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(54) **DISPLAY DRIVER AND DISPLAYING METHOD FOR CASCADE APPLICATION**

(71) Applicant: **Novatek Microelectronics Corp.**, Hsinchu (TW)

(72) Inventors: **Jen-Wei Li**, Taichung (TW); **Jen-Hao Liao**, Hsinchu County (TW)

(73) Assignee: **Novatek Microelectronics Corp.**, Hsinchu (TW)

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G09G 3/36 (2006.01)

(52) **U.S. Cl.**
CPC ***G09G 3/20*** (2013.01); ***G09G 3/3685*** (2013.01); *G09G 2310/027* (2013.01); *G09G 2310/0243* (2013.01); *G09G 2310/0291* (2013.01); *G09G 2310/0297* (2013.01); *G09G 2320/0276* (2013.01); *G09G 2320/0673* (2013.01); *G09G 2330/028* (2013.01)

(58) **Field of Classification Search**
CPC G09G 3/20; G09G 3/3685; G09G 2310/0243; G09G 2310/0291; G09G 2310/027; G09G 2330/028; G09G 2320/0276; G09G 2310/0297; G09G 2320/0673
See application file for complete search history.

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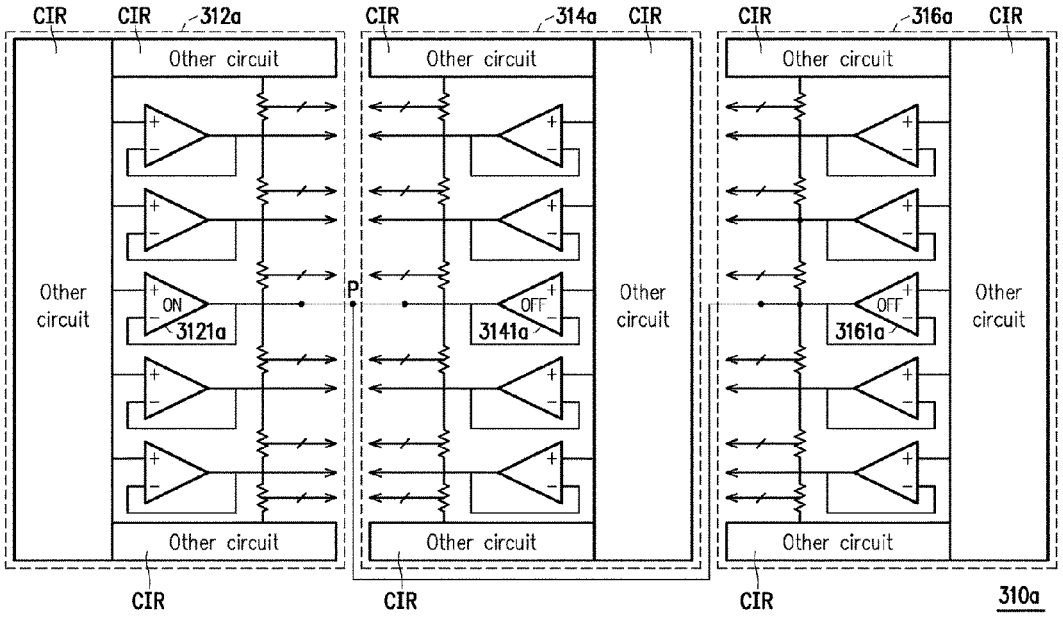
Primary Examiner — Christina Y. Leung
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

A display driver that includes a first driver integrated circuit being cascaded to a second driver integrated circuit is introduced. The first driver integrated circuit includes a first gamma voltage generator that is configured to output a plurality of first gamma voltages to output terminals of the first gamma voltage generator. The second driver integrated circuit includes a second gamma voltage generator that is configured to output a plurality of second gamma voltages to output terminals of the second gamma voltage generator. Each of the output terminals of the first gamma voltage generator is corresponded to one of the output terminals of the second gamma voltage generator. At least one of the output terminals of the first gamma voltage generator is electrically coupled to the corresponding one of the output terminals of the second gamma voltage generator to output at least one common gamma voltage of the first gamma voltages and the second gamma voltages. A method adapted to the display driver is also introduced.

26 Claims, 9 Drawing Sheets



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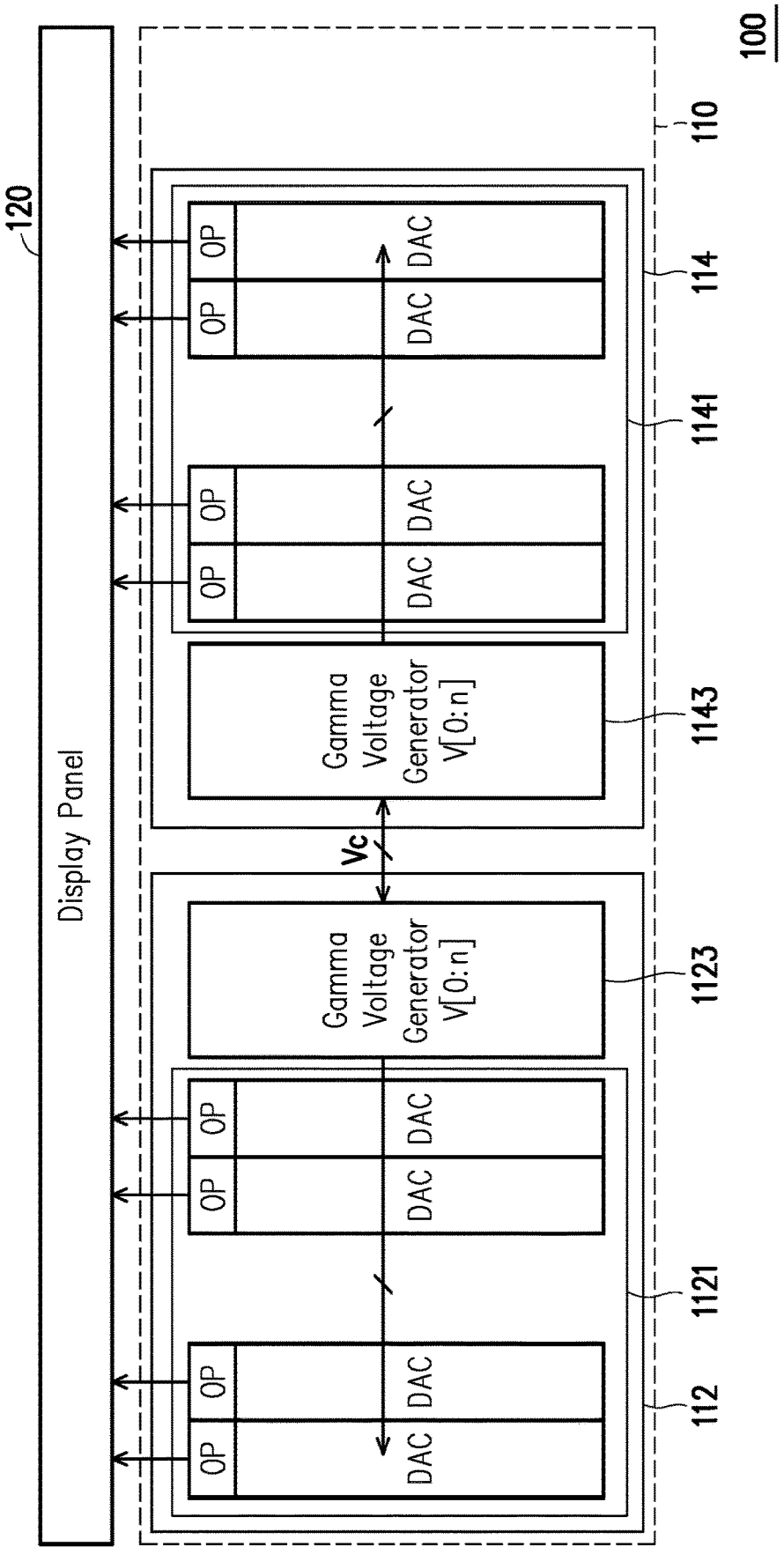
100
110
120
Display Panel
114
1141
1143
1123
1121
112
Gamma Voltage Generator V[0:n]
Vc
OP
DAC

