

Description

The invention relates to a method of driving a liquid crystal cell of the DHF (distorted helix ferroelectric) type, in which a defined light transmittance is produced and maintained by applying a defined constant holding voltage and to a circuit.

In the conventional form of driving DHF cells the cell is operated in its linear region in which the transmission variation follows the variation in the applied voltage. This leads to switching times in the millisecond range. In this mode of operation it is impossible to achieve shorter times since shorter times would lead to the helix unwinding in the cell.

This linear mode of operation permits grey values but not multiplexing. However, multiplexability is an important consideration for the technical use of liquid crystal cells.

It has surprisingly been found that driving by means of a short initial pulse followed by a constant holding voltage required to maintain the produced transmittance enables switching times to be reduced by a factor of 100.

According to the invention, therefore, multiplexability with simultaneous availability of grey values is achieved by applying a voltage pulse to change the light transmittance of the cell, the voltage pulse being multiply higher than the holding voltage which is required to maintain the light transmittance produced and having a duration of less than 100 μ s, and the product of the voltage amplitude pulses and pulse duration being less than the value required to nullify the helix structure.

In an appropriate circuit arrangement, in operation the cell is connected in series with a non-linear component.

The times thus provided are shorter than those which could be provided by comparable so-called Lagerwall cells even in the case of a drive at the same voltage. The reason is that in the Lagerwall configuration the permanent dipole on which the applied field acts is disposed parallel to the field at the start of the pulse and the only way of ensuring that any torque at all acts on the director is by director fluctuations or surface effects. In the DHF cell that part of the helix which makes a substantial contribution to the effect has a large angle between the director and the field and therefore experiences substantially the complete torque.

Another difference from the Lagerwall cell is that the drive according to the invention still enables grey stages to be provided. The main factor determining deformation of the helix is the area below the voltage pulse, i.e. the charge being stored on the cell. Consequently, by an appropriate choice of amplitude and/or pulse time any required deformation (= transmission variation of the cell) can be achieved. Accordingly, the holding voltage must then be chosen such that the altered transmission is maintained.

The constant holding voltage can be provided by an appropriate signal generator; however, since the holding voltage is typically for DHF cells a few hundred mV, it can be produced by a non-linear characteristic of a diode or of some other similar component. The use of a non-linear component has the further advantage of facilitating multiplexing. Another result of using a non-linear component is that the holding voltage is automatically chosen correctly when the cell is driven by variable pulses (grey values) since the decisive parameter for helix deformation is the cell charge stored on the initial pulse, the diode merely ensuring that such charge cannot discharge. Consequently, the exact pulse shape is not critical.

Electrochemically induced degradation of the liquid crystal is obviated by the cell being driven in the square mode and being so controlled in bipolar fashion that the average voltage is zero. In this form of operation the polarization direction of the crossed polarizers is disposed parallel or perpendicularly to the helix and the cell is dark at zero volts and bright at positive and negative voltages. The brightness state is therefore critical. If an image dot of a new image is to stay bright, therefore, the applied voltage must have its polarity reversed in order to have zero voltage as an average.

Another possibility is to apply before each pulse a short pulse of opposite polarity. It has the effect of making the average applied voltage zero or for it to be so selected as to minimize electrochemical effects.

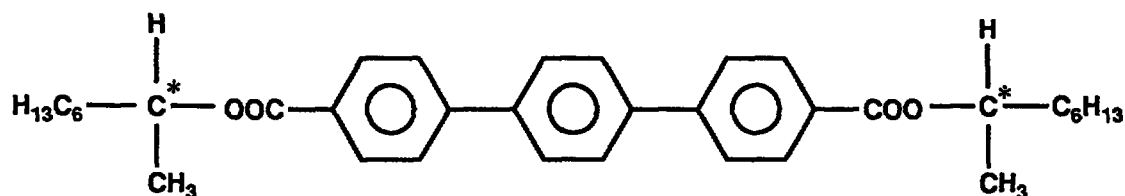
A cell of this kind is of use in display devices including television sets and terminals, in printers (replacement for laser printers) and in general wherever rapid light modulators or modulators with grey stages can be used.

