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(54) **LIQUID CRYSTAL DISPLAY DEVICE AND DRIVING METHOD**

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(57) **ABSTRACT**

There is disclosed a liquid crystal display device and driving method are provided. The liquid crystal display device includes a liquid crystal display panel where pixels are defined by gate lines and data lines that are arranged in a matrix shape. A gate driver is operable to supply a gate voltage to the liquid crystal display panel. A data driver is operable to supply a data voltage to the liquid crystal display panel. The pixels are each independently operable to be driven by drive voltages, which have different polarities from each other, and include first and second liquid crystal cells which realize the same gray level.

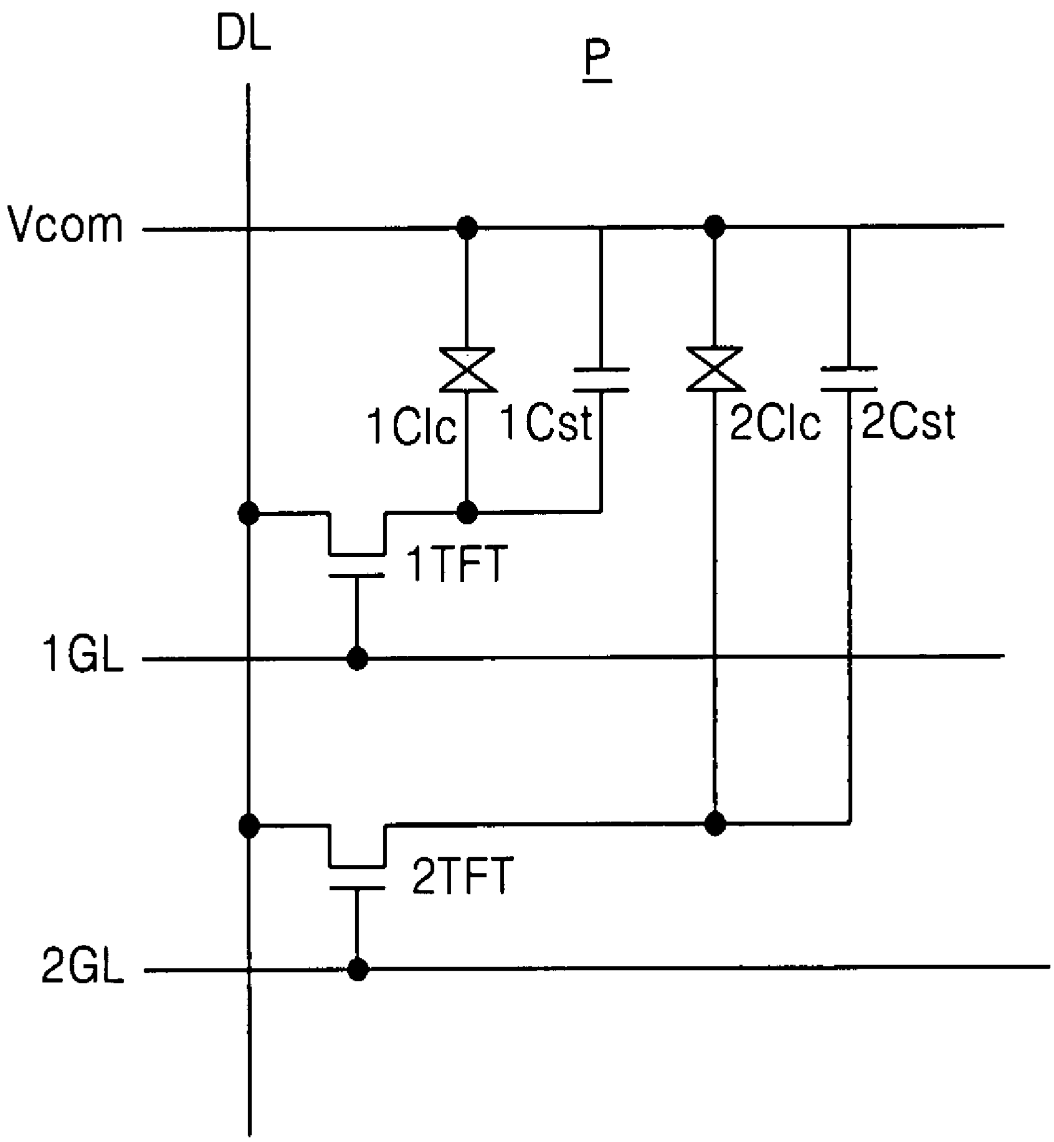


FIG. 1
RELATED ART

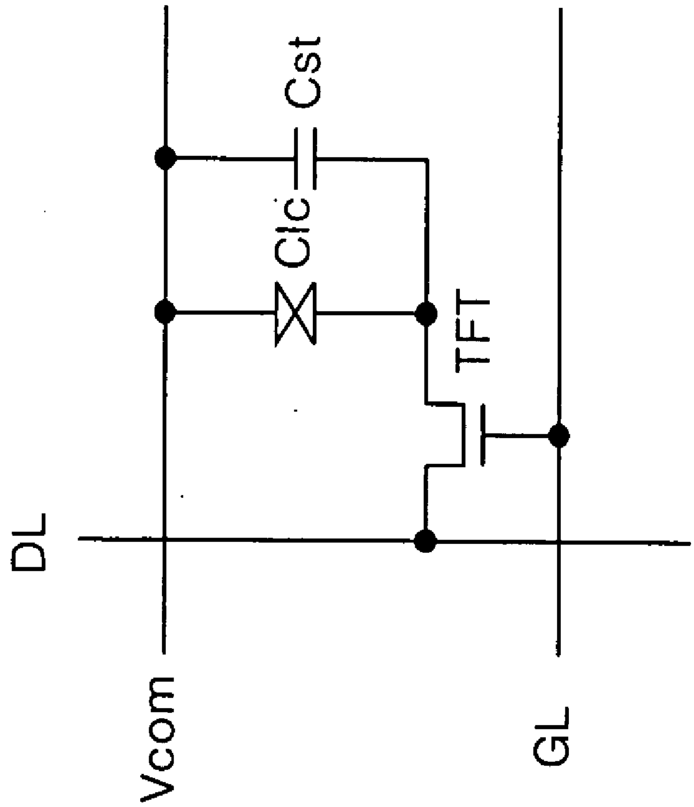


FIG. 2
RELATED ART

