US 20190333466A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2019/0333466 A1**

ZHOU et al.

(43) **Pub. Date: Oct. 31, 2019**

(54) **GAMMA COMPENSATION CIRCUIT AND DISPLAY DEVICE**

(71) Applicant: **SHENZHEN CHINA STAR OPTOELECTRONICS TECHNOLOGY CO., LTD.**, Shenzhen (CN)

(72) Inventors: **Juan ZHOU**, Shenzhen (CN); **Xianming ZHANG**, Shenzhen (CN)

(21) Appl. No.: **16/247,786**

(22) Filed: **Jan. 15, 2019**

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2018/105787, filed on Sep. 14, 2018.

(30) **Foreign Application Priority Data**

Apr. 25, 2018 (CN) 201810377784.8

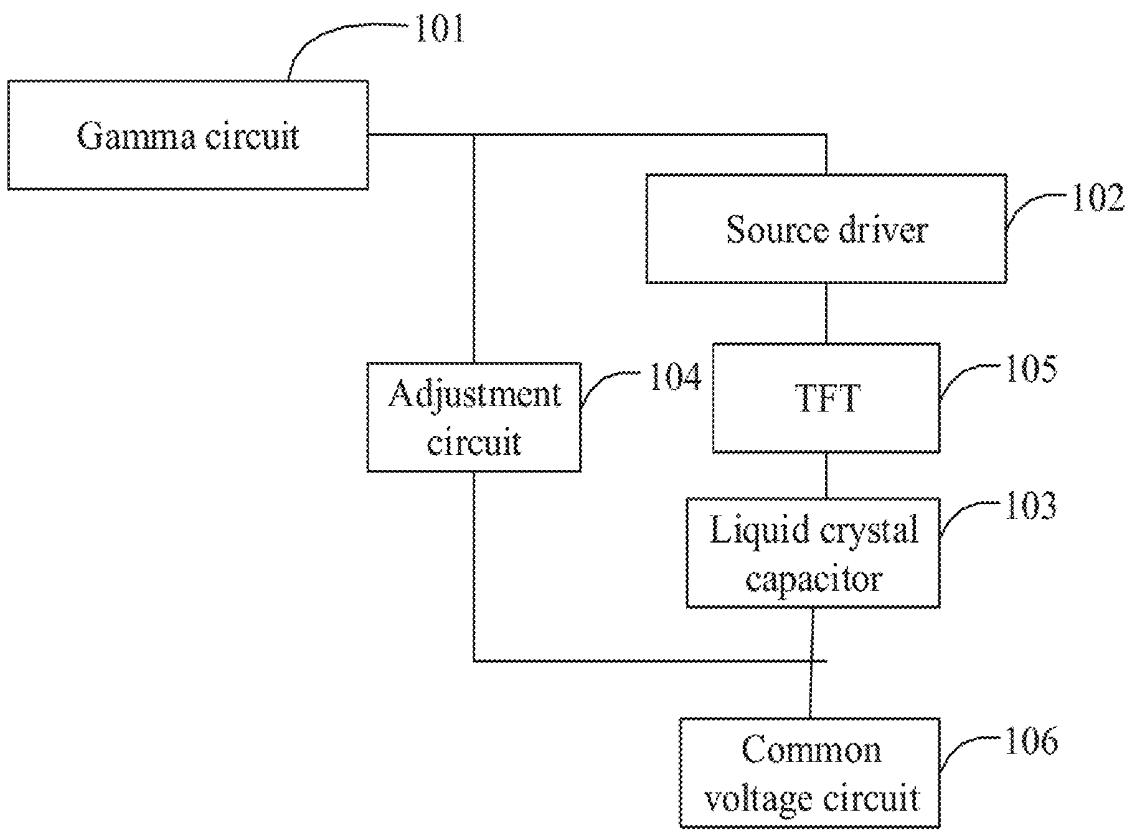
Publication Classification

(51) **Int. Cl.**
G09G 3/36 (2006.01)

(52) **U.S. Cl.**
CPC ... ***G09G 3/3696*** (2013.01); *G09G 2320/0233* (2013.01); *G09G 2320/0276* (2013.01)

(57) **ABSTRACT**

The gamma compensation circuit includes a gamma circuit, a source driver, a TFT, a liquid crystal capacitor, a common voltage circuit, and an adjustment circuit. The gamma circuit has an output terminal connected to an input terminal of the source driver. The source driver has an output an output terminal connected to the source of the TFT. The TFT's drain is connected to a first terminal of the liquid crystal capacitor. The liquid crystal capacitor has a second terminal connected to an output terminal of the common voltage circuit. The adjustment circuit has a first terminal connected to a junction of the output terminal of the gamma circuit and the input terminal of the source driver. The adjustment circuit has a second terminal connected to another junction of the second terminal of the liquid crystal capacitor and the output terminal of the common voltage circuit.



