High Performance TFT LCD Driver ICs for Large-Size Displays

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The TFT LCD market has rapidly evolved in the last decade, enabling the occurrence of large and fast growing industries covering areas such as TV, monitors and notebook applications. Whether at school, in the office or at home - the TFT LCD has become one of the most commonly used products in the world. The TFT LCD revolution is changing the way people look at their computers and TV, from CRT to LCD, from analog to digital, from bulky to light and more appealing to the eyes. The TFT LCD has already become the mainstream and competitive solution for PCs, full HDTVs and other commercial end products used by anyone, anytime and anywhere today, conquering the display market.

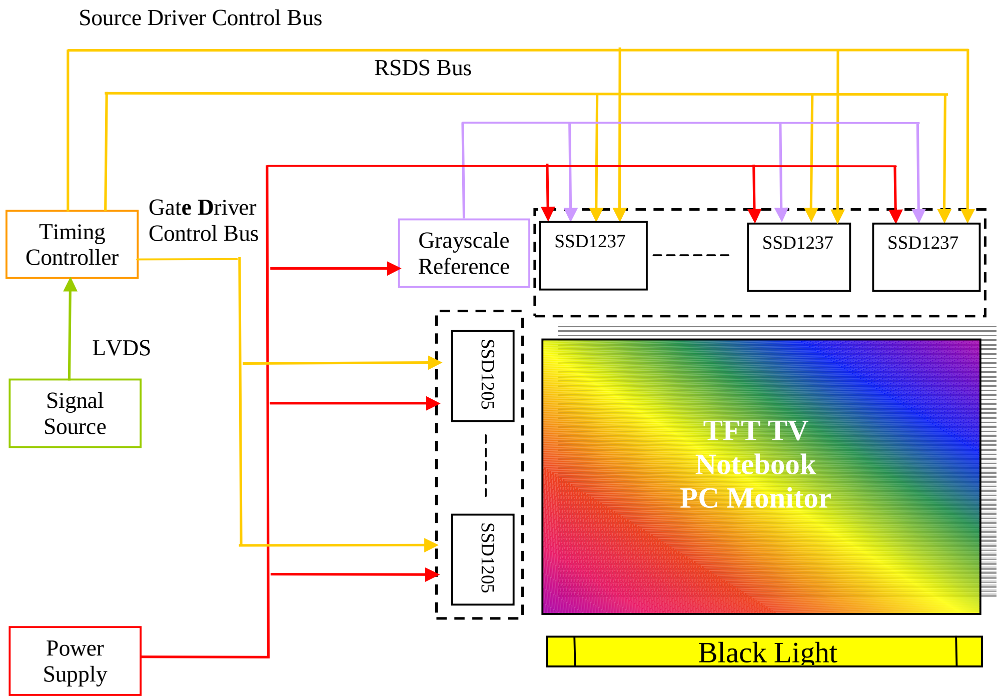
I Fast-growing TV Market

The TV market is expected to grow continuously in the coming years. Ninety-seven million shipment units and US$88 billion revenue in 2009 are forecast. Facing this huge potential and highly competitive market, major LCD-panel makers are keen to enhance their TV-panel quality by improving their technology, rather than simply manufacturing larger-sized panels. Nowadays, much more has come to be expected as normal: low reflection screen, high contrast ratio, wide viewing angle approaching 180°, full HD resolution, short response time of below 1ms, high color saturation and low power consumption, all are favorable for television. High quality and further enhancement of driver ICs are required to meet this challenging and large display market.

Figure 1: A 17" SXGA PC monitor using the Solomon Systech SSD1205 and SSD1237 gate and source driver ICs

To support the above requirements, a complete series of TFT LCD source and gate drivers from Solomon Systech Limited has been introduced for notebook, monitor and television applications. Source drivers include the SSD1237/31/11/13, which support a high LCD driving voltage up to maximum 18V with a high pin count, high color depth, fine-pitch bonding, different power mode options, small amplitude differential interface RSDS and so on. Gate drivers include the SSD1201/02/03/05, which provide various output options to meet different resolutions. Also, the PCB-less design and stagger pad arrangement are both employed to optimize the panel system usage and cost.