FIG. 1

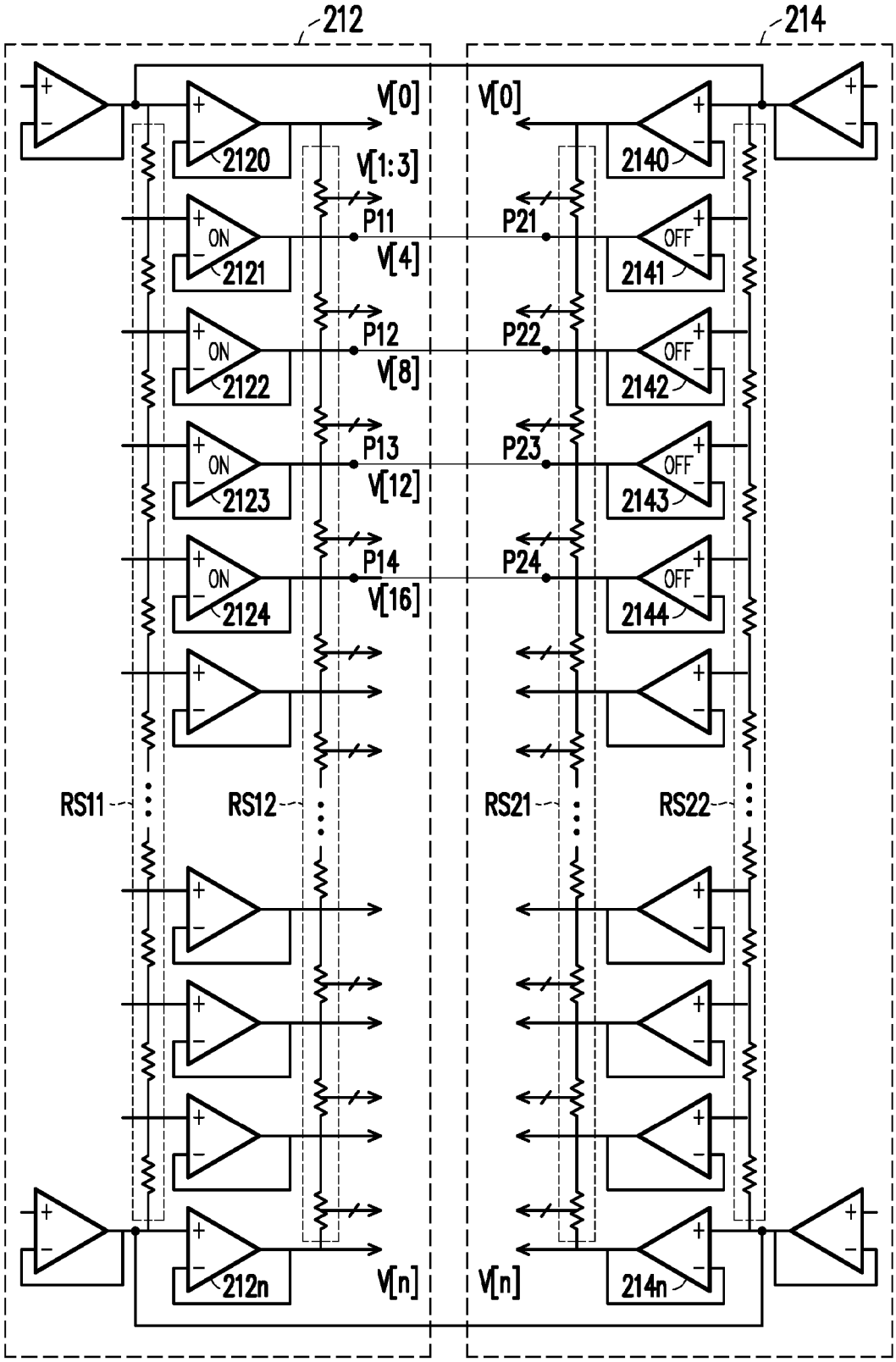
212
214
V[0]
V[0]
2120
2140
V[1:3]
P11
P21
ON
OFF
2121
2141
V[4]
P12
P22
ON
OFF
2122
2142
V[8]
P13
P23
ON
OFF
2123
2143
V[12]
P14
P24
ON
OFF
2124
2144
V[16]
RS11
RS12
RS21
RS22
212n
214n
V[n]
V[n]
210

FIG. 2

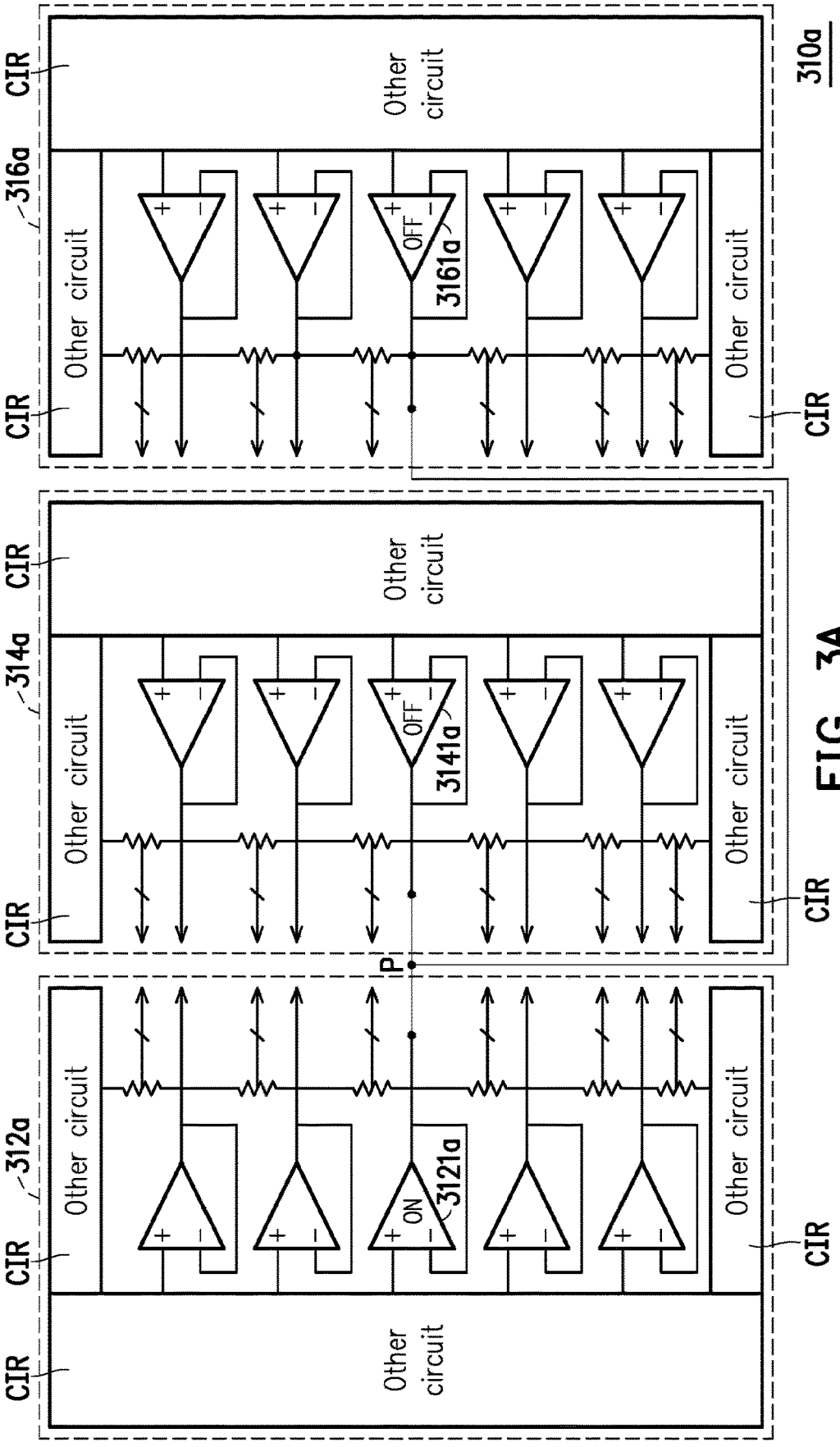
310a
CIR
316a
Other circuit
3161a
OFF
314a
3141a
312a
3121a
ON
P

