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(54) **LIQUID CRYSTAL DISPLAY DEVICE WITH SCANNING VOLTAGE ADJUSTING CIRCUIT AND METHOD FOR DRIVING SAME**

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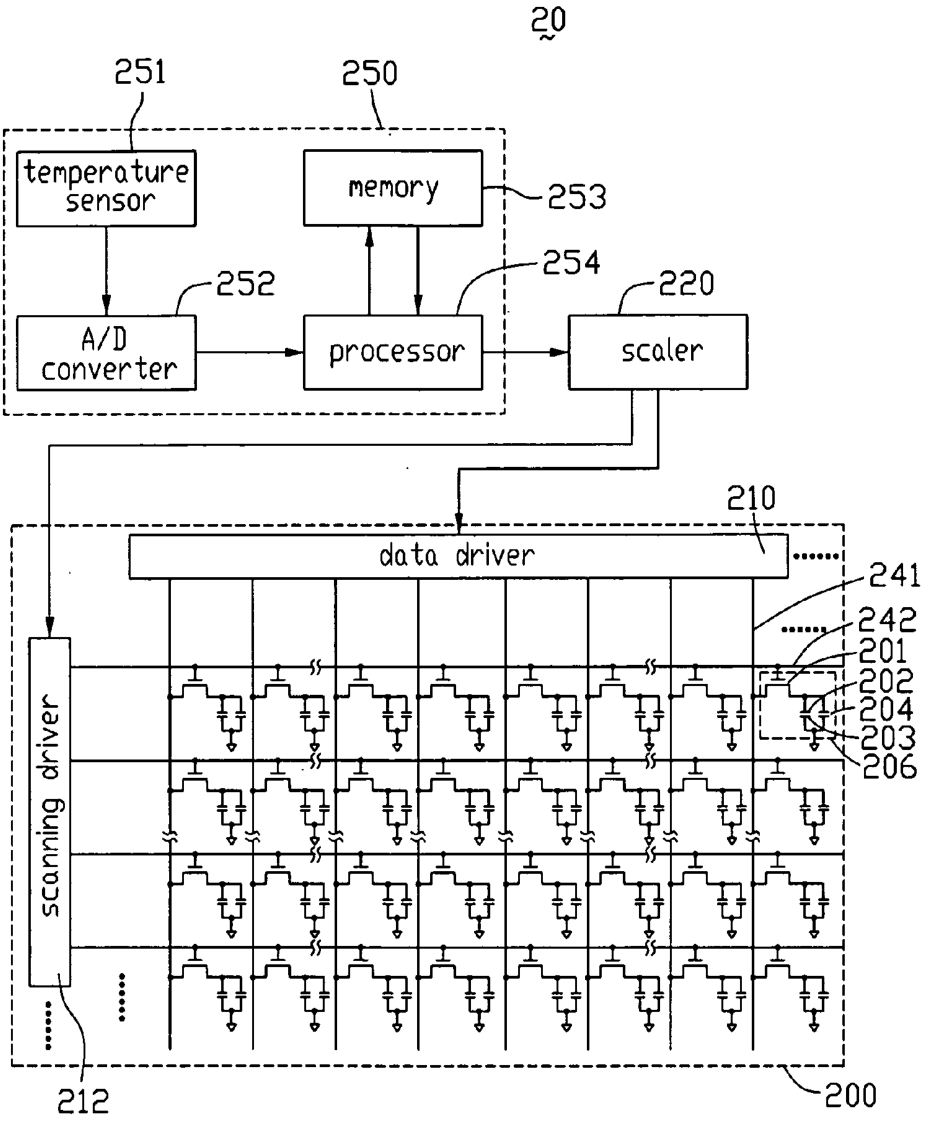
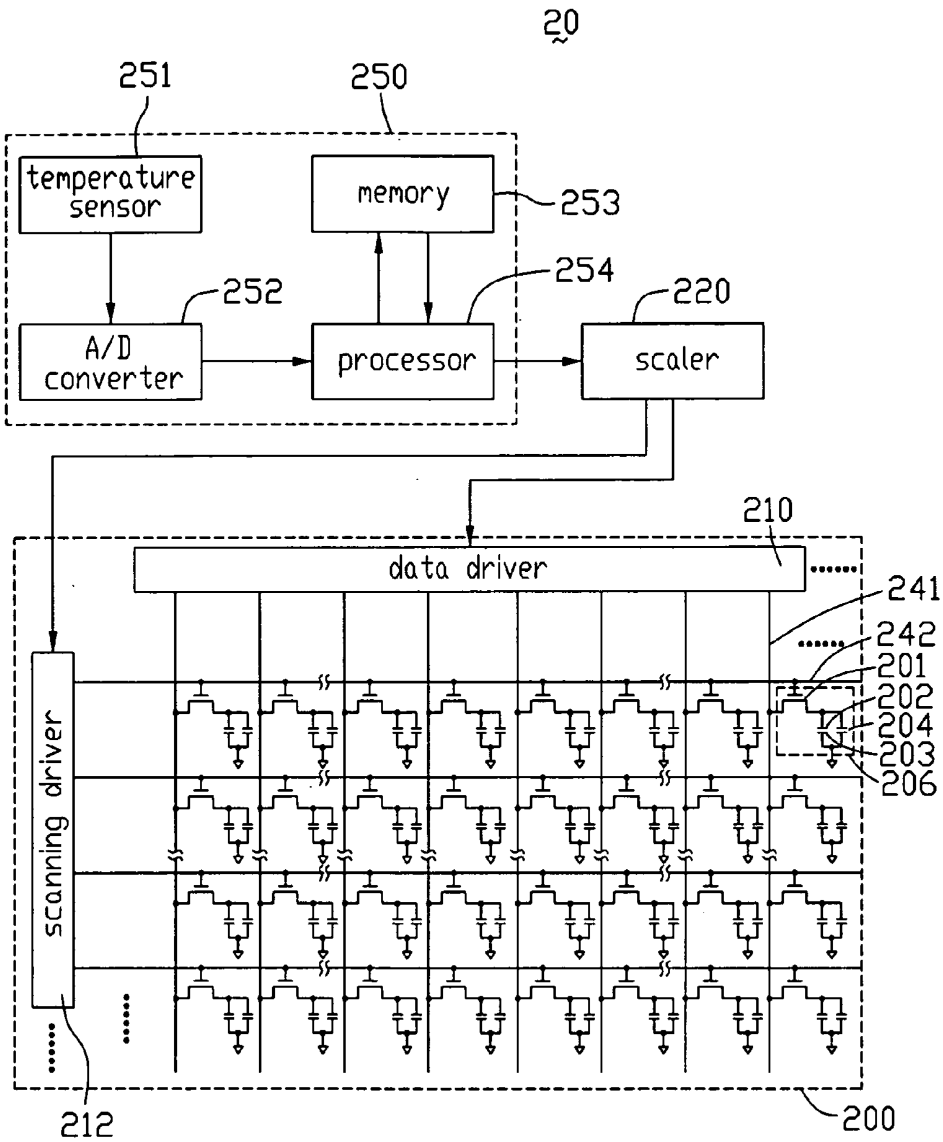
(57) **ABSTRACT**

