SOLOMON Systech's OLED Driver IC Optimizes Display Performance

Ricky Ng
Senior Design Engineer
Solomon Systech Limited

OLED panels are current-controlled devices. Precious current driving circuits are necessary in OLED driver ICs. However, voltage driving circuits is equally important and should not be overlooked.

Solomon Systech Limited, one of the world's premier OLED (Organic Light Emitting Diode) driver suppliers, leveraging its extensive experience and technical knowhow on display driver ICs, has developed OLED drivers exploiting the superior features of OLED displays - contrast, thinness, lightness, power consumption, response speed and viewing angle.

Current Drive Or Voltage Drive ?
OLED displays are well known to be current-controlled display devices, contrasting to their rival LCD displays which are voltage-controlled. Nevertheless, for high-content displays, multiplexing is necessary. Developing the driving algorithm for such a display involves many special considerations. In this context, though OLED is essentially a current-controlled device, voltage drive for a short period before current drive is necessary. It is usually referred as pre-charge. Therefore, for a multiplexed matrix OLED display, both current drive and voltage drive are required.

How About Only Current Drive?

Fig 1a depicts an electrical model of a pixel of OLED. It consists of a light emitting diode D and a capacitor C. The pixel emits light when current passes through the diode D. The parasitic capacitance is modeled by the capacitor C. This large capacitor contributes most to the necessity of pre-charging.

In a current driving system, a constant current source connects to the pixel to turn it on. This charges up the capacitor linearly, see figure 1b. Before the pixel voltage reaches the diode threshold voltage, there is no current flowing through the diode and the pixel is dark. Supply current is consumed only for charging the capacitor during this period. If the capacitance is large, and it is most likely the case, the pixel is off for a long time. And it is lit only after the pixel voltage is above the threshold. Resulting from this, the pixel becomes very dim and it brightness is difficult to be controlled.

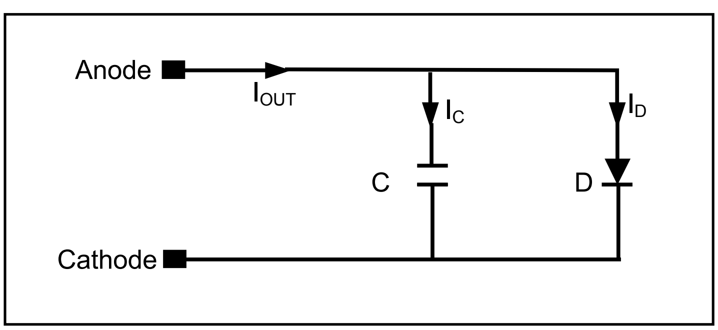

Figure 1a. Electrical model of an OLED pixel.

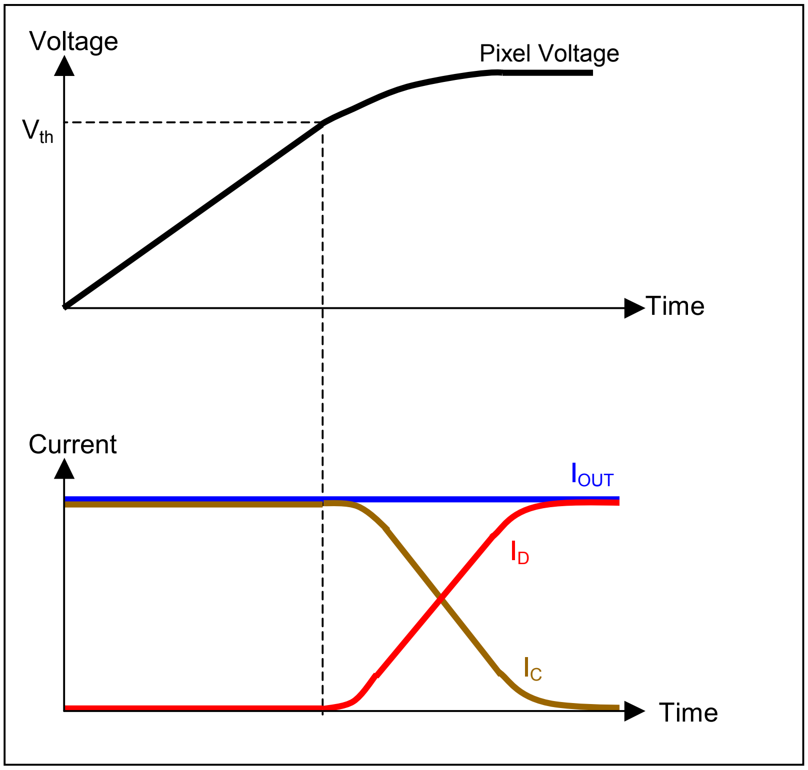

Figure 1b. Current drive only

How Does Pre-Charge Work?

Fig 1c reveals how pre-charge driving method provides a solution. Before current driving, a voltage level is applied to the pixel so that the capacitor is charged up quickly. The pixel voltage arrives at a level where desirable diode current is attained in a short time. Since the charging up is so fast that the variation in the driving strength does not matter the overall brightness of the pixel.