FIG. 3A

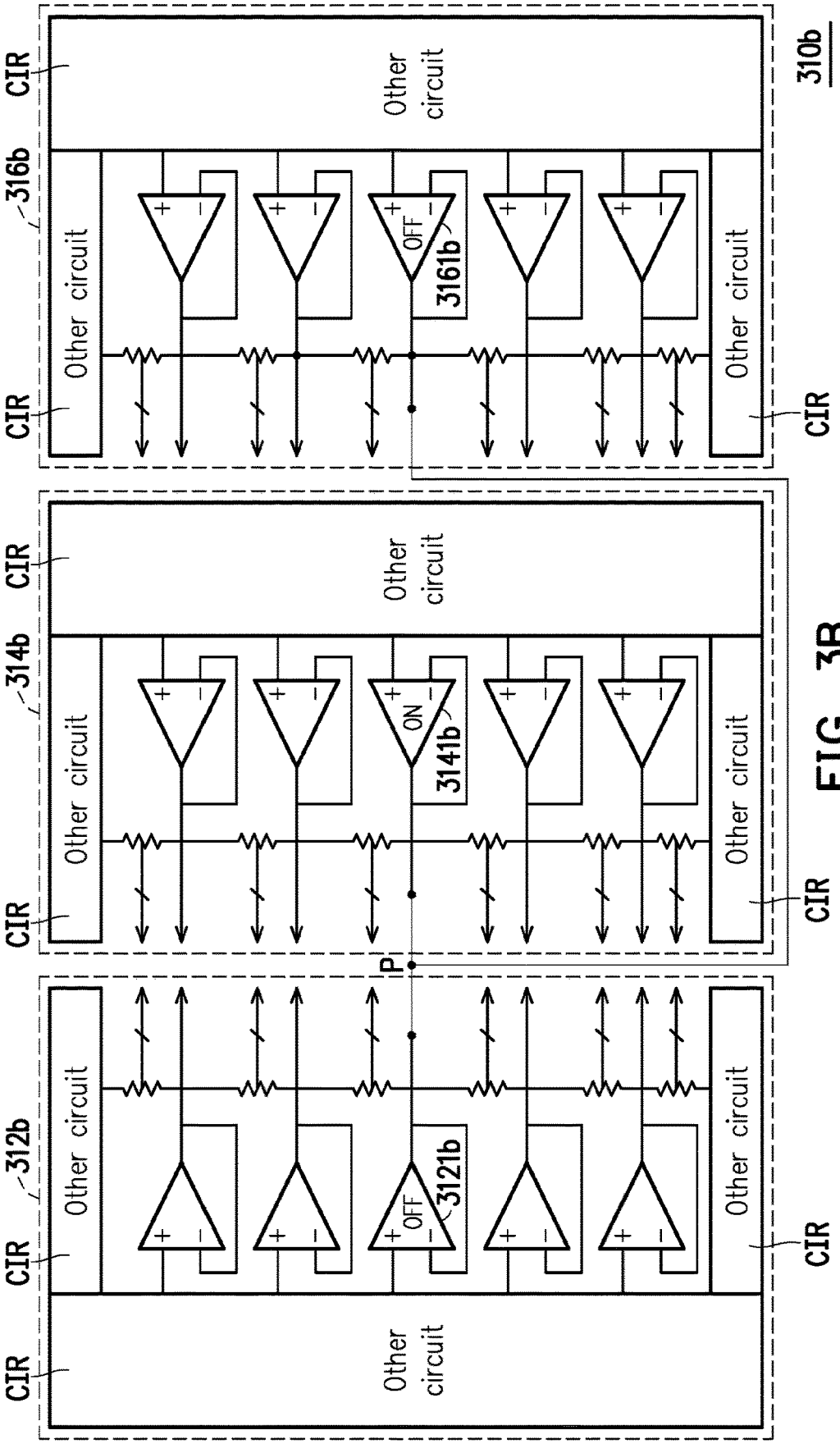
CIR
Other circuit
310b
316b
Other circuit
3161b
OFF
Other circuit
CIR
CIR
Other circuit
314b
Other circuit
3141b
ON
Other circuit
CIR
P
CIR
312b
Other circuit
3121b
OFF
Other circuit
CIR
CIR
Other circuit

FIG. 3B

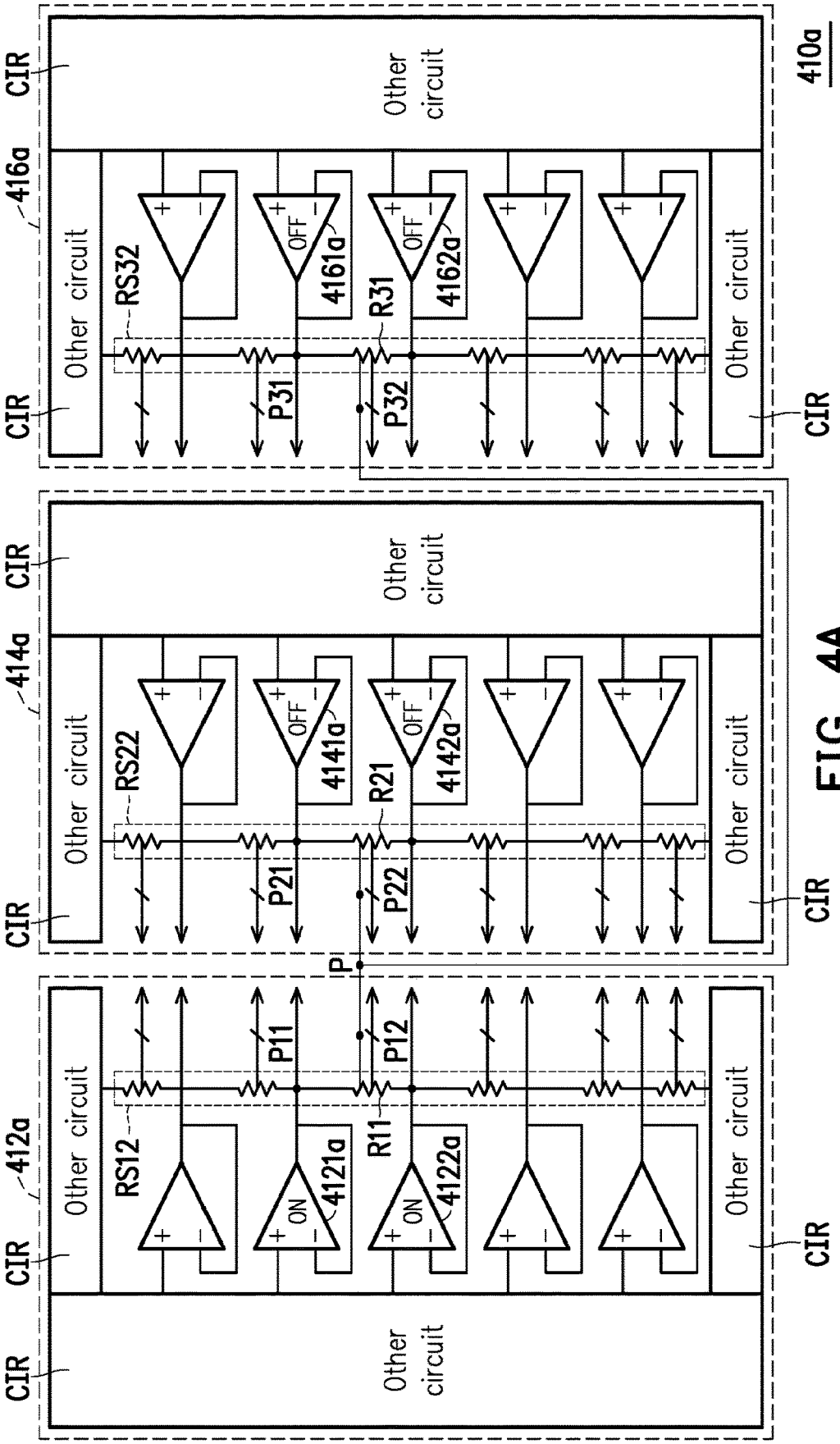
410a
CIR
Other circuit
416a
Other circuit
RS32
4161a
OFF
R31
4162a
OFF
P31
P32
414a
RS22
4141a
R21
4142a
P21
P22
P
412a
RS12
4121a
ON
R11
4122a
ON
P11
P12

FIG. 4A

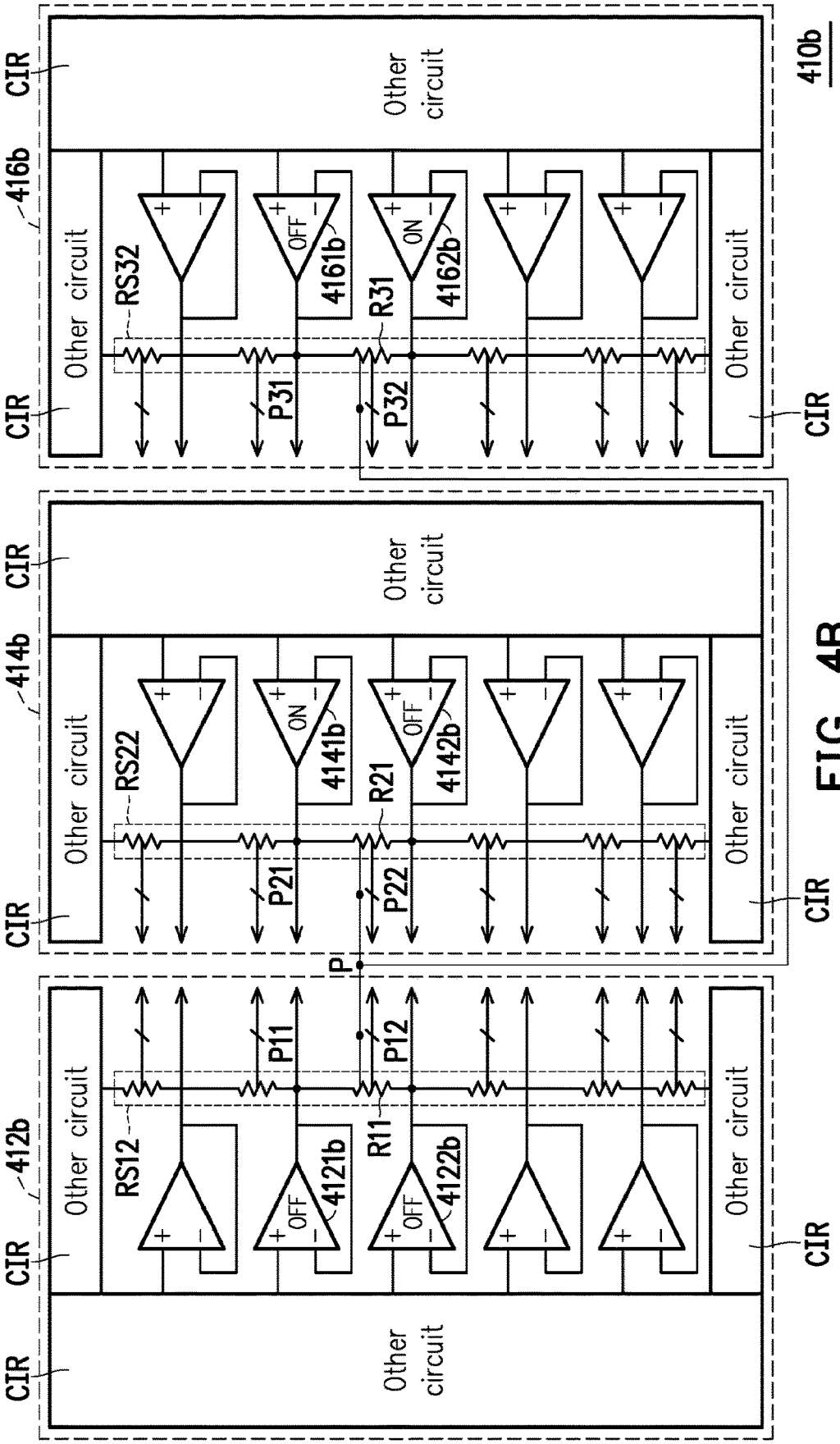
410b
CIR
416b
Other circuit
RS32
4161b
OFF
R31
4162b
ON
P31
P32
414b
RS22
4141b
ON
R21
4142b
OFF
P21
P22
P
412b
RS12
4121b
OFF
R11
4122b
OFF
P11
P12