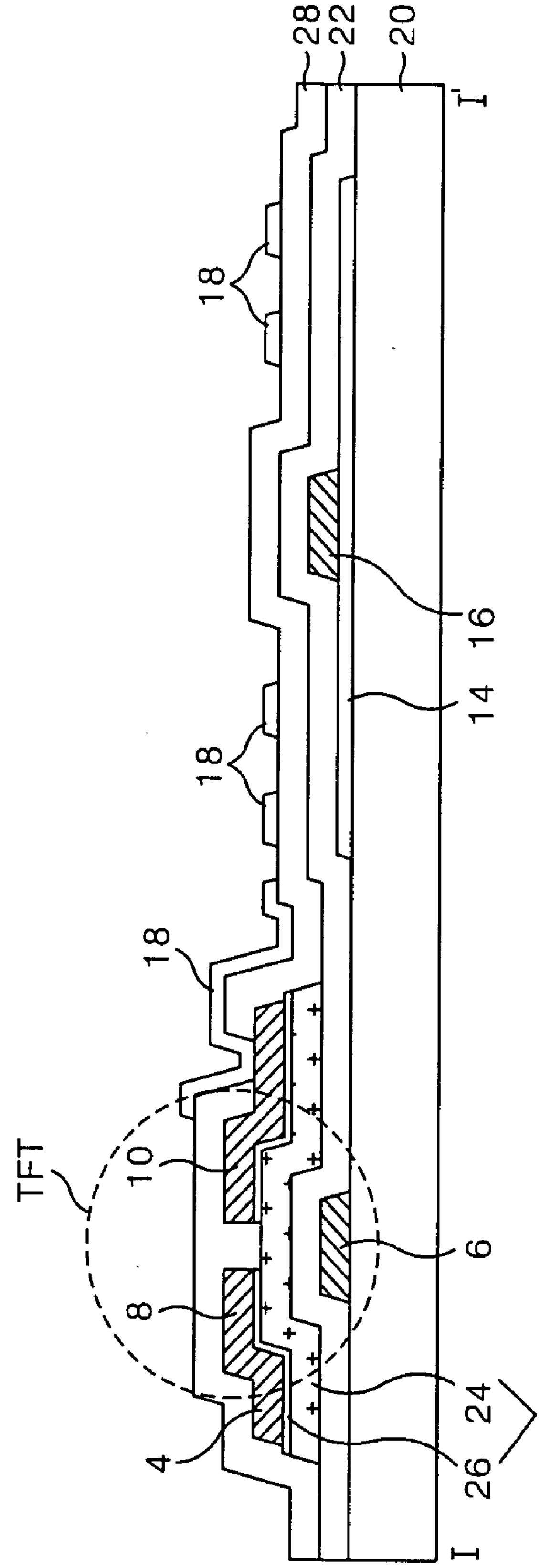


FIG. 3
RELATED ART

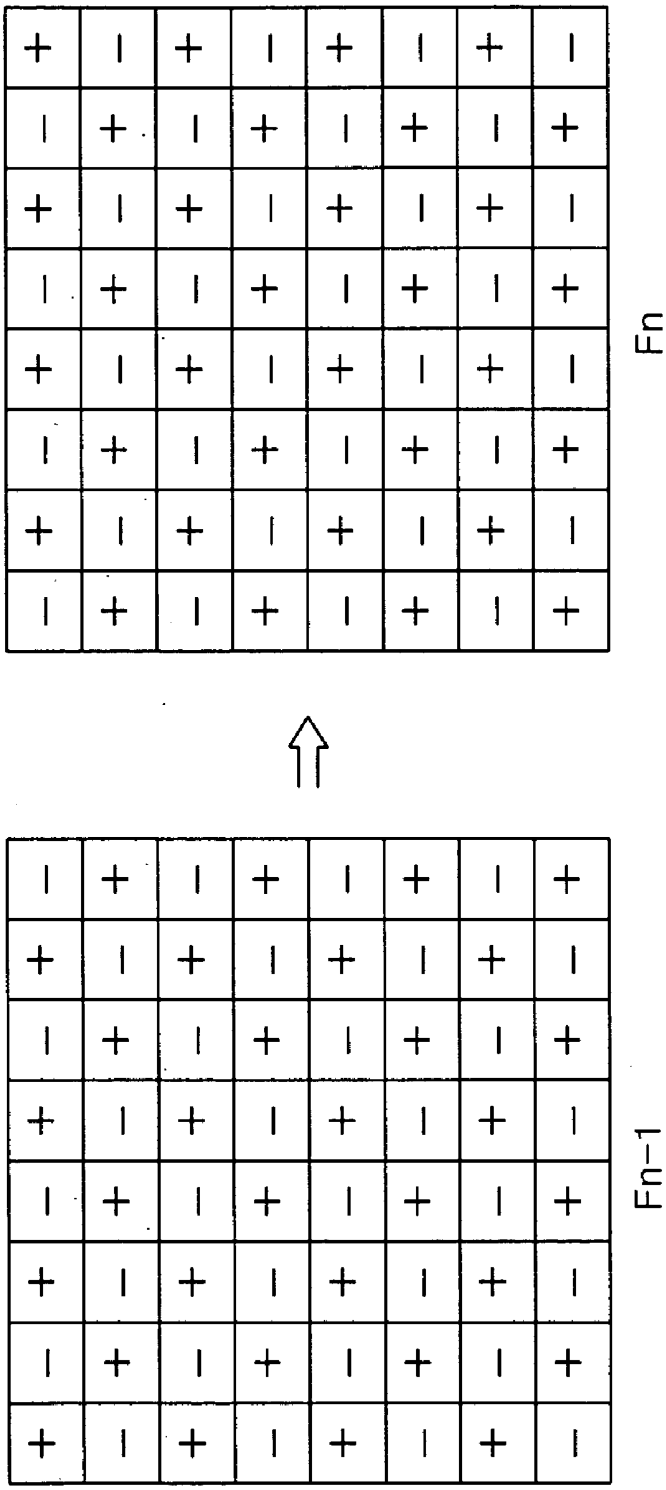


FIG. 4
RELATED ART

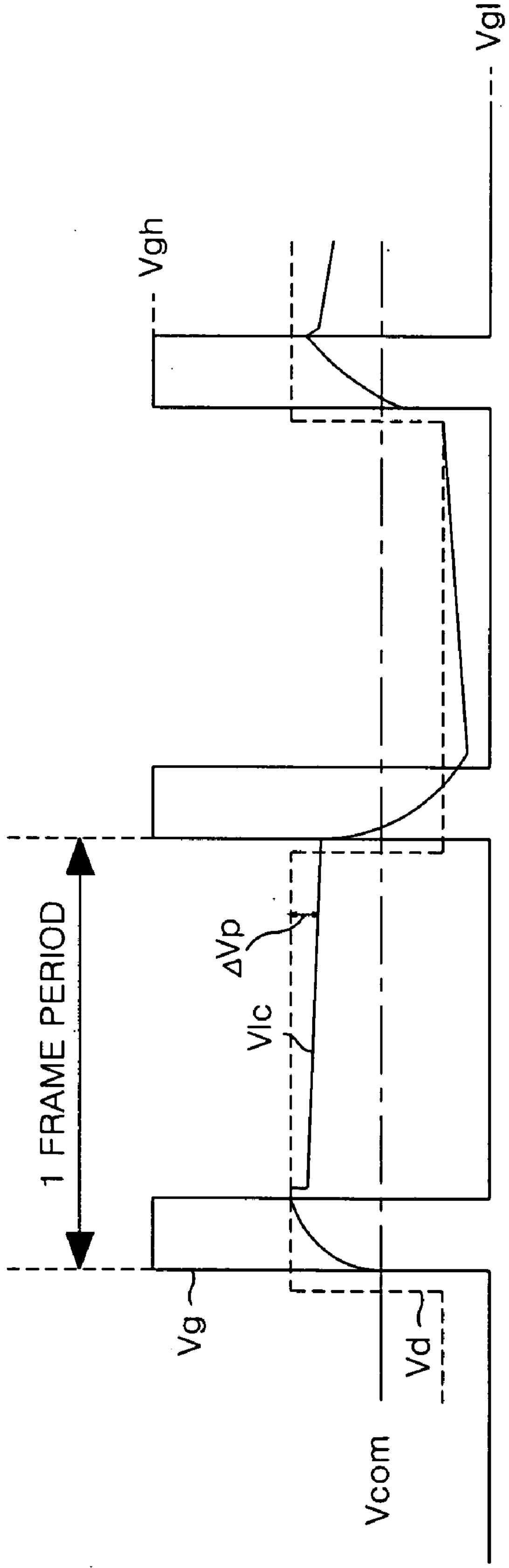


FIG.5
RELATED ART

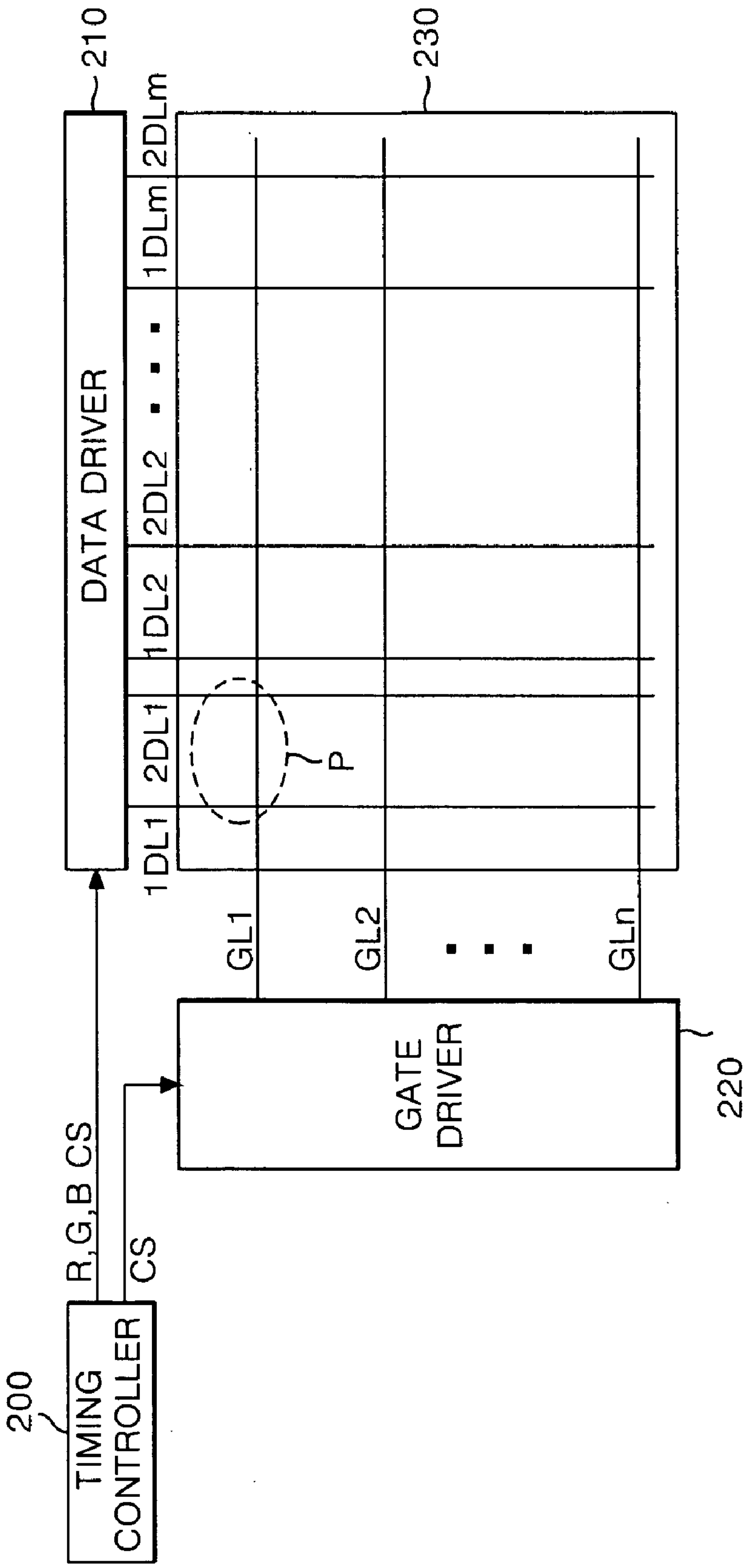


FIG.6
RELATED ART

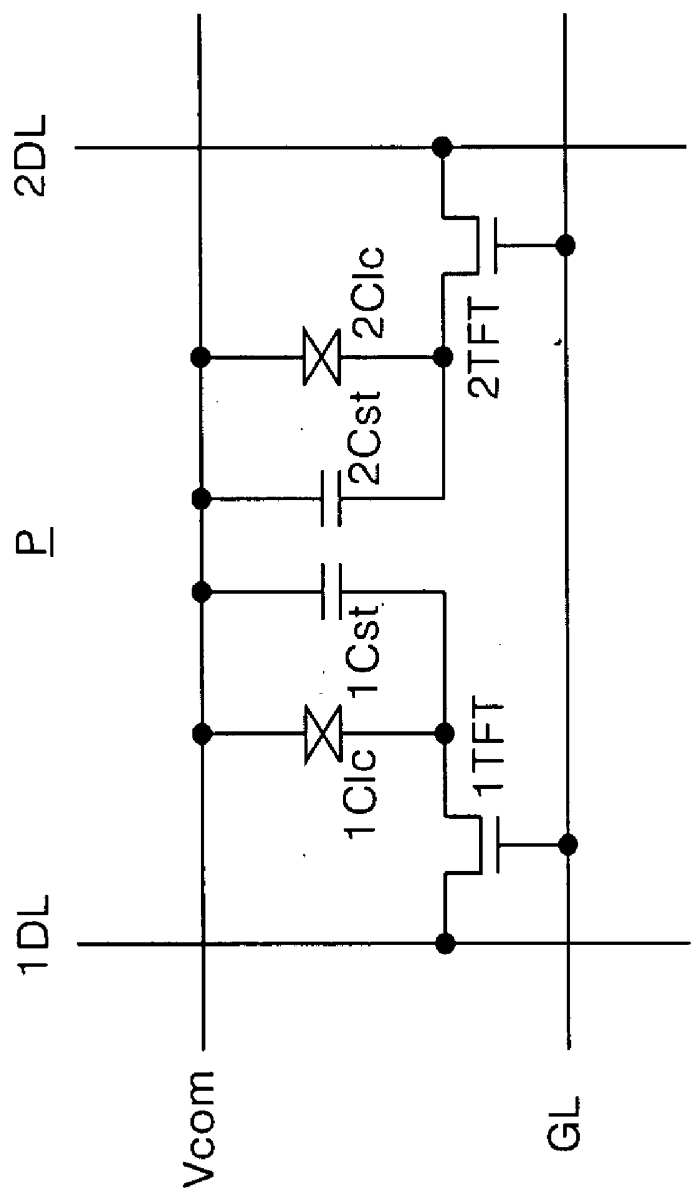


FIG. 7

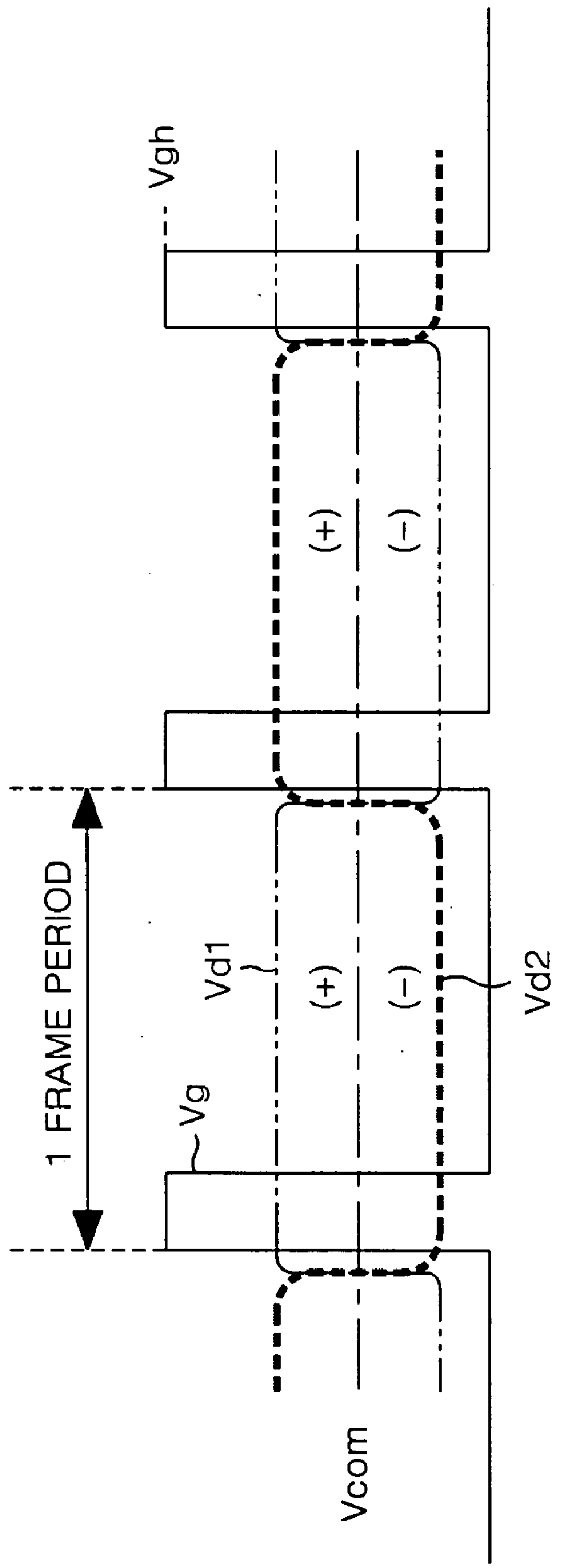


FIG. 8

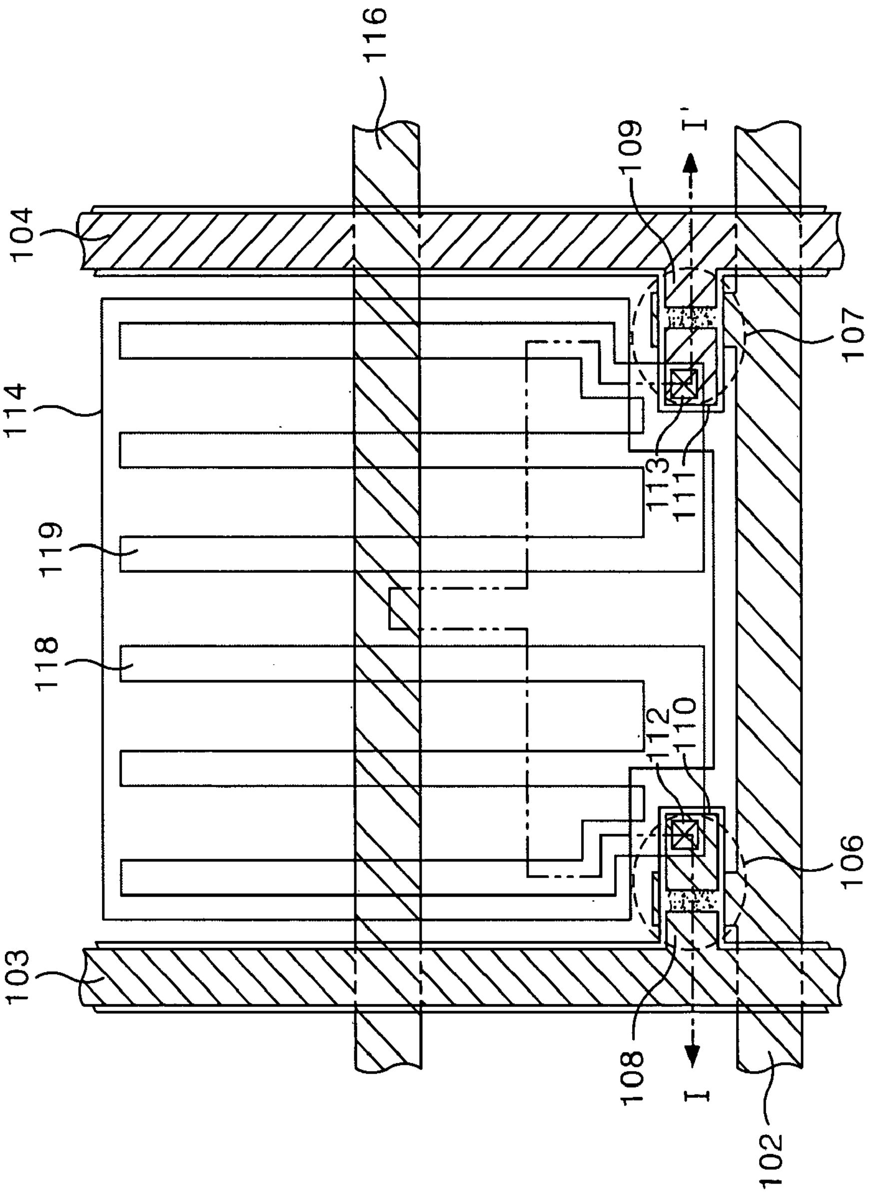


FIG.9

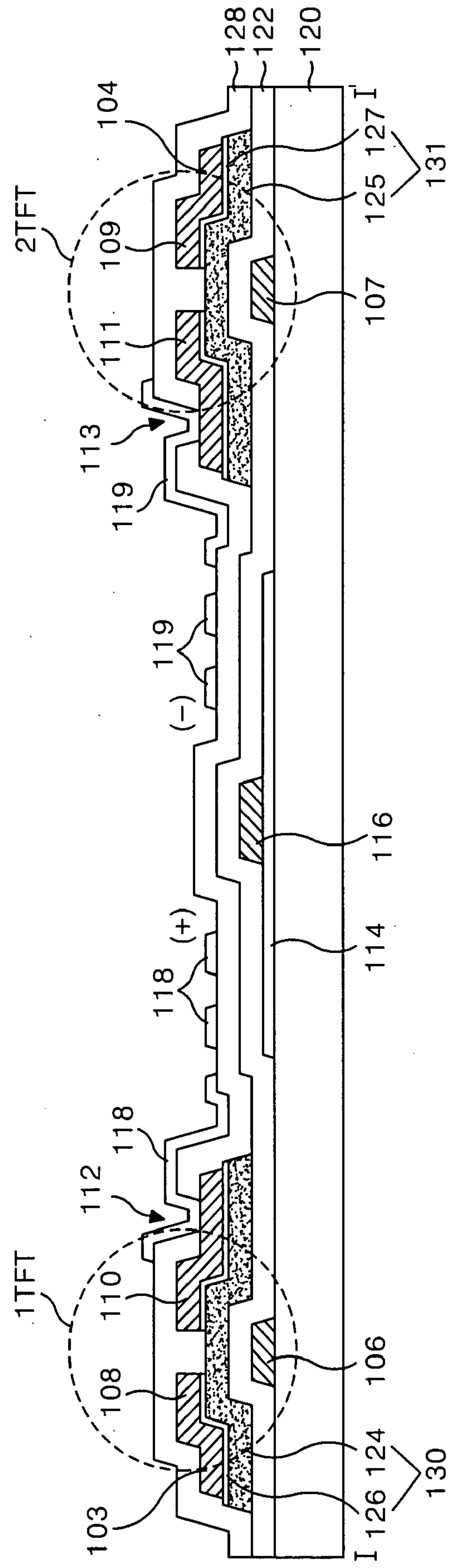
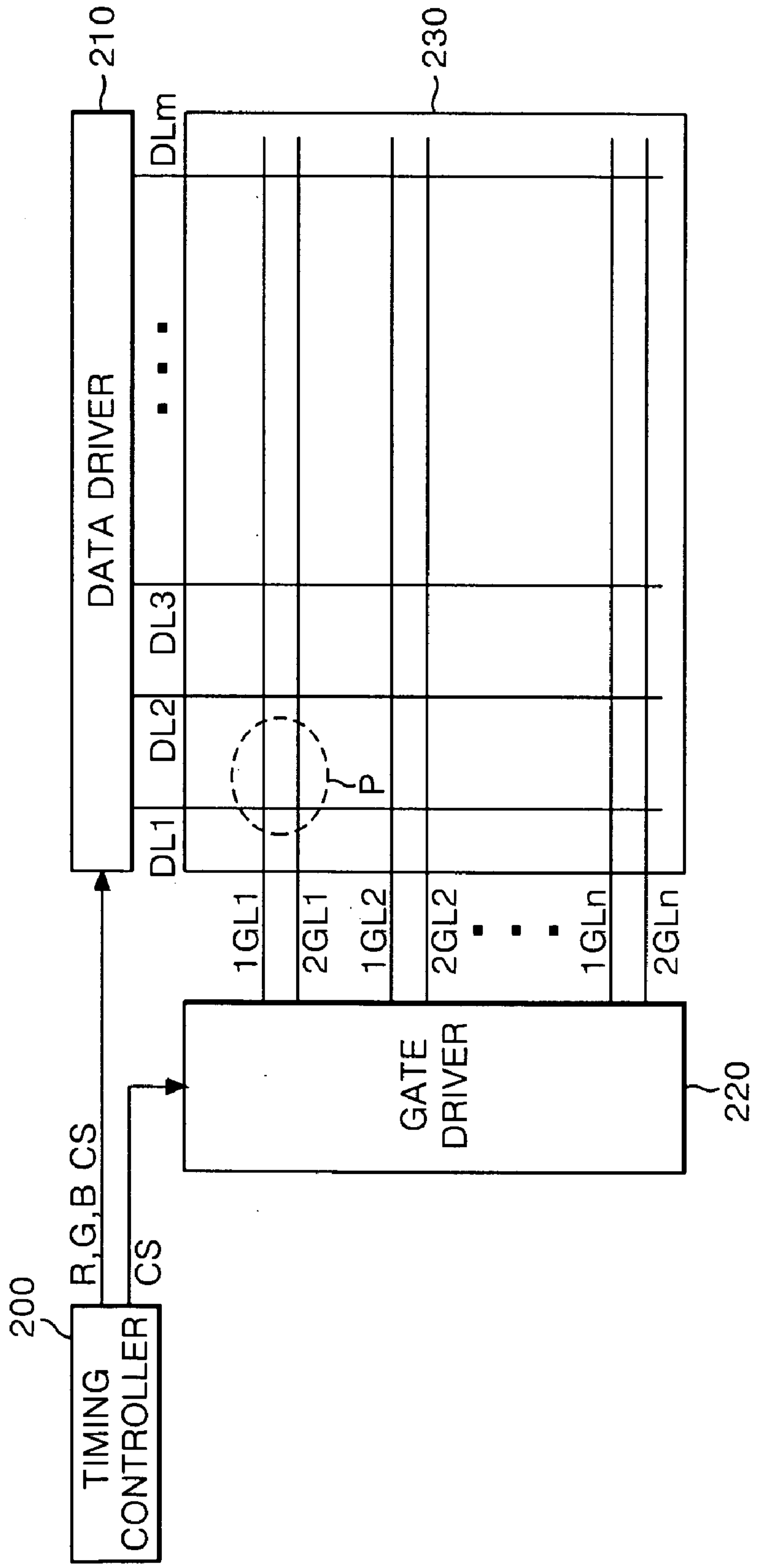