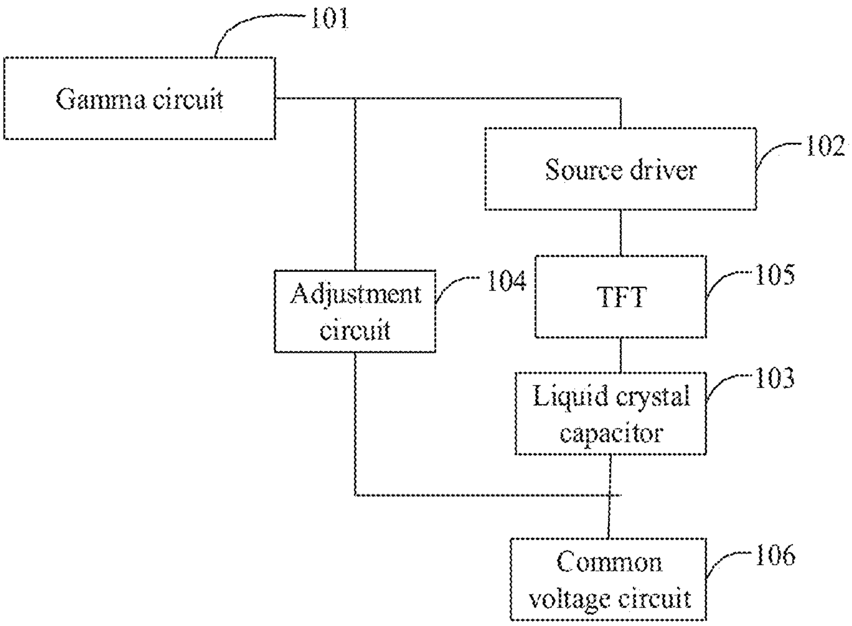

101
Gamma circuit
Source driver
102
Adjustment circuit
104
TFT
105
Liquid crystal capacitor
103
Common voltage circuit
106

