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Driving Method for DHF-Liquid Crystal Display

The invention relates to a triggering method for the pixels of a liquid crystal cell of the DHF type (DHF-LCD). DHF-LCDs are described in European Patent EP 0 309 774 B1.

Liquid crystal cells of the DHF type can be operated in two different modes. In the asymmetrical mode the cell is disposed between crossed polarisers such that the transmission is at a minimum for a certain, e.g. negative, voltage $-U_0$ and at a maximum for $+U_0$. In the symmetrical mode the cell is disposed such that the transmission for 0 V applied voltage is at a minimum and increases for positive and negative voltages.

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In the asymmetrical mode the cell is more sensitive, i.e. the electro-optical effect is approximately twice that in the symmetrical mode. Against this there is the risk that, in the event of the triggering not being free from a DC voltage, electrochemical processes are initiated or polarisation charges are generated in the orientation layers of the liquid crystal cell. Both effects may lead to phantom images. In the symmetrical mode this can be avoided by triggering an image alternately with a positive voltage and a negative voltage.

In both modes it is important to be able to switch as quickly as possible from one grey scale value to another. In the symmetrical mode this is more difficult, because a greater liquid crystal movement is required for the same change of grey scale value.

Important applications of DHF-LCDs require active matrix triggering, i.e., semiconductor elements (transistors or diodes) are associated with each pixel and permit multiplex display operation.

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The object of the invention is to provide a triggering method with which the shortest possible switching time of DHF-LCDs is achieved with the lowest possible voltage in combination with an active matrix.

5 This is achieved according to the invention by bringing each pixel to a predetermined voltage before a data pulse is supplied.

Operational embodiments of the invention will be described hereinafter with reference to the accompanying drawings in which:

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Fig. 1 is an equivalent circuit diagram of a DHF pixel;

Fig. 2 is a pulse diagram for one form of triggering pulse;

15 Fig. 3 is a pulse diagram of an alternative form of triggering pulse;

Fig. 4 is a pulse diagram of another alternative form of triggering pulse.

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In the DHF pixel equivalent circuit diagram shown in Fig. 1, the static capacity C_s is the capacity at which the director does not move. C_{hx} describes the fact that the deformation of the ferro-electrical helix is accompanied by a charge (polarisation charge). R_{hx} describes the frictional losses associated therewith. For liquid crystal mixtures with a high spontaneous polarisation C_{hx} is many times greater than C_s . The charging up of C_s is rapid and is limited solely by the output impedance of the voltage source used. The charging time of C_{hx} , on the other hand, is defined by $t=R_{hx}C_{hx}$.

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If a DHF cell is triggered with an active matrix, then there is a low-ohmic signal at the pixel during the line addressing time t_z (typically 64 msec). The pixel is then isolated until the next image (typically 40 ms). During this time the charge which has migrated to the pixel in the line addressing time is divided over the two capacities such that they are charged to the same voltage. If the resulting charge on C_{hx} is sufficient to produce the required deformation there are no problems. This applies particularly if the characteristic time t is many times shorter than t_z (C_{hx} is then charged



up directly and C_s has no significance) and/or when the voltage used is so high that sufficient charge is stored on C_{hx} after the charge equalisation.

5 Since t becomes longer than permissible particularly at low temperatures, relatively high voltages must therefore be used. This is particularly so because C_s is much smaller than C_{hx} . In order to bring sufficient charge on C_s (the majority flows to C_{hx} on the charge equalisation), a correspondingly higher charging voltage is therefore
10 required.

High charging voltages are, however, not compatible with the active matrix technology. Triggering methods which can reduce the required voltage are therefore preferable.

15 If a voltage source with the maximum voltage U_0 is available, the charge $Q_0 = C_s U_0$ is stored on the pixel with a very short triggering time to (C_{hx} is not appreciably charged). After some time of t , Q_0 has divided up over the two capacities. This cycle can be repeated several times (n
20 times), with C_{hx} always being charged up further. The total time during which a pixel is addressed is nt_0 . Since t_0 can be made very short, i.e. $n t_0 < t_z$, the total time t_z permissible for multiplexing is not exceeded and is simply distributed over a number of separate shorter times.

25 In order to ensure that a DHF cell operation is free from DC voltage, the triggering polarity must change from image to image. The pixel must therefore first be discharged before the new information can be written in. This is done by means of pulses which are applied to a full
30 line before the insertion of the data (grey scale values). Basically three variants of such pulses are suitable and are shown in Figs. 2 to 4. These figures show respectively the applied voltage U and the charge Q on the pixel and four time slots 1-4. During the times before (time slot 1) and after (time slot 4) the triggering the pixel is isolated, i.e. the voltage
35 applied is not defined.

The pre-pulses shown at the bottom of Fig. 2 during time slot 2 discharge the pixel so that the data pulses during the time slot 3 only have to effect charging to the new grey scale value.



The pre-pulses during time slot 2 as shown at the bottom of Fig. 3 already pre-charge the pixel to a suitable value. The data pulses during time slot 3 then have to supply or discharge less charge. The data pulses
5 have the same polarity as the pre-charging pulses. The pre-pulses shown in the middle and at the bottom of Fig. 4 during the time slot 2 charge the pixel to the maximum voltage. The data pulses during time slot 3 then discharge the pixel to the required grey scale value. This can be done in two ways:
10 either (1) by amplitude modulation as in Figs. 2 and 3, i.e. by pulses of different amplitudes (Fig. 4 centre), the full voltage swing from $-U_0$ to U_0 being utilisable, or (2) by pulse width modulation, i.e., by pulses of maximum voltage U_0 but different pulse lengths (bottom of Fig. 4). With this type of triggering, the polarity need not change in dependence on the
15 grey scale value as with amplitude modulation.

Pre-pulses with maximum voltage saturate the pixel, and this reduces the risk of crosstalk from data information of other lines addressed during the pre-charging pulse.

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Claims

1. A triggering method for a liquid crystal cell of DHF type, which method comprises bringing each pixel to a predetermined voltage before
5 a data pulse is supplied.
2. A triggering method according to claim 1, wherein the pixels are brought to the voltage 0 V line-wise.
- 10 3. A triggering method according to claim 1, wherein the pixels are brought line-wise to a voltage of the same polarity as the data pulse.
4. A triggering method according to claim 1, wherein the pixels are charged line-wise to the maximum voltage and the data pulses in the
15 form of amplitude-modulated signals utilise the full voltage swing between a maximum positive and maximum negative voltage.
5. A triggering method according to claim 1, wherein the pixels are charged line-wise to the maximum voltage and the data pulses consist of
20 pulse-width-modulated pulses of maximum amplitude but opposite polarity.
6. A triggering method according to claim 1, wherein the data pulse consists of a plurality of consecutive pulses at intervals, the interval
25 being equal to or greater than the characteristic charging time of the DHF helix.

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