# Driving Methods of LCD-TV Using a-Si:H TFT Integrated Gate Drivers

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## Abstract

*LCD-TV applications were successfully implemented using integrated gate drivers. Integrated gate drivers have been implemented on a HD panel for 60Hz operation and on a FHD panel for 120Hz operation. It is found that the integrated gate driver reduces the flicker of a panel.*

## 1. Introduction

In 2004, Samsung started mass production of an 14.1" XGA panel with integrated a-Si:H TFT gate drivers. Since that time, integration of gate drivers has become a mature technology. Integrated gate drivers have typically been applied to small format LCD panels with light gate-line loads. However, until now, use of integrated gate drivers in large format LCD-TV panels has not been attempted.

Two-transistor super PVA (S-PVA) was proposed by Samsung for the first time as shown in Fig.1. It has been a promising technique to achieve the widest viewing angle without gamma distortion. However, for 60Hz two transistor S-PVA driving, the number of gate IC channels as well as the number of gate lines must be doubled, resulting in increased cost of the gate driver ICs. Recently, the two transistor S-PVA technique has been applied to 120Hz driving with a pixel structure having 2 data lines and a single gate line. Two transistor S-PVA driving at 60 or 120Hz, however, requires driver ICs to have more channels for the gate lines or data lines and an increase of the panel cost due to the increment of channels on the driver IC.

This paper reports on gate driver integration for 60 and 120Hz LCD-TV panels. A HD 60Hz panel and a FHD 120Hz panel were successfully driven with integrated gate drivers. The uniformity of flicker for specific display patterns has been found to be drastically improved compared with panels driven by external gate driver ICs. By gate drivers integration, 3 gate ICs can be eliminated from a HD 60Hz panel and 8 gate ICs can be eliminated from a FHD 120Hz panel.

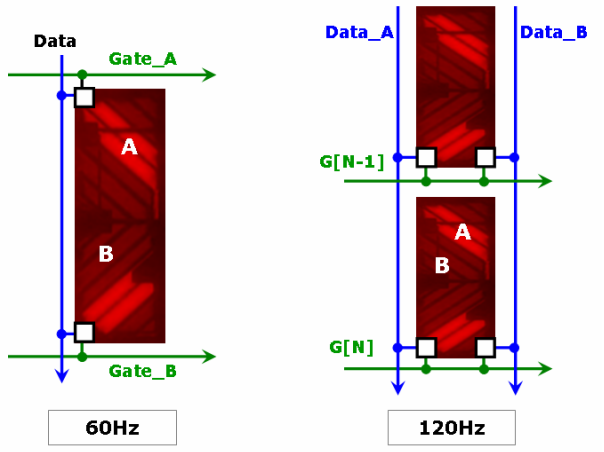



**Fig. 1** S-PVA pixel of 60Hz and 120Hz at LCD-TV

## 2. Method of drivers

Fig.2 shows timing diagrams with integrated gate drivers for 60Hz HD driving. The most significant thing at 60Hz HD driving is the enlarged duration of the gate pulse for the A sub-pixel. For the first half of the enlarged gate pulse, the A sub-pixel of the current line is pre-charged with the B sub-pixel data of the previous line, and then is charged with the desired A sub-pixel data during the second half of the gate pulse.

Charging of the B sub-pixel is identical to that of the external gate IC driving method, whereby the current line's B sub-pixel is pre-charged with the current line's A sub-pixel data. Pulse durations of Gate A and Gate B are same and the timings of Gate A and Gate B are adjustable. The signal named TP indicates the output of A sub-pixel data.