An embodiment of the invention will be described hereinafter with reference to the accompanying drawings wherein:

Fig. 1 is a diagrammatic illustration of a DHF cell with drive,

Fig. 2 is a diagrammatic circuit diagram of one possible multiplex circuit.

The liquid crystal cell 1 shown in Fig. 1 is a DHF (distorted helix ferroelectric) cell as described in Swiss Patent Application No. 1555/88 of 26 April 1988. Cell 1 has two glass plates 2, 3 which are disposed parallel to one another and at a distance of approximately 2 μm from one another and whose facing surfaces are coated with electrode segments 4, 5. The electrode segments define an image dot of a liquid crystal display. The plates 2, 3 also have on the facing surfaces PVA coatings 6, 7 treated, e.g. by rubbing, in a preferred direction and thus being effective in a known manner to orientate the liquid crystal molecules. A liquid crystal layer 8 is disposed between the plates. In the present working example the liquid crystal is a mixture of 26.1 wt.% of 5-octyl-2-[p-(octyloxy)phenyl]pyrimidine, 17.1 wt.% of 5-octyl-2-[p-(nonyloxy)phenyl]pyrimidine, 24.5 wt.% of 5-octyl-2-[p-decyloxy)phenyl]pyrimidine and 32.3 wt.% of the chiral additive



Conductor paths 9, 10 connected in a conventional manner to connecting wires 11, 12 extend to the segments 4, 5. The wires 11, 12 extend to a circuit arrangement 13 delivering the drive pulses. Disposed in series with the cell 1 is a diode arrangement 14 embodied by four silicon diodes connected in anti-parallel and in pairs. Any commercially available diodes having a cut-off current of less than 1 nA can be used.

The cell 1 is disposed between two crossed linear polarizers 15, 16 such that the transmission at the maximum negative holding voltage is minimal.

When this cell is driven with pulses of 25 V amplitude and a 10 μ s duration it provides a contrast of greater than 1:10 and a switching time of 10 μ s.

Fig. 2 shows a part of a possible multiplexer circuit for the image dots (pixels) 17, 18, 19, 20 which are defined in the following Table by their address in the form of a row (Z) and column (S) indication.

S1	S1'	S2	S2'	Z1	Z2	
0	0	0	-	-	0	positive voltage on the LC 17
0	0	+	0	+	0	negative voltage on the LC 17

Positive or negative voltage on the LC 17 means that the plate has on the side of the diodes after switching, when all the lines are at zero potential, a higher or, respectively, lower potential than the plate on the Z line.

The voltage of the non-linear element at which the diode current is so small that the discharge during the repetition period is negligible (cut-off voltage) must be at least equal to the maximum holding voltage. In this multiplex circuit arrangement two lines per column and one line per row are necessary. It permits high multiplex rates. The multiplexing circuit arrangement is based mainly on the fact that at zero voltage the cell is in fact isolated from the control lines. If this cut-off voltage of the diode is too low, four control lines must be used.

Claims

1. A method of driving a liquid crystal cell of the DHF (distorted helix ferroelectric) type in which a defined light transmittance is produced and maintained by applying a defined constant holding voltage, characterized in that a voltage pulse is applied to the cell in order to change its light transmittance, the voltage pulse being multiply higher than the holding voltage which is required to maintain the light transmittance produced and having a duration of less than 100 μ s, and the product of the voltage amplitude pulses and pulse duration being less than the value required to nullify the helix structure.

2. A liquid crystal cell of the DHF (distorted helix ferroelectric) type having drive means for carrying out the



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method according to claim 1, characterized in that the drive means contains a non-linear component connected in series with the liquid crystal and generates a voltage pulse in the cell in order to change the light transmittance of the cell, the voltage pulse being multiply higher than the holding voltage which is required to maintain the light transmittance produced and having a duration of less than 100 μ s, and the product of the voltage amplitude pulses and pulse duration being less than the value required to nullify the helix structure.