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DISPLAY DEVICE, DISPLAY SYSTEM INCLUDING THE SAME, AND METHOD OF DRIVING THE DISPLAY DEVICE

Abstract

A display device may include: a gate driver configured to apply a plurality of gate signals to each of a plurality of gate lines; a source driver configured to generate a plurality of first data signals corresponding to each of a plurality of source lines; and an interpolation circuit configured to: receive the plurality of first data signals from the source driver; and provide a second data signal, obtained by interpolating a first data signal corresponding to a first source line among the plurality of source lines and a first data signal corresponding to a third source line among the plurality of source lines, to a second source line between the first source line and the third source line.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2024-0020310 filed in the Korean Intellectual Property Office on Feb. 13, 2024, the entire contents of which are incorporated herein by reference.

BACKGROUND

1. Field

[0002] The disclosure relates to a display device, a display system including the same, and a method of driving the display device.

2. Description of the Related Art

[0003] A micro display is a small-sized and high-resolution display that serve a component of augmented reality AR and virtual reality VR devices. The image emitted from the micro display may be transmitted to the user's eyes through an optical lens. The micro display may display an image rendered using Foveated Rendering.

[0004] The foveated rendering method is a technology for rendering an image so that an area in the image the user is staring at is displayed with high quality and other areas are displayed with low quality. Compared to the conventional rendering method where all areas of the image are displayed with high quality, the foveated rendering method processes images where some areas are displayed with low quality so that the power consumed by image processing processors such as graphic processing unit GPU can be reduced.

[0005] The micro display may include a plurality of pixels and a plurality of source amplifiers. A plurality of source amplifiers can provide data signals to pixels that represent regions of the foveated rendered image. A plurality of source amplifiers may provide data signals to pixels displaying areas of foveated rendered images. A plurality of source amplifiers may remain on-state to provide data signals to each of a pixel displaying a high-quality area with a foveated rendered image and a pixel displaying a low-quality area with a foveated rendered image.

SUMMARY

[0006] One or more embodiments provide a display device capable of reducing power consumed by a source amplifier, a display system including the same, and a driving method of the display device. One or more embodiments provide a display device that improves the image quality of a low-quality area with a foveated rendered image, a display system including the same, and a method of driving the display device.

[0007] According to an aspect of the disclosure, a display device may include: a pixel array that may include: a plurality of pixels; a plurality of gate lines; and a plurality of source lines connected to the plurality of pixels. The display device may further include: a gate driver configured to apply a plurality of gate signals to each of the plurality of gate lines; a source driver configured to generate a plurality of first data signals corresponding to each of the plurality of source lines; and an interpolation circuit configured to: receive the plurality of first data signals from the source driver; and provide a second data signal, obtained by interpolating a first data signal corresponding to a first source line among the plurality of source lines and a first data signal corresponding to a third source line among the plurality of source lines, to a second source line between the first source line and the third source line.

[0008] According to an aspect of the disclosure, a display system may include: a host device

providing an image signal may include a first area rendered with a first quality and a second area rendered with a second quality lower than the first quality; and a display device may include a plurality of pixels and a plurality of source lines respectively connected to the plurality of pixels, the display device being configured to: generate a plurality of first data signals by the image signal; and provide second data signals, obtained by interpolating the plurality of first data signals, to source lines among the plurality of source lines connected to pixels among the plurality of pixels that are displaying the second area.

[0009] According to an aspect of the disclosure, a method of driving a display device may include: turning off a source amplifier that outputs a data signal to a source line connected to a pixel during a first period in which the pixel displays an area rendered with a first quality; turning on the source amplifier during a second period before the pixel displays an area rendered with a second quality higher than the first quality; and outputting the data signal for the source amplifier to the source line connected to the pixel during a third period in which the pixel displays the area rendered with the second quality.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0010] The above and other aspects, features, and advantages of certain embodiments of the present disclosure will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:

[0011] FIG. 1 is a block diagram of a display system according to one or more embodiments;

[0012] FIG. 2 is a block diagram illustrating a display panel of a display device according to one or more embodiments;

[0013] FIG. 3 is a block diagram illustrating a first display area and a second display area of a display panel in a display device according to one or more embodiments;

[0014] FIG. 4 illustrates a source driver providing a data signal to a source line;

[0015] FIG. 5 illustrates a portion of a display panel in which an image is displayed by the source driver of FIG. 4;

[0016] FIG. 6 illustrates a source driver providing a data signal to a source line according to one or more embodiments;

[0017] FIG. 7 illustrates a portion of a display panel in which an image is displayed by the source driver of FIG. 6;

[0018] FIG. 8 illustrates a source driver providing a data signal to a source line according to one or more embodiments;

[0019] FIG. 9 illustrates a source driver providing a data signal to a source line according to one or more embodiments;

[0020] FIG. 10 illustrates a portion of a display panel in which an image is displayed by the source driver of FIG. 9.

[0021] FIG. 11 illustrates a source driver providing a data signal to a source line according to one or more embodiments;

[0022] FIG. 12 illustrates a portion of a display panel in which an image is displayed by the source driver of FIG. 11;

[0023] FIG. 13 illustrates a portion of a pixel array included in a display panel in which an image is displayed by a source driver;

[0024] FIG. 14 illustrates a source driver providing a data signal to a source line according to one or more embodiments;

[0025] FIG. 15 illustrates a portion of a display panel in which an image is displayed by the source driver of FIG. 14;

[0026] FIG. **16** is a circuit diagram illustrating a source amplifier and a plurality of switches in a source driver according to one or more embodiments;
[0027] FIG. **17** is a timing diagram of control signals for controlling a source amplifier and a plurality of switches according to one or more embodiments;
[0028] FIG. **18** is a circuit diagram of a source amplifier and a plurality of switches in a first period;
[0029] FIG. **19** is a circuit diagram of a source amplifier and a plurality of switches in a second period;
[0030] FIG. **20** is a circuit diagram of a source amplifier and a plurality of switches in a third period;
[0031] FIG. **21** illustrates a source driver connected to a plurality of source lines through a multiplexer according to one or more embodiments;
[0032] FIG. **22** illustrates a source driver connected to a plurality of source lines through a multiplexer according to one or more embodiments; and
[0033] FIG. **23** is a diagram illustrating a display system according to one or more embodiments.

DETAILED DESCRIPTION

[0034] Hereinafter, embodiments of this disclosure will be described in detail so that those of ordinary skill in the art to which this disclosure belongs can easily implement it with reference to the accompanying drawings. As those skilled in the art would realize, the described embodiments may be modified in various different ways, all without departing from the spirit or scope of the disclosure.

[0035] In addition, in order to clearly describe the present disclosure in the drawings, parts which are not related to the description have been omitted, and like reference numerals refer to similar parts throughout the specification. In the flowcharts described with reference to the drawings, the order of operation may be changed, various operations may be merged, any operation may be split, and certain operations may not be performed.

[0036] In addition, the expression written as singular can be interpreted as singular or plural, unless explicit expressions such as “one” or “single” are used. Terms including ordinal numbers such as first, second, etc. may be used to describe various components, but the components are not limited by these terms. These terms may be used for the purpose of distinguishing one component from another component.

[0037] FIG. **1** is an example block diagram of a display system according to one or more embodiments.

[0038] Referring to FIG. **1**, a display system **100** may provide a user with an artificial reality system, for example, a virtual reality (VR) system, an augmented reality (AR) system, a mixed reality (MR) system, a hybrid reality system, or some combination and/or derivative system thereof. In this case, the artificial reality system may be implemented in various platforms including a head mounted display (HMD), a mobile device, a computing system, or other hardware platforms capable of providing artificial reality content to one or more viewers.

[0039] Next, the display system **100** may include a host device **110** and a display device **120**.

[0040] The host device **110** may be a computing device or a system for controlling the display device **120** to display a desired image by a user on the pixel array **122** from the outside. The host device **110** may transmit an image signal IS according to the content for presenting to the user to the display device **120**. In some embodiments, the host device **110** may render a content generated when an application is executed into an image signal IS including a plurality of areas having different display qualities. The host device **110** may render the content generated when the application is executed into an image signal IS including a first area having a first quality (e.g., high resolution). The host device **110** may render the content generated when the application is executed into an image signal IS including a second area having a second quality (e.g., low resolution) lower than the first quality. In some embodiments, the second quality is higher than the

first quality.

[0041] The host device **110** may include an image processor **111** that generates an image signal IS. In one or more embodiments, the image processor **111** may generate an image signal IS including a plurality of areas having different display qualities.

[0042] In some embodiments, the image processor **111** may perform rendering the image signal IS based on the eye tracking data ED received from the display device **120**. Specifically, the image processor **111** may receive the eye tracking data ED from the eye tracking sensor **125** in the display device **120**, and render differently the first area corresponding to the position of the user's eye and the second area which is the peripheral area of the first area based on the eye tracking data ED. For example, the image processor **111** may render the first area corresponding to the position of the user's eyes with the first quality and render the second area which is a peripheral area of the first area with the second quality.

[0043] The host device **110** may generate a driving control signal CTRL for driving the pixel array **122** based on the image signal IS. The host device **110** may transmit the generated driving control signal CTRL to the display device **120**. In this case, the driving control signal CTRL may include a control command for controlling the display device **120**, a setting data, and the like, and in one or more embodiments, the driving control signal CTRL may include an area indication data indicating a plurality of areas of the image according to the image signal IS.

[0044] In some embodiments, the area indication data may include information for the number of the plurality of areas and/or a coordinate data and a function data, etc. indicating the position of the plurality of areas within the image displayed on the display panel by the image signal IS. The image displayed on the display panel by the image signal IS may include a first display area (an area displaying the first area rendered with the first quality) and a second display area (an area displaying the second area rendered with the second quality). When the first display area has a rectangular shape, the area indication data for the first display area may include coordinate values of four vertices of the first display area.

[0045] The display device **120** may receive an image signal IS and a driving control signal CTRL which are transmitted from the host device **110** and may display two-dimensional or three-dimensional image according to the image signal IS to the user.

[0046] The display device **120** may include a display panel **121** and an eye tracking sensor **125**. In some embodiments, the display device **120** may further include a power supply circuit such as a DC/DC converter that provides a driving voltage to the display panel **121** and the eye tracking sensor **125**.

[0047] In one or more embodiments, the display panel **121** may display an image to the user according to the image signal IS received from the host device **110**. In various embodiments, one or more display panels **121** may be provided. For example, two display panels **121** may provide an image for each eye of the user. The display panel **121** may be a liquid crystal display LCD, an organic light emitting diode OLED display, an inorganic light emitting diode ILED display, a transparent OLED display TOLED, and the like.

[0048] In one or more embodiments, the display panel **121** may include a pixel array **122**, a source driver **123**, and an interpolation circuit **124**. The display panel **121** may have a backplane structure in which a pixel array **122**, a source driver **123**, and an interpolation circuit **124** are disposed on a silicon substrate (a silicon semiconductor substrate). For example, the display panel **121** may include a pixel array **122**, a source driver **123**, and an interpolation circuit **124** on a CMOS (Complementary Metal-Oxide-semiconductor) wafer.

[0049] The pixel array **122** may include a plurality of pixels, a plurality of gate lines, and a plurality of source lines respectively connected to the plurality of pixels. In one or more embodiments, a plurality of pixels may emit light primary colors such as red, green, blue, white, or yellow.

