A Pixel Structure for Reflective Color TFT-LCDs with 27-color in Still-Image

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Abstract

We have developed a pixel structure for reflective color TFT-LCD which can display 27-color in still-image. The proposed pixel can display 3 gray scale in still image; white, black and median gray. This paper shows the concept and the driving method of the proposed pixel. Finally this paper compares power consumption and area with the Toshiba's DMOG technology.

1. Introduction

Recently, there have been a lot of similar researches to reduce the power consumption of the poly-Si TFT-LCDs for the small-size and portable applications such as cellular phones and personal digital assistant (PDAs)[1~3]. These researches are focused on reducing the number of charging/discharging a data line of LCD panel for low power consumption in still image. Also in these study, every pixel has memory circuits and it can display the still image using the memorized video data in the pixel without driving the data lines.

There are two configurations of the pixels with embedded memory. In the case of the pixel with dynamic memory circuits[1], it can display the 512-color in still image by using the area-ratio dithering and it must refresh the data of the dynamic memory in the pixel regularly. The power consumption for the still image is about 1/8 of that in the moving image. Also, in the case of pixel with static memory circuits[3], power consumption for still image is drastically reduced to about 1/20 of that in moving image, but it can display only 8-color in still image since the pixel has two gray scale; black or white. Therefore we propose the new pixel structure with static memory circuits which can display 27-color in the still image.
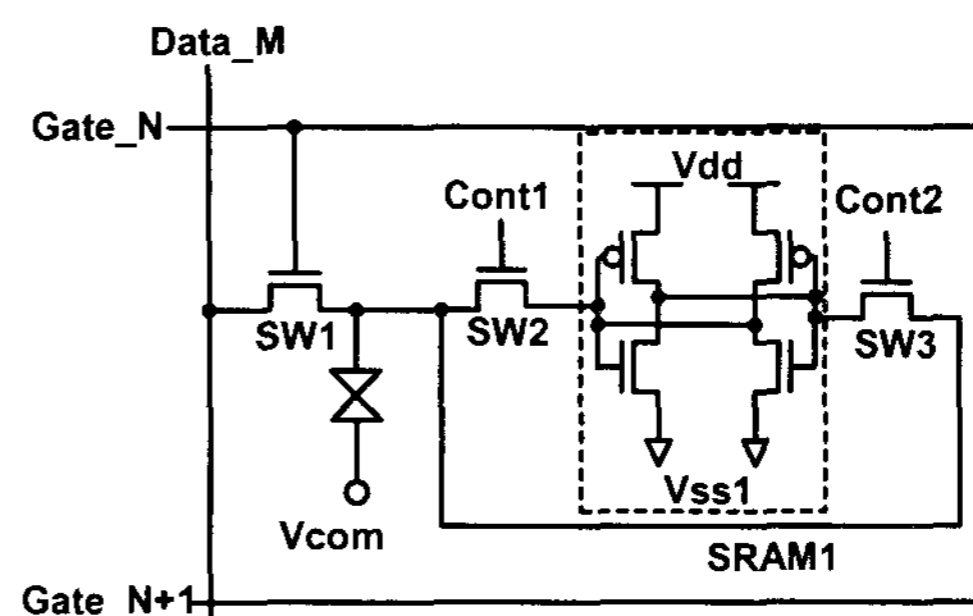

Figure 1. Conventional pixel structure with 8-color in still image mode

2. Toshiba's DMOG Technology Review

Figure 1 shows the schematic diagram of the DMOG pixel structure which can display 8-color in still image. Conventional pixel has one pixel TFT, cont1 and cont2 which will be used for polarity inversion in still image mode and SRAM 1 which has a store of still image data.

In the moving mode, cont1 and cont2 are off and this pixel is driven as general active matrix TFT-LCD with common voltage alternation.

In the pre-still image mode, still image data is supplied to the SRAM 1 during one frame.

In the still image mode, sw1 is off and data stored in SRAM1 is transferred to pixel electrode ,syncronizing with control signal. Consequently, it is not needed to use peripheral driving circuits to refresh charge and it can achieve low power consumption .

3. Proposed Pixel Structure with 27-color in Still Image Mode

3.1 Operation and Simulation Results

Figure 2 shows the schematic diagram of the proposed pixel structure that can display 27-color in the still image. Proposed pixel has one pixel TFT, SW1, additional mid line, SRAM 1, SRAM2, and five

switches for displaying 27-color still image. SRAM1 can store the video data of white and black image. On the other hand, SRAM2 can select either black/white image or median gray image.