FIG. 1

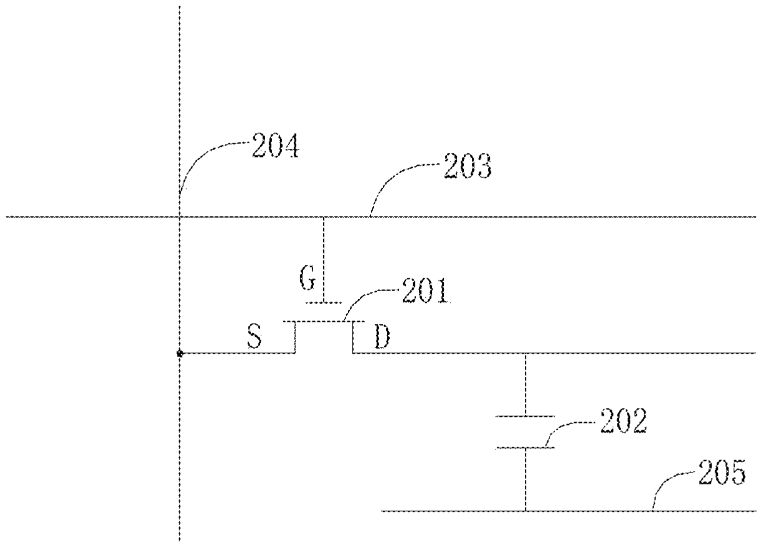


FIG. 2

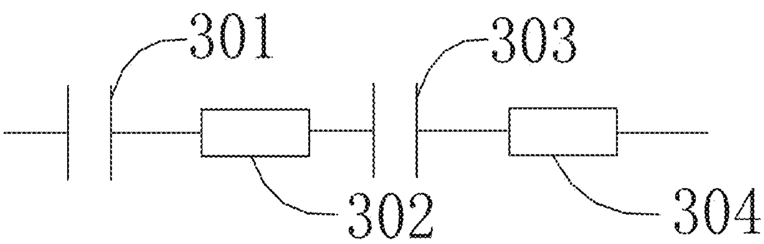


FIG. 3

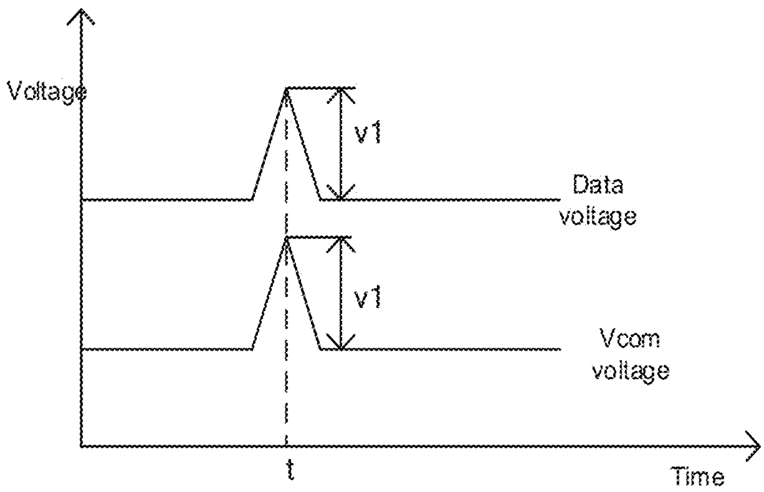

Voltage
v1
Data voltage
v1
Vcom voltage
t
Time

FIG. 4

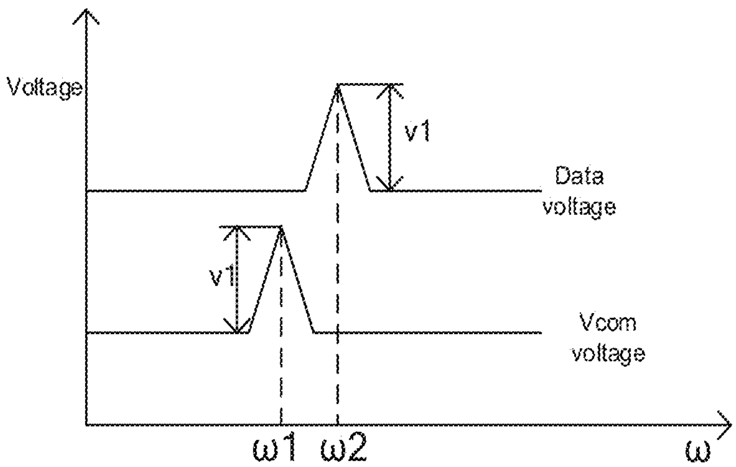

Voltage
v1
Data voltage
v1
Vcom voltage
ω1
ω2
ω

FIG. 5

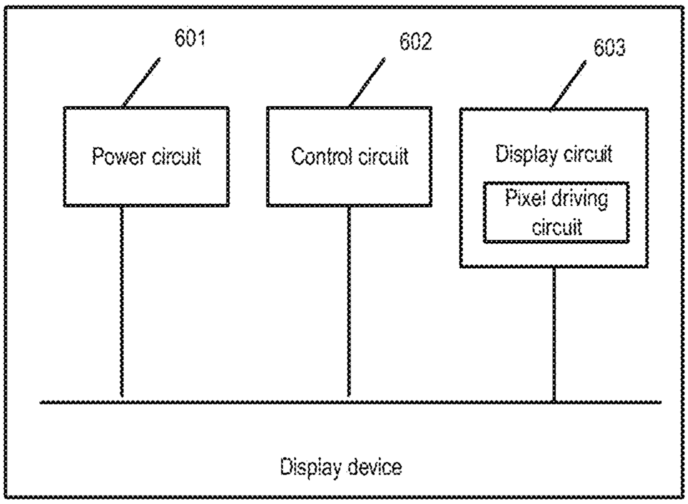

601
602
603
Power circuit
Control circuit
Display circuit
Pixel driving circuit
Display device