[0050] The source driver **123** may provide a plurality of data signals generated based on the image

signal IS to a plurality of source lines. The source driver **123** may include a plurality of source amplifiers respectively connected to a plurality of source lines and output a plurality of data signals. In some embodiments, source amplifiers that output data signals corresponding to source lines connected to pixels displaying a first display area may be turned on among a plurality of source amplifiers. Among the plurality of source amplifiers, some of the source amplifiers that output data signals corresponding to source lines connected to pixels displaying the second display area may be turned off.

[0051] The interpolation circuit **124** may interpolate the data signals output from the source driver **123** and transmit it to the pixel array **122**. The interpolation circuit **124** may transmit the data signal output from the source driver **123** to the source lines connected to pixels included in the first display area as it is. The interpolation circuit **124** may interpolate the data signal output from the source driver **123** and transmit it to the source lines connected to pixels included in the second display area.

[0052] The eye tracking sensor **125** may transmit the eye tracking data ED obtained by tracking the position and movement of the user's eyes (i.e. a user eye) to the host device **110**. In this case, eye tracking may refer to determining the position of the eye, including the orientation and position of the eye relative to the display device **120**. In one or more embodiments, an eye tracking system may include an imaging system for imaging one or more eyes. In some embodiments, the eye tracking system may include a light emitter that generates light directed to the eye such that the light reflected by the eye may be captured by the imaging system.

[0053] FIG. 2 is a block diagram illustrating a display panel of a display device according to one or more embodiments.

[0054] Referring to FIG. 2, the display panel **200** according to one or more embodiments may include a substrate **201**, a pixel array **210**, a gate driver **220**, a timing controller **230**, a source driver **240**, and an interpolation circuit **250** positioned on the substrate **201**.

[0055] The pixel array **210** may include a plurality of pixels PX for display images. Each of the plurality of pixels PX may be connected to one source line among the plurality of source lines SL1, SL2, . . . , SLk-1, and SLk, and one gate line among the plurality of gate lines GL1, GL2, . . . , GLh-1, and GLh.

[0056] The pixel PX connected to one source line among the plurality of source lines and one gate line among the plurality of gate lines may receive a data signal from the source line connected when a gate signal is supplied from the connected gate line. Based on the data signal input from a source line, a pixel may express light having predetermined luminance.

[0057] Referring to FIG. 2, although the pixel PX is shown to be connected to one source line and one gate line, the connection structure of the signal line connected to the pixel PX is not limited, and the signal line may be connected to the pixel in various currently known forms.

[0058] Next, the gate driver **220**, the timing controller **230**, the source driver **240**, and the interpolation circuit **250** may be partially or entirely manufactured through a silicon wafer manufacturing process and implemented on the same substrate **201** as the pixel array **210**. In addition, in some embodiments, the gate driver **220** and/or the source driver **240** may be implemented on the same substrate as the pixel array **210**. The gate driver **220** and/or the source driver **240** may be disposed on the periphery of the pixel array **210**.

[0059] Referring to FIG. 2, the timing controller **230** may receive the image signal IS and the driving control signal CTRL generated by the host device **110** of FIG. 1.

[0060] The timing controller **230** may generate the gate driver control signal CONT1 based on the driving control signal CTRL received from the host device **110**. In addition, the timing controller **230** may provide the generated gate driver control signal CONT1 to the gate driver **220**.

[0061] Referring to FIG. 2, based on the gate driver control signal CONT1, the gate driver **220** may provide a plurality of gate signals G1, G2, . . . , Gh-1, and Gh to each of the plurality of gate lines GL1, GL2, . . . , GLh-1, and GLh.

[0062] A plurality of gate signals **G1**, **G2**, . . . , **Gh-1**, and **GH** may be pulse-signals having an enable level and a disable level.

[0063] The gate driver **220** may sequentially apply a plurality of gate signals **G1**, **G2**, . . . , **Gh-1**, and **Gh** to each of the plurality of gate lines **GL1**, **GL2**, . . . , **GLh-1**, and **GLh**. For example, firstly, the gate driver **220** may apply a first gate signal **G1** to the first gate line **GL1**. After all pixels connected to the first gate line **GL1** receive the first gate signal **G1** from the gate driver **220**, the gate driver **220** may apply the second gate signal **G2** to the second gate line **GL2**. After all pixels connected to the second gate line **GL2** receive the second gate signal **G2** from the gate driver **220**, the gate driver **220** may apply the third gate signal **G3** to the third gate line **GL3**.

[0064] During one horizontal period **1H**, the gate driver **220** may apply a gate signal having an enable level to all pixels connected to one gate line. After **1H** from the time point when the gate driver **220** provides the first gate signal **G1** to the first gate line **GL1**, the gate driver **220** may provide the second gate signal **G2** to the second gate line **GL2**.

[0065] The timing controller **230** may generate the source driver control signal **CONT2** based on the driving control signal **CTRL** received from the host device **110** of FIG. **1**. In addition, the timing controller **230** may provide the generated source driver control signal **CONT2** to the source driver **240**.

[0066] The timing controller **230** may generate a source amplifier control signal, based on the image signal **IS** received from the host device **110**, for each of the plurality of source amplifiers included in the source driver **240** and transmit the source amplifier control signal to the source driver **240**. In this case, the source amplifier control signal may be included in the source driver control signal **CONT2**.

[0067] The timing controller **230** may determine, based on the image signal **IS** received from the host device **110**, whether a plurality of pixels connected to the plurality of source lines **SL1**, **SL2**, . . . , **SLk-1**, and **SLk** are included in the first display area. The timing controller **230** may generate a source amplifier control signal, when a pixel connected to the first source line is included in the first display area, for turning on the first source amplifier connected to the first source line. The timing controller **230** may generate a source amplifier control signal, when a pixel connected to the first source line is included in the second display area, for turning off the first source amplifier connected to the first source line. The timing controller **230** may transmit the generated source amplifier control signal to the source driver **240**.

[0068] The timing controller **230** may generate a data **DATA** in the form of a digital signal corresponding to the image signal **IS** received from the host device **110**. The timing controller **230** may transmit the generated data **DATA** in the form of a digital signal to the source driver **240**. In this case, the data **DATA** in the form of a digital signal may include grayscale information corresponding to each pixel **PX** for displaying the image signal **IS** on the pixel array **210**.

[0069] The timing controller **230** may generate a switch control signal **CONTS** based on the area indication data of the driving control signal **CTRL** received from the host device **110**. When it is determined that the pixel connected to the first source line **SL1** is included in the first display area based on the area indication data, the timing controller **230** may generate a switch control signal **CONTS** that opens the switch. When a pixel connected to the first source line **SL1** is included in the second display area based on the area indication data, the timing controller **230** may generate a switch control signal **CONTS** that closes the switch.

[0070] Referring to FIG. **2**, the source driver **240** may generate first data signals **S01**, **S02**, . . . , **S0k-1**, and **S0k** according to the source driver control signal **CONT2** provided from the timing controller **230**. The first data signals **S01**, **S02**, . . . , **S0k-1**, and **S0k** may be obtained by converting the data **DATA** in the form of a digital signal into the data signals **S01**, **S02**, . . . , **S0k-1**, and **S0k** in the form of an analog signal. The source driver **240** may transmit the generated first data signals **S01**, **S02**, . . . , **S0k-1**, and **S0k** to the interpolation circuit **250**. In this case, the source driver **240** may be referred to as a data driver.

[0071] The source driver **240** may include a switch controller **241** that controls a plurality of switches included in the interpolation circuit **250**. The switch controller **241** may receive the switch control signal **CONTS** from the timing controller **230** and generate the switch signal **SC** based on the switch control signal **CONTS**. For example, the switch controller **241** may generate a switch signal **SC** that differently drives a plurality of switches connecting a plurality of source lines connected to the pixel displaying the first display area and a plurality of switches connecting a plurality of source lines connected to the pixel displaying the second display area from the switch control signal **CONTS**.

[0072] The interpolation circuit **250** may receive the first data signals **S01**, **S02**, . . . , **S0k-1**, and **S0k** from the source driver **240** and output the second data signals **S11**, **S12**, . . . , **S1k-1**, and **S1k** from which the plurality of first data signals **S01**, **S02**, . . . , **S0k-1**, and **S0k** are interpolated. In some embodiments, the interpolation circuit **250** may provide a second data signal **S12** obtained by interpolating a second data signal **S11** corresponding to the first source line **SL1** among the plurality of source lines **SL1**, **SL2**, . . . , **SLk-1**, and **SLk** and a second data signal **S13** corresponding to the third source line **SL3** among the plurality of source lines to the second source line **SL2** between the first source line **SL1** and the third source line **SL3**. In addition, a plurality of pixels included in the pixel array **210** may emit image light by the second data signals **S11**, **S12**, . . . , **S1k-1**, and **S1k** provided by the interpolation circuit **250**.

[0073] The interpolation circuit **250** may include a plurality of switches. The plurality of switches may connect adjacent source lines among a plurality of source lines **SL1**, **SL2**, . . . , **SLk-1**, and **SLk** to each other. The plurality of switches may be controlled based on the switch signal **SC** generated by the switch controller **241**.

[0074] For example, among the plurality of switches, a first switch may connect between the first source line **SL1** and the second source line **SL2**, and a second switch may connect between the second source line **SL2** and the third source line **SL3**. When the first switch and the second switch are closed based on the switch signal **SC** generated by the switch controller **241**, the second source line **SL2** may be electrically connected to the first source line **SL1** and the third source line **SL3**.

[0075] FIG. **3** is a block diagram illustrating a first display area and a second display area of a display panel in a display device according to one or more embodiments.

[0076] Referring to FIG. **3**, the display panel **300** may include a first display area **310** and a second display area **320**. The first display area **310** may mean an area displaying an area rendered with a first quality, and the second display area **320** may mean an area displaying an area rendered with the second quality lower than the first quality. In this case, the first display area **310** may be an area corresponding to the position of the user's eye, and the second display area **320** may be an area other than the first display area.

[0077] The switch controller **241** may receive a switch control signal **CONTS** from a timing controller **230** and generate a switch signal **SC** in order to differently drive a switch connected between a plurality of source lines based on a first display area **310** and a second display area **320**.

[0078] For example, the switch signal **SC** may generate a signal to open a plurality of switches connected between a plurality of source lines connected to a plurality of pixels included in the first display area **310**. The switch signal **SC** may generate a signal for closing a plurality of switches connected between a plurality of source lines connected to a plurality of pixels included in the second display area **320**.

[0079] FIG. **4** illustrates a source driver providing a data signal to a source line.

[0080] Referring to FIG. **4**, the source driver **400** may include a plurality of source amplifiers **AMP1**, **AMP2**, **AMP3**, **AMP4**, and **AMP5** and a plurality of decoders **DEC1**, **DEC2**, **DEC3**, **DEC4**, and **DEC5**. The decoders **DEC1**, **DEC2**, **DEC3**, **DEC4**, and **DEC5** may be connected to a non-inverting terminal of each of the plurality of source amplifiers **AMP1**, **AMP2**, **AMP3**, **AMP4**, and **AMP5**. The decoders **DEC1**, **DEC2**, **DEC3**, **DEC4**, and **DEC5** may receive grayscale information corresponding to each pixel (**PX**) in the form of digital signal data.