Figure 2: Typical large TFT display system diagram

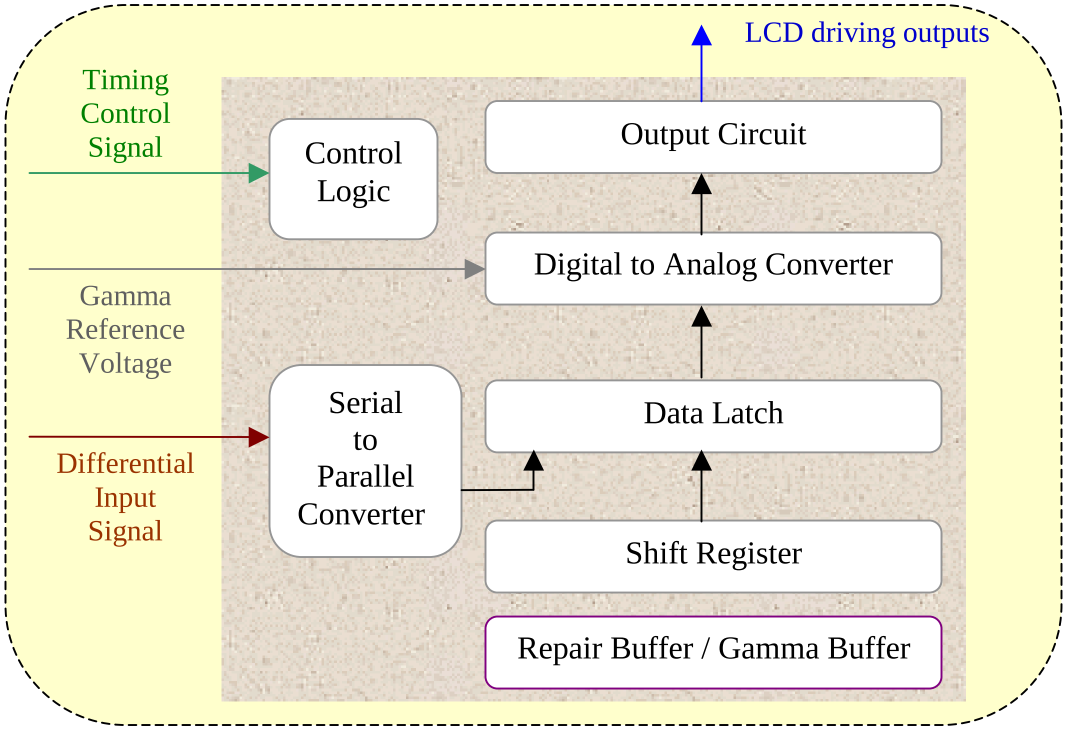


II Source Driver

The Solomon Systech SSD1211/13/37/31 TFT source driver series adopts the RSDS interface, charge sharing driving algorithm, internal 6-bit DAC (SSD1237/31), internal 8-bit DAC (SSD1211/13), dot or N-lines inversion, high driving voltage, high pin count and support systems with SVGA, SXGA, XGA, WXGA, WSXGA+, SXGA+, WUXGA, UXGA and HDTV for notebook, PC monitors and LCD TV applications.

The basic TFT source driver contains the circuit blocks of Shift Register, Data Latch, Digital to Analog Converter, Output Circuit and Gamma/Repair Buffer, as shown in Figure 3.

Figure 3: Source driver architecture



i RSDS-compliant small amplitude differential interface

Reduced Swing Differential Signaling (RSDS) interface is a type of differential signal protocol.

