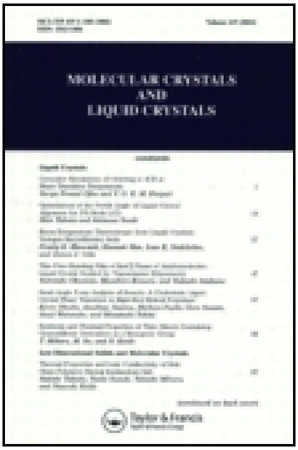

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A Dynamic Picture of a Ferroelectric Liquid Crystal Screen in Multiplex Drive

J. Wahl [a] , T. Matuszczyk [a] & S. T. Lagerwall [a]

[a] Physics Department, Chalmers University of Technology, S-412 96, Göteborg, Sweden

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A Dynamic Picture of a Ferroelectric Liquid Crystal Screen in Multiplex Drive

J. WAHL, T. MATUSZCZYK and S. T. LAGERWALL

Physics Department, Chalmers University of Technology, S-412 96 Göteborg, Sweden

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For the application of the SSFLC high-speed electro-optic effect to practical high resolution devices like large screens, the devices have to be multiplexed. We demonstrate the multiplexibility by showing a small working prototype displaying dynamic pictures with good contrast. The multiplexing ratio is virtually unlimited.

INTRODUCTION

Surface-stabilized ferroelectric liquid crystals (SSFLC) have been shown to possess a unique electro-optic effect[1]; characterized by the same low voltage, low power requirements, it has a much higher (orders of magnitude) response speed than conventional liquid crystals. In addition, proper boundary conditions give the effect the most valuable property of being bistable. The effect thus not only has a rich potential to solve the outstanding problem of thin and large passive computer, graphic and video screens but also to enter into the realm of high-speed optical processing applications.

However, due to the very different nature of the physical effect employed, the question has been raised whether it will be at all possible to matrix-address (multiplex) an SSFLC device in a similar manner as can be done for some other liquid crystal electro-optic effects. In this paper we show that the answer is affirmative. We demonstrate the multiplexibility with an addressing scheme operating on a 16×16 matrix, with a room temperature performance allowing video signals to be displayed on screens, yet allowing contrast comparable to that for static drive.

EXPERIMENTAL

The 256 pixel matrix was formed by crossing two sets of stripe electrodes 1 mm wide (including the 0.1 mm line of etched-away ITO between the stripes). The substrates are 1.5 mm thick float glass plates with a rim of 3 μm Mylar spacer in between.[2] The liquid crystal mixture has an N*–A–C* phase sequence and is a home-made cocktail consisting mainly of esters and epoxy compounds. Its C* phase goes down to about 10 degrees celsius but can be further supercooled, whereas the upper limit is unsatisfactorily low, lying at 45 degrees. The C* phase is brought into the desirable configuration by first aligning the N* phase at the rubbed polymer-coated glass surfaces and then going successively down to the A and C* phase. No mechanical shearing was used. The pitch is sufficiently long in the N* phase that the nematic is untwisted and well aligned. The director alignment is kept very well in the A phase where the layers thus adopt a fairly homogeneous bookshelf geometry. At the transition to the C* phase the molecular axes seem to split fairly symmetrically into two preferred oblique $\hat{c}$ directions corresponding to UP and DOWN electric polarizations.

THE MATRIX IN OPERATION

Figure 1 shows the set-up in which the pictures of the operating matrix were taken. The board with the matrix was placed on a simple microscope stand and the microscope illumination was used, coming from below. A simple polarizer is seen on top of the cell from which edge connectors on south and west sides lead to the electronic circuitry to the left. The close-up photographs were taken with a macro objective which is seen in the upper part of the figure. (A video camera in the same position recorded the film of the moving pictures that was actually shown at the conference.) In Figure 2 a corresponding top side view is shown. Some frame sequences are shown in Figures 3, 4 and 5.

The high switching speed of FLCD devices can be nicely experienced by observing some simple moving patterns. On observation it is striking, compared to the impression from twisted-nematic devices, that there is no "intermediate" state between subsequent pictures, neither any "decay" of preceding information.