[0081] The plurality of decoders DEC1, DEC2, DEC3, DEC4, and DEC5 may receive a plurality of voltages VG0, VG1, . . . , and VGH from a voltage generator together with the digital data GD0, GD0, GD1, GD1, GD255. When the digital data received by the plurality of decoders DEC1, DEC2, DEC3, DEC4, and DEC5 is 8-bit data, the number of the plurality of voltages VG0, VG1, . . . , and VGH may be 28 or less, and when the digital data received by the plurality of decoders DEC1, DEC2, DEC3, DEC4, and DEC5 is 10-bit data, the number of the plurality of voltages VG0, VG1, . . . , and VGH may be 210 or less. The plurality of decoders DEC1, DEC2, DEC3, DEC4, and DEC5 may select at least some of the input plurality of voltages VG0, VG1, . . . , and VGH and transmit them to the plurality of source amplifiers AMP1, AMP2, AMP3, AMP4, and AMP5.

[0082] Referring to FIG. 4, when the first digital data GD0 is input to the first decoder DEC1, the voltage transmitted by the first decoder DEC1 to the first source amplifier AMP1 may be VG0. When the third digital data GD1 is input to the third decoder DEC3, the voltage transmitted by the third decoder DEC3 to the third source amplifier AMP3 may be VG1. When the fifth digital data GD255 is input to the fifth decoder DEC5, the voltage transmitted from the fifth decoder DEC5 to the fifth source amplifier AMP5 may be VG255.

[0083] The plurality of source amplifiers AMP1, AMP2, AMP3, AMP4, and AMP5 may apply voltages VG0, VG0, VG1, VG1, and VG255 respectively received from the plurality of decoders DEC1, DEC2, DEC3, DEC4, and DEC5 to the pixels connected to the plurality of source lines SL1, SL2, SL3, SL4, and SL5.

[0084] Referring to FIG. 4, since the same digital data GD0 is input to the first decoder DEC1 and the second decoder DEC2 and the same digital data GD1 is input to the third decoder DEC3 and the fourth decoder DEC4, the logic consumption power for processing the digital data may be reduced as compared to when digital data representing different grayscale information is input to the first decoder December 1, the second decoder December 2, the third decoder December 3, and the fourth decoder December 4.

[0085] Specifically, the logic consumption power refers to the power to process the digital data when the digital logic circuit is operated, and if the same digital data is processed, the operation speed of the logic circuit is increased and the data bandwidth is reduced, so the logic consumption power to process the same digital data may be reduced than the logic consumption power to process different digital data.

[0086] FIG. 5 illustrates a portion of a display panel on which an image is displayed by the source driver of FIG. 4.

[0087] Referring to FIGS. 4 and 5, the same digital data GD0 may be input to the first decoder DEC1 and the second decoder DEC2. The first pixel 501 connected to the first source line SL1 and the second pixel 502 connected to the second source line SL2 may emit light with substantially the same brightness.

[0088] The same digital data GD1 may be input to the third decoder DEC3 and the fourth decoder DEC4. The third pixel 503 connected to the third source line SL3 and the fourth pixel 504 connected to the fourth source line SL4 may emit light with substantially the same brightness.

[0089] The different digital data GD0, GD1, and GD255 may be input to the first decoder DEC1, the third decoder DEC3, and the fifth decoder DEC5, respectively. The first pixel 501 connected to the first source line SL1, the third pixel 503 connected to the third source line SL3, and the fifth pixel 505 connected to the fifth source line SL5 may emit light with different brightness each other.

[0090] The method in which the same digital data GD0 is input to decoder 1 DEC1 and decoder 2 DEC2 and the same digital data GD4 is input to decoder 3 DEC3 and decoder 4 DEC4 may reduce the logic consumption power to process digital data compared to the method in which different digital data is input to each of decoder 1 DEC1 through decoder 4 DEC4. However, since the first source amplifier AMP1 to the fifth source amplifier AMP5 are turned on, current consumption may occur in the source driver 400 regardless of the identity of digital data input to each of the first

decoder DEC1, the second decoder DEC2, the third decoder DEC3, the fourth decoder DEC4, and the fifth decoder DEC5. That is, even if digital data input to the plurality of decoders DEC1, DEC2, DEC3, DEC4, and DEC5 are the same, the amount of power savings generated by the source driver may be insignificant.

[0091] FIG. 6 illustrates a source driver providing a data signal to a source line according to one or more embodiments.

[0092] In FIG. 6, the interpolation circuit 610 may include a plurality of resistors R1, R2, R3, and R4 and a plurality of switches SW11, SW12, SW21, SW22, SW31, SW32, SW41, and SW42. In this case, a first resistor R1 may be connected between the first source line SL1 and the second source line SL2, a first switch SW11 may be connected between the first source line SL1 and the first resistor R1, and a second switch SW12 may be connected between the second source line SL2 and the first resistor R1. In addition, a second resistor R2 may be connected between the second source line SL2 and the third source line SL3, a third switch SW21 may be connected between the second source line SL2 and the second resistor R2, and a fourth switch SW22 may be connected between the third source line SL3 and the second resistor R2. That is, each of the plurality of source lines SL1, SL2, SL3, SL4, and SL5 may be connected to another adjacent source line through a resistor, and a switch may be connected to both sides of the resistor.

[0093] The interpolation circuit 610 may receive a plurality of first data signals S01, S03, and S05 and a switch signal SC from the source driver 620. In this case, the plurality of first data signals S01, S03, and S05 may be converted into the second data signals S11, S13, and S15 through the interpolation circuit 610 and then may be provided to the plurality of source lines SL1, SL3, and SL5, respectively. In addition, operations of the plurality of switches SW11, SW12, SW21, SW22, SW31, SW32, SW41, and SW42 included in the interpolation circuit 610 may be controlled based on the switch signal SC.

[0094] When the pixels connected to the plurality of source lines SL1, SL2, SL3, SL4, and SL5 are included in the first display area, the switch signal SC received by the interpolation circuit 610 may be different from the switch signal SC received by the interpolation circuit 610 when the pixels connected to the plurality of source lines SL1, SL2, SL3, SL4, and SL5 are included in the second display area 320 of FIG. 3. When the pixels connected to the plurality of source lines SL1, SL2, SL3, SL4, and SL5 are included in the first display area 310 of FIG. 3, the plurality of switches SW11, SW12, SW21, SW22, SW31, SW32, SW41, and SW42 may be opened based on the switch signal SC. When the pixels connected to the plurality of source lines SL1, SL2, SL3, SL4, and SL5 are included in the second display area 320, some of the plurality of switches SW11, SW12, SW21, SW22, SW31, SW32, SW41, and SW42 may be closed based on the switch signal SC.

[0095] When a plurality of pixels connected to the plurality of source lines SL1, SL2, SL3, SL4, and SL5 are included in the second display area 320, the timing controller 230 of FIG. 2 may transmit the source amplifier control signals EN2 and EN4 for turning off the second source amplifier AMP2 and the fourth source amplifier AMP4 to the source driver 620.

[0096] When a plurality of pixels connected to a plurality of source lines SL1, SL2, SL3, SL4, and SL5 are included in the second display area 320, the switch controller 241 of FIG. 2 may generate a switch signal SC for closing a plurality of switches SW11, SW12, SW21, SW22, SW42, SW41, and SW42 positioned at both sides of each of the first resistor R1, the second resistor R2, the third resistor R3, and the fourth resistor R4.

[0097] The interpolation circuit 610 may receive the first data signal S01 and the first data signal S03 and transmit the second data signal S12 interpolated by the first resistor R1 and the second resistor R2 to the second source line SL2. The interpolation circuit 610 may receive the first data signal S03 and the first data signal S05 and transmit the second data signal S14 interpolated by the third resistor R3 and the fourth resistor R4 to the fourth source line SL4. In addition, the second source amplifier AMP2 connected to the second source line SL2 and the fourth source amplifier AMP4 connected to the fourth source line SL4 receiving the second data signals S12 and S14 may

be turned off based on the source amplifier control signals EN2 and EN4.

[0098] The second data signal **S12** may have a voltage in which the voltage of the first data signal **S01** and the voltage of the first data signal **S03** are divided according to the magnitudes of the first resistor **R1** and the second resistor **R2**. The second data signal **S14** may have a voltage in which the voltage of the first data signal **S03** and the voltage of the first data signal **S05** are divided according to the magnitudes of the third resistor **R3** and the fourth resistor **R4**. The voltage of the second data signals **S12** and **S14** may be calculated according to Equations 1 and 2 below.

$$S12=(R1*S03+R2*S01)/(R1+R2) \quad \text{[Equation 1]}$$

[0099] Here, **S12** may be a voltage of the second data signal **S12**, **R1** may be a first resistor, **S03** may be a voltage of the first data signal **S03**, **R2** may be a second resistor, and **S01** may be a first data signal **S01**.

$$S14=(R3*S05+R4*S03)/(R3+R4) \quad \text{[Equation 2]}$$

[0100] Here, **S14** may be a voltage of the second data signal **S14**, **R3** may be a third resistor, **S05** may be a voltage of the first data signal **S05**, **R4** may be a fourth resistor, and **S03** may be a first data signal **S03**.

[0101] That is, the voltages of the interpolated second data signals **S12** and **S14** may be calculated by using voltages **VDATA(0)**, **VDATA(100)**, and **VDATA(200)** of the first data signals **S11**, **S13**, and **S15** to be subject of interpolation and a plurality of resistors **R1**, **R2**, **R3**, and **R4** connecting the plurality of source lines **SL1**, **SL2**, **SL3**, **SL4**, **SL5** to each other. In this case, the voltages **VDATA(0)**, **VDATA(100)**, and **VDATA(200)** of the first data signals **S11**, **S13**, and **S15** to be interpolated may be determined based on the digital data **GD0**, **GD100**, and **GD200** applied to the plurality of decoders **DEC1**, **DEC3**, and **DEC5**.

[0102] Referring to FIG. 6, a static current may be generated from the resistors **R1**, **R2**, **R3**, and **R4** in the interpolation circuit **610**. However, since the voltage difference of the data signal applied to the adjacent pixel will be insufficient, the power consumption due to the static current generated by the resistors **R1**, **R2**, **R3**, and **R4** in the interpolation circuit **610** may be insufficient. Rather, since the source amplifier corresponding to the source line transmitting the interpolated data is turned off, the power consumption generated from the display panel may be reduced.

[0103] As the number of pixels connected to the plurality of source lines **SL1**, **SL2**, **SL3**, **SL4**, and **SL5** included in the second display area **320** increases, more source amplifiers are turned off and may reduce power consumption generated from the display panel, and thus the size of the second display area **320** may be set wider than that of the first display area **321**.

[0104] FIG. 7 illustrates a portion of a display panel on which an image is displayed by the source driver of FIG. 6.

[0105] Referring to FIGS. 6 and 7, it may be seen that the first digital data **GD0** is input to the first decoder **DEC1**, the second digital data **GD0** is input to the second decoder **DEC2**, the third digital data **GD100** is input to the third decoder **DEC3**, the fourth digital data **GD100** is input to the fourth decoder **DEC4**, the fifth digital data **GD200** is input to the fifth decoder **DEC5**, and the second source amplifier **AMP2** and the fourth source amplifier **AMP4** corresponding to the second source line **SL2** and the fourth source line **SL4** are turned off. Accordingly, the brightness of the second pixel **702** connected to the second source line **SL2** and the fourth pixel **704** connected to the fourth source line **SL4** may be determined regardless of the grayscale information input to the second decoder **DEC2** and the fourth decoder **DEC4**.

[0106] According to the present disclosure, although the same digital data **GD0** is applied to the decoder 2 **DEC2** as to the decoder 1 **DEC1**, the second data signal **S12** interpolated by the first data signals **S01** and **S03** may be provided to the second source line **SL2** connected to the second source amplifier **AMP2** in the off state. Although the same digital data **GD100** is applied to the fourth decoder 4 **DEC4** as to the third decoder 3 **DEC3**, the second data signal **S14** interpolated by the

first data signals **S01** and **S03** may be provided to the fourth source line **SL4** connected to the fourth source amplifier **AMP4** in the off state.

