Description

The invention relates to a display device comprising an electro-optical display medium between two supporting plates, a system of pixels arranged in rows and columns, with each pixel being formed by picture electrodes arranged on the facing surfaces of the supporting plates, and a system of row and column electrodes for presenting selection and data signals by means of which a range of voltages dependent on the electro-optical display medium can be presented across the pixels for the purpose of picture display.

The invention also relates to a method of driving such a display device.

A display device of this type is suitable for displaying alphanumerical information and video information by means of passive electro-optical display media such as liquid crystals, electrophoretic suspensions and electrochromic materials.

A display device of the type described in the opening paragraph is known from the Netherlands Patent Application NL-A-8502663 laid open to public inspection, in the name of the Applicant. In the device shown in this Application diodes are used as non-linear switching elements in an active matrix, namely two diodes per pixel. Two successive rows of pixels each time have one row electrode in common. The drive mode is such that in television applications (for example with a drive mode in accordance with the PAL or NTSC system) the information of two successive even and odd lines is presented across each pixel at an alternating polarity and at the field frequency. The information of a pixel is therefore determined by the average signal of two successive even and odd lines. Since each time two rows of picture electrodes are simultaneously written because two successive rows each time have one row electrode in common, such a device provides little flexibility as regards the choice of colour filters to be used. In fact, this choice is limitedto strip-shaped colour filters.

It is an object of the invention to provide a picture display device of the type described in the opening paragraph in which the row electrodes are not common and in which the rows of pixels are separately driven without the omission of common row electrodes leading to an increase of the number of connections.

It is also an object of the invention to provide such a display device ensuring a considerable freedom in the choice of the colour filters to be used.

The invention is based on the recognition that it is possible to give the pixels a given adjustment per row by charging or discharging the capacitances associated with these pixels after first having discharged or charged them too far (either or not accurately).

To this end a picture display device according to the invention is characterized in that the device comprises means to apply, prior to selection, an auxiliary voltage across the pixels beyond or on the limit of the voltage range to be used for picture display.

The auxiliary voltage is preferably beyond or on the limit of the range of transition in the transmission/voltage characteristic of the electro-optical medium.

A first preferred embodiment of a display device according to the invention is characterized in that the picture electrode on one of the supporting plates is connected in an electrically conducting manner to the common point of two non-linear switching elements which are arranged in series between a column electrode for data signals and an electrode for the auxiliary voltage.

The auxiliary voltage may then be a fixed reference voltage so that all pixels in a row are first charged negatively or positively to a fixed value and are subsequently charged or discharged to the correct signal value, dependent on the data signals presented.

Since this is effected for each individual row without a subsequent row or previous row being influenced, the picture information can be adapted to a colour filter to be used, which colour filter may be composed of, for example, triplets as described, for example, in the Netherlands Patent Application NL-A-861063 in the name of the Applicant, or it may have, for example a diagonal structure.

Discharging and charging prior to the actual driving operation with the picture information can be effected during the same line period in which the picture information is presented, but also during the preceding line period.

Since each row of pixels is now separately written, the voltage across these pixels can also be inverted per row, which leads to a higher face flicker frequency and hence to a steadier picture.

A second preferred embodiment of a device according to the invention is characterized in that a Zener diode is arranged between a pixel and a row or column electrode. In this case the electrode for the reference voltage may be entirely dispensed with, which leads to a relatively larger portion of the surface of the pixel to be used for the actual display. In addition the number of components in such a device is smaller, which increases the yield. Finally the parasitic capacitance is smaller whilst an optimum choice of possible electro-optical materials and the Zener diode to be used is possible.

A method according to the invention is characterized in that prior to presenting a data signal the pixels are charged positively or negatively to an auxiliary voltage beyond or on the limit of the range to be used for picture display.

The invention will now be described in greater detail by way of example with reference to the accompanying drawings in which

Fig. 1 is a diagrammatic cross-section of a display device according to the invention, taken on the line I-I in Fig. 2;

Fig. 2 is a diagrammatic plan view of the device of Fig. 1;

Fig. 3 shows the associated transmission voltage characteristic;

Fig. 4 is a diagrammatic representation of the device;

Fig. 5 shows some drive signals associated with the device;

Fig. 6 shows a modification of the previous device,

Figs. 7 and 8 show diagrammatically methods in which a device according to the invention is used for television display;

Fig. 9 shows an embodiment of a device according to the invention comprising Zener diodes and

Fig. 10 shows the current-voltage characteristics associated with the Zener diodes, whilst

Fig. 11 shows a number of modifications of the device of Fig. 9.

The Figures are diagrammatic and not to scale. Corresponding components are usually denoted by the same reference numerals.

Figs. 1 and 2 show a diagrammatic cross-section and a plan view of a part of a display device, in this embodiment a liquid crystal display device 1 which has two supporting plates 2 and 3 between which, for example a twisted nematic or a ferro-electric liquid crystalline material 4 is present. The inner surfaces of the supporting plates 2 and 3 have electrically and chemically insulating layers 5. A plurality of row and column-arranged picture electrodes 6 of indium tin oxide or another electrically conducting transparent material is provided on the supporting plate 2. Likewise, transparent picture electrodes 7 of, for example, indium tin oxide which are integrated to strip-shaped row electrodes 11 are provided on the supporting plate 3. The facing picture electrodes 6, 7 constitute the pixels of the display device.

Strip-shaped (for example, metal) column electrodes 8 are arranged between the columns of picture electrodes 6. Each picture electrode 6 is connected to a column electrode 8 by a diode 9 diagrammatically shown in Fig. 2. As is apparent from Fig. 2, the associated column electrodes 8a, 8b areprovided between two picture electrodes 6a, 6b. Furthermore liquid crystal orienting layers 10 are provided on the inner surfaces of the supporting plates 2 and 3. As is known, another orientation state of the liquid crystal molecules and hence an optically different state can be obtained by applyinga voltage across the liquid crystal layer 4. The display device may be realised as a transmissive or a reflective device and may be provided with one or two polarisers.

