A Thin Film Transistor LCD Module with Novel OverDriving Timing Controller

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Abstract

Chunghwa Picture Tubes, LTD. (CPT) has developed a Novel TFT-LCD Driving Techniquel. This new technique is developed in combination with other state-of-the-art image processing solutions such as image compression / decompression, motion detection, and noise reduction. By applying the Novel Driving Technique to the high resolution TFT-LCD, it was found that the response time can be effectively reduced with a lower overall system cost by smaller frame memory requirement, lower EMI by less memory band-width. Likewise, higher display quality can also be achieved in that the unexpected noises generated by over-drive can be eliminated.

The Novel TFT-LCD Driving Technique has been successfully implemented to the 30 inch WXGA (1280×768) resolution TFT LCD commercial TV module. It was found that the quality of moving picture was better improved compared with that of the conventional fast response driving method.

1. Introduction

The market of TFT-LCDs has been largely expanded by the diverse applications such as Note-book PC, PC Monitor, and TV. Regarding TV application, the TFT-LCD module is required to display a moving picture as well as a still picture. Similarly, TFT-LCD that is currently available has been characterized as slow optical response, so it does not provide good performance in displaying moving picture. To solve this problem, the over-drive technology has been used to improve the flat panel (particularly TFT-LCD) response time for many years. To improve the quality of moving picture on the TFT-LCD, various driving techniques have been introduced[1][2][3]. Among them, the over driving method is well known as the effective scheme for improving the response time. The over driving method makes the response time faster by applying an correctional value to a moving picture. The correctional value corresponding to a moving picture is determined by the offset value to be added to the original value.

$$\mathbf{RGB^{out}(t) = RGB(t) + OD^{Table}\,(RGB(t), RGB(t-1))}$$

Refer to the above formula, the second term OD^{Table} () is the offset value, RGB(t) is the image pixel at the current time frame, RGB(t-1) is the image pixel at the previous time frame. Fig. 1 shows how the response time (T_R / T_F) can be reduced by over-drive processing, where RGB(t+1) is the image pixel at the next time frame. With additional OD^{Table} added to RGB(t), the targeted image output is $RGB^{out}(t)$ instead of RGB(t), which can reduce the response time from T_R/T_F to $T_{R'}$ / $T_{F'}$. In principle, the over-drive processing will process the entire frame pixel by pixel. The offset value of over driving method is determined through a decision model. Such a model heavily depends on the characteristics of the flat panel. For TFT-LCD, the decision model is normally implemented by a look-up table for some major points and then further processed by interpolation computation.

The major points should be derived from the response time characteristics for a particular display device based on input voltages (at the previous time frame) and output voltages (at the current time frame).

Here, we optimized the conventional over drive technology by combining with other state-of-the-art image processing solution such as image compression / decompression, motion detection, and noise reduction. We term this new technology as " The Novel TFT-LCD Driving Technique".

