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PEN AND TOUCH INPUT SYSTEM

Abstract

A pen and touch input system according to an embodiment of the present invention includes a touch input device including a sensor unit and a control unit that controls the sensor unit, and a stylus pen capable of operating with the touch input device.

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to a pen and touch input system.

BACKGROUND ART

[0002] The present disclosure relates to a pen and touch input system and a controller, and more particularly, to a pen and touch input system and a controller for controlling a sensor unit in a touch input device including a control unit and interacting with a stylus pen.

[0003] A touch sensor is provided in various touch input devices such as mobile phones, smart phones, laptop computers, digital broadcasting terminals, personal digital assistants (PDA), portable multimedia players (PMP), navigation units, slate PCs, tablet PCs, ultrabooks, and wearable devices.

[0004] The touch sensor in the touch input device may be disposed on a display panel that displays an image or a portion of the touch input device. As a user touches a touch sensor to interact with the touch input device, the touch input device may provide an intuitive user interface to the user.

[0005] The user may use a stylus pen for a precise touch input. The stylus pen may be classified into an active stylus pen and a passive stylus pen depending on whether a battery and an electronic component are provided therein.

[0006] Although the active stylus pen has an excellent basic performance and provides additional functions (pen pressure, hovering, and buttons) in comparison with the passive stylus pen, the active stylus pen is expensive and uses a rechargeable battery as power. Thus, not many users substantially use the active stylus pen except for some advanced users.

[0007] Although the passive stylus pen is inexpensive and does not require a battery in comparison with the active stylus pen, the passive stylus pen is difficult to recognize a precise touch in comparison with the active stylus pen. In recent years, however, technologies of an electro magnetic resonance (EMR) method that is an inductive resonance method and a capacitive resonance method are proposed to realize a passive stylus pen capable of recognizing a precise touch.

[0008] Although the EMR method is excellent in writing and drawing quality that is a key function of the stylus pen, the EMR method has a great thickness and requires more costs because a separate EMR sensor panel and a separate EMR driving IC are necessarily added in addition to a capacitance touch panel.

[0009] The capacitive resonance method uses a general capacitance touch sensor and a general touch controller IC to increase a performance of the IC and support a pen touch without additional costs.

[0010] In the EMR method or the capacitive resonance method, a resonance signal is required to have a great amplitude to more accurately distinguish a touch caused by the stylus pen. Thus, a driving signal transmitted to the stylus pen needs to have the almost same resonance frequency as that of the resonance circuit contained in the stylus pen. However, according to a typical EMR method or a typical capacitive resonance method, although the resonance frequency is the same as a frequency of the driving signal, signal transmission is difficult because of extremely great attenuation of the signal transmission. As a result, despite attempts of many touch controller IC vendors for a long time, no companies have succeeded in mass production yet because a sufficient

output signal is not produced.

[0011] Thus, a feature of how to design structures of the internal resonance circuit and the pen is a key factor to manufacture an EMR or capacitive resonance stylus pen capable of producing a maximum output signal.

[0012] In case of an electro-magnetic resonance (EMR) pen among the passive stylus pens, a digitizer transmits an electromagnetic signal to the pen and then receives a resonance signal from the pen. In this digitizer, coils to which a current is induced by a magnetic signal are densely arranged to receive touch information by the pen. The digitizer may not correspond to miniaturization and thinness of the touch input device and may not be flexibly designed.

[0013] On the other hand, a typical stylus pen is required to use an expensive pressure sensor to detect pen pressure and is difficult to precisely measure the pen pressure.

DISCLOSURE

Technical Problem

[0014] The present disclosure provides a pen and touch input system including a stylus pen producing a sufficient output signal.

[0015] The present disclosure also provides a pen and touch input system including a multifunctional touch input device capable of detecting a position of a touch, driving a stylus pen, and detecting a position of the stylus pen.

[0016] The present disclosure also provides a pen and touch input system including a touch input device capable of solving a limitation in which an output voltage of a sensing circuit unit is varied according to a position of the stylus pen.

[0017] The present disclosure also provides a pen and touch input system including a touch input device capable of widening a bandwidth of an operating frequency of a touch driving signal and a pen driving signal when a screen of the touch input device is expanded to a size of a screen of a table PC.

[0018] The present disclosure also provides a pen and touch input system including a touch input device capable of relieving attenuation of a pen sensing signal when a screen of the touch input device is expanded to a size of a screen of a table PC.

[0019] The present disclosure also provides a pen and touch input system that is implemented on one layer.

[0020] The present disclosure also provides a pen and touch input system capable of improving a performance of sensing a touch caused by the stylus pen.

[0021] The present invention also provides a pen and touch input system including a stylus pen capable of detecting pen pressure with a simple structure.

[0022] The present invention also provides a pen and touch input system including a stylus pen capable of distinguishing whether a stylus pen contacts a touch device.

[0023] The problem to be solved in the present invention is not limited to the above-described problems.

Technical Solution

[0024] An embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; a plurality of second patterns each extending in the first direction and disposed adjacent to the first patterns; a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit; and a plurality of fourth patterns each extending in the second direction and disposed adjacent to the third patterns, wherein second ends of at least a portion of the plurality of second patterns are electrically connected to each other, and second ends of at least a portion of the plurality of fourth patterns are electrically connected to each other, wherein the control unit applies

a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first to fourth patterns, and the control unit receives stylus pen sensing signals from at least one pen sensing pattern of the plurality of first to fourth patterns, wherein the stylus pen comprises: a body unit having at least a portion extending in one direction; an inductor unit comprising a ferrite core disposed in the body unit and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit; and a core having at least a portion disposed in the body unit to move in the one direction by pressure applied to one end thereof, wherein the capacitor unit comprises a first electrode that operates together with the core and a second electrode fixedly installed on the first electrode in the one direction, and a capacitance of the capacitor unit is varied by the pressure applied to the one end of the core.

[0025] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; a plurality of second patterns each extending in the first direction and disposed adjacent to the first patterns; a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit; and a plurality of fourth patterns each extending in the second direction and disposed adjacent to the third patterns, wherein second ends of at least a portion of the plurality of second patterns are electrically connected to each other, and second ends of at least a portion of the plurality of fourth patterns are electrically connected to each other, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first to fourth patterns, and the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first to fourth patterns, wherein the stylus pen comprises: a body unit; an inductor unit comprising a ferrite core fixedly installed in the body unit and having a through-hole passing through in one direction and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit; and a core in which at least a portion between one end and the other end is disposed in the through-hole of the ferrite core and which moves in the one direction by pressure applied to the one end, wherein the capacitor unit comprises: a first electrode connected to the other end of core to operate together with the core; and a second electrode fixedly installed on the first electrode, and an overlap area between the first electrode and the second electrode is changed when the first electrode moves in the one direction by the pressure applied to the one end of the core.

[0026] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; a plurality of second patterns each extending in the first direction and disposed adjacent to the first patterns; a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit; and a plurality of fourth patterns each extending in the second direction and disposed adjacent to the third patterns, wherein second ends of at least a portion of the plurality of second patterns are electrically connected to each other, and second ends of at least a portion of the plurality of fourth patterns are electrically connected to each other, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen

driving pattern of the plurality of first to fourth patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first to fourth patterns, and wherein the stylus pen comprises: a body unit having at least a portion extending in one direction; an inductor unit comprising a ferrite core disposed in the body unit and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit; and a core having at least a portion disposed in the body unit to move in the one direction by pressure applied to one end thereof, wherein the ferrite core of the inductor unit operates together with the core, the inductor unit comprises a magnetic material fixedly installed in the body unit, and an inductance of the inductor unit is varied by pressure applied to the one end of the core.

[0027] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; a plurality of second patterns each extending in the first direction and disposed adjacent to the first patterns; a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit; and a plurality of fourth patterns each extending in the second direction and disposed adjacent to the third patterns, wherein second ends of at least a portion of the plurality of second patterns are electrically connected to each other, and second ends of at least a portion of the plurality of fourth patterns are electrically connected to each other, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first to fourth patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first to fourth patterns, and wherein the stylus pen comprises: a body unit; an inductor unit comprising a ferrite core disposed in the body unit and having a through-hole passing through in one direction and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit; and a core in which at least a portion between one end and the other end is disposed in the through-hole of the ferrite core and which moves in the one direction by pressure applied to the one end, wherein the ferrite core of the inductor unit is coupled with the core to operate together with the core, the inductor unit comprises fixedly installed in the body unit, and a spaced distance between the ferrite core and the magnetic material is changed when the ferrite core moves in the one direction by the pressure applied to the one end of the core.

[0028] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; a plurality of second patterns each extending in the first direction and disposed adjacent to the first patterns; a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit; and a plurality of fourth patterns each extending in the second direction and disposed adjacent to the third patterns, wherein second ends of at least a portion of the plurality of second patterns are electrically connected to each other, and second ends of at least a portion of the plurality of fourth patterns are electrically connected to each other, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first to fourth patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first to fourth patterns, and

wherein the stylus pen comprises: a body unit having at least a portion extending in one direction; an inductor unit comprising a ferrite core disposed in the body unit and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a first capacitor electrically connected to the coil of the inductor unit and a second capacitor electrically connected to the first capacitor; a core having at least a portion disposed in the body unit to move in the one direction by pressure applied to one end thereof; and a switching member disposed in the body unit to switch electrical connection between the first capacitor and the second capacitor according to a movement of the core in the one direction, wherein a capacitance of the capacitor unit is varied by the pressure applied to the one end of the core.

[0029] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; a plurality of second patterns each extending in the first direction and disposed adjacent to the first patterns; a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit; and a plurality of fourth patterns each extending in the second direction and disposed adjacent to the third patterns, wherein second ends of at least a portion of the plurality of second patterns are electrically connected to each other, and second ends of at least a portion of the plurality of fourth patterns are electrically connected to each other, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first to fourth patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first to fourth patterns, and wherein the stylus pen comprises: a body unit having at least a portion extending in one direction; an inductor unit comprising a ferrite core fixedly disposed in the body unit and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and electrically connected to the inductor unit; a core having at least a portion disposed in the body unit to move in the one direction by pressure applied to one end thereof; and a magnetic material disposed in the body unit and operating with the core to move in the one direction, wherein an inductance of the inductor unit is varied by the pressure applied to the one end of the core.

[0030] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; a plurality of second patterns each extending in the first direction and disposed adjacent to the first patterns; a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit; and a plurality of fourth patterns each extending in the second direction and disposed adjacent to the third patterns, wherein second ends of at least a portion of the plurality of second patterns are electrically connected to each other, and second ends of at least a portion of the plurality of fourth patterns are electrically connected to each other, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first to fourth patterns, and the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first to fourth patterns, wherein the stylus pen comprises: a body unit; an inductor unit comprising a ferrite core fixedly installed in the body unit and having a through-hole passing through in one direction and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in

the body unit and comprising a capacitor electrically connected to the coil of the inductor unit and an additional capacitor electrically connected to the capacitor; a core in which at least a portion between one end and the other end is disposed in the through-hole of the ferrite core and which moves in the one direction by pressure applied to the one end; and a switching member configured to switch electrical connection between the capacitor and the additional capacitor according to the pressure applied to the core, wherein the inductor unit comprises a magnetic material having a varied spaced distance from the ferrite core according to the pressure applied to the core.

[0031] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; and a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first and third patterns, and the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first and third patterns, wherein the stylus pen comprises: a body unit having at least a portion extending in one direction; an inductor unit comprising a ferrite core disposed in the body unit and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit; and a core having at least a portion disposed in the body unit to move in the one direction by pressure applied to one end thereof, wherein the capacitor unit comprises a first electrode that operates together with the core and a second electrode fixedly installed on the first electrode in the one direction, and a capacitance of the capacitor unit is varied by the pressure applied to the one end of the core.

[0032] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; and a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first and third patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first and third patterns, and wherein the stylus pen comprises: a body unit; an inductor unit comprising a ferrite core fixedly installed in the body unit and having a through-hole passing through in one direction and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit; and a core in which at least a portion between one end and the other end is disposed in the through-hole of the ferrite core and which moves in the one direction by pressure applied to the one end, wherein the capacitor unit comprises: a first electrode connected to the other end of core to operate together with the core; and a second electrode fixedly installed on the first electrode, and an overlap area between the first electrode and the second electrode is varied when the first electrode moves in the one direction by the pressure applied to the one end of the core.

[0033] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the

sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; and a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first and third patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first and third patterns, and wherein the stylus pen comprises: a body unit having at least a portion extending in one direction; an inductor unit comprising a ferrite core disposed in the body unit and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit; and a core having at least a portion disposed in the body unit to move in the one direction by pressure applied to one end thereof, wherein the ferrite core of the inductor unit operates together with the core, the inductor unit comprises a magnetic material fixedly installed in the body unit, and an inductance of the inductor unit is varied by the pressure applied to the one end of the core.

[0034] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; and a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first and third patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first and third patterns, and wherein the stylus pen comprises: a body unit; an inductor unit comprising a ferrite core disposed in the body unit and having a through-hole passing through in one direction and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit; and a core in which at least a portion between one end and the other end is disposed in the through-hole of the ferrite core and which moves in the one direction by pressure applied to the one end, wherein the ferrite core of the inductor unit is coupled with the core to operate together with the core, the inductor unit comprises a magnetic material fixedly installed in the body unit, and a spaced distance between the ferrite core and the magnetic material is changed when the ferrite core moves in the one direction by the pressure applied to the one end of the core.

[0035] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; and a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first and third patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first and third patterns, and wherein the stylus pen comprises: a body unit having at least a portion extending in one direction; an inductor unit comprising a ferrite core disposed in the body unit and a coil wound in multiple layers around at least a portion of the ferrite core; a

capacitor unit disposed in the body unit and comprising a first capacitor electrically connected to the coil of the inductor unit and a second capacitor electrically connected to the first capacitor; a core having at least a portion disposed in the body unit to move in the one direction by pressure applied to one end thereof; and a switching member disposed in the body unit to switch electrical connection between the first capacitor and the second capacitor according to a movement of the core in the one direction, wherein a capacitance of the capacitor unit is varied by the pressure applied to the one end of the core.

[0036] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; and a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first and third patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first and third patterns, and wherein the stylus pen comprises: a body unit having at least a portion extending in one direction; an inductor unit comprising a ferrite core fixedly disposed in the body unit and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and electrically connected to the inductor unit; a core having at least a portion disposed in the body unit to move in the one direction by pressure applied to one end thereof; and a magnetic material disposed in the body unit and operating with the core to move in the one direction, wherein an inductance of the inductor unit is varied by the pressure applied to the one end of the core.

[0037] Another embodiment of the present invention provides a pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; and a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, the control unit applies a stylus pen driving signal to at least one pen driving pattern of the plurality of first and third patterns, the control unit receives a stylus pen sensing signal from at least one pen sensing pattern of the plurality of first and third patterns, and wherein the stylus pen comprises: a body unit; an inductor unit comprising a ferrite core fixedly installed in the body unit and having a through-hole passing through in one direction and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit and an additional capacitor electrically connected to the capacitor; a core in which at least a portion between one end and the other end is disposed in the through-hole of the ferrite core and which moves in the one direction by pressure applied to the one end; and a switching member configured to switch electrical connection between the capacitor and the additional capacitor according to the pressure applied to the core, wherein the inductor unit comprises a magnetic material having a varied spaced distance from the ferrite core according to the pressure applied to the core.

Advantageous Effects

[0038] According to at least one of the embodiments of the present disclosure, there is an advantage in that a sufficient output signal can be generated even with a small diameter by providing an optimal structure of a resonance circuit of a stylus pen.

[0039] According to at least one of the embodiments of the present disclosure, there is an advantage of providing a stylus pen that is robust against external factors.

[0040] Using the touch input device according to the embodiment of the present invention has the advantage of detecting the touch position, driving the stylus pen, and detecting the position of the stylus pen.

[0041] Also, there is an advantage in solving the problem that the output voltage of the sensing circuit unit varies depending on the position of the stylus pen.

[0042] Also, when the screen of the touch input device is enlarged to the size of the tablet PC screen, there is an advantage in that the operating frequency bandwidth of the touch driving signal and the pen driving signal can be expanded.

[0043] Also, when the screen of the touch input device is enlarged to the size of the tablet PC screen, there is an advantage in that attenuation of the pen detection signal can be alleviated.

[0044] Also, there is an advantage of lowering the manufacturing cost of the touch input device.

[0045] Also, it has the advantage of being able to provide a thinner and smaller form factor.

