



Using the STVM100 to fully auto adjust LCD flicker

Introduction

Liquid crystal displays (LCDs), from advanced VGA computer monitors to wide-screen TVs, are very popular with consumers. Compared to its conventional cathode-ray tube (CRT) counterpart, the LCD screen is superior as it is lightweight, thin, and consumes less power. Another advantage is that in principle the LCD screen does not flicker as much as a CRT screen and the flicker on an LCD screen can be minimized. This application note presents the principle of LCDs and the cause of flicker. We also propose a solution of automatically minimizing flicker using the STVM100 (LCD VCOM calibrator).

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1 The general principle of the LCD screen

The LCD screen uses liquid crystal to control the passage of backlight. The basic structure of a TFT-LCD (Thin Film Transistor) screen may be thought of as two glass substrates sandwiching a layer of liquid crystal molecules. The whole screen has been divided into many columns and rows. In each cross of a column and a row is the display unit (pixel). The front glass substrate is fit with a color filter which gives each pixel its own color, while the back glass substrate has transistors fabricated on it. When a positive or negative voltage is applied through a transistor to a pixel, the liquid crystal changes direction and allows backlight to pass through the pixel as shown in [Figure 1](#).

In [Figure 1](#), the gate driver sends a line selection pulse to the top line and turns on the first line TFT. The data (analog voltage) is transferred from the source driver to the pixels in the first line. After the first line data is updated, the gate driver selects the second line. After the last line is scanned, the picture on the whole screen is updated which is referred to as a frame update. Then the gate driver starts from the first line again and begins the next frame update.

Figure 1. LCD screen layout

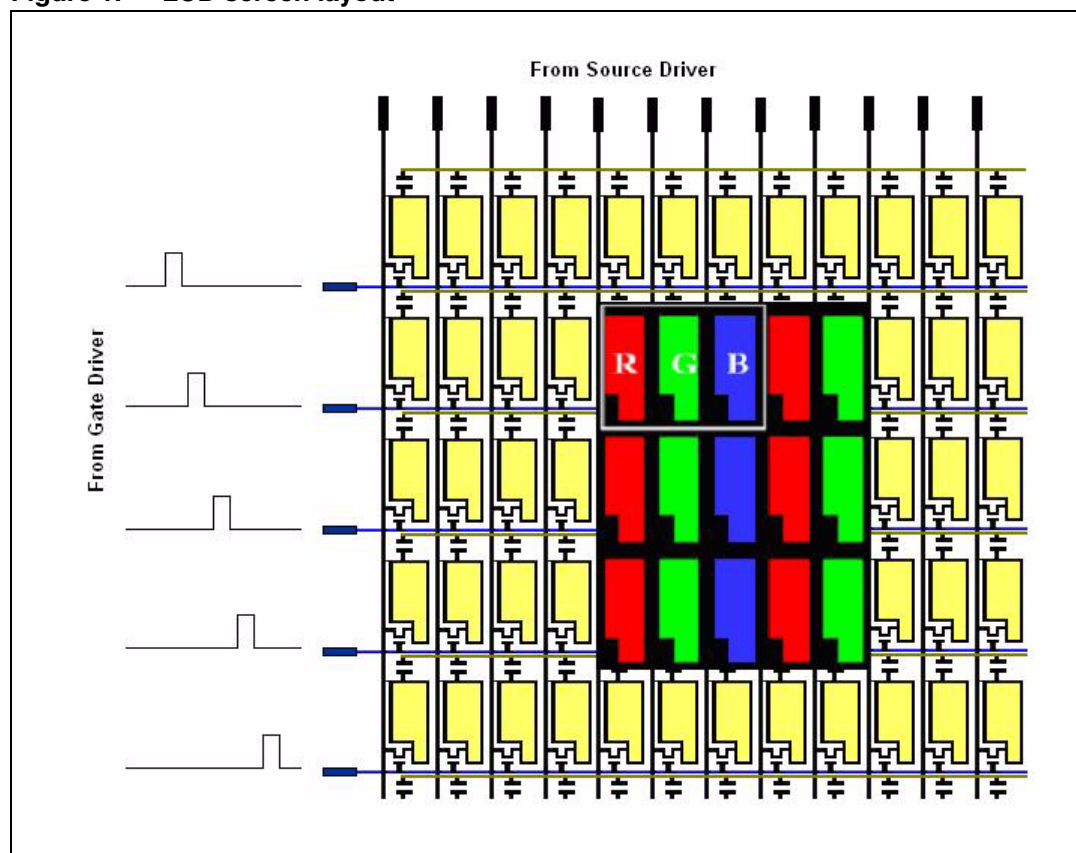
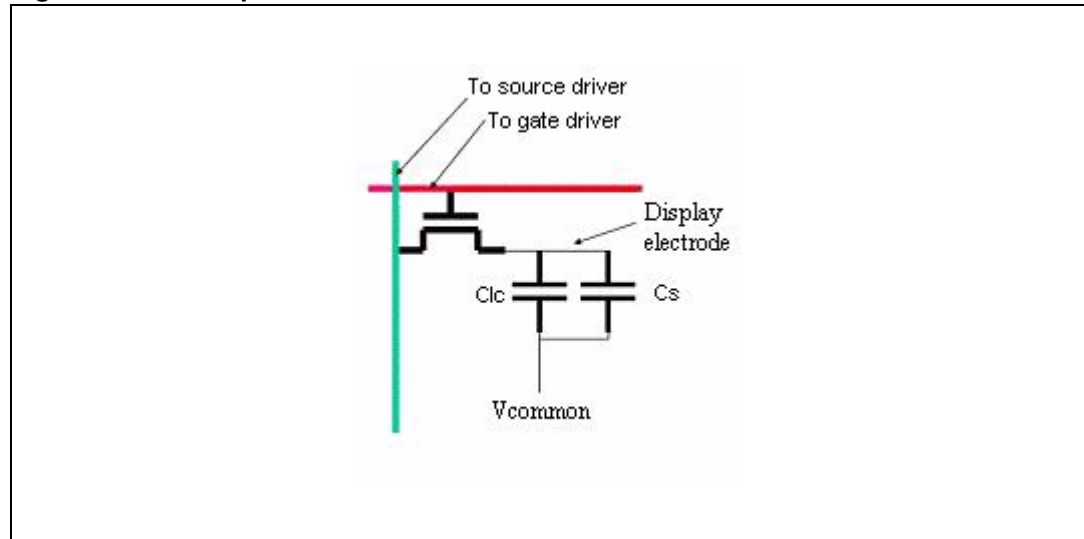