We assume the normally white TN-mode liquid crystal and figure 3 shows the reflectance to the applied voltage curve of liquid crystal. In figure 2, Vdd and Vss1 are 5V and 1V respectively and common electrode voltage (Vcom) is alternated from 0V to 6V. Figure 4 (a) and (b) show the applied voltage to liquid crystal for displaying the white and black image in the still image mode. Figure 4 (c) shows the applied voltage to liquid crystal for median gray image.

Let us examine into operation of proposed pixel. In the moving image mode, Y-node in SRAM2 is set low so that SW6, SW2 and SW3 is off and SW5 is on. Therefore this pixel is driven as general active matrix TFT-LCD with common voltage alternation.
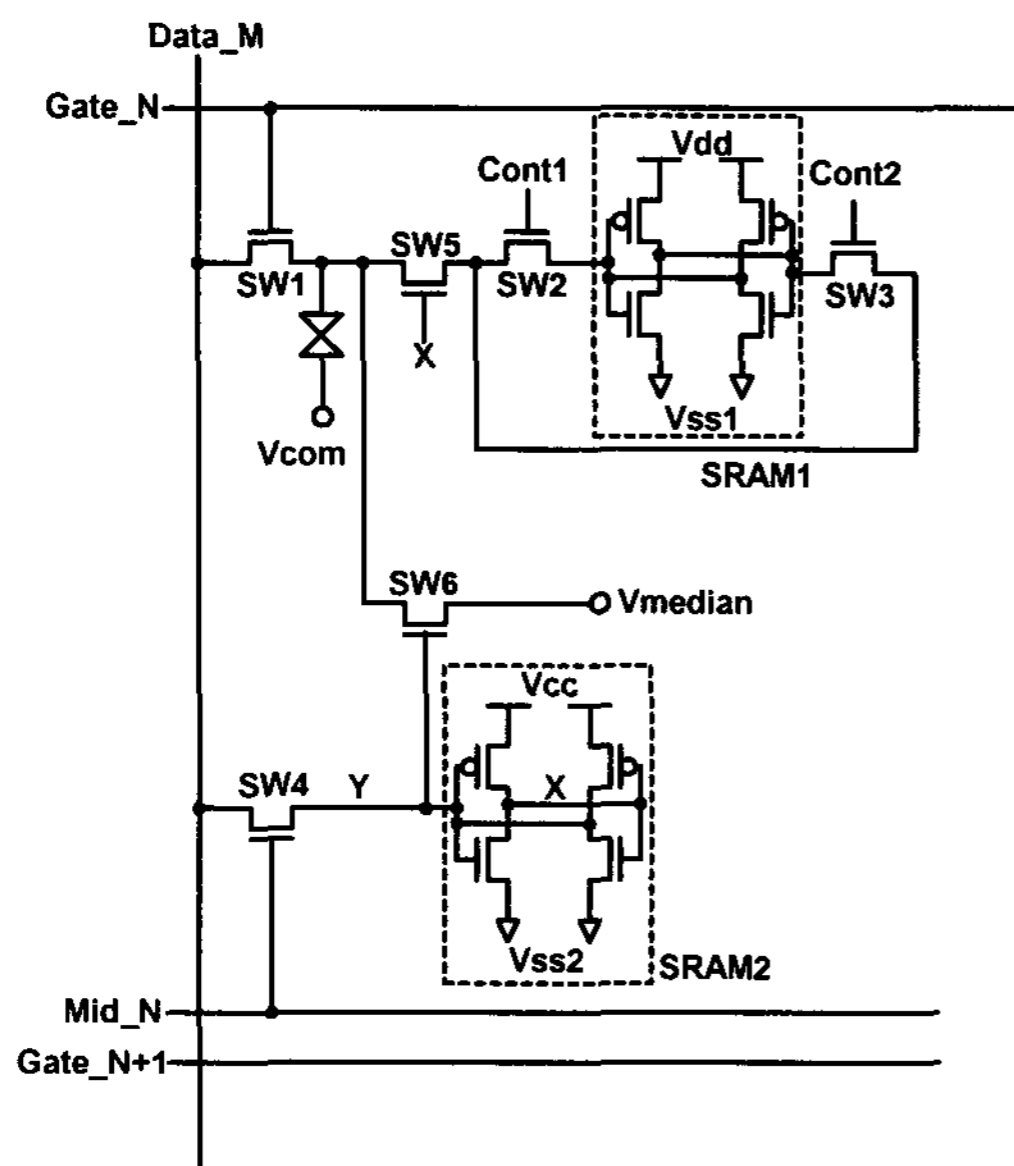