[0107] The brightness of the second pixel **702** connected to the second source line **SL2** may have a value between the brightness of the first pixel **701** connected to the first source line **SL1** and the brightness of the third pixel **703** connected to the third source line **SL3**. In this case, the brightness of the second pixel **702** may be determined based on values of the first resistor **R1** and the second resistor **R2** of the interpolation circuit **610**.

[0108] For example, when the first resistor **R1** has a higher resistance value than the second resistor **R2**, the brightness of the second pixel **702** connected to the second source line **SL2** may be determined to be close to the brightness of the third pixel **703** connected to the third source line **SL3**. On the other hand, when the first resistor **R1** has a lower resistance value than the second resistor **R2**, the brightness of the second pixel **702** connected to the second source line **SL2** may be determined to be close to the brightness of the first pixel **701** connected to the first source line **SL1**.

[0109] Likewise, in the case of the fourth pixel **704** connected to the fourth source line **SL4**, there may be a value between the brightness of the third pixel **703** connected to the third source line **SL3** and the brightness of the fifth pixel **705** connected to the fifth source line **SL5**. When the third resistor **R3** has a higher resistance value than the fourth resistor **R4**, the brightness of the fourth pixel **704** connected to the fourth source line **SL4** may be determined to be close to the brightness of the fifth pixel **705** connected to the fifth source line **SL5**. When the third resistor **R3** has a resistance value lower than the fourth resistor **R4**, the brightness of the fourth pixel **704** connected to the fourth source line **SL4** may be determined to be close to the brightness of the third pixel **703** connected to the third source line **SL3**.

[0110] The pixels **702** and **704** included in the second display area may receive the second data signals **S12** and **S14** for various grayscale information due to interpolation through the first to fourth resistors **R1**, **R2**, **R3**, and **R4**. The pixels **702** and **704** included in the second display area may display various grayscale levels based on the second data signals **S12** and **S14**. Accordingly, the image quality of the second display area of the foveated rendered image may be improved.

[0111] FIG. 8 illustrates a source driver providing a data signal to a source line according to one or more embodiments.

[0112] Referring to FIG. 8, a plurality of pixels connected to a plurality of source lines **SL1**, **SL2**, **SL3**, **SL4**, and **SL5** may be included in the first display area **310** of FIG. 3. In this case, the switch signal **SC** may open a plurality of switches **SW11**, **SW12**, **SW21**, **SW22**, **SW31**, **SW32**, **SW41**, and **SW42** in the interpolation circuit **810**. The timing controller **230** of FIG. 2 may transmit the source amplifier control signals **EN1**, **EN2**, **EN3**, **EN4**, and **EN5** operating all of the plurality of source amplifiers **AMP1**, **AMP2**, **AMP3**, **AMP4**, and **AMP5** connected to the plurality of source lines **SL1**, **SL2**, **SL3**, **SL4** and **SL5** to the source driver **820**.

[0113] The plurality of source lines **SL1**, **SL2**, **SL3**, **SL4**, and **SL5** may receive the plurality of data signals **S01**, **S02**, **S03**, **S04**, and **S05** from the source driver **820** based on the respective digital data **GD100**, **GD101**, **GD102**, **GD103**, and **GD104** input to the decoders **DEC1**, **DEC2**, **DEC3**, **DEC4**, and **DEC5** connected to the source amplifier.

[0114] The brightness of the first pixel connected to the first source line **SL1** may be determined based on the first digital data **GD100** input to the first decoder **DEC1**, the brightness of the second pixel connected to the second source line **SL2** is determined based on the second digital data **GD101** input to the second decoder **DEC2**, and the brightness of the third pixel connected to the third source line **SL3** may be determined based on the third digital data **GD102** input to the third decoder **DEC3**. Likewise, the brightness of the fourth pixel connected to the fourth source line **SL4** may be determined based on the fourth digital data **GD103** input to the fourth decoder **DEC4**, and the brightness of the fifth pixel connected to the fifth source line **SL5** may be determined based on the fifth digital data **GD104** input to the fifth decoder **DEC5**.

[0115] FIG. 9 illustrates a source driver providing a data signal to a source line according to one or

more embodiments.

[0116] Referring to FIG. 9, the interpolation circuit **900** may include a first interpolation circuit **910**, a second interpolation circuit **920**, and a third interpolation circuit **930**. The first interpolation circuit **910** may mean a circuit in which the first source line SL1, the second source line SL2, and the third source line SL3 are connected through a plurality of resistors R1 and R2 and a plurality of switches SW11, SW12, SW21, and SW22. The second interpolation circuit **920** may mean a circuit in which the third source line SL3 to the 28th source line SL28 are connected through a plurality of resistors R3 to R27 and a plurality of switches SW31, SW32, SW41, SW42, SW51, SW52, SW61, SW62, SW71 to SW272. The third interpolation circuit **930** may mean a circuit in which the 28th source line SL28, the 29th source line SL29, and the 30th source line SL30 are connected through a plurality of resistors R28 and R29 and a plurality of switches SW281, SW282, SW291, and SW292.

[0117] Referring to FIG. 9, a pixel connected to the first source line SL1 to the third source line SL3 may be included in the first area k1, a pixel connected to the fourth source line SL4 to the 27th source line SL27 may be included in the second area k2, and a pixel connected to the 28th source line SL28 to the 30th source line SL30 may be included in the third area k3. In this case, the first area k1 and the third area k3 may mean the second display area **320** of FIG. 3, and the second area k2 may mean the first display area **310** of FIG. 3.

[0118] The source driver **940** may include a plurality of source amplifiers AMP1 to AMP30 and a plurality of decoders DEC1 to DEC30. The source driver **940** may receive a second source amplifier control signal EN2 for turning off the second source amplifier AMP2 and the 29th source amplifier control signal EN29 for turning off the 29th source amplifier AMP2 from the timing controller **230** of FIG. 2.

[0119] The plurality of switches SW11, SW12, SW21, and SW22 included in the first interpolation circuit **910** may receive signals SCL for controlling to close the switch from the switch controller **241** of FIG. 2. The plurality of switches SW31, SW32, SW41, and SW42 to SW272 included in the second interpolation circuit **920** may receive signals SCL for controlling to open the switch from the switch controller **241**. The plurality of switches SW281, SW282, SW291, and SW292 included in the third interpolation circuit **930** may receive a signal SCL for controlling to close the switch from the switch controller **241**.

[0120] A plurality of pixels connected to each of the source lines SL1, SL2, and SL3 included in the first area k1 may receive a plurality of second data signals S11, S12, and S13 through the first interpolation circuit **910**. In this case, the second data signal S12 may be obtained by interpolating a plurality of first data signals S01 and S03.

[0121] A plurality of pixels connected to each of the plurality of source lines SL4 to SL27 included in the second area k2 may receive a plurality of second data signals S14 to S27 through the second interpolation circuit **920**.

[0122] A plurality of pixels connected to each of the plurality of source lines SL28 to SL30 included in the third area k3 may receive a plurality of second data signals S28 to S30 through the third interpolation circuit **930**. In this case, the second data signal S29 may be obtained by interpolating a plurality of first data signals S28 and S30.

[0123] FIG. 10 illustrates a portion of a display panel on which an image is displayed by the source driver of FIG. 9.

[0124] Referring to FIGS. 9 and 10, first digital data GD2 may be input to the first decoder DEC1, and third digital data GD50 may be input to the third decoder DEC3. The 28th digital data GD50 may be input to the 28th decoder DEC28, and the 30th digital data GD2 may be input to the 30th decoder DEC30. In addition, the second source amplifier AMP2 and the 29th source amplifier AMP29 connected to the second source line SL2 and the 29th source line SL29 may be turned off.

[0125] Accordingly, the brightness of the second pixel **1002** connected to the second source line SL2 and the 29th pixel **1010** connected to the 29th source line SL29 may be determined regardless

of the second digital data GD2 input by the second decoder DEC2 and the 29th digital data GD50 input by the 29th decoder DEC29.

[0126] Specifically, in the case of the second pixel **1002** connected to the second source line SL2, there may be a value between the brightness of the first pixel **1001** connected to the first source line SL1 and the brightness of the third pixel **1003** connected to the third source line SL3. In addition, in the case of the 29th pixel **1010** connected to the 29th source line SL29, there may be a value between the brightness of the 28th pixel **1009** connected to the 28th source line SL28 and the brightness of the 30th pixel **1011** connected to the 30th source line SL30. The brightness of the second pixel **1002** and the 29th pixel **1010** may be determined based on the values of the first resistor R1, the second resistor R2, the third resistor R3, and the fourth resistor R4 included in the first interpolation circuit **910** and the third interpolation circuit **930**.

[0127] For example, when the first resistor R1 has a higher resistance value than the second resistor R2, the brightness of the second pixel **1002** connected to the second source line SL2 may be determined to be close to the brightness of the third pixel **1003** connected to the third source line SL3. On the other hand, when the first resistor R1 has a lower resistance value than the second resistor R2, the brightness of the second pixel **1002** connected to the second source line SL2 may be determined to be close to the brightness of the first pixel **1001** connected to the first source line SL1.

[0128] Likewise, when the 28th resistor R28 has a higher resistance value than the 29th resistor R29, the brightness of the 29th pixel **1010** connected to the 29th source line SL29 may be determined to be close to the brightness of the 30th pixel **1011** connected to the 30th source line SL30, and when the 28th resistor R28 has a lower resistance value than the 29th resistor R29, the brightness of the 29th pixel **1010** connected to the 29th source line SL29 may be determined to be close to the brightness of the 28th pixel **1009** connected to the 28th source line SL28.

[0129] Next, referring to FIGS. **9** and **10**, the brightness of the fourth pixel **1004** connected to the fourth source line SL4 is determined based on the fourth digital data GD100 input to the fourth decoder DEC4, the brightness of the fifth pixel **1005** connected to the fifth source line SL5 is determined based on the fifth digital data GD2 input to the fifth decoder DEC5, and the brightness of the sixth pixel **1006** connected to the sixth source line SL6 may be determined based on the sixth digital data GD100 input to the sixth decoder DEC6. In addition, the brightness of the seventh pixel **1007** connected to the seventh source line SL7 is determined based on the seventh digital data GD70 input to the seventh decoder DEC7, and the brightness of the 27th pixel **1008** connected to the 27th source line SL27 may be determined based on the 27th digital data GD100 input to the 27th decoder DEC27.

[0130] FIG. **11** illustrates a source driver providing a data signal to a source line according to one or more embodiments.

[0131] Prior to the description of FIG. **11**, the pixels connected to each of the plurality of source lines SL1, SL2, SL3, SL4, and SL5 may be included in the second display area **320** of FIG. **3**, and the second source amplifier AMP2 and the fourth source amplifier AMP4 included in the source driver **1120** may be in an off state.

[0132] Referring to FIG. **11**, the interpolation circuit **1110** may include a plurality of resistors (R1-1, R1-2, R1-3, R2-1, R2-2, R2-3, R3-1, R3-2, R3-3, R4-1, R4-2, and R4-3) connected in parallel and a plurality of switches (SW11, SW12, SW13, SW14, SW15, SW16, SW21, SW22, SW23, SW23 SW24, SW25, SW26, SW31, SW32, SW33, SW34, SW35, SW36, SW41, SW42, SW43, SW44, SW45, and SW46) connected to both side of a plurality of resistors (R1-1, R1-2, R1-3, R2-1, R2-2, R2-3, R3-1, R3-2, R3-3, R4-1, R4-2, and R4-3), respectively. In this case, each of the plurality of resistors R1-1, R1-2, R1-3, R2-1, R2-2, R2-3, R3-1, R3-2, R3-3, R4-1, R4-2, and R4-3, may be connected to a plurality of adjacent source lines SL1, SL2, SL3, SL4, and SL5.

