New High-Voltage Generator with Several mA Output Currents using Low Temperature Poly Silicon (LTPS) Technology for TFT-LCD Panel

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Abstract

In this paper, a high-voltage generator with several mA draw output currents using LTPS-TFT technology is proposed. The new generator can be efficiently boosted about +18V output voltages with 5mA draw output currents and power efficiency η is around 84% under the conditions of +5V power-supply voltage and 250kHz frequency.

1. Introduction

Recently, the TFT-LCD panel using low-temperature polysilicon (LTPS) technology has been focused to the application for portable information devices such as cellular phones, personal digital assistants (PDA) and so on [1]. In particular, some performances of a high-resolution panel, a compact panel, a narrow bezel, light-weight panel, low-power consumption etc. have been demanded for portable information devices.

The mobility of LTPS-TFT is higher value than that of amorphous silicon (a-Si) TFT. Therefore, the control and driver circuits etc. to operate the LCD panel can be integrated on a single glass or film substrates, directly. As these results, the number of pins or wirings to connect control and driver circuits etc. can be decreased and the LCD panel using LTPS-TFT can be had some features of smart size, light-weight panel and so on.

By the way, a TFT-LCD panel needs some positive and negative bias voltages such as +5V, +10V, +15V, -4V and -7V. These bias voltages are generated by high-voltage generator on a printed circuit board and are applied to TFT-LCD panel through the X- and Y-drivers as shown in Fig.1 [1]-[3]. For the high-voltage generator, there are charge-pumping circuits, switched capacitor circuits and so on. In these circuits, there is a limit in ability of the generation of high-output voltage with around 10mA draw output currents.

In order to overcome this problem, a new high-voltage generator is proposed. And, some operating characteristics of the new generator in comparison with the conventional generator are examined by using the circuit simulator (Smart SPICE).

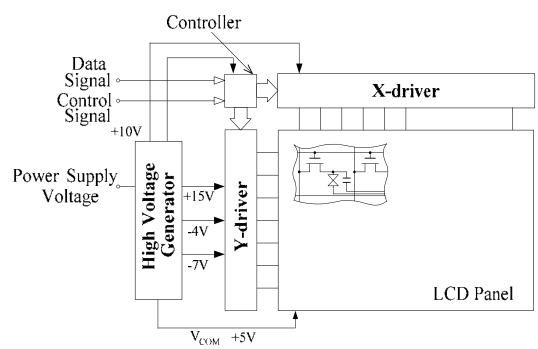

Fig. 1 Block Diagram of TFT-LCD Panel.

2. Circuit Operation

The conventional generator and the clock waveforms are shown in Fig.2 and Fig.3. The conventional generator consists of main charge-pumping circuits, a double charge-pumping circuit, level shifter using flip-flops and two switching transistors.

The output voltage is given by the following equations.

$$V_{O1} = (n+1) \cdot V_{DD} - n \cdot V_L - \sum_{i=1}^{3n+1} V_{DS\,i} \qquad (1)$$