128
122
120
I'
104
127
125
131
2TFT
109
111
107
113
119
(−)
119
116
114
(+)
118
118
112
1TFT
110
108
106
103
124
126
130
I

FIG.10



210
DATA DRIVER
230
DLm
DL3
DL2
DL1
P
1GL1
2GL1
1GL2
2GL2
1GLn
2GLn
GATE DRIVER
220
R,G,B CS
CS
200
TIMING CONTROLLER

FIG.11

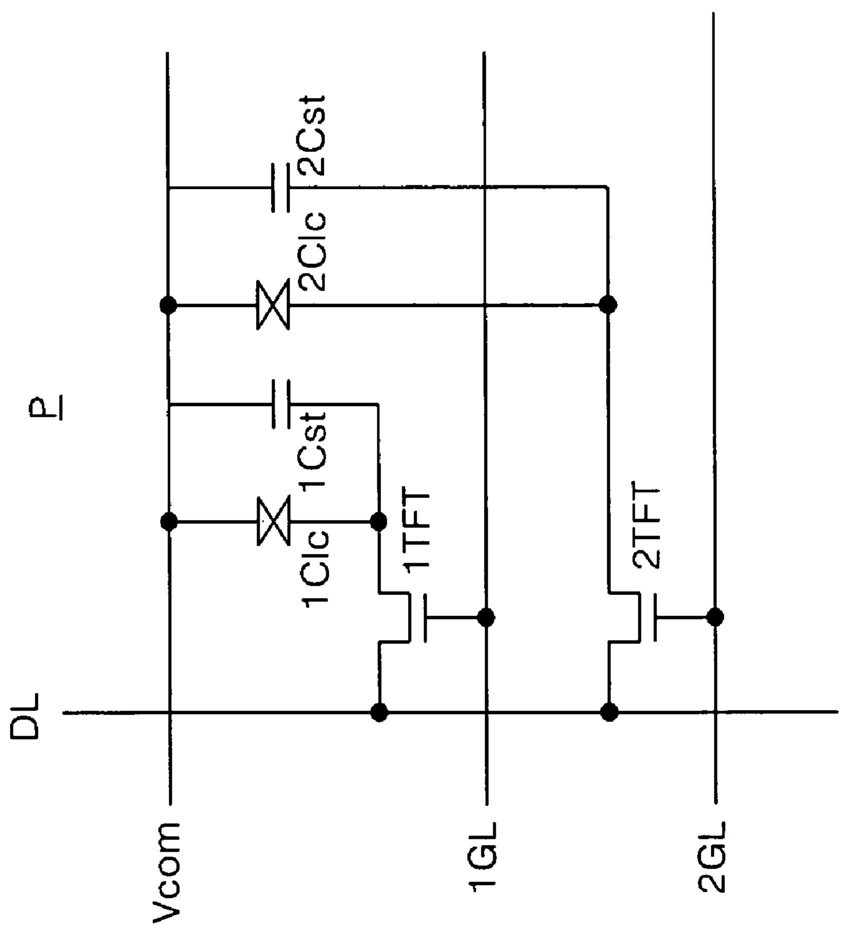


FIG.12

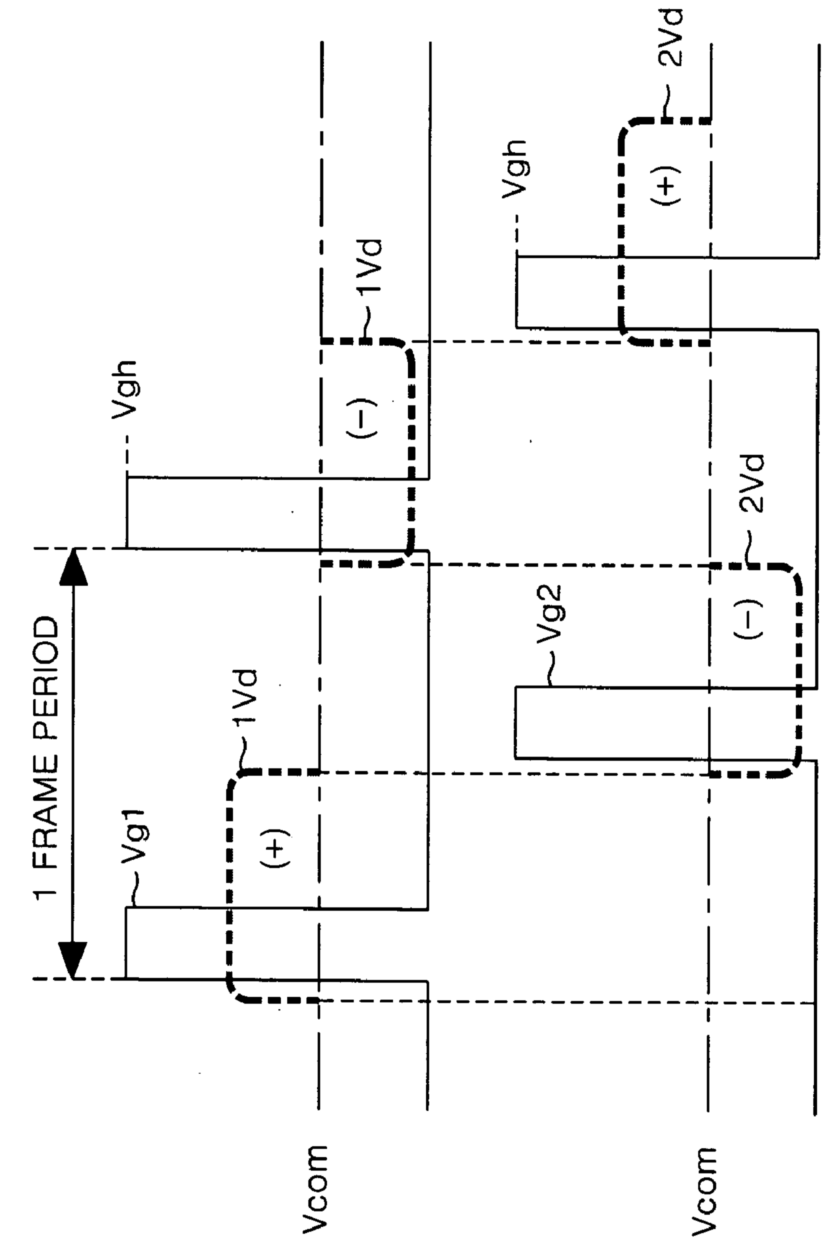
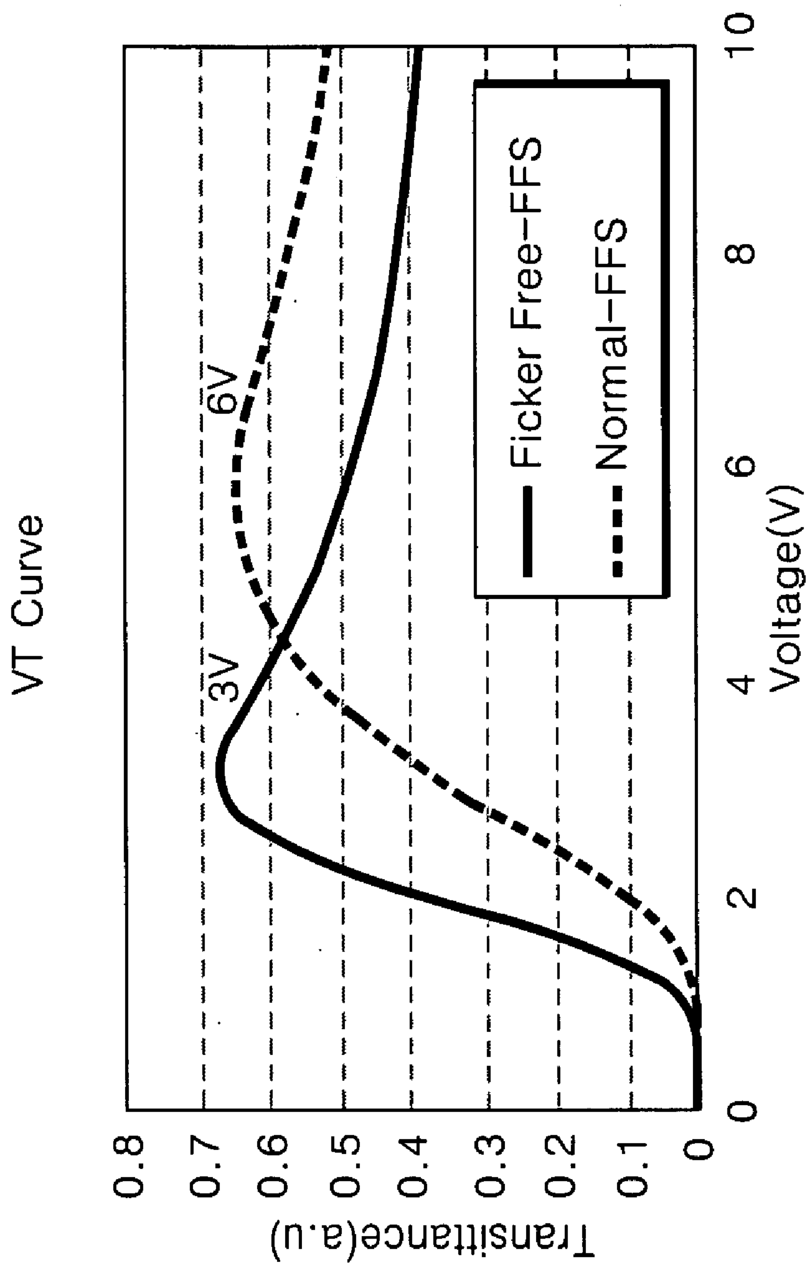