FIG. 4B

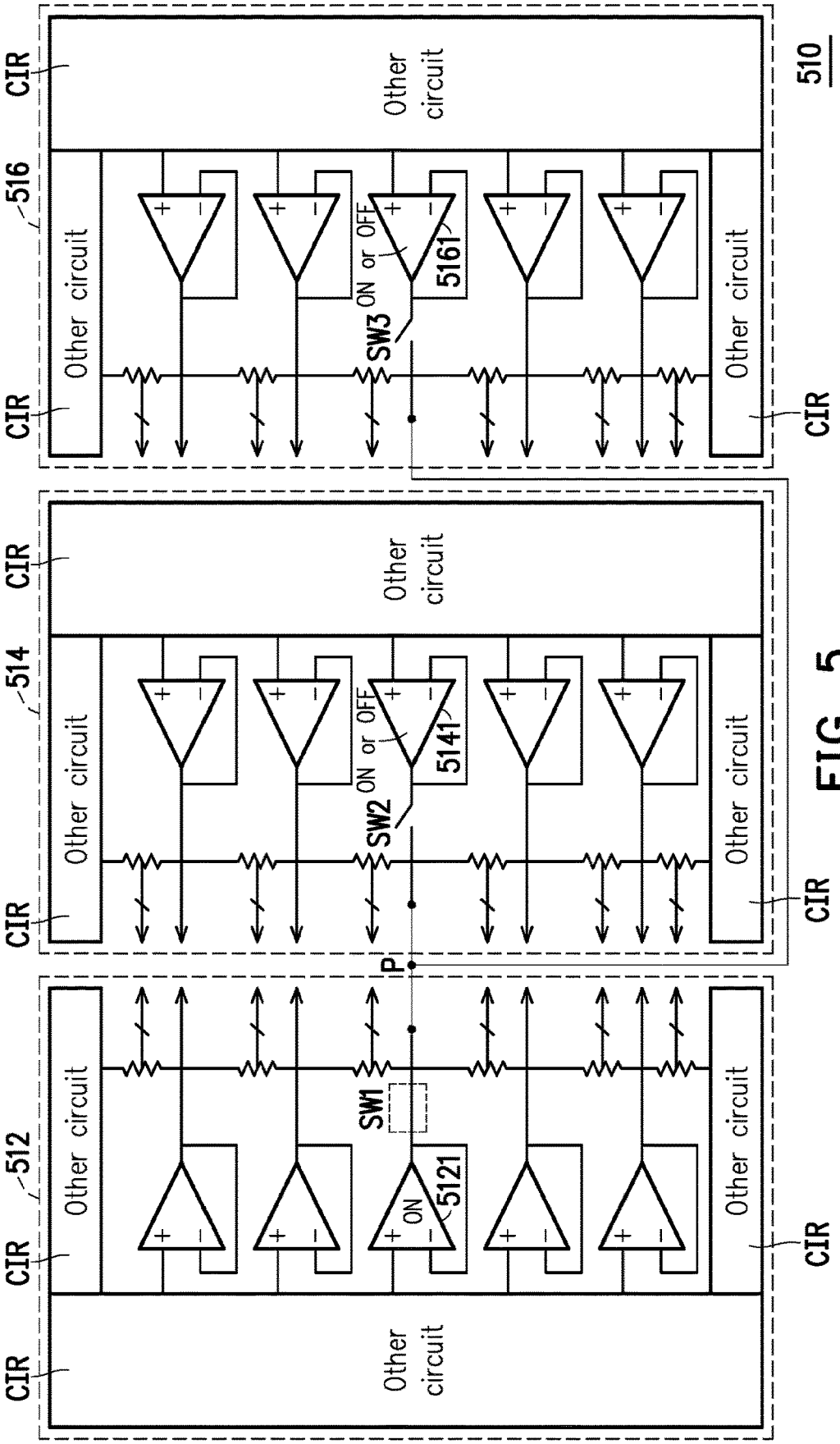
510
CIR
516
Other circuit
5161
ON or OFF
SW3
514
5141
SW2
P
512
5121
SW1
ON

FIG. 5

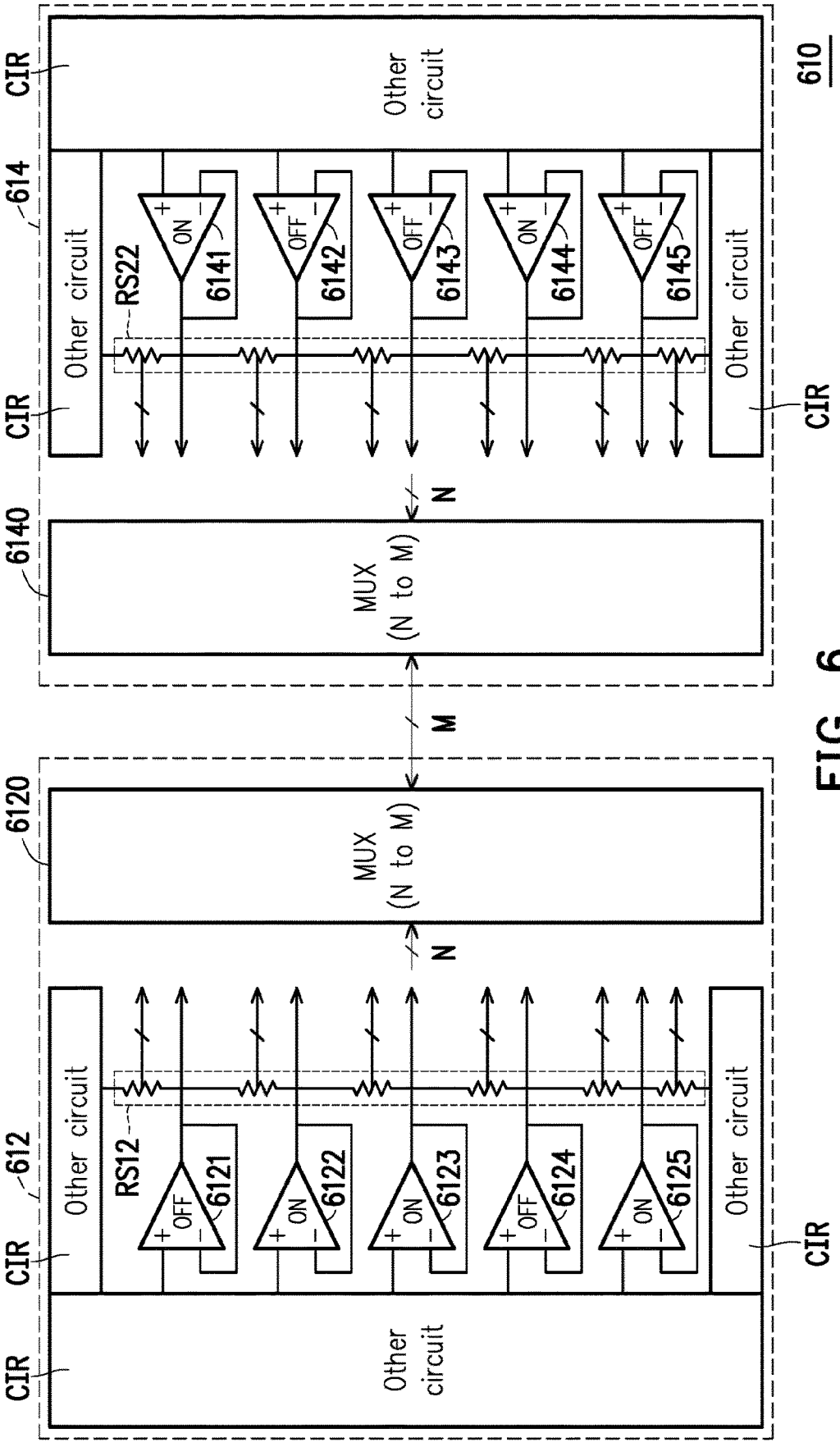
610
CIR
Other circuit
614
Other circuit
RS22
ON
6141
OFF
6142
OFF
6143
ON
6144
OFF
6145
Other circuit
CIR
CIR
N
6140
MUX
(N to M)
M
6120
MUX
(N to M)
N
612
Other circuit
RS12
OFF
6121
ON
6122
ON
6123
OFF
6124
ON
6125
Other circuit
CIR
CIR
Other circuit
CIR