TFT LCD panels mounted in monitors, space-saving desktop PCs, and notebook PCs are new in larger screen sizes and with higher definition. With the increasing volumes of screen display information, there is a trend towards higher speeds on the interface between the CPU and LCD driver. However, since the data interface frequency is higher than that for the LCD drive signal output, higher speeds mean increased effects of EMI (Electromagnetic Interference) noise caused by changes in signal level. Suppression of EMI noise is therefore a major concern in LCD panel system design, and there is strong demand for LCD drivers that minimize EMI noise.

In response to this need, Solomon Systech has been engaged in the development of TFT LCD source drivers incorporating an RSDS-compliant small amplitude differential interface that enables a low EMI level to be achieved.

The Solomon Systech source driver employs an RSDS-compliant small amplitude differential interface. The voltage amplitude has been reduced to 0.2V (±0.1V) as compared with 3V of the conventional CMOS level interface. It enables EMI noise due to signal level changes, making it possible to reduce the number of parts necessary for noise suppression. Moreover, the number of data interface lines has been halved to 18 from 36 lines of the CMOS level interface. This allows for less board wiring area and lower LCD panel costs.

The advantages of RSDS include:

(1) Using a low voltage differential swing (+/- 100mV) and a 2:1 Data Mux ratio, a less complex and lower power consumption receiver structure results.
(2) Less EMI is generated due to differential signaling pairs.
(3) A reduction in bus width can be achieved by using the RSDS interface instead of the TTL interface. In a 6-bit RSDS system, 9 pairs of data and 1 clock pair (total 20 lines) are required. In TTL, 36 data lines with 2 clock signals (total 38 lines) are needed. Hence, the bus width can be reduced by a total of 47.4%.

ii Charge sharing output driving

The charge sharing scheme used in Solomon Systech source drivers can reduce the column driver power while improving the settling time of the outputs simultaneously.

<u>How charge sharing works</u>

The charge sharing works by redistributing the energy stored in the columns of the TFT LCD. Before the charge sharing, half of the columns are driven to voltages above VCOM and the other half are below VCOM because of dot or n-line inversion. When the charge sharing starts, all columns of outputs will be connected together and the charges will be distributed evenly among all outputs. After the charge sharing, all columns of outputs will be at VCOM. Finally, the outputs can drive to their final voltage starting from the VCOM instead of undergoing the full voltage range. In Figure 4, the arrow shows the charge flowing direction during charge sharing and all outputs are connected together.

Figures 5 and 6 show the output waveforms without charge sharing and with charge sharing, respectively. Figure 6 shows that there exists a period at almost VCOM voltage in order to redistribute charge among all output pins.