According to the invention auxiliary electrodes 18 which two picture electrodes 6 have in common in this embodiment and which are provided on the side of the picture electrodes 6 different from that of the column electrodes 8 are also present between the columns of picture electrodes 6. The auxiliary electrodes 18 connect the picture electrodes 6 to a reference voltage via diodes 19 which diodes are diagrammatically shown in Fig.2. This reference voltage is chosen to be such that, dependent on the voltages used on the selection line 11 and the electro-optical material used, the capacitance associated with the pixel can always be discharged via the diode 19 to a voltage value beyond or on the limit of the range of transition in the transmission voltage characteristic of the relevant electro-optical material.

Fig. 3 shows adiagrammatically a transmission/voltage characteristic of a display cell as it occurs in the display device of Fig. 1, 2. Below a given threshold voltage (V_1 or V_{th}) the cell substantially passes no light, whereas above a given saturation voltage (V_2 or V_{sat}) the cell is substantially entirely transparent. The intermediate range constitutes the above-mentioned range of transition and is indicated in Fig. 3 by means of brace 17. In this respect it is to be noted that the absolute value of the voltage is plotted on the abscissa, because such cells are usually driven at an alternating voltage.

Fig. 4 shows diagrammatically the display device of Figs. 1, 2. Pixels 12 constituted by facing picture electrodes 6, 7 are connected via the picture electrodes 7 to row electrodes 11 at one end which together with the column electrode 8 are arranged in the form of a matrix. The pixels 12 are connected to column electrodes 8 via diodes 9. They are also connected via diodes 19 to an auxiliary electrode 18 which each time is common to two diodes 19, 19'.

For writing information a first selection/voltage V_{s1} is presented on a selection line 11 during a selection period t_s whilst the information or data voltages V_d are simultaneously presented on the column electrodes 8; this leads to a positive voltage across a pixel 12 which represents the information presented.

To prevent degradation of the liquid crystal and to be able to increase the so-called face flicker frequency, information having an alternating sign is preferably presented across the pixel 12. In a device according to the invention a negative voltage across the pixel 12 which represents the information presented is achieved by presenting a second

selection voltage V_{s2} while simultaneously presenting inverted data voltages ($-V_d$) after having discharged the capacitance associated with the pixel 2 too far (or after having negatively charged it too far).

Fig. 5 shows how the drive signals are chosen for a plurality of rows of pixels 12 in order to write them with picture information which changes sign during each field (for example in TV applications).

From the instant t_0 (see Fig. 5a) a selection voltage V_{s1} is presented on a row electrode 11 during a selection period t_s (which in this example is chosen to be equal to a line period for TV applications, namely 64 µsec) whilst information voltages or data voltages V_d are simultaneously presented on the column electrodes 8. After the instant t_1 the row of pixels 12 is no longer selected because the row electrode 11 receives a voltage V_{ns1}. This voltage is maintained until just before the next selection of the row of pixels 12. In this example this is effected by giving the selection line 11 a reset voltage just before again selecting the first row of pixels 12, namely at an instant $t_3 = t_f - t_s$ in which t_f represents a field period. The reset voltage and a reference voltage presented on the common point of the diodes 9, 19 can then be chosen to be such that the pixels 12 are charged negatively to such an extent that this voltage lies beyond the range to be used for picture display (up to a value of $\leq -V_{sat}$). In a subsequent selection period (from t_4), they are then charged to the desired value determined by data voltages $-V_d$. To this end the row electrodes receive the voltage V_{s2} and after the selection period (after t_5) has elapsed they receive a non-selection voltage V_{ns2}. In this way the voltage across the pixels is inverted during each field period.

Fig. 5b shows the same voltage variation as Fig. 5a but is then shifted over a field period plus a selection period (in this case a line period). This provides the possibility of writing two successive rows of pixels with inverse data voltages with respect to each other. Fig. 5c is identical to Fig. 5a, but is shifted over two selection periods.

For (television) pictures with half the vertical resolution in which the lines of the even and the off field are written over each other it is achieved that the picture information changes its sign and is replenished once per field period. Although the line flicker frequency is 25 Hz (30 Hz) in this case, a face flicker frequency of 50 Hz (60 Hz) is achieved between successive rows due to the phase difference of 180° introduced by changing the sign per row.

The selection voltages V_{s1} and V_{s2} may of course also be chosen to be shorter than one line period (64 µsec). In this case the reset voltage may alternately be presented during a part of the line period in which selection takes place provided there is sufficient time left to c harge the pixels 12. The voltage variation on the electrodes 11 is then effected, for example in the way as shown diagrammatically in Fig. 5a by means of the broken line 14.

The device shown is very suitable for using a drive method in which

$$V_c = \frac{Vsat+Vth}{2}$$

is chosen for the average voltage across a pixel (see Fig. 3) so that the absolute value of the voltage for the purpose of picture display across the pixels 12 is substantially limited to the range between V_{th} and V_{sat}.

A satisfactory operation as regards grey scales is obtained if, dependent on the data voltages V_d on the column electrodes 8, the voltage values across the pixels 12 are at most $V_c + V_{dmax} = V_{sat}$ and at least $V_c - C_{dmax} = V_{th}$. Elimination of V_c yields: $|V_d|_{max} = \frac{1}{2}(V_{sat}-V_{th})$, that is to say $-\frac{1}{2}(V_{sat}-V_{th}) \leq V_{dmax} \leq \frac{1}{2}(V_{sat}-V_{th})$.

In order to charge a row of pixels 12, for example, positively, the associated row electrode 11 is given a selection voltage $V_{s1} = -V_{on} - \frac{1}{2}(V_{sat}+V_{th})$ in which V_{on} is the forward voltage of the diode 9. The voltage across the pixel 12 is therefore $V_d - V_{on} - V_{s1}$; it ranges between $-\frac{1}{2}(V_{sat}-V_{th}) + \frac{1}{2}(V_{sat}+V_{th}) = V_{th}$ and $\frac{1}{2}(V_{sat}-V_{th}) + \frac{1}{2}(V_{sat}+V_{th}) = V_{sat}$ dependent on V_d.