FIG.13


VT Curve
3V
6V
Ficker Free-FFS
Normal-FFS
Voltage(V)
Transittance(a.u)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
2
4
6
8
10

LIQUID CRYSTAL DISPLAY DEVICE AND DRIVING METHOD

[0001] This application claims the benefit of the Korean Patent Application No. P06-0052737 filed on Jun. 12, 2006, which is hereby incorporated by reference.

BACKGROUND

[0002] 1. Field

[0003] The present embodiments relate to a liquid crystal display device, and more particularly to a liquid crystal display device that is adaptive for minimizing flickers and residual images, and a driving method thereof.

[0004] 2. Related Art

[0005] A liquid crystal display device controls the light transmittance of liquid crystal by use of an electric field, thereby displaying a picture. Liquid crystal display devices are mainly classified into vertical electric field applying types and horizontal electric field applying types in accordance with the location of the electric field that drives the liquid crystal.

[0006] The vertical electric field applying type drives a liquid crystal of TN mode by the vertical electric field formed between a common electrode and a pixel electrode which are opposite in upper and lower substrates. The vertical electric field applying type liquid has a high aperture ratio, but also has a narrow viewing angle of about 90°.

[0007] The horizontal electric field applying type drives a liquid crystal of in-plane switch (hereinafter, referred to as 'IPS') mode using a horizontal electric field between a common electrode and a pixel electrode that are disposed to be parallel in a lower substrate. The horizontal electric field applying type has a wide viewing angle of about 160° and a low aperture ratio and transmittance.

[0008] In order to improve the low aperture ratio and transmittance of the horizontal electric field applying type, a fringe field switching (hereinafter, referred to as 'FFS') type liquid crystal display device which is driven by a fringe field is used. The FFS type liquid crystal display device includes a pixel electrode and a common electrode plate that has an insulating film therebetween in each pixel area, and forms a gap between the common electrode plate and the pixel electrode to be narrower than a gap between the upper and lower substrates, thereby forming the fringe field. Liquid crystal molecules filled in a space between the upper and lower substrates are operated by the fringe field, thereby improving the aperture ratio and the transmittance.

[0009] FIG. **1** is a circuit diagram representing one pixel of a FFS type liquid crystal display device according to the related art. FIG. **2** is a cross sectional diagram illustrating a thin film transistor substrate included in the FFS type liquid crystal display device.

[0010] Referring to FIG. **1**, the FFS type liquid crystal display device includes a plurality of liquid crystal cells Clc which are arranged in a matrix type at the crossing part of data lines DL and gate lines GL. A TFT formed at each of the liquid crystal cells supplies a data signal from the data line DL to the liquid crystal cell Clc in response to a scan signal supplied from the gate line.

[0011] In FIG. **2**, a thin film transistor substrate of the FFS type liquid crystal display device includes a gate line GL and a data line DL which are formed to cross with a gate insulating film **22** therebetween on a lower substrate **20**. A thin film transistor is formed at each crossing part thereof. A common electrode plate **14** and a pixel electrode slit **18** which are formed with the gate insulating film **22** and a passivation film **28** therebetween so as to form a fringe field in a pixel area provided by the crossing structure. A common line **16** is connected to the common electrode plate **14**.

[0012] The common electrode plate **14** is formed in each pixel area, and receives a reference voltage (hereinafter, referred to as 'common voltage Vcom') that drives the liquid crystal through the common line **16** which is formed on the common electrode plate **14** and connected to the common electrode plate **114**. The common electrode plate **14** is formed of a transparent conductive layer and the common line **16** together with the gate line **2** is formed of a gate metal layer.

[0013] The thin film transistor TFT makes the pixel signal of the data line **4** charged and stored in the pixel electrode slit **18** in response to the gate signal of the gate line GL. For example, the thin film transistor TFT includes a gate electrode **6** connected to the gate line GL. A source electrode is connected to the data line **4**. A drain electrode **10** is connected to the pixel electrode slit **18**. An active layer overlaps the gate electrode **6** with the gate insulating film **22** to form a channel between the source electrode **8** and the drain electrode **10**. An ohmic contact layer **26** for an ohmic contact between the source and drain electrodes **8**, **10** and the active layer **24**. A semiconductor pattern **30** includes the active layer **24** and the ohmic contact layer **26**.

[0014] The pixel electrode slit **18** is connected to the drain electrode **10** of the thin film transistor TFT through a contact hole **12** which penetrates the passivation film **28** that overlaps the common electrode plate **14**. The pixel electrode slit **18** forms a fringe field with a common electrode plate **14** to make liquid crystal molecules rotate by dielectric anisotropy. The liquid crystal molecules are arranged in a horizontal direction between a thin film transistor substrate and a color filter substrate. The transmittance of the light transmitted through a pixel area is changed in accordance with the degree of rotation of the liquid crystal molecules, thereby realizing a gray level.

[0015] A storage capacitor Cst that stably maintains the video signal supplied to the pixel electrode slit **18** is formed between the common electrode plate **14** and the pixel electrode slit **18**. The storage capacitor Cst stores the voltage of the liquid crystal cell Clc at a fixed level.

[0016] The liquid crystal display device is driven by an inversion method of periodically inverting the polarity of the data charged in the liquid crystal cell to reduce flickers and residual images. The inversion method is classified into a line inversion method where the polarity of data is inverted between the adjacent liquid crystal cells in a vertical line direction. A column inversion method has the polarity of data inverted between the adjacent liquid crystal cells in a horizontal line direction. A dot inversion method has the polarity of the data inverted between the adjacent liquid crystal cells in the vertical line direction and the horizontal line direction.

[0017] In the dot inversion method, as shown in FIG. **1**, the polarities of the data supplied to each of the adjacent liquid crystal cells are contrary to each other in the vertical direction and the polarities of the data supplied to each of the adjacent liquid crystal cells are contrary to each other in the horizontal direction. The polarity of the data is inverted for each frame (Fn−1, Fn).

[0018] A feed-through voltage ΔVp is generated that results in the flickers and the residual images during the driving of the liquid crystal display device by the dot inversion method.

[0019] Referring to FIG. **4**, a gate voltage Vg is supplied to the gate electrode **8** of the TFT **6** and a data voltage Vd is supplied to the source electrode **10**. If a gate high voltage Vgh being not less than a threshold voltage of the TFT **6** is applied to the gate electrode **8** of the TFT **6**, a channel is formed between the source electrode **10** and the drain electrode **12**, and the data voltage Vd is charged in the liquid crystal cell Clc and the storage capacitor Cst through the source electrode **10** and the drain electrode **12** of the TFT.

[0020] The feed-through voltage ΔVp is the difference between the data voltage and the voltage charged in the liquid crystal.

[0021] The feed-through voltage ΔVp is not fixed because the polarity of the data is inverted for each frame (Fn−1, Fn) or in accordance with the gray level. Thus, the common voltage Vcom is not located in the center of the positive data voltage and the negative data voltage. For example, the feed-through voltage ΔVp in the positive data voltage for displaying a white color and the feed-through voltage ΔVp in the negative data voltage for displaying a white color are not the same in magnitude, thus an effective value of the data voltage for expressing the same gray level is not fixed in accordance with the polarity. Accordingly, the common voltage being a DC voltage cannot be set as an optimal common voltage value corresponding to the center of the positive data voltage and the negative data voltage. A brightness difference is generated between frames, thereby still resulting in the flickers and the residual images.

[0022] Accordingly, a liquid crystal display device that is adaptive for minimizing flickers and residual images is desired.

SUMMARY

[0023] In one embodiment, a liquid crystal display device includes a liquid crystal display panel where pixels defined by gate lines and data lines are arranged in a matrix shape. A gate driver supplies a gate voltage to the liquid crystal display panel. A data driver supplies a data voltage to the liquid crystal display panel, and the pixels are each independently driven by drive voltages of which the polarities are different from each other, and include first and second liquid crystal cells which realize the same gray level.

[0024] In one embodiment, each pixel is defined by one gate line that crosses a first data line to which a first data voltage is supplied and a second data line to which a second data voltage is supplied.

[0025] In one embodiment, polarities of the first and second data voltages are inverted for each frame.

[0026] In the liquid crystal display device, the first liquid crystal cell includes a first thin film transistor located at the crossing area of the gate line and the first data line, a first pixel electrode connected to the first thin film transistor, and a common voltage supplier which forms an electric field with the first pixel electrode. The second liquid crystal cell includes a second thin film transistor located at the crossing area of the gate line and the second data line, a second pixel electrode connected to the second thin film transistor, and the common voltage supplier which forms an electric field with the second pixel electrode.

[0027] In the liquid crystal display device, the polarity of a pixel voltage supplied to each of the first and second liquid crystal cells is inverted for each frame.

[0028] In the liquid crystal display device, the first and second liquid crystal cells have a symmetric structure to each other.

[0029] In the liquid crystal display device, the first and second pixel electrodes include a plurality of line-shaped finger parts that are parallel to the data line.