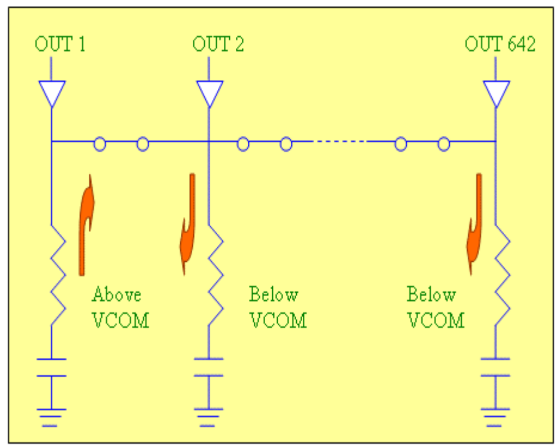


Figure 4: Column voltages during charge sharing

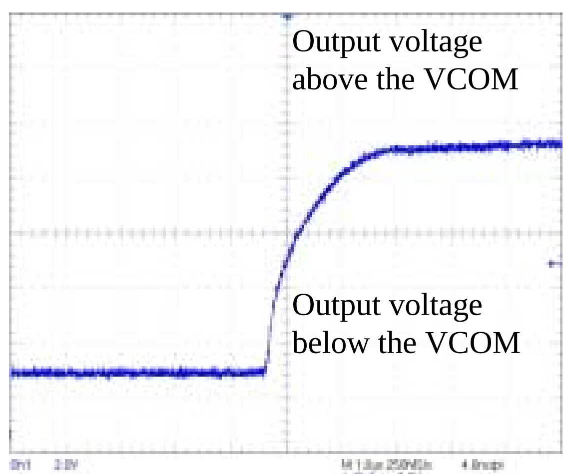


Figure 5: Output waveform without charge sharing

Advantage
The charge sharing will neither reduce the bias current nor decrease the overall slew rate of the output, because charge sharing only uses the energy stored in the outputs. As a result, these source drivers can achieve higher driving capability with less power consumption.

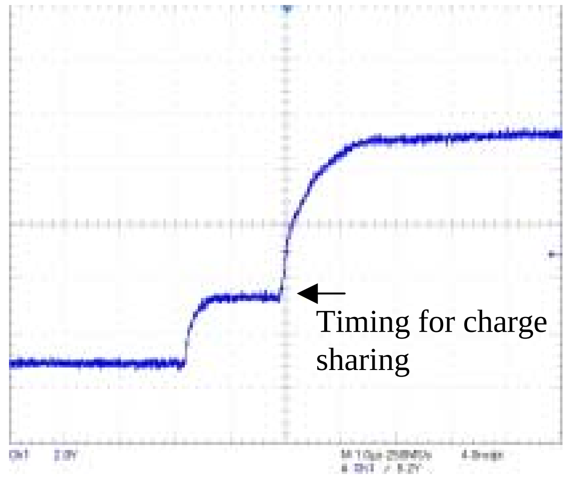


Figure 6: SSD1237 output waveform with charge sharing

Change of charge sharing time
The charge sharing time controlled by users depends on the panel loading without external circuitry or additional input pins. The user can use two pins, QSR0 and QSR1, to control the time in SSD1237AU5R1, all of which are tied off within the TCP or COF package.

Table 1: Charge sharing pin definition in SSD1237AU5R1

QSR1	QSR0	Charge share time
0	0	No charge sharing
0	1	66 RSDS CLKs
1	0	99 RSDS CLKs
1	1	For testing use only

iii Power control options

In order to meet different application power requirements, there are four power control options in the source driver SSD1237, as shown in Table 2. There are two pins in SSD1237 for the power mode selection.

Table 2: Four power options provided by SSD1237

Application example	Analog current consumption
12.1” 1280X800	Ultra Low Power
14.1” 1280X768/800	Low Power
17” 1280X1024	Normal, 100%
19” 1280X1024	Strong

iv High LCD driving voltage

High performance TFT LCD panels, which offer high display quality with a wide viewing angle, are already available in the market, and are in increasing demand. However, these high-performance TFT LCD panels require a high LCD driving voltage. This creates a need for an LCD driver capable of generating the necessary high voltage in addition to supporting a high-definition display. The Solomon Systech SSD1211 offers 18V-driving voltage, adequate for supporting different quality enhanced algorithms such as MVA, S-PVA, IPS, and over-drive systems. It also operates over a wide LCD driving voltage range, from a maximum of 18V to a minimum of 8V. To minimize output voltage variation, the auto-zero-based offset compensation method is employed. After each line starts to pulse, it samples the unexpected noise and offset, and then subtracts it from the instantaneous value of the contaminated signal at either the input or the output of the op-amp. As a result, less than +/- 10mV output voltage variation can be achieved despite the high 18V voltage level. This makes it possible to achieve an LCD panel offering a high quality, flicker-free display with a wide viewing angle.

v High pin count

To reduce the total system cost, the high pin count source driver has emerged. The source driver SSD1237 provides 642 output pins with adapting fine-pitch bonding. Hence, the number of pins has been increased while keeping the system cost constant. For a SXGA panel (1280X1024), 10 pieces of source drivers (384 pins) are required conventionally, but now just 6 pieces of source driver are needed if the pin number is 642 instead. Forty percent cost savings can be achieved as a result. That's why the 960-output pins source driver is the next target for the driver industry.