FIG. 6

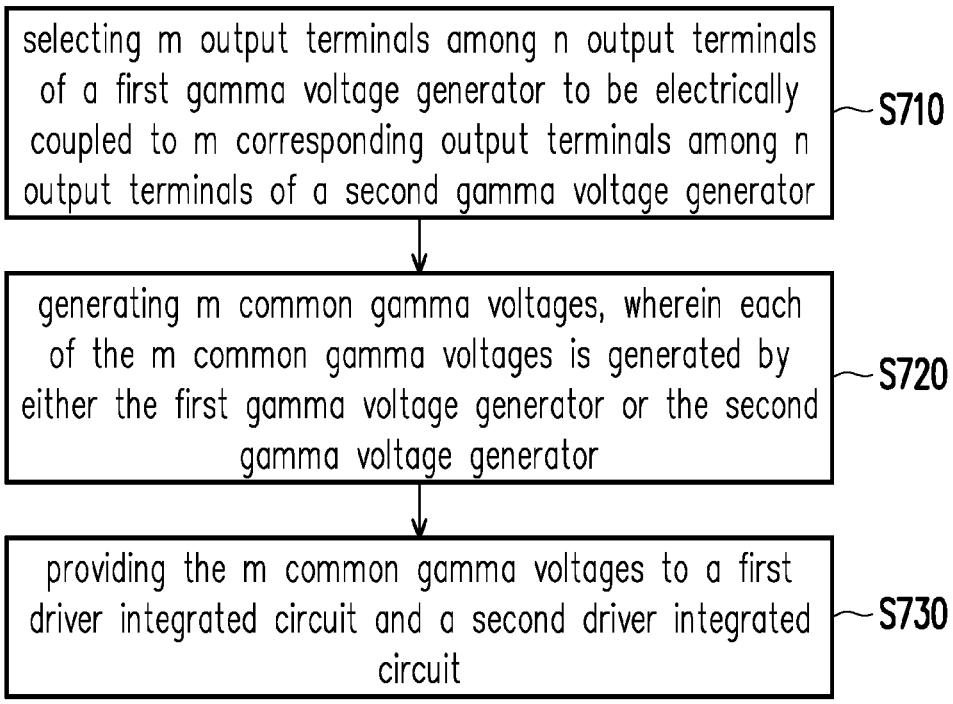
selecting m output terminals among n output terminals of a first gamma voltage generator to be electrically coupled to m corresponding output terminals among n output terminals of a second gamma voltage generator
S710
generating m common gamma voltages, wherein each of the m common gamma voltages is generated by either the first gamma voltage generator or the second gamma voltage generator
S720
providing the m common gamma voltages to a first driver integrated circuit and a second driver integrated circuit
S730

FIG. 7

DISPLAY DRIVER AND DISPLAYING METHOD FOR CASCADE APPLICATION

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

CROSS-REFERENCE TO RELATED APPLICATION

This application is a Reissue Application of U.S. Pat. No. 10,872,550 issued on Dec. 22, 2020. The entirety of the above-mentioned patent is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND

Technical Field

The disclosure generally relates to data display, and more particularly relates to a display driver and a displaying method that are capable of improving display quality for a cascade application.

Description of Related Art

In a cascade application, two or more driver integrated circuits (ICs) may be used to drive a same display panel. However, because of the non-ideal manufacturing and designing processes, the driving voltages generated by two or more driver ICs for displaying same display data may be different, resulting in non-uniformity (such as two-band phenomenon) in the display panel.

As demand for better display quality has grown recently, there has grown a need for more creative method and design to improve the display quality of display devices, specifically for cascade applications.

Nothing herein should be construed as an admission of knowledge in the prior art of any portion of the present disclosure.

SUMMARY

A display driver and a method thereof that are capable of improving the display quality in a cascade application are introduced herein.

The display driver includes a first driver integrated circuit and a second driver integrated circuit. The first driver integrated circuit includes a first gamma voltage generator that is configured to output a plurality of first gamma voltages to output terminals of the first gamma voltage generator. The second driver integrated circuit comprises a second gamma voltage generator that is configured to output a plurality of second gamma voltages to output terminals of the second voltage generator. Each of the output terminals of the first gamma voltage generator is corresponded to one of the output terminals of the gamma voltage generator. The first driver integrated circuit is cascaded to the second driver integrated circuit, and at least one of the output terminals of the first gamma voltage generator is electrically coupled to the corresponding one of the output terminals of the second gamma voltage generator to output at least one common gamma voltage of the first gamma voltages and the second gamma voltages.

The method that is adapted to a display driver having a first driver integrated circuit being cascaded to a second driver integrated circuit is introduced, where the first driver integrated circuit has a first gamma voltage generator and the second driver integrated circuit has a second gamma voltage generator. The method includes steps of selecting m output terminals among n output terminals of the first gamma voltage generator to be electrically coupled to m corresponding output terminals among n output terminals of the second gamma voltage generator; generating m common gamma voltages, wherein each of the m common gamma voltages is generated by either the first gamma voltage generator or the second gamma voltage generator; and providing the m common gamma voltages to the first driver integrated circuit and the second driver integrated circuit.

To make the aforementioned more comprehensible, several embodiments accompanied with drawings are described in detail as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure.

FIG. **1** illustrates a schematic diagram of a display system according to an embodiment of the disclosure.

FIG. **2**, FIG. **3**A, FIG. **3**B, FIG. **4**A, FIG. **4**B, FIG. **5** and FIG. **6** illustrate schematic diagrams of display drivers according to some embodiments of the disclosure.

FIG. **7** illustrates a flowchart diagram of a method adapted to a display driver according to an embodiment of the disclosure.

DESCRIPTION OF THE EMBODIMENTS

It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present disclosure. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless limited otherwise, the terms "connected," "coupled," and "mounted," and variations thereof herein are used broadly and encompass direct and indirect connections, couplings, and mountings.

Referring to FIG. **1**, a display system **100** includes a display driver **110** and a display panel **120**, in which the display driver **110** is configured to drive the display panel **120**. In some embodiments of the disclosure, the display panel **120** may be a liquid crystal display (LCD) panel or an organic light emitting diode (OLED) panel, but the display panel **120** is not limited to any specific type of display panel.

The display driver **110** may include driver integrated circuits (ICs) **112** and **114** being cascaded to each other, where the driver ICs **112** and **114** are configured to drive the display panel **120**. The driver IC **112** includes a gamma voltage generator **1123** and a source drive circuit **1121**, in which the gamma voltage generators **1123** is configured to generate a plurality of gamma voltages V[**0**] to V[n] (also

known as first gamma voltages), n is a natural number. The first gamma voltages V[0] to V[n] are supplied to the source drive circuit **1121** through the output terminals of the gamma voltage generator **1123**. The source drive circuit **1121** is coupled to output terminals of the gamma voltage generator **1123** to receive the gamma voltages V[0] to V[n] from the gamma voltage generator **1123**. The source drive circuit **1121** is configured to drive the display panel **120** according to the first gamma voltages V[0] to V[n].

The driver IC **114** includes a gamma voltage generator **1143** and a source drive circuit **1141**, in which the gamma voltage generators **1143** is configured to generate a plurality of gamma voltages V[0] to V[n] (also known as second gamma voltages). The second gamma voltages V[0] to V[n] are supplied to the source drive circuit **1141** through the output terminals of the gamma voltage generator **1143**. The source drive circuit **1141** is coupled to output terminals of the gamma voltage generator **1143** to receive the gamma voltages V[0] to V[n] from the gamma voltage generator **1143**. The source drive circuit **1141** is configured to drive the display panel **120** according to the second gamma voltages V[0] to V[n]. In the embodiment shown in FIG. **2**, two driver ICs **112** and **114** are illustrated. However, the disclosure is not limited thereto and the number of cascaded driver ICs could be more than two. In other words, the display driver **110** includes at least two driver ICs.

In some embodiments of the disclosure, each of the output terminals of the gamma voltage generator **1123** corresponds to one of the output terminal of the gamma voltage generator **1143**; and at least one output terminal of the gamma voltage generator **1123** is electrically coupled to the corresponding one of the gamma voltage generator **1143** to form common output terminals of the gamma voltage generators **1123** and **1143**. The common output terminals output common gamma voltages Vc which is provided to both of the source drive circuit **1121** of the driver IC **112** and the source drive circuit **1141** of the driver IC **114**. A number of the common output terminals of the gamma voltage generators **1123** and **1143** is determined according to design needs, and the disclosure is not limited to any specific number of the common output terminals of the gamma voltage generators **1123** and **1143**.