$$\text{Here, } V_L = \frac{I_O}{f \cdot C_K} \qquad (2)$$

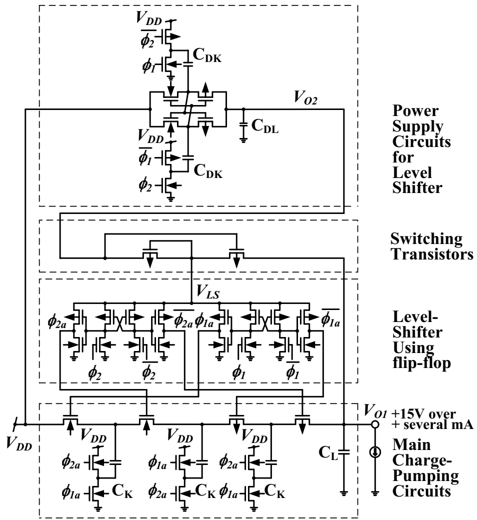

Fig. 2 Conventional Generator

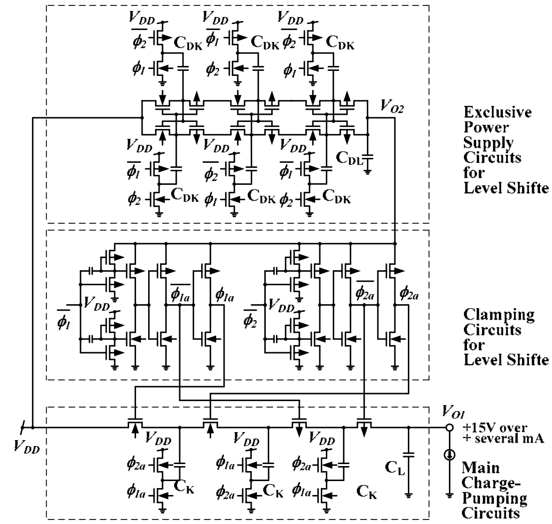

Fig. 4 New Proposed Generator

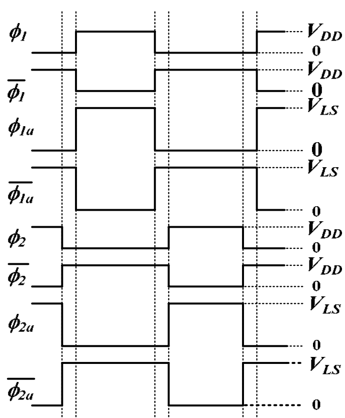

Fig. 3 Clock Waveforms

Here, V_{DD} is single power-supply voltage, n is the number of stages, V_L is the voltage loss caused by charging or discharging of C_K during the pumping operation, V_{DSi} is the drain-source voltage of some transfer transistors, a rectifying transistor and clock drivers, I_O is the draw output current and f is the operating clock frequency [4].

There are some futures in the conventional generator as follows [3].

(1) By using the level shifter, the transfer and rectifying transistors operate in a non-saturation region and the turn-on resistance of transfer and rectifying transistors can be reduced.

(2) The conventional generator is no voltage loss by the threshold voltage because the power-supply circuit for the level shifter composes of a double charge-pumping circuit and it can boost to the desired voltage [5] [6].

Here, the two switching transistors execute an operation that the main charge-pumping circuit is driven by the output voltage V_{O2} of the double charge-pumping circuit when the output voltage V_{O1} of the main charge-pumping circuit is lower value than the output voltage V_{O2}. Also, the main charge-pumping circuit is operated by V_{O1} when V_{O1} is higher value than V_{O2}.

However, since the output voltage V_{O1} of main charge-pumping circuit decreases by a output current increase, the power-supply voltage V_{LS} of level shifter reduces and turn-on resistance of transfer and rectifying transistors also increases. As the result, the power efficiency η decreases.

To solve these problems, the new proposed high-voltage generator is illustrated in Fig.4. The used clock waveforms are same pulse as shown in Fig.3. The new proposed generator consists of main charge-pumping circuits, double charge-pumping circuits and some clamping circuits for level shifters [7]. The new proposed generator can executes a stable operation and the power efficiency η can also obtain high value because the level shifter operates by steady high voltage from the double charge-pumping circuits even if the output current I_{O1} of main charge-pumping circuits rapidly increases.

3. Simulation Results

To verify the performance of the new proposed generator, the computer simulation is carried out by using Smart-SPICE. The circuit analysis is simulated based on an assumption that the single power supply voltage V_{DD} is +5V、the kick capacitor C_K and the load capacitor C_L of main charge-pumping circuits are 0.2μF, the kick capacitor C_{DK} and the load capacitor C_{DL} of double charge-pumping circuits are 20nF, the kick capacitor C_{CK} of clamping circuits are 50pF and the clock frequency f is 250kHz. Also, in the main charge-pumping circuits of the conventional and new proposed generators, both, the channel width and length of transfer and rectifying transistors (W/L) employs optimized dimension of 4000/3 for NTFT and 6000/3 for PTFT owing to obtainment of several mA draw output currents.