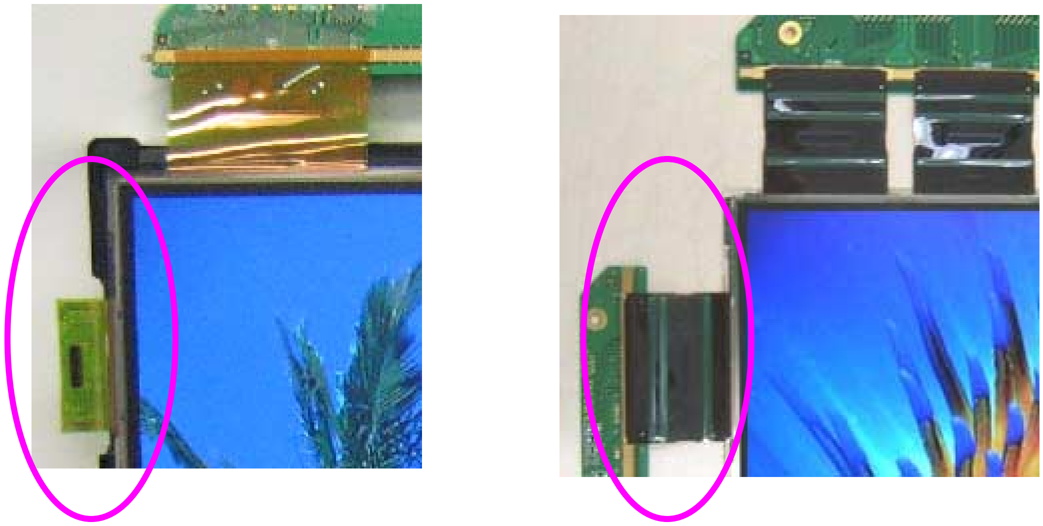
III Gate driver

The Solomon Systech SSD1201/2/3/5 gate driver series support different output options, operating at low logic voltage: 2.3 – 3.6V and high maximum gate voltage: up to 42V. Employing selective shift direction and cascade functions, flexible and compact panel design can be achieved.

i PCB-less design

In order to reduce total system cost, these gate driver support PCB-less design for the COF packaging. PCB-less design is employed in SSD1205, as shown in Figure 7. This design can reduce the physical size and weight of the TFT-module, hence, the overall cost of the monitor/TV system. In this design, the source driver has a designated pin, which is used to send TCON signals to the gate drivers.

Figure 7: PCB-less design SSD1205 (left hand side) and transitional design gate driver (right hand side)

