CLAIMS

1. A liquid crystal display device formed on an insulating substrate and performing pause drive in an alternating-voltage drive mode, the device comprising:

a plurality of scanning signal lines;

a plurality of data signal lines crossing each of the scanning signal lines;

pixel forming portions formed at intersections of the scanning signal lines and the data signal lines;

a correction circuit for outputting either a corrected image signal obtained by subjecting an input image signal to a tone emphasizing process for emphasizing a temporal change in the signal or an image signal being the input image signal not subjected to the tone emphasizing process;

a scanning signal line driver circuit for sequentially selecting and scanning the scanning signal lines;

a data signal line driver circuit for writing signal voltages to the data signal lines in accordance with the image signal, as well as at least one of first and second correction voltages in accordance with the corrected image signal, the first correction voltage having a higher absolute value than the signal voltage, the second correction voltage having a lower absolute value than the signal voltage; and

a timing control circuit for controlling the scanning signal line driver circuit and the data signal line driver circuit, wherein,

the pause drive alternatingly repeats a drive period consisting of a plurality of drive frames and a pause period following the drive period and lasting until the start of the

next drive period,

the correction circuit outputs the corrected image signal to the data signal line driver circuit at least during the first drive frame of the drive period and also outputs the image signal to the data signal line driver circuit during the last drive frame, and

the data signal line driver circuit writes the first or second correction voltage at least once to the data signal line, and further, writes a signal voltage having the same polarity as the written first or second correction voltage, once to the data signal line.

2. The liquid crystal display device according to claim 1, wherein,

the correction circuit includes:

frame memory for storing the input image signal every frame;

a table having stored correction values correlated with grayscale values at least for a current frame for the input image signal; and

an adder circuit for outputting either the corrected image signal or the image signal to the data signal line driver circuit in accordance with the input image signal,

the table provides the adder circuit with a correction value correlated with the grayscale value for the current frame for the input image signal every time the adder circuit is provided with the grayscale value for the current frame, and

the adder circuit outputs the corrected image signal by correcting the grayscale value for the input image signal

with the correction value provided by the table and also outputs the image signal without correcting the grayscale value for the input image signal.

3. The liquid crystal display device according to claim 2, wherein,

the correction circuit further includes a comparator circuit for obtaining a grayscale value for a current frame for the input image signal and a grayscale value for a previous frame stored in the frame memory and outputting the obtained values to the table, and

the table has stored therein correction values correlated with combinations of grayscale values for the current and previous frames for the input image signal, and outputs a correction value for a corresponding one of the combinations to the adder circuit when grayscale values for the current and previous frames for the input image signal are provided by the comparator circuit.

4. The liquid crystal display device according to claim 3, wherein the adder circuit outputs the corrected image signal in each of two or more consecutive drive frames including the first drive frame, and outputs the image signal during the last drive frame.

5. The liquid crystal display device according to claim 3, wherein,

the comparator circuit further obtains an inverting direction in which the input image signal is inverted in polarity for each of the drive periods, and

the table includes first and second tables having different correction values stored for corresponding polarity directions, such that every time grayscale values for the current and previous frames for the input image signal and a polarity direction are provided by the comparator circuit, the adder circuit is provided with a correction value correlated with the grayscale values for the current and previous frames from one of the first and second tables that corresponds to the polarity direction.

6. The liquid crystal display device according to claim 1, wherein,

the correction circuit includes:

frame memory for storing the input image signal every frame;

a comparator circuit for obtaining a grayscale value for a current frame for the input image signal and a grayscale value for a previous frame stored in the frame memory;

a table having correction values stored for essentially equal grayscale values for the current and previous frames for the input image signal; and

an adder circuit for outputting either the corrected image signal or the image signal to the data signal line driver circuit in accordance with the input image signal,

the comparator circuit provides the table with grayscale values for the current and previous frames for the input image signal when the grayscale values for the current and previous frames for the input image signal are essentially equal,

the table outputs to the adder circuit a correction

value correlated with the grayscale values for the current and previous frames provided by the comparator circuit,

when the grayscale values for the current and previous frames for the input image signal are essentially equal, the adder circuit outputs the corrected image signal by correcting the grayscale value for the input image signal with the correction value provided by the table and also outputs the image signal without correcting the grayscale value for the input image signal, and

when the grayscale values for the current and previous frames for the input image signal are essentially not equal, the adder circuit outputs the corrected image signal at least once without correcting the grayscale value for the input image signal.

7. The liquid crystal display device according to claim 6, wherein, when the grayscale values for the current and previous frames for the input image signal are essentially not equal, the adder circuit further outputs the corrected image signal without correcting the grayscale value for the input image signal.

8. The liquid crystal display device according to claim 2 or 6, further comprising a temperature sensor for measuring an ambient temperature around the liquid crystal display device, wherein,

the table includes a plurality of sub-tables having stored different correction values for predetermined temperature ranges, such that one of the sub-tables is selected in accordance with temperature information provided by the

temperature sensor.