Each of the source drive circuits **1121** and **1141** includes a plurality of digital-to-analog converters DACs and a plurality of operational amplifiers OPs, where each of the DACs is electrically coupled to one of the OPs. The source drive circuits **1121** and **1141** are configured to drive the display panel **120** according to the common gamma voltages and non-common gamma voltages outputted by the gamma voltage generators **1123** and **1143**.

Referring to FIG. **2**, a display driver **210** according to an embodiment of the disclosure is illustrated. The display driver **210** includes a driver IC **212** and a driver IC **214**, where the driver IC **212** is cascaded to the driver IC **214** and both of the driver ICs **212** and **214** are configured to drive a display panel (not shown). The driver IC **212** includes a plurality of buffers **2120** to **212**n, and resistor strings RS**11** and RS**12**. The resistor string RS**11** includes a plurality of resistors coupled in series. Each of the buffers **2120** to **212**n is configured to output one of the gamma voltages. For examples, the buffers **2120**, **2121**, **2122**, **2123** and **2124** outputs the gamma voltages V[0], [V4], V[8], V[12] and V[16], respectively.

The resistor string RS**12** includes a plurality of resistors coupled in series, wherein the first resistor of the resistor string RS**12** is coupled to the output terminal of the buffer **2120**, and the last resistor of the resistor string RS**12** is coupled to the output terminal of the buffer **212**n. The resistor strings RS**12** has a plurality of output nodes that outputs gamma voltages among the gamma voltages V[0] to V[n]. For example, the resistor string RS**12** generates the gamma voltages V[1:3], V[5:7], V[9:11], and so on. In some embodiments of the disclosure, the resistor string RS**12** may be considered as the voltage divider circuits that are configured to generate voltages with different voltage levels.

The driver IC **214** includes a plurality of buffers **2140** to **214**n, and resistor strings RS**21** and RS**22**. The buffers **2140** to **214**n and resistor strings RS**21** and RS**22** of the driver IC **214** are similar to the buffers **2120** to **212**n and the resistors strings RS**11** and RS**12** of the driver IC **212**, respectively. Thus, the detailed description about the buffers **2140** to **214**n and resistor strings RS**21** and RS**22** are omitted hereinafter.

In FIG. **2**, the output terminals of the buffers **2121** to **2124** of the driver IC **212** are electrically coupled to the output terminals of the buffer **2141** to **2144** of the driver IC **214**, respectively, to form common output terminals of the driver IC **212** and the driver IC **214**. In other words, the nodes P**11**, P**12**, P**13** and P**14** of the driver IC **212** is electrically coupled to the nodes P**21**, P**22**, P**23** and P**24** of the driver IC **214**, respectively. The common output terminals are configured to output common gamma voltages. In the embodiment shown in FIG. **2**, the gamma voltages V[4], V[8], V[12] and V[16] are common gamma voltages of the driver IC **212** and the driver IC **214**.

In some embodiments of the disclosure, the buffers that are coupled to one common output terminal are operated in opposite states (e.g., ON and OFF states). As an example, the buffers **2121** and **2141** are coupled to the common output terminal, and only one of the buffers **2121** and **2141** is turned on at a time to generate the common gamma voltage V[4]. In other words, the common gamma voltage V[4] is generated by either the buffer **2121** of the driver IC **212** or the corresponding buffer **2141** of the driver IC **214**. Similarly, only one of the buffers **2122** and **2142** is turned on at a time to generate the common gamma voltage V[8]; only one of the buffers **2123** and **2143** is turned on at a time to generate the common gamma voltage V[12]; and only one of the buffers **2124** and **2144** is turned on at a time to generate the common gamma voltage V[16].

Referring to FIG. **3**A, a display driver **310**a according to an embodiment of the disclosure is illustrated. The display driver **310**a includes drive ICs **312**a, **314**a and **316**a being cascaded to each other. Each of the driver ICs **312**a, **314**a and **316**a includes a plurality of buffers and a resistor string, where the buffers are similar to the buffer **2120** to **212**n of the driver IC **212** in FIG. **2**, and the resistor string is similar to the resistor string RS**12** of the driver IC **212** in FIG. **2**. As such, the detailed description about the buffers and the resistor string of each of the driver ICs **312**a, **314**a and **316**a are omitted hereafter.

The driver ICs **312**a, **314**a and **316**a include buffers **3121**a, **3141**a and **3161**a, respectively, where the buffer **3121**a of the driver IC **312**a corresponds to the buffer **3141**a of the driver IC **314**a and the buffer **3161**a of the driver IC **316**a. The output terminals of the buffers **3121**a, **3141**a and **3161**a are all coupled a common node P. A common gamma voltage is generated and outputted to the common node P by one of the buffers **3121**a, **3141**a and **3161**a. For example, if the buffer **3121**a is turned on to generate the common gamma voltage at the common node P, the other buffers **3141**a and **3161**a are turned off. In other words, only one of the buffers **3121**a, **3141**a and **3161**a is turned on at a time to generate the common gamma voltage at the common node P.

Referring to FIG. **3**B, a display driver **310**b that includes driver ICs **312**b, **314**b and **316**b according to an embodiment of the disclosure is illustrated. The driver ICs **312**b, **314**b and **316**b in FIG. **3**B are similar to the driver ICs **312**a, **314**a and **316**a in FIG. **3**A, thus the detailed description about the driver ICs **312**b, **314**b and **316**b is omitted hereafter.

A difference between the display driver **310**b in FIG. **3**B and the display driver **310**a in FIG. **3**A is the state of the buffers. In FIG. **3**A, the buffer **3121**a in the driver IC **312** is turned on while the other two corresponding buffers **3141**a and **3161**a in the driver ICs **314** and **316** are turned off at a time to generate the common gamma voltage at the common node P. In FIG. **3**B, the buffer **3141**b is turned on while the other two corresponding buffers **3121**b and **3161**b of the driver ICs **312** and **316** are turned off at a time to generate the common gamma voltage at the common node P. In other words, only one of the buffers **3121**b, **3141**b and **3161**b that are coupled to the common node P is turned on at a time to generate the common gamma voltage.

Referring to FIG. **4**A, a display driver **410**a that includes driver ICs **412**a, **414**a and **416**a is illustrated. The driver IC **412**a includes a resistor Ru coupled between output terminals of buffers **4121**a and **4122**a through nodes P**11** and P**12**; the driver IC **414**a includes a resistor R**21** coupled between output terminals of buffers **4141**a and **4142**a through nodes P**21** and P**22**; and the driver IC **416**a includes a resistor R**31** coupled between output terminals of buffers **4161**a and **4162**a through nodes P**31** and P**32**. The resistor R**11** of the resistor string RS**12** corresponds to the resistor R**21** of the resistor string RS**22** and the resistor R**31** of the resistor string RS**32**.

Each of resistor strings RS**12**, RS**22** and RS**32** of the driver ICs **412**a, **414**a and **416**a, respectively has a plurality of output nodes to output gamma voltages. The output node corresponding to the resistor R**11** of the resistor string RS**12** is electrically coupled to the output node corresponding to the resistor R**21** of the resistor string RS**22** and the output node that corresponds to the resistor R**31** of the resistor string RS**32**. In other words, there is a common output node P that is electrically coupled to the output nodes corresponding to the resistors R**11**, R**21** and R**31**.

In FIG. **4**A, the buffer **4121**a of the driver IC **412**a corresponds to the buffer **4141**a of the driver IC **414**a and the buffer **4161**a of the driver IC **416**a; and the buffer **4122**a of the driver IC **412**a corresponds to the buffer **4142**a of the driver IC **414**a and the buffer **4162**a of the driver IC **416**a. During an operation, only one of the buffers **4121**a, **4141**a and **4161**a are turned on at a time; and only one of the buffer **4122**a, **4142**a and **4162**a are turned on at the same time. As shown in FIG. **4**, only the buffer **4121**a is turned on while the corresponding buffers **4141**a and **4161**a are turned off. Similarly, only the buffer **4122**a is turned on while the corresponding buffers **4142**a and **4162**a are turned off. In this way, the common gamma voltage is generated at the common output node P, and this common gamma voltage is provided to source drive circuits (not shown) of all driver ICs **412**a, **414**a and **416**a to drive the display panel (not shown).

Referring to FIG. **4**B, a display driver **410**b that includes driver ICs **412**b, **4146** and **416**b according to an embodiment of the disclosure is illustrated. The driver ICs **412**b, **414**b and **416**b in FIG. **4**B are similar to the driver ICs **412**a, **414**a and **416**a in FIG. **4**A, thus the detailed description about the driver ICs **412**b, **414**b and **416**b is omitted hereafter.

A difference between the display driver **410**b in FIG. **4**B and the display driver **410**a in FIG. **4**A is the state of the buffers. In FIG. **4**A, the buffer **4121**a and **4122**a of the driver IC **412**a are turned on while the other corresponding buffers **4141**a, **4161**a, **4142**a and **4162**a are turned off at a time to generate the common gamma voltage at the common node P. In FIG. **4**B, the buffer **4141**b of the driver IC **414**b is turned on while the corresponding buffers **4121**b and **4161**b of the driver ICs **412**b and **416**b are turned off. Meanwhile, the buffer **4162**b of the driver IC **416**b is turned on while the corresponding buffers **4122**b and **4142**b of the driver ICs **412**b and **414**b are turned off.