Figure 2 shows the detailed pixel schematic. The C_{lc} is the equivalent capacitance of the liquid crystal. The C_s is the capacitance built inside to maintain the signal between frame updates. The light transmitted from the pixel is related to the absolute voltage (from the source driver) applied to the pixel so that different gray scales can be obtained. The data-receiving side of the capacitor is called the display electrode and the other side is called the common electrode (VCOM). The VCOM of all pixels are interconnected.

Figure 2. Basic pixel schematic

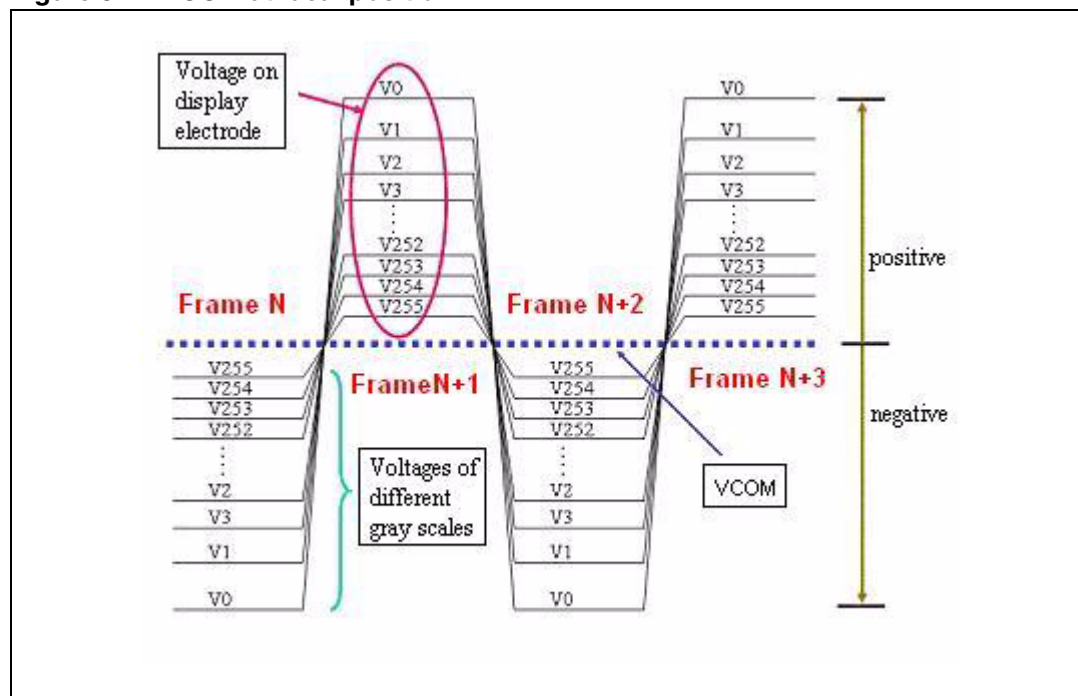


Since the molecules of the liquid crystal cannot be set at a constant voltage for a long time without being damaged. The voltage on the pixels should be alternated in intervals to avoid this damage. The solution is to set the VCOM to about half of the supply voltage (AVDD) in order to divide the display voltage into two different polarities in different frames. When the voltage on the display electrode is higher than the voltage on the VCOM, this is the positive polarity voltage, otherwise it is the negative polarity. When the absolute differential voltage on the display electrode is constant, regardless of the voltage polarity, the gray scale displayed is the same. In both cases the directions of the molecules of the liquid crystal are completely different. By using this polarity inversion, the direction of the molecules has changed and they will not be damaged.

2 Location of flicker in LCDs

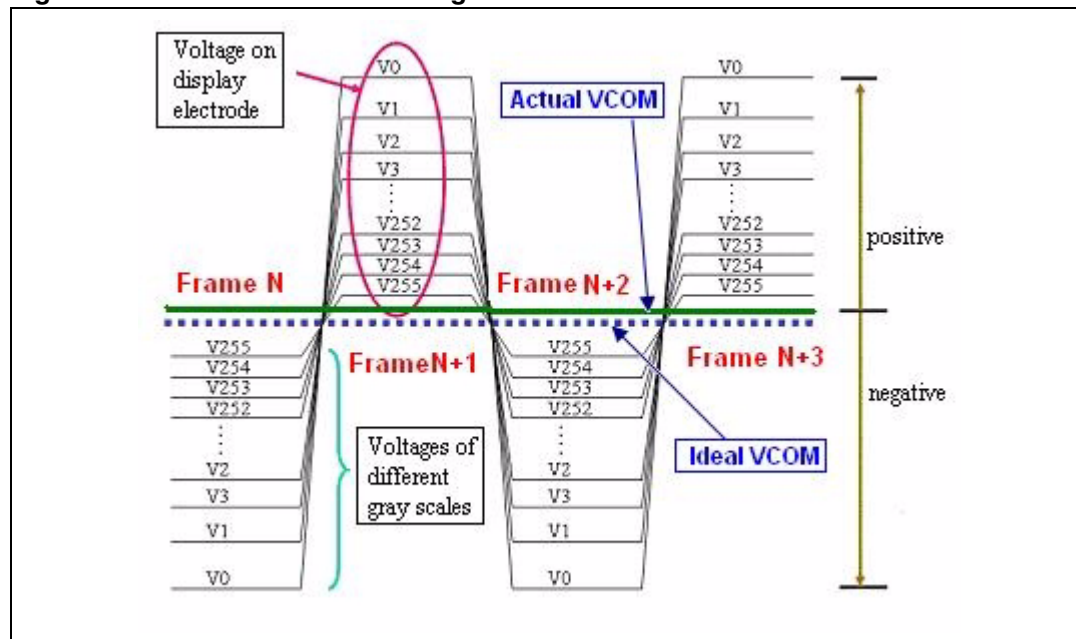
Due to the inversion as described in [Section 1: The general principle of the LCD screen](#), the voltage on VCOM is fixed and the voltage on the display electrode changes according to the different gray scales. There are 256 gray scales (8 bits of color) in [Figure 3](#). If we consider, for example, the gray scale V0, in order to keep the V0 gray scale continuously displayed on the panel, the voltage on the display electrode must be very high during one interval and very low during another. In different frames, still using V0 as an example, the absolute differential voltage of the display electrode and the VCOM is fixed. So the displayed gray scale has not changed although the voltages on the two ends of Clc alternate. This is the ideal case and is shown in [Figure 3](#).