[0046] Also, there is an advantage of improving the signal-noise-ratio (SNR) of the signal output from the stylus pen.

[0047] Also, there is an advantage of improving the reception sensitivity of touch input.

[0048] Also, there is an advantage of being able to calculate a more accurate touch position.

[0049] Also, it has the advantage of being able to perform palm rejection.

[0050] Also, there is an advantage of reducing the manufacturing costs of the stylus pen capable of detecting the pen pressure.

[0051] Also, there is an advantage of precisely measuring the pen pressure by the stylus pen.

[0052] The effect of the present invention is not limited to the above-mentioned effect, and better effects or unique effects can be exhibited for each embodiment in the [mode for invention] described later.

Description

DESCRIPTION OF DRAWINGS

[0053] FIG. 1A is a conceptual view illustrating a pen and touch input system including a stylus pen and a touch input device.

[0054] FIG. 1B is a view for explaining uplink and downlink in the pen and touch input system in FIG. 1A.

[0055] FIG. 1C is a view for explaining a gap between a +driving channel and a -driving channel in the uplink.

[0056] FIG. 1D is a conceptual view illustrating another embodiment of the pen and touch input system including a stylus pen and a touch input device.

[0057] FIG. 2A is a schematic view illustrating a signal transmission operation between the stylus pen and the touch input device.

[0058] FIG. 2B is a schematic view illustrating a portion of a laminated structure of the touch input device in FIG. 1A.

[0059] FIGS. 2C and 2D are schematic views illustrating a portion of the laminated structure of the touch input device in FIG. 1D.

[0060] FIG. 3 is a schematic block diagram representing the touch input device.

[0061] FIG. 4 is a view illustrating the stylus pen according to embodiments.

[0062] FIG. 5 is a view illustrating an inductor unit of the stylus pen in detail.

[0063] FIG. 6 is a graph representing an inductance and a Q value according to frequency variation.

[0064] FIGS. 7 and 8 are views illustrating an enamel wire and litz wire, respectively.

[0065] FIG. 9 is a view illustrating a winding scheme of a plurality of layers.

[0066] FIGS. **10** to **12** are graphs representing results of comparative experiments.

[0067] FIG. **13** is a schematic view for explaining that an output voltage V_{out} of a capacitor voltage amplitude (CVA) varies according to a position of a stylus pen **10** on a typical flexible display panel.

[0068] FIG. **14** is a view for explaining through current sensing that output voltages V_{out1} and V_{out2} of the CVA are varied according to the position of the stylus pen **10** in FIG. **13**.

[0069] FIG. **15** is a view for explaining through voltage sensing that the output voltages V_{out1} and V_{out2} of the CVA are varied according to the position of the stylus pen **10** in FIG. **13**.

[0070] FIG. **16** is a schematic configuration view illustrating a sensor unit **100** according to a first embodiment of the present invention.

[0071] FIG. **17** is a schematic configuration view illustrating an example of the sensor unit **100** in FIG. **16**.

[0072] FIG. **18** is a schematic configuration view illustrating another example of the sensor unit **100** in FIG. **16**.

[0073] FIG. **19** is a schematic configuration view illustrating a sensor unit **100'** according to a second embodiment of the present invention.

[0074] FIG. **20** is a schematic configuration view illustrating an example of the sensor unit **100'** in FIG. **19**.

[0075] FIG. **21** is a schematic configuration view illustrating another example of the sensor unit **100'** in FIG. **19**.

[0076] FIG. **22** is a schematic configuration view illustrating another example of the sensor unit **100'** in FIG. **19**.

[0077] FIG. **23** is a schematic configuration view illustrating another example of the sensor unit **100'** in FIG. **19**.

[0078] FIG. **24** is a view illustrating the touch input device in FIG. **20** in detail.

[0079] FIG. **25** is a view for explaining a method by which a control unit **300** of FIG. **24** applies a pen driving signal for driving the stylus pen to a plurality of second patterns **102A**.

[0080] FIGS. **26A** to **26F** are schematic views for explaining an operation principle of a stylus sensing mode in the touch input device of FIG. **24**.

[0081] FIG. **27** is a view illustrating the touch input device in FIG. **21** in detail.

[0082] FIG. **28** is a view illustrating the touch input device in FIG. **22** in detail.

[0083] FIG. **29** is a view illustrating the touch input device in FIG. **23** in detail.

[0084] FIG. **30** is a schematic view illustrating a sensor unit according to a modified example, which may replace the sensor unit according to the above-described various embodiments.

[0085] FIG. **31** is a view illustrating a modified example of the sensor unit in FIG. **30**.

[0086] FIG. **32** is a modified example of the sensor unit according to the above-described various embodiments.

[0087] FIG. **33** is a modified example of the sensor unit according to the above-described various embodiments.

[0088] FIG. **34** is a modified example of the sensor unit according to the above-described various embodiments.

[0089] FIG. **35** is a modified example of the sensor unit according to the above-described various embodiments.

[0090] FIG. **36** is a modified example of the sensor unit according to the above-described various embodiments.

[0091] FIG. **37** is a modified example of the sensor unit according to the above-described various embodiments.

[0092] FIG. **38** is a modified example of the sensor unit according to the above-described various embodiments.

[0093] FIG. **39** is a modified example of the sensor unit according to the above-described various

embodiments.

[0094] FIG. **40** is a view for explaining a first modified example of a fifth pattern **105** in FIG. **33**.

[0095] FIG. **41** is a view illustrating a modified example of FIG. **40**.

[0096] FIG. **42** is a view for explaining a modified example of a fifth pattern **105'** in

[0097] FIG. **40**.

[0098] FIG. **43** is a view illustrating a modified example of FIG. **42**.

[0099] FIGS. **44** and **45** are views for explaining modified examples of a third pattern **103** and a fourth pattern **104** in the sensor unit in FIG. **34** or **35**.

[0100] FIG. **46** is a schematic view illustrating a portion of a touch input device according to another embodiment.

[0101] FIG. **47** is a view illustrating an example of an arrangement form of a trace and an electrode (or pattern) of a touch unit according to an embodiment.

[0102] FIG. **48** is a view illustrating another example of an arrangement form of a trace and an electrode (or pattern) of a touch unit according to an embodiment.

[0103] FIG. **49** is a view illustrating a case in which the stylus pen is disposed on the sensor unit of the touch unit according to an embodiment.

[0104] FIG. **50** is a graph representing a method for measuring a signal of the touch unit according to an embodiment in FIGS. **48** and **49**.

[0105] FIGS. **51** and **52** are graphs representing a sensing signal caused by the stylus pen according to an embodiment.

[0106] FIGS. **53** and **54** are graphs representing a sensing signal caused by the stylus pen according to another embodiment.

[0107] FIG. **55** is a view illustrating a case in which the stylus pen is disposed on the sensor unit of the touch unit according to an embodiment.

[0108] FIGS. **56** and **57** are graphs representing a sensing signal caused by the stylus pen according to an embodiment.

[0109] FIGS. **58** and **59** are graphs representing a sensing signal caused by the stylus pen according to an embodiment.

[0110] FIG. **60** is a schematic block diagram representing the touch input device.

[0111] FIG. **61** is a schematic view illustrating a portion of the touch unit according to an embodiment.

[0112] FIG. **62** is a view illustrating an example of an arrangement form of a trace and an electrode (or pattern) of a touch unit according to another embodiment.

[0113] FIG. **63** is a schematic view for explaining a method for driving the stylus pen in a touch input device **2** or a stylus driving device according to the present invention.

[0114] FIGS. **64A** and **64B** are a view for explaining a method for activating the stylus pen in the touch input device **2** or the stylus driving device in detail according to the present invention.

[0115] FIGS. **65A** and **65B** is a schematic view for explaining a method for detecting a signal emitted from the stylus pen in the touch input device **2** according to the present invention.

[0116] FIGS. **66A** to **68B** are views for explaining a method for detecting a signal emitted from the stylus pen in the touch input device **2** in detail according to the present invention.

[0117] FIGS. **69A** and **69B** are a view illustrating various wiring structures of a second electrode in the touch input device according to the present invention.

[0118] FIGS. **70A** to **71C** are view illustrating experiment processes for verifying a signal detection capability of the stylus pen by using the touch input device and results thereof according to an embodiment of the present invention.

[0119] FIG. **72** is a block diagram representing a touch unit and a host.

[0120] FIG. **73** is a view representing an example of touch data provided from the touch unit to the host.

[0121] FIG. **74** is a view illustrating an embodiment of a resonant circuit unit **12** of the stylus pen

illustrated in FIG. 4.

[0122] FIGS. 75A and 75B are a view illustrating a portion of a structure of a resonant circuit unit of a stylus pen according to a first aspect.

[0123] FIGS. 76A and 76B are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a second aspect.

[0124] FIGS. 77A and 77B are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a third aspect.

[0125] FIGS. 78A to 78C are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a fourth aspect.

[0126] FIG. 79 is a graph showing a variation of a capacitance value of the stylus pen according to the fourth aspect.

[0127] FIGS. 80A to 80C are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a fifth aspect.

[0128] FIGS. 81A and 81B are resonant structure of a dielectric material of FIGS. 80A to 80C.

[0129] FIG. 82 is a graph showing a variation of a capacitance value of the stylus pen according to the fifth aspect.

[0130] FIGS. 83A and 83B are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a sixth aspect.

[0131] FIG. 84 is a graph showing a variation of a capacitance value of the stylus pen according to the sixth aspect.

[0132] FIG. 85 is a view illustrating another embodiment of the resonant circuit unit 12 of the stylus pen illustrated in FIG. 4.

[0133] FIGS. 86A and 86B are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a first aspect.

[0134] FIG. 87 is a graph showing a variation of a capacitance value of the stylus pen according to the first aspect.

[0135] FIGS. 88A and 88B is a view illustrating a structure of a magnetic material of FIGS. 86A and 86B.

[0136] FIGS. 89A and 89B are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a second aspect.

[0137] FIGS. 90A and 90B are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a third aspect.

[0138] FIG. 91 is a graph showing a variation of a capacitance value of the stylus pen according to the third aspect.

[0139] FIGS. 92A and 92B are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a fourth aspect.

[0140] FIG. 93 is a view illustrating another aspect of the resonant circuit unit 12 of the stylus pen illustrated in FIG. 4.

[0141] FIGS. 94A to 94C are a view for explaining an operation according to pen pressure of the stylus pen of FIG. 93.

[0142] FIG. 95 is a schematic view illustrating an equivalent circuit of the resonant circuit unit of the stylus pen of FIG. 93.

[0143] FIG. 96 is a view illustrating another embodiment of the resonant circuit unit 12 of the stylus pen illustrated in FIG. 4.

[0144] FIGS. 97A and 97B are a view for explaining an operation according to the pen pressure of the stylus pen of FIG. 96.

[0145] FIG. 98 is a schematic view illustrating an equivalent circuit of the resonant circuit unit of the stylus pen of FIG. 96.

[0146] FIG. 99 is a view illustrating another embodiment of the resonant circuit unit 12 of the stylus pen illustrated in FIG. 4.

[0147] FIGS. **100A** to **100C** are a view for explaining an operation according to the pen pressure of the stylus pen of FIG. **99**.

[0148] FIG. **101** is a schematic view illustrating an equivalent circuit of the resonant circuit unit of the stylus pen of FIG. **99**.

[0149] FIG. **102** is a graph showing a variation of a LC value according to the pen pressure of the stylus pen of FIG. **99** as an example.

[0150] FIG. **103** is a graph showing a frequency response characteristic of the stylus pen of FIG. **99** as an example.

[0151] FIGS. **104A** and **104B** are a schematic view illustrating a stylus pen **10f** according to a fourth embodiment.

[0152] FIGS. **105A** and **105B** are a schematic view illustrating a stylus pen **10g** according to a fifth embodiment.

[0153] FIGS. **106A** and **106B** are a schematic view illustrating a stylus pen **10h** according to a sixth embodiment.

[0154] FIGS. **107A** and **107B** are a schematic view illustrating a stylus pen **10i** according to a seventh embodiment.

[0155] FIGS. **108A** and **108B** are a schematic view illustrating a stylus pen **10j** according to an eighth embodiment.

[0156] FIGS. **109A** and **109B** are a schematic view illustrating a stylus pen **10k** according to a ninth embodiment.

MODE FOR INVENTION

[0157] Hereinafter, the present invention will be described with reference to the accompanying drawings showing various embodiments of the invention. The present invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, the present invention covers various modifications, equivalents, and/or alternatives of the embodiments of the invention. When the drawings are described, like reference numerals refer to like elements throughout.

[0158] Also, it will be understood that the embodiments disclosed in this specification includes some variations without limitations to the shapes as illustrated in the figures. In the drawings, the thicknesses of layers and regions are exaggerated for clarity of illustration. Also, in the drawings, the thickness of some layers and regions are exaggerated for convenience of description.

[0159] In the specification, it will be understood that when a layer (or film), a region, or a plate is referred to as being ‘on’ another layer, region, or plate, it can be directly on the other layer, region, or plate, or intervening layers, regions, or plates may also be present. On the other hand, it will also be understood that when a layer, a film, an area or a plate is referred to as being “directly on” another one, intervening layers, films, areas, and plates may not be present. Further, in the specification, the term “on” or “above” represents a feature of being positioned on or below the object, and does not represent a feature of being positioned “on” or “above” the object based on a gravitational direction.

[0160] In this specification, expressions such as “have”, “may have”, “includes”, or “may include” refer to the presence of a corresponding characteristic (e.g., a numerical value, function, operation, or component such as a part), and does not exclude the presence of additional features.

[0161] In this specification, expressions such as “A or B”, “at least one of A or/and B”, or “one or more of A and/or B” may include all possible combinations of the items listed together. For example, the expressions “A or B”, “at least one of A and B”, or “at least one of A or B” may refer to all of (1) including at least one A, (2) including at least one B, or (3) a case of including both at least one A and at least one B.

[0162] In this specification, expressions such as “first” or “second” used herein may modify various components regardless of order and/or importance and be used only to distinguish one component from another component instead of limiting the corresponding component. For

example, a first user device and a second user device may represent different user devices regardless of order or importance. For example, a first component referred to as a first component in one embodiment can be referred to as a second component in another embodiment without departing from the scope of the appended claims, and similarly, the second component may also be renamed as the first component.

[0163] When a component (e.g., a first component) is (operatively or communicatively) “coupled or connected with/to” another component (e.g., a second component), it should be understood that one component may be connected to another component in a direct way or through another component (e.g., a third component). When a component (e.g., a first component) is directly “coupled or connected with/to” another component (e.g., a second component), it may be understood that no other component (e.g., a third component) exists between one component and another component.

[0164] In this specification, the expression “configured to (or set to)” may be used interchangeably with, e.g., “suitable for”, “having the capacity to”, “designed to”, “adapted to”, “made to”, or “capable of” depends on situations. The term “configured to (or set to)” may not necessarily refer to only “specifically designed to” in terms of hardware. Instead, in some circumstances, the expression “a device configured to~” may indicate that the device is “capable of~” with other devices or components. For example, the phrase “a processor configured to (or set to) perform A, B, and C” may indicate a generic-purpose processor (e.g., a CPU or an application processor) capable of performing corresponding operations by executing one or more software programs stored in a dedicated processor (e.g., an embedded processor) or memory device for performing the corresponding operation.

[0165] Terms used herein may be used only to describe specific embodiments, and may not be intended to limit the scope of other embodiments. The terms of a singular form may include plural forms unless referred to the contrary. Terms used herein, including technical or scientific terms, may have the same meanings as commonly understood by a person skilled in the art described in this document. Among the terms used in this specification, terms defined in a general dictionary may be interpreted as having the same or similar meaning as the meaning in the context of the related art, and unless explicitly defined in this specification, it should not be construed in an ideal or overly formal sense. In some cases, even terms defined in this document may not be construed to exclude embodiments of this document.

[0166] A touch input device according to various embodiments of the present document may include at least one of, e.g., a smartphone, a tablet personal computer (PC), a mobile phone, a video phone, an e-book reader, a laptop personal computer (PC), a netbook computer, a mobile medical device, a camera, or a wearable device. According to various embodiments, the wearable device may include at least one of an accessory (e.g., a watch, a ring, a bracelet, an anklet, a necklace, glasses, contact lenses, or a head-mounted-device (HMD)), a fabric or integrated garment (e.g., electronic clothing), a body attachable (e.g., a skin pad or tattoo), and a bio-implantable (e.g., an implantable circuit).

