# High Color Depth Driver LSIs for TFT-LCDs

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**Abstract**

We designed 10bit source driver LSI, then the high color depth and the low power consumption are realized thru it. It is adopted mini-LVDS receiver with high speed data transmission and good data recovery performance, Hybrid type DAC to reduce decoder size and OP-AMP with low power consumption and high slew rate.

In addition we show our results of the 10-bit gray scale TFT-LCD source driver for 42-inch diagonal size and WXGA resolution TFT-LCD TV applications.

## 1. Objective and background

After the multimedia era had set in, the importance of display device has been increased because it is an unavoidable tool that plays an important role as an interface between human beings and machines. In contrast with the conventional display, flat panel displays have been rapidly growing in the display market. Moreover, TFT-LCD is extending its market share in the large size and high resolution LCD TV market as well as in the mobile display market. Not only the large panel size and high resolution, but also precise color depth is applied to TFT-LCDs. The effort to represent colors over 8-bit(256 level) shades of gray, that is 10-bit(1024 level) or 12-bit(4096 level) shades of gray, has been studied[1].

Therefore, We designed 10-bit driver LSI for large size and high resolution TFT-LCDs. The 10bit source LSI is very low- power consumption and can support high color depth. And we show our results of the 10-bit gray scale TFT-LCD data driver for 42-inch diagonal size and WXGA resolution TFT-LCD TV applications.

## 2. Display Driver Circuit Design

### 2.1. High-Speed Signal Interface: mini-LVDS Receiver System

Figure 1 shows the desired receiver circuit which is an asynchronous comparator consisting of an input stage with low voltage differential input common-mode range, gain-boosting stage and buffer stage. This asynchronous comparator as a mini-LVDS[2] receiver with rail-to-rail input common-mode voltage range and dual gain-stage allows wide operating frequency range and high-gain. Having low voltage differential input common-mode range makes it possible to maintain good data recovery performance regardless of common-mode voltage and differential voltage variations due to electrical noises such as reflection or signal return crosstalk, and non-zero impedance of GND path.

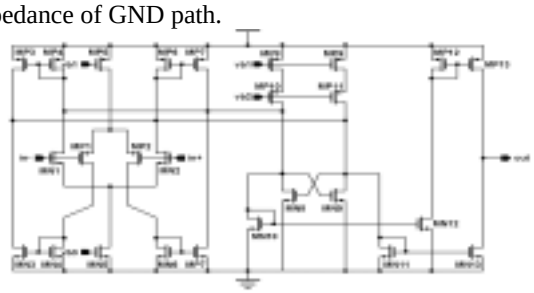

Figure 1. Asynchronous comparator as a mini-LVDS receiver

### 2.2. Digital-to-Analog Converter for 10-bit Shades of Gray

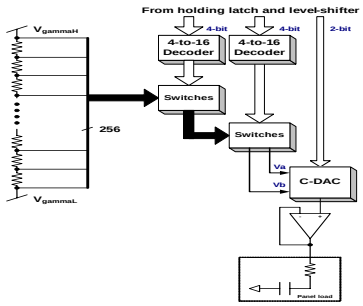


Figure 2. Hybrid type DAC structure.

The gray levels are generated from a central resistor (gamma levels) and fed to the input stage of output buffer through 1-out-of $2^N$ switch DAC where N is the number of bits for representing gray scale level. In case of 10-bit, 10-to-1024 decoder and 1024 switches for each column are needed. So the chip size is exceedingly increased. Therefore, to reduce the size of decoder and switches, number of bits for gray level from MSB to LSB is divided into some blocks such as 4-MSB + 4-LSB for 8-bit gray scale. Hitachi announced hybrid type DAC of resistive DAC and binary weighted capacitor DAC. When the hybrid type DAC is applied to 10-bit

gray level driver, 8-bit resistor string DAC and 2-bit binary weighted capacitor DAC can be an area efficient DAC structure. Figure 2 is shown hybrid type DAC structure.

### 2.3. Unit-Gain Operational Amplifier as an Output Buffer

From the low power perspective, each column has its own buffer, so few hundreds of unit-gain OPAMP is included in each chip and consequently it causes unacceptably high power consumption. Moreover, because the slew rate of an OPAMP is proportional to its bias current, trade off between bias current and slew rate is inevitable. Therefore, low quiescent current and high slew rate unit-gain OPAMP is necessary for an output buffer of TFT-LCD driver circuit. Figure 3 shows the typical unit-gain OPAMP with rail-to-rail folded cascade input stage and class-AB output buffer structure. The unit-gain OPAMP has 10uA of quiescent current and 3.4V/usec of slew rate. Moreover, Not only the low quiescent current and high slew rate, but the offset cancellation is important to design TFT-LCD driver circuit.

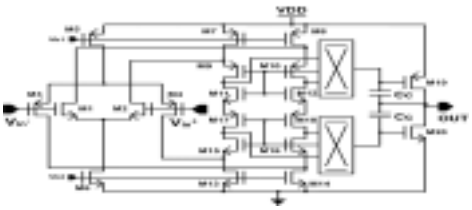

Fig. 3. Circuit diagram of modified OPAMP structure

### 2.4. Development of 10-bit Gray Scale TFT-LCD Source Driver LSI

we successively developed a 10-bit gray scale TFT-LCD source driver LSI for 42-inch diagonal size and WXGA resolution TFT-LCD TV applications. Input image data is mini-LVDS compatible and the LSI consumes low power as well as small die size of 16000um x 3300um. Figure 4 shows the micro-photograph of the fabricated IC and figure 5 shows an experimental results of demonstrating test images.

## 3. Conclusions

LCD industry is expanding successively to the TV market and the challenges of large size and high resolution LCD panels were essential to compete with other displays such as PDPs. In addition, to provide better impression of color and represent fine natural color, over 10-bit gray scale is needed.

Therefore, we designed low power consumption and high color depth driver LSI for the large size, high resolution TFT-LCD and having high gray scale over 1024 level shades.

## 4. References

[1] Paul Matthijs, “Grayscale resolution : How much is enough?,” Barco White Paper, 2003.

[2] “The mini-LVDS Interface Specification,” Application Report, Texas Instruments, August, 2001

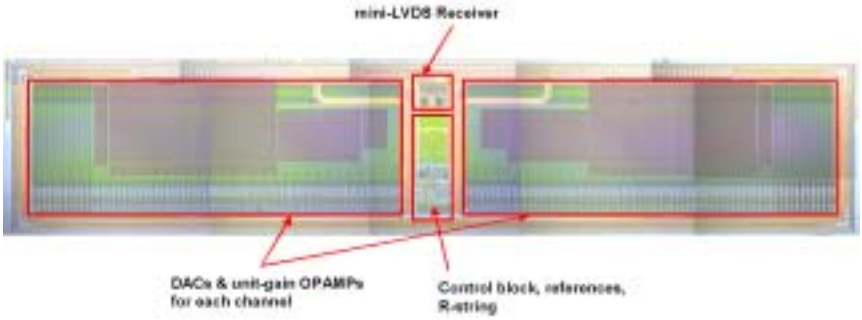


Figure 4. Microphotograph of the fabricated 10-bit gray scale TFT-LCD data driver LSI.

Figure 5. Test image (a) 1024 gray level color bar image (b) picture image.