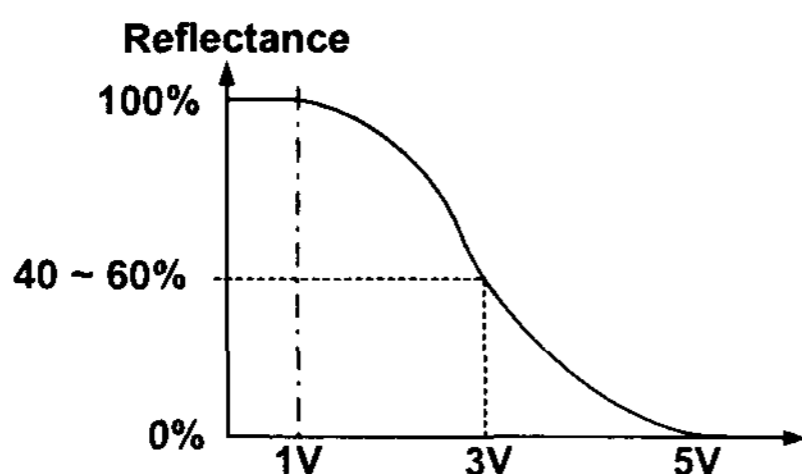Figure 2. Proposed pixel structure with 27-color in still image mode.

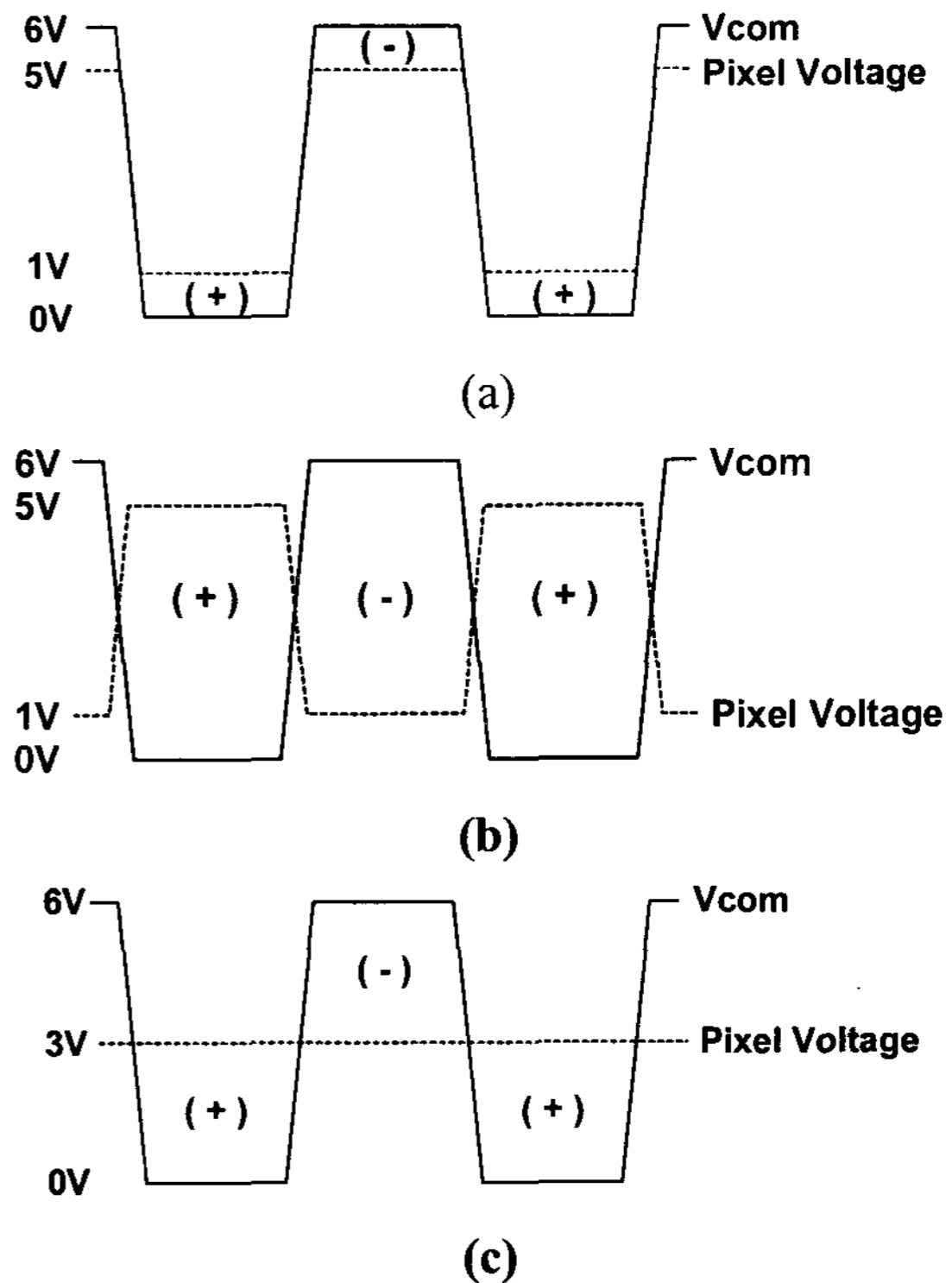Figure 3. Reflectance to applied voltage of liquid crystal.