FIG. 6

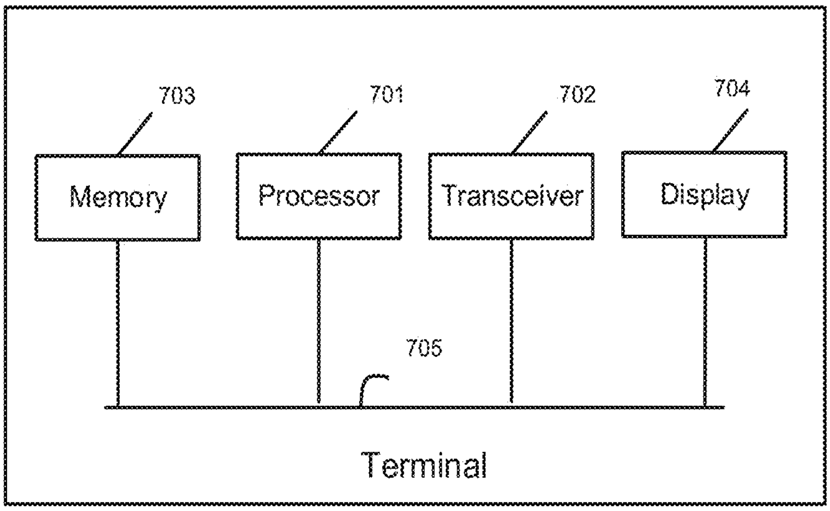

703
701
702
704
Memory
Processor
Transceiver
Display
705
Terminal

FIG. 7

GAMMA COMPENSATION CIRCUIT AND DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuing application of POT Patent Application No. PCT/CN2018/105787, filed on Sep. 14, 2018, which claims priority to Chinese Patent Application No. 201810377784.8, filed on Apr. 25, 2018, both of which are hereby incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

[0002] The present invention is generally related to the field of circuit structure, and more particularly to a gamma compensation circuit and a display device.

BACKGROUND OF THE INVENTION

[0003] In the circuit of a liquid crystal display (LCD) device adopting thin film transistors (TFTs) in a **3**T structure, when the source driver output a row of data voltage to charge liquid crystal capacitors and storage capacitors, capacitance coupling may occur between the data voltage and the common voltage (Vcom), resulting in ripple voltage in Vcom and causing crosstalk. This leads to unstable voltage difference across the liquid crystal capacitor and compromises display quality of the LCD device.

[0004] To improve the impact of the crosstalk, a solution is to use an operation amplifier to conduct negative feedback to compensate Vcom. However, the operation amplifier is limited by its slew rate (SR) and may not timely compensate the high-frequency noises in Vcom. The crosstalk is therefore not satisfactorily resolved, and the display quality is not much improved.

SUMMARY OF THE INVENTION

[0005] The present invention teaches a gamma compensation circuit and a display device effectively reducing the impact by the crosstalk, and enhancing the display quality of the display device.

[0006] The present invention first teaches a gamma compensation circuit, including a gamma circuit, a source driver, a TFT, a liquid crystal capacitor, a common voltage circuit, and an adjustment circuit.

[0007] The gamma circuit has an output terminal connected to an input terminal of the source driver. The source driver has an output an output terminal connected to the source of the TFT. The TFT's drain is connected to a first terminal of the liquid crystal capacitor. The liquid crystal capacitor has a second terminal connected to an output terminal of the common voltage circuit. The adjustment circuit has a first terminal connected to a junction of the output terminal of the gamma circuit and the input terminal of the source driver. The adjustment circuit has a second terminal connected to another junction of the second terminal of the liquid crystal capacitor and the output terminal of the common voltage circuit. The adjustment circuit superimposes a first ripple voltage in a common voltage.

[0008] As the ripple voltage in Vcom is superimposed onto the gamma voltage output from the gamma circuit by the adjustment circuit, the resulted gamma voltage now includes the ripple voltage caused by crosstalk to Vcom. The resulted gamma voltage is then passed to the source driver. The data voltage output from the source driver also includes a component of the ripple voltage. When the data voltage is applied to a terminal of the liquid crystal capacitor, as Vcom operates at another terminal of the liquid crystal capacitor, the impact of the ripple voltage on the voltage difference across the liquid crystal capacitor would be reduced as both Vcom and the data voltage have the same component from the ripple voltage. Therefore, the voltage difference across the liquid crystal capacitor is more stable than the prior art. As the voltage difference across the liquid crystal capacitor determines a grey-level brightness, the gamma compensation circuit of the present invention may achieve uniform grey-level brightness, thereby enhancing display quality of the LCD device.

[0009] The TFT **105** has its gate connected to a scan line.

[0010] The adjustment circuit includes multiple resistors and capacitors series-connected together. Through the multiple capacitors and resistors, DC component in Vcom's feedback voltage is filtered multiple times so that the DC component is significantly reduced or even removed. As such, the DC component's impact to the gamma voltage may be considerably reduced or even removed. The adjustment circuit on one hand introduces ripple voltage into the gamma voltage and, on the other hand, lowers the impact of Vcom's DC component.