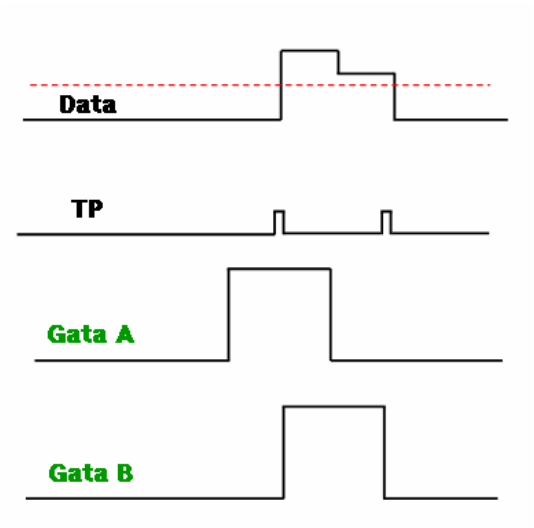



**Fig. 2** Timing diagrams for HD 60Hz driving with integrated gate drivers

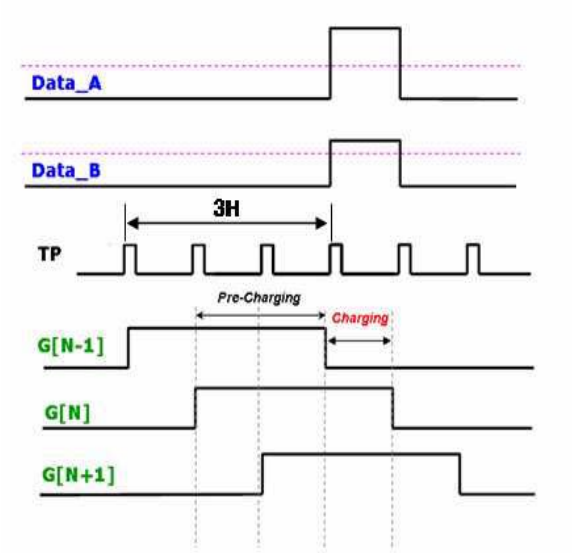



**Fig. 3** Timing diagrams for FHD 120Hz driving with integrated gate drivers

Fig.3 shows timing diagrams for 120Hz FHD S-PVA driving. The driving scheme for the integrated gate driver is similar to the driving scheme using external gate ICs. Pre-charging for 2/3 pulse duration is used with previous 2 lines and charging with desired data is done for 1/3 pulse duration, that is, 7.4us. In the case of 120Hz FHD driving method, optimization of the pixel design and the gate timing is required because the available charging time is only about 7.4us. In order to maximize available charging time, the dual-bank integrated gate drivers were adopted for the minimized gate signal delay.

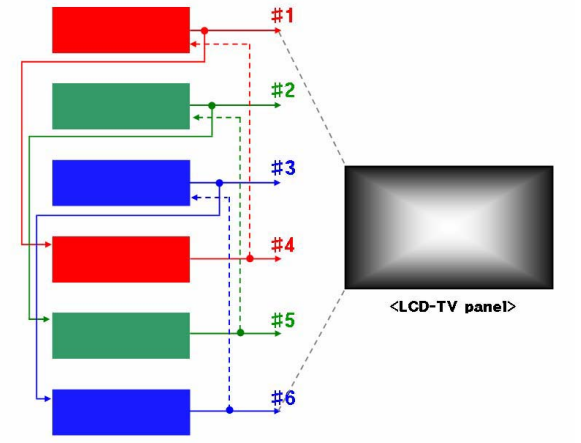



**Fig. 4** Circuit diagram of integrated gate drivers for 120Hz FHD panels

Fig.4 shows the circuit diagram of integrated gate drivers for FHD driving. In order to driving these circuits, 3 pairs of CLK signals (1 & 4, 2 & 5, 3 & 6) are required and each CLK pair drives periodically located gate drivers. The 1st gate drivers make a carry signal (solid line) to get ready to turn on the 4th gate drivers. When the 4th gate driver is turned on, the output of 4th gate driver discharges the 1st gate driver (dotted line). This operation is similar to the operating 60Hz HD panel with 2 pairs of CLK signal.

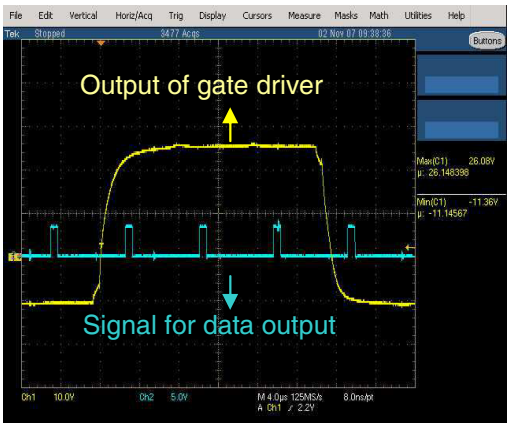
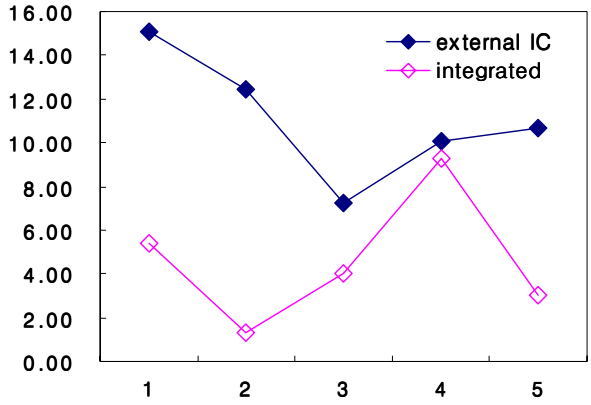