Figure 4. Driving waveforms in still image mode, (a) white image, (b) black image and (c) median gray image.

In the still image, we allot one frame for memorization between the black and white video data to SRAM1 and assign another frame for selection between black/white image and median gray image. If we set the Y-node high in SRAM2, voltage of the median gray-scale; DC 3V, is applied to pixel electrode through the SW6. On the contrary, if we set Y-node low, the video data of SRAM1 is transferred to the pixel electrode for displaying the black or white image. Consequently, this panel can display the black/white image or median gray image in still image mode without driving the data line. Finally, before returning to the moving image mode, all mid lines are driven high by the medium driver and Y-nodes of all SRAM2 are set low.

Figure 5 is the simulation result which shows median gray image in still image mode and the explanation for each frame follows.

- Frame1: pre-moving image mode ; Mid_N is on and data_M is low, so all pixels prepare acceptance for moving image data.

- Frame2 : Moving image mode ; Gate_N is on and 5V of moving image data is written to pixel electrode,
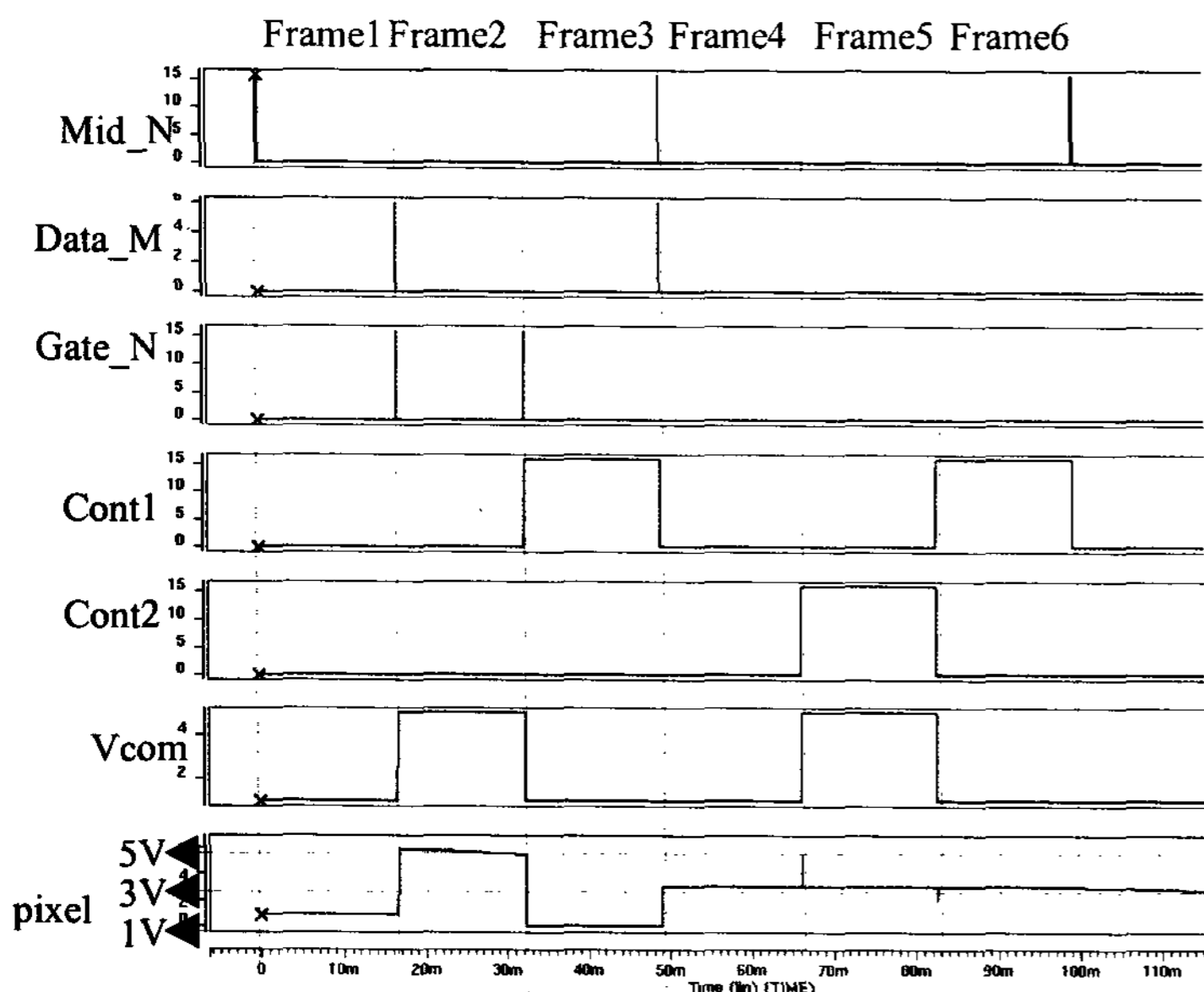
Figure 5. Simulated waveformes for median gray image as it is converted from moving image mode to still image mode

