A touch controller includes a touch data generator that is connected to a plurality of sensing lines, the touch data generator sensing a change in capacitance of a sensing unit connected to each of the sensing lines and generating touch data by processing the sensing signal corresponding to the result of sensing; and a signal processor that controls a timing of generating the touch data by receiving at least one piece of timing information for driving a display panel from a timing controller, and then providing either the timing information or a signal generated from the timing information as a control signal to the touch data generator.
FIG. 1

SIGNAL PROCESSOR
FIG. 2A

X sensing line

Y sensing line

21

SU

22

plate

FIG. 2B

C_{sen}

C_b

C_{sig}

C_{sig'}

TIME
FIG. 3A

TOUCH DATA GENERATOR from SU SIGNAL PROCESSOR TIMING CONTROLER

FIG. 3B

TOUCH DATA GENERATOR from SU SIGNAL PROCESSOR TIMING CONTROLER
FIG. 4A

VSYNC

HSYNC

VCOM

Gate

ctrl

dotclk

FIG. 4B

VSYNC

HSYNC

VCOM

ctrl
FIG. 5A

FIG. 5B

\[ 20 \cdot \log_{10} \left(1 + \frac{C_h + \Delta C}{C_f} \right) \]

\[ \frac{1}{2 \pi (C_s + \Delta C + C_f) R_f} \quad \frac{1}{2 \pi C_f R_f} \]
FIG. 6A

![Diagram of a sensing line circuit](image)

FIG. 6B

![Graph showing Vout/Vin in dB](image)
FIG. 7A

Diagram of a circuit with multiple amplifiers (AMP1, AMP2, AMP3) connected in series with resistors (R_f1, R_f2, R_f3) and capacitors (C_f1, C_f2, C_f3). The input (V_in) is connected to the first amplifier (AMP1) with a feedback loop involving C_s1, C_h1, and SL1. The outputs (V_out1, V_out2, V_out3) are connected to the respective amplifiers.
FIG. 8A

FIG. 8B
FIG. 9E

FIG. 9F

FIG. 9G

V_{ADC\_IN}

V_{cm}
FIG. 10A

FIG. 10B

(a) Vin -- Vref -- Vout

(b) Not touched

Touched

V_{ADC_IN}
FIG. 12B

TIMING CONTROLLER
T/C

VOLTAGE GENERATOR

DISPLAY PANEL

S/D

G/D
FIG. 14A

![Diagram of Sensor input, Display output, Memory, AFE, MCU, Control Logic, Power Generator, Output Driver, Timing information, and Sleep status]

FIG. 14B

<table>
<thead>
<tr>
<th>TSC</th>
<th>Display</th>
<th>Power Generator</th>
<th>Timing information</th>
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<tr>
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</tr>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>On</td>
</tr>
</tbody>
</table>
FIG. 15C

FIG. 15D

<table>
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<tr>
<th>Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window glass</td>
</tr>
<tr>
<td>Air gap or resin</td>
</tr>
<tr>
<td>ITO (sensor)</td>
</tr>
<tr>
<td>Glass</td>
</tr>
<tr>
<td>Polarizer</td>
</tr>
<tr>
<td>Top Glass</td>
</tr>
<tr>
<td>ITO (cathode)</td>
</tr>
<tr>
<td>OLED</td>
</tr>
<tr>
<td>Metal (anode)</td>
</tr>
<tr>
<td>Bottom Glass</td>
</tr>
</tbody>
</table>
FIG. 16A
FIG. 16C

FIG. 16D

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
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<td>Metal (anode)</td>
<td></td>
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<tr>
<td>Bottom Glass</td>
<td></td>
</tr>
</tbody>
</table>
FIG. 17B

BACK SIDE OF IC (BUMP FACE DOWN)

CONNECTOR

COMPONENT

COMPONENTS FOR DDI

GLASS
TOUCH CONTROLLER HAVING INCREASED SENSING SENSITIVITY, AND DISPLAY DRIVING CIRCUIT AND DISPLAY DEVICE AND SYSTEM HAVING THE TOUCH CONTROLLER

PRIORITY CLAIM


BACKGROUND

[0002] The inventive concepts relate to a touch controller, and more particularly, to a touch controller having increased sensing sensitivity, and a display driving circuit and a display device and system including the touch controller.

[0003] As a consequence of the need for thinner and lighter display devices, flat display devices have replaced cathode ray tubes (CRTs). Examples of flat display devices are LCDs, field emission displays (FEDs), organic light emitting diodes (OLEDs), and plasma display panels (PDPs).

[0004] In general, such flat display devices include a plurality of pixels that are arranged in a matrix in order to display an image. In an LCD which is an example of flat display device, a plurality of scan lines that deliver a gate selection signal and a plurality of data lines that deliver data to the pixels are arranged to intersect one another, whereby a plurality of pixels are formed where the scan lines and the data lines intersect one another.

[0005] A touch screen panel, e.g., a capacitive touch screen panel, includes a plurality of sensing units. If a user touches a screen of the touch screen panel with his/her finger or a touch pen, a capacitance value of a corresponding sensing unit changes. In general, the touch screen panel is attached to an upper part of a flat display device, and when a user’s finger or a touch pen approaches or touches the sensing units of the touch screen panel, the capacitance value of a corresponding sensing unit is provided to a touch screen processor. The touch screen processor senses a capacitance of the corresponding sensing unit by using the sensing lines, and determines whether the touch screen panel is touched with a user’s finger or a touch pen or determines the touched location on the touch screen panel. The sensing units may be included in a display panel in order to minimize a reduction in yield and brightness and an increase in the thickness of the display panel, caused when the touch screen panel is attached to the display panel.

[0006] FIG. 1 is a block diagram of a general touch screen system 10. Referring to FIG. 1, the touch screen system includes a touch screen panel 11 having a plurality of sensing units and a signal processor 12 that senses and processes a change in a capacitance of each of the sensing units and then generates touch data.

[0007] The touch screen panel 11 includes a plurality of sensing units disposed in a row and a plurality of sensing units disposed in a column. Referring to FIG. 1, the touch screen panel 11 includes a plurality of rows in which a plurality of sensing units are disposed, in which a plurality of sensing units are arranged in each of the rows. The plurality of sensing units arranged in each of the rows are electrically connected to one another. Also, the touch screen panel 11 includes a plurality of columns in which a plurality of sensing units are disposed, in which a plurality of sensing units are arranged in each of the columns. The plurality of sensing units arranged in each of the columns are electrically connected to one another.

[0008] The signal processor 12 generates the touch data by sensing a change in the capacitance of each of the plurality of sensing units of the touch screen panel 11. For example, signal processor 12 may sense a change in the capacitance of each of the plurality of sensing units in the plurality of rows and in the plurality of columns in order to determine whether the touch screen panel 11 is touched with a user’s finger or a touch pen, or to determine the touched location on the touch screen panel 11.

[0009] However, the plurality of sensing units of the touch screen panel 11 contain a parasitic capacitance component. Such a parasitic capacitance component may be classified into a horizontal parasitic capacitance component generated between a plurality of sensing units and a vertical parasitic capacitance component generated between a sensing unit and a display panel. If the whole parasitic capacitance has a large value, a change in the capacitance of a sensing unit touched by a user’s finger or a touch pen has a relatively small value, compared to the value of the whole parasitic capacitance. The closer the user’s finger or the touch pen approaches the sensing unit, the greater the capacitance value of the sensing unit. However, when the sensing unit has a large parasitic capacitance value, the sensing sensitivity of the sensing unit is lowered. Also, a change in an electrode voltage VCOM applied onto the display panel may cause a sensing noise to occur during the touching of the sensing unit through the vertical parasitic capacitance component.

[0010] In addition, the performance of the touch screen system 11 may be affected by various noise factors which are generated in an undesirable environment. Examples of the various noise factors are electromagnetic noise in the air, a skin accumulated noise, and a noise generated in the touch screen system 10. Such noises may degrade the sensing sensitivity of the touch screen system 10.

SUMMARY

[0011] The inventive concept provides a touch controller in which a sensing unit is affected less by a parasitic capacitance component and a noise, and a display driving circuit and a display device and system including the touch controller.

[0012] According to an aspect of the inventive concept, there is provided a touch controller that includes a touch data generator connected to a plurality of sensing lines, the touch data generator sensing a change in capacitance of a sensing unit connected to each of the sensing lines and generating touch data by processing a sensing signal indicative of a sensed change in the capacitance, responsive to a control signal; and a signal processor controlling a timing of generating the touch data responsive to at least one piece of timing information for driving a display panel as provided from a timing controller, the signal processor providing either the timing information or a signal generated from the timing information as the control signal to the touch data generator.

[0013] According to another aspect of the inventive concept, there is provided a display driving circuit including a display panel driving circuit unit including a timing controller generating at least one piece of timing information for driving a display panel; and a touch controller disposed to sense whether a touch screen panel is touched, the touch controller
generating a sensing signal by sensing a change in capacitance of a sensing unit on the touch screen panel and processing the sensing signal, the touch controller including a touch data generator generating the sensing signal by sensing the change in the capacitance of the sensing unit via a sensing line, and generating touch data by processing the sensing signal, responsive to a control signal, and a signal processor controlling a timing of generating the touch data responsive to the timing information from the timing controller and supplying either the timing information or a signal generated from the timing information as the control signal to the touch data generator.

[0014] According to another aspect of the inventive concept, there is provided a display panel including a display panel displaying an image corresponding to received image data; a touch screen panel having a plurality of sensing units, a capacitance value of each of the sensing units varies according to a touching operation; a display panel driving circuit unit connected to the display panel to drive the display panel, the display panel driving circuit unit including a timing controller for generating timing information related to a display operation; and a touch controller connected to the touch screen panel to sense whether the touch screen panel is touched, the touch controller generating touch data based on the result of the sensing and controlling a timing of generating the touch data according to the timing information.

[0015] According to another aspect of the inventive concept, there is provided a touch controller including a voltage reading circuit reading first voltages from a plurality of sensing units connected to a plurality of sensing lines, respectively; a first amplification circuit offsetting influences in the read first voltages caused by a capacitance component generated in each of the plurality of sensing units, amplifying the resultant first voltages, and then outputting second voltages, and an integration circuit integrating the second voltages.

[0016] According to another aspect of the inventive concept, there is provided a display device including a panel unit including a plurality of sensing units performing a touch screen operation; a display driving circuit unit receiving at least one piece of first timing information from an external host, and generating image data to display an image on the panel unit; and a touch controller connected to the plurality of sensing units to sense a change in capacitances of the plurality of sensing units, the touch controller generating touch data from at least one selected from the at least one piece of first timing information and a plurality of pieces of timing information generated by the display driving circuit unit.