[0133] The interpolation circuit **1110** may include a plurality of first resistors R1-1, R1-2, and R1-3 connected in parallel between the first source line SL1 and the second source line SL2, a plurality

of first switches SW11, SW13, and SW15 connected between one end of each of the plurality of first resistors R1, R1-2, and R1-3 and the first source line SL1, and a plurality of second switches SW12, SW14, and SW16 connected between the other end of each of the plurality of first resistors R1-1, R1-2, and R1-3 and the second source line SL2.

[0134] The interpolation circuit 1110 may include a plurality of second resistors R2-1, R2-2, and R2-3 connected in parallel between the second source line SL2 and the third source line SL3, a plurality of third switches SW21, SW23, and SW25 connected between one end of each of a plurality of second resistors R2-1, R2-2, and R2-3 and the second source line SL2, and a plurality of fourth switches SW22, SW24, and SW26 connected between the other end of each of a plurality of second resistors R2-1, R2-2, and R2-3 and the third source line SL3. In addition, the plurality of third resistors R3-1, R3-2, and R3-, the plurality of fourth resistors R4-1, R4-2, and R4-3 and the plurality of switches SW31, SW32, SW33, SW34, SW35, SW36, SW41, SW42, SW43, SW44, SW45, and SW46 included in the interpolation circuit 1110 may be also connected in the above manner.

[0135] In the present disclosure, the switch controller 241 of FIG. 2 may generate a switch signal SC of FIG. 2 for controlling a plurality of switches SW11, SW12, SW13, SW14, SW15, SW21, SW22, SW23, SW24, SW25, SW26, SW31, SW32, SW33, SW34, SW35, SW36, SW41, SW42, SW43, SW44, SW45, and SW46 included in the interpolation circuit. In this case, the switch signal SC may include one of a signal for opening a switch and a signal for closing the switch. The switch controller 241 may individually provide switch signals SC to the plurality of switches SW11, SW12, SW13, SW14, SW15, SW16, SW21, SW22, SW23, SW24, SW25, SW26, SW31, SW32, SW33, SW34, SW35, SW36, SW41, SW42, SW43, SW44, SW45, and SW46. In addition, the switch controller 241 may provide the same switch signal SC for each of the two switches directly connected to both sides of the plurality of resistors R1-1, R1-2, R2-3, R3-1, R3-2, R3-3, R4-1, R4-2, and R4-3.

[0136] In one or more embodiments, among the plurality of resistors R1-1, R1-2, R-3, R2-1, R2-2, R3-3, R4-1, R4-2, and R4-3 included in an interpolation circuit 1110, a plurality of switches SW11, SW12, SW21, SW22, SW31, SW32, SW41, and SW42 connected to both sides of the resistors R1-1, R1-2, R1-3, R2-1, R2-2, R3-3, R4-1 adjacent to the source driver 1120 may receive a switch signal SCL in which the switch is closed from the switch controller 241.

[0137] Among a plurality of resistors included in the interpolation circuit 1110, a plurality of switches SW13, SW14, SW33, and SW34 connected to both sides of the resistors R1-2 and R3-2 located at the upper side of the resistor adjacent to the source driver 1120 may receive the switch signal SCL-1 in which the switch is closed from the switch controller 241. Among a plurality of resistors included in the interpolation circuit 1110, a plurality of switches SW23, SW24, SW43, and SW44 connected to both sides of the resistors R2-2, and R4-2 located at the upper side of the resistor adjacent to the source driver 1120 may receive the switch signal SCL-2 in which the switch is open from the switch controller 241.

[0138] Among a plurality of resistors included in the interpolation circuit 1110, a plurality of switches SW15, SW16, SW35, and SW36 connected to both sides of the resistors R1-3, and R3-3 located at the upper side in the interpolation circuit 1110 may receive the switch signal SCL-3 in which the switch is closed from the switch controller 241. Among a plurality of resistors included in the interpolation circuit 1110, a plurality of switches SW25, SW26, SW45, and SW46 connected to both sides of the resistors R2-3, and R4-3 located at the upper side in the interpolation circuit 1110 may receive the switch signal SCL-4 in which the switch is closed from the switch controller 241.

[0139] Referring to FIG. 11, the method of providing the same switch signal SC for each of the two switches directly connected to both sides of the plurality of resistors (R1-1, R1-2, R1-3, R2-1, R2-2, R2-3, R3-1, R3-2, R3-3, R4-1, R4-2, and R4-3) may significantly reduce the number of switch signal lines compared to the method in which the plurality of switches (SW11, SW12, SW13,

SW14, SW15, SW16, SW21, SW22, SW23, SW24, SW25, SW26, SW31, SW32, SW33, SW34, SW35, SW36, SW41, SW42, SW43, SW44, SW45, and SW46) receive the switch signal SC individually.

[0140] FIG. 12 illustrates a portion of a display panel on which an image is displayed by the source driver of FIG. 11.

[0141] Referring to FIGS. 11 and 12, it will be explained assuming that all of the resistors (R1-1, R1-2, R1-3, R2-1, R2-2, R2-3, R3-1, R3-2, R3-3, R4-1, R4-2, and R4-3) of FIG. 11 have the same resistance value R.

[0142] The brightness of the first pixel 1201 connected to the first source line SL1, the second pixel 1202 connected to the second source line SL2, the third pixel 1203 connected to the third source line SL3, the fourth pixel 1204 connected to the fourth source line SL4, and the fifth pixel 1205 connected to the fifth source line SL5 may represent when all the switches SW11, SW12, SW13, SW14, SW15, SW16, SW21, SW22, SW23, SW24, SW25, SW26, SW31, SW32, SW33, SW34, SW35, SW36, SW41, SW42, SW43, SW44, SW45, and SW46 included in the interpolation circuit 1110 of FIG. 11 are closed.

[0143] Since a plurality of switches SW11, SW12, SW13, SW14, SW15, and SW16 connected between the first source line SL1 and the second source line SL2 are all closed, a plurality of resistors R1-1, R1-2, and R1-3 connected in parallel between the first source line SL1 and the second source line SL2 may have a total $R/3$ value.

[0144] Since the plurality of switches SW21, SW22, SW23, SW24, SW25, and SW26 connected between the second source line SL2 and the third source line SL3 are all closed, the plurality of resistors R2-1, R2-2, and R2-3 connected in parallel between the second source line SL2 and the third source line SL3 may have a total $R/3$ value.

[0145] Since a plurality of switches SW31, SW32, SW33, SW34, SW35, and SW36 connected between the third source line SL3 and the fourth source line SL4 are all closed, a plurality of resistors R3-1, R3-2, and R3-3 connected in parallel between the third source line SL3 and the fourth source line SL4 may have a total $R/3$ value.

[0146] Since the plurality of switches SW41, SW42, SW43, SW44, SW45, and SW46 connected between the fourth source line SL4 and the fifth source line SL5 are all closed, the plurality of resistors R4-1, R4-2, and R4-3 connected in parallel between the fourth source line SL4 and the fifth source line SL5 may have a total $R/3$ value.

[0147] A first digital data GD0 may be input to the first decoder DEC1, a third digital data GD100 may be input to the third decoder DEC3, and a fifth digital data GD200 may be input to the fifth decoder DEC5. In addition, the second source amplifier AMP2 and the fourth source amplifier AMP4 corresponding to the second source line SL2 and the fourth source line SL4 may be turned off. Accordingly, the brightness of the second pixel 1202 connected to the second source line SL2 and the fourth pixel 1204 connected to the fourth source line SL4 may be determined regardless of digital data input to the second decoder DEC2 and the fourth decoder DEC4.

[0148] Specifically, in the case of the second pixel 1202 connected to the second source line SL2, there may be a value between the brightness of the first pixel 1201 connected to the first source line SL1 and the brightness of the third pixel 1203 connected to the third source line SL3. In addition, in the case of the fourth pixel 1204 connected to the fourth source line SL4, there may be a value between the brightness of the third pixel 1203 connected to the third source line SL3 and the brightness of the fifth pixel 1205 connected to the fifth source line SL5.

[0149] Next, the first pixel 1206 connected to the first source line SL1, the second pixel 1207 connected to the second source line SL2, the third pixel 1208 connected to the third source line SL3, the fourth pixel 1209 connected to the fourth source line SL4, and the fifth pixel 1210 connected to the fifth source line SL5 indicate the brightness of the pixel when the plurality of switches SW23, SW24, SW25, SW26, SW33, SW34, SW35, and SW36 included in the interpolation circuit 1110 are opened, and the plurality of switches SW11, SW12, SW13, SW14,

SW15, SW16, SW21, SW22, SW31, SW32, SW41, SW42, SW43, SW44, SW45, and SW46 are closed.

[0150] In this case, the total resistance values of a plurality of resistors R1-1, R1-2, and R1-3 connected in parallel between the first source line SL1 and the second source line SL2 may have an $R/3$ value, and the total resistance values of a plurality of resistors R2-1, R2-2, and R2-3 connected in parallel between the second source line SL2 and the third source line SL3 may have an R value. In addition, the total resistance values of the plurality of resistors R3-1, R3-2, and R3-3 connected in parallel between the third source line SL3 and the fourth source line SL4 may have an R value, and the total resistance values of the plurality of resistors R4-1, R4-2, and R4-3 connected in parallel between the fourth source line SL4 and the fifth source line SL5 may have an $R/3$ value.

[0151] Accordingly, the brightness of the second pixel 1207 connected to the second source line SL2 may be determined to be close to the brightness of the first pixel 1206 connected to the first source line SL1. The brightness of the fourth pixel 1209 connected to the fourth source line SL4 may be determined to be close to the brightness of the fifth pixel 1210 connected to the fifth source line SL5.

[0152] FIG. 13 illustrates a portion of a pixel array included in a display panel on which an image is displayed by a source driver.

[0153] Referring to FIG. 13, the pixel array 1300 may include a plurality of pixels for displaying an image, and the plurality of pixels may be included in the first display area 1301, the second display area 1302, and the third display area 1303 in the pixel array 1300. A plurality of pixels may express light having different luminance for each of the display areas 1301, 1302, and 1303. In this case, the first display area 1301 may be an area displaying a area rendered with a first quality, the second display area 1302 may be an area displaying an area rendered with a second quality lower than the first quality, and the third display area 1303 may be an area displaying an area rendered with a third quality lower than the second quality. For example, the first display area 1301, the second display area 1302, and the third display area 1303 may be areas displaying areas rendered in $10\times$, $4\times$, and $1\times$ qualities, respectively.

[0154] The first display area 1301 may be an area displaying a focus area in which the user's gaze is seated or fixed based on the eye tracking data ED of FIG. 1. In this case, the size of the focus area may be based on an arc/angle covered by the user's gaze or a movement amount of the user's gaze.