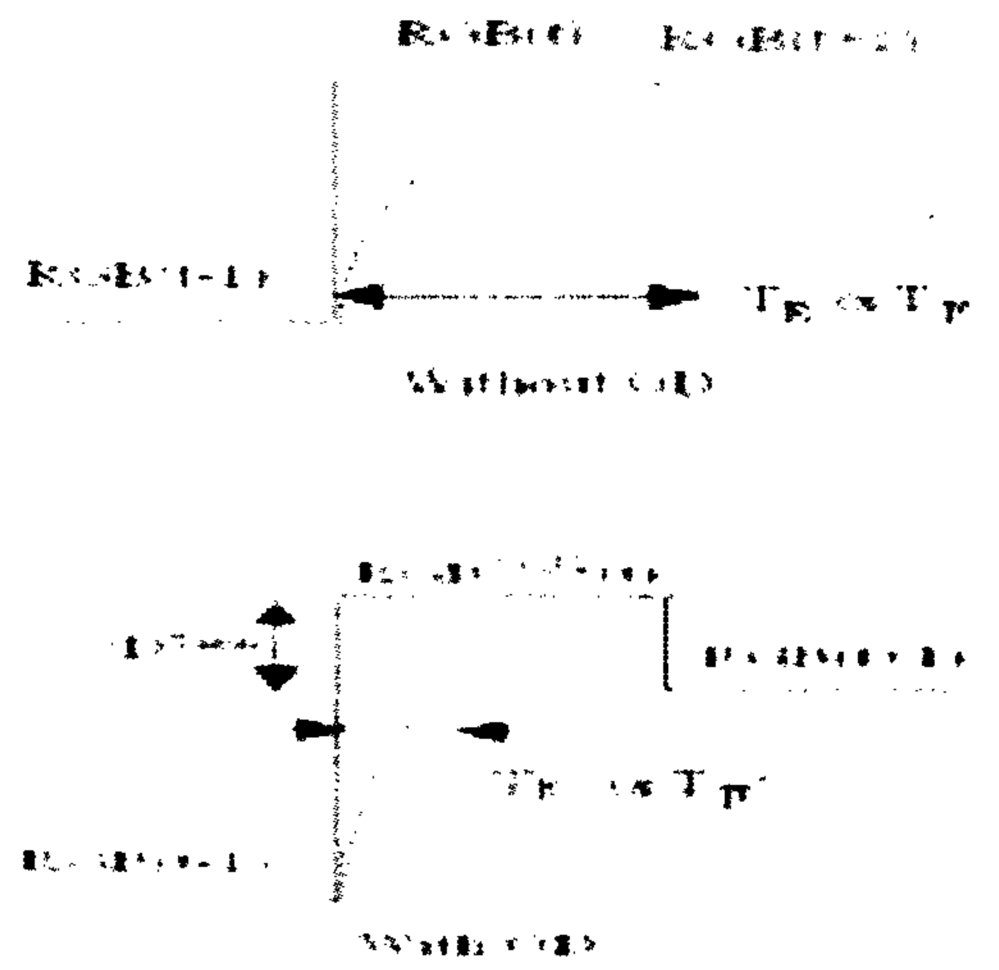

Fig.1 Over-drive processing to reduce the response time

2. The Novel TFT-LCD Driving Technique

As we mentioned in the previous section, "The Novel TFT-LCD Driving Technique" architecture (Fig.2) combines with the over drive processing requires one-frame delay mechanism for getting the pixel value of the previous frame. A compression mechanism is used for reducing the bandwidth demands of the frame buffer access for implementing the one-frame delay. In order to keep the compressed image integrity, the incoming image in RGB color components format will be converted into the ITU-R BT.601 YUV [4] one before compression processing. After image compression, the compressed frame image will be stored into memory buffer. Then, the controller will enhance the overdriving effect by processing the original data before looking up the table. Likewise, it is generally desired to minimize the amount of data to be stored in a frame memory in order to reduce the system cost and EMI effect. These compression and decompression functions can help to reduce both the buffer size and bandwidth requirement for frame buffer storage.

To access the external SDRAM as frame memory buffer, one frame memory controller is built in as the temporary data storage before the SDRAM. Similarly, the auto-refresh cycles are generated by the frame memory controller with programmable refresh period and cycle numbers.

Typically, the overdriving can improve the response time efficiently but it also increases the noise data in some cases, particularly when the input image content is noise itself or when it is given to the display device through an unreliable transmission channel, such as poor analog front-end processor or signal cable. Hence, the Novel Overdriving applies the motion and noise detector that is used to avoid the enhanced noise. The motion and noise detector receives motion information from the pre-frame buffer processor and compares current and previous frames to calculate temporal difference value of a certain pixel.

One internal threshold can be used to determine the image is a still image or not, whether a pixel is detected as the motion pixel, whether an offset value is determined and added to the current frame image through the look-up table.