[0017] According to another aspect of the inventive concept, there is provided a display system including a host controller; a panel unit including a plurality of sensing units performing a touch screen operation; a display driving unit receiving at least one piece of first timing information from the host controller, and generating image data to display an image on the panel unit; and a touch controller connected to the plurality of sensing units to sense a change in capacitances of the plurality of sensing units, the touch controller generating touch data based on at least one of the first timing information and timing information generated by the display driving circuit unit.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0018] Exemplary embodiments of the inventive concept will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings in which:

[0019] FIG. 1 is a block diagram of a general touch screen panel system;

[0020] FIG. 2A illustrates a parasitic capacitance component generated in each of a plurality of sensing units of a touch screen panel according to an embodiment of the inventive concept;

[0021] FIG. 2B is a graph showing a change in the capacitance of a sensing unit illustrated in FIG. 2A when the sensing unit is touched;

[0022] FIG. 2C is a graph showing a change in the capacitance of a sensing unit illustrated in FIG. 2A when a sensing unit is touched and a noise is generated;

[0023] FIGS. 3A, 3B, and 3C are block diagrams of a touch controller according to embodiments of the inventive concept;

[0024] FIGS. 4A and 4B are waveform diagrams of various signals for generating the control signal ctrl illustrated in FIGS. 3A to 3C, according to embodiments of the inventive concept;

[0025] FIGS. 5A, 5B, 6A, 6B, 7A, 7B, and 8A-8D are circuit diagrams and graphs illustrating various embodiments of a touch data generator according to the inventive concept;

[0026] FIG. 9A and FIG. 9B are block and circuit diagrams of a touch data generator according to embodiments of the inventive concept;

[0027] FIG. 9C is a circuit diagram of an integration circuit that is another embodiment of an integration circuit illustrated in FIG. 9A according to the inventive concept;

[0028] FIG. 9D is a waveform diagram illustrating an input signal Vin and a timing of turning on the switches SW1 to SWm of FIG. 9B according to an embodiment of the inventive concept;

[0029] FIG. 9E is a waveform diagram of various signals supplied to the touch controller of FIG. 9B according to an embodiment of the inventive concept;

[0030] FIG. 9F is a timing diagram illustrating the operation of the integration circuit of FIG. 9B according to an embodiment of the inventive concept;

[0031] FIG. 9G is a graph showing a variation in an integration voltage of the integration circuit of FIG. 9B according to an embodiment of the inventive concept;

[0032] FIG. 10A is a circuit diagram of another embodiment of the integration circuit included in the touch data generator of FIG. 9B, according to the inventive concept;

[0033] FIG. 10B is a waveform diagram of an output voltage Vout and the voltage reference signal Vref used in the integration circuit of FIG. 10A, and an input signal Vin, according to an embodiment of the inventive concept;

[0034] FIG. 11 is a block diagram of a touch controller according to another embodiment of the inventive concept;

[0035] FIG. 12A is a block diagram of a general LCD that includes a plurality of touch controllers according to an embodiment of the inventive concept;

[0036] FIG. 12B is a block diagram of a general LCD that includes a touch controller according to another embodiment of the inventive concept;

[0037] FIG. 13 is a block diagram of an integrated circuit (IC), in which a touch controller and a display driving unit are integrated together, according to an embodiment of the inventive concept;

[0038] FIGS. 14A and 14B illustrate an interrelation between a touch controller and a display driving unit as illustrated in FIG. 13.
FIGS. 15A to 15C illustrate embodiments of a printed circuit board (PCB) structure of a display device that includes a touch panel, according to the inventive concept.

FIG. 15D illustrates the panel structure of the display device illustrated in FIG. 15A, 15B, or 15C, according to an embodiment of the inventive concept.

FIGS. 16A to 16C illustrate embodiments of a PCB structure of a display device 800, in which a touch panel and a display panel are united together, according to the inventive concept.

FIG. 16D illustrates the panel structure of the display device illustrated in FIG. 16A, 16B, or 16C, according to another embodiment of the inventive concept.

FIGS. 17A and 17B illustrate the structure of a semiconductor chip that includes a touch controller and a display driving circuit unit, and the structure of an FPCB according to embodiments of the inventive concept, and

FIGS. 18A and 18B illustrate embodiments of a display device having a semiconductor chip in which a touch controller and a display driving circuit are included, according to the inventive concept.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Hereinafter, exemplary embodiments of the inventive concept will be described in detail with reference to the accompanying drawings. Like reference numerals denote like elements throughout the drawings.

FIG. 2A illustrates a parasitic capacitance component generated in each of a plurality of sensing units SU of a touch screen panel 21 according to an embodiment of the inventive concept. FIG. 2B is a graph showing a change in the capacitance of a sensing unit SU illustrated in FIG. 2A when the sensing unit is touched. FIG. 2C is a graph showing a change in the capacitance of a sensing unit SU illustrated in FIG. 2A when the sensing unit is touched and a noise is generated.

Referring to FIG. 2A, the touch screen panel 21 includes the plurality of sensing units SU. The plurality of sensing units SU may be arranged near or on a display panel 22 that displays an image. For example, the reference numeral ‘22’ may denote an upper plate of a display panel to which a predetermined electrode voltage VCOM is applied. The display panel having the upper plate 22 may be a liquid crystal display (LCD) panel, to which the electrode voltage VCOM may be applied as a common electrode voltage. If the display panel is an organic light-emitting display panel, a cathode having a direct-current (DC) voltage may be applied to an upper plate thereof.

The touch screen panel 21 includes a plurality of sensing units SU connected to a plurality of sensing lines arranged in a row (in an x-axis direction) and a plurality of sensing lines SU connected to a plurality of sensing lines arranged in a column (in a y-axis direction). If a user’s finger or a touch pen approaches or touches any of the sensing units SU, a capacitance value of the particular sensing unit SU is changed. Whether the touch screen panel 21 is touched, and the touched location on the touch screen panel 21, may be determined by generating a sensing signal by sensing a change in the capacitance value of each of the sensing units by using the plurality of sensing lines and then processing the sensing signal.

Parasitic capacitance components are present due to an arrangement of the plurality of sensing units SU. For example, the parasitic capacitance components include a horizontal parasitic capacitance component Ch generated between adjacent sensing units and a vertical parasitic capacitance component Cv generated between a sensing unit and the display panel 22. If a parasitic capacitance value is greater than the value of a capacitance component generated when a user’s finger or a touch pen approaches or touches a sensing unit, even when the capacitance value of the sensing unit is changed by touching the sensing unit, the sensing sensitivity of the touching is lowered.

Referring to FIG. 2B, the sensing unit SU contains a basic capacitance component Ch including a parasitic capacitance component, and a capacitance value of the sensing unit SU is changed when an object, e.g., a user’s finger or a touch pen, approaches or touches the sensing unit SU. For example, when a conductive object approaches or touches the sensing unit SU, the capacitance value of the sensing unit SU increases. Referring to FIG. 2B, in a section A, the capacitance value of the sensing unit SU is Ch since the conductive object does not approach the sensing unit SU; in a section B, the conductive object touches the sensing unit SU; and in a section C, the conductive object approaches the sensing unit SU.

As illustrated in FIG. 2C, the capacitance value of the sensing unit SU may be affected greatly when various noises are present. In this case, a processor or controller (not shown) cannot determine precisely whether an object touches the sensing unit SU and the touched location on the sensing unit SU by simply checking whether the capacitance value of the sensing unit SU increases or decreases, thereby greatly degrading the sensing sensitivity of a touch screen device.

FIGS. 3A, 3B, and 3C are block diagrams of a touch controller 110 according to embodiments of the inventive concept. Here, a display driving circuit 120 that drives a display panel (not shown) to display an image and a host controller 130 that controls the overall operations of the touch controller 110, are further illustrated in order to help explain the operation of the touch controller 110.

Referring to FIG. 3A, the touch controller 110 may include a signal processor 111 and a touch data generator 112. The display driving circuit 120 may include a timing controller 121 that controls an image to be displayed on the display panel, a gate driver 122, and a source driver 123.

The signal processor 111 controls the overall operations of internal circuits of the touch controller 110 in relation to a touch screen operation. Although not shown, the touch data generator 112 is electrically connected to a plurality of sensing units SU via sensing lines and generates a sensing signal by sensing a change in the capacitance of each of the plurality of sensing units SU when they are touched. Also, the touch data generator 112 generates and outputs touch data processed by the touch signal. The signal processor 111 or the host controller 130 performs a logic operation based on the touch data, and determines whether a touch screen (not shown) is touched and the touched location on the touch screen.

The touch controller 110 receives at least one piece of timing information Timing info for driving a display panel (not shown), and may use the timing information Timing info in order to generate the touch data data. The timing informa-
tion Timing info may be generated by either the timing controller 121 included in the display driving circuit 120 or directly by the host controller 130. FIG. 3A illustrates that the timing information Timing info is generated by the timing controller 121 and the touch controller 110 receives the timing information Timing info from the timing controller 121. The signal processor 111 receives the at least one piece of timing information Timing info and transmits a control signal ctrl based on the at least one piece of timing information Timing info to the touch data generator 112.

[0056] The control signal ctrl may be generated based on a wave form of the timing information Timing info. The control signal ctrl may be generated directly by the timing controller 121 and provided to the signal processor 111, or the signal processor 111 may generate the control signal ctrl from the timing information Timing info received from the timing controller 121. Also, as described above, the host controller 130 may generate the timing information Timing info, and similarly, the control signal ctrl may be generated by the host controller 130 and provided to the touch controller 110. If the host controller 130 generates the control signal ctrl, the control signal ctrl may be supplied to the signal processor 111 or may be supplied directly to the touch data generator 112. Hereinafter, it is assumed that the signal processor 111 generates the control signal ctrl as illustrated in FIGS. 3A to 3C.

[0057] The timing controller 121 generates at least one signal for controlling a timing of displaying an image. For example, the timing controller 121 may receive a vertical synchronization signal Vsync and a horizontal synchronization signal Hsync directly from the external host controller 130, or may generate the vertical synchronization signal Vsync and the horizontal synchronization signal Hsync based on a data enable signal (not shown) received from the host controller 130. Also, the timing controller 121 may control generation of a common electrode voltage, e.g., an electrode voltage VCOM, and generation of a gate line signal by generating at least one timing signal.

[0058] The signal processor 111 generates the control signal ctrl in synchronization with the at least one piece of timing information Timing info received from the timing controller 121, and supplies the control signal ctrl to the touch data generator 112 in order to control a timing of generating the touch data data. That is, if a voltage applied to the display panel, e.g., a common electrode voltage applied to an upper plate of the display panel, changes, then a noise may be contained in a sensing signal. Accordingly, the signal processor 111 controls the touch data data to be generated during a period when the voltage is in a stable state.