In order to negatively charge the same row of pixels 12 (in a subsequent field or frame period) at a subsequent selection with inverted data voltages, these are first charged negatively too far by means of a reset voltage V_{reset} on the row electrode 11 via diodes 19 connected to a reference voltage. Subsequently the selected row electrode receives a selection voltage $V_{s2} = -V_{on} + \frac{1}{2}(V_{sat}+V_{th})$ (in the same line period or in a subsequent period). The pixels 12 which are negatively charged too far are now charged via the diodes 9 to $V_d - V_{on} - V_{s2}$, that is to say to values between $-\frac{1}{2}(V_{sat}-V_{th}) - \frac{1}{2}(V_{sat}-V_{th}) = -V_{sat}$ and $\frac{1}{2}(V_{sat}-V_{th}) - \frac{1}{2}(V_{sat}-V_{th}) = -V_{th}$ so that information with the opposite sign is presented across the pixels 12. In the case of non-selection the requirement must be satisfied that neither diodes 9 nor the diodes 19 can conduct, in other words for the voltage V_A at the junction point 13 it must hold that $V_A \geq V_d$ and $V_A \leq V_{ref}$ or $V_{Amin} \geq V_{Dmax}$ (1) and $V_{Amax} \leq V_{ref}$ (2). For the lowest non-selection voltage V_{ns1} it then holds that:

(1) $V_{Amin} = V_{ns1} + V_{th}$ $V_{Dmax} = \frac{1}{2}(V_{sat}-V_{th})$,

or

$V_{ns1} \geq \frac{1}{2}(V_{sat}-V_{th})-V_{th}$ (3)

It follows from (2) that

$V_{ns1}+V_{sat} \leq V_{ref}$ or
$V_{ns1} \leq V_{ref}-V_{sat}$ (4)

Combination of (3) and (4) yields

$V_{ref}-V_{sat} \geq V_{ns1} \geq \frac{1}{2}(V_{sat}-V_{th})-V_{th}$
$V_{ref} \geq 3/2(V_{sat}-V_{th})$ (5)

For the highest non-selection voltage V_{ns2} it similarly holds that:

$V_{Amin}=V_{ns2}-V_{sat} \geq \frac{1}{2}(V_{sat}-V_{th})$ or
$V_{ns2} \geq \frac{1}{2}(V_{sat}-V_{th})+V_{sat}$ (3')

and

$V_{ns2}-V_{th} \leq V_{ref}$ or $V_{ns2} \leq V_{ref}+V_{th}$ (4')

Combination of (3') and (4') yields;

$V_{ref}+V_{th} \geq V_{ns2} \geq \frac{1}{2}(V_{sat}-V_{th}) + V_{sat}$ or
$V_{ref} \geq 3/2(V_{sat}-V_{th})$ (5).

The reference voltage 3/2 $(V_{sat}-V_{th})$ thus suffices to block the diodes 19, 19' after writing both data and inversed data by means of the method described above. In summary it holds for the voltages V_{ns}, V_s, V_{ref} and V_{reset} that:

$V_{s1}=-V_{on}-\frac{1}{2}(V_{sat}+V_{th})$;
$V_{s2}=-V_{on}+\frac{1}{2}(V_{sat}+V_{th})$;
$V_{ns1}=\frac{1}{2}(V_{sat}-V_{th})-V_{th}$;
$V_{ns2}=\frac{1}{2}(V_{sat}-V_{th})+V_{sat}$;
$V_{ref}=3/2\ (V_{sat}-V_{th})$;
$V_{res}=V_{on}+5/2V_{sat}-3/2V_{th}$.

When reversing the sign of the diodes 9, 19 as is diagrammatically shown in Fig. 4a, the same type of drive mode may be used. Similar relations, be it with reversed sign, then apply to the drive signals.

Fig. 6 shows diagrammatically a modification of the device of Fig. 4. Since per column of pixels both a column electrode 8 and an auxiliary electrode 18 is present, such a realisation is at the expense of surface area which may otherwise be utilised for picture electrodes. Other wise the reference numerals have the same significance as in the previous embodiment. The drive mode is also identical.

As has been stated, the advantage of a device and a method according to the invention is that each row of pixels can be separately driven without extra on connection lines being required and with a free choice as regards the colour filters to be used.

It has been described hereinbefore how the information can be alternately reversed in sign for lines to be written under a simultaneous inversion of the selection voltages. The voltage across the pixel is inverted. Figs. 7 and 8 show examples thereof.

In these examples subsequent picture lines are denoted from the top to the bottom by means of the numerals 1,2, 3... 575 (PAL system)for the sake of simplicity. The odd field thus comprises the lines 1, 3, 5, ... 575. the even field comprises the lines 2, 4, 6, ... 574.

Fig. 7 shows a first example in which the first row 21 of pixels is first written with information of the first picture line (+(1)) of the odd field. The second row 22 is subsequently written with inverted information of the third picture line (-(3)), that is to say the second picture line of the odd field, the third row 23 is written with information of the fifth picture line (+(5)), that is to say the third picture line of the odd field, the fourth row 24 is written with inverted information of the seventh picture line (-(7)), etc. In this way 288 rows of pixels are first written with information of the odd field in the so-called half resolution mode. Subsequently the same rows 21, 22, 23, 24 are written with information of the even field which is now presented with opposite sign across the row of pixels (denoted by broken lines). This means that the first row 21 of pixels is read with inverted information of the second picture line (-(2)), that is to say the first picture line of the even field, the second row 22 is written with information of the fourth picture line (+(4)), that is to say the second picture line of the even field, etc.

In this way all pixels, considered with respect to time, receive the average information of two successive picture lines with the information of each picture line per picture period being also inverted. Thus row 21 shows the average of the first and second picture lines (1/2) and row 22 shows the average of the third and fourth picture lines (3/4), row 23 shows the average of the fifth and sixth picture lines (5/6), etc. (see Fig. 7). The minimum face flicker frequency is then 50 Hz (PAL) or 60 Hz (NTSC).

Fig. 8 shows how a device according to the invention can be similarly driven in full resolution mode. In this case 575 rows of pixels are read, whilst the information of one picture line (for example the third picture line) is presented in an inverted way to the second row 22 (-(3)) and is presented unchanged to the third row 23 (+(3)) of the pixels whilst simultaneously adapting selection voltages. The data voltage is presented inverted during half a line period whilst row 22 is selected and row 23 is not selected, and the other half of

the line period it is presented unchanged whilst row 22 is no longer selected and row 23 is selected.