9. The liquid crystal display device according to claim 2 or 6, further comprising a temperature sensor for measuring an ambient temperature around the liquid crystal display device, wherein,

the correction circuit further includes nonvolatile memory for storing a plurality of data items for different correction values for predetermined temperature ranges, and

the nonvolatile memory selects one of the data items in accordance with temperature information provided by the temperature sensor and provides the selected data item to the table.

10. The liquid crystal display device according to claim 8 or 9, wherein,

the temperature sensor is provided on the insulating substrate, and

the temperature sensor provides the temperature information to the timing control circuit via serial communication.

11. The liquid crystal display device according to claim 8 or 9, wherein the temperature sensor is provided in the timing control circuit.

12. The liquid crystal display device according to claim 1, wherein the pixel forming portion includes a thin-film transistor having a control terminal connected to the scanning signal line, a first conductive terminal connected to the data

signal line, a second conductive terminal connected to a pixel electrode to which the first correction voltage, the second correction voltage, or the signal voltage is to be applied, and a channel layer formed of an oxide semiconductor.

13. The liquid crystal display device according to claim 12, wherein the oxide semiconductor is InGaZnOx mainly composed of indium (In), gallium (Ga), zinc (Zn), and oxygen (O).

14. The liquid crystal display device according to claim 1, wherein the pixel forming portion includes a thin-film transistor having a control terminal connected to the scanning signal line, a first conductive terminal connected to the data signal line, a second conductive terminal connected to a pixel electrode to which the first correction voltage, the second correction voltage, or the signal voltage is to be applied, and a channel layer formed of either an amorphous semiconductor or a polycrystalline semiconductor.

15. The liquid crystal display device according to any of claims 1 through 14, wherein the liquid crystal display device is driven by dot-by-dot inversion drive, line-by-line inversion drive, column-by-column inversion drive, or frame-by-frame inversion drive in the alternating-voltage drive mode.

16. A method for driving a liquid crystal display device performing pause drive in an alternating-voltage drive mode and including a plurality of scanning signal lines, a

plurality of data signal lines crossing each of the scanning signal lines, pixel forming portions formed at intersections of the scanning signal lines and the data signal lines, a correction circuit for outputting either a corrected image signal obtained by subjecting an input image signal to a tone emphasizing process for emphasizing a temporal change in the signal or an image signal being the input image signal not subjected to the tone emphasizing process, a scanning signal line driver circuit for sequentially selecting and scanning the scanning signal lines, and a data signal line driver circuit for writing to the data signal lines correction voltages in accordance with the corrected image signal or signal voltages in accordance with the image signal, the method comprising the steps of:

outputting the corrected image signal obtained by subjecting the input image signal to the tone emphasizing process for emphasizing the temporal change in the signal to the data signal line driver circuit at least during the first drive frame in a drive period;

outputting the image signal being the input image signal not subjected to the tone emphasizing process to the data signal line driver circuit during the last drive frame in the drive period;

writing at least one of first and second correction voltages at least once to the data signal line in accordance with the corrected image signal subjected to an emphasizing correction process, wherein the first correction voltage has a higher absolute value than the signal voltage, and the second correction voltage has a lower absolute value than the signal voltage; and

writing a signal voltage having the same polarity as the first or second correction voltage, once to the data signal line immediately after the writing of the first or second correction voltage.

CLAIMS

1. A liquid crystal display device formed on an insulating substrate and performing pause drive in an alternating-voltage drive mode, the device comprising:

a plurality of scanning signal lines;

a plurality of data signal lines crossing each of the scanning signal lines;

pixel forming portions formed at intersections of the scanning signal lines and the data signal lines;

a correction circuit for outputting a corrected image signal which is corrected with a correction value for correcting a grayscale value of an input image signal when the correction value is provided to the correction circuit and the input image signal whose grayscale value is not corrected when the correction value is not provided to the correction circuit;

a scanning signal line driver circuit for sequentially selecting and scanning the scanning signal lines;

a data signal line driver circuit for writing either correction voltages generated in accordance with the corrected image signal or signal voltages generated in accordance with the input image signal to the data signal lines; and

a timing control circuit for controlling the scanning signal line driver circuit and the data signal line driver circuit, wherein,

the pause drive alternatingly repeats a drive period

consisting of a plurality of drive frames and a pause period following the drive period and lasting until the start of the next drive period, an image written during the drive period being kept displayed during the pause period,

the correction value is determined only by the grayscale value for a current frame for the input image signal,

the correction circuit includes an adder circuit for outputting either the corrected image signal or the input image signal to the data signal line driver circuit,

the adder circuit outputs a first correction image signal obtained by adding the correction value to the grayscale value for the current frame for the input image signal, a second correction image signal obtained by subtracting the correction value from the grayscale value for the current frame for the input image signal or the input image signal whose grayscale value for the current frame is not corrected to the data signal line driver circuit during a first drive frame of the drive period and also outputs the input image signal to the data signal line driver circuit during a last drive frame of the drive period, and

the data signal line driver circuit respectively generates the signal voltage, a first correction voltage having a higher absolute value than the signal voltage or a second correction voltage having a lower absolute value than the signal voltage based on the input image signal, the first correction image signal or the second correction image signal, and writes the first correction voltage, the second correction voltage or the signal voltage to the data signal line during the first drive frame of the drive period, and further, writes the signal voltage having the same polarity as the voltage written during

the first drive frame, to the data signal line during the last drive frame.