[0059] The touch controller 110 and the display driving circuit 120 may be integrated in one semiconductor chip. That is, in an embodiment of the inventive concept, the touch controller 110 receives at least one piece of timing information Timing info from the display driving circuit 120 and performs an operation in synchronization with the timing information Timing info, the timing information Timing info may be transmitted via a wire interconnecting the touch controller 110 and the display driving circuit 120 in one semiconductor chip.

[0060] FIGS. 3B and 3C are block diagrams illustrating various ways of generating the touch data data illustrated in FIG. 3A according to embodiments of the inventive concept. FIG. 3B illustrates a case where the touch controller 110 receives information control/timing related to a timing of driving a display panel (not shown) directly from the host controller 130. In this case, the timing controller 121 may skip generating timing information Timing info based on the information control/timing received from the host controller 130 and supplying it to the touch controller 110. The signal processor 111 receives the information control/timing from the host controller 130, generates a control signal ctrl based on the information control/timing, and supplies the control signal ctrl to the touch data generator 112.

[0061] FIG. 3C illustrates a case where information generated by a timing controller 121 and information generated by the host controller 130 are multiplexed into timing information Timing info and the timing information Timing info is supplied to the touch controller 110. To this end, a selection unit 140 that allows a signal to be selectively supplied may be disposed between the touch controller 110 and the display driving circuit 120 illustrated in FIG. 3C. For example, the selection unit 140 may be embodied as a multiplexer (MUX). The selection unit 140 may be disposed between the touch controller 110 and the display driving circuit 120 or may be disposed before a signal processor 111 included in the touch controller 110. The selection unit 140 selectively outputs the information generated by the timing controller 121 or the information generated by the host controller 130 in response to a predetermined control signal (not shown). In this case, if the display driving circuit 120 operates in a normal mode, the information generated by the timing controller 121 may be supplied to the touch controller 110. If the display driving circuit 120 enters a power down mode, e.g., a sleep mode, the information generated by the host controller 130 may be supplied to the touch controller 110.

[0062] FIG. 4A is a waveform diagram of various signals for generating the control signal ctrl illustrated in FIGS. 3A to 3C, according to an embodiment of the inventive concept. Referring to FIG. 4A, a horizontal synchronization signal Hsync is activated after a vertical synchronization signal Vsync is activated. A logic level of a common electrode voltage, e.g., an electrode voltage VCOM, changes in synchronization with the horizontal synchronization signal Hsync. The control signal ctrl may be generated from at least one of various types of timing information, e.g., the vertical or horizontal synchronization signal Hsync or Vsync, timing information for generating a common electrode voltage, Dot-Clk information). A timing of generating touch data data is controlled according to a timing of activating the control signal ctrl, and a noise may be prevented from being generated in the touch data data, caused by a change in an electrode applied to a display panel.

[0063] FIG. 4B is a waveform diagram of various signals for generating the control signal ctrl illustrated in FIGS. 3A to 3C, according to another embodiment of the inventive concept. Referring to FIG. 4B, a porch section in which a horizontal synchronization signal Hsync is not activated, is present before and after a section in which a vertical synchronization signal Vsync is activated. A common electrode voltage applied to a display panel is controlled not to change during the porch section. In this case, it is possible to reduce a noise generated due to a change in a voltage applied to a display panel by activating the control signal ctrl in the porch section of the vertical synchronization signal Vsync.

[0064] FIGS. 5A to 8D are circuit diagrams and graphs illustrating various embodiments of a touch data generator according to the inventive concept. In detail, FIGS. 5A to 8D illustrate methods of reducing influences caused by a vertical or horizontal parasitic capacity components present in a
sensing unit by using an amplification circuit, according to embodiments of the inventive concept.

[0065] Specifically, FIG. 5A is a circuit diagram of a touch data generator 210A, such as the touch data generator 112 of FIG. 3A, according to an embodiment of the inventive concept. FIG. 5B is a graph showing frequency characteristics of an amplifier AMP included in the touch data generator 210A of FIG. 5A according to an embodiment of the inventive concept. Referring to FIG. 5A, the touch data generator 210A includes an amplification circuit 211A that is connected to a sensing unit SU and generates a sensing signal Vout corresponding to a change in the capacitance of the sensing unit SU. The touch data generator 210A may further include a signal output unit 212A that receives the sensing signal Vout and outputs the sensing signal Vout in response to a control signal ctrl, and an analog-to-digital converter (ADC) 213A that receives an analog signal from the signal output unit 212A and converts the analog signal into a digital signal. The signal output unit 212A may be a sample/hold circuit that retains the sensing signal Vout and outputs the sensing signal Vout in response to the control signal ctrl.

[0066] The amplification circuit 211A includes at least one amplifier AMP. Although not shown, the at least one amplifier AMP may include a plurality of amplifiers respectively connected to a plurality of sensing lines arranged in a plurality of rows and columns in a touch screen panel. Otherwise, the amplifier AMP may be constructed such that the amplifier AMP is switched to be connected with one of the plurality of sensing lines, so that the amplifier AMP may be shared by the plurality of sensing lines. For convenience of explanation, FIG. 5A illustrates a case where one amplifier AMP is connected to one sensing line.

[0067] A first input terminal, e.g., an inversion input terminal (-) of the amplifier AMP is connected to the sensing unit SU in order to sense a change in the capacitance of the sensing unit SU. As illustrated in FIG. 5A, the capacitance of the sensing unit SU may include a parasitic capacitance component, e.g., a horizontal parasitic capacitance component Cs, and a capacitance variation Csig caused when the sensing unit SU is touched.

[0068] An input signal Vin having a predetermined frequency is supplied to a second input terminal of the amplifier AMP. The input signal Vin may be a signal, e.g., a square-wave or sinusoidal-wave signal having a predetermined pulse cycle. The logic level and frequency of the input signal Vin may be adjusted appropriately. The frequency of the input signal Vin may fall within a pass band of the amplifier AMP having high-pass filtering characteristics. Although not shown, a direct-current (DC) voltage (e.g., ground voltage) signal may be supplied to second input terminals of amplifiers connected to the sensing lines other than the sensing line that performs a sensing operation. Thus, referring to FIG. 5A, one node of the horizontal parasitic capacitance component Cs is represented as being applied to a ground voltage.

[0069] A capacitor Cf may be connected between the first input terminal and an output terminal of the amplifier AMP, and a predetermined resistor Rf may further connected between the first input terminal and the output terminal of the amplifier AMP to be parallel to the capacitor Cf. Accordingly, the amplifier AMP may act as a high-pass filter having a predetermined voltage gain.

[0070] The amplifier AMP generates the sensing signal Vout, the voltage level of which varies according to a change in the capacitance of the sensing unit SU. FIG. 5B illustrates the pass-band characteristics and voltage gain of the amplifier AMP. As illustrated in FIG. 5A, the frequency of the input signal Vin may be greater than

\[ \frac{1}{2\pi C_f R_f}. \]

If the frequency of the input signal Vin falls within the pass band of the amplifier AMP, the gain of the amplifier AMP is calculated by a numerical formula,

\[ 20 \log_{10} \left(1 + \frac{C_s + \Delta C}{C_f}\right). \]

[0071] When as expressed in the above equation, the capacitance of the sensing unit SU changes when the sensing unit SU is touched, the logic level of the sensing signal Vout generated by the amplifier AMP is changed according to the change in the capacitance of the sensing unit SU. The amplifier AMP generates the sensing signal Vout corresponding to the capacitance value of the sensing unit SU in an analog manner. Whether the touch screen panel is touched, or the touched location on the touch screen panel, may be determined by sensing a change in the voltage of the sensing signal Vout.

[0072] The control signal ctrl may be generated using at least one piece of timing information and may be used in order to generate touch data data using the sensing signal Vout. The signal output unit 212A receives the sensing signal Vout from the amplification circuit 211A, retains the sensing signal Vout, and supplies the sensing signal Vout to the ADC 213A in response to the activated control signal ctrl. The ADC 213A generates the touch data data by converting the sensing signal Vout that is analog signal into a digital signal, and supplies the converted result to the outside.

[0073] As described above, whether a touch screen is touched, and the touched location on the touch screen, may be determined by performing a sensing operation and generating the touch data data. Also, generation of a noise caused by a change in a voltage applied to a display panel may be minimized by controlling a timing of generating the touch data data in response to the control signal ctrl.

[0074] However, if the value of the parasitic capacitance component Cs between a plurality of sensing units SU is increased, then the gain of the amplifier AMP is also increased. In this case, the capacitor Cf connected between the first input terminal and the output terminal of the amplifier AMP should have a large value in order for the level of the voltage output from the amplifier AMP to be in a predetermined range (e.g., within the voltage range in which a system can operate). However, if the capacitance of the capacitor Cf has a large value, a change in the voltage of the amplifier AMP, i.e., a ratio Csig/Cf of the capacitance variation Csig to the value of the capacitor Cf, when the touch screen panel is touched becomes small, thereby lowering the sensing sensitivity of the touching. The sensing lines of the touch screen panel may be formed of a transparent conductive material, e.g., an indium-tin oxide (ITO). Thus, when the distances between sensing units SU are large, the sensing lines become conspicuous, and thus, the distances between the sensing units SU should be determined to be small. However, if the
distances between the sensing units are small, the value of the horizontal parasitic capacitance component \( C_h \) generated in each of the sensing units becomes greater, and thus, sensing sensitivity of touching may be degraded. Various embodiments of a touch data generator capable of improving sensing sensitivity by reducing a parasitic capacitance component according to the inventive concept will now be described.

[0075] Referring to FIG. 6A, a touch data generator 210B includes an amplification circuit 211B that generates a sensing signal \( V_{out} \) corresponding to a change in the capacitance of a sensing unit SU. The touch data generator 210B may further include a signal output unit 212B that receives the sensing signal \( V_{out} \) and outputs it according to a control signal ctrl, and an ADC 213B that generates touch data by converting the sensing signal \( V_{out} \) that is an analog signal received from the signal output unit 212B into a digital signal.

[0076] The amplification circuit 211B of FIG. 6A may increase sensing sensitivity by reducing influences caused by a horizontal capacitance component \( C_h \) generated in the sensing unit SU (a parasitic capacitance component between a plurality of sensing units SU). To this end, a ground voltage or a DC voltage is not applied to an amplifier AMP corresponding to a sensing line adjacent to a sensing line via which a sensing operation is performed, but rather an input signal \( V_{in} \) is applied to a second input terminal, e.g., \( + \) terminal, of an amplifier AMP corresponding to a sensing line adjacent to a sensing line via which a sensing operation is performed.