Similarly the information of the fifth picture line is presented inverted to row 24(-5) and unchanged to row 25(+5), etc. The lines of the even field are also presented to the rows 21, 22, 23, 24, 25 in an inverted form and in an unchanged form. In this way the average value of two picture lines is presented across 575 rows of pixels each time with an alternating sign of the voltage across the display element, more specifically the average value of the first and second picture lines across row 21 (1/2), of the second and third picture lines across row 22-(2/3), etc. (see Fig. 8). The rows are a gain entirely independent as regards selection so that any colour filter pattern can be used and the flicker is small (the face flicker frequency is again 50 Hz (60 Hz) due to this drive mode).

Fig. 9 shows diagrammatically a device according to the invention in which the auxiliary voltage is obtained by using the Zener characteristic of a Zener diode 15. Pixels 12 arranged in a matrix are again present at crossings of row electrodes 11 and column electrodes 8 whilst the pixels 12 are connected to the row electrodes 11 via the Zener diodes 15.

Here again it holds for a drive around $V_c = \frac{1}{2}(V_{sat}+V_{th})$ that with data voltages $V_d(-\frac{1}{2}(V_{sat}-V_{th}) \leq V_d \leq \frac{1}{2}(V_{sat}-V_{th}))$ the voltage across the pixels 12 can be limited to the range between V_{th} and V_{sat}. The associated selection voltages are again $V_{s1} = -V_{on}-\frac{1}{2}(V_{sat}+V_{th})$; $V_{s2} = -V_{on}+\frac{1}{2}(V_{sat}+V_{th})$.

It also holds that in the case of non-selection at the point 16 the voltage must be such that there is no conductance through the Zener diode, neither in the forward direction nor as a Zener conductance.

In this case allowance must be made for the statistical behaviour of the Zener diodes used. This is shown diagrammatically in Fig. 10 in which the solid line shows a nominal current/voltage characteristic and the limitation of the spreading range is indicated by means of a broken line and a dot-and-dash line. V_{Zmin} is the highest admissible voltage at which the current for all possible characteristics is still sufficiently low to prevent discharge within a field period of a capacitor associated with a pixel. V_{Zmax} is the lowest voltage to cause the current passed through the Zener diode to be sufficiently large to negatively charge a pixel to at least $-V_{sat}$ within the reset period (for example 64 µsec).

For the lowest non-selection voltage (V_{ns1}) these conditions then lead for a voltage V_A - (junction 16) to

$$V_{Amax} \leq V_{ns1} \text{ and } V_{Amin} \geq V_{ns1} + V_{Zmin}$$

in which V_{Zmin} is the said maximum zener voltage of the zener diode 15 (see Fig. 10).

With $V_{Amin} = -V_{dmax}-V_{sat}$ and $V_{Amax} = V_{dmax}-V_{th}$ this leads (so called negative selection) with $V_{dmax} = \frac{1}{2}(V_{sat}-V_{th})$ to

$$V_{dmax}-V_{th} \leq V_{ns1} \leq V_{Amin}-V_{Zmin}, \text{ or}$$
$$-\tfrac{1}{2}(V_{sat}-V_{th})-V_{sat}-V_{Zmin} \geq V_{ns1} \geq \tfrac{1}{2}(V_{sat}-V_{th})-V_{th} \quad (6),$$

for example

$$V_{ns1} = \tfrac{1}{2}(V_{sat}-V_{th})-V_{th}.$$

In the same manner these conditions for the highest non-selection voltage V_{ns2} (positive selection) for which it holds that

$V_{Amin} = -V_{dmax}+V_{th}$ and $V_{Amax} = V_{dmax}+V_{sat}$ lead to
$V_{dmax}+V_{sat} \leq V_{ns2} \leq -V_{dmax}+V_{th}-V_{Zmin}$ or
$-\tfrac{1}{2}(V_{sat}-V_{th})+V_{th}-V_{Zmin} \geq V_{ns2} \geq \tfrac{1}{2}(V_{sat}-V_{th})+V_{sat}$ - (7)

For example

$$V_{ns2} = \tfrac{1}{2}(V_{sat}-V_{th})+V_{sat}$$

Addition of the left-hand and right-hand members of the equations (6) and (7) leads to

$$-2(V_{sat}-V_{th})-2V_{Zmin} \geq 2(V_{sat}-V_{th}) \text{ or}$$
$$-V_{Zmin} \geq 2(V_{sat}-V_{th})$$

The possibility of using this device is therefore determined by the minimum Zener breakdown voltage and the maximum width of the transition range in the transmission/voltage characteristic (denoted by brace 17 in Fig. 3) of the relevant liquid crystalline liquid or another electro-optical medium.

The maximum Zener breakdown must at least be provided in order to discharge the pixels to a voltage beyond or on the verge of the transmission range. For the reset voltage it therefore holds that $V_{reset} = V_{Zmax}+\frac{1}{2}(V_{sat}-V_{th})+V_{sat}$. The device of Fig. 9 can thus be driven with the same pattern of selection voltages as is shown in Fig. 5 in which it now holds that

$$V_{s1} = -V_{on}-\tfrac{1}{2}(V_{sat}+V_{th});$$
$$V_{s2} = -V_{on}+\tfrac{1}{2}(V_{sat}+V_{th});$$
$$V_{ns1} = \tfrac{1}{2}(V_{sat}-V_{th})-V_{th};$$
$$V_{ns2} = \tfrac{1}{2}(V_{sat}-V_{th})+V_{sat};$$
$$V_{res} = V_{Zmax}+\tfrac{1}{2}(V_{sat}-V_{sat}-V_{th})+V_{sat}.$$

The invention is of course not limited to the embodiments shown, but several variations are possible within the scope of the invention. There are various possibilities for the diodes. In addition to the diodes which are conventionally used in the

technology for display devices, for example, a pn diode, Schottky diode or pin diode formed in monocrystalline, polycrystalline or amorphous silicon, CdSe or another semiconductor material may be considered, whilst the diodes may be formed both vertically and laterally.

The Zener diode in the device of Fig. 9 may alternatively be arranged the other way around or it may be present between the column electrode 8 and the pixel 12 as is diagrammatically shown in Fig. 11. For such configurations similar expressions for the (non)selection voltages, data voltages and reset voltage may be derived as for the device of Fig. 9, whilst the same voltage values of the drive signals apply for the device of Fig. 11b and the inverted voltage values apply for the circuits according to Figs. 11a and 11c. In addition the availability of a reset voltage renders the above-described device and method particularly suitable for use in a ferroelectric display medium as described in the non-pre-published Netherlands Patent Application NL-A-8700627 in the name of the Applicant.