An exemplary liquid crystal display device includes a scanning voltage adjusting circuit (**250**), a scaler (**220**), and a liquid crystal display panel (**200**). The scanning voltage adjusting circuit is configured for detecting an environment temperature and generating a scanning voltage adjusting signal corresponding to the environment temperature. The scaler is capable of receiving the scanning voltage adjusting signal and generating a scanning voltage according to the scanning voltage adjusting signal. The liquid crystal display (LCD) panel is configured to be driven by the scanning voltage and thereby display images.





20
251
250
temperature sensor
memory
253
254
252
220
A/D converter
processor
scaler
210
data driver
241
242
201
202
204
203
206
scanning driver
212
200

FIG. 1

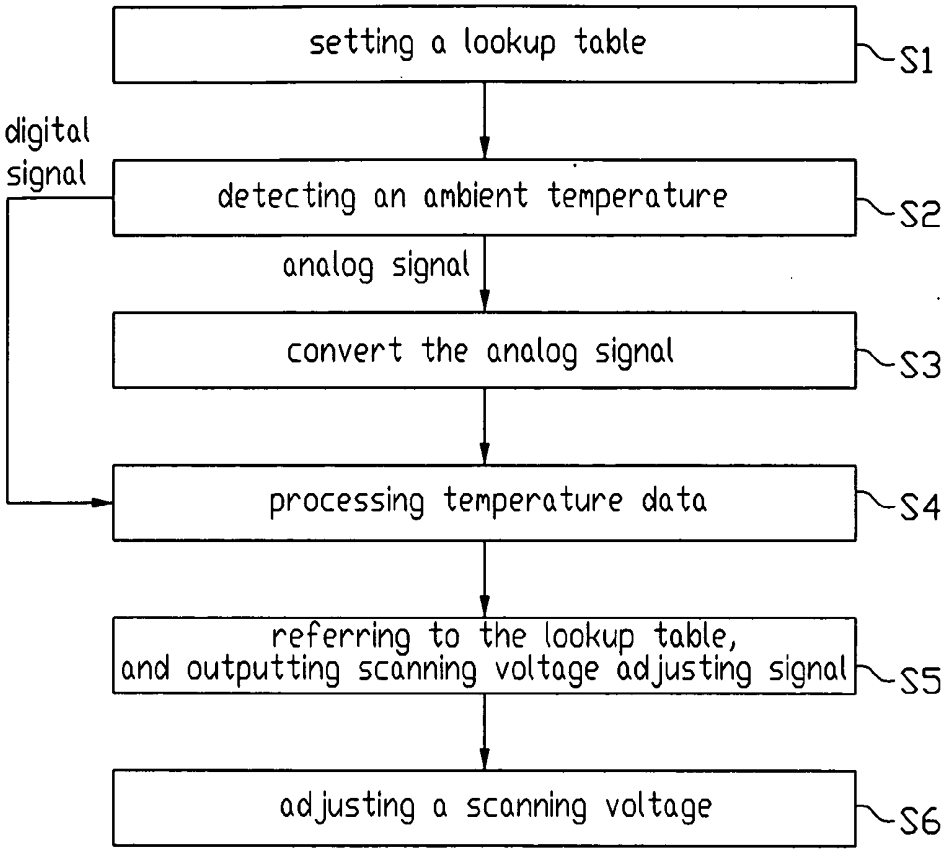

setting a lookup table
S1
digital signal
detecting an ambient temperature
S2
analog signal
convert the analog signal
S3
processing temperature data
S4
referring to the lookup table, and outputting scanning voltage adjusting signal
S5
adjusting a scanning voltage
S6

FIG. 2

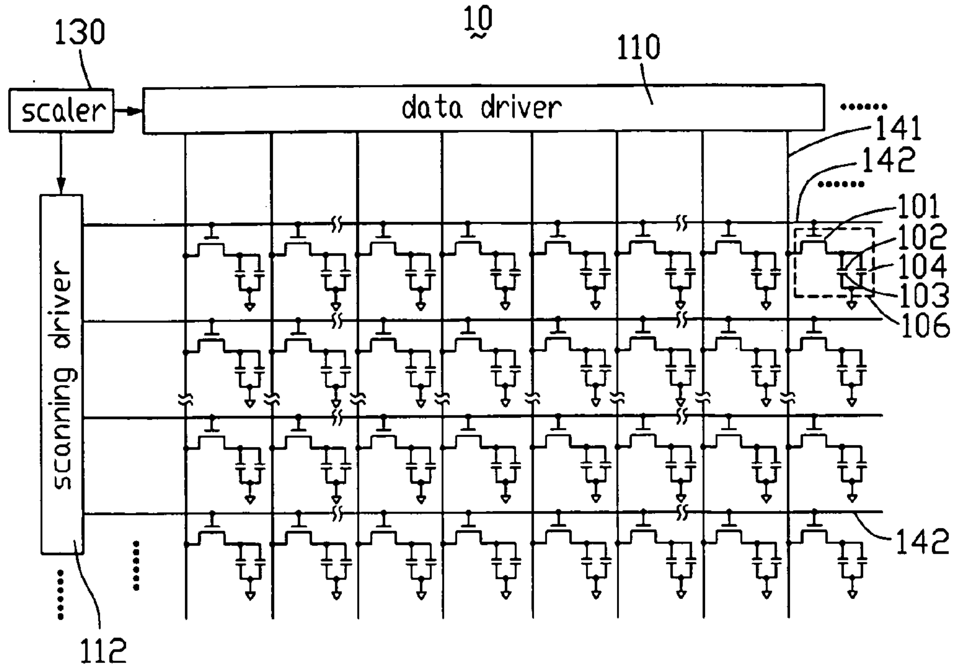


FIG. 3
(RELATED ART)