[0077] That is, if a first electrode and second electrode of a horizontal parasitic capacitor act as a first sensing line via which a sensing operation is performed and a second sensing line adjacent to the first sensing line, respectively, then the same voltage is applied to the first sensing line and the second sensing line. In this case, the horizontal parasitic capacitance component \( C_h \) is removed from the numerical formula of calculating the gain of the amplifier AMP.

[0078] Although FIG. 6A illustrates the second electrode of the horizontal parasitic capacitor is connected directly to the corresponding second input terminal of the amplifier AMP, the inventive concept is not limited thereto. Unlike as illustrated in FIG. 5A, in the current embodiment of FIG. 6A, the input signal \( V_{in} \) is commonly supplied to second input terminals, i.e., (+) input terminals, of a plurality of amplifiers AMP.

When the input signal \( V_{in} \) is supplied to the second input terminal, i.e., the (+) input terminal, of the amplifier AMP, a voltage of the first input terminal, i.e., a (-) input terminal, of the amplifier AMP becomes equal to the voltage of the second input terminal, i.e., the (+) input terminal. That is, since the input signal \( V_{in} \) is also supplied to the second input terminal of the amplifier AMP connected to the adjacent sensing line, a voltage of the adjacent sensing line also becomes equal to the value of the input signal \( V_{in} \). For this reason, the voltage of the first line via which a sensing operation is performed is equal to the voltage of the second sensing line adjacent to the first sensing line, and thus, the gain of the amplifier AMP is not related to the value of the horizontal parasitic capacitance component \( C_h \). That is, the same voltage \( V_{in} \) is applied to sensing lines adjacent to each other; in order to reduce the influences caused by a horizontal parasitic capacitance component in the sensing unit.

[0079] FIG. 6B is a graph showing the frequency characteristics of the amplifier AMP of FIG. 6A according to an embodiment of the inventive concept. As described above, the frequency of an input signal \( V_{in} \) is determined to fall within a pass band of the amplifier AMP. That is, the frequency of the input signal \( V_{in} \) may be determined to be greater than illustrated in FIG. 6B. Also, the gain of the amplifier AMP of FIG. 6A is equal to

\[
20 \log_{10} \left( 1 + \frac{C_{sig}}{C_f} \right)
\]

That is, the gain of the amplifier AMP is not related to the value of a horizontal parasitic capacitance component \( C_h \) connected to a corresponding sensing line.

[0080] Even if the value of a horizontal parasitic capacitance component \( C_h \) present in a sensing line of a touch screen panel increases, the gain of the amplifier AMP is not changed. Thus, the capacitance value of the capacitor \( C_f \) of FIG. 6A does not need to be increased so that the gain of the amplifier AMP falls within a predetermined range. Accordingly, it is possible to appropriately increase the ratio \( C_{sig}/C_f \) that represents sensing sensitivity and to improve the sensing sensitivity of the capacitance variation \( C_{sig} \) when touching is made.

[0081] FIGS. 7A and 7B are circuit diagrams illustrating in detail the touch data generator 210B of FIG. 6A. For convenience of explanation, the signal output circuit 212B and the ADC 213B included in the touch data generator 210B are not illustrated here.

[0082] As illustrated in FIG. 7A, the touch data generator 210B may include a plurality of amplifiers, e.g., a first amplifier AMP1 to a third amplifier AMP3, which are connected to a plurality of sensing lines, e.g., a first sensing line SL1 to a third sensing line SL3, respectively. The first and third amplifiers AMP1 to AMP3 sense a change in the capacitances of sensing units (not shown) corresponding thereto and generate first to third sensing signals \( V_{out1} \) to \( V_{out3} \) corresponding to the sensed changes, respectively. First to third capacitors \( C1 \) to \( C3 \) and first to third resistors \( R1 \) to \( R3 \) may be connected in parallel between first input terminals, e.g., (+) input terminals, and output terminals of the respective first to third amplifiers AMP1 to AMP3.

[0083] Also, an input signal \( V_{in} \) having a predetermined frequency is commonly supplied to the second input terminal, e.g., the (+) input terminals) of the first to third amplifiers AMP1 to AMP3. The first to third amplifiers AMP1 to AMP3 correspond to and are connected to the first to third sensing lines SL1 to SL3, respectively. Thus, the first to third amplifiers AMP1 to AMP3 sense a change in the capacitances of the corresponding first to third sensing lines SL1 to SL3 and generate the first to third sensing signals \( V_{out1} \) to \( V_{out3} \), respectively. In FIG. 7A, horizontal parasitic capacitance components \( C_{h1} \) to \( C_{h3} \) are generated between the first to third sensing lines SL1 to SL3.

[0084] The operation of the touch data generator 210B will now be described assuming that a sensing operation is per-
formed using the second sensing line SL2. The first input terminal, e.g., the (-) input terminal, of the second amplifier AMP2 is connected to the second sensing line SL2, and thus, the second amplifier AMP2 generates the second sensing signal Vout2 corresponding to the capacitance value of a corresponding sensing unit. The input signal Vin that is supplied to the second amplifier AMP2 is also supplied to the second input terminals, i.e., the (+) input terminals, of the first and third amplifiers AMP1 and AMP3. Voltages of the respective first input terminals, e.g., the (-) input terminals, of the first and third amplifiers AMP1 and AMP3 become equal to voltages of the respective second input terminals, e.g., the (+) input terminals, of the first and third amplifiers AMP1 and AMP3. Thus, voltages of the first and third sensing lines SL1 and SL3 being respectively connected to the first input terminals, e.g., the (-) input terminals, of the respective first and third amplifiers AMP1 and AMP3 become equal to a voltage of the second sensing line SL2. Thus, voltages of adjacent sensing lines become equal to or similar to each other. Accordingly, influences caused by the horizontal capacitance components Ch1 and Ch2 may be reduced as illustrated above in FIG. 6B.

[0085] FIG. 7B is a circuit diagram of a touch data generator 210D designed to perform the operation of the touch data generator of FIG. 7A, in which one amplifier AMP is shared by first to third sensing lines SL1 to SL3, according to another embodiment of the inventive concept. The touch data generator 210D of FIG. 7B may further include first to third switches SW1 to SW3 that switch connection of a first input terminal, e.g., an (-) input terminal, of the amplifier AMP between the first to third sensing lines SL1 to SL3, respectively, so that the first to third sensing lines SL1 to SL3 may be selectively connected to the first input terminal, e.g., the (-) input terminal, of the amplifier AMP.

[0086] When a sensing operation is performed using the second sensing line SL2, the second switch SW2 is switched on to connect the second sensing line SL2 to the first input terminal, e.g., the (-) input terminal, of the amplifier AMP. Also, the first switch SW1 connected to the first sensing line SL1 adjacent to the second sensing line SL2 is switched on to connect the first sensing line SL1 to a line that transmits an input signal Vin. The third switch SW3 connected to the third sensing line SL3 adjacent to the second sensing line SL2 is also switched on to connect the third sensing line SL3 to the line that transmits the input signal Vin.

[0087] Accordingly, the amplifier AMP senses a capacitance value of a corresponding sensing unit (not shown) via the second sensing line SL2 and generates a sensing signal Vout according to the sensed capacitance value. Since the input signal Vin is supplied to the first sensing line SL1 and the third sensing line SL3 adjacent to the second sensing line SL2, a voltage of the second sensing line SL2 becomes equal to those of the first and third sensing lines SL1 and SL3. Thus, influences caused by a horizontal parasitic capacitance component Ch2 are reduced, thereby improving sensing sensitivity of touching.

[0088] FIGS. 8A to 8C are circuit diagrams respectively illustrating touch data generators 210C, 210D, and 210E that are various embodiments of the touch data generator 112 of FIG. 3A, 3B or 3C, according to the inventive concept. Referring to FIGS. 8A to 8C, the touch data generators 210C, 210D, and 210E further include an additional capacitor, e.g., a second capacitor Cq, in order to compensate for a parasitic capacitance component present in a sensing unit SU. Accordingly, sensing sensitivity may be improved by removing a horizontal or vertical parasitic capacitance components present in the sensing unit SU.

[0089] Referring to FIG. 8A, the touch data generator 210C includes an amplifier AMP having a first input terminal, e.g., a (+) input terminal, which is connected to a sensing line and a second input terminal, e.g., a (-) input terminal to which an input signal Vin is supplied. A first capacitor Cf and a resistor Rf may be connected in parallel between the first input terminal and an output terminal of the amplifier AMP.

[0090] The touch data generator 210C may further include a second capacitor Cq that is connected to the sensing line and has a predetermined capacitance value. A first electrode of the second capacitor Cq is connected to the sensing line and a predetermined voltage signal Vq is applied to a second electrode of the second capacitor Cq. The polarity of electric charges induced in the second capacitor Cq is controlled to be opposite to that of electric charges induced in a parasitic capacitance component C1 (horizontal and vertical parasitic capacitance components) present in the sensing unit SU by the capacitance of the second capacitor Cq and the voltage signal Vq. For example, if electric charges having a positive (+) polarity, which are induced in a parasitic capacitor, are supplied to the sensing line, then electric charges induced in the first electrode of the second capacitor Cq is controlled to have a negative (-) polarity. Also, if the voltage signal Vq supplied to the second electrode of the second capacitor Cq may be synchronized with the input signal Vin supplied to the second input terminal of the amplifier AMP, and in this case, the value of the voltage signal Vq may be defined as xVin. Thus, the gain of the amplifier AMP may be calculated as follows:

\[
\text{gain} = \frac{1 + x\text{Cf} + Cq + Csig + \text{x}Cq\text{Rf} - \text{x}Cq\text{Rf}}{1 + x\text{Cf} Rf}
\]

[0091] In an equation of calculating the gain of the amplifier AMP in a high-frequency band may be obtained from Equation (1), as follows:

\[
\text{gain} = \frac{Cf + Cq + Csig + Cq - xCq}{Cf}
\]

[0092] As described above, 'xCq', and 'Cq', 'Csig', expressed in Equations (1) and (2) may be controlled to be equal to or similar to each other by adjusting the capacitance value of the second capacitor Cq and the logic level x of the voltage signal Vq. If 'xCq' and 'Cq' are equal to each other, 'Csig' and 'xCq' are controlled to be equal to each other, and thus, the gain of the amplifier AMP may become 'Csig'. If 'xCq', and 'Cq' are similar to each other, sensitivity is improved. That is, a change in the gain of the amplifier AMP caused by the parasitic capacitance component C1 may be reduced by adjusting 'x' and 'Cq', thereby improving sensing sensitivity of a capacitance variation Csig when touching is made. In this case, it is unnecessary to apply the same voltage to sensing lines adjacent to the sensing line on which a sensing operation is performed.