Figure 3 presents a small pattern moving anti-clockwise on the chessboard-like background. Figure 4 shows a dynamic pattern of

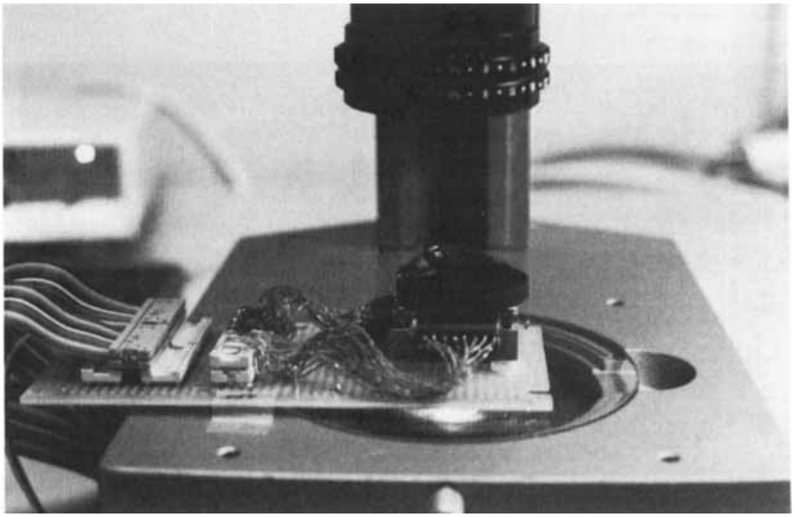


FIGURE 1 The small 16 × 16 matrix mounted on a board with top polarizer shown. Camera above, illumination below; electronics at left not shown.

expanding and shrinking closed loops that could only be generated, like the previous one, by multiplex addressing. Figure 5, finally, displays a text strip (Ferroelectric Liquid Crystals) moving in opposite direction to a middle strip, with a static information (FLCD) below.

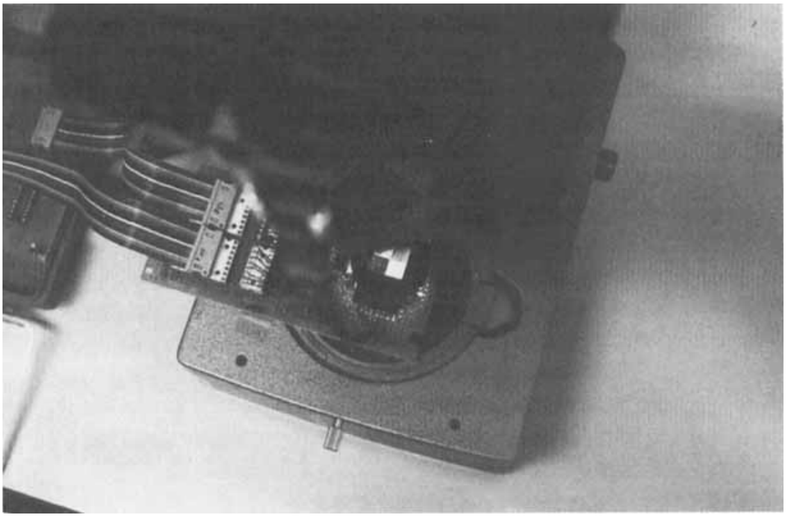


FIGURE 2 Top-side view of the matrix looking obliquely through the top polarizer.