Figure 3. VCOM at ideal position



During the manufacturing of LCDs, process variations can cause deviation in the optimal VCOM from the ideal voltage of $1/2 AVDD$. This is illustrated in [Figure 4](#).

Figure 4. Error of VCOM resulting in flicker



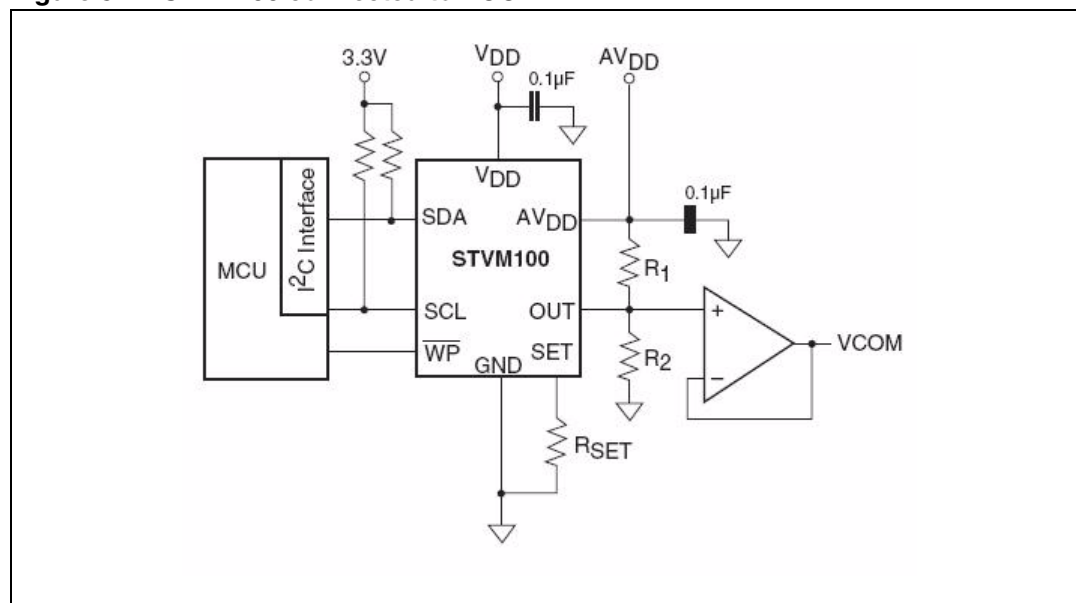
This error of VCOM results in a visible flicker in the panel screen and the flicker cannot be eliminated since the VCOM error is due to the manufacturing process. Considering the example of the V0 gray scale, in frame N+1, the absolute voltage between the display electrode and VCOM is smaller than in frame N+2. This difference results in a different gray scale in the two different frames which generates flicker. Traditionally, VCOM is adjusted by tuning a mechanical potentiometer in a voltage divider. This method is simple but the VCOM value cannot be adjusted very accurately. It requires too much manpower and the accuracy also depends on the skill of each operator and even different shifts of the same operator. Even worse, the mechanical potentiometer value can be changed inadvertently, (eg. during transport).

3 Using the STVM100 to adjust the VCOM

The digital VCOM calibrator STVM100 (refer to the datasheet) provided by STMicroelectronics can completely replace the mechanical potentiometer and it is more accurate, more robust and enables automation.

The STVM100 provides a digital I2C interface to control the sink current output (IOUT). This output drives an external resistive voltage divider, which can then be applied to an external VCOM buffer. Three external resistors R1, R2, and RSET determine the highest and lowest value of the VCOM. An increase in the output sink current lowers the voltage on the external divider so that the VCOM can be adjusted by 128 steps within this range. Once the desired VCOM setting is achieved, it can be stored in the internal EEPROM that is automatically recalled during each power-up. [Figure 5](#) shows the basic connection of the STVM100 to VCOM. With I2C interface to a flicker auto adjustment system, the VCOM can be adjusted in a fully automated manner.