[0093] FIG. 8B illustrates a touch data generator 210D capable of reducing influences caused by interference in a sensing line due to a change in a voltage applied to a display
panel (not shown) according to another embodiment of the inventive concept. For example, if a touch screen panel is included in a mobile LCD, interference may occur due to alternation of an electrode voltage VCOM applied to an upper plate electrode of a display panel.

[0094] A vertical capacitance component \( C_v \) is generated between the sensing line and the display panel. The vertical capacitance component \( C_v \) influences an output of the amplifier AMP due to alternation of the electrode voltage VCOM applied to an upper plate electrode of the display panel alternately. To solve this problem, the input signal \( V_{in} \) is supplied to the second input terminal of the amplifier AMP, in synchronization with the electrode voltage VCOM. If a swing amplitude of the input signal \( V_{in} \) is set to be less than that of the electrode voltage VCOM, then negative (-) electric charges are gathered on an upper electrode of a vertical parasitic capacitor, e.g., an electrode connected to the sensing line when the input signal \( V_{in} \) is at logic high. In this case, positive (+) electric charges are gathered on an upper electrode of the second capacitor \( C_q \) by adjusting appropriately a capacitance value of the second capacitor \( C_q \) and a voltage signal \( V_q \). where the amount of the positive (+) electric charges is equal to or similar to the amount of the negative (-) electric charges gathered on the vertical parasitic capacitor. Thus, an output of the amplifier AMP may be hardly or less affected by the vertical capacitance component \( C_v \) and a variation in the electrode voltage VCOM.

[0095] If the input signal \( V_{in} \) and the voltage signal \( V_q \) are synchronized with the electrode voltage VCOM, then the electrode voltage VCOM may be expressed as \( V_{Vin} \) and the voltage signal \( V_q \) may be expressed as \( V_{Vin} \). In this case, the gain of the amplifier AMP of FIG. 8B may also be expressed as follows:

\[
\text{gain} = \frac{1 + x(C_f + C_{ig} + (1-x)C_y + (1-y)C_y)R_f}{1 + xC_f R_f}.
\]

[0096] An equation of calculating the gain of the amplifier AMP in a high-frequency band be obtained from Equation (3), as follows:

\[
\text{gain} = \frac{C_f + C_{ig} + (1-x)C_y + (1-y)C_y}{C_f}.
\]

[0097] As expressed in Equation (4), influences caused by a variation in the electrode voltage VCOM may be reduced by adjusting the capacitance value of the second capacitor \( C_q \) and the logic level \( x \) of the voltage signal \( V_q \). For example, since the electrode voltage VCOM has a predetermined level, an output of the amplifier AMP may not be influenced or be influenced less by a variation in the electrode voltage VCOM by offsetting or reducing \( C_f(1-x)C_y + (1-y)C_y \) expressed in Equations (3) and (4), by adjusting the capacitance value of the second capacitor \( C_q \) and the level \( y \) of the voltage signal \( V_q \). Accordingly, in addition to reduction of influences caused by the vertical parasitic capacitance component, influences caused by an upper plate electrode voltage VCOM are reduced.

[0098] FIG. 8C is a circuit diagram of a touch data generator 210E that is another embodiment of the touch data generator 112 of FIG. 3A, 3B, or 3D according to the inventive concept. The touch data generator 210E of FIG. 8C includes all the features of the touch data generator 210B illustrated in FIG. 6A and the touch data generator 210D illustrated in FIG. 8B, and is capable of effectively reducing a horizontal and vertical parasitic capacitance component \( C_h \) and \( C_v \) generated in a sensing unit SU. In this case, the influences caused by the horizontal parasitic capacitance component are reduced as described with respect to FIG. 6A, and the influences caused by the vertical parasitic capacitance component and the voltage VCOM are reduced as described with respect to FIG. 8B. Also, although not shown, the circuit construction of the touch data generators 210B illustrated in FIGS. 7A and 7B may be applied to the touch data generator 210E of FIG. 8C in order to effectively reduce the horizontal parasitic capacitance component \( C_h \) generated in the sensing unit SU.

[0099] Referring to FIG. 8C, parasitic capacitance components generated in the sensing unit SU may include the horizontal parasitic capacitance component \( C_h \) and the vertical parasitic capacitance component \( C_v \). A voltage of a sensing line via which a sensing operation is performed is controlled to be equal to a voltage of a sensing line adjacent to the sensing line via which the sensing operation is performed in order to reduce the horizontal parasitic capacitance component \( C_h \) generated between adjacent sensing lines. To this end, an input voltage \( V_{Vin} \) is applied to not only an amplifier AMP that performs a sensing operation on a predetermined sensing line but also a second input terminal of another amplifier AMP corresponding to a sensing line adjacent to the predetermined sensing line. Thus, since the voltages of the predetermined sensing line and the adjacent sensing line are equal to each other, the amplifier AMP may be affected less by the horizontal capacitance component \( C_h \). FIG. 8C illustrates that one electrode of a horizontal parasitic capacitor is connected directly to a second input terminal of the corresponding amplifier AMP, but the inventive concept is not limited thereto. For example, the one electrode of the horizontal parasitic capacitor may be electrically connected to a first or second input terminal of an amplifier AMP connected to a sensing line adjacent to the sensing line connected to the horizontal parasitic capacitor.

[0100] FIG. 8D is a circuit diagram of a voltage adjustment circuit 221 that adjusts the logic level of a voltage signal \( V_q \) applied to the second capacitor \( C_{ig} \), and \( V_{Vin} \), and \( V_q \), according to an embodiment of the inventive concept. The voltage adjustment circuit 221 of FIG. 8D may be included in the touch data generators 210C to 210E of FIGS. 8A to 8C, according to an embodiment of the inventive concept. The voltage adjustment circuit 221 of FIG. 8D may control the logic level of the voltage signal \( V_q \) by using an input signal \( V_{Vin} \), a common voltage \( V_{cm} \), resistors \( R_{q1} \) and \( R_{q2} \), and so on.

[0101] FIGS. 9A and 9B are block and circuit diagrams of a touch data generator 310 and 310' according to embodiments of the inventive concept. FIG. 9C is a circuit diagram of an integration circuit 313B that is another embodiment of the integration circuit 313 in FIG. 9A, according to the inventive concept. In particular, compared to the previous embodiments, the touch data generators 310 and 310’ illustrated in FIGS. 9A and 9B further include the integration circuit 313. The touch data generator 310 may include a voltage reading circuit 311, an amplification circuit 312, an integration circuit 313, and an ADC circuit 314.

[0102] Although not shown, the voltage reading circuit 311 reads a voltage \( V_{read} \) output from each of a plurality of
sensing units connected to a plurality of sensing lines included in a touch screen panel. For example, the voltage reading circuit 311 may include various switches and a buffer for providing an input signal Vin as illustrated in FIG. 7B.

[0104] Also, the amplification circuit 312 amplifies the voltage Vread read from the voltage reading circuit 311 and outputs the result of amplification. The result of amplification output from the amplification circuit 312 may be supplied to the integration circuit 313 as a sensing signal Vout. The amplification circuit 312 amplifies the voltage Vread output from the voltage reading circuit 311 so that a change in the capacitance of a sensing unit (not shown) may be sensed. Also, the amplification circuit 312 may include at least one amplifier for performing an amplification operation, and the at least one amplifier may include a plurality of amplifiers being respectively connected to a plurality of sensing lines. Alternatively, the at least one amplifier is switched to be connected with one of the plurality of sensing lines so that the at least one amplifier may be shared by the plurality of sensing lines.

[0105] The integration circuit 313 may integrate the sensing signal Vout received from the amplification circuit 312. As described above, the sensing signal Vout output from the amplification circuit 312 may contain a plurality of noise components, and the noise components may be effectively removed by integrating the sensing signal Vout by the integration circuit 313. In the current embodiment, the integration circuit 313 may include various types of circuits needed to receive and integrate an input signal and output the result of integration. The integration circuit 313 may one of various types of integrators, e.g., a switched capacitor integrator or a Gm-C integrator.

[0106] The ADC circuit 314 may convert an analog voltage VADC_IN received from the integration circuit 313 into touch data data which is a digital signal. Although not shown, the touch data data may be supplied to either a signal processor included in a touch controller or a host controller outside the touch controller. It is possible to determine whether the touch screen panel is touched or a touched location on the touch screen panel by performing an operation on the touch data data.

[0107] Referring to FIG. 9B, the touch data generator 310' of this example uses a switched capacitor integration circuit 313, as an integration circuit. Otherwise, as illustrated in FIG. 9C, a Gm-C integration circuit 313B may be used as an integration circuit. In the touch data generator 310 of FIG. 9B, a voltage reading circuit 311 and an amplification circuit 312 operate as described above with reference to FIG. 9A and thus are not described again here. In FIG. 9B, a capacitance component Cb generated in each of a plurality of sensing units denotes a whole capacitance component that includes horizontal and vertical parasitic capacitance components.

[0108] Referring to FIG. 9B, one amplification circuit 312 may be shared by the plurality of sensing units. When a voltage from a first sensing unit is read according to a switching operation of a first switch SW1, the remaining sensing units may be connected to an input signal Vin according to switching operations of a second switch SW2 to an mth switch SWm, respectively. Then, similarly, a voltage of the second sensing unit may be read and the remaining sensing units may be driven by a driving circuit (e.g., a buffer included in the voltage reading circuit 311). The input signal Vin may be a square-wave signal or a sinusoidal-wave having a predetermined pulse cycle. The logic level or frequency of the input signal Vin may be adjusted appropriately.

[0109] FIG. 9D is a waveform diagram illustrating an input signal Vin and a timing of turning on the switches SW1 to SWm of FIG. 9B according to an embodiment of the inventive concept. The input signal Vin may be a square-wave signal or a sinusoidal-wave signal but FIG. 9D illustrates that the input signal Vin is a square-wave signal. Also, as illustrated in FIG. 9D, the input signal Vin may have a predetermined rising time and a predetermined falling time. Also, the switches SW1 to SWm may be sequentially turned on not to overlap with one another. Periods of time in which the switches SW1 to SWm are respectively turned on may be equal to or greater than the pulse cycle of the input signal Vin.

[0110] In FIG. 9B, the amplification circuit 312 may output an output signal Vout, the voltage level of which depends on a change in the capacitance of a sensing unit. The value of the output signal Vout of the amplification circuit 312 may be calculated as follows:

$$V_{out} = \frac{Vin + \alpha R_f (C_f + C_{ab} + C_{2} + C_{p} (Vin - V_{cm})} {1 + \alpha R_f C_f}$$

[0111] If in Equation (5), a capacitance component Cb is completely offset, that is, when \((C_f + C_{ab}) Vin - V_{cm} C_p \) is satisfied, the relationship between the sensing signal Vout and the input signal Vin may be defined as follows:

$$\frac{V_{out}}{Vin} = \frac{1 + \alpha R_f (C_f + C_{ab})} {1 + \alpha R_f C_f}$$

[0112] When an object touches a touch screen panel, a capacitance component Cs in between the touch screen panel and the object has a predetermined intensity, and thus, a voltage of the sensing signal Vout corresponding to the capacitance component Cs may change. The amplifier AMP1 may output a sensing signal Vout corresponding to the capacitance value of a sensing unit in an analog manner. Whether the touch screen panel is touched and a touched location on the touch screen panel may be determined by sensing a change in the voltage of the sensing signal Vout, caused when the touch screen panel is touched.