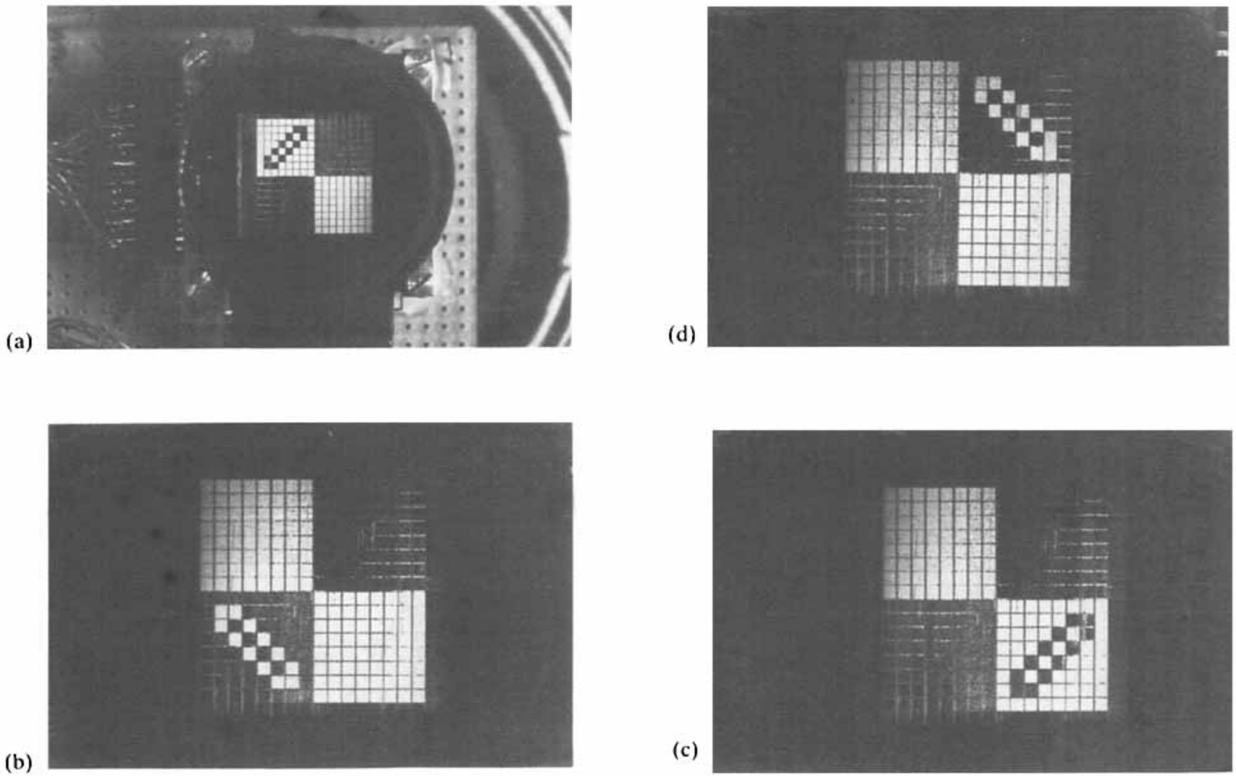
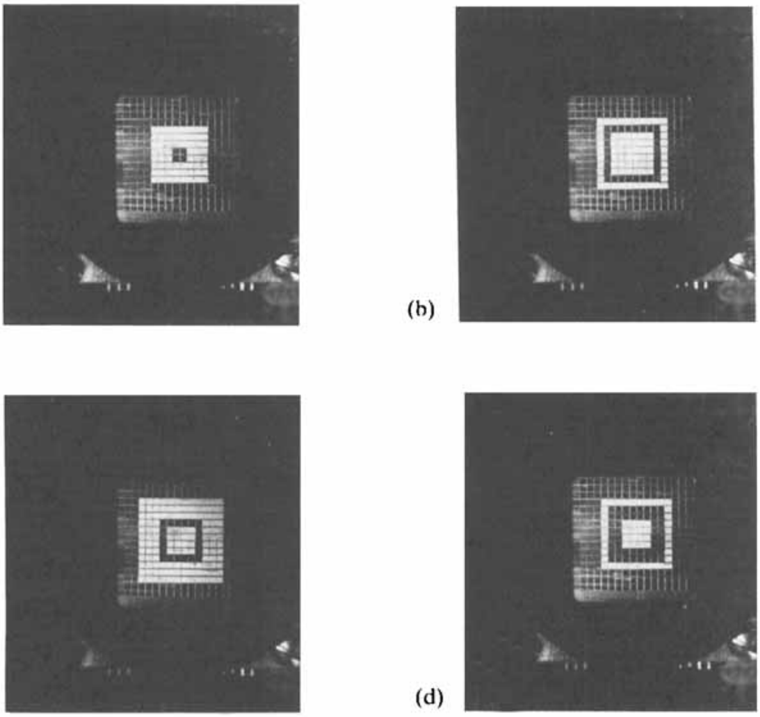


FIGURE 3 The matrix looking head-on through the polarizer with a pattern moving in an anti-clockwise fashion. The pixel size is roughly 1 mm by 1 mm.