Claims

1. A display device comprising an electro-optical display medium between a first (3) and a second (2) supporting plate, a system of picture elements (12) arranged in rows and columns, picture elements being defined by picture electrodes (6, 7) on the facing surfaces of the supporting plates (2, 3), a system of row electrodes (11) for presenting selection voltages being provided on the first supporting plate (3) and a number of column electrodes (8a, 8b) for presenting data voltages being provided on the second supporting plate (2), the selection and data voltages for each picture element (12) via a first non-linear two-pole switching element (9), connected between a column electrode (8a, 8b) and a picture electrode (6) on the second supporting plate (2), determining a voltage across said picture element within the display medium's voltage range intended for picture display, characterized in that each picture element of the display device is associated with a second non-linear two-pole switching element (19, 19') connected between said picture electrode (6) on the second supporting plate (2) and an electrode (18) for a reference voltage to charge the picture element to an auxiliary voltage beyond or on one of the limits of the voltage range intended for picture display prior to selection of said picture element.

2. A display device according to claim 1 characterized in that the first (9) and second (19, 19') switching element are arranged in series between the column electrode (8a, 8b) and the electrode for the reference voltage, the common point of the switching elements being connected in an electrically conductive manner to the picture electrode (6) of the picture element.

3. A display device according to claim 1 characterized in that the first (9) and the second (19, 19') switching element are arranged in series between the column electrode (8a, 8b) and the electrode (18) for the reference voltage, the first and the second switching element being electrically interconnected via the picture electrode (6) of the picture element.

4. A display element as claimed in Claims 1-3 characterized in that in a row of picture electrode (6) two juxtaposed picture electrodes (6) are connected via an non-linear two-pole switching element (19, 19') to a common electrode (18) for the reference voltage located between the picture electrodes (6).

5. A display device comprising an electro-optical display medium between a first (3) and a second (2) supporting plate, a system of picture elements arranged in rows and columns, picture elements being defined by picture electrodes (6, 7) on the surfaces of the supporting plates (2, 3), a system of row electrodes (11) for presenting selection voltages being provided on the first supporting plate (3) and a number of column electrodes (8a, 8b) for presenting data voltages being provided on the second plate (2), the selection and data voltages for each picture element (12) via a two-pole switching element (15) in series with said picture element determining voltages across said picture element (12) within the display medium's voltage range intended for picture display, characterized in that the display device comprises means to enable charging of said picture element to an auxiliary voltage beyond or on one of the limits of the voltage range intended for picture display prior to selection of said picture element said means for charging said picture element to said auxiliary voltage comprising a Zener-diode, said Zener-diode having a minimum break-down voltage equal to at least twice the voltage range intended for picture display.

6. A method of driving a display device comprising an electro-optical display medium between

technology for display devices, for example, a pn diode, Schottky diode or pin diode formed in monocrystalline, polycrystalline or amorphous silicon, CdSe or another semiconductor material may be considered, whilst the diodes may be formed both vertically and laterally.

The Zener diode in the device of Fig. 9 may alternatively be arranged the other way around or it may be present between the column electrode 8 and the pixel 12 as is diagrammatically shown in Fig. 11. For such configurations similar expressions for the (non)selection voltages, data voltages and reset voltage may be derived as for the device of Fig. 9, whilst the same voltage values of the drive signals apply for the device of Fig. 11b and the inverted voltage values apply for the circuits according to Figs. 11a and 11c. In addition the availability of a reset voltage renders the above-described device and method particularly suitable for use in a ferroelectric display medium as described in the non-pre-published Netherlands Patent Application NL-A-8700627 in the name of the Applicant.

Claims

1. A display device comprising an electro-optical display medium between a first (3) and a second (2) supporting plate, a system of picture elements (12) arranged in rows and columns, picture elements being defined by picture electrodes (6, 7) on the facing surfaces of the supporting plates (2, 3), a system of row electrodes (11) for presenting selection voltages being provided on the first supporting plate (3) and a number of column electrodes (8a, 8b) for presenting data voltages being provided on the second supporting plate (2), the selection and data voltages for each picture element (12) via a first non-linear two-pole switching element (9), connected between a column electrode (8a, 8b) and a picture electrode (6) on the second supporting plate (2), determining a voltage across said picture element within the display medium's voltage range intended for picture display, characterized in that each picture element of the display device is associated with a second non-linear two-pole switching element (19, 19') connected between said picture electrode (6) on the second supporting plate (2) and an electrode (18) for a reference voltage to charge the picture element to an auxiliary voltage beyond or on one of the limits of the voltage range intended for picture display prior to selection of said picture element.

2. A display device according to claim 1 characterized in that the first (9) and second (19, 19') switching element are arranged in series between the column electrode (8a, 8b) and the electrode for the reference voltage, the common point of the switching elements being connected in an electrically conductive manner to the picture electrode (6) of the picture element.

3. A display device according to claim 1 characterized in that the first (9) and the second (19, 19') switching element are arranged in series between the column electrode (8a, 8b) and the electrode (18) for the reference voltage, the first and the second switching element being electrically interconnected via the picture electrode (6) of the picture element.

4. A display element as claimed in Claims 1-3 characterized in that in a row of picture electrode (6) two juxtaposed picture electrodes (6) are connected via an non-linear two-pole switching element (19, 19') to a common electrode (18) for the reference voltage located between the picture electrodes (6).

5. A display device comprising an electro-optical display medium between a first (3) and a second (2) supporting plate, a system of picture elements arranged in rows and columns, picture elements being defined by picture electrodes (6, 7) on the surfaces of the supporting plates (2, 3), a system of row electrodes (11) for presenting selection voltages being provided on the first supporting plate (3) and a number of column electrodes (8a, 8b) for presenting data voltages being provided on the second plate (2), the selection and data voltages for each picture element (12) via a two-pole switching element (15) in series with said picture element determining voltages across said picture element (12) within the display medium's voltage range intended for picture display, characterized in that the display device comprises means to enable charging of said picture element to an auxiliary voltage beyond or on one of the limits of the voltage range intended for picture display prior to selection of said picture element said means for charging said picture element to said auxiliary voltage comprising a Zener-diode, said Zener-diode having a minimum break-down voltage equal to at least twice the voltage range intended for picture display.

