Development of Simple-Matrix LCD Module for Motion Picture

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Abstract

A simple-matrix LCD module (12.1-in. SVGA) has been developed so as to ensure low cost and high fidelity reproduction of motion picture information. The points of the development are as follows:

(1) By applying a new drive system "High Contrast-Addressing (HC-Addressing)", which uses a new multiple line selection technique capable of efficient memory access and a new algorithm for multiple gray shades without flicker, and a new high performance liquid crystal panel system, fast response 150 ms (half of conventional models), high contrast 40 : 1 (twice as conventional models), 256 k colors, and flicker-free images have been achieved.

(2) By suppressing image pattern dependence of the frequency of driving waveform and applying compensation voltage for the distortion of the waveform, crosstalk problems have been solved.

Introduction

As a result of intensive progress of multimedia and new information society supported by development of digital technology and communication infrastructure, the display environment is changing remarkably. The number of pixels has been increased from VGA to SVGA and then to XGA. The number of display colors has been increased from 4,096 colors to 256 k colors and then to 16 M colors. This remarkable progress is stimulated by the request for interactive use of all audio and video information as naturally as possible irrespective of time and place. Especially, the remarkable spread of CD-ROM mounted personal computers (PC) is stimulating the request for the multimedia display capable of displaying motion picture. Hence, it is becoming more important to realize high contrast and fast response of Simple-Matrix LCD excelling in cost performance. The high contrast-addressing (HC-addressing) LCD has been developed so as to ensure low cost and high fidelity reproduction of motion picture information. Applying the new drive system HC-addressing which uses the multiple line selection technique and new algorithm, we have realized a 12.1-in. SVGA LCD which can display 256 k colors, ensuring high response speed twice or more higher than that of conventional Simple-Matrix LCD as well as flickerless high contrast. This paper discusses the outline of HC-Addressing LCD module.

1. Background

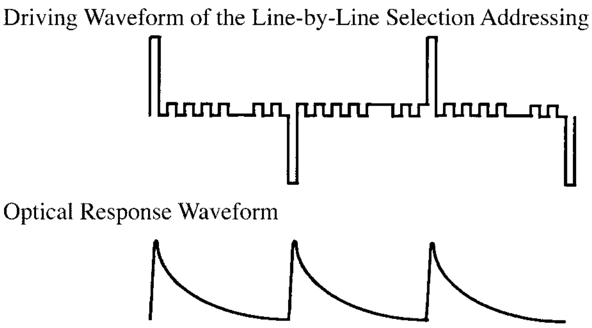

Figure 1: Driving waveform of the line-by-line selection addressing and the optical response waveform

If the viscosity of liquid crystal material is lowered or the gap of liquidcrystal layer is reduced so as to realize fast response, the root-mean-square (rms.) response of liquid crystal is disabled but the frame response (response to the driving voltage waveform itself) is enabled. Consequently, if the liquid crystal is driven by the conventional line-by-line selection addressing, in which the applied voltage is concentrated in one part of one frame period, the transmission of off display pixel parts increases and the transmission of on display pixel parts reduces. As a result, the contrast of displayed images lowers, so that satisfactory display characteristics cannot be obtained. **Figure 1** shows the driving waveform of the Line-by-line selection addressing and the optical response waveform in case of the frame response. The transmission which rises due to application of a selection pulse reduces remarkably during a non-selected period. Recently, the active addressing (AA) [1] and the multiple line addressing (MLA) [2] have been proposed as the driving method which can suppress the above-mentioned frame response phenomenon. The feature of AA and MLA is that several scanning lines can be selected simultaneously and the selection pulse interval can be shortened without reducing the selection pulse width. This implies that the selection pulse can be dispersed over one frame period. As a result, the frame response phenomenon can be suppressed, and high contrast can be obtained. However, unlike the Line-by-line selection addressing, these methods need a computing circuit of orthogonal functions, frame memories to store tentatively the image data, and multilevel column drivers. This results in increase of required circuit scale. Hence, it is important to simplify the circuit system, realize it at reasonable price and with high quality so as to market the products.

2. HC-Addressing

To suggest solutions for the above problems, we have developed a new drive system, "HC-Addressing ". This system consists of cost-effective and high-efficiency memory structure and offer a display performance of gray scale with less flicker and less shadowing.