2. The liquid crystal display device according to claim 1, wherein,

the correction circuit includes a table storing the correction values;

the table provides the adder circuit with the correction value correlated with the grayscale value for the current frame for the input image signal every time the adder circuit is provided with the input image signal, and

the adder circuit outputs the first correction image signal when the grayscale value for the current frame for the input image signal is smaller than a boundary value correlated with a predetermined grayscale value, outputs the second correction image signal when the grayscale value for the current frame for the input image signal is larger than the boundary value, and outputs the input image signal when the grayscale value for the current frame for the input image signal is the same as the boundary value.

3. The liquid crystal display device according to claim 2, further comprising a temperature sensor for measuring an ambient temperature around the liquid crystal display device, wherein,

the table includes a plurality of sub-tables having stored different correction values for predetermined temperature ranges, such that one of the sub-tables is selected in accordance with temperature information provided by the temperature sensor.

4. The liquid crystal display device according to claim 2, further comprising a temperature sensor for measuring an ambient temperature around the liquid crystal display device, wherein,

the correction circuit further includes nonvolatile memory for storing a plurality of data items for different correction values for predetermined temperature ranges, and

the nonvolatile memory selects one of the data items in accordance with temperature information provided by the temperature sensor and provides the selected data item to the table.

5. The liquid crystal display device according to claim 3 or 4, wherein,

the temperature sensor is provided on the insulating substrate, and

the temperature sensor provides the temperature information to the timing control circuit via serial communication.

6. The liquid crystal display device according to claim 3 or 4, wherein the temperature sensor is provided in the timing control circuit.

7. The liquid crystal display device according to claim 1, wherein the pixel forming portion includes a thin-film transistor having a control terminal connected to the scanning signal line, a first conductive terminal connected to the data signal line, a second conductive terminal connected to a pixel

electrode to which the first correction voltage, the second correction voltage, or the signal voltage is to be applied, and a channel layer formed of an oxide semiconductor.

8. The liquid crystal display device according to claim 7, wherein the oxide semiconductor is InGaZnOx mainly composed of indium (In), gallium (Ga), zinc (Zn), and oxygen (O).

9. The liquid crystal display device according to claim 1, wherein the pixel forming portion includes a thin-film transistor having a control terminal connected to the scanning signal line, a first conductive terminal connected to the data signal line, a second conductive terminal connected to a pixel electrode to which the first correction voltage, the second correction voltage, or the signal voltage is to be applied, and a channel layer formed of either an amorphous semiconductor or a polycrystalline semiconductor.

10. The liquid crystal display device according to any of claims 1 through 9, wherein the liquid crystal display device is driven by dot-by-dot inversion drive, line-by-line inversion drive, column-by-column inversion drive, or frame-by-frame inversion drive in the alternating-voltage drive mode.

11. A method for driving a liquid crystal display device performing pause drive that alternatingly repeats a drive period consisting of a plurality of drive frames and a pause period following the drive period and lasting until the start of the next drive period, an image written during the drive period being kept displayed during the pause period, the method comprising:

a step of providing

a plurality of scanning signal lines,

a plurality of data signal lines crossing each of

the scanning signal lines,

pixel forming portions formed at intersections of the scanning signal lines and the data signal lines,

a correction circuit for outputting a corrected image signal which is corrected with a correction value for correcting a grayscale value of an input image signal when the correction value is provided to the correction circuit and the input image signal whose grayscale value is not corrected when the correction value is not provided to the correction circuit,

a scanning signal line driver circuit for sequentially selecting and scanning the scanning signal lines,

a data signal line driver circuit for writing to the data signal lines correction voltages generated in accordance with the corrected image signal or signal voltages generated in accordance with the input image signal, and

a timing control circuit for controlling the scanning signal line driver circuit and the data signal line driver circuit;

a step of outputting to the data signal line a first correction image signal obtained by adding a correction value correlated with a grayscale value for a current frame for the input image signal to the grayscale value for the current frame when the grayscale value for the current frame is smaller than a boundary value correlated with a predetermined grayscale value, outputting to the data signal line a second

correction image signal obtained by subtracting the correction value from the grayscale value for the current frame when the grayscale value for the current frame is larger than the boundary value, and outputting to the data signal line the input image signal when the grayscale value for the current frame is the same as the boundary value;

a step of respectively generating the signal voltage, a first correction voltage having a higher absolute value than the signal voltage or a second correction voltage having a lower absolute value than the signal voltage based on the input image signal, the first correction image signal or the second correction image signal;

a step of writing the first correction voltage, the second correction voltage or the signal voltage to the data signal line during a first drive frame of the drive period; and

a step of writing the signal voltage having the same polarity as the voltage written during the first drive frame, to the data signal line during a last drive frame of the drive period.