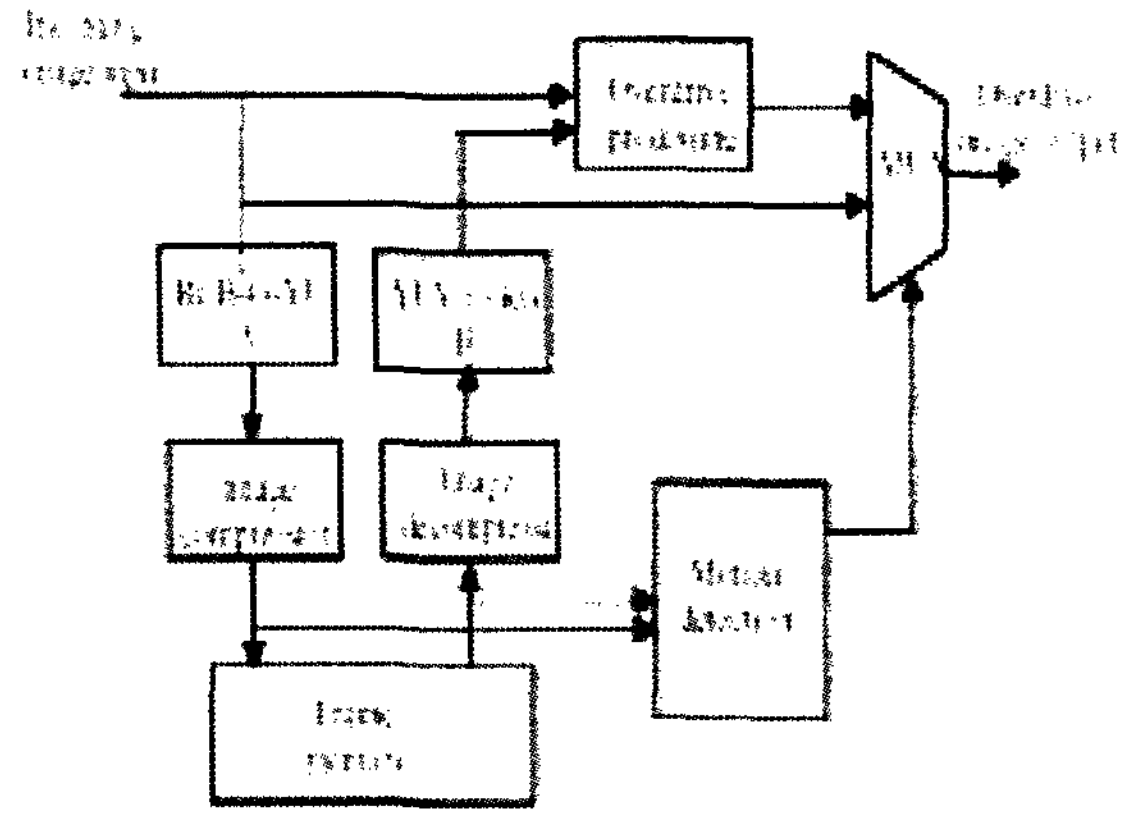

Fig.2 The Novel TFT-LCD Driving Technique architecture

3. Result

We have integrated the Novel TFT-LCD Driving Technique into timing controller ASIC which was used in 30 inch WXGA (1280×768) resolution TFT-LCD TV panel. The result of optical response can be seen in Fig. 3 and Fig. 4, where the response time has been significantly improved. When the overdriving function is off, the ratio of gray-to-gray T_R and T_F under 16ms are 60 and 40 percentage respectively. On the contrary, when the overdriving function is on, ratios are up to 100 and 88 percentage, respectively.

Last but not the least, it is found that the image compression/decompression process can reduce frame memory requirement. It needs only one single SDRAM (with 1Mx16) for the display resolutions of WXGA. Furthermore, base on the external SDRAM and EEPROM over driving architecture, the reduced frame memory requirement means the lower overall system cost.

The overall compression ratio resulting from the compression mechanism can reach the factor of 3. Also, the external SDRAM can be driven by the clock same as the input image data rate without the need of clock doubling or multiplying. Keep fewer data bus demand and lower clock rate for accessing SDRAM are the key factors to help reduce the overall system EMI levels.

The motion and noise detector integrated in the system is used to eliminate the enhanced noise and determine whether the image is a still image or not. Then the output image distortion due to compression and decompression can be totally eliminated. And the quality of still images will not be degraded.