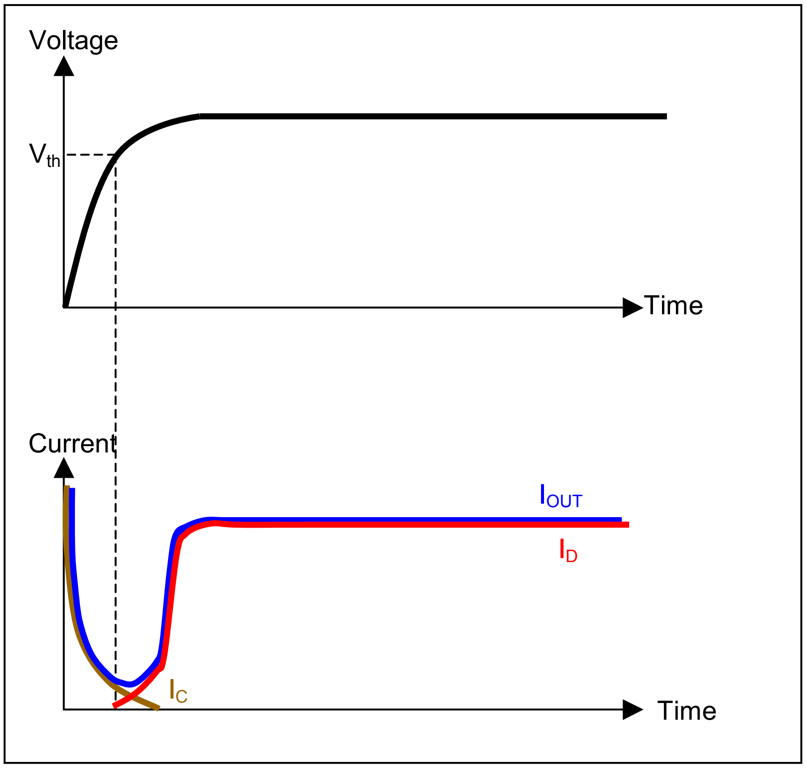

Figure 1c. Current drive with precharge

How Accurate Should The Pre-Charge Voltage Be?

If the pre-charge voltage is too high or too low, the pixel brightness becomes queer. The practical accuracy requirement depends on several factors covering both optical and electrical characteristics.

The brightness generally responds to the average current flowing through the diode. Assuming that the pixel voltage V deviates (ΔV) from the target level during pre-charge but reaches the level within the current drive period, and also assuming that the short pre-charge time is negligible, the deviation of the average current, ΔI, can be approximated as

$$\Delta I = \frac{\text{Capacitance} \bullet \Delta V}{\text{Time}}$$

If the tolerance of the average current is U%,

$$\frac{\text{Capcitance} \bullet \Delta V}{\text{Time}} < U\% \bullet I$$

$$\Rightarrow \quad \Delta V < \frac{U\% \bullet I \bullet \text{Time}}{\text{Capcitance}}$$

This inequality shows the pre-charge voltage has to be more accurate if the capacitance is larger, the current is smaller or the drive time is shorter. In practice, the pre-charge voltage tolerance is rarely smaller than 100mV or beyond 1V.

How long & How Fast Should Pre-charge Be?

Of course, the precharge time should be long enough and the skew rate should be fast enough for the pixel voltage to reach the desired level. Meanwhile, driver IC designers and application developers have to make compromises. Increasing the pre-charging time means reducing the current drive time while current drive is important to OLED displays. Strengthening the pre-charging circuits inevitably increases design complexity, chip size and its cost. Moreover, further complication comes from the fact that the optimum settings for different panels and applications are different.

It should be noted that the skew rate usually drops as the loading goes up. The pre-charging loading of a row with a bright horizontal line on the display is very different from a row with only a few lit pixels. To determine the pre-charge period and the driving strength, the slowest skew rate has to be accommodated, otherwise some rows with more ON-pixels would not have enough pre-charge, and they would appear to be dimmer than other rows. The display brightness would become uneven. This irregularity is display-pattern-dependent. (Fig. 2)

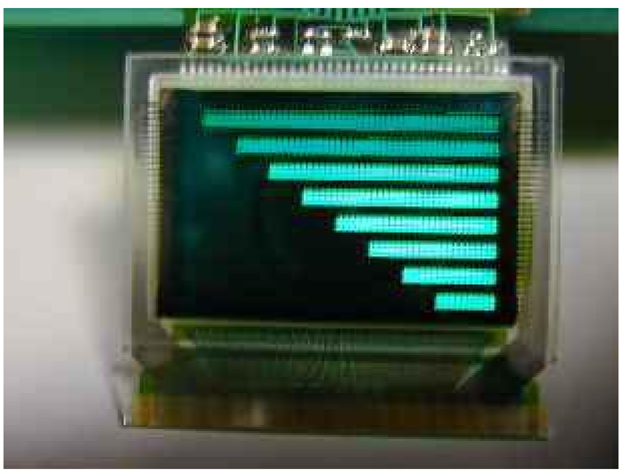

Fig. 2 Pattern Dependence Tests

The Versatile Solution

Pre-charging is one of the critical elements in designing and applying OLED driver ICs for multiplex matrix OLED displays, while it is vital for maximizing the full potential of the superior nature of OLED displays.

Solomon Systech's OLED Driver ICs SSD130X series (Fig 3), in addition to the proprietary driving algorithm, provide the essential pixel precharge feature. They allow programmable precharge time, adjustable voltage level, and variable skew rate. Application developers can optimize these parameters for different panels characteristics and application requirements to achieve the best display performance.

Fig. 3 Solomon Systech OLED Driver IC SSD1301T