Referring to FIG. **5**, a display driver **510** that includes driver ICs **512**, **514** and **516** according to an embodiment of the disclosure is illustrated. Each of the driver ICs **512**, **514** and **516** includes a plurality of buffers and a resistor string that are similar to the buffers and resistor strings shown in FIG. **3**A, thus the detailed description about the buffers and the resistor strings of the driver ICs **512**, **514** and **516** is omitted hereafter.

The driver ICs **512**, **514** and **516** include the buffers **5121**, **5141** and **5161**, respectively, where the buffer **5121** of the driver IC **512** corresponds to the buffer **5141** of the driver IC **514** and the buffer **5161** of the driver IC **516**. The driver ICs **512**, **514** and **516** further include switches SW**1**, SW**2** and SW**3**, wherein the switch SW**1** is coupled between the output terminal of the buffer **5121** and a common node P, the switch SW**2** is coupled between the output terminal of the buffer **5141** and the common node P, and the switch SW**3** is coupled between the output terminal of the buffer **5161** and the common node P. The switches SW**1**, SW**2**, SW**3** are configured to electrically connect or electrically isolate the common node P from the buffers **5121**, **5141** and **5161**, respectively.

During an operation, the switches SW**1**, SW**2** and SW**3** are controlled such that only one of the buffer **5121**, **5141** and **5161** is configured to generate a common gamma voltage at the common node P. For example, the switches SW**1**, SW**2** and SW**3** are controlled to electrically coupled the output terminal of the buffer **5121** to the common node P and isolate the output terminals of the buffers **5141** and **5161** from the common node P. Meanwhile, the buffer **5121** of the driver IC **512** is turned on to generate the common gamma voltage at the common node P. In this way, regardless of the states of the buffers **5141** and **5161** (e.g., ON state or OFF state), only the gamma voltage generated by the buffer **5121** of the driver IC **512** is provided to the common node P.

Referring to FIG. **6**, a display driver **610** that includes driver ICs **612** and **614** according to an embodiment of the disclosure is illustrated. Each of the driver ICs **612** and **614** includes a plurality of buffers and a resistor string for generating a plurality of gamma voltages. Particular, the driver IC **612** includes buffers **6121** to **6125** and a resistor string RS**11**; and the driver IC **614** includes buffers **6141** to **6145** and the resistor string RS**22**. The buffers and the resistor string of the driver ICs **612** and **614** in FIG. **6** are similar to the buffers and the resistor string in FIG. **2**, thus the detailed description about the buffers and the resistor string of the driver ICs **612** and **614** is omitted hereafter.

The driver IC **612** further includes a multiplexer **6120** which is coupled to the output terminals of the resistor string RS**12** and the output terminals of the buffers **6121** to **6125**; and the driver IC **614** further includes a multiplexer **6140** which is coupled to the output terminals of the resistor string RS**22** and the output terminals of the buffers **6141** to **6145**. In some embodiments, the multiplexers **6120** and **6140** may be n-to-m multiplexers that are configured to select M out of N input signals, where N and M are natural number, and M is smaller than N. The multiplexers **6120** may select M out

of N output nodes of the buffers **6121** to **6125** and the resistor string RS**12**. The multiplexer **6140** may select M out of N output nodes of the of the buffers **6141** to **6145** and the resistor string RS**22**, wherein the M output nodes selected by the multiplexer **6140** are corresponded to the M output nodes selected by the multiplexer **6120**.

The M output nodes selected by the multiplexer **6140** is electrically coupled to the corresponding M output nodes selected by the multiplexer **6120** to form M common output nodes, where M output nodes output M common gamma voltages for the driver ICs **612** and **614**. The buffers of the driver IC **612** and the corresponding buffers of the driver IC **614** that are related to the selected M output nodes are controlled such that only one of the buffer from the driver IC **612** and the corresponding one of the driver IC **614** are turned on at a time. For example, when the multiplexer **6120** and **6140** select to connect the output nodes of the buffers **6121** to **6125** of the driver IC **612** to the corresponding output nodes of buffers **6141** to **6145** of the driver IC **614**, only one of the buffers **6121** and **6141** are turned on at a time, only one of the buffer **6122** and **6142** are turned on at a time, and so on.

In an alternative embodiment, when the multiplexers **6120** and **6140** select to connect an output node of the resistor string RS**12** of the driver IC **612** to the corresponding output node of the resistor string RS**22** of the driver IC **614**, the buffers related to the output node of the resistor string RS**12** and the corresponding buffers related to the corresponding output node of the resistor string RS**22** are controlled such that only one of the buffer from the driver IC **612** and the corresponding one of the driver IC **614** are turned on at a time. For example, when the multiplexers **6120** and **6140** select to connect an output node of the resistor located between the buffer **6121** and **6122** of the resistor string RS**12** to the output node of the resistor located between the buffer **6141** and **6142** of the resistor string RS**22**, the buffers **6121** and **6122** of the driver IC **612** and the corresponding buffers **6141** and **6142** of the driver IC **614** are controlled such that only one of the buffer **6121** and the corresponding buffer **6141** is turned on at a time, and only one of the buffer **6122** and the corresponding buffer **6142** is turned on at a time.

In FIG. **3**A to FIG. **6**, the display driver further includes other circuits CIR that are configured to cooperate with the buffers and resistor string of each of the driver ICs to generate the gamma voltages and to drive the display panel. One of skilled in the arts would be clear about the structure and operation of the other circuits CIR as shown in FIG. **3**A to FIG. **6**, thus the detailed description about the other circuits CIR of FIG. **3**A to FIG. **6** is omitted hereafter.

Referring to FIG. **7**, a flowchart of a method adapted to a display driver having a first driver integrated circuit being cascaded to a second driver integrated circuit is illustrated, wherein the first driver integrated circuit comprising a first gamma voltage generator and the second driver integrated circuit comprising a second gamma voltage generator. In step S**710**, m output terminals among n output terminals of the first gamma voltage generator are selected to be electrically coupled to m corresponding output terminals among n output terminals of the second gamma voltage generator. In step S**720**, m common gamma voltages are generated, wherein each of the m common gamma voltages is generated by either the first gamma voltage generator or the second gamma voltage generator. In step S**730**, the m common gamma voltages are provided to the first driver integrated circuit and the second driver integrated circuit.

From the above embodiments, at least one common output nodes (output terminals) of gamma voltage generators in different driver ICs are formed to generate at least one common gamma voltage, where each of the at least one common gamma voltage is generated by only one of the gamma voltage generators. The common gamma voltage will be provided to source drive circuits of different driver ICs so as to drive a display panel. In this way, the display uniformity is achieved and the display quality is improved for a cascade application.

It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the disclosed embodiments without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the disclosure cover modifications and variations of this disclosure provided they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A display driver, comprising:

a first driver integrated circuit, comprising a first gamma voltage generator configured to output [a plurality of] *n* first gamma voltages to *n* output terminals of the first gamma voltage generator,

a second driver integrated circuit, comprising a second gamma voltage generator configured to output [a plurality of] *n* second gamma voltages to *n* output terminals of the second gamma voltage generator, wherein each of the *n* output terminals of the first gamma voltage generator is corresponded to one of the *n* output terminals of the second gamma voltage generator,

wherein [the first driver integrated circuit cascaded to the second driver integrated circuit, at least one of] *m output terminals among* the *n* output terminals of the first gamma voltage generator is electrically coupled to the corresponding [one of] *m output terminals among* the *n* output terminals of the second gamma voltage generator to form [a] *m* common output [terminal] *terminals*, and [at least one] *m* common gamma [voltage of] *voltages that are selected from* the *n* first gamma voltages and the *n* second gamma voltages [is] *are* outputted to the *m* common output [terminal] *terminals, wherein n and m are natural numbers, and n is greater than m.*

2. The display driver of claim **1**, wherein

the first driver integrated circuit further comprises a first source driver circuit being coupled to the first gamma voltage generator, the first source driver circuit is configured to drive a display panel according to the [at least one] *m* common gamma [voltage] *voltages*,

the second driver integrated circuit further comprises a second source driver circuit being coupled to the second gamma voltage generator, the second source driver circuit is configured to drive the display panel according the [at least one] *m* common gamma [voltage] *voltages*.

3. The display driver of claim **2**, wherein

the [at least one] *m* common gamma [voltage comprises] *voltages comprise* a first common gamma voltage,

the first common gamma voltage is generated by either the first gamma voltage generator or the second gamma voltage generator, and

the first common gamma voltage is outputted to both of the first source [drive] *driver* circuit and the second source [drive] *driver* circuit.

4. The display driver of claim **3**, wherein

the first gamma voltage generator comprises:

a plurality of first buffers, each of the first buffers is configured to generate one of the first gamma voltages, and

a first resistor string, configured to generate at least one of the first gamma voltages, and

the second gamma voltage generator comprises:

a plurality of second buffers, each of the second buffers is configured to generate one of the second gamma voltages; and

a second resistor string, configured to generate at least one of the second gamma voltages.