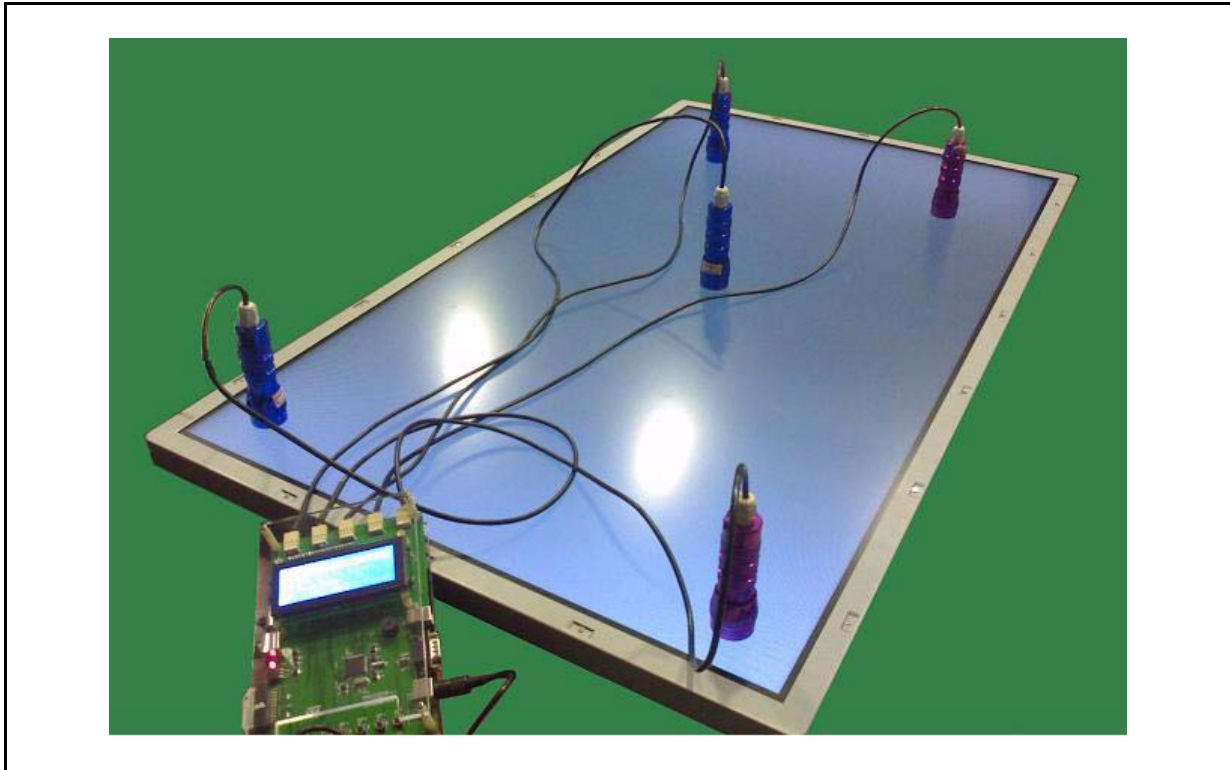
Figure 5. STVM100 connected to VCOM



In order to allow the STVM100 to adjust LCD flicker in a fully automated manner, STMicroelectronics has developed an LCD flicker auto adjustment system.

The STVM100 LCD flicker auto adjusting system includes the following major features:

- Available for dot, line, column and frame inversion
- 1 gray scale accuracy out of a range of 128
- Fast adjusting: average time < 3.2 seconds
- VGA (Variable Gain Adjusting) technology to suit full size LCD panels
- Multichannel: support 1 - 5 input channel(s)
- Two input modes: buttons on board and PS/2 compatible keyboard
- Support serial port and USB links to PC
- Automated logging function via corresponding PC software tool
- Energy saving mode saves power consuming up to 85%

Figure 6. STVM100 LCD flicker auto adjusting system

After powering on the system, the user simply connects the I2C cable from the system to the panel and disconnects the cable after several seconds when the adjustment is complete. The system can check multiple points of a panel and has numerous features for users to configure. The VCOM data can also be uploaded to a PC for statistical analysis to monitor process variation. For detailed information, please contact local ST sales office.

4 Conclusion

This application note describes the basic principle behind the operation of liquid crystal displays (LCDs) and describes the primary causes of screen flicker. We also propose a solution for minimizing this flicker by using the STVM100 (LCD VCOM calibrator), replacing the old solution requiring the use of digital potentiometers and manual in-line adjustment. The STVM100 allows for fully automated implementation of the flicker adjustment in the manufacturing line. STMicroelectronics has developed an LCD flicker auto adjustment system which can be used in conjunction with the STVM100, significantly simplifying this process.

5 Revision history

Table 1. Document revision history

Date	Revision	Changes
16-May-2008	1	Initial release.

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