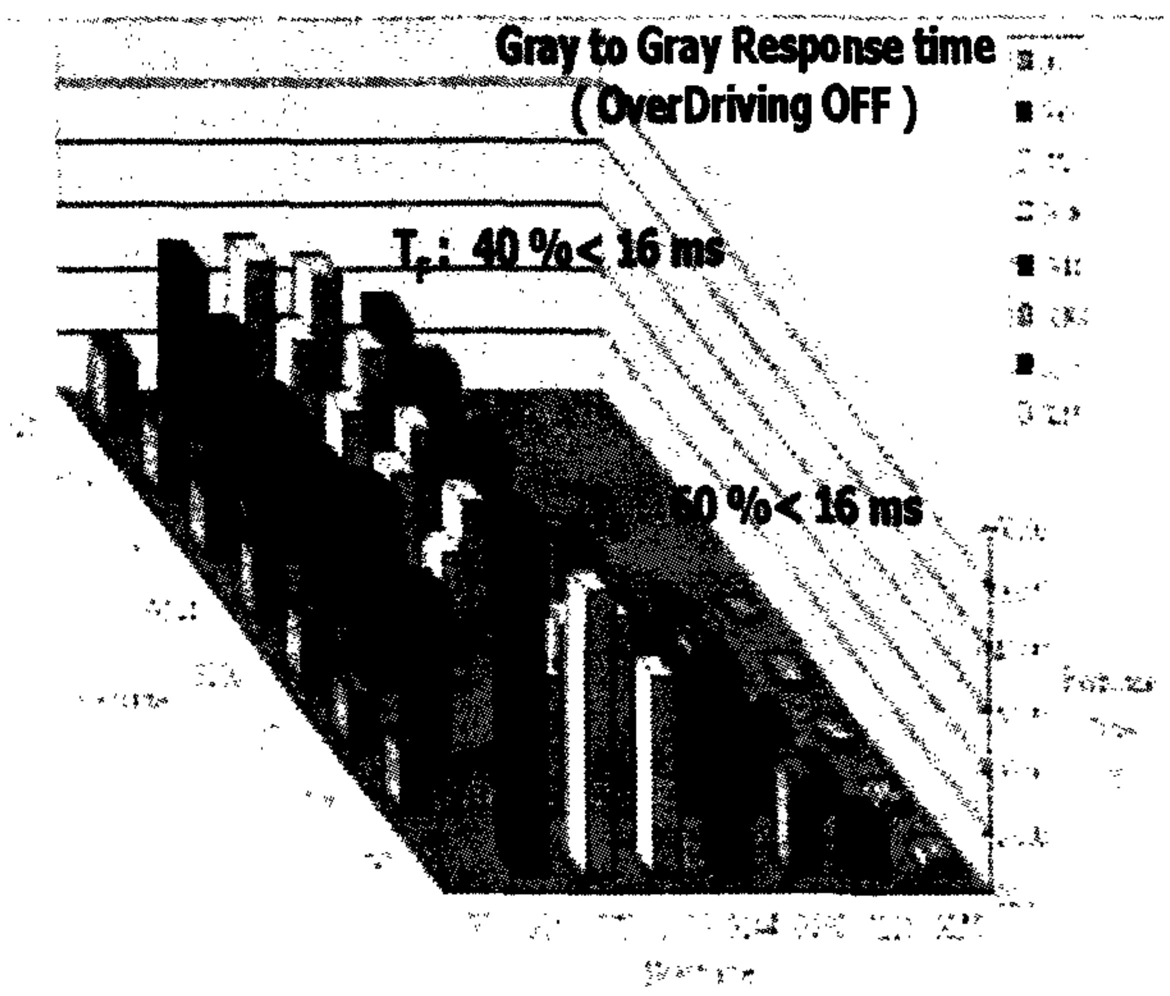

Fig. 3 Response Time (OverDriving OFF)