[0011] The adjustment circuit may further include a phase adjustment unit. The phase adjustment unit is for adjusting the phase of the first ripple voltage and the phase of the second ripple voltage obtained after the first ripple voltage runs through the series-connected resistors and capacitors of the adjustment circuit. Through the phase adjustment unit, the first and second ripple voltages would have consistent phases, thereby further enhancing the stability of the voltage difference across the liquid crystal capacitor, maintaining the uniformity of grey-level brightness, and improving display quality of the LCD device.

[0012] The common voltage circuit includes operation amplifier and feedback circuit.

[0013] A display device may include multiple above-described TFTs arranged in an array on a panel of the display device. The panel may be a liquid crystal display panel.

[0014] The gamma voltage is output from the output e inal of the gamma circuit. The gamma voltage is input into the source driver.

[0015] A data signal is output from the output terminal of the source driver. The data signal is for adjusting the TFT's grey-level brightness.

[0016] The output terminal of the source driver is connected to source of the TFT through a data line of the display device.

[0017] The present invention also teaches a display device including the gamma compensation circuit described above.

[0018] The present invention further teaches a terminal including the display device described above.

[0019] The present invention has the following advantages.

[0020] As the ripple voltage in Vcom is superimposed onto the gamma voltage output from the gamma circuit by the adjustment circuit, the resulted gamma voltage now includes the ripple voltage caused by crosstalk to Vcom. The resulted gamma voltage is then passed to the source driver. The data voltage output from the source driver also includes a component of the ripple voltage. When the data voltage is applied to a terminal of the liquid crystal capacitor, as Vcom operates at another terminal of the liquid crystal capacitor, the impact of the ripple voltage on the voltage difference across the liquid crystal capacitor would be reduced as both Vcom and the data voltage have the same component from the ripple voltage. Therefore, the voltage difference across the liquid crystal capacitor is more stable than the prior art. As the voltage difference across the liquid crystal capacitor determines a grey-level brightness, the gamma compensation circuit of the present invention may achieve uniform grey-level brightness, thereby enhancing display quality of the LCD device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] In order to more clearly illustrate the embodiments of the present invention or prior art, the following figures will be described in the embodiments are briefly introduced. It is obvious that the drawings are merely some embodiments of the present invention, those of ordinary skill in this field can obtain other figures according to these figures without paying the premise.

[0022] FIG. **1** is a structural schematic diagram showing a gamma compensation circuit according to the present invention.

[0023] FIG. **2** is a circuit diagram showing the connection between a TFT and a liquid crystal capacitor in the gamma compensation circuit of FIG. **1**.

[0024] FIG. **3** is a circuit diagram showing an adjustment circuit in the gamma compensation circuit of FIG. **1**.

[0025] FIG. **4** is a waveform diagram showing a second ripple voltage superimposed on a data voltage in the present invention.

[0026] FIG. **5** is a waveform diagram showing the phase difference between a data voltage and Vcom voltage in the present invention.

[0027] FIG. **6** is a structural schematic diagram showing a display device according to the present invention.

[0028] FIG. **7** is a structural schematic diagram showing a terminal according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0029] The following descriptions for the respective embodiments are specific embodiments capable of being implemented for illustrations of the present invention with referring to appended figures. These embodiments are a portion of all possible embodiments of the present invention. Those of ordinary skill in this field can obtain other embodiments without innovative efforts, and these embodiments should be considered still covered the scope of the present invention.

[0030] It should be noted that terms used in the following description are for describing specific embodiments, and they are not intended to limit the present invention. It should also be noted that singular terms such as “a” “the,” in the following description and the claims should also plural conditions, Unless the context clearly indicates otherwise, terms like “and,” “or,” should also include other or all possible combinations of the referred elements.

[0031] It should also be noted that, throughout the following description, same or similar reference numbers are applied to same or similar elements.

[0032] It should also be noted that, in the following description, reference numbers may be repeated in different embodiments for clarification and simplification sakes. They should not be interpreted that there is a certain relationship between the embodiments.

[0033] It should be noted that that terms “connect,” “connected,” should be interpreted broadly. They may refer to mechanical or electrical connection. They may refer to internal connection, direct connection, or indirect connection through some intermediate element. For those skilled in the related art should be able to understand the correct meaning of these terms.