6. A method of driving a display device comprising an electro-optical display medium between

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a first (3) and a second (2) supporting plate and a system of picture elements arranged in rows and columns being defined by picture electrodes (6, 7) on the facing surfaces of the supporting plates (2, 3) a number of row electrodes for presenting selection voltages being provided on the first supporting plate (3) and a number of column electrodes (8a, 8b) for presenting data voltages being provided on the second supporting plate (2) in which at least during a part of a line selection a row of picture elements (12) is selected via the row electrodes (11) and data voltages are presented via the column electrodes (8a, 8b), the selection and data voltages via a first non-linear two-pole switching element (9), connected between a column electrode (8a, 8b) and a picture electrode (6) on the second supporting plate (2) determining a voltage across each picture element (12) within the display medium's voltage range intended for picture display, characterized in that said picture element is charged or discharged to an auxiliary voltage beyond or on one of the limits of the voltage range intended for picture display via a two-pole non-linear switching element (19, 19') which is arranged between an electrode (18) for a reference voltage and said picture electrode (6) on the second supporting plate (2) prior to presenting a data signal to said column electrode.

7. A method of driving a display device comprising an electro-optical display medium between a first (3) and a second supporting plate (2) and a system of picture elements arranged in rows and columns being defined by picture electrodes (6, 7) on the facing surfaces of the supporting plates (2, 3) a number of row electrodes (11) for presenting selection voltages being provided on the first supporting plate (3) and a number of column electrodes (8a, 8b) for presenting data voltages being provided on the second supporting plate (2) in which at least during a part of a line selection period a row of picture elements (12) is selected via the row electrodes (11) and data voltages are presented via the column electrodes (8a, 8b), the selection and data voltages via a two-pole switching element (15) in series with the picture element determining voltages across each picture element (12) within the display medium's voltage range intended for picture display, characterized in that said picture element is charged or discharged to an auxiliary voltage beyond or on one of the limits of the voltage range intended for picture display, via a Zener-diode which has a minimum breakdown voltage equal to at least twice the voltage range intended for picture display, prior to presenting a data signal to the column electrode associated with said picture element.

8. A method according to Claims 6 or 7, characterized in that during the same line selection period first the auxiliary voltage and subsequently the voltage to be used for display is presented across the picture elements.

9. A method according to Claims 6 or 7, characterized in that the auxiliary voltage is presented during a line selection period preceding the line selection period for in which the voltage for display is presented.

10. A method according to Claim 6 to 9, characterized in that the voltages across a row of picture elements are presented with an inverted polarity with respect to the row of picture elements which has just been written.

Patentansprüche

1. Wiedergabeanordnung mit einem elektrooptischen Wiedergabemedium zwischen einer ersten (3) und einer zweiten (2) Trägerplatte, mit einem System von Bildelementen (12) in Zeilen und Spalten, wobei die Bildelemente durch Bildeletroden (6, 7) auf den einander zugewandten Flächen der Trägerplatten (2, 3) definiert werden, mit einem System von Zeilenelektrolen (11) für die Lieferung von Wählspannungen auf der ersten Trägerplatte (3) und mit einer Anzahl von Spaltenelektroden (8a, 8b) für die Lieferung von Datenspannungen auf der zweiten Trägerplatte (2), wobei die Wähl- und Datenspannungen für jedes Bildelement (12) über ein erstes nicht-lineares Zweipolschaltelement (9), das zwischen einer Spalteneletrode (8a, 8b) und einer Bildelektrode (6) auf der zweiten Trägerplatte (2) angeschlossen ist, eine Spannung am Bildelement innerhalb des für Bildwiedergabe vorgesehenen Spannungsbereichs des Wiedergabemediums bestimmt, dadurch gekennzeichnet, daß jedes Bildelement der Wiedergabeanordnung einem zweiten nicht-linearen Zweipolschaltelement (19, 19'), das zwischen der Bildelektrode (6) auf der zweiten Trägerplatte (2) und einer Elektrode (18) für eine Bezugsspannung angeschlossen ist, zum Laden des Bildelements auf eine Hilfsspannung vorbei oder auf einer der Begrenzungen des für Bildwiedergabe vor der Wahl des Bildelements vorgesehenen Spannungsbereichs zugeordnet ist.

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2. Wiedergabeanordnung nach Anspruch 1, dadurch gekennzeichnet, daß das erste (9) und das zweite (19, 19') Schaltelement zwischen der Spaltenelektrode (8a, 8b) und der Elektrode für die Bezugsspannung in Reihe geschaltet sind, wobei der gemeinsame Punkt der Schaltelemente auf eine elektrisch leitende Weise mit der Bildelektrode (6) des Bildelements verbunden ist.

3. Wiedergabeanordnung nach Anspruch 1, dadurch gekennzeichnet, daß das erste (9) und das zweite (19, 19') Schaltelement zwischen der Spaltenelektrode (8a, 8b) und der Elektrode (18) für die Bezugsspannung in Reihe geschaltet sind, wobei das erste und das zweite Schaltelement über die Bildelektrode (6) des Bildelements elektrisch miteinander verbunden sind.

4. Wiedergabeelement nach Anspruch 1 bis 3, dadurch gekennzeichnet, daß in einer Zeile der Bildelektroden (6) zwei aneinandergelagerte Bildelektroden (6) über ein nicht-lineares Zweipolschaltelement (19, 19') mit einer gemeinsamen zwischen den Bildelektroden vorhandenen Elektrode (18) für die Bezugsspannung verbunden sind.

5. Wiedergabeanordnung mit einem elektrooptischen Wiedergabemedium zwischen einer ersten (3) und einer zweiten (2) Trägerplatte, mit einem System von Bildelementen in Zeilen und Spalten, wobei die Bildelemente durch Bildelektroden (6, 7) auf den einander zugewandten Flächen der Trägerplatten (2, 3) definiert werden, mit einem System von Zeilenelektroden (11) für die Lieferung von Wählspannungen auf der ersten Trägerplatte (3) und mit einer Anzahl von Spaltenelektroden (8a, 8b) für die Lieferung von Datenspannungen auf der zweiten Trägerplatte (2), wobei die Wähl- und Datenspannungen für jedes Bildelement (12) über ein Zweipolschaltelement (15) in Reihe mit dem Bildelement Spannungen am Bildelement (12) innerhalb des für Bildwiedergabe vorgesehenen Spannungsbereichs des Wiedergabemediums bestimmt, dadurch gekennzeichnet, daß die Wiedergabeanordnung Mittel zur Ladungsermöglichung des Bildelements auf eine Hilfsspannung vorbei oder auf einer der Begrenzungen des für Bildwiedergabe vor der Wahl des Bildelements vorgesehenen Spannungsbereichs enthält, wobei die Mittel zum Aufladen des Bildelements auf die Hilfsspannung eine Zenerdiode enthält, die eine minimale Durchbruchspannung gleich wenigstens dem Zweifachen des für Bildwiedergabe vorgesehenen Spannungsbereichs führt.