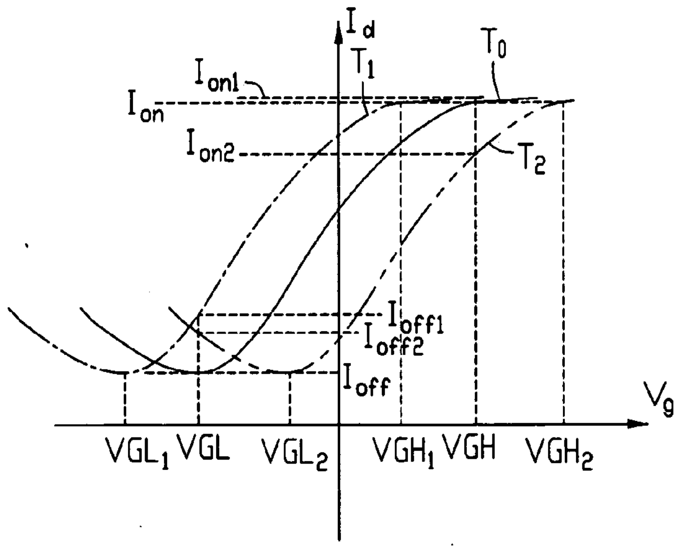


FIG. 4
(RELATED ART)

LIQUID CRYSTAL DISPLAY DEVICE WITH SCANNING VOLTAGE ADJUSTING CIRCUIT AND METHOD FOR DRIVING SAME

FIELD OF THE INVENTION

[0001] The present invention relates to liquid crystal display (LCD) devices and methods for driving LCD devices, and particularly to an LCD device with a scanning voltage adjusting circuit and a method for driving such LCD device.

BACKGROUND

[0002] Because LCD devices have the advantages of portability, low power consumption, and low radiation, they have been widely used in various portable information products such as notebooks, personal digital assistants (PDAs), video cameras, and the like. Furthermore, LCD devices are considered by many to have the potential to completely replace cathode ray tube (CRT) monitors and televisions.

[0003] FIG. **3** is an abbreviated circuit diagram of a conventional LCD device. The LCD device **10** includes a scaler **130**, a data driver **110**, a scanning driver **112**, a multiplicity of data lines **141** connected to the data driver **10**, and a multiplicity of scanning lines **142** connected to the scanning driver **112**. The data lines **141** are arranged parallel to each other with each data line **141** aligned parallel to a first direction. The scanning lines **142** are arranged parallel to each other with each scanning line **142** aligned parallel to a second direction that is perpendicular to the first direction. Thereby, the crossing data lines **141** and scanning lines **142** cooperatively define a multiplicity of pixel regions **106**.

[0004] Each pixel region **106** has a thin film transistor (TFT) **101**, a pixel electrode **102**, a common electrode **103** generally opposite to the pixel electrode **102**, a liquid crystal layer (not shown) sandwiched between the pixel electrode **102** and the common electrode **103**, and a storage capacitor **104**. The pixel electrode **102**, the common electrode **103**, and the liquid crystal layer sandwiched therebetween cooperatively define a liquid crystal capacitor (not labeled). The storage capacitor **104** is connected with the liquid crystal capacitor in parallel.

[0005] The TFT **101** includes a gate electrode (not labeled) connected to the corresponding scanning line **142** for receiving scanning signals therefrom, a source electrode (not labeled) connected to the corresponding data line **142** for receiving display signals therefrom, and a drain electrode (not labeled) connected to the pixel electrode **103** and the storage capacitor **104** for providing display signals thereto.

[0006] In operation, the scaler **130** outputs data signals and scanning signals to the data driver **110** and the scanning driver **112**, respectively. In a first time period, the scanning driver **112** provides a switch-on voltage VGH to the gate electrode of the TFT **101** of each pixel region **106** via the corresponding scanning line **142**. Thus the TFT **101** is switched on, and the data driver **110** then provides a gray scale voltage to the pixel electrode **102** and the storage capacitor **104** via the corresponding data line **141** and the activated TFT **101**. The liquid crystal capacitor and the storage capacitor **104** are charged to the gray scale voltage for displaying images. In a second time period, the scanning driver **112** provides a switch-off voltage VGL to the gate electrode of the TFT **101** via the scanning line **142**. Thus, the TFT **101** is switched off. The gray scale voltage of the liquid crystal capacitor and the storage capacitor **104** is maintained for displaying of images by the LCD device **10**.

[0007] Generally, the TFT **101** is made from semiconductor material. Typically, the electrical properties of the semiconductor material are sensitive to changes in temperature. When the temperature rises or drops, electrical properties of the TFT **101**, such as the current density-voltage (I-V) curve, can change dramatically. The dramatically changed electrical properties may adversely influence the display quality of the LCD device **10**.

