AN3110
Application note

Using the STVM100 to automatically adjust VCOM voltage in e-paper

Introduction

The widespread use of multimedia electronic devices, coupled with environmental concerns over the manufacturing and use of traditional paper products, provide the opportunity for the utilization of electronic paper (e-paper).

Electronic paper is the best replacement for conventional paper. A high-quality image can be displayed for weeks without power. Energy is consumed only during the short refresh time. Unlike its counterpart, liquid crystal display (LCD) devices, e-paper does not require a backlight, which not only saves energy, but also makes reading more comfortable.

Achieving high-quality images on e-paper requires the correct setting of the VCOM voltage on the PC board. STMicroelectronics offers the STVM100 VCOM calibrator which is ideal for e-paper applications and allows the VCOM voltage to be set automatically. In this application note, the e-paper principle is briefly described so that the user can understand the necessity of an accurate VCOM voltage setting and how the STVM100 can be used for this purpose.

1 General principle of e-paper

Using Electrophoretic Display (EPD) technology, pre-charged particles within the capsules can be either driven to the top plate (common electrode) of the e-paper which is white due to the reflection of the light, or driven to the bottom plate (column electrodes) of the paper which is dark. The particles are in a bi-stability state so that the position can be maintained even though there is no power applied to the e-paper.

Similar to liquid crystal display (LCD) devices, some of the EPD devices are also formatted by pixels with the active matrix controlled using TFT (Thin-Film Transistor) technology.

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 and then the third, and so on. Once the last line has been scanned, the entire picture on the screen has been updated (whole e-paper refresh). Then the gate driver begins again from the first line and starts the next refresh if required. The line selection pulse pattern is configurable in the gate driver.

Figure 1. E-paper display layout

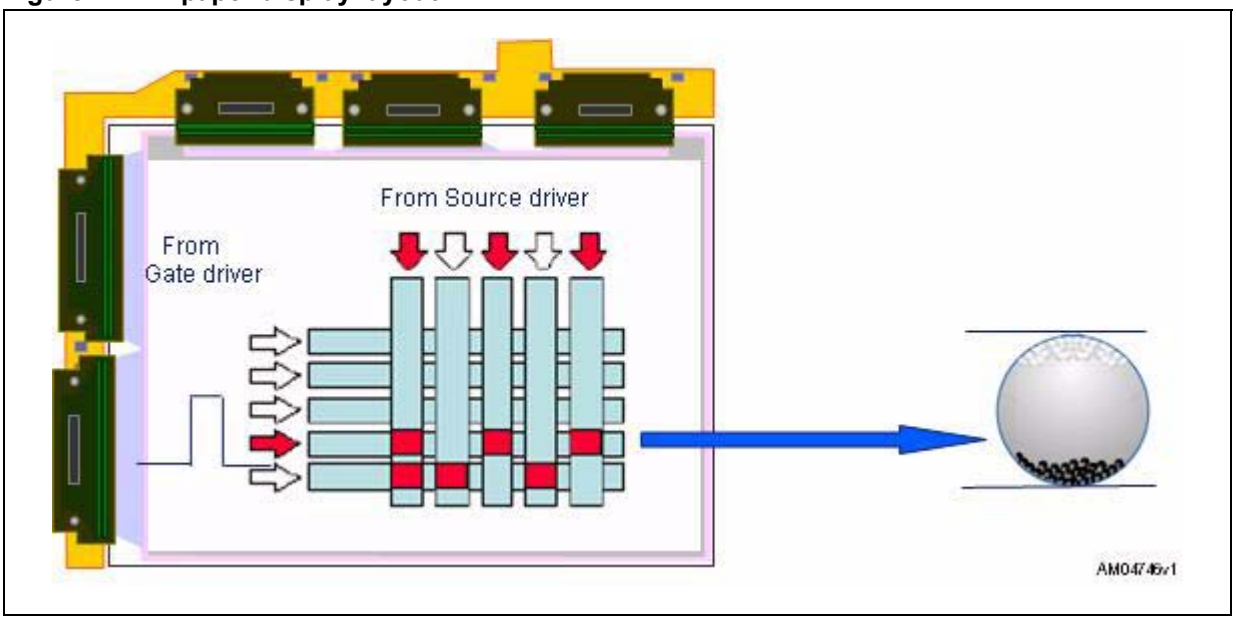
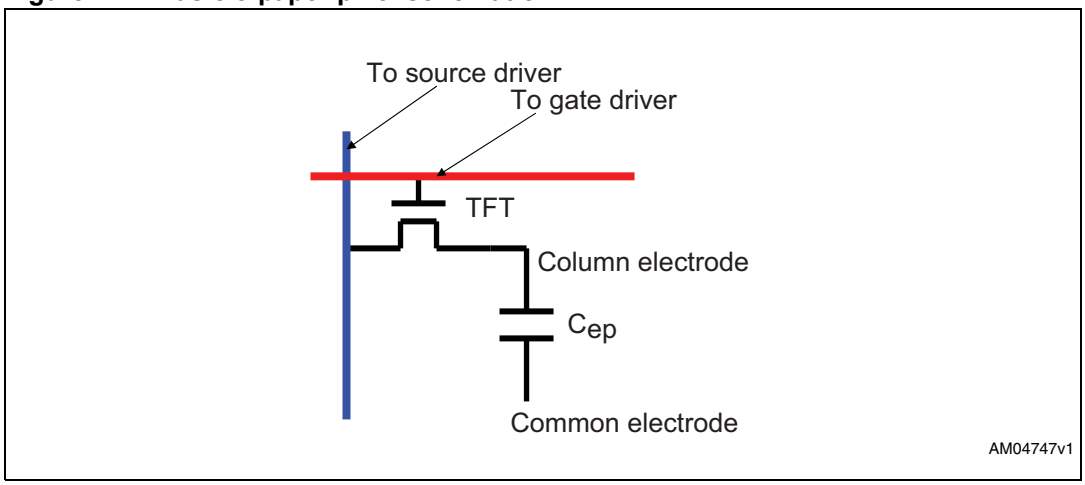