[0030] In the liquid crystal display device, the common voltage supplier includes a common electrode plate that is formed in a pixel area where the pixel is provided and which forms a fringe electric field with the first and second pixel electrodes. A common line supplies a common voltage to the common electrode plate.

[0031] In the liquid crystal display device, the common voltage supplier includes a finger-shaped common electrode which is located parallel to the finger parts of the first and second pixel electrodes to form a horizontal electric field with the finger part.

[0032] In the liquid crystal display device, each of the pixels is defined by one data line and first and second gate lines.

[0033] In the liquid crystal display device, a first data voltage synchronized with a first gate voltage from the first gate line is supplied to the data line. A second data voltage synchronized with a second gate voltage from the second gate line is supplied to the data line.

[0034] In the liquid crystal display device, the first data voltage and the second data voltage have different polarities from each other.

[0035] In the liquid crystal display device, the polarities of the first and second data voltages are inverted for each frame.

[0036] In the liquid crystal display device, the first liquid crystal cell includes a first thin film transistor located at the crossing area of the first gate line and the data line, a first pixel electrode connected to the first thin film transistor, and a common voltage supplier which forms an electric field with the first pixel electrode; and the second liquid crystal cell includes a second thin film transistor located at the crossing area of the second gate line and the data line, a second pixel electrode connected to the second thin film transistor, and the common voltage supplier which forms an electric field with the second pixel electrode.

[0037] In the liquid crystal display device, the polarity of a pixel voltage supplied to each of the first and second liquid crystal cells is inverted for each frame.

[0038] In the liquid crystal display device, the first and second pixel electrodes include a plurality of line-shaped finger parts which are parallel to the data line.

[0039] In the liquid crystal display device, the common voltage supplier includes a common electrode plate which is formed in a pixel area where the pixel is provided and which forms a fringe electric field with the first and second pixel electrodes. A common line supplies a common voltage to the common electrode plate.

[0040] In the liquid crystal display device, the common voltage supplier includes a common electrode located parallel to the finger parts of the first and second pixel electrodes to form a horizontal electric field with the finger part.

[0041] In the liquid crystal display device, the pixel realizes any one color of red, green and blue.

[0042] A driving method of a liquid crystal display device having a liquid crystal display panel where pixels are arranged in a matrix shape according to another aspect of the present invention includes the steps of dividing each of the pixels into first and second liquid crystal cells which can be independently driven; supplying a common voltage to the first and second liquid crystal cells; and realizing the same gray level in the first and second liquid crystal cells by supplying the drive voltages, which are the same in magnitude on the basis of the common voltage and different in polarity, to the first and second liquid crystal cells.

[0043] In the driving method, the polarity of a drive voltage supplied to each of the first and second liquid crystal cells are inverted for each frame.

[0044] In the driving method, the first liquid crystal cell is defined by a gate line and a first data line to which a first data voltage is supplied. The second liquid crystal cell is defined by the gate line and a second data line to which a second data voltage, which has a different polarity from the first data voltage, is supplied.

[0045] In the driving method, the first liquid crystal cell is defined by a data line and a first gate line to which a first gate voltage is supplied. The second liquid crystal cell is defined by the data line and a second gate line to which a second gate voltage is supplied.

[0046] In the driving method, realizing the same gray level in the first and second liquid crystal cells includes the steps of realizing a first gray level in the first liquid crystal cell by supplying the first gate voltage to the first gate line and supplying a first data voltage synchronized with the first gate voltage to the data line. Realizing the same gray level as the first gray level in the second liquid crystal cell by supplying the second gate voltage to the second gate line and supplying a second data voltage synchronized with the second gate voltage to the data line.

[0047] In the driving method, the first data voltage and the second data voltage have different polarities from each other.

[0048] In the driving method, the polarities of the first and second data voltages are inverted for each frame.

[0049] In the driving method, liquid crystals of the first and second liquid crystal cells are driven by a fringe electric field between the drive voltage and the common voltage.

[0050] In the driving method, liquid crystals of the first and second liquid crystal cells are driven by a horizontal electric field between the drive voltage and the common voltage.

[0051] The driving method further includes the step of optimizing the magnitude of the common voltage between a first drive voltage supplied to the first liquid crystal cell and a second drive voltage supplied to the second liquid crystal cell after realizing the same gray level in the first and second liquid crystal cells.

BRIEF DESCRIPTION OF THE DRAWINGS

[0052] FIG. **1** is a circuit diagram briefly representing one pixel in an FFS type liquid crystal display device according to the related art;

[0053] FIG. **2** is a cross sectional diagram representing a thin film transistor array substrate of the FFS type liquid crystal display device according to the related art;

[0054] FIG. **3** is a diagram briefly representing a data polarity of a liquid crystal display panel which is driven by a dot inversion method according to the related art;

[0055] FIG. **4** is a waveform diagram representing a drive characteristic of a liquid crystal display device of a dot inversion method according to the related art;

[0056] FIG. **5** is a block diagram briefly representing a liquid crystal display device according to one embodiment;

[0057] FIG. **6** is a circuit diagram specifically representing one pixel in FIG. **5**;

[0058] FIG. **7** is a waveform diagram representing a drive characteristic of the liquid crystal display device according the first embodiment;

[0059] FIG. **8** is a plan view representing a thin film transistor array substrate of an FFS type liquid crystal display device;

[0060] FIG. **9** is a cross sectional diagram illustrating the thin film transistor array substrate taken along the line I-I' of FIG. **8**;

[0061] FIG. **10** is a block diagram briefly representing a liquid crystal display device according to a second embodiment;

[0062] FIG. **11** is a circuit diagram specifically representing one pixel in FIG. **10**;

[0063] FIG. **12** is a waveform diagram representing a drive characteristic of the liquid crystal display device according to the second embodiment; and

[0064] FIG. **13** is an experimental data representing the decrease of a liquid crystal drive voltage of the liquid crystal display device.

DETAILED DESCRIPTION

[0065] In one embodiment, the liquid crystal display device divides the pixel realizing any one color of red R, green G and blue B into first and second sub-pixels which have different polarities and have the same gray level at the same time. The first and second sub-pixels express the same gray level, but any one of the first and second sub-pixels express the gray level by a positive data and the other expresses the gray level by a negative data. The positive and negative data are simultaneously realized within one pixel even though the magnitude of the feed-through voltage ΔVp is not identical. The effective value that expresses the gray level can be stored regardless of the polarity at a fixed level. The same brightness can be expressed irrespective of the common voltage value and the magnitude of the feed-through voltage for each frame (Fn−1, Fn), thereby solving the flicker problem.

[0066] For example, the driving by the positive and negative data is all possible within each pixel. A user sets an optimal common voltage value corresponding to the center of a positive data voltage and a negative data voltage while the flick problem is solved, thus it is possible to minimize the residual image. The same brightness is expressed regardless of the location of the common voltage for each frame (Fn−1, Fn). If the common voltage value is set as an optimal value with which the residual image is minimized between the positive data voltage and the negative data voltage after removing the flickers, then the flickers and the residual images can be minimized.

[0067] Hereinafter, embodiments for representing the foregoing operational effect will be specifically explained in reference to the drawings.

[0068] FIG. **5** is a block diagram briefly representing a liquid crystal display device according to a first embodiment.

[0069] Referring to FIG. **5**, the liquid crystal display device includes a liquid crystal display panel **230** where m×n pixels P are arranged in a matrix type. A data driver **210** supplies first and second data voltages to first and second data lines **1**DL**1**, **2**DL**1**, **1**DL**2**, **2**DL**2**, . . . , **1**DLm, **2**DLm of the liquid crystal display panel **230**. A gate driver **220** supplies a gate voltage to the gate lines G**1** to Gn. A timing controller controls the data driver **210** and the gate driver **220** by use of a synchronization signal.

[0070] The liquid crystal display panel **230** includes a thin film transistor array substrate and a color filter array substrate which face each other with liquid crystal therebetween.

[0071] The data driver **210** converts a digital video data RGB into an analog gamma voltage (data signal) that corresponds to the gray level value in response to a control signal CS from the timing controller **200**, and supplies the analog gamma voltage to the first and second data lines **1**DL**1**, **2**DL**1**, **1**DL**2**, **2**DL**2**, . . . , **1**DLm, **2**DLm.

[0072] The gate driver **220** sequentially supplies a gate voltage to the gate lines GL**1** to GLn to select a horizontal line of a liquid crystal display panel **230** to which a data signal is supplied in response to the control signal CS from the timing controller **200**.

[0073] The timing controller **200** generates a control signal CS that controls the gate driver **220** and the data driver **210** by use of a vertical/horizontal synchronization signal Vsync, Hsync and a clock signal DCLK.

[0074] FIG. **6** is a circuit diagram briefly representing one pixel of FIG. **5**. As shown in FIG. **6**, each pixel includes first and second data lines **1**DL, **2**DL. Gate lines cross the first and second data lines **1**DL, **2**DL. A first thin film transistor **1**TFT and a first liquid crystal cell **1**Clc are formed at the crossing area of the first data line **1**DL and the gate line GL. A second thin film transistor **2**TFT and a second liquid crystal cell **2**Clc are formed at the crossing area of the second data line **2**DL and the gate line GL.

[0075] In one embodiment, the first thin film transistor **1**TFT supplies the positive (or negative) data voltage from the first data line **1**DL to the first liquid crystal cell **1**Clc in response to a scan signal (or gate voltage) supplied from the gate line GL. The second thin film transistor **2**TFT supplies the negative (or positive) data voltage from the second data line **2**DL to the second liquid crystal cell **2**Clc in response to the gate voltage supplied from the gate line GL. The data voltage supplied from the first data line **1**DL and the data voltage supplied from the second data line **2**DL are the same in magnitude and contrary to each other in polarity. Each of the liquid crystal cells **1**Clc, **2**Clc can be independently driven, thus one pixel can be divided into two sub-pixels which realizing the same color.

[0076] FIG. **7**. illustrates a drive characteristic of a liquid crystal display device according to the first embodiment. As shown in FIG. **7**, a gate voltage Vg is supplied to gate electrodes of the first and second thin film transistors **1**TFT, **2**TFT. A first data voltage Vd**1** is supplied to a source electrode of the first thin film transistor **1**TFT and a second data voltage Vd**2** is supplied to a source electrode of the second thin film transistor **2**TFT. A difference voltage between the common voltage Vcom and the first data voltages Vd**1** is the same in magnitude as a difference voltage between the common voltage Vcom and the second data voltages Vd**2**, and the polarities of the first and second data voltages Vd**1**, Vd**2** are contrary to each other.