6. Verfahren zum Steuern einer Wiedergabeanordnung mit einem elektrooptischen Wiedergabemedium zwischen einer ersten (3) und einer zweiten (2) Trägerplatte, und mit einem System von Bildelementen (12) in Zeilen und Spalten, wobei die Bildelemente durch Bildelektroden (6, 7) auf den einander zugewandten Flächen der Trägerplatten (2, 3), definiert werden, mit einer Anzahl von Zeilenelektroden (11) für die Lieferung von Wählspannungen auf der ersten Trägerplatte (3) und mit einer Anzahl von Spaltenelektroden (8a, 8b) für die Lieferung von Datenspannungen auf der zweiten Trägerplatte (2), wobei wenigstens für einen Teil einer Zeilenwahl eine Bildelementzeile (12) über die Zeilenelektroden (11) gewählt wird und Datenspannungen über die Spaltenelektroden (8a, 8b) zugeführt werden, wobei die Wähl- und Datenspannungen über ein erstes nicht-lineares Zweipolschaltelement (9), das zwischen einer Spaltenelektrode (8a, 8b) und einer Bildelektrode (6) auf der zweiten Trägerplatte (2) angeschlossen ist, eine Spannung an jedem Bildelement (12) innerhalb des für Bildwiedergabe vorgesehenen Spannungsbereichs des Wiedergabemediums bestimmen, dadurch gekennzeichnet, daß das Bildelement über ein nicht-lineares Zweipolschaltelement (19, 19') auf eine Hilfsspannung vorbei oder auf einer der Begrenzungen des für Bildwiedergabe vorgesehenen Spannungsbereichs aufgeladen oder entladen wird, vor dem Anlegen eines Datensignals an die Spaltenelektrode, wobei dieses Zweipolschaltelement zwischen einer Elektrode (18) für eine Bezugsspannung und einer Bildelektrode (6) auf der zweiten Trägerplatte (2) angeordnet ist.

7. Verfahren zum Steuern einer Wiedergabeanordnung mit einem elektrooptischen Wiedergabemedium zwischen einer ersten (3) und einer zweiten (2) Trägerplatte, und mit einem System von Bildelementen in Zeilen und Spalten, wobei die Bildelemente durch Bildelektroden (6, 7) auf den einander zugewandten Flächen der Trägerplatten (2, 3) definiert werden, mit einer Anzahl von Zeilenelektroden (11) für die Lieferung von Wählspannungen auf der ersten Trägerplatte (3) und mit einer Anzahl von Spaltenelektroden (8a, 8b) für die Lieferung von Datenspannungen auf der zweiten Trägerplatte (2), wobei wenigstens in einem Teil einer Zeilenwählzeit eine Bildelementzeile (12) über die Zeilenelektroden (11) gewählt wird und über die Spaltenelektroden (8a, 8b) Datenspannungen zugeführt werden, und die Wähl- und Da-

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tenspannungen über ein Zweipolschaltelement (15) in Reihe mit dem Bildelement Spannungen an jedem Bildelement (12) innerhalb des für Bildwiedergabe vorgesehenen Spannungsbereichs des Wiedergabemediums bestimmen, dadurch gekennzeichnet, daß das Bildelement auf eine Hilfsspannung vorbei oder auf einer der Begrenzungen des für Bildwiedergabe vorgesehenen Spannungsbereichs über eine Zenerdiode aufgeladen oder entladen wird, die eine minimale Durchbruchspannung gleich wenigstens dem Zweifachen des für Bildwiedergabe vorgesehenen Spannungsbereichs führt vor dem Anlegen eines Datensignals an die dem Bildelement zugeordneten Spaltenelektrode.

8. Verfahren nach Anspruch 6 oder 7, dadurch gekennzeichnet, daß in derselben Zeilenwählzeit zunächst die Hilfsspannung und anschließend die für Wiedergabe vorgesehene Spannung über die Bildelemente angelegt werden.

9. Verfahren nach Anspruch 6 oder 7, dadurch gekennzeichnet, daß die Hilfsspannung in einer Zeilenwählzeit vor der Zeilenwählzeit zugeführt wird, in der die Spannung für die Wiedergabe zugeführt wird.

10. Verfahren nach Anspruch 6 bis 9, dadurch gekennzeichnet, daß die Spannungen über eine Bildelementzeile in bezug auf die gerade geschriebene Bildelementzeile mit invertierter Polarität zugeführt werden.

Revendications

1. Dispositif d'affichage comprenant un milieu d'affichage électro-optique entre une première plaque de support (3) et une seconde plaque de support (2), un système d'éléments d'image (12) disposés en rangées et colonnes, les éléments d'image étant définis par des électrodes d'image (6, 7) sur les surfaces des plaques de support (2, 3) qui se font face, un système d'électrodes de rangées (11) pour présenter des tensions de sélection étant prévu sur la première plaque de support (3) et un certain nombre d'électrodes de colonnes (8a, 8b) pour présenter des tensions de données étant prévu sur la seconde plaque de support (2), les tensions de sélection et de données pour chaque élément d'image (12) via un premier élément de commutation bipolaire asymétrique (9), connecté entre une électrode de colonne (8a, 8b) et une électrode d'image (6) sur la seconde plaque de support (2), déterminant une tension sur l'élément d'image dans la gamme de tensions du milieu d'affichage destinée à l'affichage de l'image, caractérisé en ce que chaque élément d'image du dispositif d'affichage est associé à un second élément de commutation bipolaire asymétrique (19, 19') connecté entre l'électrode d'image (6) sur la seconde plaque de support (2) et une électrode (18) pour une tension de référence destinée à charger l'élément d'image à une tension auxiliaire située au-delà ou sur une des limites de la gamme de tensions destinée à l'affichage de l'image avant la sélection de l'élément d'image.