hence pixel voltage has reached 5V but voltage drop occurs because of leakage current.

- Frame3 : Still image setting mode ; Gate_N and cont1 are on and still image data is written to SRAM1 and pixel electrode.

- Frame4 : Mid frame; This frame decides whether the pixel displays black/white gray or not median gray. This simulation result is supposed to median gray in still image mode, so Vmedian node is shorted to pixel electrode and pixel voltage has been reached 3V.

- Frame5, frame6 : Still image mode ; At this mode, although cont1 and cont2 alternately are on, the data of SRAM1 not affects pixel electrode because sw5 is off. So we can ascertain that pixel voltage is held by 3V.

3.2 Panel Design

We designed full panel and performed layout in order to know area, through "Virtuoso" which is the layout tool. Figure 6 shows the block diagram of poly-Si TFT-LCD panel with the proposed pixel. It consists of the analog data driver with 24-analog video inputs, gate driver and mid driver for driving the mid-line, Vcom driver for common electrode alternation and control driver for driving the cont1 and cont2 in figure 2. Figure 7 shows the layout view of the proposed pixel and conventional pixel. The layout area of the

proposed pixel is the 113μm×339μm. it is an increase of 50% on prior pixel. We have extracted capacitance based on the layout of figure 7. Capacitance of the data line, gate line, cont1 and cont2 line; which are extracted by the TMA Raphael[4] simulation, are increased to 35%, 8.1%, 12.1% and 43.6%, respectively.
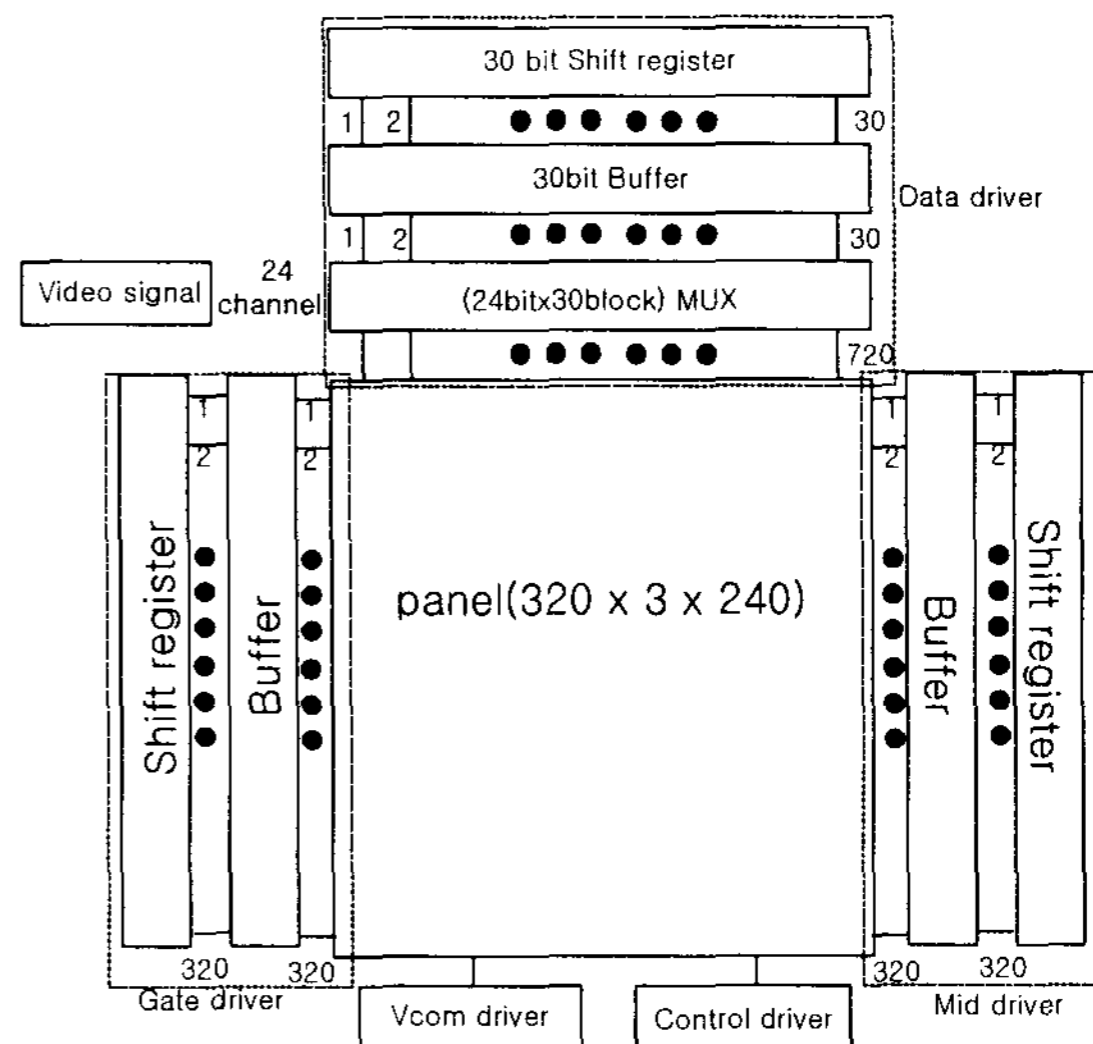
**Figure 6. Block diagram of proposed poly-Si TFT-LCD.**
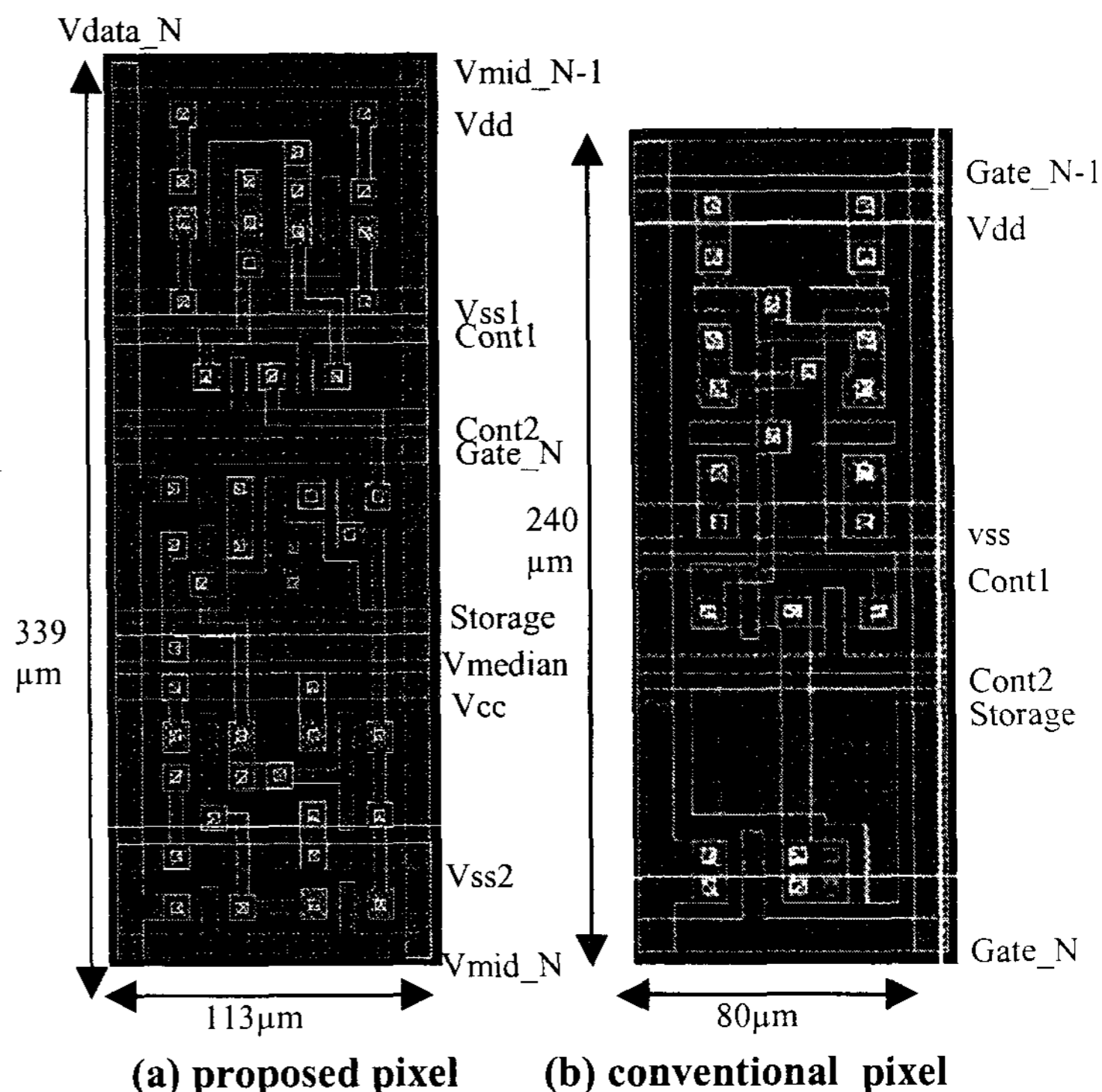
(a) proposed pixel   (b) conventional pixel