[0008] FIG. **4** shows I_d-V_g curves of a sample one of the TFTs **101** of the LCD device **10** at different temperatures. I_d represents a current density flowing through the TFT **101**. V_g represents a scanning voltage applied to the gate electrode of the TFT **101**. Curve T_0 represents an I_d-V_g curve of the TFT **101** at room temperature. Curve T_1 represents an I_d-V_g curve of the TFT **101** at a temperature higher than room temperature. Curve T_2 represents an I_d-V_g curve of the TFT **101** at a temperature lower than room temperature.

[0009] In the LCD field generally, the switch-on voltage VGH of the TFT **101** is set at a point corresponding to a stable high current I_{on}, and the switch-off voltage VGL of the TFT **101** is set at a point corresponding to the lowest current I_{off}. Under conditions where the temperature drifts higher or lower, the switch-on voltages corresponding to the stable high current drift to become VGH_1 and VGH_2, and the switch-off voltages VGL corresponding to the lowest current drift to become VGL_1 and VGL_2. However, in the LCD device **10**, the switch-on and switch-off voltages are predetermined and fixed at VGH and VGL. When the temperature changes, under the control of the switch-on voltage VGH, the switch-on current is I_{on1} or I_{on2}. The switch-on current I_{on1} is higher than the predetermined current I_{on1} and the switch-on current I_{on2} is lower than the predetermined current I_{on}. The higher switch-on current I_{on1} and the lower switch-on current I_{on2} lead to overcharging and undercharging of the liquid crystal capacitor and the storage capacitor **104**, respectively. The higher switch-off currents I_{off1} and I_{off2} lead to leakage currents in the TFT **101**. The overcharging, undercharging, and leakage currents cause abnormal charging or discharging of the liquid crystal capacitor and the storage capacitor **104**. This is liable to degrade the display quality of the LCD device **10**.

[0010] Accordingly, what is needed is an LCD device and a method for driving the LCD device which can overcome the above-described deficiencies.

SUMMARY

[0011] In a first aspect, a liquid crystal display device includes a scanning voltage adjusting circuit, a scaler, and a liquid crystal display panel. The scanning voltage adjusting circuit is configured for detecting an environment temperature and generating a scanning voltage adjusting signal corresponding to the environment temperature. The scaler is capable of receiving the scanning voltage adjusting signal and generating a scanning voltage according to the scanning voltage adjusting signal. The liquid crystal display (LCD) panel is configured to be driven by the scanning voltage and thereby display images.

[0012] In a second aspect, a method for driving a liquid crystal display device is provided. The liquid crystal display device includes a scanning voltage adjusting circuit, a scaler, and a liquid crystal display panel. The method includes the following steps. The scanning voltage adjusting circuit detects an environment temperature and generates a scanning voltage adjusting signal corresponding to the environment temperature. The scaler receives the scanning voltage adjusting signal and generates a scanning voltage according to the scanning voltage adjusting signal to drive the liquid crystal display panel to display an image.

[0013] In a third aspect, a method for driving a liquid crystal display device is provided. The method includes the following steps: providing a liquid crystal display device comprising a scanning voltage adjusting circuit, a scaler, and a liquid crystal display panel; detecting an environment temperature and generating a scanning voltage adjusting signal corresponding to the environment temperature by the scanning voltage adjusting circuit; receiving the scanning voltage adjusting signal, and generating a scanning voltage according to the scanning voltage adjusting signal by the scaler; and driving the liquid crystal display panel with the scanning voltage to display an image.

[0014] Other novel features and advantages will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings. In the drawings, all the views are schematic.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** is essentially an abbreviated circuit diagram of an LCD device according to a preferred embodiment of the present invention.

[0016] FIG. **2** is a flowchart summarizing an exemplary method for driving the LCD device of FIG. **1**.

[0017] FIG. **3** is essentially an abbreviated circuit diagram of a conventional LCD device.

[0018] FIG. **4** shows current density-voltage curves of a sample TFT of the LCD device of FIG. **3** at different temperatures.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0019] Reference will now be made to the drawings to describe various embodiments of the present invention in detail.

[0020] FIG. **1** is an abbreviated circuit diagram of an LCD device according to a preferred embodiment of the present invention. The LCD device **20** includes a scanning voltage adjusting circuit **250**, a scaler **220**, and an LCD panel **200**.