[0077] Alternatively, if the common voltage Vcom is 0V even though the first data voltage Vd**1** and the second data voltage Vd**2** have the same polarity, the first data voltage Vd**1** and the second data voltage Vd**2** are contrary to each other in polarity, and the polarities of the first and second data voltages Vd**1**, Vd**2** become contrary thereto in the next frame in comparison with the previous frame.

[0078] If a gate high voltage Vgh of not less than a threshold voltage of the first thin film transistor **1**TFT is applied to the gate electrode of the first thin film transistor **1**TFT, a channel is formed between the source electrode and the drain electrode, and the first data voltage **1**Vd is charged in the first liquid crystal cell **1**Clc and the first storage capacitor **1**Cst through the source electrode and the drain electrode of the first thin film transistor **1**TFT.

[0079] If the gate high voltage Vgh of not less than a threshold voltage of the second thin film transistor **2**TFT is applied to the gate electrode of the second thin film transistor **2**TFT, a channel is formed between the source electrode and the drain electrode, and the second data voltage **2**Vd is charged in the second liquid crystal cell **2**Clc and the second storage capacitor **2**Cst through the source electrode and the drain electrode of the second thin film transistor **2**TFT.

[0080] Each pixel having the foregoing circuit and composition characteristic can be divided into first and second liquid crystal cells (or sub-pixels) which express the same gray level while having different polarities from each other. Accordingly, the positive and negative data are simultaneously realized within one pixel even though the level of the feed-through voltage ΔVp is not identical. Thus, the effective value for expressing the gray level is fixed. The same brightness can be expressed irrespective of the location of the common voltage and the magnitude of the feed-through voltage ΔVp for each frame (Fn−1, Fn), thereby solving the flicker problem.

[0081] The driving by the positive and negative data is all possible within each pixel. For example, a user may judge the common voltage value that can minimize the residual image between the positive (+) data voltage and the negative (−) data voltage while the flicker problem is solved.

[0082] In one embodiment, the same brightness is expressed regardless of the location of the common voltage for each frame (Fn−1, Fn). If the common voltage value is set as an optimal value with which the residual image is minimized between the positive data voltage and the negative data voltage after removing the flickers, then the flickers and the residual images can be minimized.

[0083] FIGS. **8** and **9** are a plan view and a cross sectional diagram representing a structure of an FFS (fringe field switch) type thin film transistor array substrate where, for example, the circuit composition and drive shown in FIGS. **6** and **7** is possible.

[0084] The thin film transistor substrate of the FFS type liquid crystal display device shown in FIGS. **8** and **9** includes first and second data lines **103**, **104** which cross a gate line **102** with a gate insulating film **122** therebetween on a lower substrate **120**. A first thin film transistor **1**TFT is formed at the crossing area of the first data line **103** and the gate line **102**. A second thin film transistor **2**TFT formed at the crossing area of the second data line **104** and the gate line **102**. A common electrode plate **114** and first and second electrode slits **118**, **119** are formed with a gate insulating film **122** and a passivation film **128** therebetween so as to form a fringe field in a pixel area defined by the gate line **102** and the first and second data lines **103**, **104**. A common line **116** is connected to the common electrode plate **114**.

[0085] The common electrode plate **114** is formed in each pixel area, and receives a common voltage Vcom (or reference voltage) for driving liquid crystal through the common line **116** which is formed on the common electrode plate **114** to be connected thereto. The common electrode plate **114** is formed of a transparent conductive layer. The common line **116** together with the gate line **102** is formed of a gate metal layer.

[0086] The first thin film transistor **1**TFT makes a pixel signal of the first data line **103** charged and stored in the first pixel electrode slit **118** in response to the gate signal of the gate line **102**. For example, the first thin film transistor **1**TFT includes a first gate electrode **106** connected to the gate line **102**. A first source electrode **108** is connected to the first data line **103**. A first drain electrode **110** is connected to the first pixel electrode slit **118**. A first active layer **124** overlaps the first gate electrode **106** with the gate insulating film **22** therebetween and forms a channel between the first source electrode **108** and the first drain electrode **110**. A first ohmic contact layer **126** for the ohmic contact between the first source and first drain electrodes **108**, **110** and the first active layer **124**. A first semiconductor pattern **130** includes the first active layer **124** and the first ohmic contact layer **126**.

[0087] The first pixel slit **118** is connected to the first drain electrode **110** of the first thin film transistor **1**TFT through a first contact hole **112** which penetrates the passivation film **128**, and is formed to overlap the common electrode **114**.

[0088] The second thin film transistor **2**TFT makes the pixel signal of the second data line **104** charged and kept in the second pixel electrode slit in response to the gate signal of the gate line **102**. For example, the second thin film transistor **2**TFT includes a second gate electrode **107** connected to the gate line **102**. A second source electrode **109** is connected to the second data line **104**. A second drain electrode **111** is connected to the second pixel electrode slit **119**. A second active layer **125** overlaps the second gate electrode **107** with the gate insulating film **122** therebetween and forms a channel between the second source electrode **109** and the second drain electrode **111**. A second ohmic contact layer **127** provides an ohmic contact between the second source and second drain electrodes **109**, **111** and the second active layer **125**. A second semiconductor pattern **131** includes the second active layer **125** and the second ohmic contact layer **127**.

[0089] The second pixel slit **119** is connected to the second drain electrode **111** of the second thin film transistor **2**TFT through a second contact hole **113** which penetrates the passivation film **128**, and is formed to overlap the common electrode **114**. The first and second electrode slits **118**, **119** are made of a plurality of finger parts of a finger shape that are formed parallel to the data lines **103**, **104**.

[0090] In one embodiment, the FFS type liquid crystal display device with such a configuration forms a first fringe field between the common electrode plate **114** and the positive (+) voltage (or negative voltage) in the first pixel electrode slit **118**, and forms a second fringe field between the common electrode plate **114** and the negative (−) voltage in the second pixel electrode slit **119**. For example, liquid crystal molecules arranged in a horizontal direction between a thin film transistor substrate and a color filter substrate are rotated by dielectric anisotropy. Accordingly, it is possible to form two kinds of fringe fields having different polarities from each other within one pixel.

[0091] Accordingly, the same brightness can be expressed irrespective of the location of the common voltage and the magnitude of the feed-through voltage ΔVp for each frame (Fn−1, Fn), for example, solving the flicker problem. In one embodiment, at the same time, as the driving by the positive and negative data is all possible within each pixel, a user sets an optimal common voltage value corresponding to the center of a positive data voltage and a negative data voltage while the flick problem is solved. Accordingly, it is possible to minimize the residual image.

[0092] FIG. **10** is a block diagram illustrating a liquid crystal display device according to a second embodiment. FIG. **11** is a circuit diagram briefly representing one pixel P, for example, in FIG. **10**.

[0093] In the liquid crystal display device shown in FIGS. **10** and **11**, one pixel P is defined by one data line DL and first and second gate lines **1**GL, **2**GL. The liquid crystal display device according to the second embodiment is substantially the same in structure as that of the first embodiment except, for example, the above difference. Accordingly, the same configuration as the first embodiment will be given the same reference numeral, and the repeated explanation will be omitted.

[0094] The liquid crystal display device includes a liquid crystal display panel **230** where m×n pixels P are arranged in a matrix type. A gate driver **220** supplies first and second gate voltages to first and second gate lines **1**GL**1**, **2**GL**1**, **1**GL**2**, **2**GL**2**, . . . , **1**GLm, **2**GLm of the liquid crystal display panel **230**. A data driver **210** supplies first and second data voltages to the data lines DL**1** to DLm. A timing controller **200** controls the data driver **210** and the gate driver **220** by use of a synchronization signal.

[0095] The data driver **210** converts a digital video data RGB into an analog gamma voltage (data signal) corresponding to the gray level value in response to a control signal CS from the timing controller **200**, and supplies the analog gamma voltage to the data lines DL**1** to DLm.

[0096] The gate driver **220** sequentially supplies a gate voltage to the gate lines **1**GL**1**, **2**GL**1**, **1**GL**2**, **2**GL**2**, . . . , **1**GLn, **2**GLn to select a horizontal line of a liquid crystal display panel **230** to which a data signal is supplied in response to the control signal CS from the timing controller **200**.

[0097] As shown in FIG. **11**, each pixel P includes first and second gate lines **1**GL, **2**GL. Data lines DL cross the first and second gate lines **1**GL, **2**GL. A first thin film transistor **1**TFT and a first liquid crystal cell **1**Clc are formed at the crossing area of the first gate line **1**GL and the data line DL. A second thin film transistor **2**TFT and a second liquid crystal cell **2**Clc are formed at the crossing area of the second gate line **2**GL and the data line DL.

[0098] The first thin film transistor **1**TFT supplies the positive (or negative) first data voltage from the data lines DL to the first liquid crystal cell **1**Clc in response to a first gate voltage supplied from the first gate line **1**GL. The second thin film transistor **2**TFT supplies the negative (or positive) second data voltage from the data lines DL to the second liquid crystal cell **2**Clc in response to the second gate voltage supplied from the second gate line **2**GL.

[0099] The first data voltage is supplied from the data line DL and synchronized with the first gate voltage and the second data voltage which is supplied from the data line DL and synchronized with the second gate voltage are the same in magnitude and contrary to each other in polarity. Accordingly, one pixel is also made of two liquid crystal cells **1**Clc, **2**Clc which can be independently driven in the second embodiment. Accordingly, one pixel can be divided into two sub-pixels which realize the same color.

[0100] The drive characteristic of the liquid crystal display device according to the second embodiment will be explained as follows in reference to FIG. **12**. As shown in FIG. **12**, a first gate voltage Vg**1** is supplied to the gate electrode of the first thin film transistor **1**TFT and a positive (or negative) first data voltage **1**Vd is supplied to the source electrode of the first thin film transistor **1**TFT. A second gate voltage Vg**2** is supplied to the gate electrode of the second thin film transistor **2**TFT and a negative (or positive) second data voltage **2**Vd is supplied to the source electrode of the second thin film transistor **2**TFT. For example, the first and second thin film transistors **1**TFT, **2**TFT within one pixel are sequentially turned on by the first and second gate voltages Vg**1**, Vg**2**, and sequentially supply the first and second data voltages **1**Vd, **2**Vd, which are sequentially supplied from one data line DL and of which the polarities are different from each other, to the first and second liquid crystal cells **1**Clc, **2**Clc.

[0101] In order to supply the gate voltage twice within one pixel for one frame, the gate driver **220** that supplies the gate voltage and the data driver **210** that supplies the data voltage are driven at double the speed. For example, if the liquid crystal display device is driven at 60 Hz in the first embodiment of the present invention, the liquid crystal display device is driven at 120 Hz in the second embodiment.