Figure 7. Layout view of proposed pixel and DMOG pixel, its channel length is 6μm

Table 1 shows panel power consumption. we assumed that the video data is inverted at each pixel charging time. Also power of data driver contains power of video line at table 1. As you know, when it is charging or discharging data line capacitor, the major power consumption occurs in data driver. To save power consumption, we must avoid refreshing charge to data line. So if a driver integrates the proposed pixel, we dramatically can save power consumption in still image mode, because of not driving the data driver.

Figure 8 shows power dissipation for each image mode. As stated above, in still image mode, the power consumption is only caused by SRAM , control driver and Vcom driver. Consequently, the power consumption of still image is saved by 92% compared with moving image mode.

Table 1. Power consumption for each panel block

	DMOG pixel	Proposed pixel
Gate driver	0.53mW	0.55mW
mid driver		0.51mW
SRAM(vdd)	0.86mW	1.0mW
SRAM(vcc)		0.14mW
Data driver	13.39mW	21.16mW
Vcom driver	0.24mW	0.31mW
control1 driver	0.08mW	0.1mW
control2 driver	0.08mW	0.15mW
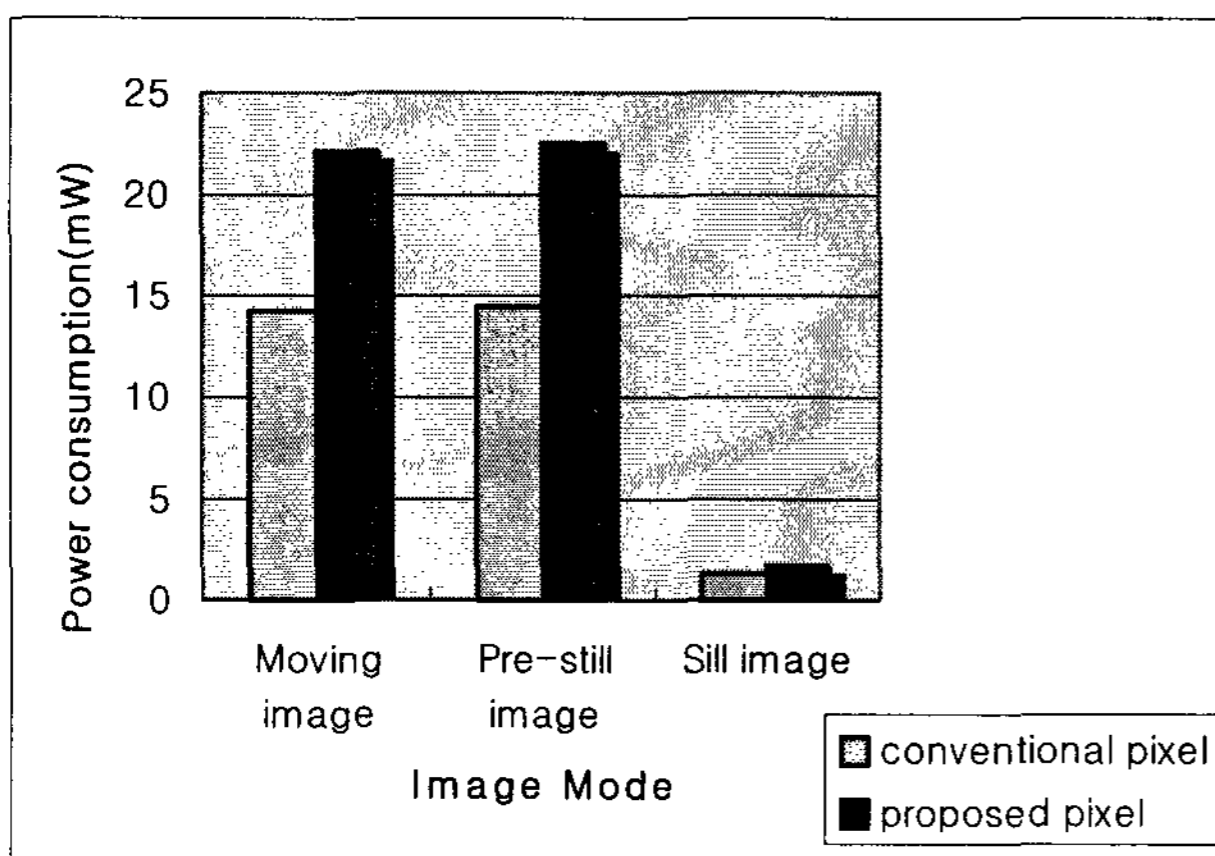
Figure 8. Power consumption for each image mode
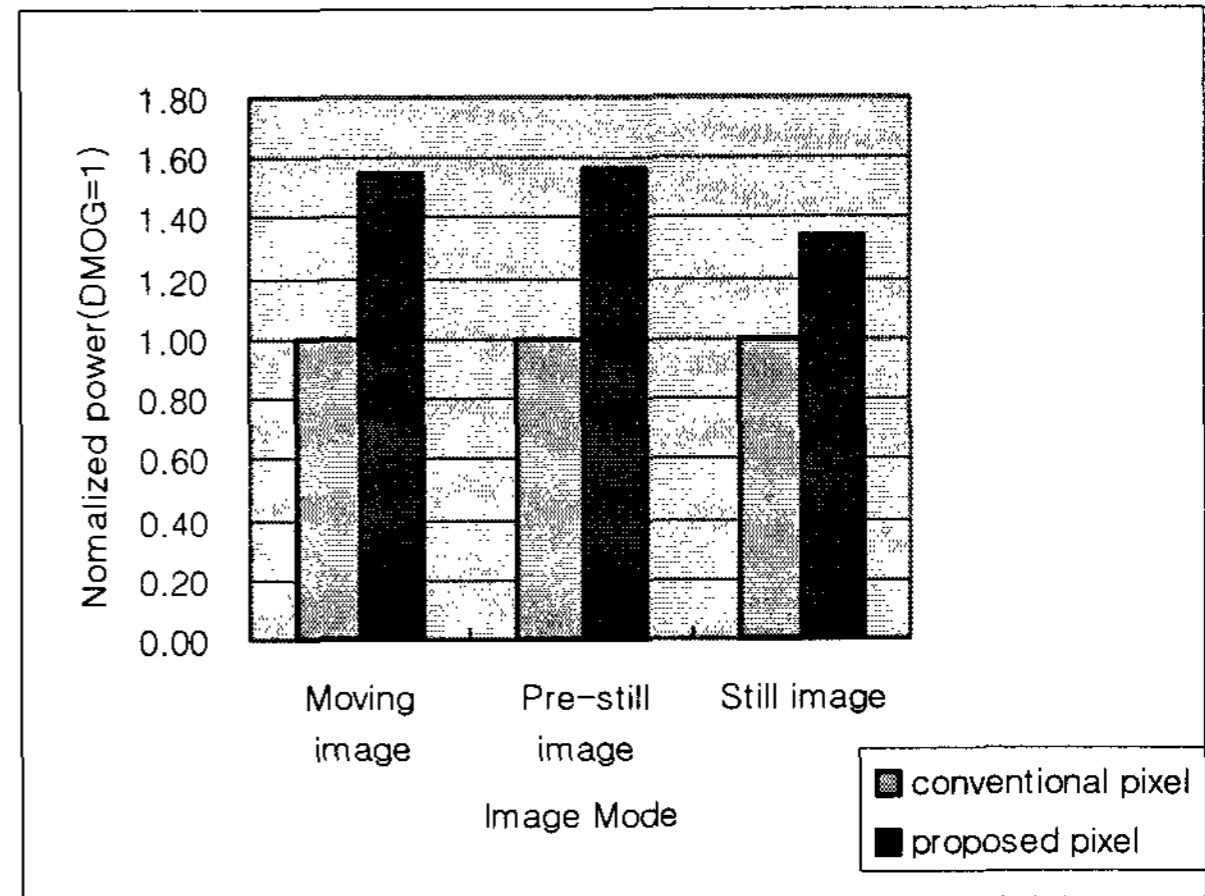
figure 9 Comparison of power between proposed pixel and conventional pixel.

Figure 9 shows comparison of power between proposed pixel and conventional pixel. when proposed pixel operates on moving image mode and still image mode, power consumption of the former is increased by 55% and the latter is increased by 34% .

4 Conclusion

We have reviewed the concept and the operation of the proposed pixel, which can display the 27-color in still image mode without driving of the data lines. we Also compared proposed pixel to the conventional DMOG pixel in terms of area and power consumption. Consequently, panel area is increased by 99.5% and power dissipation with proposed pixel is increased by 50% compared to the prior pixel.

5. References

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