(a) (b) (c) (d)

FIGURE 4 Demonstration of true multiplexing by filling the matrix with expanding and shrinking squares.

MULTIPLEXING

A picture element in the cell can be switched between two stable states by applying a positive or negative voltage pulse, denoted as UP respective DOWN switching hereafter. The switching threshold is related to the critical pulse area $(V \cdot \tau)_c$. In order to prevent electrolytic effects there should be no DC voltage present on a long time average. Thus any switching pulse should be compensated by one or more (preferably preceding) pulses of opposite polarity.

Addressing of the SSFLC matrix is performed by scanning one set of electrode lines (rows), while applying desired data waveforms to the second set of electrode lines (columns). During scanning the matrix pixels of the selected row receive the effective signal capable to switch the FLC molecules in either direction while all other see only pulses which are sufficently below the threshold.

The applied multiplexing scheme is presented in Figure 6. The

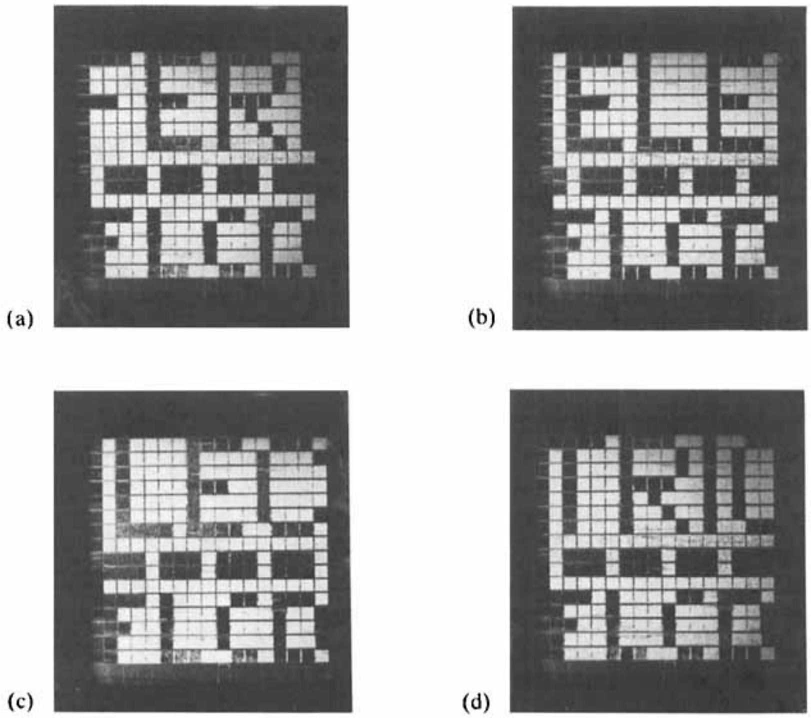


FIGURE 5 Text strips with moving and static information.

voltage across each matrix element is a superposition of respective row and column waveforms. Thus both positive and negative pulses can be obtained, using a single power supply.

In the example shown each switching pulse is preceded by a full size counter pulse. This provides the desired DC compensation without unnecessarily extending the driving sequence. All non-addressed matrix elements see waveforms consisting of two one-third amplitude pulses of opposite polarity. These are moreover separated by zero-voltage periods which prevent adding-up to a critical pulse area. The one-third pulses constitute an inherent and inevitable AC field that, for materials of negative dielectric anisotropy has a stabilizing (i.e. threshold-raising) effect on the bistable switching positions, because the created dielectric torque contributes to the forces keeping molecules parallel to the glass surface.