Figure 2 shows the detailed pixel schematic. The C_{ep} is the equivalent capacitance of the e-paper. The position of the pre-charged particles in the capsules between the two electrodes depends on the absolute voltage applied on the electrodes.

The common electrodes of all the pixels are connected together and a constant Vcommon voltage (VCOM) is required to drive this electrode. The VCOM voltage should be set correctly panel-by-panel for the best performance. Residual pixels (“ghosting” effect) will appear after content refresh if the VCOM voltage is not set correctly.

After the line is selected by the gate driver, the corresponding column electrode is connected to the source driver by the TFT. When the source driver supplies positive voltage to the column electrodes, the positively-charged particles are repelled by the positive electric field and moved to the top plate of the capsule. The white particles are reflective and reflect the ambient light to the viewer so that this pixel is viewed white. Otherwise, if negative voltage is supplied to the column electrode, the positively-charged particles are attracted to the negative electric field and moved towards the bottom side of the capsule which then appears dark.

Figure 2. Basic e-paper pixel schematic



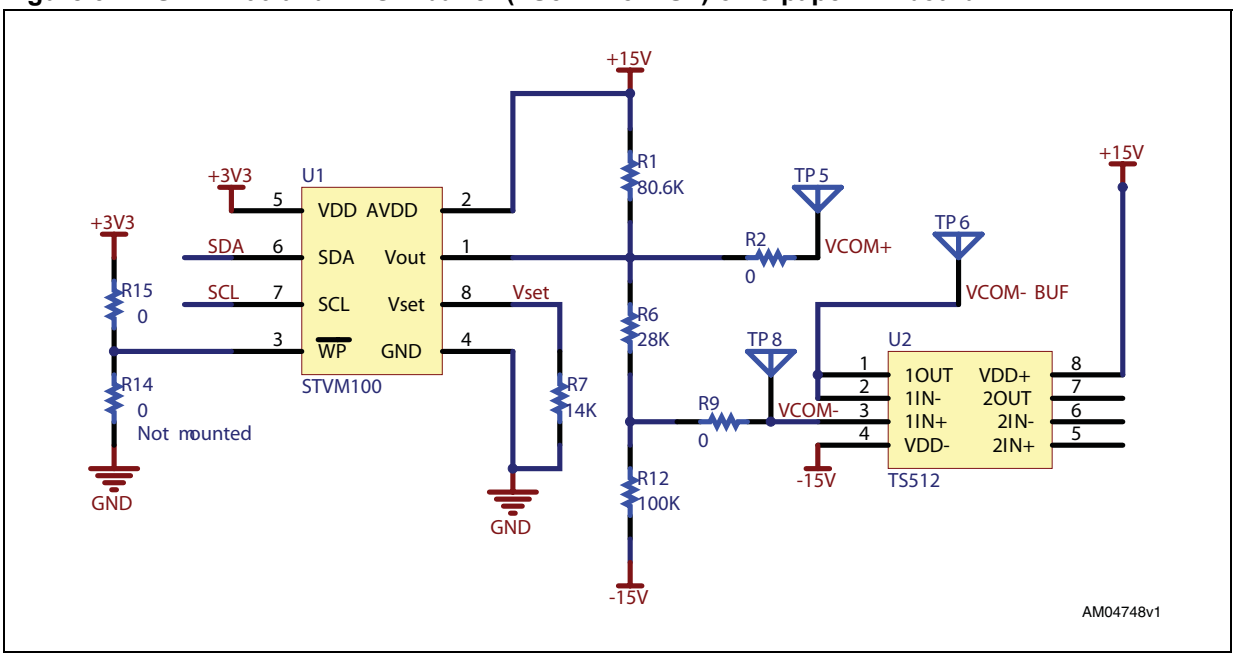
2 E-paper VCOM calibration using the STVM100