[0102] In one embodiment, a voltage difference between the common voltage Vcom and the first data voltages **1**Vd is the same in magnitude as a voltage difference between the common voltage Vcom and the second data voltages **2**Vd. The polarities of the first and second data voltages **1**Vd, **2**Vd are contrary to each other. If the common voltage Vcom is 0V even though the first data voltage **1**Vd and the second data voltage **2**Vd have the same polarity, the first data voltage **1**Vd and the second data voltage **2**Vd are contrary to each other in polarity. The polarities of the first and second data voltages **1**Vd, **2**Vd become contrary thereto in the next frame in comparison with the previous frame.

[0103] In one embodiment, each pixel is divided into the first and second liquid crystal cells (or sub-pixels) that express the same gray level while having different polarities from each other. Accordingly, the same operation and effect as the first embodiment can be derived. For example, the positive and negative data are simultaneously realized within one pixel even though the magnitude of the feed-through voltage ΔVp is not identical. The effective value for expressing the gray level can be fixed. Accordingly, the same brightness can be expressed irrespective of the location of the common voltage and the magnitude of the feed-through voltage ΔVp for each frame (Fn−1, Fn), and the common voltage is optimized, thereby making it possible to minimize the flickers and the residual images.

[0104] In one embodiment, one pixel P is defined by one data line DL and the first and second gate lines **1**GL, **2**GL. For example, the source electrodes of the first and second thin film transistors **1**TFT, **2**TFT are each connected to the data line DL. The gate electrode of the first thin film transistor **1**TFT is connected to the first gate line **1**GL and the gate electrode of the second thin film transistor **2**TFT is connected to the second gate line **2**GL. The thin film transistor array substrate according to the second embodiment is the same in structure as that of the first embodiment except, for example, such a structural difference.

[0105] Alternatively, the data voltages having different polarities from each other are supplied to the first and second pixel electrode slits **118**, **119**, thus a potential difference is generated between the first pixel electrode slit **118** and the second pixel electrode slit **119**. For example, the drive voltage of the liquid crystal can be reduced from 6V to 3V as in the experimental data, as shown in FIG. **13**, thus it is possible to reduce power consumption.

[0106] In one embodiment, the method of driving the liquid crystal display device by dividing one pixel into the first and second sub-pixels which have different polarities from each other and express the same gray level can not only be applied to the fringe field switch type liquid crystal display device, but also be applied to the liquid crystal display device of the in-plane switch IPS mode where it is driven by the horizontal electric field between the pixel electrode and the common electrode and of the twisted nematic TN mode where it is driven by the vertical electric field.

[0107] In the IPS mode, a common electrode instead of the common electrode plate and the common electrode line shown in FIGS. **9** and **10** is formed parallel to the first and second pixel electrode slits to form the horizontal electric field. The common electrode is formed in a finger shape.

[0108] In one embodiment, the liquid crystal display device and the driving method thereof according to the present invention divides the pixel, which realizes any one color of red R, green G and blue B, into the first and second sub-pixels, which have different polarities from each other and have the same gray level, in order to drive, thus the effective value for expressing the gray level is fixed and stored irrespective of the polarity. For example, the same brightness can be expressed irrespective of the common voltage value and the magnitude of the feed-through voltage ΔVp for each frame, thereby solving the flicker problem.

[0109] In one embodiment, at the same time, the driving by the positive and negative data is all possible within each pixel. The common voltage value has an optimal value with which the residual image is minimized between the positive data voltage and the negative data voltage while the flicker problem is solved. Accordingly, it is possible to minimize the flickers and the residual images.

[0110] Although the present invention has been explained by the embodiments shown in the drawings described above, it should be understood to the ordinary skilled person in the art that the invention is not limited to the embodiments, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.

What is claimed is:

1. A liquid crystal display device, comprising:

a liquid crystal display panel where pixels are defined by gate lines and data lines that are arranged in a matrix shape;

a gate driver that is operable to supply a gate voltage to the liquid crystal display panel;

a data driver that is operable to supply a data voltage to the liquid crystal display panel, and wherein the respective pixels are operable to be independently driven by drive voltages, which have different polarities from each other, and include first and second liquid crystal cells which realize the same gray level.

2. The liquid crystal display device according to claim **1**, wherein each pixel is defined by one gate line which crosses a first data line to which a first data voltage is supplied and a second data line to which a second data voltage is supplied.

3. The liquid crystal display device according to claim **2**, wherein polarities of the first and second data voltages are inverted for each frame.

4. The liquid crystal display device according to claim **2**,

wherein the first liquid crystal cell includes a first thin film transistor located at the crossing area of the gate line and the first data line, a first pixel electrode is connected to the first thin film transistor, and a common voltage supplier forms an electric field with the first pixel electrode; and

wherein the second liquid crystal cell includes a second thin film transistor located at the crossing area of the gate line and the second data line, a second pixel electrode connected to the second thin film transistor, and the common voltage supplier forms an electric field with the second pixel electrode.

5. The liquid crystal display device according to claim **4**, wherein the polarity of a pixel voltage supplied to each of the first and second liquid crystal cells is inverted for each frame.

6. The liquid crystal display device according to claim **4**, wherein the first and second liquid crystal cells have a symmetric structure to each other.

7. The liquid crystal display device according to claim **4**, wherein the first and second pixel electrodes include a plurality of line-shaped finger parts that are parallel to the data line.

8. The liquid crystal display device according to claim **4**, wherein the common voltage supplier includes:

a common electrode plate that is formed in a pixel area where the pixel is provided and forms a fringe electric field with the first and second pixel electrodes; and

a common line that is operable to supply a common voltage to the common electrode plate.

9. The liquid crystal display device according to claim **7**, wherein the common voltage supplier includes:

a finger-shaped common electrode that is located parallel to the finger parts of the first and second pixel electrodes to form a horizontal electric field with the finger part.

10. The liquid crystal display device according to claim **1**, wherein each of the pixels is defined by one data line and first and second gate lines.

11. The liquid crystal display device according to claim **10**, wherein a first data voltage is synchronized with a first gate voltage from the first gate line and is supplied to the data line, and a second data voltage is synchronized with a second gate voltage from the second gate line and is supplied to the data line.

12. The liquid crystal display device according to claim **11**, wherein the first data voltage and the second data voltage have different polarities from each other.

13. The liquid crystal display device according to claim **12**, wherein the polarities of the first and second data voltages are inverted for each frame.

14. The liquid crystal display device according to claim **10**, wherein the first liquid crystal cell includes a first thin film transistor located at the crossing area of the first gate line and the data line, a first pixel electrode is connected to the first thin film transistor, and a common voltage supplier forms an electric field with the first pixel electrode; and the second liquid crystal cell includes a second thin film transistor located at the crossing area of the second gate line and the data line, a second pixel electrode connected to the second thin film transistor, and the common voltage supplier which forms an electric field with the second pixel electrode.

15. The liquid crystal display device according to claim **14**, wherein the polarity of a pixel voltage supplied to each of the first and second liquid crystal cells is inverted for each frame.

16. The liquid crystal display device according to claim **14**, wherein the first and second pixel electrodes include a plurality of line-shaped finger parts that are parallel to the data line.

17. The liquid crystal display device according to claim **14**, wherein the common voltage supplier includes:

a common electrode plate formed in a pixel area where the pixel is provided and which forms a fringe electric field with the first and second pixel electrodes; and

a common line that supplies a common voltage to the common electrode plate.

18. The liquid crystal display device according to claim **16**, wherein the common voltage supplier includes:

a common electrode that is located parallel to the finger parts of the first and second pixel electrodes to form a horizontal electric field with the finger part.

19. The liquid crystal display device according to claim **1**, wherein the pixel realizes any one color of red, green or blue.

20. A driving method of a liquid crystal display device having a liquid crystal display panel where pixels are arranged in a matrix shape, the method comprising:

dividing the respective pixels into first and second liquid crystal cells that can be independently driven;

supplying a common voltage to the first and second liquid crystal cells; and

realizing the same gray level in the first and second liquid crystal cells by supplying the drive voltages, which are the same in magnitude and different in polarity, to the first and second liquid crystal cells.

21. The driving method according to claim **20**, wherein the polarity of a drive voltage supplied to each of the first and second liquid crystal cells is inverted for each frame.

22. The driving method according to claim **20**, wherein the first liquid crystal cell is defined by a gate line and a first data line to which a first data voltage is supplied; and the second liquid crystal cell is defined by the gate line and a second data line to which a second data voltage, which has a different polarity from the first data voltage, is supplied.

23. The driving method according to claim **20**, wherein the first liquid crystal cell is defined by a data line and a first gate line to which a first gate voltage is supplied; and the second liquid crystal cell is defined by the data line and a second gate line to which a second gate voltage is supplied.

24. The driving method according to claim **23**, wherein the step of realizing the same gray level in the first and second liquid crystal cells includes:

supplying the first gate voltage to the first gate line and supplying a first data voltage synchronized with the first gate voltage to the data line to realize a first gray level in the first liquid crystal cell; and

supplying the second gate voltage to the second gate line and supplying a second data voltage synchronized with the second gate voltage to the data line to realize the same gray level as the first gray level in the second liquid crystal cell.

25. The driving method according to claim **24**, wherein the first data voltage and the second data voltage have different polarities from each other.

26. The driving method according to claim **25**, wherein the polarities of the first and second data voltages are inverted for each frame.

27. The driving method according to claim **20**, wherein liquid crystals of the first and second liquid crystal cells are driven by a fringe electric field between the drive voltage and the common voltage.

28. The driving method according to claim **20**, wherein liquid crystals of the first and second liquid crystal cells are driven by a horizontal electric field between the drive voltage and the common voltage.

29. The driving method according to claim **20**, further comprising:

optimizing the magnitude of the common voltage between a first drive voltage supplied to the first liquid crystal cell and a second drive voltage supplied to the second liquid crystal cell after realizing the same gray level in the first and second liquid crystal cells.

* * * * *

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摘要(译)

公开了一种液晶显示装置和驱动方法。液晶显示装置包括液晶显示面板，其中像素由栅极线和以矩阵形状排列的数据线限定。栅极驱动器可操作以向液晶显示面板提供栅极电压。数据驱动器可操作以向液晶显示面板提供数据电压。每个像素可独立操作以由驱动电压驱动，驱动电压具有彼此不同的极性，并包括实现相同灰度级的第一和第二液晶单元。