2·1 Optimization of the Number of Rows Selected at a Time

Although the frame response phenomenon suppression effect is improved as the number of rows selected at a time is increased, the scale of circuit, such as the generator of orthogonal functions, the computing circuit of orthogonal functions, drivers, etc. increases. The number of rows selected at a time was set to 4 which ensures small circuit scale and high frame response suppression effect.

2·2 Drive Algorithm

Figure 2 shows the module block diagram of an HC-Addressing LCD module. The row drivers apply the voltage to the liquid crystal (LC) panel according to the specific orthogonal function generated by the generator of orthogonal functions.The column drivers apply the voltage obtained from the dot product of specific orthogonal function and image data stored tentatively in the frame memory.

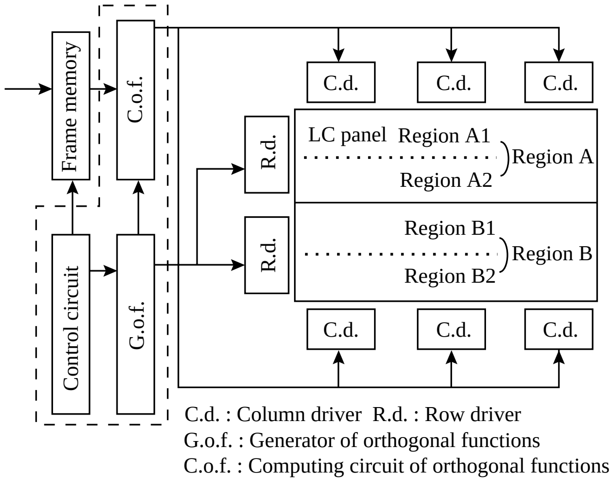

Figure 2: Block diagram of HC-Addressing LCD module

Our drive method, like the AA and MLA explained above, is designed to apply several selection pulses in one frame period, using the orthogonal function. So as to reduce the memory circuit scale, it applies the selection pulse application method differing from that applied to the AA and MLA .

Here, the LC panel is divided into two regions, upper and lower regions(namely region A and region B). **Figure 3** shows the driving waveform of several addressing methods. The AA and the MLA are designed so that the selection pulses, being uniformly dispersed in one frame period, are applied to the regions A and B. The upper and lower screens of our system are divided further into two parts, and the four regions A1, A2, B1, and B2 are driven separately. In the first half of one frame period the selection pulses are applied to the regions A1 and B1, and in the second half of one frame period the selection pulses are applied to A2 and B2. Thus, the half (upper or lower) of screen of LC panel is driven in the first half of one frame, and the next half is driven in the second half. Therefore the required memory capacity is only 1/2 of memory capacity of the other methods.

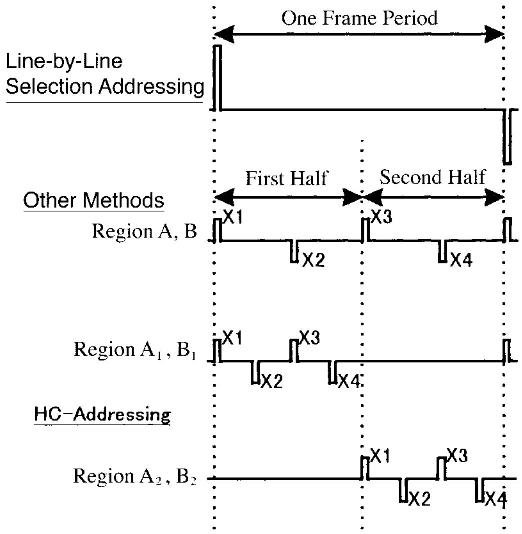

Figure 3: Driving waveform of HC-Addressing and other methods

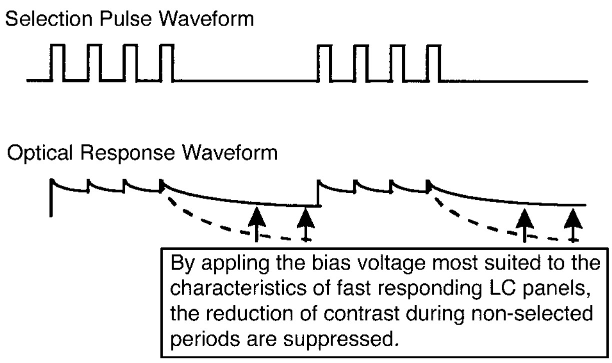

Figure 4: Optical response waveform of HC-Addressing

Figure 4 shows the selection pulse waveform and the optical response waveform of HC-Addressing.