[0155] In the present disclosure, the second display area 1302 and the third display area 1303 may be determined based on the degree of separation from the first display area 1301. Specifically, the degree of separation may be determined based on an adjacent distance from a plurality of pixels included in the upper, right, lower and left outer borders 1311, 1312, 1313, and 1314 of the first display area 1301 to a plurality of pixels included in the upper, right, lower and left outer borders 1321, 1322, 1323, and 1324 of the second display area 1302. In this case, the degree of separation may mean a distance between the gate lines GL1, GL2, GL3, . . . , and GL10 or the source lines SL1, SL2, SL3, . . . , SL10 from the upper, right, lower and left outer borders 1311, 1312, 1313, and 1314 of the first display area 1301 to the upper, right, lower and left outer borders 1321, 1322, 1323, and 1324 of the second display area 1302.

[0156] A plurality of pixels within the first display area 1301 that are at a distance less than a first reference value from the upper outer border 1311 may be included in the second display area 1302, and a plurality of pixels within the first display area 1301 that are at a distance equal to or greater than a first reference value from the upper outer border 1311 may be included in the third display area 1303.

[0157] A plurality of pixels within the first display area 1301 that are at a distance less than a second reference value from the right outer border 1312 may be included in the second display area 1302, and a plurality of pixels within the first display area 1301 that are at a distance equal to or greater than a second reference value from the right outer border 1312 may be included in the third

display area **1303**.

[0158] A plurality of pixels within the first display area **1301** that are at a distance less than a third reference value from the lower outer border **1313** may be included in the second display area **1302**, and a plurality of pixels within the first display area **1301** that are at a distance equal to or greater than a third reference value from the lower outer border **1313** may be included in the third display area **1303**.

[0159] A plurality of pixels within the first display area **1301** that are at a distance less than a fourth reference value from the left outer border **1314** may be included in the second display area **1302**, and a plurality of pixels within the first display area **1301** that are at a distance equal to or greater than a fourth reference value from the left outer border **1314** may be included in the third display area **1303**.

[0160] The second display area **1302** may include a plurality of pixels spaced apart according to first to fourth reference values from each of the plurality of pixels included in the upper, right, lower, and left outer borders **1311**, **1312**, **1313**, and **1314** of the first display area **1301**. For example, a distance between two gate lines from pixels included in the upper outer border **1311** of the first display area **1301** may be set as a first reference value. A distance between the six source lines from the pixels included in the right outer border **1312** of the first display area **1301** may be set as a second reference value. A distance between the two gate lines from the pixels included in the lower outer border **1313** of the first display area **1301** may be set as a third reference value. A distance between zero (0) number of the source line from pixels included in the left outer border **1314** of the first display area **1301** may be set as a fourth reference value.

[0161] The pixels of the upper outer border **1321** of the second display area **1302** may be connected to the ninth gate line GL9 separated by two gate lines from the seventh gate line GL7 to which the pixels of the upper outer border **1311** of the first display area **1301** are connected. The pixels of the right outer border **1322** of the second display area **1302** may be connected to the eighth source line SL8 separated by six source lines from the second source line SL2 to which the pixels of the right outer border **1312** of the first display area **1301** are connected. The pixels of the lower outer border **1323** of the second display area **1302** may be connected to the second gate line GL2 separated by two gate lines from the fourth gate line GL4 to which the pixels of the lower outer border **1313** of the first display area **1301** are connected. The pixels of the left outer border **1324** of the second display area **1302** may be connected to the first source line SL1 to which pixels of the left outer border **1314** of the first display area **1301** are connected.

[0162] The third display area **1303** may include a spaced border apart from the outer borders **1311**, **1312**, **1313**, and **1314** of the first display area **1301** according to a predetermined criterion. For example, the pixels included in the upper side of the third display area **1303** may be connected to the tenth gate line GL10 separated by three gate lines from the seventh gate line GL7 to which pixels of the upper border **1311** of the first display area **1301** are connected. The pixels included on the right side of the third display area **1303** may be connected to the tenth source line SL10 separated by eight source lines from the second source line SL2 to which the pixels on the right border **1312** of the first display area **1301** are connected. The pixels included in the lower side of the third display area **1303** may be connected to the first gate line GL1 separated by three gate lines from the fourth gate line GL4 to which the pixels of the lower border **1313** of the first display area **1301** are connected. The pixels included in the left side of the third display area **1303** may be connected to the first source line SL1 to which pixels of the left border **1314** of the first display area **1301** are connected.

[0163] FIG. **14** illustrates a source driver providing a data signal to a source line according to one or more embodiments.

[0164] Referring to FIGS. **13** and **14**, a pixel connected to each of the first source line SL1 and the second source line SL2 may be included in the first area m1, and a pixel connected to the third source line SL3, the fourth source line SL4, the fifth source line SL5, and the sixth source line SL6

may be included in the second area m2. In this case, the first area m1 may mean a second display area **1302** of FIG. **13**, and the second area m2 may mean a third display area **1303** of FIG. **13**. And, the switch controller **241** of FIG. **2** may generate a switch signal SC that closes all switches connected to the first source line SL1 to the sixth source line SL6 in the interpolation circuit **1420**. [0165] In addition, a plurality of switches in the interpolation circuit **1420** may be driven based on the switch signal SC received from the switch controller **241**. The source driver **1410** may include a plurality of source amplifiers AMP1, AMP2, AMP3, AMP4, AMP5, and AMP6 and a plurality of decoders DEC1, DEC2, DEC3, DEC4, DEC5, and DEC6. The plurality of first data signals S01, S03, S04, and S06 received from the source driver **1410** may be converted into second data signals S11, S13, S14, and S16 via the interpolation circuit **1420** and then may be provided to the plurality of source lines SL1, SL3, SL4, and SL6, respectively.

[0166] In addition, when the first source line SL1 and the second source line SL2 are included in the first area m1, the timing controller **230** of FIG. **2** may transmit a source amplifier control signal EN2 for turning off the second source amplifier AMP2 connected to the second source line SL2 to the second source amplifier AMP2.

[0167] In addition, when the third source line SL3 to the sixth source line SL6 are included in the second area m2, the timing controller **230** may transmit the source amplifier control signals EN4 and EN5 to the fourth source amplifier AMP4 and the fifth source amplifier AMP5 for turning off the fourth source amplifier AMP4 and the fifth source amplifier AMP5 connected to the fourth source line SL4 and the fifth source line SL5.

[0168] In addition, in the second area m2, two off state amplifiers AMP4 and AMP5 are placed between the on-state amplifiers AMP3 and AMP6, but the present disclosure is not limited thereto. For example, the further away from the first display area **1301** of FIG. **13**, the greater the number of off state amplifiers may be placed between the on state amplifiers. In this way, by turning off more source amplifiers connected with the source lines included in the display area further away based on their distance from the first display area **1301**, the amount of power saving generated from the source driver **1410** may be increased.

[0169] FIG. **15** illustrates a portion of a display panel on which an image is displayed by the source driver of FIG. **14**.

[0170] Referring to FIGS. **14** and **15**, it may be seen that the first digital data GD0 is input to the first decoder DEC1, the third digital data GD100 is input to the third decoder DEC3, the sixth digital data GD200 is input to the sixth decoder DEC6, and the second source amplifier AMP2, the fourth source amplifier AMP4, and the fifth source amplifier AMP5 connected to the second source line SL2, the fourth source line SL4, and the fifth source line SL5 are turned off. Accordingly, the brightness of the second pixel **1502** connected to the second source line SL2, the fourth pixel **1504** connected to the fourth source line SL4, and the fifth pixel **1505** connected to the fifth source line SL5 may be determined regardless of the digital data GD0, GD100, and GD200 received from the second decoder DEC2, the fourth decoder DEC4, and the fifth decoder DEC5, respectively.

[0171] Specifically, in the case of the second pixel **1502** connected to the second source line SL2, there may be a value between the brightness of the first pixel **1501** connected to the first source line SL1 and the brightness of the third pixel **1503** connected to the third source line SL3.

[0172] In addition, the fourth pixel **1504** connected to the fourth source line SL4 and the fifth pixel **1505** connected to the fifth source line SL5 may have a value between the brightness of the third pixel **1503** connected to the third source line SL3 and the brightness of the sixth pixel **1506** connected to the sixth source line SL6. In addition, the fourth pixel **1504** may be closer to the brightness of the third pixel **1503** than the fifth pixel **1505**, and the fifth pixel **1505** may be closer to the brightness of the sixth pixel **1506** than the fourth pixel **1504**.

[0173] FIG. **16** is a circuit diagram illustrating a source amplifier and a plurality of switches in a source driver according to one or more embodiments.

[0174] Referring to FIG. **16**, the source driver **1600** may include a first source amplifier AMP1, a

first decoder DEC1, a first switch SW1, a second switch SW2, and a third switch SW3. The first source amplifier AMP1 may be connected to the first source line SL1 through a first switch SW1, a second switch SW2, and a third switch SW3. The first switch SW1 may be connected to the first source line SL1 connected to the output terminal of the first source amplifier AMP1. The second switch SW2 may be connected to the first signal line 1601 connected between the inverting terminal of the first source amplifier AMP1 and the first switch SW1. The third switch SW3 may be connected to the inverting terminal of the first source amplifier AMP1 and the second signal line 1602 connected to the first source line SL1. In this case, the second signal line may be a signal line in which an upper end of the first switch SW1 connected on the first source line SL1 and an inverting terminal of the first source amplifier AMP1 are connected.

[0175] The gate driver 220 of FIG. 2 may provide gate signals to all pixels connected to one gate line among the plurality of gate lines. After 1H, which is the time taken for the gate driver 220 to apply the gate signal to all pixels connected to one gate line, the gate driver 220 may provide the gate signal to another gate line. In addition, the source driver 1600 may provide the first data signal to a plurality of source lines corresponding to the gate line in response to the gate signal of the gate driver 220.

[0176] Referring to FIG. 16, the source driver 1600 may apply the first data signal to the pixel included in the second display area 1302 of FIG. 13 and then apply the first data signal to the pixel included in the first display area 1301 of FIG. 13 after 1H. In this case, while the source driver 1600 applies the first data signal to the pixel included in the second display area 1302 of FIG. 13, the first source amplifier AMP1 may be off state. The first source amplifier AMP1 may receive a source amplifier control signal EN1 for turning off the first source amplifier AMP1 from the timing controller 230 of FIG. 2.

[0177] A ready-state of the source amplifier will be described by dividing into a first period P01 which is off-state of the source amplifier of the first source amplifier AMP1, a second period P02 which is ready-state of the source amplifier of the first source amplifier AMP1, and a third period P03 which is the on-state of the source amplifier of the third source amplifier AMP3.

[0178] FIG. 17 is a timing diagram of control signals for controlling a source amplifier and a plurality of switches according to one or more embodiments.

[0179] In the first period P1, the first source amplifier AMP1 may receive a source amplifier control signal EN1 for turning off the first source amplifier AMP1 from the timing controller 230 of FIG. 2. The first switch SW1, the second switch SW2, and the third switch SW3 may receive switch signals CS1, CS2, and CS3 for opening the switch from the switch controller 241 of FIG. 2. The circuit diagram will be described with reference to FIG. 18.

[0180] FIG. 18 is a circuit diagram of a source amplifier and a plurality of switches in a first period.

[0181] Referring to FIGS. 17 and 18, since the first source amplifier AMP1 is turned off state and all switches SW1, SW2, and SW3 are open, the first data signal provided by the source driver 240 of FIG. 2 to the first source line SL1 may not be generated. In this case, the first data signal corresponding to the adjacent source line may be interpolated through the interpolation circuit 250 of FIG. 2, and the interpolated second data signal may be provided to the first source line SL1.