[0113] A noise may be contained in the sensing signal Vout output from the amplification circuit 312, and the integration circuit 313A included in a touch controller according to an embodiment of the inventive concept may reduce influences caused by the noise effect. In general, noise has a Gaussian distribution, and thus, an average of the values of noise components in a predetermined section may be zero. Thus, it is possible to effectively remove the noise from an output voltage Vout by using a predetermined integration circuit.

[0114] The integration circuit 313A may include an operation amplifier AMP3 in order to perform an integration operation. A capacitor C2 may be connected between a first input terminal, e.g., a negative input terminal, and an output terminal of the operation amplifier AMP3. A switch RST may also be connected between the first input terminal and the output terminal of the operation amplifier AMP3 to be parallel to the capacitor C2.

[0115] Also, a common voltage Vcm may be applied to a second input terminal, e.g., a positive input terminal, of the
operation amplifier AMP3. The common voltage Vcm may correspond to an intermediate level of voltage input to the ADC circuit 314.

[0116] Also, a plurality of switches \( \phi_1 \) and \( \phi_2 \) and a capacitor C1 may be connected to the first input terminal, e.g., the negative input terminal, of the operation amplifier AMP3. An integration operation may be performed based on switching operations of the switches \( \phi_1 \) and \( \phi_2 \) and a charging operation of the capacitor C1. The output voltage Vout of the amplification circuit 312 may be supplied to the inside of the integration circuit 313A via a predetermined buffer.

[0117] FIG. 9E is a waveform diagram of various signals supplied to the touch controller according to an embodiment of the inventive concept. A common voltage Vcm having a predetermined level may be applied, and an input signal Vin and a voltage signal Vq supplied to a capacitor Cq may have a predetermined frequency and a voltage having an intermediate level corresponding the common voltage Vcm. For example, FIG. 9E illustrates a case where the input signal Vin and the voltage signal Vq are generated in synchronization with a horizontal synchronization signal HSYNC. The voltage signal Vq may be controlled using values of the resistors Rq1 and Rq2 connected to amplifier AMP2, and influences caused by a capacitance component Cb generated in a sensing unit may be reduced by adjusting the logic level of the voltage signal Vq.

[0118] FIG. 9F is a timing diagram illustrating the operation of the integration circuit 313A of FIG. 9D according to an embodiment of the inventive concept. As illustrated in FIG. 9F, two switches \( \phi_1 \) may be controlled in the same way and the remaining switches \( \phi_2 \) may be controlled in the same way. First, the switches \( \phi_1 \) may be turned on at a time t1, and the capacitor C1 may thus be charged with the difference between the input signal Vin and the output voltage Vout.

[0119] While a predetermined voltage is charged in the capacitor C1, the switches \( \phi_1 \) may be turned off and the remaining switches \( \phi_2 \) may be turned on at a time t2. In this case, the operation amplifier AMP3 may perform an integration operation so that a voltage of the first input terminal, e.g., a negative input terminal, of the amplifier AMP3 may follow a voltage of the second input terminal, e.g., a positive input terminal, thereof. Thus, an integration voltage VADC_IN may increase or decrease according to the difference between the output voltage Vout and the input signal Vin. When the output voltage Vout is entirely integrated, the result of integration may not fall within the dynamic range of the ADC circuit 314, and thus, according to an embodiment of the inventive concept, a voltage ‘Vout-Vin’ may be integrated according to time, as illustrated in FIG. 9B. Thus, the result of integrating the voltage ‘Vout-Vin’ may be less than or greater than the common voltage Vcm. That is, a voltage of an input signal supplied to the ADC circuit 314 is set to be less than or greater than the common voltage Vcm, and thus, an output of the ADC circuit 314 may be averaged, thereby removing a low-frequency noise effectively.

[0120] FIG. 9G is a graph showing a variation in an integration voltage VADC_IN of the integration circuit 313A of FIG. 9B according to an embodiment of the inventive concept. Referring to FIG. 9G, the integration voltage VADC_IN may be output to be less than or greater than the common voltage Vcm. For example, if the output voltage Vout is greater than a voltage of the input signal Vin, the integration voltage VADC_IN may be greater than the common voltage Vcm, and if the output voltage Vout is less than the voltage of the input signal Vin, the integration voltage VADC_IN may be less than the common voltage Vcm. Also, as illustrated in FIG. 9G, the integration voltage VADC_IN is not influenced by noise, and thus, a controller (not shown) may easily determine whether a touch screen panel is touched by setting a threshold appropriately.

[0121] FIG. 10A is a circuit diagram of an integration circuit 313C that is another embodiment of the integration circuit 313A included in the touch data generator 310 of FIG. 9B, according to the inventive concept. Referring to FIG. 10A, the integration circuit 313C uses a reference signal Vref as an input signal instead of the input signal Vin used in the embodiment of FIG. 9B. The integration circuit 313C of FIG. 10A is a switched capacitor integration circuit but it may be embodied as a Gm-C integration circuit.

[0122] FIG. 10B is a waveform diagram of an output voltage Vout and the reference signal Vref used in the integration circuit 313C of FIG. 10A, and an input signal Vin, according to an embodiment of the inventive concept. The reference signal Vref may be embodied as a square-wave signal or a sinusoidal-wave signal as the input signal Vin, and an amplitude of the reference signal Vref may be greater than that of the input signal Vin.

[0123] Referring to FIG. 10B(a), the amplitude of the reference signal Vref may be set to correspond to an intermediate level of an inclined section of the output voltage Vout, so that an integration voltage VADC_IN when touching is not made may approximate nearly a common voltage Vcm. Also, FIG. 103(b) reveals if reference signal Vref is used instead of the input signal Vin, then the integration voltage VADC_IN when touching is not made approximates more the common voltage Vcm. Thus, sensing sensitivity may be improved greatly by increasing the difference of the integration voltages VADC_IN between when touching is not made and when touching is made.

[0124] FIG. 11 is a block diagram of a touch controller 400 according to another embodiment of the inventive concept. Referring to FIG. 11, the touch controller 400 includes elements for performing operations to generate touch data. For example, the touch controller 400 includes a voltage reading circuit 410, a first amplification circuit 420, a first anti-aliasing filter (AAF) 430, an integration circuit 440, and an ADC 450. The touch controller 400 may further include a second amplification circuit 470 that has the same or similar characteristics as the first amplification circuit 420, and a second AAF 480 that has the same or similar characteristics as the first AAF 430. A main signal path is formed using the first amplification circuit 420 and the first AAF 430, and a sub signal path is formed using the second amplification circuit 470 and the second AAF 480.

[0125] When the capacitance of a sensing unit (not shown) changes, an output voltage corresponding to the change in the capacitance is generated using the voltage reading circuit 410 and the first amplification circuit 420. The output voltage output from the first amplification circuit 420 may pass through the first AAF 430. Touch data generated by the ADC 450 may pass through a digital filter 460 in a subsequent operation. In this case, before passing through the digital filter 460, the touch data may pass through an AAF so that a high-frequency component may be removed from the touch data. To this end, the first AAF 430 may be disposed between the first amplification circuit 420 and the integration circuit 440.
A plurality of signals that indicate a change in the capacitances of a plurality of sensing units (not shown), respectively, are supplied sequentially to the voltage reading circuit 410. In order to sense a change in the capacitances of the plurality of sensing units, a plurality of pulse signals each having a particular frequency corresponding to one of the plurality of sensing units are supplied to the voltage reading circuit 410. The second amplification circuit 470 and the second AAF 480 may be further included in the touch controller 200 in order to extract only an actual signal component from an output of the first AAF 430. Also, a pulse signal, e.g., an input signal Vin, the phase of which is the same as that of a pulse signal supplied to first amplification circuit 420 is supplied to the second amplification circuit 470. Although not shown, a voltage of the sensing unit is applied to one input terminal of an amplifier included in the first amplification circuit 420, where an amplifier included in the second amplification circuit 470 may have a structure in which one input terminal is connected to an output terminal. The difference between an output of the first AAF 430 and an output of the second AAF 480 is calculated by a predetermined subtractor, and thus, only an actual signal component is supplied to the integration circuit 440.

The frequencies of pulse signals supplied to the elements of the touch controller 400 of FIG. 11 may be synchronized with a line scan frequency of a display (not shown) in order to minimize frequency interferences during a displaying operation. For example, the input signal Vin supplied to the voltage reading circuit 410 may also be supplied to the first amplification circuit 420, the second amplification circuit 470 and the integration circuit 440. Also, a voltage signal, the phase of which is equal or similar to the phase of the input signal Vin and the amplitude of which is different from the amplitude of the input signal Vin may be supplied to the first amplification circuit 420, the second amplification circuit 470, and the integration circuit 440.

FIG. 12A is a block diagram of a general LCD 500A that includes a plurality of touch controllers T/C according to an embodiment of the inventive concept. Referring to FIG. 12A, the LCD 500A may include a timing controller 510A that controls the overall timing for displaying an image and a voltage generator 520A that generates various voltages for driving the LCD 500A. The LCD 500A may further include a display panel 550A, at least one gate driver 530A that drives a gate line of the display panel 550A, and at least one source driver 540A that drives a source line of the display panel 550A. Each of the touch controllers T/C may receive timing information from the timing controller 510A. Thus, the touch controllers T/C may be included in the at least one gate driver 530A or the at least one source driver 540A, respectively. FIG. 12A illustrates that the touch controllers T/C are included, for example, in the at least one source driver 540A, respectively. The timing information transmitted from the timing controller 510A to the source driver 540A may be supplied simultaneously to the touch controllers T/C included in the at least one source driver 540A. The touch controllers T/C sense a capacitance value of a sensing unit of a touch screen panel (not shown) that may be attached to the display panel 550A, and generate touch data from the timing information received from the timing controller 510A.

FIG. 12B is a block diagram of a general LCD 500B that includes a touch controller T/C according to an embodiment of the inventive concept. Referring to FIG. 12B, in the LCD 500B, the touch controller T/C is included in a timing controller 510B. In this case, the touch controller T/C may receive timing information directly in the timing controller 510B. Although not shown, the touch controller T/C may be electrically connected to a touch screen panel that may be attached to a display panel 550B, and thus may sense a change in the capacitance of a sensing unit of the touch screen panel and generate touch data according to the change in the capacitance.