[0021] The scanning voltage adjusting circuit **250** includes a temperature sensor **251**, an analog-to-digital (A/D) converter **252**, a memory **253**, and a processor **254**. The temperature sensor **251** can for example be a thermal resistor or a thermocouple, and is arranged at an outside of the LCD panel **200** for detecting an ambient temperature of the LCD panel **200**. The temperature sensor **251** is connected to the A/D converter **252**, and outputs analog temperature signals to the A/D converter **252**. The A/D converter **252** receives the analog temperature signals, and sends digital temperature signals to the processor **254**. The memory **253** is connected to the processor **254**. The memory **253** is typically a non-volatile random access memory (NVRAM), which can for example be an electrically erasable programmable read-only memory (EEPROM). The processor **254** receives digital temperature signals from the A/D converter **252** and the memory **253**, and then outputs scanning voltage adjusting signals to the scaler **220**.

[0022] The scaler **220** receives the scanning voltage adjusting signals from the processor **254**, and outputs scanning voltages and data voltages to the LCD panel **200**.

[0023] The LCD panel **200** includes a data driver **210** receiving data signals from the scaler **220**, a scanning driver **212** receiving scanning voltages from the scaler **220**, a multiplicity of data lines **241** connected to the data driver **210**, and a multiplicity of scanning lines **242** connected to the scanning driver **212**. The data lines **241** are arranged parallel to each other, and each data line **241** extends parallel to a first direction. The scanning lines **242** are arranged parallel to each other, and each scanning line **242** extends parallel to a second direction that is perpendicular to the first direction. Thereby, the crossing data lines **241** and scanning lines **242** cooperatively define a multiplicity of pixel regions **206**.

[0024] Each pixel region **206** has a thin film transistor (TFT) **201**, a pixel electrode **202**, a common electrode **203** generally opposite to the pixel electrode **202**, a liquid crystal layer (not shown) sandwiched between the pixel electrode **202** and the common electrode **203**, and a storage capacitor **104**. The pixel electrode **202**, the common electrode **203**, and the liquid crystal layer sandwiched therebetween cooperatively define a liquid crystal capacitor (not labeled). The storage capacitor **204** is connected with the liquid crystal capacitor in parallel.

[0025] The TFT **201** includes a gate electrode (not labeled), a source electrode (not labeled), and a drain electrode (not labeled). The gate electrode is connected to the corresponding scanning line **142** for receiving scanning signals therefrom. The source electrode (not labeled) is connected to the corresponding data line **142** for receiving data signals therefrom. The drain electrode (not labeled) is connected to the pixel electrode **103** and the storage capacitor **104** for providing display signals thereto.

[0026] FIG. **2** is a flowchart summarizing an exemplary method for driving the LCD device **20**. The method includes: step S**1**, setting a lookup table; step S**2**, detecting an ambient temperature; step S**3**, converting a temperature signal from an analog signal to a digital signal if the temperature signal is an analog signal; step S**4**, processing temperature data; step S**5**, referring to the lookup table, and outputting a scanning voltage adjusting signal; and step S**6**, adjusting a scanning voltage.

[0027] Regarding step S**1**, due to the complexity of LCD fabrication technology, the switch-on voltages VGH and switch-off voltages VGL of the TFTs **201** are usually different at different temperatures. Accordingly, the precise switch-on voltages VGH and switch-off voltages VGL corresponding to different temperatures T are obtained through experiments. Information on relationships of the switch-on voltage VGH versus the temperature T, and the switch-off voltage VGL versus the temperature T, are stored in the memory **253** in the form of a lookup table. In the lookup table, the information can for example be recorded in the form of eight-digit binary numbers, which range from 00,000,000 to 11,111,111. Thus, 256 steps (or levels) for the scanning voltage can be preset in the memory **253**.

[0028] In step S**2**, the temperature sensor **251** detects an ambient temperature of the LCD panel **200**, and outputs a corresponding temperature signal. The temperature sensor **251** can be a digital sensor that outputs digital temperature signals, or an analog sensor that outputs analog temperature signals.

[0029] In step S**3**, on a condition that the temperature sensor **251** outputs analog temperature signals, the A/D converter **252** converts the analog temperature signal into a digital temperature signal. The digital temperature signal is then transmitted to the processor **254**. In this embodiment, the digital temperature signal is transmitted in the form of an eight-digit binary number in accordance with the temperature information stored in the memory **253**. Alternatively, on a condition that the temperature sensor **252** outputs a digital temperature signal, then step S3 is omitted. The digital temperature information is transmitted to the processor **254** via the AID converter **252** unchanged.