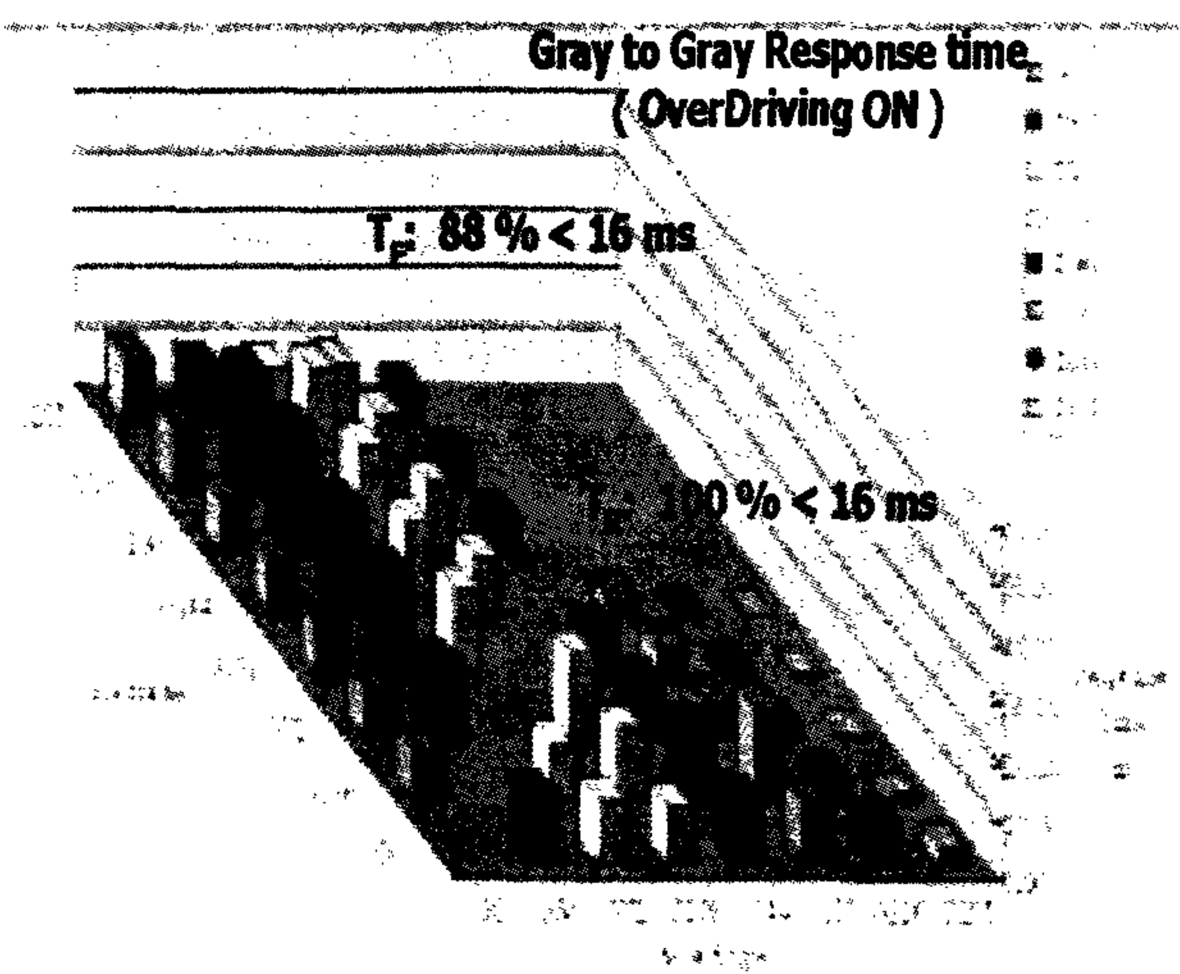

Fig. 4 Response Time (OverDriving ON)

4. Conclusion

By applying the Novel TFT-LCD Driving Technique to the 30 inch WXGA (1280×768) resolution TFT LCD commercial TV module, the moving picture quality is improved more than with conventional fast response driving method.

The Novel TFT-LCD Driving Technique embedded in timing controller can serve a better option as an alternative to the conventional method characterized as slow response time.

5. References

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[4] ITU-R BT.601-R 1995, Studio encoding parameters of Digital Television for standard 4:3 and wide screen 16:9 aspect ratios