[0167] Hereinafter a controller for controlling a sensor unit in a touch input device including the sensor unit and interacting with a stylus pen according to an embodiment of the present invention will be described with reference to the accompanying drawings.

[0168] According to an embodiment of the present invention, a pen and touch input system including: a touch input device including a sensor unit and a control unit for controlling the sensor unit; and a stylus pen interacting with the touch input device will be described with reference to the accompanying drawings.

[0169] FIG. 1A is a conceptual view illustrating a pen and touch input system including a stylus pen and a touch input device.

[0170] Referring to FIG. 1A, a stylus pen **10** may receive (or uplink) a signal outputted from a touch input device **2** or a touch screen **20** around a touch screen **20** of the touch input device **2** and

transmit (or downlink) a signal to the touch screen **20**. Here, since the touch input device **2** includes a sensor unit and a control unit for controlling the sensor unit and interacts with the stylus pen **10**, the touch input device **2** may be referred to as a 'pen and touch input device'.

[0171] FIG. **1B** is a view for explaining uplink and downlink in the pen and touch input system in FIG. **1A**.

[0172] Referring to a left drawing of FIG. **1B**, in the uplink, an electromotive force (V_2 , or V_{emf}) is formed in a coil inside the stylus pen **10** of FIG. **1A**. Referring to a right drawing of FIG. **1B**, in the downlink, an electromotive force V_1 or V_{emf} is formed in the sensor unit of the touch input device **20**. That is, the coil inside the stylus pen and the sensor unit of the touch input device operate as a transformer.

[0173] FIG. **1C** is a view for explaining a gap between a +driving channel and a -driving channel in the uplink.

[0174] Referring to FIG. **1C**, the gap between the +driving channel and the -driving channel in the uplink has an optimum gap according to a shape and a position of an inductor in the stylus pen. Referring to a general stylus pen design standard, the gap between the +driving channel and the -driving channel may be at least one channel gap (4 mm) or more.

[0175] FIG. **1D** is a conceptual view illustrating another embodiment of the pen and touch input system including a stylus pen and a touch input device.

[0176] Referring to FIG. **1D**, a touch input device **2** is foldable. A stylus pen **10** may receive a signal outputted from the touch input device **2** or a touch screen **20** around the touch screen **20** of the touch input device **2** and transmit a signal to the touch screen **20**.

[0177] In a member such as the rectangular foldable touch input device **2** or the touch screen **20** contained therein, a long side disposed at a left side on a plane is referred to as a first long side **LS1**, a long side disposed at a right side is referred to as a second long side **LS2**, a short side disposed at an upper side is referred to as a first short side **SS1**, and a short side disposed at a lower side is referred to as a second short side **SS2**.

[0178] The foldable touch input device **2** may be bent along a predetermined folding direction based on a folding axis **AXIS_F** crossing the first and second short sides **SS1** and **SS2**. That is, the foldable touch input device **2** may be converted between a folded state and an unfolded state along the folding direction based on the folding axis **AXIS_F**.

[0179] FIG. **2A** is a schematic view illustrating a signal transmission operation between the stylus pen and the touch input device.

[0180] Referring to (a) of FIG. **2A**, a touch screen **20a** includes a digitizer **29**, a display panel **251**, a sensor unit **21**, and a window **22**.

[0181] In the case of an electro-magnetic resonance (EMR) type pen among passive stylus pens, when the digitizer **29** transmits a magnetic signal **B** to an EMR type stylus pen **10a**, a resonant circuit contained in the stylus pen **10a** resonates with the magnetic signal **B**. Then, the digitizer **29** receives the resonated magnetic signal **B** from the stylus pen **10a**.

[0182] The digitizer **29** may be attached to a bottom surface of the display panel **251** and include a ferrite sheet that blocks a magnetic field generated by an antenna loop and a flexible printed circuit board (FPCB) having a plurality of conductive antenna loops and an eddy current generated from other electrical elements or components when the antenna loop forms a magnetic field.

[0183] In the FPCB, the plurality of antenna loops for detecting an input position of a resonance signal are provided as a plurality of layers. One antenna loop overlaps at least one another antenna loop in a Z-axis direction. Accordingly, the FPCB has a great thickness. Thus, when using the digitizer **29**, the touch input device **2** is hardly reduced in thickness and size.

[0184] When the digitizer **29** is mounted on the foldable and flexible touch input device **2**, deformation may occur in the FPCB attached to an area folded when folding is generated. Repeated folding may cause stress to be applied to a wire member forming the antenna loop and resultantly cause a damage to the wire member. The ferrite sheet blocks influence of the magnetic field

generated by the antenna loop on the inside of the touch input device **2**. The ferrite sheet may have a great thickness, be easily deformed when the touch input device **2** is folded, and be damaged by the repeated folding.

[0185] Referring to (b) of FIG. 2A, a touch screen **20b** includes a display panel **251**, a sensor unit **21**, and a window **22**.

[0186] In the case of a stylus pen **10** including a resonance circuit, when an electrode (or pattern) of the sensor part **21** transmits a magnetic signal B to the stylus pen, the resonance circuit contained in the stylus pen **10** resonates with the magnetic signal B. Accordingly, an electrode (or pattern) of the sensor unit **21** may receive a resonated electromagnetic signal (E and/or B) from the stylus pen **10**. When the electrode (or pattern) of the sensor part **21** is made of a metal mesh having low resistance, a magnetic signal transmitted from the stylus pen **10** may be detected.

[0187] Likewise, when compared with the digitizer **29**, since a touch screen **20c** does not require an additional unit or module for transmitting a magnetic signal to the stylus pen **10**, the touch screen **20b** may be manufactured thinner with low manufacturing costs.

[0188] Referring to (c) of FIG. 2A, a touch screen **20c** includes a loop coil **264**, a display panel **251**, a sensor unit **21**, and a window **22**.

[0189] In the case of a stylus pen **10** including a resonance circuit, when the loop coil **264** transmits a magnetic signal B to the stylus pen, the resonance circuit contained in the stylus pen **10** resonates with the magnetic signal B. Accordingly, an electrode (or pattern) of the sensor unit **21** may receive a resonated electromagnetic signal (E and/or B) from the stylus pen **10**.

[0190] When compared with the digitizer **29**, since the loop coil **264** does not receive a magnetic signal B for detecting a touch position, a wire structure may be simplified, and the touch screen **20c** may be manufactured thinner. Thus, thinness and miniaturization of the touch input device **2** may be obtained. Also, since the loop coil **264** may be formed in various positions with various sizes, the touch screen **20c** may be also applied to the foldable/flexible touch input device **2**.

[0191] The loop coil **264** may include a substrate on which the antenna loop is disposed and a ferrite sheet. The antenna loop may be made of a conductive material such as copper and silver. The antenna loop may be disposed on the same layer as the sensor unit **21** in addition to the substrate. In this case, the antenna loop may be made of a conductive material having a high transmittance and a low impedance, such as a metal mesh, ITO, graphene, and a silver nanowire. Also, the antenna loop may be disposed below the window. In this case, the substrate may not be contained in the loop coil **264**.

[0192] In the above, the sensor unit **21** may include a plurality of electrodes (or patterns) for detecting touch coordinates. For example, the sensor unit **21** includes a plurality of first touch electrodes for detecting touch coordinates in a first direction and a plurality of second touch electrodes for detecting touch coordinates in a second direction crossing the first direction. Although the sensor unit **21** is illustrated as one layer in FIG. 2, the first touch electrode and the second touch electrode may be disposed on different layers, may overlap each other, may not overlap each other, or may be disposed with a separate layer therebetween.

[0193] Referring to (d) of FIG. 2A, a touch screen **20d** includes a display panel **251**, a sensor unit **21**, and a window **22**.

[0194] In case of an active stylus pen **10'** including a resonance circuit, the resonance circuit contained in the active stylus pen **10'** resonates by using a power source (e.g., a battery for storing a power such as a secondary battery) and a capacitor such as EDLC (electric double layered capacitor) in the active stylus pen **10'**. Then, the electrode of the sensor unit **21** may receive a resonated electromagnetic signal (E and/or B) from the stylus pen **10**. When the electrode (or pattern) of the sensor part **21** is made of a metal mesh having a low resistance, a magnetic signal transmitted from the stylus pen **10'** may be detected. The active stylus pen **10'** may include a circuit that outputs an electromagnetic signal E and/or B having a predetermined frequency using a power source in addition to a resonance circuit to generate an electromagnetic signal. Also, the active

stylus pen **10'** may include all of the resonance circuit and circuits that the electromagnetic signal E and/or B having a predetermined frequency.

[0195] The touch screen **20d** may receive an electromagnetic signal from the stylus pen **10'** without transmitting a magnetic signal to the stylus pen **10'**. That is, since the touch screen **20d** does not require an additional unit or module for generating a signal for resonating the resonance circuit contained in the stylus pen **10'**, thinness and miniaturization of the touch screen **20d** may be obtained, and power consumption and manufacturing costs may be reduced.

[0196] Next, a structure of the touch screen **20b** of (b) of FIG. 2A will be described in detail with reference to FIGS. 2B to 2D.

[0197] FIG. 2B is a schematic view illustrating a portion of a laminated structure of the touch input device in FIG. 1A.

[0198] Referring to FIG. 2B, the display panel **251** may include a circuit driving layer **2512** disposed on a substrate **2510**. The circuit driving layer **2512** may include a circuit for driving a light emitting layer **2514** of a pixel displaying an image. For example, the circuit driving layer **2512** may include a plurality of thin-film transistors and a capacitor.

[0199] The light emitting layer **2514** may be disposed on the circuit driving layer **2512**. The light emitting layer **2514** may include an organic light emitting layer. The light emitting layer **2514** may emit light with various luminance according to a driving signal transmitted from the circuit driving layer **2512**.

[0200] A common electrode layer **2516** may be disposed on the light emitting layer **2514**. The common electrode layer **2516** may have at least one slit-type opening.

[0201] An encapsulation layer (not shown) may be disposed on the common electrode layer **2516**. The encapsulation layer (not shown) may include an inorganic layer or a laminated layer of an inorganic layer and an organic material. For another example, glass or an encapsulation film may be applied as an encapsulation layer (not shown).

[0202] A touch electrode layer **21** or a touch electrode may be disposed on the encapsulation layer (not shown). The touch electrode layer **21** that recognizes a touch input may perform a function of a touch member. The touch electrode layer **21** may include a plurality of touch areas and touch electrodes. Since the touch electrode layer **21** recognizes a touch input of an object such as a finger or a stylus pen, the touch electrode layer **21** may also be referred to as a 'sensor unit' or a 'sensor layer'.

[0203] A polarization layer **23** may be disposed on the touch electrode layer **21**. The polarization layer **23** may serve to reduce reflection of external light. The polarization layer **23** may be attached onto the touch electrode layer **21** through an adhesive layer. Alternatively, the polarization layer **23** may be omitted.

[0204] A protection layer **22** may be disposed on the polarization layer **23**. For example, the protection layer **22** may include a window member or a cover layer. The protection layer **22** may be attached onto the polarization layer **23** by an optically clear adhesive.

[0205] A magnetic field shielding layer **24** may be disposed below the display panel **251**. The magnetic field shielding layer **24** may include a ferrite sheet that blocks a magnetic field. In addition, the magnetic field shielding layer **24** may include ferrite powder bonded to a lower portion of the substrate **2510**. The magnetic field shielding layer **24** may block an eddy current generated in other electrical elements and components when the touch electrode layer **21** and/or the stylus pen **10** form a magnetic field.

[0206] FIGS. 2C and 2D are schematic views illustrating a portion of the laminated structure of the touch input device in FIG. 1D.

[0207] Although the laminated structure of FIG. 2C is the same as that of FIG. 2B, the magnetic field shielding layer **24** may be disposed on an area FA (hereinafter, referred to as a folding area) folded when the foldable touch input device **2** is folded based on the folding axis AXIS_F.

[0208] When the laminated structure of FIG. 2D is compared with that of FIG. 2C, the magnetic

field shielding layer **24** may be disposed on an area except for the folding area FA or an area contained in the folding area FA. For example, the magnetic field shielding layer **24** may include a first sheet **24a** disposed between the folding area FA and the long side LS1 and a second sheet **24a** disposed between the folding area FA and the long side LS2. The magnetic field shielding layer **24** may include a plurality of sheets in addition to the two sheets, and even in this case, the magnetic field shielding layer **24** may be disposed on an area of a rear surface of the display panel **251** except for the folding area FA or a portion of the folding area FA.

[0209] Next, the touch input device **2** according to an embodiment will be described with reference to FIG. **3**.

[0210] FIG. **3** is a schematic block diagram representing the touch input device capable of interacting with the stylus pen.

[0211] As illustrated in the drawing, a touch input device **2** may include a wireless communication unit **210**, a memory **220**, an interface unit **230**, a power supply unit **240**, a display unit **250**, a touch unit **260**, and a control unit **270**. Since components illustrated in FIG. **3** are not essential for realizing the touch input device, the touch input device described in the present disclosure may include more or less components than the above-described components.

[0212] In more detail, among the above-described components, the wireless communication unit **210** may include at least one module for allowing wireless communication between the touch input device **2** and a wireless communication system, between the touch input device **2** and another touch input device **2**, or between the touch input device **2** and an external server. Also, the wireless communication unit **210** may include at least one module connecting the touch input device **2** to at least one network.

[0213] The wireless communication unit **210** may include a wireless internet module **211** and a short-range communication module **212**.

[0214] The wireless Internet module **211** refers to a module for wireless internet connection and may be incorporated in the touch input device **2**. The wireless internet module **211** is configured to transmit and receive a wireless signal over a communication network according to wireless internet technologies. For example, the wireless internet technologies include WLAN (Wireless LAN), Wi-Fi (Wireless Fidelity) Direct, DLNA (Digital Living Network Alliance), WiBro (Wireless Broadband), WiMAX (World Interoperability for Microwave Access), HSDPA (High Speed Downlink Packet Access), HSUPA (High Speed Uplink Packet Access), NR (New Radio), LTE (Long Term Evolution), and LTE-A (Long Term Evolution-Advanced), and the wireless internet module **211** transmits and receives data according to at least one wireless internet technology within a scope including internet technologies that are not listed above.

[0215] The short-range communication module **212** is for short-range communication, and at least one of Bluetooth™, RFID (Radio Frequency Identification), infrared communication (Infrared Data Association; IrDA), UWB (Ultra Wideband), ZigBee, NFC (Near Field Communication), Wi-Fi, Wi-Fi Direct, or Wireless USB (Wireless Universal Serial Bus) may be used to support the short-range communication. The short-range communication module **212** may support wireless communication between the touch input device **2** and the wireless communication system, between the touch input device **2** and the wireless communication capable device, or between the touch input device **2** and a network in which an external server is disposed through wireless area networks. The short-range wireless communication network may be a short-range wireless personal area networks.

[0216] Here, the wireless communication capable device may be a mobile terminal (e.g., a smart phone, a tablet PC, and a notebook) capable of (or interoperable) exchanging data with the touch input device **2** according to the present invention. The short-range communication module **212** may sense or recognize a wireless communication enabled device that is communicatable with the touch input device **2** around the touch input device **2**. Further, the control unit **270** may transmit at least a portion of data processed by the touch input device **2** to the wireless communication enabled device

through the short-range communication module **212** when the sensed wireless communication enabled device is a device authenticated to communicate with the touch input device **2** according to an embodiment. Thus, a user of the wireless communication enabled device may use the data processed by the touch input device **2** through the wireless communication enabled device.

[0217] Also, the memory **220** stores data supporting various functions of the touch input device **2**. The memory **220** may store a plurality of application programs (or applications) executed in the touch input device **2** and data for operation of the touch input device **2**, and commands.

[0218] The interface unit **230** may serve as a path to various kinds of external devices connected to the touch input device **2**. The interface unit **230** may include at least one of a wired/wireless headset port, an external charger port, a wired/wireless data port, a memory card port, a port for connecting a device equipped with an identification module, an audio I/O (Input/Output) port, a video I/O port, and an earphone port.

[0219] The power supply unit **240** receives external power or internal power under the control of the control unit **270** and supplies a power to each component contained in the touch input device **2**. The power supply unit **240** may include a battery, and the battery may be an internal battery or a replaceable battery.

[0220] The display unit **250** displays (or outputs) information processed in the touch input device **2**. For example, the display unit **250** may display execution screen information of an application program executed in the touch input device **2**, or UI (User Interface) or GUI (Graphic User Interface) information according to the execution screen information.

[0221] The display unit **250** may include a LCD display (liquid crystal display), an OLED (organic light-emitting diode) display, an electronic ink display (e-ink display), a quantum dot light-emitting display, and a micro-LED (light emitting diode) display.