The VCOM values vary according to the type of e-paper. Each of the VCOM values is well tested and provided by the e-paper manufacturer who normally labels the e-paper PC board with a barcode and a decimal value. The common distribution range is from –0.5 V to –2.5 V, but this range varies according to the technology.

The digital VCOM calibrator STVM100 (see datasheet at *www.st.com)* can completely replace the mechanical potentiometer as an automatic, more accurate, and robust solution.

The STVM100 provides a digital I^2C interface to control the sink current output (I_{OUT}). This output drives an external resistive voltage divider, which can then be applied to an external VCOM buffer (TS512, precision dual operational amplifier). Four external resistors R1, R6, R7 and R12 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 3* shows the basic connection of the STVM100 in e-paper applications.

Figure 3. STVM100 and VCOM buffer (TS512 from ST) on e-paper PC board



In this example, by choosing 1% accuracy resistors of R1, R6, R7 and R12 with a supply of ±15 V, a range of –0.5 V to – 2.5 V can be obtained at point VCOM– by writing 0 to 127 to the STVM100 through the I^2C bus. The VCOM– is buffered by the TS512 to VCOM– BUF which is applied to the VCOM plate of the e-paper.

The advantages of this circuit are:

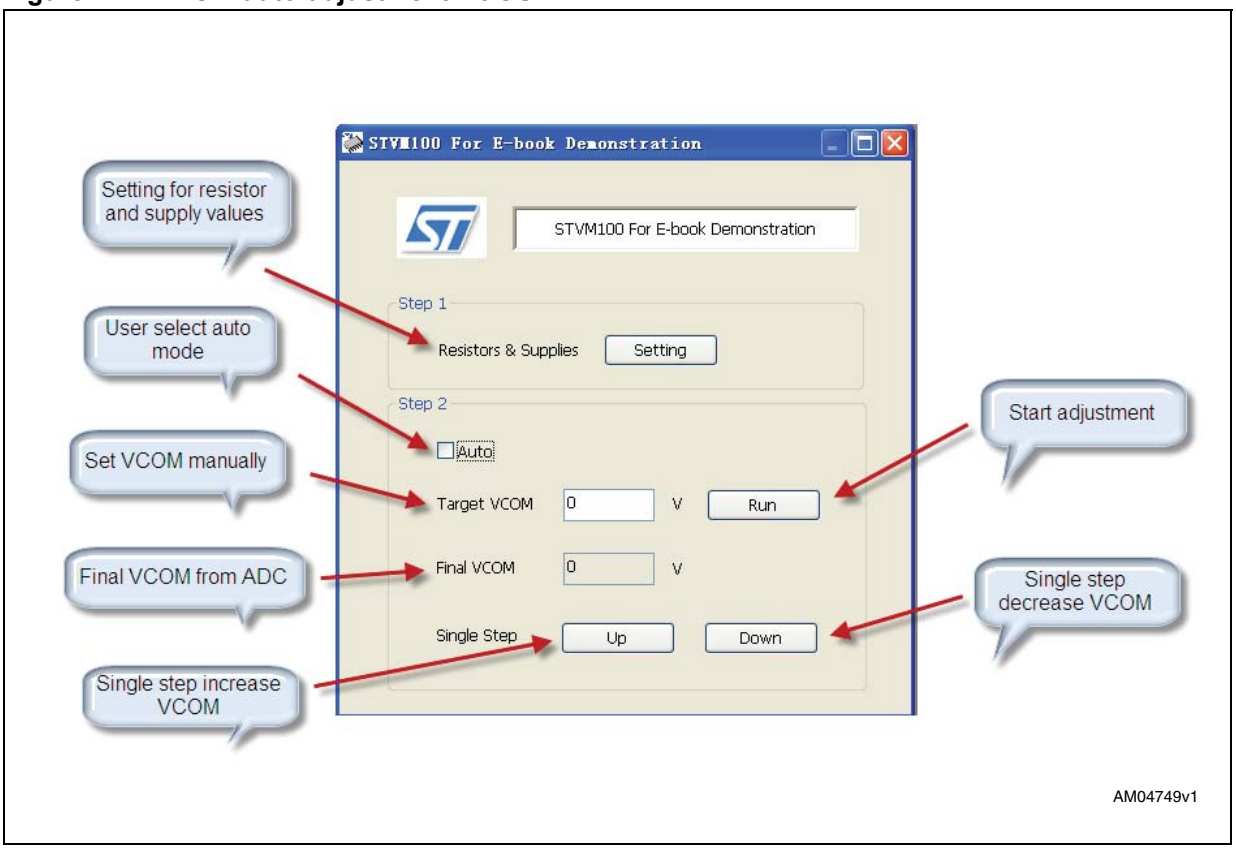
- The STVM100 replaces the conventional variable resistor (VR). The STVM100 is robust, accurate, easily configurable, and provides automatic adjustment capability.
- The TS512 supports ±18 V (here ±15 V is used) which is necessary in e-paper applications.
- No additional supply is required, making the power management circuit design easier.