In the presented driving scheme the UP and DOWN states are simultaneously written, i.e. only one scan is used for every new frame. The selection ratio remains in the range of 3:1 independently of the

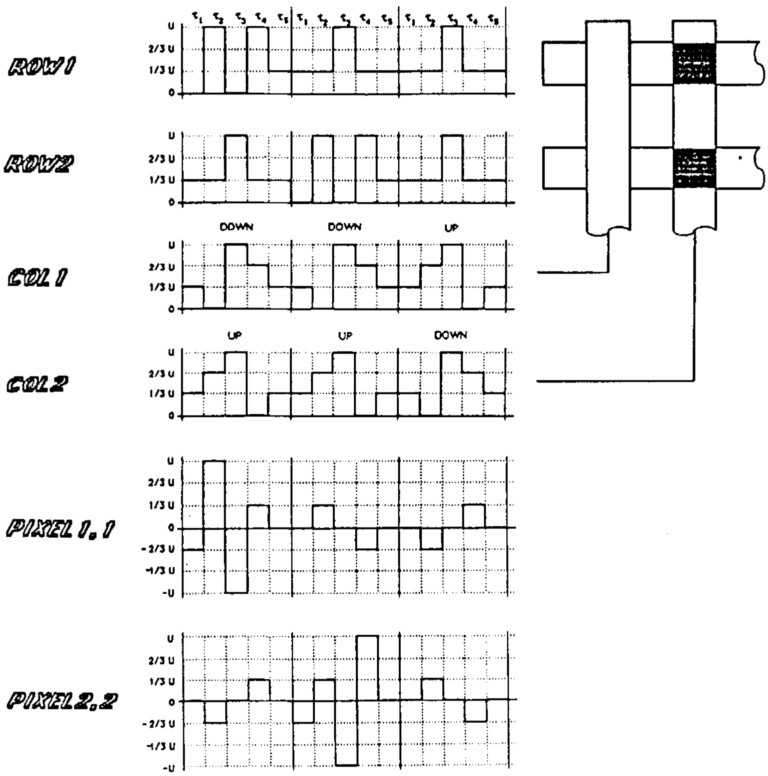


FIGURE 6 Driving scheme to the matrix applied.

number of scanned rows. Hence the multiplexing ratio, as can be checked on the 16 × 16 matrix, is virtually unlimited. Thus, a multiplexing ratio of more than 1000:1 was simulated electronically without any noticeable change in contrast.

ELECTRONIC CIRCUITRY

The experimental FLCD driver, cf. Figure 7, utilizes commercial Twisted-Nematic LCD integrated drivers (Hitachi HD 61 100 and HD 61 103 for columns and rows respectively). Their internal circuitry for generation of TN driving waveforms obviously cannot be used. Therefore the proper waveforms are generated externally in the "waveform synthesizer unit" of the FLCD driver and then supplied

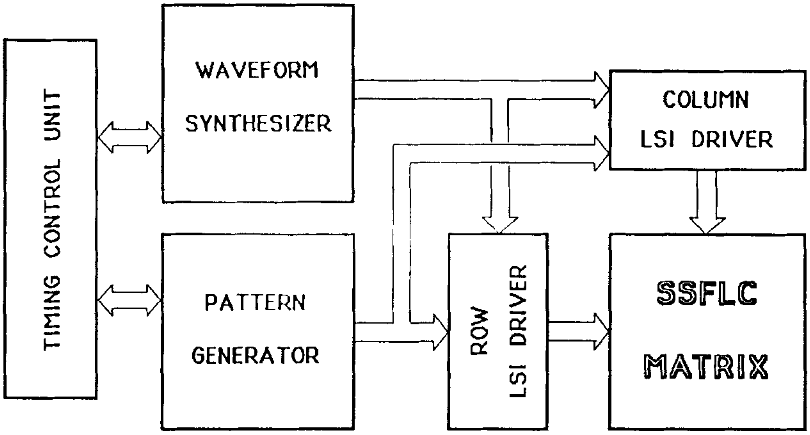


FIGURE 7 Simplified block diagram of the electronic FLCD driver.

to the respective row and column driver. As it could be seen in the Figure 6, four waveforms are necessary to perform the driving:

—row, selected
—row, non-selected
—column, UP
—column, DOWN

The row and the column drivers supply the desired waveform to each electrode line of the matrix during each driving sequence. This process is controlled by the "pattern generator" unit by means of supplying picture data to the final drivers. The width of switching pulses, as well as data transfer is managed by the "timing control unit." Since the presented FLCD driver is the experimental one, all important parameters of the driving are freely programmable.

Acknowledgments

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