[0222] The display unit **250** includes a display panel **251** for displaying an image, and a display controller **252** connected to the display panel **251** to supply signals for displaying an image to the display panel **251**. For example, the display panel **251** may include a plurality of scan lines, a plurality of pixels connected to the same signal lines as a plurality of data lines, and a scan driving/receiving unit for supplying a scan signal to the scan lines, and the display controller **252** may include a data driver IC for generating a data signal to be applied to the data line, a timing controller for processing an image signal and controlling an overall operation of the display unit **250**, and a power management IC.

[0223] The touch unit **260** senses a touch (or touch input) applied to a touch area by using a predetermined method, e.g., a capacitive method. For example, the touch unit **260** may be configured to convert a change in capacitance, voltage, or current generated in a specific portion into an electrical input signal. The touch unit **260** may be configured to detect a position, area, and capacitance of a touch object that applies a touch on the touch area when touched. Here, the touch object that is an object applying a touch to the touch sensor may include, e.g., a user's body portion (a finger or a palm) and a passive or active stylus pen **10**.

[0224] The touch unit **260** includes a touch panel **261** including the sensor unit **21** in FIG. 2 and a touch controller **262** that transmits touch data to the control unit **270** and/or the display controller **252** by applying a driving signal to the touch panel **261** and receiving a sensing signal from the touch panel **261**. The touch panel **261** may include a sensor unit capable of sensing a touch input of the finger or the stylus pen. The sensor unit may include a plurality of patterns (or electrodes). The sensor unit may sense an object such as the finger or the stylus pen and drive the stylus pen. The sensor unit will be described in detail with reference to FIG. 16.

[0225] The touch controller **262** may include a first driving/receiving unit connected to at least one of the plurality of first touch electrodes of the sensor unit **21** in FIG. 2 to apply a driving signal and receive a sensing signal; a second driving/receiving unit connected to at least one of the plurality of second touch electrodes to apply a driving signal and receive a sensing signal; and a MCU (micro control unit) that controls operations of the first driving/receiving unit and the second

driving/receiving unit and obtains a touch position by using sensing signals outputted from the first and second driving/receiving units.

[0226] The touch controller **262** may be integrated with the control unit **270**, which will be described later, into one IC or integrated with the display controller **252** into one IC. Alternatively, the touch controller **262** may be integrated into one IC with the display controller **252** and the control unit **270**. The touch controller **262** and the control unit **270**, the touch controller **262** and the display controller **252**, or the touch controller **262**, the display controller **252**, and the control unit **270** may be integrated into one and referred to as a 'control unit'.

[0227] The display panel **251** and the touch panel **261** may form a mutual layer structure or be integrated with each other to be referred to as the touch screen **20**.

[0228] The controller **270** may control driving of the touch input device **2** and output touch coordinate information in response to a touch sensing result of the touch input device **2**. Also, the control unit **270** may change a frequency of the driving signal in response to the touch sensing result.

[0229] The controller **270** controls an overall operation of the touch input device **2** in addition to an operation related to the application program. The controller **270** may provide or process information or functions suitable for the user by processing a signal, data, and information inputted or outputted through the above-described components or driving the application program stored in the memory **220**.

[0230] Also, the controller **270** may control at least a portion of the components described with reference to FIG. **3** to drive the application programs stored in the memory **220**. Furthermore, the control unit **270** may combine and operate at least two components of the components contained in the touch input device **2** for driving of the application program.

[0231] Although the touch unit **260** is contained in the touch input device **2** together with the display unit **250** as described above, the touch input device **2** may include only the touch unit **260**.

[0232] FIG. **4** is a view illustrating the stylus pen according to embodiments.

[0233] The stylus pens of FIG. **4** commonly include a resonance circuit unit **12** in a housing thereof.

[0234] The resonance circuit unit **12** that is a LC resonance circuit may resonate with the driving signal outputted from the touch screen **20** of FIGS. **2** and **3**. The driving signal may include a signal (e.g., a sine wave or a square wave) having a frequency corresponding to a resonance frequency of the resonance circuit unit **12**. In order to resonate, the resonance circuit unit **12** may have the same or similar resonance frequency as that of the driving signal. The resonance frequency of the stylus pen **10a** and **10b** is determined according to a design value of the resonance circuit unit **12** of the stylus pen **10a** and **10b**. When the sensor unit **21** of FIG. **2B** or the loop coil **264** of FIG. **2C** generates an electromagnetic field caused by a driving signal, the resonance circuit unit **12** of the stylus pen **10a** and **10b** resonates by using a signal received through variation of the magnetic field.

[0235] When an inductance of the inductor unit **14** and/or a capacitance of the capacitor unit **13**, which are included in the resonant circuit unit **12**, are/is varied, the resonant frequency of the resonant circuit unit **12** is varied. That is, when a pen pressure is applied to the stylus pen **10**, the resonant frequency of the resonant circuit unit **12** is varied, and thus a frequency of the electromagnetic field (electromagnetic force) output from the stylus pen **10** is varied. Accordingly, the touch controller **262** may calculate a variation amount of the inductance and/or capacitance of the resonant circuit unit **12** from the varied frequency of the electromagnetic force to detect the pen pressure.

[0236] Elements of the stylus pen **10a** and **10b** may be accommodated in the housing. Although the housing may have a cylindrical shape, a polygonal column shape, a column shape in which at least a portion is curved, an entasis shape, a frustum of pyramid shape, and a circular truncated cone shape, the embodiment of the present invention is not limited thereto. Since the inside of the housing is empty, the elements of the stylus pen **10a** and **10b** such as the resonance circuit unit **12**

may be accommodated in the housing. The housing may be made of a non-conductive material. The housing may be also referred to as a body unit.

[0237] As illustrated in FIG. 4A, the EMR-type stylus pen **10a** includes the resonance circuit unit **12**. The resonance circuit unit **12** includes an inductor unit **14** and a capacitor unit **13**. The inductor unit **14** includes a ferrite core **115** and a coil **116** wound around an outer surface of the ferrite core **115**.

[0238] The EMR-type stylus pen **10a** may further include a tip **11a**. The tip **11a** that is an end portion of the stylus pen **10a** may pass through the ferrite core **115** or protrude from the ferrite core **115** as illustrated in FIG. 4A. The tip **11a** may be a non-conductive tip or an electrode core made of a conductive material, e.g., a rigid resin mixed with conductive metal or conductive powder. Here, the tip **11a** may not be electrically connected to the resonance circuit unit **12**.

[0239] The ferrite core **115** may be, e.g., a cylindrical ferrite material. In the ferrite core **115**, a through-hole which has a predetermined diameter (e.g., 1 mm) and through which the tip **11a** is inserted and passes may be formed. In addition, the ferrite core **115** may have a cylindrical shape, a polygonal column shape, a column shape in which at least a portion is curved, an entasis shape, a frustum of pyramid shape, a circular truncated cone shape, a toroid shape, and a ring shape.

[0240] The coil **116** may be wound over an entire length of the ferrite core **115** in the axial direction or wound over a partial length thereof. The coil **116** is electrically connected to the capacitor unit **13**.

[0241] The capacitor unit **13** may include a plurality of capacitors connected in parallel. Each of the capacitors on a printed board may have a different capacitance and be trimmed within a manufacturing process.

[0242] As illustrated in FIG. 4B, the ECR (Electrically Coupled Resonance)-type stylus pen **10b** includes a conductive tip **11b** and a resonance circuit unit **12**. The resonance circuit unit **12** may include an inductor unit **14** and a capacitor unit **13** and be grounded. The inductor unit **14** includes a ferrite core **115** and a coil **116** wound around an outer surface of the ferrite core **115**.

[0243] Although a whole or at least a portion of the conductive tip **11b** may be made of a conductive material (e.g., metal, conductive rubber, conductive fabric, or conductive silicone), the embodiment of the present invention is not limited thereto.

[0244] The coil **116** may be wound over an entire length of the ferrite core **115** in the axial direction or wound over a partial length thereof. The coil **116** is electrically connected to the capacitor unit **13**.

[0245] The capacitor unit **13** may include a plurality of capacitors connected in parallel. Each of the capacitors on a printed board may have a different capacitance and be trimmed within a manufacturing process.

[0246] FIG. 5 is a conceptual view illustrating the inductor unit of the stylus pen in detail in FIGS. 4A and 4B.

[0247] Referring to FIG. 5, the inductor unit **14** includes a ferrite core **115** and a coil **116** wound around the ferrite core **115**.

[0248] Here, an inductance of the inductor unit **14** is determined by <Equation 1> below.

[00001]
$$L = \frac{SN^2}{l}$$
 [Equation1]

[0249] As known from <Equation 1>, an inductance L is proportional to a permeability of the ferrite core **115**, a cross-sectional area of the coil **116**, and the square of the number of windings and is inversely proportional to a winding length of the coil **116**.

[0250] A design of the inductor unit **14** in the resonance circuit unit **12** accommodated in the stylus pen illustrated in FIG. 4A and FIG. 4B is extremely important. In particular, in the design of the inductor unit **14**, an inductance L and a Q value are extremely important parameters as illustrated in FIG. 6. Here, the Q value that is an amount of representing a coil characteristic as a resonance circuit element is expressed by an equation $Q=2\pi fL/R$. Here, L and R indicate an inductance and a

resistance of the coil, respectively, and f indicates a frequency. As the Q value of the coil increases, sharpness of the resonance characteristic increases.

[0251] When the stylus pen illustrated in FIGS. 4A and 4B is designed, L may have a sufficiently large self-resonance frequency relative to a frequency to be used, and the Q value may have a maximum value at the frequency to be used. In order to satisfy this, a material of the ferrite core, the kind of a wire of the coil, and a winding scheme are required to be optimized. Also, a method for obtaining a high output signal while maintaining a thin diameter of the pen is required.

[0252] In embodiments below, a most optimized design method of the stylus pen in terms of materials of a plurality of ferrite cores, kinds of wires of the coil, and winding schemes will be described.

(1) Material of Ferrite Core

[0253] Manganese (Mn) and nickel (Ni) are used as a material of the ferrite core used in this embodiment.

(2) Kind of Wire

[0254] The wire of the coil used in this embodiment includes an enamel wire and a litz wire.

[0255] As illustrated in FIG. 7, an enamel wire **100** that is a wire manufactured by coating a surface of a copper wire **101** with an insulating enamel **102** and heating the wire at a high temperature is used for windings or wirings of electrical devices, communication devices, and electrical instruments. In the embodiment, the enamel wire having a total thickness T of 0.2 mm, an wire diameter ϕ of 0.18 mm, and a coating thickness t of 0.01 mm is used.

[0256] As illustrated in FIG. 8, a LITZ wire **200** is a specially insulating wire formed by twisting several thin insulating wires **100** (e.g., enamel wire) each having a diameter of about 0.1 mm into a single wire and performing insulation coating **201** on the single wire with nylon. The litz wire **200** may reduce a surface effect by increasing a surface area and be used for a coil of a high frequency circuit.

[0257] In the embodiment, the litz wire having a total thickness T of 0.2 mm, an wire diameter ϕ of 0.06 mm, and a coating thickness t of 0.007 mm is used.

(3) Winding Scheme

[0258] In the embodiment of the present invention, a winding scheme having a multilayer winding structure is used to obtain a sufficient inductance value (i.e., sufficient number of windings) in a limited space of the stylus pen. Specifically, as illustrated in FIGS. 9A and 9B, two kinds of multilayer winding schemes are used.

[0259] The winding scheme of FIG. 9A, which is a simplest winding scheme, is a sequential layer winding scheme by which a lower layer is wound and then an upper layer is wound. Here, the scheme of FIG. 9A is performed such that winding of a directly above layer starts at a point at which winding of a previous layer disposed directly below is finished. Hereinafter, this winding scheme is referred to as a U-type winding scheme.

[0260] The winding scheme of FIG. 9B that is an alternate layer winding scheme in which adjacent winding layers are alternately wound is performed such that adjacent layers is wound in an inclined zigzag form. Hereinafter, this winding scheme is referred to as a zigzag-type winding scheme. Specifically, this winding scheme is performed such that winding of a second layer is sequentially wound on winding of a first layer and then winding of a third layer is wound between the winding of the first layer and the winding of the second layer, and winding of a fourth layer is wound on the winding of the second layer and then winding of a fifth layer is wound between the winding of the second layer and the winding of the fourth layer. The above-described zigzag winding scheme may minimize a voltage difference between the windings of adjacent layers to reduce a winding self-capacitance. Here, the winding self capacitance, which is a kind of parasitic capacitance, is a parameter representing electric field energy stored in the winding.

Comparative Experiment 1 (Comparison of Characteristic Value for Each Material)

[0261] The Q values are measured by changing the material of the ferrite core to manganese,

nickel, and magnesium in a state in which the coil including the enamel wire is wound in the U-type of winding scheme.

[0262] As a result of the measurement, a difference between the characteristics of the Q values for each material of the core is insignificant, and the measured Q value is not enough to be implemented as a product.

Comparative Experiment 2 (Comparison of Characteristic Value for Each Winding Scheme)

[0263] The Q values are measured for an inductor 1 and an inductor 2, in which the enamel wire and the litz wire are respectively used as the wire of the coil, in a state in which the coil including the ferrite core made of manganese (Mn) is wound in the U-type of winding scheme.

[0264] FIG. 10 is a view illustrating Q values of the inductors 1 and 2 measured while changing a frequency through an E4980A precision LCR meter manufactured by KEYSIGHT TECHNOLOGIES.

[0265] In FIG. 10, a indicates a waveform showing a change of the Q value with respect to the frequency of the inductor 1 (manganese core/enamel wire/U-type winding scheme), and b indicates a waveform showing a change of the Q value with respect to the frequency of the inductor 2 (manganese core/litz wire/U-type winding scheme).

[0266] The inductor 2 manufactured by using the litz wire has an almost maximum Q value at a frequency (frequency f1) of about 400 kHz, and the inductor 1 manufactured by using the enamel wire has an almost maximum Q value at a frequency (frequency f2) of about 150 kHz.

[0267] As a result of comparison between a and b in FIG. 10, it may be known that the maximum Q value of the inductor 2 is about 1.5 times greater than the maximum Q value of the inductor 1. Thus, it may be known that the litz wire is superior to the enamel wire as the coil of the inductor that forms the resonance circuit of the stylus pen.

[0268] However, the maximum Q value of the inductor 2 measured in the comparative experiment 2 is about $\frac{1}{2}$ of a target value $Q_{\text{sub.target}}$ required for commercialization.

Comparative Experiment 3 (Comparison of Characteristic Value for Each Winding Scheme)

[0269] The Q values are measured for inductors 3 to 5 manufactured such that the enamel wire and the litz wire are respectively used as the wires of the coils and the wires are wound in the U-type winding scheme and the zigzag-type winding scheme in a state the ferrite core is made of manganese (Mn).

[0270] FIG. 10 is a view illustrating the Q values of the inductors 3 to 5 measured while changing a frequency through an E4980A precision LCR meter manufactured by KEYSIGHT TECHNOLOGIES.

[0271] In FIG. 11, a indicates a waveform showing a change of the Q value with respect to the frequency of the inductor 3 (manganese core/enamel wire/U-type winding scheme), b indicates a waveform showing a change of the Q value with respect to the frequency of the inductor 4 (manganese core/enamel wire/zigzag-type winding scheme), and c indicates a waveform showing a change of the Q value with respect to the frequency of the inductor 5 (manganese core/litz wire/zigzag-type winding scheme).

[0272] As known from the waveform c of FIG. 11, the inductor 5 manufactured by the litz wire/zigzag-type winding scheme has an almost maximum Q value at a frequency (frequency f3) of about 300 kHz. Each of the inductor 4 manufactured by the enamel wire/zigzag-type winding scheme and the inductor 3 manufactured by the enamel wire/U-type winding scheme has an almost maximum Q value at a frequency (frequency f2) of about 150 kHz.

[0273] Also, as a result of comparison between a, b, and c of FIG. 11, it may be known that the maximum Q value of the inductor 5 is about 1.5 times greater than that of the inductor 4 and is two times or more greater than that of the inductor 3. Thus, it may be known that the zigzag-type winding scheme is superior to the U-type winding scheme in the winding scheme of the inductor that forms the resonance circuit of the stylus pen.

[0274] However, the maximum Q value of the inductor 5 (manganese core/litz wire/zigzag-type

winding scheme) measured in the comparative experiment 2 is about $\frac{3}{4}$ of the target value Q.sub.target required for commercialization.