FIG. 13 is a block diagram of an integrated circuit (IC) 600, in which a touch controller 610 and a display driving unit 630 are integrated together, according to an embodiment of the inventive concept. In FIG. 13, the IC 600 is embodied as a semiconductor chip that communicates with a host controller 650. The semiconductor chip 600 includes the touch controller 610 as described above in the previous embodiments, and the display driving unit 630 that acts as a display driving circuit. Since the touch controller 610 and the display driving unit 630 are integrated together in the same semiconductor chip 600, manufacturing costs may be saved. Also, a sensing signal output from the touch controller 610 and a signal output from the display driving unit 630 may be synchronized with each other, thereby reducing influences caused by noise generated during a touch screen operation.

The touch controller 610 may be constructed in various ways in order to perform the touch screen operation. For example, the touch controller 610 may include a readout circuit 611 that generates touch data, a parasitic capacitance compensation circuit 612 that reduces a parasitic capacitance component in a sensing unit, an ADC 613 that converts analog data into a digital signal, a supply voltage generator 614 that generates a supply voltage, a memory unit 615, an MCU 616, a digital FIR LPF 617, an oscillator 618 that generates a low-power oscillation signal, an interface unit 619 that exchanges a signal with the host controller 650, and a control logic unit 620. The display driving unit 630 may include a source driver 631 that generates gray-scale data for a displaying operation, a gray-scale voltage generator 632, a display memory 633 that stores display data, a timing control logic unit 634, and a power generator 635 that generates at least one supply voltage. The display driving unit 630 may further include a central processing (CPU) and RGB interface unit 636 that controls the overall operations of the display driving unit 630 or performs an interface with the host controller 650.

The touch controller 610 may receive at least one piece of timing information Timing info from the display driving unit 630. For example, the control logic unit 620 of the touch controller 610 receives various timing information VSYSYN, HSYNCN, and Dotclk to be synchronized with a display output signal from the timing control logic unit 634 of the display driving unit 630. The control logic unit 620 may generate a control signal for controlling a timing of generating the touch data, from the at least one piece of timing information Timing info.

The display driving unit 630 may also receive at least one piece of information from the touch controller 610. Referring to FIG. 13, the display driving unit 630 may receive a status signal, e.g., a sleep status signal, from the touch controller 610. The display driving unit 630 receives the sleep status signal from the touch controller 610 and performs an operation corresponding to the sleep status signal. If the touch controller 610 enters a sleep mode, it means that touching has not been made for a predetermined time. In this case, the display driving unit 630 may discontinue supplying the timing information Timing info to the touch controller 610.
Therefore, it is possible to save power consumption in a device, e.g., a mobile device, in which the semiconductor chip 600 is installed.

[0134] Also, as illustrated in FIG. 13, each of the touch controller 610 and the display driving unit 630 includes a circuit block that generates power, a memory that stores predetermined data, and a control unit that controls the operations of the remaining blocks. Thus, if the touch controller 610 and the display driving unit 630 are integrated together in the same semiconductor chip, then the memory, the circuit block, and the control unit may be embodied to be used commonly by the touch controller 610 and the display driving unit 330.

[0135] FIGS. 14A and 14B illustrate an interrelation between a touch controller and a display driving unit as illustrated in FIG. 13. Referring to FIG. 14A, a semiconductor chip 600 that drives a display device (not shown) may include the touch controller (including the memory, AFE, MCU and control logic as shown for example) and the display driving unit (including the power generator, output driver, control logic and display memory as shown for example), and the touch controller and the display driving unit may exchange at least one piece of information, e.g., timing information and status information, with each other. Also, each of the touch controller and the display driving unit may supply a supply voltage to the other or may receive the supply voltage from the other. FIG. 14A schematically illustrates the touch controller and the display driving unit for convenience of explanation, in which an analog front end (AFE) included in the touch controller may include a voltage reading circuit, an amplification circuit, an integration circuit, and an ADC. A case where the touch controller provides sleep status information to the display driving unit and the display driving unit applies the supply voltage to the touch controller according to an embodiment of the inventive concept, will now be described.

[0136] As illustrated in FIG. 14B, if a display is turned on and a touch input is deactivated, i.e., if both the touch controller and the display enter a sleep mode, then the display driving unit prevents a supply voltage or timing information from being supplied to the touch controller. In this case, only a register included in the display driving unit may be activated, thereby minimizing power consumption.

[0137] If the touch input is deactivated and the display is activated, i.e., if the touch controller enters the sleep mode and the display enters a normal mode, then the display driving unit generates the supply voltage to be used therein but the supply voltage is not applied to the touch controller since the touch controller does not consume power. Also, the display driving unit does not provide the timing information to the touch controller.

[0138] If the touch input is activated and the display is deactivated, i.e., if the touch controller enters the normal mode and the display enters the sleep mode, then it is periodically checked whether touching is made since the touch input is activated. In this case, the display driving unit is kept deactivated while operating in a low-power consumption mode. However, in order to check whether touching is made, the display driving unit generates the timing information and the supply voltage to be applied to the touch controller and supply them to the touch controller.

[0139] In general, when both the touch input and the display are activated, i.e., if both the touch controller and the display enter the normal mode, then the display driving unit generates the timing information and the supply voltage and applies them to the touch controller.

[0140] It is concluded from the above four cases that the supply voltage generator of the display driving unit may generate a supply voltage when at least one of the touch controller and the display driving unit is activated. Also, a control logic unit of the display driving unit may generate the timing information and supply it to the touch controller only when the touch controller operates.

[0141] FIGS. 15A to 15C illustrate embodiments of a printed circuit board (PCB) structure of a display device 700 that includes a touch panel 720, according to the inventive concept. Here, the touch panel 720 and a display panel 740 are disposed apart from each other.

[0142] Referring to FIG. 15A, the display device 700 may include a window glass 710, the touch panel 720, and the display panel 740. A polarizing plate 730 may be disposed between the touch panel 720 and the display panel 740 for an optical characteristic.

[0143] In general, the window glass 710 is formed of acrylic or tempered glass and protects a module from external impacts or scratches caused by repeated touches. The touch panel 720 is formed by patterning transparent electrodes, for example, indium tin oxide (ITO) electrodes, on a glass substrate or a polyethylene terephthalate (PET) film. A touch screen controller 721 may be mounted on a flexible printed circuit board (FPCB) in the form of a chip on board (COB), and senses a change in the capacitance of each of the electrodes, extracts the coordinates of a touching point, and provides the coordinates of the touching point to a host controller (not shown). In general, the display panel 740 is manufactured by putting two pieces of glass, i.e., an upper glass plate and a lower glass plate, together. Also, in general, the display driving circuit 741 is attached to a mobile display panel in the form of a chip on glass (COG).

[0144] FIG. 15B illustrates another embodiment of the PCB structure of the display device 700 that includes a touch panel 720, according to the inventive concept. Referring to FIG. 15B, a touch controller 721 may be disposed on a main board 760 and a voltage signal transmitted from a sensing unit (not shown) may be exchanged between the touch panel 720 and the touch controller 721 via an FPCB. A display driving circuit 741 may be mounted on a display panel 740 in the form of a COG as illustrated in FIG. 15A. The display driving circuit 741 may be electrically connected to the main board 760 via the FPCB. That is, the touch controller 721 and the display driving circuit 741 may exchange various information and signals with each other via the main board 760.

[0145] FIG. 15C illustrates another embodiment of the PCB structure of the display device 700, in which a touch controller and a display driving unit are integrated together in the same semiconductor chip 751, according to the inventive concept. Referring to FIG. 15C, the display device 700 may include a window glass 710, a touch panel 720, a polarizing plate 730, and a display panel 740. In particular, the semiconductor chip 751 may be mounted on a display panel 740 in the form of COG. The touch panel 720 and the semiconductor chip 751 may be electrically connected to each other via an FPCB.

[0146] FIG. 15D illustrates the panel structure of the display device 700 illustrated in FIG. 15A, 15B, or 15C, according to an embodiment of the inventive concept. FIG. 15D illustrates an organic light-emitting diode (OLED) as the display device 700. Referring to FIG. 15D, a sensing unit may
be formed by patterning a transparent electrode, e.g., an ITO (sensor) and may be formed on a glass plate separated apart from a display panel. The glass plate on which the sensing unit is disposed may be separated apart from a window glass via a predetermined air gap or resin, and may be separated apart from an upper glass plate and a lower glass plate that constitute the display panel via a polarizing plate.  

[0147] FIGS. 16A to 16C illustrate embodiments of a PCB structure of a display device 800, in which a touch panel and a display panel are united together, according to the inventive concept. Referring to FIG. 16A, the display device 800 may include a window glass 810, a display panel 820, and a polarizing plate 830. In particular, the touch panel may be fabricated by patterning transparent electrodes on an upper glass plate of the display panel 820 rather than on an additional glass plate. FIG. 16A illustrates that a plurality of sensing units SU are arranged on the upper glass plate of the display panel 820. Although not shown, when a panel structure is fabricated as described above, a touch controller and a display driving circuit may be integrated together in the same semiconductor chip 821.

[0148] If the touch controller and the display driving circuit may be integrated together in the same semiconductor chip 821, then a voltage signal \( T_{\text{sig}} \) and image data \( I_{\text{data}} \) are supplied to the semiconductor chip 821 from each of the sensing units SU and an external host, respectively. Also, the semiconductor chip 821 processes the image data \( I_{\text{data}} \), generates gray-scale data (not shown) for actually driving the display device 800, and supplies the gray-scale data to the display panel 820. To this end, the semiconductor chip 821 may include pads related to touch data and pads related to the image data \( I_{\text{data}} \) and the gray-scale data. The semiconductor chip 821 receives the voltage signal \( T_{\text{sig}} \) from each of the sensing units SU via a conductive line connected to one side of the touch panel. When the pads are arranged on the semiconductor chip 821, the pad for receiving the voltage signal \( T_{\text{sig}} \) may be located adjacent to the conductive line for delivering the voltage signal \( T_{\text{sig}} \) in order to reduce noise in data. Although not shown in FIG. 16A, if the conductive line for supplying the gray-scale data to the display panel 820 is disposed to be opposite to a conductive line for supplying a touch data voltage signal \( T_{\text{sig}} \), then the pad for providing the gray-scale data may also be located to be opposite to pads for receiving the voltage signal \( T_{\text{sig}} \).

[0149] The display device 800 of FIG. 16B has a construction similar to that of the display device of FIG. 16A. Referring to FIG. 16B, a voltage signal transmitted from a sensing unit is supplied directly to a semiconductor chip 821 via a conductive line rather than via an FPC.