3 STVM100 auto-adjustment demonstration kit

Since the target VCOM value is given by a decimal value or by a barcode on the manufacturer's e-paper PC board, ST has also developed an auto-adjustment demonstration kit to facilitate calibration.

Only four single wires are needed to connect the e-paper PC board and the adjustment kit, and the user can input the target VCOM value either manually or by a barcode reader in the GUI as shown in *Figure 4*. After a single click on the "Run" button, no more than 1 second later, the target VCOM is correctly adjusted and appears in the "Final VCOM" text box. In this GUI, single-step up/down buttons are also available for the user to do a simple comparison and confirmation of the VCOM value.

Figure 4. VCOM auto-adjustment kit GUI



4 Auto-adjustment demonstration kit test results

Table 1 gives an example of the lab test results of the auto-adjustment kit.

It can be seen that this board has a maximum 11 mV difference between the target VCOM write and the actual measured on VCOM– BUF. The results demonstrate its suitability for the e-book VCOM application.

Please contact local ST sales office for the availability of the demonstration board hardware and software.

Table 1. Test results of the auto-adjustment kit

Target voltage for VCOM– BUF (V)	Measured voltage on VCOM– BUF (V)	Delta between target and measured voltage on VCOM– BUF (V)
–0.65	–0.657	–0.007
–0.75	–0.757	–0.007
–0.85	–0.852	–0.002
–0.95	–0.95	0
–1	–0.998	0.002
–1.1	–1.096	0.004
–1.2	–1.193	0.007
–1.3	–1.29	0.01
–1.4	–1.404	–0.004
–1.5	–1.5	0
–1.51	–1.5	0.01
–1.52	–1.517	0.003
–1.53	–1.533	–0.003
–1.54	–1.533	0.007
–1.55	–1.549	0.001
–1.56	–1.565	–0.005
–1.57	–1.565	0.005
–1.58	–1.581	–0.001
–1.59	–1.581	0.009
–1.6	–1.597	0.003
–1.7	–1.694	0.006
–1.8	–1.792	0.008
–1.9	–1.889	0.011
–2	–2.003	–0.003
–2.1	–2.1	0

Table 1. Test results of the auto-adjustment kit (continued)

Target voltage for VCOM– BUF (V)	Measured voltage on VCOM– BUF (V)	Delta between target and measured voltage on VCOM– BUF (V)
–2.2	–2.198	0.002
–2.3	–2.295	0.005
–2.4	–2.393	0.007
–2.5	–2.491	0.009
–2.6	–2.589	0.011
–2.7	–2.691	0.009
Maximum error (V)		0.011

Note: VCOM– BUF is the point on the demonstration board which connects to the VCOM panel on the e-book. Please refer to Figure 3 for a detailed description.

5 Conclusion

The STVM100 VCOM calibrator is ideally suited for the e-paper and e-book display applications. By taking advantage of its 7-bit, non-volatile common voltage setting capability, it allows easy and automated configuration of e-book display panels in a manufacturing environment.

An STVM100 auto-adjustment kit is also available to demonstrate how VCOM accuracy of better than ±16 mV is easily achievable.

6 Revision history

Table 2. Document revision history

Date	Revision	Changes
07-Jan-2010	1	Initial release.