Comparative Experiment 4 (Comparison of Characteristic Value for Each Material of Core)

[0275] In this embodiment, manganese and nickel are used as the material of the ferrite core, and it is generally known that nickel has permeability of 200 to 300 and manganese has permeability of 3000 to 5000.

[0276] Since the manganese used in this embodiment is approximately 15 times greater in permeability than nickel, assuming that the coils have the same cross-sectional area and length, the number of windings of manganese may be reduced by approximately four times from that of windings of nickel to obtain the same inductance value. Thus, in terms of the number of windings, it may be known that manganese is more effective to use than nickel.

[0277] Since the inductor unit **14** has a complicated structure including the coil wound around the core, a parasitic capacitance is additionally formed. Since the Q value decreases by the parasitic capacitance, an amplitude of a resonance signal may be reduced.

[0278] The parasitic capacitance formed in the inductor unit **14** may be formed between the wound coils or between the core and the coil. Here, as described above, the parasitic capacitance between the wound coils may be reduced by adopting the zigzag-type winding scheme.

[0279] In this embodiment, the material of the core having permittivity lower than that of manganese is tested to reduce the parasitic capacitance between the core and the coil. As a result of the test, it may be known that nickel is an optimum material for the ferrite core.

[0280] An important physical property in manganese and nickel, which are mainly used as the material of the ferrite core is permeability, which gives an important effect on the inductance value as shown in <Equation 1>. However, since the permittivity in manganese and nickel as the ferrite core element is not an important physical property, nickel substantially does not have relevant information in a data sheet provided by a manufacturer.

[0281] In this embodiment, the permittivity of manganese and nickel is measured by using the E4980A precision LCR meter of KEYSIGHT TECHNOLOGIES to check the permittivity of manganese and nickel, and measurement results are shown in table 1 below.

TABLE-US-00001 TABLE 1 Permittivity of manganese Permittivity of nickel Measurement 2400 — 1 Measurement 8300 2 2

[0282] Measurement 1 and Measurement 2 are measured by using the same E4980A precision LCR meter manufactured by KEYSIGHT TECHNOLOGIES, and the Measurement 1 represents permittivity that is automatically calculated by measurement software. According to the Measurement 1, it may be known that while the permittivity of manganese is 2400, the permittivity of nickel is not measured.

[0283] The Measurement 2 is a method of calculating permittivity by measuring a capacitance, an area, and a distance between the ferrite cores, and according to Measurement 2, the permittivity of manganese is 8300 and the permittivity of nickel is 2.

[0284] It is confirmed that there is a big difference between permittivity measurement results of the Measurement 1 and the Measurement 2, and particularly the Measurement 2 shows a considerable error according to the capacitance, the area, and the distance. However, as the results of the Measurement 1 and the Measurement 2, it may be known that nickel has permittivity that is at least 1/1000 less than that of manganese.

[0285] In the comparative experiment 4, the Q values are measured for inductors 6 and 7 manufactured by changing the winding type into the U-type and the zigzag-type in a state in which the material of the ferrite core is nickel, and the kind of the wire is the litz wire.

[0286] FIG. 12 is a view illustrating Q values of the inductors 6 and 7 measured while changing a frequency through an E4980A precision LCR meter manufactured by KEYSIGHT TECHNOLOGIES.

[0287] In FIG. 12, a indicates a waveform showing a change of the Q value with respect to the

frequency of the inductor 6 (nickel core/litz wire/U-type winding scheme), and b indicates a waveform showing a change of the Q value with respect to the frequency of the inductor 7 (nickel core/litz wire/zigzag-type winding scheme).

[0288] As known from the waveform b of FIG. 12, the inductor 7 manufactured by the nickel core/litz wire/zigzag-type winding scheme has an almost maximum Q value at a frequency (frequency f5) of about 400 kHz. The inductor 7 manufactured by the nickel core/litz wire/U-type winding scheme has an almost maximum Q value at a frequency (frequency f6) of about 200 kHz. As a result of comparison between a and b in FIG. 11, it may be known that the maximum Q value of the inductor 7 is about two times greater than that of the inductor 6.

[0289] The maximum Q value of the inductor 7 (nickel core/litz wire/zigzag-type winding scheme) measured in the comparative experiment 4 almost reaches a target value Q target required for commercialization.

[0290] In the comparative experiments 1 to 4 described above, the Q values are tested by manufacturing the inductors while changing a combination of the material of the ferrite core, the kind of the wire of the coil, and the winding scheme, and the test results show that the highest Q value is obtained when the inductor unit of the capacitive resonance stylus pen is designed by using the nickel core, the litz wire, and the zigzag-type winding scheme. Also, it may be known that the maximum Q value of the inductor manufactured by the above-described combination reaches the target value Q.sub.target for commercialization.

[0291] Although the experiment is performed by using the nickel core as the ferrite core and the litz wire as the wire of the core in this embodiment, similar results may be obtained when a material with permittivity of 1000 or less is used as the ferrite core instead of the nickel core, and a wire in which a single wire surrounds two or more insulating strands is used instead of the litz wire.

[0292] Hereinafter, a reason why an output voltage Vout of CVA (Capacitor Voltage Amplitude) varies according to a position of the stylus pen on the touch screen will be described before the touch input device in the pen and touch input system according to an embodiment of the present invention is described in detail.

[0293] FIG. 13 is a schematic view for explaining that the output voltage (Vout) of CVA (Capacitor Voltage Amplitude) varies according to a position of the stylus pen 10 on a typical touch screen.

[0294] Referring to FIG. 13, a reason why an output of the CVA is different depending on the position of the stylus pen 10 on the touch screen is that impedance ratios of both sides with respect to the stylus pen 10 on a sensing line are different.

[0295] Based on a major axis of the typical touch screen, a resistance R of a metal mesh touch sensor is approximately 1.2k ohm, and the capacitor C is approximately 250 pF.

[0296] Based on ten distributed models, at a driving frequency of 300 kHz, an impedance of the capacitor is approximately 200 times (120 ohm vs. $1/(2\pi \cdot 300k \cdot 25 \text{ pF}) = 21k \text{ ohm}$) greater than a resistance thereof. Therefore, the capacitor is a main factor.

[0297] FIG. 14 is a view for explaining that output voltages Vout1 and Vout2 of the CVA are different according to the position of the stylus pen 10 in FIG. 13 through current sensing, and FIG. 15 is a view for explaining that the output voltages Vout1 and Vout2 of the CVA are different according to the position of the stylus pen 10 in FIG. 13 through voltage sensing.

[0298] Referring to FIGS. 14 and 15, the output voltage of the CVA are different according to the position of the stylus pen 10 on the sensing line. That is, the output voltage of the CVA increases as the stylus pen 10 moves toward the sensing circuit unit 50 and decreases as the stylus pen 10 moves away from the sensing circuit unit 50.

[0299] Hereinafter, a touch input device according to various embodiments of the present invention will be described in detail with the accompanying drawings.

[0300] FIG. 16 is a schematic configuration view illustrating the sensor unit 100 according to a first embodiment of the present invention.

[0301] The touch input device according to the first embodiment of the present invention may be a

portrait-type touch input device. In this portrait type touch input device, a width is smaller than a height, and a control unit (not shown) for controlling the sensor unit **100** may be disposed below the sensor unit **100**. For example, the touch input device corresponds to a shape of a smartphone. [0302] The sensor unit **100** may detect a position of an object such as a finger positioned on the screen, drive the stylus pen **10** in FIG. 1A, and detect a position of the stylus pen on the screen by detecting a signal (stylus pen signal) emitted from the stylus pen.

[0303] The sensor unit **100** includes a plurality of patterns (or a plurality of electrodes).

[0304] The sensor unit **100** may include a plurality of first to fourth patterns **101**, **102**, **103**, and **104**.

[0305] A first pattern **101** has a shape extending in an arbitrary first direction y. The first direction may be a major axis direction of the screen of the touch input device. The first pattern **101** may also be referred to as Active TX (ATX). The first pattern **101** has a predetermined shape in which an electrical path is formed along the arbitrary first direction y.

[0306] A second pattern **102** has a shape extending in the first direction y, is disposed adjacent to the first pattern **101**, and is spaced a predetermined distance from the first pattern **101**. The second pattern **102** may also be referred to as Dummy TX (DTX). The second pattern **102** may be disposed adjacent to the first pattern **101** and have a predetermined shape in which an electrical path is formed along the arbitrary first direction y.

[0307] The third pattern **103** has a shape extending in a second direction x different from the first direction. The second direction x may be a direction perpendicular to the first direction y, and may be a minor axis direction of the screen of the touch input device. The third pattern **103** may also be referred to as Active RX (ARX). The third pattern **103** has a predetermined shape in which an electrical path is formed along the arbitrary second direction x.

[0308] A fourth pattern **104** has a shape extending in the second direction x, is disposed adjacent to the third pattern **103**, and is spaced a predetermined distance from the third pattern **103**. The fourth pattern **104** may also be referred to as Dummy RX (DRX). The fourth pattern **104** may be disposed adjacent to the first pattern **103** and have a predetermined shape in which an electrical path is formed along the arbitrary second direction x.

[0309] The third and fourth patterns **103** and **104** are disposed on the first and second patterns **101** and **102** and are spaced a predetermined distance from the first and second patterns **101** and **102**. The sensor unit in which the first to fourth patterns are disposed on the same layer will be described in detail with reference to FIG. 27.

[0310] A plurality of first patterns **101** are arranged in the second direction x, and a plurality of second patterns **102** are also arranged in the second direction x. A plurality of third patterns **103** are arranged in the first direction y, and a plurality of fourth patterns **104** are also arranged in the first direction y.

[0311] Since the first pattern **101** extends in the first direction y, the third pattern **103** extends in the second direction x, and the first direction y is longer than the second direction x, the number of the first plurality of patterns **101** is less than the number of the third plurality of patterns **103**. Thus, the number of channels of the plurality of first patterns **101** is less than that of channels of the plurality of third patterns **103**.

[0312] Here, the number of the plurality of first patterns **101** and the number of the plurality of third patterns **103** may increase or decrease according to a size of the screen of the touch input device.

[0313] The number of the plurality of second patterns **102** may be equal to that of the plurality of first patterns **101** in a one-to-one correspondence manner. The other ends (or second ends) of the plurality of second patterns **102** are electrically connected to each other through a conductive pattern. Here, the conductive pattern may be a metal mesh or a silver trace.

[0314] One ends (or first ends) of the plurality of second patterns **102** may be electrically connected to a control unit (not shown). Here, as illustrated in FIG. 17, one ends of two or more

second patterns **102** among the plurality of second patterns **102** may be electrically connected to each other through a conductive pattern. Due to this configuration, the number of channels of the plurality of second patterns **102** may be reduced to a half of the number of the channels of the plurality of first patterns **101**. Here, two or more second patterns **102** among the plurality of second patterns **102** may be adjacent to each other.

[0315] As illustrated in FIG. **18**, each of the one ends of the plurality of second patterns **102** may be individually connected to one conductive pattern.

[0316] Referring to FIG. **16** again, since the plurality of third patterns **103** are arranged in the first direction y, the number of the plurality of third patterns **103** is greater than that of the plurality of first patterns **101**. Thus, the number of the channels of the plurality of third patterns **103** is greater than that of the channels of the plurality of first patterns **101**.

[0317] The number of the plurality of fourth patterns **104** may be equal to that of the plurality of third patterns **103** in a one-to-one correspondence manner. The other ends (or second ends) of the plurality of fourth patterns **104** are electrically connected to each other through a conductive pattern.

[0318] In the sensor unit **100** of the touch input device in FIG. **16**, the plurality of first patterns **101** and the plurality of third patterns **103** basically sense a touch of an object such as a finger. To this end, the plurality of first patterns **101** operate as touch driving electrodes (TX electrodes) to which a touch driving signal is applied, and the plurality of third patterns **103** operate as touch sensing electrodes (RX electrodes or touch receiving electrodes) to which a touch sensing signal is received, and vice versa.

[0319] Various combinations of the plurality of first to fourth patterns **101**, **102**, **103**, and **104** may be used so that the sensor unit **100** of the touch input device shown in FIG. **16** drives and senses the stylus pen. The various combinations are shown in <Table 2> below. In <Table 2> below, ‘1’ refers to the plurality of first patterns **101**, ‘2’ refers to the plurality of second patterns **102**, ‘3’ refers to the plurality of third patterns **103**, and ‘4’ refers to the plurality of fourth patterns **104**.

| TABLE-US-00002 | | TABLE 2 | | Stylus downlink | | Finger Touch | | Operation | | uplink signal | | Operation | | | | | | | | | | | | | | | | |
|----------------|-------|------------|-------|-----------------|-------|--------------|-------|-----------|-------|---------------|-------|-----------|-------|-------|-------|-------|-------|-------|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | | Driving | | Sensing | | signal | | magnitude | | magnitude | | Stylus | | | | | | | | | | | | | | | | |
| | | Major | | Minor | | X- Y- | | Major | | Minor | | X- Y- | | | | | | | | | | | | | | | | |
| | | additional | | channel | | No. | | Tx | | Rx | | axis | | | | | | | | | | | | | | | | |
| | | axis | | axis | | axis | | axis | | axis | | axis | | | | | | | | | | | | | | | | |
| | | Driving | | Sensing | | Major | | Minor | | X- Y- | | Major | | | | | | | | | | | | | | | | |
| | | 1 | | 2 | | 3 | | 4 | | 1 | | 2 | | | | | | | | | | | | | | | | |
| 1 | 3 | 2 | 1 | 3 | Small | Small | Small | Yes | No | 2 | 1 | 3 | 2 | 1 | 4 | Large | Small | Large | Yes | Yes | 3 | 1 | 3 | 2 | 2 | 3 | Large | Large |
| Small | Yes | Yes | 4 | 1 | 3 | 2 | 2 | 4 | Large | Large | Large | Yes | Yes | 5 | 1 | 3 | 4 | 1 | 3 | Large | Small | Small | Yes | No | 6 | 1 | 3 | 4 |
| 1 | 4 | Large | Small | Large | Yes | Yes | 7 | 1 | 3 | 4 | 2 | 3 | Large | Large | Small | Yes | Yes | 8 | 1 | 3 | 4 | 2 | 4 | Large | Large | | | |
| Large | Yes | Yes | 9 | 1 | 3 | 2 | 4 | 1 | 3 | Large | Large | Small | Small | Yes | No | 10 | 1 | 3 | 2 | 4 | 1 | 4 | Large | Large | Small | | | |
| Large | Yes | Yes | 11 | 1 | 3 | 2 | 4 | 2 | 3 | Large | Large | Large | Small | Yes | Yes | 12 | 1 | 3 | 2 | 4 | 2 | 4 | Large | Large | Large | | | |
| Large | Yes | Yes | 13 | 1 | 3 | 1 | 1 | 3 | Small | Small | Small | No | No | 14 | 1 | 3 | 1 | 1 | 4 | Small | Small | Large | No | Yes | 15 | 1 | | |
| 3 | 1 | 2 | 3 | Small | Large | Small | No | Yes | 16 | 1 | 3 | 1 | 2 | 4 | Small | Large | Large | No | Yes | 17 | 1 | 3 | 3 | 1 | 3 | Small | Small | |
| Small | No | No | 18 | 1 | 3 | 3 | 1 | 4 | Small | Small | Large | No | Yes | 19 | 1 | 3 | 3 | 2 | 3 | Small | Large | Small | No | Yes | 20 | 1 | 3 | |
| 3 | 2 | 4 | Small | Large | Large | No | Yes | 21 | 1 | 3 | 1 | 3 | 1 | 3 | Small | Small | Small | Small | No | No | 22 | 1 | 3 | 1 | 3 | 1 | 4 | |
| Small | Small | Small | Large | No | Yes | 23 | 1 | 3 | 1 | 3 | 2 | 3 | Small | Small | Large | Small | No | Yes | 24 | 1 | 3 | 1 | 3 | 2 | 4 | | | |
| Small | Small | Large | Large | No | Yes | 25 | 1 | 3 | 2 | 3 | 1 | 3 | Large | Small | Small | Small | Yes | No | 26 | 1 | 3 | 2 | 3 | 1 | 4 | | | |
| Large | Small | Small | Large | Yes | Yes | 27 | 1 | 3 | 2 | 3 | 2 | 3 | Large | Small | Large | Small | Yes | Yes | 28 | 1 | 3 | 2 | 3 | 2 | 4 | | | |
| Large | Small | Large | Large | Yes | Yes | 29 | 1 | 3 | 1 | 4 | 1 | 3 | Small | Large | Small | Small | Yes | No | 30 | 1 | 3 | 1 | 4 | 1 | 4 | | | |
| Small | Large | Small | Large | Yes | Yes | 31 | 1 | 3 | 1 | 4 | 2 | 3 | Small | Large | Large | Small | Yes | Yes | 32 | 1 | 3 | 1 | 4 | 2 | 4 | | | |
| Small | Large | Large | Large | Yes | Yes | | | | | | | | | | | | | | | | | | | | | | | |

[0320] Referring to the <Table 2> above, in various combinations No. 1 to No. 32, the plurality of first patterns **101** and the plurality of third patterns **103** are used for sensing a touch of an object such as a finger. Specifically, the plurality of first patterns **101** operate as touch driving electrodes, and the plurality of third patterns **103** operate as touch receiving electrodes, and vice versa.