[0150] The display device 800 of FIG. 16C also has a construction similar to that of the display device of FIG. 16A. However, referring to FIG. 16C, in the display device 800, a signal path in which a voltage signal transmitted from a sensing unit to a semiconductor chip 821 is different from in the display device of FIG. 16A. In the current embodiment, a pad for receiving the voltage signal from the sensing unit is disposed closest to a conductive line from among a plurality of pads arranged on the semiconductor chip 821.

[0151] FIG. 16D illustrates the panel structure of the display device 800 illustrated in FIG. 16A, 16B, or 16C, according to another embodiment of the inventive concept. In a display device according to an embodiment of the inventive concept, a touch panel and a display panel may be effectively united together. Referring to FIG. 16D, an OLED is embodied as the display device 800. In the current embodiment, a sensing unit is fabricated by forming a transparent electrode, e.g., an ITO (sensor), directly on an upper glass plate of the display panel, rather than on an additional glass plate or on a PET film. In this case, a touch display panel may be fabricated while reducing manufacturing costs and module thickness, but the distance between the transparent electrode and a top glass of the display device 800 becomes small, thereby increasing a vertical parasitic capacitance component in the sensing unit. However, according to the above embodiments, it is possible to reduce influences, caused by the whole parasitic capacitance components including a vertical parasitic capacitance component generated in a sensing unit. Accordingly, as described above, the touch panel and the display panel may be united together effectively.

[0152] FIGS. 17A and 17B illustrate the structure of a semiconductor chip that includes a touch controller and a display driving circuit unit, and the structure of an FPCB according to embodiments of the inventive concept. The semiconductor chip includes pads for transmitting and receiving signals related to the touch controller and pads for transmitting and receiving signals related to the display driving circuit unit. The pads may be electrically connected to a touch panel, a display panel, and a host controller via connection terminals of the FPCB. When the semiconductor chip is fabricated, a region in which the touch controller is located may be separated apart from a region in which the display driving circuit unit is located. When the connection terminals are arranged in the FPCB, connection terminals connected to the signals related to the touch controller and connection terminals connected to the signals related to the display driving circuit unit may be disposed to correspond to the pads of the semiconductor chip.

[0153] FIGS. 18A and 18B illustrate embodiments of a display device having a semiconductor chip in which a touch controller and a display driving circuit are included, according to the inventive concept. Specifically, FIG. 18A illustrates that the semiconductor chip is disposed on a glass plate of a display panel in the form of COG, and FIG. 18B illustrates that the semiconductor chip is disposed on a film of a display panel in the form of chip on film (COF). In general, when the touch controller and the display driving circuit are disposed on different chips, the touch controller may be disposed in the form of COF and the display driving circuit may be disposed in the form of COG, but in another embodiment according to the inventive concept, the semiconductor chip that includes the touch controller and the display driving circuit may have a COG or COF structure.

[0154] While the inventive concept has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood that various changes in form and details may be made therein without departing from the spirit and scope of the following claims.

1. A touch data generator configured for use within a touch screen controller (TSC) in a touch display device comprising a touch screen panel, and a display driving circuit (DDI), wherein the touch data generator comprises:

- an amplifier comprising a positive input terminal receiving an alternating reference voltage, a negative input terminal receiving a sensor input, an output terminal providing an output voltage, and a resistance-capacitance (RC) feedback circuit biasing the amplifier,
wherein the sensor input comprises a sensor capacitance including a touch capacitance and a capacitive background noise component, and
the amplifier is configured to remove the capacitive background noise component from the sensor input while amplifying the reference voltage in response to the touch capacitance.

2. The touch data generator of claim 1, wherein the DDI comprises a timing controller configured to provide at least one control/timing signal to the TSC, and the reference voltage is synchronously related to the at least one control/timing signal.

3. The touch data generator of claim 2, wherein the gain of the amplifier is about one plus the ratio of the touch capacitance and a capacitance of the feedback capacitor.

4. The touch data generator of claim 2, further comprising: a sample and hold circuit configured to receive the output voltage, and an analog-to-digital converter configured to receive an output from the sample and hold circuit and generate sensor data related to the touch capacitance of the sensor input.

5. The touch data generator of claim 2, wherein the capacitive background noise component is a horizontal parasitic capacitance arising from operation of the touch screen.

6. The touch data generator of claim 2, wherein the capacitive background noise component is a vertical parasitic capacitance arising from operation of the touch screen in relation to an applied control voltage, and the touch data generator comprises a cancellation capacitor connected between the negative input terminal of the amplifier and a cancellation control voltage.

7. The touch data generator of claim 6, wherein the cancellation control voltage is synchronously related to the reference voltage by a factor controlled within the operation of the TSC to remove the vertical parasitic capacitance.

8. The touch data generator of claim 2, wherein the capacitive background noise component comprises a vertical parasitic capacitance and a horizontal parasitic capacitance arising from operation of the touch screen, and the touch data generator further comprises a cancellation capacitor connected between the negative input terminal of the amplifier and a cancellation control voltage.

9. The touch data generator of claim 8, wherein the cancellation control voltage is synchronously related to the reference voltage by a factor controlled within the operation of the TSC to remove the capacitive background noise component.

10. The touch data generator of claim 2, wherein the capacitive background noise component comprises a vertical parasitic capacitance arising from operation of the touch screen in relation to an applied control voltage, and a horizontal parasitic capacitance arising from operation of the touch screen, and the touch data generator further comprises a cancellation capacitor connected between the negative input terminal of the amplifier and a cancellation control voltage.

11. The touch data generator of claim 10, wherein the cancellation control voltage is synchronously related to the reference voltage.

12. The touch data generator of claim 2, further comprising:

- a signal processor configured to receive the at least one control/timing signal from the timing controller.

13. The touch data generator of claim 4, further comprising:

- a signal processor configured to receive the at least one control/timing signal from the timing controller, generate a sample and hold control signal synchronously related to the at least one control/timing signal, and apply the sample and hold control signal to the sample and hold circuit to control operation of the sample and hold circuit.

14. A touch data generator configured for use within a touch screen controller (TSC) in a touch display device comprising a touch screen panel, and a display driving circuit (DDI), wherein the touch data generator comprises:

- driving and sensing control circuit detecting a sensor input and passing the detected sense input to an amplifier, wherein the sensor input comprises a touch capacitance and a capacitive background noise component;

- the amplifier comprises a positive input terminal receiving an alternating reference voltage, a negative input terminal receiving the sensor input, an output terminal providing an output voltage, and a resistance-capacitance (RC) feedback circuit biasing the amplifier, and

- the DDI comprises a timing controller configured to provide at least one control/timing signal to the TSC, such that the reference voltage is synchronously related to the at least one control/timing signal.

15. The touch data generator of claim 14, wherein the driving and sensing circuit comprises a plurality of sense lines respectively incorporating a sense line switch, wherein each one of the plurality of sense lines and corresponding sense line switches forms a sensor input channel, and each sensor input channel is sequentially switched onto the negative input terminal of the amplifier.

16. The touch data generator of claim 1, wherein the display driving circuit is configured to drive a liquid crystal display panel, a plasma display panel, a light emitting diode display panel, or an organic light emitting display panel.

17. A method operating a touch screen controller (TSC) in a touch display device comprising a touch screen panel and a display driving circuit (DDI), the method comprising:

- coupling a positive input terminal of an amplifier to an alternating reference voltage;

- coupling a negative input terminal of the amplifier to a driving and sensing control circuit to receive a sensor input, wherein the sensor input comprises a touch capacitance and a capacitive background noise component; and

- biasing the amplifier with a resistance-capacitance (RC) feedback circuit to amplify the reference voltage in response to the touch capacitance while removing the capacitive background noise component.

18. The method of claim 17, wherein the reference voltage is synchronously related to at least one control/timing signal provided to the TSC by the DDI.

19. The method of claim 17, wherein the reference voltage is amplified with a gain approximately equal to one plus the ratio of the touch capacitance and a capacitance of a feedback capacitor in the RC feedback circuit.

20. The method of claim 17, wherein the capacitive background noise component is at least one of a horizontal para-
sic capacitance arising from operation of the touch screen, and a vertical parasitic capacitance arising from operation of the touch screen in relation to an applied control voltage.

21. The method of claim 17, further comprising:
   coupling a cancellation capacitor between the negative input terminal of the amplifier and a cancellation control voltage.

22. The method of claim 21, wherein the cancellation control voltage is synchronously related to the reference voltage.

23. The method of claim 22, wherein the capacitive background noise component comprises a horizontal parasitic capacitance arising from operation of the touch screen and a vertical parasitic capacitance arising from operation of the touch screen in relation to an applied control voltage.

24. A touch display device, comprising:
   a display;
   a display driving circuit (DDI) configured to control operation of the display;
   a touch screen;
   a touch screen controller (TSC) configured to control operation of the touch screen, wherein the TSC comprises a touch data generator configured to generate sense data corresponding to sensor input related to user-defined touch data received via the touch screen, the touch data generator comprising:
   an amplifier comprising a positive input terminal receiving an alternating reference voltage, a negative input terminal receiving the sensor input, an output terminal providing an output voltage, and a resistance-capacitance (RC) feedback circuit biasing the amplifier, wherein the sensor input comprises sensor capacitance including a touch capacitance and a capacitive background noise component, and
   the amplifier is configured to remove the capacitive background noise component from the sensor input while amplifying the reference voltage in response to the touch capacitance.

25. The touch display device of claim 24, wherein the DDI comprises a timing controller configured to provide at least one control/timing signal to the TSC, and the reference voltage is synchronously related to the at least one control/timing signal.

26. The touch display device of claim 25, wherein the gain of the amplifier is about one plus the ratio of the touch capacitance and a capacitance of a feedback capacitor in the RC feedback circuit.

27. The touch display device of claim 25, wherein the touch data generator further comprises a sample and hold circuit configured to receive the output voltage, and an analog-to-digital converter configured to receive an output from the sample and hold circuit and generate sensor data corresponding to the touch capacitance.

28. The touch display device of claim 25, wherein the capacitive background noise component is a horizontal parasitic capacitance arising from operation of the touch screen.

29. The touch display device of claim 25, wherein the capacitive background noise component is a vertical parasitic capacitance arising from operation of the touch screen in relation to an applied control voltage, and the touch data generator further comprises a cancellation capacitor connected between the negative input terminal of the amplifier and a cancellation control voltage.

30. The touch display device of claim 29, wherein the cancellation control voltage is synchronously related to the reference voltage by a factor controlled within the operation of the TSC to remove the vertical parasitic capacitance.

31. The touch display device of claim 25, wherein the display is a liquid crystal display panel, a plasma display panel, a light emitting diode display panel, or an organic light emitting display panel.

32-65. (canceled)

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