2. Dispositif d'affichage suivant la revendication 1, caractérisé en ce que le premier élément de commutation (9) et le second élément de commutation (19, 19') sont disposés en série entre l'électrode de colonne (8a, 8b) pour la tension de référence, le point commun des éléments de commutation étant connecté d'une manière conductrice de l'électricité à l'électrode d'image (6) de l'élément d'image.

3. Dispositif d'affichage suivant la revendication 1, caractérisé en ce que le premier élément de commutation (9) et le second élément de commutation (19, 19') sont disposés en série entre l'électrode de colonne (8a, 8b) et l'électrode (18) pour la tension de référence, le premier et le second élément de commutation étant interconnectés électriquement via l'électrode d'image (6) de l'élément d'image.

4. Dispositif d'affichage suivant l'une quelconque des revendications 1 à 3, caractérisé en ce que, dans une rangée d'électrodes d'image (6) deux électrodes d'image (6), juxtaposées sont connectées via un élément de commutation bipolaire asymétrique (19, 19') à une électrode commune (18) pour la tension de référence disposée entre les électrodes d'image (6).

5. Dispositif d'affichage comprenant un milieu d'affichage électro-optique entre une première plaque de support (3) et une seconde plaque de support (2), un système d'éléments d'image disposés en rangées et colonnes, les éléments d'image étant définis par des électrodes d'image (6, 7) sur les surfaces des plaques de support (2, 3), un système d'électrodes de rangées (11) pour présenter des tensions de sélection étant prévu sur la première plaque de support (3) et un certain nombre d'électrodes de colonnes (8a, 8b) pour présenter des tensions de données étant prévu sur la seconde plaque (2), les tensions de sélection et de données pour chaque élément d'image (12)

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déterminant, via un élément de commutation bipolaire (15) en série avec l'élément d'image, des tensions sur l'élément d'image (12) dans la gamme de tensions du milieu d'affichage destinée à l'affichage de l'image, caractérisé en ce que le dispositif d'affichage comprend des moyens pour permettre la charge de l'élément d'image jusqu'à une tension auxiliaire au-delà ou sur une des limites de la gamme de tensions destinée à l'affichage d'image avant la sélection de l'élément d'image, les moyens destinés à charger l'élément d'image jusqu'à la tension auxiliaire comprenant une diode Zener, la diode Zener présentant une tension de claquage minimale égale au moins au double de la gamme de tensions destinée à l'affichage d'image.

6. Procédé pour l'excitation d'un dispositif d'affichage comprenant un milieu d'affichage électro-optique entre une première plaque de support (3) et une seconde plaque de support (2) et un système d'éléments d'image disposés en rangées et colonnes étant défini par des électrodes d'image (6, 7) sur les surfaces des plaques de support (2, 3) qui se font face, un certain nombre d'électrodes de rangées pour présenter des tensions de sélection étant prévu sur la première plaque de support (3) et un certain nombre d'électrodes de colonnes (8a, 8b) pour présenter des tensions de données étant prévu sur la seconde plaque de support (2), dans lequel au moins pendant une partie d'une sélection de ligne, une rangée d'éléments d'image (12) est sélectionnée via les électrodes de rangées (11) et des tensions de données sont présentées, via les électrodes de colonnes (8a, 8b), les tensions de sélection et de données, via un premier élément de commutation bipolaire asymétrique (9) connecté entre une électrode de colonne (8a, 8b) et une électrode d'image (6) sur la seconde plaque de support (2), déterminant une tension sur chaque élément d'image (12) dans la plage de tensions du milieu d'affichage destiné à l'affichage de l'image, caractérisé en ce que l'élément d'image est chargé ou déchargé jusqu'à une tension auxiliaire au-delà ou sur une des limites de la gamme de tensions destinée à l'affichage de l'image, via un élément de commutation asymétrique bipolaire (19, 19') qui est disposé entre une électrode (18) pour une tension de référence et l'électrode d'image (6) sur la seconde plaque de support (2) avant de présenter un signal de données à l'électrode de colonne.

7. Procédé pour l'excitation d'un dispositif d'affichage comprenant un milieu d'affichage électro-optique entre une première plaque de support (3) et une seconde plaque de support (2) et un système d'éléments d'image disposés en rangées et en colonnes étant défini par des électrodes d'image (6, 7) sur les surfaces des plaques de support (2, 3) qui se font face, un certain nombre d'électrodes de rangées (11) destinées à présenter des tensions de sélection étant prévu sur la première plaque de support (3) et une certain nombre d'électrodes de colonnes (8a, 8b) destinées à présenter des tensions de données étant prévu sur la seconde plaque de support (2), dans lequel au moins pendant une partie d'une période de sélection de ligne, une rangée d'éléments d'image (12) est sélectionnée via les électrodes de rangées (11) et des tensions de données sont présentées via les électrodes de colonnes (8a, 8b), les tensions de sélection et de données, via un élément de commutation bipolaire (15) en série avec l'élément d'image déterminant des tensions sur chaque élément d'image (12) dans la gamme de tensions du milieu d'affichage destinée à l'affichage de l'image, caractérisé en ce que l'élément d'image est chargé ou déchargé jusqu'à une tension auxiliaire située au-delà ou sur une des limites de la gamme de tensions destinée à l'affichage de l'image, via une diode Zener qui présente une tension de claquage minimale égale au moins au double de la gamme de tensions destinée à l'affichage de l'image, avant de présenter un signal de données à l'électrode de colonne associée à l'élément d'image.

8. Procédé suivant la revendication 6 ou 7, caractérisé en ce que pendant la même période de sélection de ligne, tout d'abord la tension auxiliaire et ensuite la tension à utiliser pour l'affichage sont présentées sur les éléments d'image.

9. Procédé suivant la revendication 6 ou 7, caractérisé en ce que la tension auxiliaire est présentée pendant une période de sélection de ligne précédant la période de sélection de ligne pendant laquelle la tension pour l'affichage est présentée.

10. Procédé suivant l'une quelconque des revendications 6 à 9, caractérisé en ce que les tensions sur une rangée d'éléments d'image sont présentées avec une polarité inversée par rapport à la rangée d'éléments d'image qui vient de faire l'objet d'une inscription.

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