[0321] At least one or two of the plurality of first to fourth patterns **101**, **102**, **103**, and **104** may operate as a stylus driving electrode for driving the stylus pen. At least One or two of the plurality

of first to fourth patterns **101**, **102**, **103**, and **104** may be used to form a current loop for driving the stylus pen. For example, an X-axis driving may be performed by one of the plurality of first patterns **101** and the plurality of second patterns **102**, and a Y-axis driving may be performed by one of the plurality of third patterns **103** and the plurality of fourth patterns **104**. The driving of the stylus pen may be performed by either the X-axis driving or the Y-axis driving or by both the X-axis driving and the Y-axis driving.

[0322] At least one or two of the plurality of first to fourth patterns **101**, **102**, **103**, and **104** may operate as a sensing electrode for sensing a stylus pen signal emitted from the stylus pen. Since both X-axis sensing and Y-axis sensing are required to sense the stylus pen signal, two patterns of the plurality of first to fourth patterns **101**, **102**, **103**, and **104** are used. An X-axis sensing may be performed by one of the plurality of first patterns **101** and the plurality of second patterns **102**, and a Y-axis sensing may be performed by one of the plurality of third patterns **103** and the plurality of fourth patterns **104**.

[0323] In the <Table 2> above, the 'uplink signal magnitude' represents a magnitude of a driving signal for driving the stylus pen **10** of FIG. 1A. When the same stylus pen driving signal is applied to each of the plurality of first patterns **101** and the plurality of second patterns **102**, and magnitudes of signals received by the stylus pen are compared, the uplink signal is relatively greater when the stylus pen driving signal is applied to the plurality of second patterns **102** than when the stylus pen driving signal is applied to the plurality of first patterns **101**.

[0324] This is because the other ends (or second ends) of the plurality of first patterns **101** are not electrically connected not to form a current loop while the other ends (or the second end) of the plurality of second patterns **102** are electrically connected to form at least one current loop when two or more second patterns to which the stylus pen driving signal is applied are properly selected. When current flows through each first pattern **101**, since RC of each first pattern **101** is charged, the current may not flow smoothly from one end (or the first end) to the other end (or the second end) of each first pattern **101**. Also, a stylus pen driving signal applied through the plurality of first patterns **101** is transmitted to the plurality of second patterns **101** in which the current loop is formed through the capacitive coupling. Here, signal attenuation occurs by the capacitive coupling.

[0325] Likewise, the uplink signal is relatively greater when the stylus pen driving signal is applied to the plurality of fourth patterns **104** than when the stylus pen driving signal is applied to the plurality of third patterns **103**.

[0326] In the <Table 2> above, the 'downlink signal magnitude' represents a magnitude of stylus pen signal received from the stylus pen **10** of FIG. 1A. When the same stylus pen driving signal is received by each of the plurality of first patterns **101** and the plurality of second patterns **102**, and magnitudes of the signals are compared, the downlink signal is relatively greater when the stylus pen driving signal is received by the plurality of second patterns **102** than when the stylus pen driving signal is received by the plurality of first patterns **101**.

[0327] This is because, although the other ends (the second end) of the plurality of second patterns **102** are electrically connected to form a current loop, the other ends (the first end) of the plurality of first patterns **101** are not electrically connected to each other, particularly, the stylus pen signal is transmitted to the plurality of first patterns **101** from the plurality of second patterns **101** in which the current loop is formed through the capacitive coupling, and thus attenuation of the downlink signal occurs.

[0328] Likewise, the downlink signal is relatively greater when the stylus pen signal is received through the plurality of fourth patterns **104** than when the stylus pen signal is received through the plurality of third patterns **103**.

[0329] In <Table 2> above, the 'stylus additional channel' represents whether an additional channel is necessary for the stylus pen in addition to the touch sensing. When the plurality of second patterns **102** and/or the plurality of fourth patterns **104** are used for driving or sensing the stylus pen, an additional channel is required (marked by 'Yes' in the <Table 2>). Also, when the plurality

of first patterns **101** and/or the plurality of third patterns **103** for touch sensing are used for driving or sensing the stylus pen, an additional channel is not required (marked by 'No' in the <Table 2>). [0330] Hereinafter, some examples of the various combinations Nos. 1 to 32 of the <Table 2> above will be described in detail below. Here, combinations not described will be sufficiently understood by a person skilled in the art through the following detailed description.

[0331] In case of No. 1, the plurality of first patterns **101** are used as a touch driving electrode for sensing a touch of an object and a stylus sensing electrode for sensing a stylus pen signal. The plurality of second patterns **102** are used as a stylus driving electrode for driving the stylus pen. The plurality of third patterns **103** are used as the stylus sensing electrode for sensing the stylus pen signal as well as the touch sensing electrode for sensing the touch of the object. Also, the plurality of fourth patterns **104** are electrically floated. Here, the feature of being electrically floated may represent that only the other ends (second ends) of the plurality of fourth patterns **104** are electrically connected to each other, and one end (first ends) of the plurality of fourth patterns **104** are not connected to each other.

[0332] In case of No. 1, since the plurality of second patterns **102** are used as the stylus driving electrode, the uplink signal has a relatively large magnitude. Since the plurality of first patterns **101** and the plurality of third patterns **103** are used as the stylus sensing electrode, the downlink signal has a relatively small magnitude. Also, since the plurality of second patterns **102** are separately used as the stylus driving electrode, an additional channel for driving the stylus pen is required, but an additional channel for sensing the stylus pen is not required.

[0333] In case of No. 4, the plurality of first patterns **101** are used as the touch driving electrode for sensing the touch of the object. The plurality of second patterns **102** are used as the stylus sensing electrode for sensing the stylus pen signal as well as the stylus driving electrode for driving the stylus pen. The plurality of third patterns **103** are used as the touch sensing electrode for sensing the touch of the object. The plurality of fourth patterns **104** are used as the stylus sensing electrode for sensing the stylus pen signal.

[0334] In case of No. 4, since the plurality of second patterns **102** are used as the stylus driving electrode, the uplink signal has a relatively large magnitude. The plurality of second patterns **102** and the plurality of fourth patterns **104** are used as the stylus sensing electrode, the downlink signal has a relatively large magnitude. Also, since the plurality of second patterns **102** are separately used as the stylus sensing electrode and the stylus driving electrode, and the plurality of fourth patterns **104** are separately used as the stylus sensing electrode, a separate additional channel is required for driving and sensing the stylus pen.

[0335] In case of No. 8, the plurality of first patterns **101** are used as the touch driving electrode for sensing the touch of the object. The plurality of second patterns **102** are used as the stylus sensing electrode for sensing the stylus pen signal. The plurality of third patterns **103** are used as the touch sensing electrode for sensing the touch of the object. Also, the plurality of fourth patterns **104** are used as the stylus sensing electrode for sensing the stylus pen signal as well as the stylus driving electrode for driving the stylus pen.

[0336] In the case of No. 8, since the plurality of fourth patterns **104** are used as the stylus driving electrode, the uplink signal has a relatively large magnitude. The plurality of second patterns **102** and the plurality of fourth patterns **104** are used as the stylus sensing electrode, the downlink signal has a relatively large magnitude. Also, since the plurality of second patterns **102** are separately used as the stylus sensing electrode, and the plurality of fourth patterns **104** are separately used as the stylus driving electrode and the stylus sensing electrode, a separate additional channel is required for driving and sensing the stylus pen.

[0337] In case of No. 12, the plurality of first patterns **101** are used as the touch driving electrode for sensing the touch of the object. The plurality of second patterns **102** are used as the stylus sensing electrode for sensing the stylus pen signal as well as the stylus driving electrode for driving the stylus pen. The plurality of third patterns **103** are used as the touch sensing electrode for

sensing the touch of the object. Also, the plurality of fourth patterns **104** are used as the stylus sensing electrode for sensing the stylus pen signal as well as the stylus driving electrode for driving the stylus pen.

[0338] In case of No. 12, since the plurality of second and fourth patterns **102** and **104** are used as the stylus driving electrode, the uplink signal has a relatively large magnitude. The plurality of second patterns **102** and the plurality of fourth patterns **104** are used as the stylus sensing electrode, the downlink signal has a relatively large magnitude. Also, since the plurality of second patterns **102** are separately used as the stylus driving electrode and the stylus sensing electrode, and the plurality of fourth patterns **104** are separately used as the stylus driving electrode and the stylus sensing electrode, a separate additional channel is required for driving and sensing the stylus pen.

[0339] In case of No. 13, the plurality of first patterns **101** are used as the touch driving electrode for sensing the touch of an object, the stylus driving electrode for driving the stylus pen, and the stylus sensing electrode for sensing the stylus pen signal. The plurality of third patterns **103** are used as the stylus sensing electrode for sensing the stylus pen signal as well as the touch sensing electrode for sensing the touch of the object. Also, the plurality of second and fourth patterns **102** and **104** are electrically floated.

[0340] In case of No. 13, since the plurality of first patterns **101** are used as the stylus driving electrode, the uplink signal has a relatively large magnitude. Since the plurality of first patterns **101** and the plurality of third patterns **103** are used as the stylus sensing electrode, the downlink signal has a relatively small magnitude. Also, since the plurality of first patterns **101** are used as the stylus driving electrode and the stylus sensing electrode, and the plurality of fourth patterns **103** are used as the stylus sensing electrode, a separate additional channel is not required for driving and sensing the stylus pen.

[0341] In case of No. 17, the plurality of first patterns **101** are used as the touch driving electrode for sensing the touch of the object and a stylus sensing electrode for sensing the stylus pen signal. The plurality of third patterns **103** are used as the touch sensing electrode for sensing the touch of the object, the stylus driving electrode for driving the stylus pen, and the stylus sensing electrode for sensing the stylus pen signal. Also, the plurality of second and fourth patterns **102** and **104** are electrically floated.

[0342] In the case of No. 17, since the plurality of fourth patterns **104** are used as the stylus driving electrode, the uplink signal has a relatively small magnitude. Since the plurality of first patterns **101** and the plurality of third patterns **103** are used as the stylus sensing electrode, the downlink signal has a relatively small magnitude. Also, since the plurality of second patterns **102** are separately used as the stylus sensing electrode, and the plurality of fourth patterns **103** are used as the stylus driving electrode and the stylus sensing electrode, a separate additional channel is not required for driving and sensing the stylus pen.

[0343] In case of No. 21, the plurality of first patterns **101** are used as the touch driving electrode for sensing the touch of an object, the stylus driving electrode for driving the stylus pen, and the stylus sensing electrode for sensing the stylus pen signal. The plurality of third patterns **103** are used as the touch sensing electrode for sensing the touch of the object, the stylus driving electrode for driving the stylus pen, and the stylus sensing electrode for sensing the stylus pen signal. Also, the plurality of second and fourth patterns **102** and **104** are electrically floated.

[0344] In case of No. 21, since the plurality of first and third patterns **101** and **103** are used as the stylus driving electrode, the uplink signal has a relatively small magnitude. Since the plurality of first patterns **101** and the plurality of third patterns **103** are used as the stylus sensing electrode, the downlink signal has a relatively small magnitude. Also, since the plurality of second patterns **102** are used as the stylus driving electrode and the stylus sensing electrode, and the plurality of third patterns **103** are used as the stylus driving electrode and the stylus sensing electrode, a separate additional channel is not required for driving and sensing the stylus pen.

[0345] Among the various combinations No. 1 to No. 32 in the <Table 2> above, in Nos. 1, 5, 9,

25, and 29, driving is 'Yes' and sensing is 'No' in a column of 'Stylus additional channel'. The Nos. 1, 5, 9, 25, and 29 use the plurality of first and third patterns **101** and **103** for sensing the stylus pen and the plurality of second and/or fourth patterns **102** and **104** for driving the stylus pen. When the stylus pen is driven, since formation of a magnetic field for resonating the stylus pen may be somewhat difficult although the plurality of second and/or fourth patterns **102** and **104** are used, as illustrated in FIG. **17** two or more adjacent one ends (the first end) of the second patterns may be electrically connected to each other. Likewise, two or more adjacent one ends (the first end) of the fourth patterns may be electrically connected to each other. This configuration has an advantage of reducing the additional channel for driving the stylus pen.

[0346] The control unit (not shown) controls the sensor unit **100**.

[0347] Specifically, as shown in No. 1 to No. 32 of the <Table 2> above, the control unit (not shown) may apply a touch driving signal to the plurality of first patterns **101** and receive a touch sensing signal from the plurality of third patterns **103**.

[0348] As shown in No. 1 to No. 32 of the <Table 2> above, the control unit (not shown) may apply a stylus pen driving signal to at least one of the plurality of first to fourth patterns **101** to **104** and receive a stylus pen sensing signal from at least one of the plurality of first to fourth patterns **101** to **104**.

[0349] As shown in No. 1 to No. 32 of the <Table 2> above, the control unit (not shown) may apply a stylus pen driving signal to at least one of the plurality of first patterns **101** or the plurality of third patterns **103**.

[0350] As shown in Nos. 1 to 3, 5 to 7, 9 to 11, 13 to 15, 17 to 19, 21 to 23, 25 to 27, and 29 to 31 of the <Table 2> above, the control unit (not shown) may apply a stylus pen sensing signal to at least one of the plurality of first patterns **101** or the plurality of third patterns **103**.

[0351] As shown in Nos. 1 to 12 and 25 to 32 of the <Table 2> above, the control unit (not shown) may apply a stylus pen driving signal to at least one of the plurality of second patterns **102** or the plurality of fourth patterns **104**.

[0352] As shown in Nos. 2 to 4, 6 to 8, 10 to 12, 14 to 16, 19 to 20, 22 to 24, 26 to 28, and 30 to 32 of the <Table 2> above, the control unit (not shown) may apply a stylus pen sensing signal to at least one of the plurality of second patterns **102** or the plurality of fourth patterns **104**.

[0353] The control unit (not shown) may select at least one of the plurality of first to fourth patterns **101** to **104** as a pen driving electrode and apply a stylus pen driving signal to the selected pen driving electrode. Here, the feature of selecting at least one of the plurality of first to fourth patterns **101** to **104** as the pen driving electrode may be varied according to a position of the stylus pen **10** on the touch screen **20** of the touch input device **2** of FIG. **1A**. A pattern selected when the stylus pen is in the hover state may be different from a pattern selected when the stylus pen is in the contact state. For example, the control unit (not shown) may select one of the first and second patterns **101** and **102** as the pen driving electrode when the stylus pen is in the hover state and one of the third and fourth patterns **103** and **104** as the pen driving electrode when the stylus pen is in the contact state, and vice versa.

[0354] The control unit (not shown) may select at least two of the plurality of first to fourth patterns **101** to **104** as the pen sensing electrode to sense the stylus pen signal emitted from the stylus pen through the selected pen sensing electrode. Here, the feature of selecting at least two of the plurality of first to fourth patterns **101** to **104** as the pen sensing electrode may be varied according to a position of the stylus pen **10** on the touch screen **20** of the touch input device **2** of FIG. **1A**. A pattern selected when the stylus pen is in the hover state may be different from a pattern selected when the stylus pen is in the contact state. For example, the control unit (not shown) may select one of the first and second patterns **101** and **102** as the pen driving electrode when the stylus pen is in the hover state and one of the third and fourth patterns **103** and **104** as the pen driving electrode when the stylus pen is in the contact state, and vice versa.

[0355] FIG. **19** is a schematic configuration view illustrating a sensor unit **100'** according to a

second embodiment of the present invention;

[0356] The touch input device according to the second embodiment of the present invention may be a landscape-type touch input device. In this landscape-type touch input device, a width is greater than a height, and a control unit (not shown) for controlling the sensor unit **100'** may be disposed below the sensor unit **100'**. For example, the touch input device may correspond to a shape of a tablet PC.