[0182] Next, according to FIG. 17, in the second period P02, the first source amplifier AMP1 may receive the source amplifier control signal EN1 for operating the first source amplifier AMP1 from the timing controller 230 of FIG. 2. The first switch SW1 and the third switch SW3 may receive switch signals CS1 and CS3 for opening the switch from the switch controller 241 of FIG. 2. In addition, the second switch SW2 may receive a switch signal CS2 for closing the switch from the switch controller 241. This will be described with reference to FIG. 19. This will be described with reference to FIG. 19.

[0183] FIG. 19 is a circuit diagram of a source amplifier and a plurality of switches in a second period.

[0184] Referring to FIGS. 17 and 19, the first source amplifier AMP1 may be in an on-state, the first switch SW1 and the third switch SW3 may be open, and the second switch SW2 may be closed. In this case, the first data signal provided by the source driver 240 of FIG. 2 to the first source line SL1 may not be generated because the first switch SW1 is open, but the second switch SW2 is closed so that the first source amplifier AMP1 may be driven in advance. When the pre-driven first source amplifier AMP1 is used, an image quality delay phenomenon caused by a time to drive the first source amplifier AMP1 in the third period P03 may be prevented.

[0185] Next, according to FIG. 17, in the third period P03, the first source amplifier AMP1 may receive the source amplifier control signal EN1 for operating the first source amplifier AMP1 from the timing controller 230 of FIG. 2. In addition, the first switch SW1 and the third switch SW3 may receive switch signals CS1 and CS3 for closing the switch from the switch controller 241 of FIG. 2, and the second switch SW2 may receive a switch signal CS2 for opening the switch from the switch controller 241. This will be described with reference to FIG. 20. This will be described with reference to FIG. 20.

[0186] FIG. 20 is a circuit diagram of a source amplifier and a plurality of switches in a third period.

[0187] Referring to FIGS. 17 and 20, the first source amplifier AMP1 may be in an on state, the first switch SW1 and the third switch SW3 may be closed, and the second switch SW2 may be open. In this case, since the first switch SW1 is closed, the first data signal S01 provided by the source driver 240 of FIG. 2 to the first source line SL1 may be generated. In addition, since the first source amplifier AMP1 previously driven in the second period P02 may be used in the third period P03, image quality delay phenomenon caused by the time to drive the first source amplifier AMP1 may be prevented.

[0188] FIG. 21 illustrates a source driver connected to a plurality of source lines through a multiplexer according to one or more embodiments.

[0189] Referring to FIG. 21, each of a plurality of pixels 2111, 2112, and 2113 may include n sub-pixels. For example, each of the plurality of pixels 2111, 2112, and 2113 may include three R, G, and B sub-pixels. Each of the plurality of pixels 2111, 2112, and 2113 may include three sub-pixels of the same color. The plurality of source lines SL1 to SL9 may be connected to sub-pixels in the plurality of pixels 2111, 2112, and 2113, respectively.

[0190] A plurality of source lines SL1 to SL9 may be connected to the source driver 2130 through the interpolation circuit 2120. The interpolation circuit 2120 may include a first resistor R1, a second resistor R2, and a plurality of switches SW11, SW12, SW21, and SW22. The source driver 2130 may include a first source amplifier AMP1, a second source amplifier AMP2, a third source amplifier AMP3, a first decoder DEC1, a second decoder DEC2, and a third decoder DEC3.

[0191] Referring to FIG. 21, the second source amplifier AMP2 may receive a source amplifier control signal EN2 for turning off the second source amplifier AMP2 from the timing controller 230 of FIG. 2. Accordingly, the brightness of the plurality of sub-pixels R2, G2, and B2 included in the second pixel 2112 may be determined regardless of the digital data GD100 input to the second decoder DEC2.

[0192] Referring to FIG. 21, the first multiplexer MUX1 may be connected to three sub-pixels R1, G1, and B1 included in the first pixel 2111. The first multiplexer MUX1 may receive the first multiplexer control signal SCM1 from the timing controller 230 of FIG. 2. The first multiplexer MUX1 may apply the second data signals S11, S12, and S13 to only one sub-pixel among the three connected sub-pixels R1, G1, and B1 based on the first multiplexer control signal SCM1.

[0193] The second multiplexer MUX2 may be connected to three sub-pixels R2, G2, and B2 included in the second pixel 2112. The second multiplexer MUX2 may receive the second multiplexer control signal SCM2 from the timing controller 230. The second multiplexer MUX2 may apply the second data signals S14, S15, and S16 to only one sub-pixel among the three connected sub-pixels R2, G2, and B2 based on the second multiplexer control signal SCM2.

[0194] The third multiplexer MUX3 may be connected to three sub-pixels R3, G3, and B3 included in the third pixel **2113**. The third multiplexer MUX3 may receive the third multiplexer control signal SCM3 from the timing controller **230**. The third multiplexer MUX3 may apply the second data signals S17, S18, and S19 to only one sub-pixel among the three connected sub-pixels R3, G3, and B3 based on the third multiplexer control signal SCM3.

[0195] The first multiplexer MUX1, the second multiplexer MUX2, and the third multiplexer MUX3 may apply data signals to only one sub-pixel of the same color based on the first multiplexer control signal SCM1, the second multiplexer control signal SCM2, and the third multiplexer control signal SCM3 generated from the timing controller **230**. For example, the first multiplexer MUX1, the second multiplexer MUX2, and the third multiplexer MUX3 may apply the second data signals S11, S14, and S17 to only the R-colored sub-pixels R1, R2, and R3 among the plurality of sub-pixels connected based on the first multiplexer control signal SCM1, the second multiplexer control signal SCM2, and the third multiplexer control signal SCM3.

[0196] The second data signal S14 interpolated through the interpolation circuit **2120** may be applied to the R sub-pixel R2 included in the second pixel **2112**. In this case, the interpolated data signal may be obtained by interpolating a first data signal applied to the R sub-pixel R1 included in the first pixel **2111** and a first data signal applied to the R sub-pixel R3 included in the third pixel **2113**. Accordingly, the brightness of the R sub-pixel R2 included in the second pixel **2112** may have a value between the brightness of the R sub-pixel R1 included in the first pixel **2111** and the brightness of the R sub-pixel R3 included in the third pixel **2113**.

[0197] Similarly, the second data signal S15 interpolated through the interpolation circuit **2120** may be applied to the G sub-pixel G2 included in the second pixel **2112**. In this case, the interpolated data signal may be obtained by interpolating a first data signal applied to the G sub-pixel G1 included in the first pixel **2111** and a first data signal applied to the G sub-pixel G3 included in the third pixel **2113**. Accordingly, the brightness of the G sub-pixel G2 included in the second pixel **2112** may have a value between the brightness of the G sub-pixel G1 included in the first pixel **2111** and the brightness of the G sub-pixel G3 included in the third pixel **2113**.

[0198] The second data signal S16 interpolated through the interpolation circuit **2120** may be applied to the B sub-pixel B2 included in the second pixel **2112**. In this case, the interpolated data signal may be obtained by interpolating the first data signal applied to the B sub-pixel B1 included in the first pixel **2111** and the first data signal applied to the B sub-pixel B3 included in the third pixel **2113**. Accordingly, the brightness of the B sub-pixel B2 included in the second pixel **2112** may have a value between the brightness of the B sub-pixel B1 included in the first pixel **2111** and the brightness of the B sub-pixel B3 included in the third pixel **2113**.

[0199] FIG. **22** illustrates a source driver connected to a plurality of source lines through a multiplexer according to one or more embodiments.

[0200] Referring to FIG. **22**, the first multiplexer MUX1 to the ninth multiplexer MUX9 may apply a second data signal to only one sub-pixel (R1, G1, B1, R2, G2, B2, R3, G3, B3, R4, G4, B4, R5, G5, B5, R6, G6, B6, R7, G7, B7, R8, G8, B8, R9, G9, and B9) among R, G, and B sub-pixels (R1, G1, B1, R2, G2, B2, R3, G3, B3, R4, G4, B4, R5, G5, B5, R6, G6, B6, R7, G7, B7, R8, G8, B8, R9, G9, and B9) included in each of the first pixel **2211** to ninth pixel **2219** based on the first multiplexer control signal SCM1 to the ninth multiplexer control signal SCM9. In this case, the first multiplexer control signal SCM1 to the ninth multiplexer control signal SCM9 may be generated by the timing controller **230** of FIG. **2**.

[0201] The interpolation circuit **2120** may include a first resistor R1, a second resistor R2, a third resistor R3, a fourth resistor R4, a fifth resistor R5, and a sixth resistor R6, and may include a plurality of switches SW11, SW12, SW21, SW22, SW31, SW32, SW41, SW42, SW51, SW52, SW61, and SW62 connected to both sides of each resistor.

[0202] The source driver **2130** may include a first source amplifier AMP1, a second source amplifier AMP2, a third source amplifier AMP3, a fourth source amplifier AMP4, a fifth source

amplifier AMP5, a sixth source amplifier AMP6, a seventh source amplifier AMP7, an eighth source amplifier AMP8, and a ninth source amplifier AMP9. The source driver 2130 may include first to ninth decoders DEC1 to DEC9 connected to respective source amplifiers.

[0203] Referring to FIG. 22, the fourth source amplifier AMP4, the fifth source amplifier AMP5, and the sixth source amplifier AMP6 may receive source amplifier control signals EN4, EN5, and EN6 from the timing controller 230 for turning off the fourth source amplifier AMP4, the fifth source amplifier AMP5, and the sixth source amplifier AMP6, respectively. Accordingly, the brightness of the plurality of sub-pixels R4, G4, B4, R5, G5, B5, R6, G6, and B6 included in the fourth pixel 2214, the fifth pixel 2215, and the sixth pixel 2216 may be determined irrespective of the digital data GD101, GD102, and GD103 input to the fourth decoder DEC4, the fifth decoder DEC5, and the sixth decoder DEC6.

[0204] The second data signal applied to the R sub-pixels R4, R5, and R6 included in the fourth pixel 2214, the fifth pixel 2215, and the sixth pixel 2216 may be applied with an interpolated data signal based on the interpolation circuit 2220 of the present disclosure. In this case, the interpolated data signal may be obtained by interpolating a first data signal applied to the R sub-pixels R1, R2, and R3 included in the first pixel 2211, the second pixel 2212, and the third pixel 2213 and a first data signal applied to the R sub-pixels R7, R8, and R9 included in the seventh pixel 2217, the eighth pixel 2218, and the ninth pixel 2219. Accordingly, the brightness of the R sub-pixels R4, R5, and R6 included in the fourth pixel 2214, the fifth pixel 2215, and the sixth pixel 2216 may have a value between the brightness of the R sub-pixels R1, R2, and R3 included in the first pixel 2211, the second pixel 2212, the third pixel 2213 and the brightness of the R sub-pixels R7, R8, and R9 included in the seventh pixel 2217, the eighth pixel 2218, and the ninth pixel 2219.

[0205] The second data signal applied to the G sub-pixels G4, G5, and G6 included in the fourth pixel 2214, the fifth pixel 2215, and the sixth pixel 2216 may be applied with an interpolated data signal based on the interpolation circuit 2220 of the present disclosure. In this case, the interpolated data signal may be obtained by interpolating the first data signal applied to the G sub-pixels G1, G2, and G3 included in the first pixel 2211, the second pixel 2212, and the third pixel 2213, and the first data signal applied to the G sub-pixels G7, G8, and G9 included in the seventh pixel 2217, the eighth pixel 2218, and the ninth pixel 2219. Accordingly, the brightness of the G sub-pixels G4, G5, and G6 included in the fourth pixel 2214, the fifth pixel 2215, and the sixth pixel 2216 may have a value between the brightness of the G sub-pixels G1, G2, and G3 included in the first pixel 2211, the second pixel 2212, and the third pixel 2213 and the brightness of the G sub-pixels G7, G8, and G9 included in the seventh pixel 2217, the eighth pixel 2218, the ninth pixel 2219.