[0034] To better understand the present invention, the existing solution in the prior art is briefly reviewed as follows. An existing gamma voltage compensation circuit may include power voltage VADD, common voltage Vcom, operation amplifier, output voltage Vcomout, and feedback voltage. Vcom is converted from VADD. Vcom is passed through the operational amplifier and superimposed onto the feedback voltage to obtain Vcomout. Vcomout is applied to the TFT as reference voltage. When influenced by crosstalk, Vcomout is adjusted through negative feedback so as to reduce the impact of crosstalk. However, the operation amplifier is limited by its slew rate (SR) and may not timely compensate the high-frequency noises in Vcom. The crosstalk is therefore not satisfactorily resolved, and the display quality is not much improved.

[0035] As shown in FIG. **1**, a gamma compensation circuit includes a gamma circuit **101**, a source driver **102**, a TFT **105**, a liquid crystal capacitor **103**, a common voltage circuit **106**, and an adjustment circuit **104**.

[0036] The gamma circuit **101** has an output terminal connected to an input terminal of the source driver **102**. The source driver **102** has an output terminal connected to the source of the TFT **105**. The TFT **105**’s drain is connected to a first terminal of the liquid crystal capacitor **103**. The liquid crystal capacitor **103** has a second terminal connected to an output terminal of the common voltage circuit **106**. The adjustment circuit **104** has a first terminal connected to a junction of the output terminal of the gamma circuit **101** and the input terminal of the source driver **102**. The adjustment circuit **104** has a second terminal connected to another junction of the second terminal of the liquid crystal capacitor **103** and the output terminal of the common voltage circuit **106**. The adjustment circuit **104** is for superimposing a first ripple voltage in a common voltage output from the common voltage circuit **106** onto a gamma voltage output from the output terminal of the gamma circuit **101**.

[0037] As the ripple voltage in Vcom is superimposed onto the gamma voltage output from the gamma circuit by the adjustment circuit, the resulted gamma voltage now includes the ripple voltage caused by crosstalk to Vcom. The resulted gamma voltage is then passed to the source driver. The data voltage output from the source driver also includes a component of the ripple voltage. When the data voltage is applied to a terminal of the liquid crystal capacitor, as Vcom operates at another terminal of the liquid crystal capacitor, the impact of the ripple voltage on the voltage difference across the liquid crystal capacitor would be reduced as both Vcom and the data voltage have the same component from the ripple voltage. Therefore, the voltage difference across the liquid crystal capacitor is more stable than the prior art. As the voltage difference across the liquid crystal capacitor determines a grey-level brightness, the gamma compensation circuit of the present invention may achieve uniform grey-level brightness, thereby enhancing display quality of the LCD device.

[0038] Selectively, the TFT **105** has its gate connected to a scan line.

[0039] FIG. **2** shows an embodiment of the connection between the TFT and the liquid crystal capacitor in the gamma compensation circuit of FIG. **1**. As illustrated, the TFT **201** has its source (S) connected to the output terminal **204** of the source driver, its gate (G) connected to the scan line **203**, and its drain (D) connected to the first terminal of the liquid crystal capacitor **202**. The liquid crystal capacitor **202** has the second terminal connected to Vcom **205**. Please note that the scan line **203** and Vcom **205** are simplified as single lines in the drawing. When the scan line **203** provides a scan signal, the TFT **201** is turned on. A data signal is supplied by the source driver through a data line. The Vcom **205** has a constant voltage. The brightness adjustment to the TFT is achieved through the data signal.

[0040] As shown in FIG. **3**, the adjustment circuit includes a first capacitor **301**, a second capacitor **303**, a first resistor **302**, and a second resistor **304**. The first capacitor **301** has a first terminal connected a first terminal of the first resistor **302**. The first resistor **302** has a second terminal connected to a first terminal of the second capacitor **303**. The second capacitor **303** has a second terminal connected to a first terminal of the second resistor **304**. By configuring two capacitors, DC component in Vcom's feedback voltage is filtered twice so that the DC component is significantly reduced or even removed and a pure second ripple voltage is obtained. As such, the DC component's impact to the gamma voltage output from the gamma circuit may be considerably reduced or even removed. In other words, the adjustment circuit on one hand introduces ripple voltage into the gamma voltage and, on the other hand, lowers the impact of Vcom's DC component. FIG. **4** shows how the second ripple voltage is superimposed onto the data voltage. As illustrated, if Vcom is raised v**1** due to the crosstalk resulted from capacitance coupling, the fluctuation is also superimposed onto the data voltage and the data voltage also rises for v**1**. The voltage difference across the liquid crystal capacitor therefore remains stable, thereby achieving uniform grey-level brightness.