The performances of the new proposed generator are illustrated in Fig.5-Fig7. As can be understood in Fig.5, the conventional generator can not generate the high-output voltage with the draw output currents of 6mA over. On the other hand, the new proposed generator can be operated to generate a certain high-output voltage even if the draw output current I_O becomes 10mA as shown in Fig.5.

Moreover, the power efficiency η of the new generator is good value as around 84% at the about +18V output voltage in comparison with the conventional one of around 82% at the about +17V output voltage having 5mA draw output currents as shown in Fig.6. Also, the characteristic of the clock frequency versus the power efficiency is demonstrated in Fig.7. The new proposed generator can be operated by high-clock frequency of 1MHz as shown in Fig.7.

By the way, the power efficiency η is given by the following equations.

$$\eta = \frac{V_{O1} \cdot I_O}{V_{DD} \cdot (I_{IN1} + I_{IN2} + I_{LS})} \times 100[\%] \qquad (3)$$

Here, I_{IN1} are the current flowing to main charge-pumping circuits and some clock drivers, I_{IN2} is the current flowing to the exclusive power supply circuits, I_{LS} is the current flowing to the level-shift circuits, V_{O1} and I_O are the output voltage and the output current of main charge-pumping circuits, respectively. Also, the power efficiency η of the conventional generator is also given as same as the above equation (3).

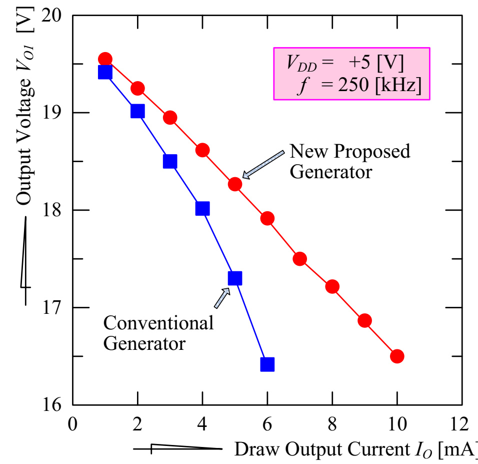

Fig. 5 Output Current I_O vs. Output Voltage V_O

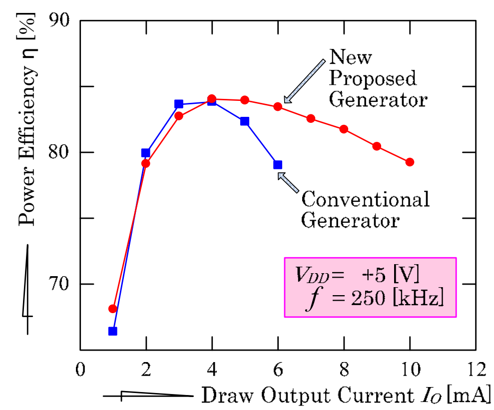

Fig. 6 Output Current I_O vs. Power Efficiency η

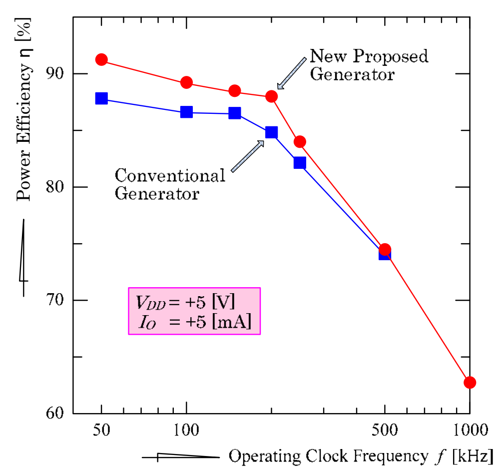

Fig. 7 Clock Frequency f vs. Power Efficiency η

4. Conclusion

In this paper, a new high-voltage generator using LTPS technology for TFT-LCD panel was proposed. The new generator is possible to obtain the boosting desired voltage with the several mA draw output currents. The power efficiency η is about 84/79% at the about +18/+16.5V output voltage having 5/10mA output currents, respectively. In addition, the circuit technology of the new generator is suitable to integrate all electronic circuits on a single glass or film substrate in the near feature.

4. Acknowledgements

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5. References

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