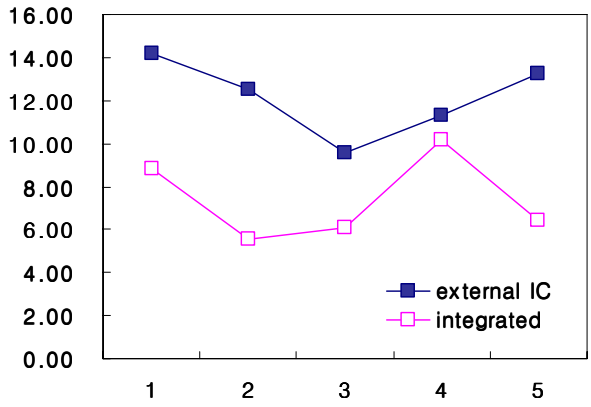

**Fig. 5** Waveform of integrated gate driver with data signal output of the FHD 120Hz panel

## 3. Results

A waveform of an integrated gate driver output is shown in Fig. 5. The duration of the gate pulse is 22us, which is three times that of the ideal charging time for each pixel. The integrated gate driver has an output pulse with slow rising and falling transitions compared to an ideal square wave pulse. However, this long transition can reduce the coupling effect between the gate line and the pixel electrode, which reduces the panel's flicker. As shown in Fig.6, the average value of measured flickers at 5 points on the panel is 40% lower than that of a conventional panel with external gate ICs.




(a) at 36% gray (22Gray)




(b) At 50% gray (32Gray)

**Fig. 6** Comparison of 5-point flicker at 36% and 50% Gray from HD 60Hz LCD panels with external gate ICs and integrated gate drivers

Fig. 7 shows FHD 120Hz LCD-TV panel which was fabricated on Samsung's 8th generation line. In this FHD panel, 12 source driver ICs (960ch) to drive data lines are used without external gate ICs. Previous FHD panel driven by an external gate driver has 8 (= 4 + 4) gate ICs on both sides of the panel, so that we can reduce 8 gate ICs in the new panel. In the case of HD panel, 3 gate ICs can be removed compared with the conventional HD panel with an external gate driver.

**Fig. 7** FHD 120Hz panel with integrated gate drivers

Table 1 summarizes the optical characteristics of FHD LCD TV. The brightness of the panel is over 500cd/cm$^2$ and contrast ratio is larger than 3000:1. The integrated gate driver can successfully drive S-PVA panel with wide viewing angle. The non-uniformity of the panel with the integrated gate driver is less than 10%. Other optical properties are also identical to those of a conventional panel so that the integrated gate driver can drive S-PVA panel without degradation of image quality.

**Table 1** Optical property of FHD LCD-TV panel with integrated gate drivers

| Properties | Measured data | Unit |
|---|---|---|
| Brightness | > 500 | cd/m$^2$ |
| Contrast ratio | > 3000:1 | |
| Viewing angle | 178 | degree |
| Brightness uniformity | < 10 | % |
| Gamma | 2.2 | |

## 4. Summary

HD and FHD LCD-TV panels were successfully addressed by integrated gate drivers without degradation of optical property. By using integrated gate drivers, we can remove 8 gate ICs for FHD panel and 3 gate ICs for HD panel. FHD panel can be driven by 12 source ICs without an external gate driver. It is anticipated that the external gate driver ICs in LCD-TV panels will disappear soon in the same way that they are no longer required for notebook LCD. Furthermore, non-uniformity of brightness is less than 10% and 40% reduced flicker is measured at the new panel compared with the conventional panel. Without degradation of optical property, we can produce LCD-TV panel with integrated gate drivers.

## 5. References

[1] S.S. Kim, *et al,* Journal of the SID, Vol. 12, Number 4, 2004
[2] S. H. Moon, *et al,* SID Digest 2007, pp. 1478-1481