[0041] The adjustment circuit may further include a phase adjustment unit. The phase adjustment unit is for adjusting the phase of the first ripple voltage and the phase of the second ripple voltage obtained after the first ripple voltage runs through the series-connected resistors and capacitors of the adjustment circuit. Through the phase adjustment unit, the first and second ripple voltages would have consistent phases, thereby further enhancing the stability of the voltage difference across the liquid crystal capacitor, maintaining the uniformity of grey-level brightness, and improving display quality of the LCD device. FIG. **5** shows the phase difference between the data voltage and Vcom. As illustrated, after the first ripple voltage runs through the series-connected resistors and capacitors of the adjustment circuit, a phase delay (ω**2**−ω**1**) is introduced into the second ripple voltage, where ω is the angular frequency. As such, the liquid crystal capacitor may have varying voltage difference at different times. It may even be possible that that a second ripple may occur when the second ripple voltage is not superimposed at appropriate times. The second ripple may severely affect grey-level brightness uniformity and display quality. Through the phase adjustment unit in the adjustment circuit, it may adjust the phase ω**2** to be consistent with the phase ω**1**, thereby enhancing the stability of the voltage difference across the liquid crystal capacitor and the uniformity of grey-level brightness, and improving display quality of the LCD device.

[0042] The common voltage circuit includes operation amplifier and feedback circuit.

[0043] A display device may include multiple above-described TFTs arranged in an array on a panel of the display device. The panel may be a liquid crystal display panel.

[0044] The gamma voltage is output from the output e inal of the gamma circuit. The gamma voltage is input into the source driver.

[0045] A data signal is output from the output terminal of the source driver. The data signal is for adjusting the TFT's grey-level brightness.

[0046] The output terminal of the source driver is connected to source of the TFT through a data line of the display device.

[0047] The present invention also teaches a display device including the gamma compensation circuit shown in FIG. **1**.

[0048] FIG. **6** is a structural schematic diagram showing the display device. As illustrated, the display device includes a power circuit **601**, a control circuit **602**, and a display circuit **603**. The display circuit **603** includes a pixel driving circuit. The power circuit **601** converts an input voltage into appropriate voltage and current required by the display device. The control circuit **602** controls the display circuit **603** so that the pixel driving circuit may turn on and off lighting elements so as to show various texts and pictures. The display circuit **603** also includes an array of lighting elements such as LED lamps, OLED lamps, or other similar elements. The present invention does not impose specific requirement on the types of the lighting elements. It should be noted that the above description is for illustration only. In alternative embodiments, the display device may include a control circuit and a display circuit with the power circuit integrated into the control circuit.

[0049] The present invention further teaches a terminal including the above described display device.

[0050] FIG. **7** is a structural schematic diagram showing the terminal. As illustrated, the terminal includes one or more processors **701**, a transceiver **702**, a memory **703**, a display **704**, and a bus **705**. The processor **701**, transceiver **702**, memory **703**, and display **704** are connected through the bus **703** or other means. In the present embodiment, the processor **701**, transceiver **702**, memory **703**, and display **704** are connected through the bus **703**.

[0051] The processor **701** may be central processing unit (CPU), other general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or other programmable logic device, transistor logic device, discrete hardware assembly, etc. The general-purpose processor may be a microprocessor or any other routine processor.

[0052] The memory **703** stores instruction and/or data for the processor **701**. The memory **703** may include read-only memory (ROM), random access memory (RAM). A portion of the memory **703** may also be non-volatile RAM. The memory **703** may also store various messages.

[0053] The processor **701** accesses codes stored in the memory **702** through the bus **703** to perform various functions.

[0054] The display **704** displays various texts, pictures processed by the processor **701**.

[0055] Above are embodiments of the present invention, which does not limit the scope of the present invention. Any equivalent amendments within the spirit and principles of the embodiment described above should be covered by the protected scope of the invention.