[0030] In step S4, the processor **254** processes the digital temperature signal in order to confirm the ambient temperature conditions. The processing can for example include ignoring invalid data, calculating average temperature values, weighting average temperature values, and variance analysis of the temperature data. Accordingly, the ambient temperature conditions can be confirmed.

[0031] In step S5, when the ambient temperature conditions are confirmed, the processor **254** refers to the lookup table of the memory **253** to find the listed temperature T_x that is the nearest one to the confirmed ambient temperature. Then the switch-on voltage VGH_x and the switch-off voltage VGL_x corresponding to the temperature T_x are set to be the scanning voltages of the TFT **201** of the LCD panel **200**. In order to set up the scanning voltages of the TFT **201**, the processor **254** outputs a scanning voltage adjusting signal to the scaler **220**.

[0032] In step S6, the scaler **220** outputs the switch-on voltage VGH_x and switch-off voltage VGL_x to the scanning driver **212** according to the voltage adjusting signal. Then the scanning driver **212** outputs the switch-on voltage VGH_x and the switch-off voltage VGL_x to switch the TFTs **201** of the LCD panel **200** for displaying of images.

[0033] In the above-described LCD device **200**, the temperature sensor **251** of the scanning voltage adjusting circuit **250** is used to detect the ambient temperature. The processor **254** finds an appropriate switch-on voltage VGH and an appropriate switch-off voltage VGL of the TFTs **201** according to the lookup table stored in the memory **253**, and sends a scanning voltage adjusting signal to the scaler **220** to adjust the scanning voltages output therefrom. Therefore TFTs **201** in the LCD panel **200** are switched on with a higher and stable current flowing therethrough, and are switched off with a lowest current flowing therethrough in accordance with the ambient environment. Accordingly, undercharging, overcharging, and leakage current phenomena are reduced or even eliminated, and the display quality of the LCD device **20** can be significantly improved.

[0034] In an alternative embodiment, the temperature sensor **251** can instead be arranged at a non-display area of the LCD panel **220**. Thus the temperature sensor **251** can detect a precise working temperature of the TFTs **201**, thereby enabling precise adjusting of the scanning voltage. In addition, more than one temperature sensor **251** can be arranged at different positions on or in the LCD panel **220**. Thus the temperature sensors **251** may detect an overall temperature condition of the LCD panel **220**. Furthermore, the scanning voltage adjusting circuit **250** can be formed on a glass substrate used in the LCD panel **200** through system on glass (SOG) technology or chip on glass (COG) technology. This not only increases production efficiency, but also lowers a cost of the LCD device **200**.

[0035] It is to be understood, however, that even though numerous characteristics and advantages of the present embodiments have been set out in the foregoing description, together with details of the structures and functions of the embodiments, the disclosure is illustrative only; and that changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A liquid crystal display device, comprising:

a scanning voltage adjusting circuit configured for detecting an environment temperature and generating a scanning voltage adjusting signal corresponding to the environment temperature;

a scaler capable of receiving the scanning voltage adjusting signal and generating a scanning voltage according to the scanning voltage adjusting signal; and

a liquid crystal display (LCD) panel configured to be driven by the scanning voltage and thereby display images.

2. The liquid crystal display device of claim **1**, wherein the scanning voltage adjusting circuit comprises a memory, at least one temperature sensor, and a processor, information on relationships of scanning voltage versus temperature are stored in the memory, the at least one temperature sensor is configured to detect the environment temperature and send at least one corresponding environment temperature signal to the processor, and the processor is configured to process the at least one environment temperature signal and output a scanning voltage adjusting signal to the scaler according to the information on relationships of scanning voltage versus temperature.

3. The liquid crystal display device of claim **2**, wherein the memory is a non-volatile random access memory.

4. The liquid crystal display device of claim **2**, wherein the at least one temperature sensor is a digital type temperature sensor.

5. The liquid crystal display device of claim **2**, wherein the scanning voltage adjusting circuit further comprises an analog-to-digital converter, the at least one temperature sensor comprises at least one analog type temperature sensor, and the temperature signal detected by the at least one analog type temperature sensor is converted to a digital temperature signal by the analog-to-digital converter and is then sent to the processor.

6. The liquid crystal display device of claim **2**, wherein at least one of the at least one temperature sensor is provided at a non-display area of the LCD panel.

7. The liquid crystal display device of claim **2**, wherein the at least one temperature sensor is one of a thermal resistor and a thermoelectric couple.