Our system is designed so that the bias voltage most suited to the characteristics of fast responding LC panels is applied. Moreover, the signal is read from the memory with high speed so that the drive frequency is increased by two times. Therefore, the change of transmission during non-selected periods and then the reduction of contrast are suppressed.

2•3 Gray Shades

In the conventional frame rate control (FRC) system, the duration of FRC sequence increases as the number of gray shades is increased. This results in increase of flicker, causing reduction of picture quality if the FRC system are used for the fast responding LC panel. Hence, our system applies the new algorithm characterized by the shortened FRC sequence (as compared to the conventional systems), so that the flicker-free smooth 64 gray shades (256 k colors) display is realized on the fast responding LC panel.

2•4 Low-Shadowing

We have developed a new low-shadowing technology in order to prevent driving waveform distortion, which is caused by increased capacity component as the cell-gap is reduced in the fast responding LC panel. Shadowing is a phenomenon that the brightness in upper and lower directions appears different from that in the background when stripe-pattern or block-pattern is on display. This is mainly caused by the following reasons:

i) The frequency of column voltage waveform depends on the image pattern.As the frequency of waveform increases, the rms voltage drops down.

ii) The rms voltage deviates in accordance with the distorted voltage, which is induced to the row electrode from the column electrode via the LC layer. To eliminate these negative causes in the HC-Addressing LCD module, various techniques are employed; orthogonal function is rotated among the frames, polarity inversion period is optimized, and a new circuit is applied to detect the induced distortion voltage and compensate the row voltages. These contributed to achieve low-shadowing images on display.

3. Specifications of HC-Addressing LCD Module

3·1 Dimensions

Narrow frame and thin package, like the conventional models, have been realized.

3·2 Interface

The low voltage differential signaling (LVDS) system which is compatible with thin film transistor (TFT) LCD is applied, measures against electromagnetic interference are taken and the number of input signal lines is reduced.

Table 1 Specifications of HC-Addressing LCD module.

Items	Obtained Data	unit
Module Dimensions	275 (W) x 202 (H) x 8.9 (D)	mm
Displayable Range	245.98 (W) x 184.48 (H)	mm
Display Format	800 x RGB (W) x 600 (H) SVGA	——
Dot Size	0.0825 x RGB (W) x 0.2875 (H)	mm
Weight	520	g
Interface	LVDS method	——
Number of Colors	260,000	——
Viewing Angle	Right/Left: 140	degrees
	Up/Down: 90	degrees
Contrast Ratio	40 : 1	——
Response Time	Rise Time: 100	ms
	Decay Time: 50	ms
Brightness	80	cd/mm^2

3·3 Display Performance

Fast response 150 ms (1/2 as compared to conventional models), high contrast 40:1 (2times as compared to a conventional model), 256 k colors and flicker-free images have been attained. The fast response 150 ms or less has been attained as a result of development of narrow cell gap panels and highly reliable liquid crystal material with low viscosity. The high contrast 40:1 has been realized owing to adoption of HC-Addressing, optimization of liquid crystal material and retardation film, and improvement of smoothness of color filter.

Conclusions

The "HC-Addressing", which has been reviewed in this paper, is a remarkablyeffective driving system to maintain the optimal contrast on a fast response LCD panel. It contributes to improvement in display performance of a simple-matrix LCD. The HC-Addressing will play an important role in a multi-media generation. In the future, LCDs will be implemented to larger, high-definition devices such as XGA, not only for notebook-type PCs but also desk-top PCs. We are intending to improve further the display performance, reduce power dissipation by developing the system controller with memory inside the one chip IC. The HC-Addressing will be widely implemented as a new driving system for a simple-matrix LCD and contribute its wider applications.

Acknowledgments

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References

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