What is claimed is:

1. A gamma compensation circuit for a display device, comprising a gamma circuit, a source driver, a thin film transistor (TFT), a liquid crystal capacitor, a common voltage circuit, and an adjustment circuit, wherein

the gamma circuit has an output terminal connected to an input terminal of the source driver; the source driver has an output terminal connected to the source of the TFT; the TFT's drain is connected to a first terminal of the liquid crystal capacitor; the liquid crystal capacitor has a second terminal connected to an output terminal of the common voltage circuit; the adjustment circuit has a first terminal connected to a junction of the output terminal of the gamma circuit and the input terminal of the source driver; the adjustment circuit has a second terminal connected to another junction of the second terminal of the liquid crystal capacitor and the output terminal of the common voltage circuit; and the adjustment circuit converts a first ripple voltage in a common voltage output from the common voltage circuit into a second ripple voltage, and superimposes the second ripple voltage onto a gamma voltage.

2. The gamma compensation circuit according to claim **1**, wherein the TFT has its gate connected to a scan line of the display device.

3. The gamma compensation circuit according to claim **1**, wherein the adjustment circuit comprises a plurality of resistors and a plurality of capacitors series-connected together.

4. The gamma compensation circuit according to claim **1**, wherein the adjustment circuit further comprises a phase adjustment unit for adjusting a first phase of the first ripple voltage and a second phase of the second ripple voltage so that the first and second phases are identical.

5. The gamma compensation circuit according to claim **1**, wherein the common voltage circuit comprises at least an operational amplifier and a feedback circuit.

6. The gamma compensation circuit according to claim **1**, wherein the display device comprises a plurality of the TFTs arranged in an array on a panel of the display device; and the panel is a liquid crystal display panel.

7. The gamma compensation circuit according to claim **6**, wherein the gamma voltage is output from the output terminal of the gamma circuit; and the gamma voltage is input into the source driver.

8. The gamma compensation circuit according to claim **6**, wherein a data signal is output from the output terminal of the source driver; and the data signal adjusts the TFT's grey-level brightness.

9. The gamma compensation circuit according to claim **1**, wherein the output terminal of the source driver is connected to source of the TFT through a data line of the display device.

10. A display device, comprising a gamma compensation circuit as claimed in claim **1**.

11. The display device according to claim **10**, wherein the TFT has its gate connected to a scan line.

12. The display device according to claim **10**, wherein the adjustment circuit comprises a plurality of resistors and a plurality of capacitors series-connected together.

13. The display device according to claim **12**, wherein the adjustment circuit further comprises a phase adjustment unit for adjusting a first phase of the first ripple voltage and a second phase of the second ripple voltage so that the first and second phases are identical.

14. The display device according to claim **10**, wherein the common voltage circuit comprises at least an operational amplifier and a feedback circuit.

15. The display device according to claim **10**, wherein the display device comprises a plurality of the TFTs arranged in an array on a panel of the display device; and the panel is a liquid crystal display panel.

16. The display device according to claim **15**, wherein the gamma voltage is output from the output terminal of the gamma circuit; and the gamma voltage is input into the source driver.

17. The display device according to claim **15**, wherein a data signal is output from the output terminal of the source driver; and the data signal adjusts the TFT's grey-level brightness.

18. The display device according to claim **10**, wherein the output terminal of the source driver is connected to source of the TFT through a data line of the display device.

* * * * *

专利名称(译)	伽马补偿电路及显示装置		
公开(公告)号	US20190333466A1	公开(公告)日	2019-10-31
申请号	US16/247786	申请日	2019-01-15
[标]申请(专利权)人(译)	深圳市华星光电技术有限公司		
申请(专利权)人(译)	深圳市中国星光电科技有限公司.		
当前申请(专利权)人(译)	深圳市中国星光电科技有限公司.		
[标]发明人	ZHOU JUAN ZHANG XIANMING		
发明人	ZHOU, JUAN ZHANG, XIANMING		
IPC分类号	G09G3/36		
CPC分类号	G09G3/3696 G09G2320/0276 G09G2320/0233 G09G2320/0209 G09G2320/0673		
优先权	201810377784.8 2018-04-25 CN		
外部链接	Espacenet USPTO		

摘要(译)

伽马补偿电路包括伽马电路，源极驱动器，TFT，液晶电容器，公共电压电路和调节电路。伽马电路的输出端子连接到源极驱动器的输入端子。源极驱动器的输出端连接到TFT的源极。 TFT的漏极连接到液晶电容器的第一端子。液晶电容器的第二端子连接到公共电压电路的输出端子。调节电路的第一端子连接到伽马电路的输出端子与源极驱动器的输入端子的连接点。调节电路的第二端子连接到液晶电容器的第二端子和公共电压电路的输出端子的另一结。