[0206] The second data signal applied to the B sub-pixels B4, B5, and B6 included in the fourth pixel 2214, the fifth pixel 2215, and the sixth pixel 2216 may be applied with an interpolated data signal based on the interpolation circuit 2220 of the present disclosure. In this case, the interpolated data signal may be obtained by interpolating the first data signal applied to the B sub-pixels B1, B2, and B3 included in the first pixel 2211, the second pixel 2212, and the third pixel 2213, and the first data signal applied to the B sub-pixels B7, B8, and B9 included in the seventh pixel 2217, the eighth pixel 2218, and the ninth pixel 2219. Accordingly, the brightness of the B sub-pixels B4, B5, and B6 included in the fourth pixel 2214, the fifth pixel 2215, and the sixth pixel 2216 may have a value between the brightness of the B sub-pixels B1, B2, and B3 included in the first pixel 2211, the second pixel 2212, and the third pixel 2213 and the brightness of the B sub-pixels B7, B8, and B9 included in the seventh pixel 2217, the eighth pixel 2218, the ninth pixel 2219.

[0207] In summary, the brightness of the sub-pixels R4, G4, B4, R5, G5, B5, R6, G6, and B6 included in the fourth pixel 2214, the fifth pixel 2215, and the sixth pixel 2216 may have a value between the brightness of the sub-pixels R1, G1, B1, R2, G2, B2, R3, G3, and B3 included in the first pixel 2211, the second pixel 2212, and the third pixel 2213 the brightness of the sub-pixels R7, G7, B7, R8, G8, B8, R9, G9, and B9 included in the seventh pixel 2217, the eighth pixel 2218 and the ninth pixel 2219.

[0208] FIG. 23 is a diagram illustrating a display system according to one or more embodiments.

[0209] Referring to FIG. 23, the display system **2300** according to one or more embodiments may include a processor **2310**, a memory **2320**, a display device **2330**, and a peripheral device **2340** electrically connected to the system bus **2350**.

[0210] The processor **2310** may control input/output of data of the memory **2320**, the display device **2330**, and the peripheral device **2340**, and may perform image processing of image data transmitted between corresponding devices.

[0211] The memory **2320** may include a volatile memory such as a dynamic random access memory DRAM and/or a nonvolatile memory such as a flash memory. The memory **2320** may include a DRAM, a phase-change random access memory PRAM, a magnetic random-access memory MRAM, a resistive random access memory ReRAM, a ferroelectric random access memory FRAM, a NOR flash memory, a NAND flash memory, and a fusion flash memory (for example, a memory that combines a static random access memory SRAM buffer with NAND flash memory and NOR interface logic). The memory **2320** may store image data acquired from the peripheral device **2340** or an image signal processed by the processor **2310**.

[0212] The display device **2330** includes a display panel **2331**, and the display panel **2331** may include an interpolation circuit **2332**.

[0213] The interpolation circuit **2332** receive a plurality of data signals from a source driver of the present disclosure and may provide a data signal obtained by interpolating a first data signal corresponding to a first source line among the plurality of source lines and a second data signal corresponding to a second source line among the plurality of source lines to a third source line between the first source line and the second source line.

[0214] The peripheral device **2340** may be a device that converts a video into an electrical signal such as a camera, a scanner, a webcam, or a still image. The image data acquired through the peripheral device **2340** may be stored in the memory **2320** or may be displayed on the panel **2331** in real time.

[0215] The display system **2300** may be provided in a mobile electronic product such as a smartphone, but is not limited thereto, and may be provided in various types of electronic products displaying an image.

[0216] Although the embodiments of the present disclosure have been described in detail above, the scope of the present disclosure is not limited thereto, and various modifications and improvements of those skilled in the art using the basic concept of the present disclosure defined in the following claims also belong to the scope of the present disclosure.

[0217] In some embodiments, each component or combination of two or more components described with reference to FIG. 1 to FIG. 23 may be implemented as a digital circuit, a programmable or unprogrammable logic device or array, an application specific integrated circuit ASIC, or the like.

[0218] Although the embodiments of the present disclosure have been described in detail above, the scope of the present disclosure is not limited thereto, and various modifications and improvements of those skilled in the art using the basic concept of the present disclosure defined in the following claims also belong to the scope of the present disclosure.

Claims

1. A display device comprising: a pixel array comprising: a plurality of pixels; a plurality of gate lines; and a plurality of source lines connected to the plurality of pixels; a gate driver configured to apply a plurality of gate signals to each of the plurality of gate lines; a source driver configured to generate a plurality of first data signals corresponding to each of the plurality of source lines; and an interpolation circuit configured to: receive the plurality of first data signals from the source driver; and provide a second data signal, obtained by interpolating a first data signal corresponding

to a first source line among the plurality of source lines and a first data signal corresponding to a third source line among the plurality of source lines, to a second source line between the first source line and the third source line.

2. The display device of claim 1, wherein the interpolation circuit comprises: a first resistor connected between the first source line and the second source line; a first switch connected between the first source line and the first resistor; a second switch connected between the second source line and the first resistor; a second resistor connected between the second source line and the third source line; a third switch connected between the second source line and the second resistor; and a fourth switch connected between the third source line and the second resistor.

3. The display device of claim 2, wherein the interpolation circuit comprises: a plurality of first resistors connected in parallel between the first source line and the second source line; a plurality of first switches respectively connected between each of the plurality of first resistors and the first source line; a plurality of second switches respectively connected between each of the plurality of first resistors and the second source line; a plurality of second resistors connected in parallel between the second source line and the third source line; a plurality of third switches respectively connected between each of the plurality of second resistors and the second source line; and a plurality of fourth switches respectively connected between each of the plurality of second resistors and the third source line.

4. The display device of claim 2 further comprising: a timing controller configured to receive an image signal, comprising a first area rendered with a first quality and a second area rendered with a second quality lower than the first quality, from a host device.

5. The display device of claim 4, wherein the timing controller is further configured to: receive area indication data, indicating a first display area displaying the first area and a second display area displaying the second area, from the host device; and generate a switching control signal for controlling the first switch, the second switch, the third switch, and the fourth switch based on the area indication data.

6. The display device of claim 5, wherein the timing controller is further configured to: generate the switch control signal for controlling the first switch, the second switch, the third switch, and the fourth switch to open when pixels connected to each of the first source line, the second source line, and the third source line are in the first display area, based on the area indication data.

7. The display device of claim 5, wherein the timing controller is further configured to: generate the switch control signal for controlling the first switch, the second switch, the third switch, and the fourth switch to close when pixels connected to each of the first source line, the second source line, and the third source line are in the second display area, based on the area indication data.

8. The display device of claim 7, wherein the source driver comprises a plurality of source amplifiers respectively connected to each of the first source line, the second source line, and the third source line, and wherein the timing controller is further configured to generate a source amplifier control signal for turning off a second source amplifier connected to the second source line, among the plurality of source amplifiers.

9. The display device of claim 8, wherein the source driver further comprises: a plurality of first amplifier switches, each respectively connected to an output terminal of each of the plurality of source amplifiers; a plurality of second amplifier switches, each respectively connected between an inverting terminal of each of the plurality of source amplifiers and each of the plurality of first amplifier switches; and a plurality of third amplifier switches, each respectively connected to the inverting terminal of each of the plurality of source amplifiers and each of the first source line, the second source line, and the third source line.

10. The display device of claim 8, wherein the first source line, the second source line, and the third source line are respectively connected to a plurality of sub-pixels in one pixel through a multiplexer, and wherein the multiplexer is configured to receive the second data signal from the interpolation circuit and provide the second data signal to only one sub-pixel among the plurality of

sub-pixels.

11. The display device of claim 10, wherein the plurality of sub-pixels have different colors.

12. The display device of claim 1, further comprising: a plurality of the second source lines including the second source line, wherein the interpolation circuit is further configured to provide a plurality of the second data signal, obtained by interpolating the first data signal corresponding to the first source line and the first data signal corresponding to the third source line, to the plurality of second source lines.

13. The display device of claim 12, wherein the interpolation circuit comprises: a first resistor connected between one of the plurality of second source lines and the first source line; a first switch connected between the first source line and the first resistor; a second switch connected between one of the plurality of second source lines and the first resistor; at least one second resistor connected between a first adjacent second source line and a second adjacent second source line among the plurality of second source lines; a third switch connected between the first adjacent second source line and the at least one second resistor; a fourth switch connected between the second adjacent second source line and the at least one second resistor; a third resistor connected between another one of the plurality of second source lines and the third source line; a fifth switch connected between the other one of the plurality of second source lines and the third resistor; and a sixth switch connected between the third source line and the third resistor.

14. A display system comprising: a host device providing an image signal comprising a first area rendered with a first quality and a second area rendered with a second quality lower than the first quality; and a display device comprising a plurality of pixels and a plurality of source lines respectively connected to the plurality of pixels, the display device being configured to: generate a plurality of first data signals by the image signal; and provide second data signals, obtained by interpolating the plurality of first data signals, to source lines among the plurality of source lines connected to pixels among the plurality of pixels that are displaying the second area.

15. The display system of claim 14 further comprising an eye tracking sensor configured to: track a position of a user eye to obtain eye tracking data; and transmit the eye tracking data to the host device.

16. The display system of claim 15, wherein the host device further comprises an image processor configured to: render the first area corresponding to the position of the user eye with the first quality; and render the second area which is a peripheral area of the first area with the second quality based on the eye tracking data.

17. The display system of claim 14, wherein the host device is further configured to transmit a driving control signal comprising area indication data indicating the first area and the second area to the display device according to the image signal, and wherein the display device is further configured to generate a gate driver control signal, a source driver control signal, and a switch control signal based on the driving control signal.

18. The display system of claim 17, wherein the display device further comprises: a switch controller configured to: receive the switch control signal from the host device; and generate a switch signal for differently driving a plurality of switches connecting between source lines among the plurality of source lines connected to pixels among the plurality of pixels displaying the first area, and a plurality of switches connecting between source lines among the plurality of source lines connected to pixels among the plurality of pixels displaying the second area.

19. A method of driving a display device comprising: turning off a source amplifier that outputs a data signal to a source line connected to a pixel during a first period in which the pixel displays an area rendered with a first quality; turning on the source amplifier during a second period before the pixel displays an area rendered with a second quality higher than the first quality; and outputting the data signal for the source amplifier to the source line connected to the pixel during a third period in which the pixel displays the area rendered with the second quality.

20. The method of claim 19, wherein turning off the source amplifier during the first period

comprises receiving a switch signal that causes a first switch connected between an output terminal of the source amplifier and the source line, a second switch connected to a first signal line connected between an inverting terminal of the source amplifier and the first switch, and a third switch connected to the inverting terminal of the source amplifier and a second signal line connected to the source line, to open a switch from a switch controller, and wherein turning on the source amplifier during the second period comprises: receiving the switch signal for the first switch and the third switch to open the switch from the switch controller; receiving the switch signal for the second switch to close the switch from the switch controller; outputting the data signal for the source amplifier to the source line connected to the pixel during the third period; receiving the switch signal for the first switch and the third switch to close the switch from the switch controller; and receiving the switch signal for the second switch to open the switch from the switch controller.