8. The liquid crystal display device of claim **2**, wherein the LCD panel comprises a scanning driver connected to the scaler, a data driver connected to the scaler, a plurality of scanning lines connected to the scanning driver, a plurality of data lines connected to the data driver, a plurality of thin film transistors, and a plurality of pixel electrodes, each of the thin film transistors has a gate electrode connected to a corresponding scanning line, a source electrode connected to a corresponding data line, and a drain electrode connected to a corresponding pixel electrode.

9. The liquid crystal display device of claim **1**, wherein the scanning voltage adjusting circuit is formed on the LCD panel through system on glass technology or chip on glass technology.

10. A method for driving a liquid crystal display device, the liquid crystal display device comprising a scanning voltage adjusting circuit, a scaler, and a liquid crystal display panel, the method comprising:

the scanning voltage adjusting circuit detecting an environment temperature and generating a scanning voltage adjusting signal corresponding to the environment temperature; and

the scaler receiving the scanning voltage adjusting signal, and generating a scanning voltage according to the scanning voltage adjusting signal to drive the liquid crystal display panel to display an image.

11. The method of claim **10**, wherein the scanning voltage adjusting circuit comprises a memory, a temperature sensor, and a processor, information on relationships of scanning voltage versus temperature are stored in the memory, and the method further comprises: the temperature sensor detecting the environment temperature, and sending a corresponding environment temperature signal to the processor; and the processor comparing the environment temperature signal with the information stored in the memory to confirm one or more scanning voltages corresponding to the environment temperature, and sending a scanning voltage adjusting signal according to the one or more scanning voltages.

12. The method of claim **11**, wherein the information on relationships of scanning voltage versus temperature comprises relationships of switch-on voltage versus temperature.

13. The method of claim **11**, wherein the information on relationships of scanning voltage versus temperature comprises relationships of switch-off voltage versus temperature.

14. The method of claim **11**, wherein the memory is a non-volatile random access memory.

15. The method of claim **11**, wherein the temperature sensor is one of a thermal resistor and a thermoelectric couple.

16. The method of claim **11**, wherein the temperature sensor is provided at a non-display area of the LCD panel.

17. The method of claim **11**, wherein the scanning voltage adjusting circuit further comprises an analog-to-digital converter, and the temperature sensor is an analog type temperature sensor, and the method further comprises: the analog-to-digital converter converting the temperature signal detected by the temperature sensor to a digital temperature signal, and sending the digital temperature signal to the processor.

18. A method for driving a liquid crystal display device, comprising:

providing a liquid crystal display device comprising a scanning voltage adjusting circuit, a scaler, and a liquid crystal display panel;

detecting an environment temperature and generating a scanning voltage adjusting signal corresponding to the environment temperature by the scanning voltage adjusting circuit;

receiving the scanning voltage adjusting signal, and generating a scanning voltage according to the scanning voltage adjusting signal by the scaler; and

driving the liquid crystal display panel with the scanning voltage to display an image.

19. The method of claim **18**, wherein the scanning voltage adjusting circuit comprises a memory, a temperature sensor, and a processor, information on relationships of scanning voltage versus temperature are stored in the memory, and the method further comprises: the temperature sensor detecting the environment temperature, and sending a corresponding environment temperature signal to the processor; and the processor comparing the environment temperature signal with the information stored in the memory to confirm one or more scanning voltages corresponding to the environment temperature, and sending a scanning voltage adjusting signal according to the one or more scanning voltages.

20. The method of claim **19**, wherein the information on relationships of scanning voltage versus temperature comprises relationships of switch-on voltage versus temperature and relationships of switch-off voltage versus temperature.

* * * * *

专利名称(译)	具有扫描电压调节电路的液晶显示装置及其驱动方法		
公开(公告)号	US20080309609A1	公开(公告)日	2008-12-18
申请号	US12/214173	申请日	2008-06-16
[标]申请(专利权)人(译)	群康科技(深圳)有限公司 群创光电股份有限公司		
申请(专利权)人(译)	INNOCOM科技（深圳）有限公司. 群创光电股份有限公司.		
当前申请(专利权)人(译)	群创光电 INNOCOM科技（深圳）有限公司.		
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摘要(译)

示例性液晶显示装置包括扫描电压调节电路（250），缩放器（220）和液晶显示面板（200）。扫描电压调整电路用于检测环境温度并产生与环境温度对应的扫描电压调整信号。定标器能够接收扫描电压调节信号并根据扫描电压调节信号产生扫描电压。液晶显示（LCD）面板被配置为由扫描电压驱动，从而显示图像。