[0357] The sensor unit **100'** of the touch input device according to the second embodiment of the present invention has the same configuration as that of the sensor unit **100** of the touch input device according to the first embodiment in FIG. **16**, and the sensor unit **100'** only rotates at 90° from the sensor unit **100**.

[0358] The sensor unit **100'** of the touch input device according to the second embodiment of the present invention includes a plurality of first to fourth patterns **101**, **102**, **103**, and **104**. The first pattern **101** and the second pattern **102** are adjacent to each other and each have a shape extending in one direction. Alternatively, each of the first pattern **101** the second pattern **101** may have a predetermined shape in which an electrical path is formed along the one direction. The third pattern **103** and the fourth pattern **104** are adjacent to each other and each have a shape extending in a different direction from the one direction. Alternatively, each of the third pattern **103** and the fourth pattern **104** may have a predetermined shape in which an electrical path is formed in the different direction. The other ends (second ends) of the plurality of second patterns **102** are electrically connected to each other, and the other ends (second ends) of the plurality of fourth patterns **104** are also electrically connected to each other.

[0359] When the sensor unit **100'** of the touch input device according to the second embodiment in FIG. **19** has a size of about 10 to 14 inches, which is the size of a landscape-type tablet PC, and is implemented as with an example of No. 1 in the <Table 2> above, the number of total channels and the number of driving trace channels (TX Trace Channels) of the sensor unit **100'** are summarized in <Table 3> below.

TABLE-US-00003 TABLE 3 Number of channels (about 10 inches or more) Finger TX (101) 42
Finger RX (103) 56 Stylus TX (102) 21 Top channel (101 + 102 + 103) 119 TX Trace channel (101 + 102) 63

[0360] In the <Table 3> above, the number of channels of Stylus TX is a value obtained by dividing the number of the plurality of first patterns **101** by 2. This is because the number of channels are reduced by half as two adjacent one ends of one ends (first ends) of the plurality of second patterns **102** are electrically connected while the number of the plurality of second patterns **102** is equal to that of the plurality of first patterns **101** as illustrated in FIG. **20**.

[0361] In the <Table 3> above, the number of TX Trace channels is a sum of the number of channels of Finger TX and the number of channels of Stylus TX. The number of the TX Trace channels is a key factor in determining a thickness of a bezel in a width direction of the touch input device according to the second embodiment. This is because the control unit (not shown) is disposed below (or above) the sensor unit **100'** in the touch input device according to the second embodiment. As the number of the TX Trace channels is reduced, the thickness of the bezel in the width direction of the touch input device may be reduced.

[0362] While there is no problem when the screen of the touch input device shown in FIG. **19** has a size of a screen of a smartphone, e.g., 6.9 inches, when the size of the screen of the touch input device shown in FIG. **19** increases to 11 inches or 12.9 inches that is a size of a screen of a tablet PC, lengths of the first to fourth patterns **101**, **102**, **103**, and **104** of the sensor unit **100'** also increase, so that a resistance value and a capacitance value of the sensor unit increase. Since the increase of the resistance and capacitance values allows an operating frequency bandwidth of each of the touch driving signal applied to one pattern used as the touch driving electrode among the first to third patterns and the stylus driving signal for driving the stylus pen to decrease, an operating frequency bandwidth required for a design may not be obtained. The resistance and

capacitance values may be reduced to solve the above-described limitation. However, the feature of reducing the resistance and capacitance values is limited, and the above-described limitation is not still solved although the values are maximally reduced.

[0363] Also, the stylus pen signal received from the stylus pen and inputted to the control unit of the touch input device is attenuated as much as the sensor unit **100'** increases. Particularly, as the stylus pen sensing signal is attenuated in a process of being transmitted to the control unit from a portion spaced farthest from the control unit in the first to fourth patterns **101**, **102**, **103**, and **104** of the sensor unit **100'**, a voltage value required for a design is not outputted.

[0364] The above-described limitations may be solved by using the plurality of second patterns **102** as the stylus pen sensing electrode for sensing the stylus pen signal as with examples of Nos. 3, 4, 7, 8, 11, 12, 15, 16, 19, 20, 23, 24, 27, 28, 31, and 32 of the <Table 2> or by using the plurality of fourth patterns **104** as the stylus pen sensing electrode for sensing the stylus pen signal as with examples of Nos. 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, and 32 of the <Table 2>. In the above examples, since the plurality of second and fourth patterns **102** and **104** directly receive electromotive force through electromagnetic induction caused by the stylus pen, there is no signal attenuation through capacitive coupling from the second pattern **102** to the first pattern **101** and from the fourth pattern **104** to the third pattern **103**.

[0365] As a specific example, the sensor unit **100'** of the touch input device according to the second embodiment has a size of about 10 to 14 inches, which is the size of the landscape-type tablet PC, and when the sensor unit **100'** is implemented as with an example of No. 3 in the <Table 2> above, the number of total channels and the number of driving trace channels (TX Trace Channels) of the sensor unit **100'** are summarized in <Table 4> below.

TABLE-US-00004 TABLE 4 Number of channels (about 10 inches or more) Finger TX 42 Finger RX 56 Stylus TX 42 Top channel 140 TX Trace channel 84

[0366] In the <Table 4> above, the number of channels of Stylus TX is equal to that of the plurality of second patterns **102**. This is because the number of the plurality of second patterns **102** is equal to that of the plurality of first patterns **101**, and each of one ends of the plurality of second patterns **102** is individually connected to one conductive pattern as illustrated in FIG. 21.

[0367] In the <Table 4> above, the number of TX Trace channels is a sum of the number of channels of Finger TX and the number of channels of Stylus TX. The number of the TX Trace channels is a key factor in determining a thickness of the bezel in the minor axis of the touch input device. As the number of the TX Trace channels is reduced, the thickness of the bezel in the minor axis of the touch input device may be reduced.

[0368] The example of the above <Table 4> has a disadvantage in that the number of channels slightly increases compared to the above <Table 3>, but has an advantage in that a voltage value of the stylus sensing signal received by the control unit increases because the pen sensing signal emitted from the stylus pen is received through the plurality of second patterns **102**. The present applicant confirms through experiments that the voltage value of the stylus sensing signal received by the control unit is approximately two times greater than that in the <Table 3>.

[0369] Also, since each of the plurality of second patterns **102** is one channel, when the plurality of second patterns **102** are used as the stylus driving electrode (Stylus TX), a distance between the channels is reduced by half, and a stylus driving resolution is improved.

[0370] As another specific example, when the sensor unit **100'** of the touch input device according to the second embodiment has a size of about 10 to 14 inches, which is the size of the landscape-type tablet PC, and is implemented as with an example of No. 8 in the <Table 2> above, the number of total channels and the number of driving trace channels (TX Trace Channels) of the sensor unit **100'** are summarized in <Table 5> below.

TABLE-US-00005 TABLE 5 Number of channels (about 10 inches or more) Finger TX 42 Finger RX 56 Stylus TX 56 Top channel 154 TX Trace channel 42

[0371] In the <Table 5> above, the number of channels of the Stylus TX is equal to that of the

plurality of fourth patterns **104**. This is because the number of the plurality of fourth patterns **104** is equal to that of the plurality of third patterns **103**, and each of one ends of the plurality of fourth patterns **104** is individually connected to one conductive pattern as illustrated in FIG. **22**.

[0372] In the <Table 5> above, the number of the TX Trace channels is equal to that of the number of channels of the Finger TX. The number of the TX Trace channels is a key factor in determining a thickness of the bezel in the minor axis of the touch input device. As the number of the TX Trace channels is reduced, the thickness of the bezel in the minor axis of the touch input device may be reduced.

[0373] The example of the above <Table 5> has a disadvantage in that the number of total channels slightly increases compared to the above <Table 3>, but has an advantage in that a voltage value of the stylus pen sensing signal received by the control unit increases because the pen sensing signal emitted from the stylus pen is received through the plurality of fourth patterns **104**.

[0374] Also, since each of the plurality of fourth patterns **104** is one channel, when the plurality of fourth patterns **104** are used as the stylus driving electrode (Stylus TX), a distance between the channels is reduced by half, and the stylus driving resolution is improved.

[0375] Also, since the number of the TX trace channels may be reduced to $\frac{1}{4}$ to $\frac{1}{3}$ compared to the example in the <Table 3>, a thickness of a bezel B in the width direction of the touch input device may be reduced.

[0376] FIG. **23** is a schematic configuration view illustrating another example of the sensor unit **100'** in FIG. **19**.

[0377] In a sensor unit **100''** of FIG. **23**, each first pattern **101'** includes at least two or more first-a patterns **101a** and first-b patterns **101b**, and each second pattern **102'** includes at least two or more second-a patterns **102a** and second-b patterns **102b**. A plurality of third and fourth patterns **103** and **104** are the same as those of the sensor unit **100** of FIG. **19**.

[0378] The first-a pattern **101a** and the first-b pattern **101b** are arranged in an extension direction of the first pattern **101'**. The second-a pattern **102a** and the second-b pattern **201b** are arranged in an extension direction of the second pattern **102'**.

[0379] The other ends of the plurality of second-a patterns **102a** are electrically connected, and the other ends of the plurality of second-b patterns **102b** are electrically connected. Here, the other ends of the plurality of second-a patterns **102a** face the other ends of the plurality of second-b patterns **102b**.

[0380] One ends of two or more adjacent second-a patterns of the plurality of second-a patterns **102a** may be electrically connected to each other. One ends of two or more adjacent second-b patterns of the plurality of second-b patterns **102b** may be electrically connected to each other. Here, each of the one ends of the plurality of second-a patterns and the one ends of the plurality of second-b patterns is individually connected to a conductive pattern as illustrated in FIG. **9**

[0381] As a specific example, when the sensor unit **100''** in FIG. **23** has a size of about 10 to 14 inches, which is the size of the landscape-type tablet PC, and is implemented as with the example of No. 1 in the <Table 2> above, the number of total channels and the number of driving trace channels (TX Trace Channels) of the sensor unit **100''** are summarized in <Table 6> below.

TABLE-US-00006 TABLE 6 Number of channels (about 10 inches or more) Finger TX 84 Finger RX 56 Stylus TX 42 Top channel 182 TX Trace channel 126

[0382] In the <Table 6> above, the number of channels of Stylus TX is a value obtained by dividing the number of the plurality of second patterns **102'** by 2. This is because the number of the plurality of second patterns **102'** is equal to that of the plurality of first patterns **101'**, and two adjacent second patterns of the plurality of second patterns **102'** are electrically connected to each other.

[0383] In the <Table 6> above, the number of TX Trace channels is a sum of the number of channels of Finger TX and the number of channels of Stylus TX. The number of TX Trace channels is a key factor in determining a thickness of the bezel in the minor axis of the touch input device.

As the number of the TX Trace channels is reduced, the thickness of the bezel in the minor axis of the touch input device may be reduced.

[0384] The above <Table 6> has a disadvantage in that the number of channels slightly increases compared to the example of the <Table 3> above, but has an advantage in that an operating frequency bandwidth of each of the touch driving signal applied to the touch driving electrode and the pen driving signal for driving the stylus pen is widened by reducing a resistance value and a capacitance value of the sensor unit **100** because a length of each of the first pattern **101'** and the second pattern **102'** is reduced by half.

[0385] FIG. **24** is a view illustrating the touch input device in FIG. **20** in detail.

[0386] Referring to FIG. **24**, a touch input device **500** may include a sensor unit **100A** and a control unit **300** for controlling the sensor unit **100A**.

[0387] The sensor unit **100A** is an example of the sensor unit **100'** in FIG. **20**. Thus, the sensor unit **100A** includes a plurality of first to fourth patterns **101A**, **102A**, **103A**, and **104A**.

[0388] The first pattern **101A** has a shape extending in a first direction (width direction). The first direction may be a major axis direction L of a screen of the touch input device. The first pattern **101A** may also be referred to as Active TX (ATX).

[0389] The first pattern **101A** may includes a plurality of main pattern parts and a connection pattern part connecting two adjacent main pattern parts among the plurality of main pattern parts. Here, although the main pattern part may have a diamond shape, the embodiment of the present invention is not limited thereto. For example, the main pattern part may have various shapes that are different from that of the connection pattern part.

[0390] The first pattern **101A** may have an opening in which the second pattern **102A** is disposed. The opening may have a shape corresponding to an outer shape of the first pattern **101A**. The first pattern **101A** may have a structure surrounding the second pattern **102A**. The first pattern **101A** is spaced a predetermined distance from the second pattern **102A**.

[0391] The second pattern **102A** has a shape extending in the first direction, is disposed adjacent to the first pattern **101A**, and is spaced a predetermined distance from the first pattern **101A**. The second pattern **102A** may also be referred to as Dummy TX (DTX).

[0392] The second pattern **102A** is disposed in the first pattern **101A**.

[0393] The second pattern **102A** may includes a plurality of main pattern parts and a connection pattern part connecting two adjacent main pattern parts among the plurality of main pattern parts. Here, although the main pattern part may have a diamond shape, the embodiment of the present invention is not limited thereto. For example, the main pattern part may have various shapes that are different from that of the connection pattern part.

[0394] The main pattern part of the second pattern **102A** may have a shape corresponding to that of the main pattern part of the first pattern **101A**, and the connection pattern part of the second pattern **102A** may have a shape corresponding to that of the connection pattern part of the first pattern **101A**.

[0395] The third pattern **103A** has a shape extending in a second direction different from the first direction. The second direction may be a direction perpendicular to the first direction, and may be a minor axis direction of the screen of the touch input device. The third pattern **103A** may also be referred to as Active RX (ARX).

[0396] The third pattern **103A** may includes a plurality of main pattern parts and a connection pattern part connecting two adjacent main pattern parts among the plurality of main pattern parts. Here, although the main pattern part may have a diamond shape, the embodiment of the present invention is not limited thereto. For example, the main pattern part may have various shapes that are different from that of the connection pattern part.

[0397] The third pattern **103A** may have an opening in which the fourth pattern **104A** is disposed. The opening may have a shape corresponding to an outer shape of the third pattern **103A**. The third pattern **103A** may have a structure surrounding the fourth pattern **104A**. The third pattern **103A** is

spaced a predetermined distance from the fourth pattern **104A**.

[0398] The fourth pattern **104A** has a shape extending in the second direction, is disposed adjacent to the third pattern **103A**, and is spaced a predetermined distance from the third pattern **103A**. The fourth pattern **104A** may also be referred to as Dummy RX (DRX).

[0399] The fourth pattern **104A** is disposed in the third pattern **103A**.

[0400] The fourth pattern **104A** may include the plurality of main pattern parts and the connection pattern part connecting two adjacent main pattern parts among the plurality of main pattern parts. Here, although the main pattern part may have a diamond shape, the embodiment of the present invention is not limited thereto. For example, the main pattern part may have various shapes that are different from that of the connection pattern part.

[0401] The main pattern part of the fourth pattern **104A** may have a shape corresponding to that of the main pattern part of the third pattern **103A**, and the connection pattern part of the fourth pattern **104A** may have a shape corresponding to that of the connection pattern part of the third pattern **103A**.

[0402] The third and fourth patterns **103A** and **104A** are disposed on the first and second patterns **101A** and **102A** and are spaced a predetermined distance from the first and second patterns **101A** and **102A**. The sensor unit in which the first to fourth patterns are disposed on the same layer will be described in detail with reference to FIG. 30.

[0403] Although not shown in the drawing, one ends (first ends) of the plurality of first patterns **101A** are electrically connected to the control unit **300**, and the other ends (second ends) are electrically opened. Here, each of the one ends (first end) is relatively close to the control unit **300**, and each of the other ends (second end) is relatively far from the control unit **300**.

[0404] Although not shown in the drawing, each of the one ends of the plurality of first patterns **101A** may be electrically connected to each other through the control unit **300** and the conductive pattern. The conductive patterns connecting the plurality of first patterns **101A** and the control unit **300** may be arranged in the bezel B of a width direction of the touch input device **500**.

[0405] Two adjacent one ends of the one ends (first ends) of the plurality of second patterns **102A** may be electrically connected to each other by a first conductive pattern and then electrically connected to the control unit **300** through a second conductive pattern. The other ends (second ends) of the plurality of second patterns **102A** are electrically connected to each other through the conductive pattern. Here, each of the one ends (first end) is relatively close to the control unit **300**, and each of the other ends (second end) is relatively far from the control unit **300**.