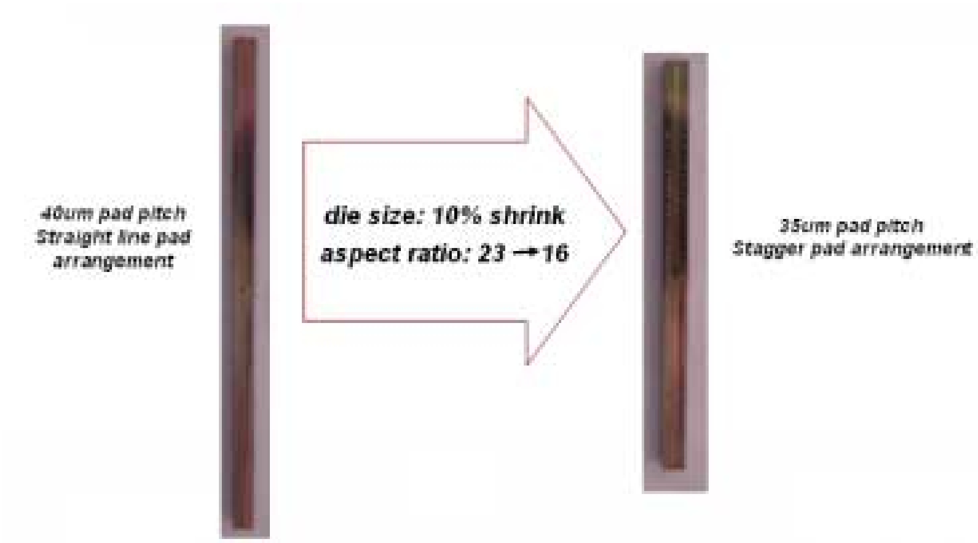


ii Stagger Pad Arrangement

A stagger pad arrangement is currently employed in Solomon Systech's gate driver SSD1205A and source driver SSD1237A, which allows for super fine pitch packaging. The traditional TCP bonding has a limitation of 40µm pad pitch and the fine-pitch COF bonding can achieve a 25µm pad pitch.

The advantages of the stagger pad arrangement and fine pitch packaging enable to develop a smaller, shorter die with a smaller aspect ratio, which makes it easier to handle and fabricate. Additionally, no extra hardware is required and it is transparent to the user when applying this technique. Figure 8 shows the differences between a straight pad configuration and a stagger pad configuration. The die size of SSD1205 can be reduced 10% if the stagger pad arrangement is used instead of the straight pad configuration.

Figure 8: SSD1205 die pictures with straight line pad configuration and with stagger pad configuration



IV Conclusions

The trends of the TFT LCD monitor and TV are towards higher resolution, better quality, and larger panel size. An existing portfolio of source and gate drivers from Solomon Systech can fulfill wide-ranging application needs.

In the near future, Solomon Systech plans to roll out a series of new source drivers with emerging interface standards, including, PPDS and mini-LVDS, that feature higher driving voltage, pin count and color depth, in order to meet future challenges.

Table 3: Products Description (Source driver and gate driver)

Source Driver				
Part Number	**SSD1231**	**SSD1237**	**SD1213**	**SSD1211**
Number of output channels	**384**	**618 / 642**	**480**	**384 / 414**
Gray Level	**6-bit**	**6-bit**	**8-bit**	**8-bit**
Logic Supply Voltage	**2.7 - 3.6V**	**2.3 - 3.6V**	**2.5 - 3.6V**	**2.5 - 3.6V**
LCD Driving Voltage	**12V**	**13.5V**	**18V**	**18V**
Max. Interface Clock Frequency	**85MHz**	**85MHz**	**85MHz**	**85MHz**
Gamma Correction Input	**9 + 9**	**7 + 7**	**9 + 9**	**11 + 11**
Inversion	**Dot / n-line**	**Dot / n-line**	**Dot / n-line**	**Dot / n-line**
Interface	**RSDS**	**RSDS**	**RSDS**	**RSDS**
Package	**TAB / COF**	**TAB / COF**	**TAB / COF**	**TAB / COF**
Application	**Monitor, NB**	**Monitor, NB**	**TV, Monitor**	**TV, Monitor**
Special Features		**- 4 Gamma Buffer - for PCB-less gate driver**		**- 2 Gamma Buffer**

Gate Driver				
Part Number	**SSD1201**	**SSD1202**	**SSD1203**	**SSD1205**
Number of output channels	**256 / 263**	**300**	**384**	**200 / 240 / 256 263 / 270**
Logic Supply Voltage	**2.5 - 3.6**	**2.5 - 3.6**	**2.5 - 3.6**	**2.3 - 3.6**
Maximum Gate Voltage	**42V**	**42V**	**42V**	**42V**
Max Interface Clock Freq.	**200KHz**	**200KHz**	**200KHz**	**200KHz**
Package	**TAB / COF**	**TAB / COF**	**TAB / COF**	**TAB / COF**
Remarks	**--**	**--**	**--**	**PCB-less design**