5. The display driver of claim **4**, wherein

each of the first buffers is corresponded to one of the second buffers,

the first common gamma voltage is generated by either one of the first buffers or the corresponding one of the second buffers, wherein the one of the first buffers is electrically connected to the corresponding one of the second buffers.

6. The display driver of claim **5**, wherein only one of the one of the first buffers and the corresponding one of the second buffers is turned on at a time.

7. The display driver of claim **5**, wherein

the first gamma *voltage* generator further comprises a first switch coupled between an output terminal of the one of the first buffers and the output terminal of the first gamma *voltage* generator,

the second gamma *voltage* generator further comprises a second switch coupled between an output terminal of the corresponding one of the second buffers and the output terminal of the second gamma *voltage* generator, and

only one of the first switch and the second switch is turned on at a time.

8. The display driver of claim **4**, wherein

each node in the first resistor string is corresponded to a node in the second resistor string,

the first common gamma voltage is generated by either one node of the first resistor string or the corresponding node of the second resistor string, wherein the one node of the first resistor string is electrically connected to the corresponding node of the second resistor string.

9. The display driver of claim **4**, wherein

the first gamma voltage generator comprises a first multiplexer connected to the m common output terminals,

the second gamma voltage generator comprises a second multiplexer connected to the m common output terminals,

[each of the first gamma voltage generator and the second gamma voltage generator comprise a multiplexer**]** *the first multiplexer and the second multiplexer are* configured to select *the* m common gamma voltages among *the* n *first* gamma voltages *and the n second gamma voltages*, **[**wherein n and m are natural numbers, and n is greater than m,**]** and

each of the m common gamma voltages is generated by either the first gamma voltage generator or the second gamma voltage generator.

10. The display driver of claim **9**, wherein

the m output terminals of the first gamma voltage generator are selected to be coupled to *the* m corresponding output terminals of the second gamma voltage generator through m connection lines, *the m connection lines are connected to the m common output terminals*, and

the first buffers that are **[**related**]** *connected* to the m connection lines and the second buffers that are **[**related**]** *connected* to the m connection lines are controlled such that **[**the**]** *a* common gamma voltage *among the m common gamma voltages* in each of the m connection lines is generated by either an output terminal of *the* first gamma voltage generator or a corresponding output terminal of the second gamma voltage generator.

11. The display driver of claim **10**, wherein

them connection lines include a connection line that connects one of the first buffers to a corresponding one of the second buffers, and

either one of the first buffers or the corresponding one of the second buffers are turned on at a time to output a common gamma voltage in the connection line.

12. The display driver of claim **10**, wherein

the m connection lines include a connection line that connects a node of the first resistor string to a corresponding node of the second resistor string,

the node of the first resistor string is located between two first buffers among the first buffers,

the corresponding node of the second resistor string is located between two second buffers among the second buffers, the two second buffers correspond to the two first buffers, and

the *two of the* first buffers **[**that are related to the node of the first resistor string and the**]** *and* corresponding *two* second buffers **[**that are related to the corresponding one of the second resistor string**]** are controlled such that **[**one of**]** the *two* first buffers **[**that are related to the node of the first resistor string**]** or **[**a corresponding one of**]** the *two* second buffers **[**that are related to the corresponding node of the second resistor string is**]** *are* turned on at a time.

13. A method adapted to a display driver having a first driver integrated circuit **[**being cascaded to**]** *and* a second driver integrated circuit, the first driver integrated circuit comprising a first gamma voltage generator and the second driver integrated circuit comprising a second gamma voltage generator, the method comprising:

selecting m output terminals among n output terminals of the first gamma voltage generator to be electrically coupled to m corresponding output terminals among n output terminals of the second gamma voltage generator to form m common output terminals;

generating m common gamma voltages and outputting the m common gamma voltages to the m common output terminals, wherein each of the m common gamma voltages is generated by either the first gamma voltage generator or the second gamma voltage generator;

providing the m common gamma voltages to the first driver integrated circuit and the second driver integrated circuit, *wherein n and m are natural numbers, and n is greater than m.*

14. The method of claim **13**, wherein

the first driver integrated circuit further comprises a first source **[**drive**]** *driver* circuit being coupled to the first gamma voltage generator,

the second driver integrated circuit further comprises a second source **[**drive**]** *driver* circuit being coupled to the second gamma voltage generator, and

the m common gamma voltages are provided to both of the first source **[**drive**]** *driver* circuit and the second source **[**drive**]** *driver* circuit.

15. A display driver, comprising:

m common output terminals;

a first driving circuit, comprising a first gamma voltage generator coupled to the m common output terminals and configured to generate n first gamma voltages; and

a second driving circuit, comprising a second gamma voltage generator coupled to the m common output terminals and configured to generate n second gamma voltages, wherein each of the n second gamma voltages is corresponded to one of the n first gamma voltages,

wherein m common gamma voltages that are selected from the n first gamma voltages and the n second gamma voltages are outputted to the m common output

terminals, wherein n and m are natural numbers, and n is greater than m, wherein

the first gamma voltage generator comprises a first multiplexer connected to the m common output terminals,

the second gamma voltage generator comprises a second multiplexer connected to the m common output terminals,

the first multiplexer and the second multiplexer are configured to select the m common gamma voltages among the n first gamma voltages and the n second gamma voltages, and

each of the m common gamma voltages is generated by either the first gamma voltage generator or the second gamma voltage generator.

16. The display driver of claim 15, wherein

the first driving circuit further comprises a first source driver being coupled to the first gamma voltage generator, the first source driver is configured to drive a display panel according to the m common gamma voltages,

the second driving circuit further comprises a second source driver being coupled to the second gamma voltage generator, the second source driver is configured to drive the display panel according to the m common gamma voltages.

17. The display driver of claim 16, wherein

the m common gamma voltage comprises a first common gamma voltage,

the first common gamma voltage is generated by either the first gamma voltage generator or the second gamma voltage generator, and

the first common gamma voltage is provided to both of the first source driver and the second source driver.

18. A display driver, comprising:

m common output terminals; and

a plurality of gamma voltage generators, each gamma voltage generator is configured to generate a plurality of gamma voltages,

wherein each of the gamma voltage generators comprises a multiplexer being connected to the m common output terminals, the multiplexer is configured to select m common gamma voltages among the gamma voltages generated by a corresponding one of the gamma voltage generators, and the multiplexer is further configured to output the selected m common gamma voltages to the m common output terminals.

19. The display driver of claim 18, further comprising:

a plurality of source drivers, each of the source drivers is coupled to a corresponding gamma voltage generator and configured to drive a display panel according to the m common gamma voltages.

20. The display driver of claim 19, wherein

the m common gamma voltages are generated by either one of the gamma voltage generators, and

the m common gamma voltages are provided to all of the source drivers.

21. A display driver, comprising:

a first driving circuit, comprising a first gamma voltage generator configured to output a first gamma voltage to a first output terminal,

a second driving circuit, comprising a second gamma voltage generator configured to output a second gamma voltage to a second output terminal corresponding to the first output terminal,

wherein the first output terminal and the second output terminal form a common output terminal, and a common gamma voltage of the first gamma voltage and the second gamma voltage is outputted to the common output terminal, wherein

the first gamma voltage generator comprises a first multiplexer connected to the common output terminal,

the second gamma voltage generator comprises a second multiplexer connected to the common output terminal,

the first multiplexer and the second multiplexer are configured to select the common gamma voltage among the first gamma voltage and the second gamma voltage, and

the common gamma voltage is generated by either the first gamma voltage generator or the second gamma voltage generator.

22. The display driver of claim 21, wherein

the first driving circuit further comprises a first source driver being coupled to the first gamma voltage generator, the first source driver is configured to drive a display panel according to the common gamma voltage,

the second driving circuit further comprises a second source driver being coupled to the second gamma voltage generator, the second source driver is configured to drive the display panel according to the common gamma voltage.

23. The display driver of claim 22, wherein

the common gamma voltage is generated by either the first gamma voltage generator or the second gamma voltage generator, and

the common gamma voltage is provided to both of the first source driver and the second source driver.

24. A display driver, comprising:

a plurality of gamma voltage generators, each gamma voltage generator comprises n output terminals and is configured to output n gamma voltages to the n output terminals, wherein each of the n output terminals of one of the gamma voltage generators is respectively corresponded to one of n output terminals of each of the other gamma voltage generators,

wherein m output terminals among the output terminals of the one of the gamma voltage generators are electrically coupled to the corresponding m output terminals among the n output terminals of each of the other gamma voltage generators to form m common output terminals, and m common gamma voltages from the gamma voltage generators are outputted to the m common output terminals, wherein n and m are natural numbers, and n is greater than m, wherein

each of the gamma voltage generators comprises a multiplexer being connected to the m common output terminals, the multiplexer is configured to select the m common gamma voltages among the n gamma voltages, and

each of the m common gamma voltages is generated by one of the gamma voltage generators.

25. The display driver of claim 24, further comprising:

a plurality of source drivers, each of the source drivers is coupled to a corresponding gamma voltage generator and configured to drive a display panel according to the m common gamma voltages.

26. The display driver of claim 25, wherein

the m common gamma voltages comprise a first common gamma voltage,

the first common gamma voltage is generated by one of the gamma voltage generators, and

the first common gamma voltage is provided to all of the source drivers.

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