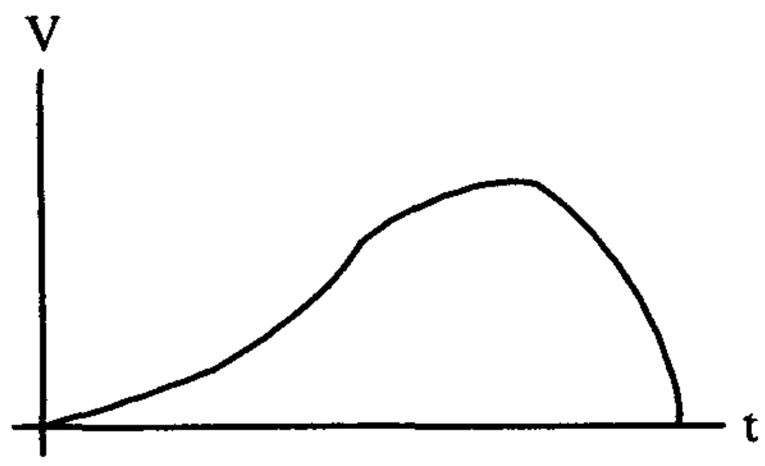

Figure 4d Incompletely display pixel