[0406] The second conductive patterns connecting the plurality of second patterns **102A** and the control unit **300** may be arranged in the bezel B of the width direction of the touch input device **500** as illustrated in FIG. 24. Here, the second conductive patterns connecting the plurality of second patterns **102A** and the control unit **300** may be arranged in the bezel B of the width direction of the touch input device **500** together with conductive patterns (not shown) connecting the plurality of first patterns **101A** and the control unit **300**.

[0407] When the other ends of the plurality of second patterns **102A** are electrically connected to each other, a total impedance is reduced because capacitances for respective second patterns **102A** are added. Thus, an effect in which each of the other ends of the plurality of second patterns **102A** is AC GND is obtained.

[0408] Although not shown in the drawings, the other ends of the plurality of second patterns **102A**, which are electrically connected to each other, may be grounded. Also, although not shown in the drawings, the other ends of the plurality of second patterns **102A** may not be electrically connected to each other, and a predetermined capacitor may be connected to each of the other ends of the second patterns **102A**.

[0409] The plurality of first patterns **101A** and the plurality of second patterns **102A** may be disposed on the same layer. The first pattern **101A** and the second pattern **102A** may be formed on the same layer by using a metal mesh.

[0410] Although not shown in the drawing, one ends (first ends) of the plurality of third patterns **103A** are electrically connected to the control unit **300**, and the other ends (second ends) are electrically opened. Here, each of the one ends (first end) is relatively close to the control unit **300**, and each of the other ends (second end) is relatively far from the control unit **300**. The one ends of the plurality of third patterns **103A** may be electrically connected to the control unit **300** through a conductive pattern.

[0411] One ends (or first ends) of the plurality of fourth patterns **104A** may be electrically opened. Here, the other ends (second ends) of the plurality of fourth patterns **104A** may be electrically connected to each other in the same manner as the plurality of second patterns **102A**. Here, each of the one ends (first end) is relatively close to the control unit **300**, and each of the other ends (second end) is relatively far from the control unit **300**.

[0412] Although not shown in the drawings, the other ends of the plurality of second patterns **104A**, which are electrically connected to each other, may be grounded. Also, the other ends of the plurality of fourth patterns **104A** may not be electrically connected to each other, and a predetermined capacitor may be connected to each of the other ends of the fourth patterns **104A**.

[0413] The plurality of third patterns **103A** and the plurality of fourth patterns **104A** may be disposed on the same layer. The third pattern **103A** and the fourth pattern **104A** may be formed on the same layer by using a metal mesh. Here, the third pattern **103A** and the fourth pattern **104A** may be disposed on a layer different from that of the first pattern **101A** and the second pattern **102A**. For example, the third pattern **103A** and the fourth pattern **104A** may be disposed on a first layer, and the first pattern **101A** and the second pattern **102A** may be disposed on a second layer that is different from the first layer. The sensor unit in which the first to fourth patterns are disposed on the same layer will be described in detail with reference to FIG. **30**.

[0414] The control unit **300** may be electrically connected to the sensor unit **100A** and control an operation of the sensor unit **100A**. The control unit **300** and the sensor unit **100A** may be electrically connected to each other through a conductive pattern.

[0415] The control unit **300** may include a plurality of driving circuit units **310** and a plurality of sensing circuit units **330**. Here, although not shown in the drawing, at least one of the plurality of driving circuit units **310** and the plurality of sensing circuit units **330** may not be contained in the control unit **300** and may be disposed outside the control unit **300**.

[0416] The plurality of driving circuit units **310** may include a driving circuit unit providing a touch sensing signal for sensing a position of a touch of an object such as a finger to the plurality of first patterns **101A** and a driving circuit unit providing a pen driving signal for driving the stylus pen.

[0417] The plurality of sensing circuit units **330** may include a sensing circuit unit for detecting a position of a touch of an object such as a finger by receiving a sensing signal through the plurality of third patterns **103A** and a sensing circuit unit for sensing the stylus pen. Here, some sensing circuit units among the plurality of sensing circuit units may perform touch position sensing in addition to stylus pen sensing.

[0418] The control unit **300** may control the sensor unit **100A** to operate in one of the touch sensing mode, the antenna driving mode, and the stylus pen sensing mode. The control unit **300** may selectively electrically connect the plurality of driving/sensing circuit units **310** and **330** to the sensor unit **100A** according to each mode. To this end, the control unit **300** may include a plurality of switches electrically connecting the plurality of driving/sensing circuit units **310** and **330** to the sensor unit **100A** according to a command of the control unit **300**.

[0419] An operation mode of the touch input device **500** in FIG. **24** will be described in detail. Here, since the example of No. 1 in the above <Table 2> is illustrated in FIG. **24**, a description will be provided based on the example.

[0420] In the touch driving/sensing mode, the control unit **300** may electrically connect the plurality of driving circuit units **310** to the plurality of first patterns **101A** of the sensor unit **100A** to

sense a position of a touch of an object such as a finger. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of first patterns **101A** with the plurality of driving circuit units **310**.

[0421] Also, the control unit **300** may electrically connect the plurality of sensing circuit units **330** for touch position sensing to the plurality of third patterns **103A** of the sensor unit **100A**. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of third patterns **103A** with the plurality of sensing circuit units **330**.

[0422] In the driving/touch sensing mode, the control unit **300** simultaneously or sequentially applies a driving signal (or touch driving signal) for touch sensing to the plurality of first patterns **101A** and receives a sensing signal (or touch sensing signal) received from the plurality of third patterns **103A**. The plurality of sensing circuit units of the control unit **300** electrically connected to the plurality of third patterns **103A** may output information on capacitance variation contained in the input sensing signal as a predetermined voltage value. The control unit **300** may process the outputted voltage value to detect a touch position.

[0423] In the touch driving/sensing mode, the control unit **300** may electrically connect the plurality of driving circuit units **310** to the plurality of second patterns **102A** to prevent capacitive coupling from being generated between the plurality of first patterns **101A** and the plurality of second patterns **102A**. Here, the control unit **300** may control the same driving signal as the driving signal applied to the plurality of first patterns **101A** to be applied to the plurality of second patterns **102A**. Also, the control unit **300** may control a predetermined reference potential to be applied to the plurality of second patterns **102A** when the driving signal is applied to the plurality of first patterns **101A**.

[0424] In the antenna driving mode (or stylus driving mode, or stylus uplink mode), the control unit **300** electrically connect the plurality of driving circuit units **310** for driving the antenna to the plurality of second patterns **102A** of the sensor unit **100A**. The control unit **300** may control the plurality of switches to electrically connect the conductive patterns connected to the plurality of second patterns **102A** with the plurality of driving circuit units **310**.

[0425] outputted from each driving circuit unit **310** connected to the plurality of second patterns **102A**. For example, the control unit **300** may control: a pulse signal having a predetermined frequency to be outputted from a first driving circuit unit; any pulse signal not to be outputted from a second driving circuit unit; and a reverse pulse signal having a phase opposite to that of the pulse signal outputted from the first driving circuit unit to be outputted from the third driving circuit unit, among the plurality of driving circuit units connected to the plurality of second patterns **102A**. In this case, a current loop is formed by the second pattern electrically connected to the first driving circuit unit and the second pattern electrically connected to the third driving circuit unit. A magnetic field is generated by the formed current loop, and the stylus pen adjacent to the sensor unit **100A** may be driven by the magnetic field.

[0426] The control unit **300** may control opposite driving signals to be outputted from two random driving circuit units among the plurality of driving circuit units **310** electrically connected to the plurality of second patterns **102A**. Thus, the control unit **300** may variously change and set a size and a position of the current loop. For example, when the control unit **300** detects a position of the stylus pen adjacent to the sensor unit **100A**, the control unit **300** may control opposite driving signals to be outputted from the driving circuit unit electrically connected to two second patterns disposed around the position of the stylus pen, and when the control unit **300** does not detect the position of the stylus pen, the control unit **300** may control opposite driving signals to be outputted from the driving circuit unit electrically connected to two second patterns disposed both outermost portions among the plurality of second patterns **102A**.

[0427] FIG. **25** is a view for explaining a method by which the control unit **300** applies a pen driving signal for driving the stylus pen to the plurality of second patterns **102A**; For reference, in FIG. **25**, one second pattern **102A** in FIG. **24** is simply illustrated as one line Ch, and each line Ch

is one channel

[0428] As illustrated in FIG. 25, two adjacent second patterns are electrically connected to form one channel. In this configuration, the same signal is applied to the two electrically connected second patterns. FIG. 25 is a view illustrating a state in which 84 second patterns are connected by two to form 42 channels Ch0, Ch1, . . . Ch41.

[0429] For example, when the stylus pen 50 is disposed between a second channel Ch2 and a third channel Ch3 among the 42 channels Ch0, Ch1, . . . Ch41, the control unit 300 may control a pen driving signal to be outputted to one or more channels disposed at a side of the second channel Ch2 based on the stylus pen 50 and a pen driving signal having an inverted phase of the above-described pen driving signal to one or more channels disposed at a side of the third channel Ch3 based on the stylus pen 50.

[0430] In the stylus sensing mode (or stylus downlink mode), the control unit 300 may electrically connect the plurality of sensing circuit units 330 for stylus sensing to the plurality of first patterns 101A and the plurality of third patterns 103A of the sensor unit 100A. The control unit 300 may control the plurality of switches to electrically connect the conductive patterns connected to the plurality of first and third patterns 101A and 103A with the plurality of sensing circuit units 330.

[0431] The touch input device 500 according to an embodiment of the present invention has an advantage in that an output voltage value of the plurality of sensing circuit units 330 is hardly changed according to the position of the stylus pen on the sensor unit 100A in the stylus sensing mode due to the configuration of the sensor unit 100A. A specific principle for this will be described with reference to FIGS. 26A to 26F.

[0432] FIGS. 26A to 26F are schematic views for explaining an operation principle of the stylus sensing mode in the touch input device of FIG. 24.

[0433] FIG. 26A is a schematic circuit diagram of modeling one first pattern 101A in FIG. 24 and the sensing circuit unit of the control unit 300 electrically connected thereto, and FIG. 26B is a schematic circuit diagram of modeling the second pattern 102A disposed in one first pattern 101A. FIG. 26C is a voltage distribution graph in the circuit diagram of FIG. 26A, and FIG. 26D is a voltage distribution graph in the circuit diagram of FIG. 26B.

[0434] Referring to FIGS. 26A and 26C, when the stylus pen approaches an arbitrary point A spaced away from the sensing circuit unit 330 on the first pattern 101A, a voltage V_{emf} (hereinafter, referred to as an 'induced voltage') induced by a signal emitted from the stylus pen is generated at the corresponding point A. When the induced voltage V_{emf} is generated at the point A, since an equivalent capacitance of the first pattern 101A viewed from the point A to the left side decreases, an equivalent impedance increases. Thus, as most of the induced voltage V_{emf} is applied to the left side of the point A, and a voltage of about 0 V is applied to the right side of the point A, almost no current flows. Furthermore, as the voltage of about 0 V applied to the right side of the point A gradually decreases by equivalent resistances of the first pattern 101A, almost no voltage is applied to an input terminal of the sensing circuit unit.

[0435] Referring to FIGS. 26B and 26D, when the induced voltage V_{emf} is generated at the point A, since the other ends of each second pattern 102A are electrically connected to each other on the left side of the point A, an equivalent capacitance viewed from the point A to the left side increases, and an equivalent impedance approaches almost 0. Thus, a voltage of 0 V is applied to the left side of the point A, and the voltage V_{emf} is applied to the right side of the point A without causing a voltage drop at equivalent resistors because one end of the second pattern 102A is opened.

[0436] When FIGS. 26C and 26D are compared, it may be known that a potential difference as much as the voltage V_{emf} exists at any position between the first pattern 101A and the second pattern 102A. The potential difference as much as the voltage V_{emf} between the first pattern 101A and the second pattern 102A causes capacitive coupling between the first pattern 101A and the second pattern 102A. As illustrated in FIG. 26E, current flows from the second pattern 102A to the first pattern 101A by the capacitive coupling. Although current generated from the first pattern

101A itself gradually decreases as a distance from the position of the stylus pen to the sensing circuit unit of the control unit **300** increases, since current is introduced to the first pattern **101A** from the second pattern **102A**, current outputted from the first pattern **101A** to the sensing circuit unit **330** of the control unit **300** has almost no difference from the position of the pen. Thus, the control unit **300** may sense the position of the stylus pen through the sensing circuit unit **330** electrically connected to the first pattern **101A**.

[0437] As illustrated in FIGS. **26A** to **26E**, it may be known that a potential difference between the first pattern **101A** and the second pattern **102A** is constant as the voltage V_{emf} although the point A moves to the left or right side. Thus, the control unit **300** may sense the stylus pen from a constant signal outputted from the sensing circuit unit **330** regardless of whether the position of the stylus pen on the sensor unit **100A** is close to or far from the sensing circuit unit.

[0438] Although the current is introduced to the first pattern **101A** from the second pattern **102A** by the capacitive coupling in a description of FIG. **26E**, the embodiment of the present invention is not limited thereto. For example, current may be also introduced to the first pattern **101A** from the second pattern **102A** by magnetic coupling (magnetic field coupling).

[0439] The principle of FIGS. **26A** to **26E** described above is directly applied to any one of the third pattern **103** and the fourth pattern **104** in the second direction. Also, the principle is directly applied to the touch input device according to the first embodiment in FIG. **16**.

[0440] FIG. **26F** is a voltage distribution graph when the sensing circuit unit **330** is connected to a right open terminal of the modeled circuit diagram of the second pattern **102A** in FIG. **26B**. That is, the voltage distribution graph of FIG. **26F** illustrates a case in which one end of the second pattern **102A** is connected to the sensing circuit unit **330** of the control unit **300**. When FIGS. **26F** and **26D** are compared, in case of FIG. **26F**, a voltage drop is gradually generated by equivalent resistors in a direction toward the right side of the point A. Thus, in the case of FIG. **26F**, since a potential difference as much as the voltage V_{emf} between the first pattern and the second pattern is not maintained, current may not flow from the second pattern to the first pattern as with FIG. **26E**. Thus, the current outputted from the first pattern gradually decreases as the position of the pen moves away from the control unit **300**. In the stylus sensing mode, one end of the second pattern **102A** may be opened and floated.

[0441] While there is no problem when the screen of the touch input device in FIG. **26** has a size of the screen of the smartphone, e.g., 6.9 inches, when the size of the screen of the touch input device in FIG. **26** increases to 10 inches or 14 inches that is the size of the screen of a tablet PC, the sensor unit **100A** also increases, so that a resistance value and a capacitance value of the sensor unit **100A** increase. The increase in the resistance and capacitance values causes the operating frequency bandwidth of each of the touch drive signal applied to the touch drive electrode and the pen drive signal for driving the stylus pen to be much narrower than that of the smartphone (6.9 inches). Thus, an operating frequency bandwidth required for design is not obtained.

[0442] In addition, the pen sensing signal received from the stylus pen is also attenuated as much as the sensor unit **100A** increases. In particular, a voltage value necessary for design is not outputted from the sensor unit **100A** because the pen sensing signal at a portion farthest from the control unit **300** is attenuated in a process of being transmitted to the control unit **300**.

[0443] Hereinafter, touch input devices capable of solving the above-described limitations will be described.

[0444] FIG. **27** is a view illustrating the touch input device in FIG. **21** in detail.

[0445] Referring to FIG. **27**, a touch input device **500''** may include a sensor unit **100A''** and the control unit **300** for controlling the sensor unit **100A''**.

[0446] The sensor unit **100A''** includes the plurality of first to fourth patterns **101A**, **102A''**, **103A**, and **104A**. Here, since the plurality of first, third, and fourth patterns **101A**, **103A**, and **104A** are the same as the plurality of first, third, and fourth patterns **101A**, **103A**, and **104A** illustrated in FIG. **24**, a description thereof will be omitted.

[0447] Hereinafter, the plurality of second patterns **102A**" will be described, an a description on the same portion as the plurality of second patterns **102A** of FIG. **12** will be omitted for convenience.

[0448] Each of one ends (first ends) of the plurality of second patterns **102A**" may be electrically connected to the control unit **300** by a conductive pattern. This aspect is different from the plurality of second patterns **102A**.

[0449] The other ends (second ends) of the plurality of second patterns **102**" are electrically connected to each other through a conductive pattern. Here, each of the one ends is relatively close to the control unit **300**, and each of the other ends is relatively far from the control unit **300**.

[0450] An operation mode of the touch input device **500**" in FIG. **27** will be described in detail.

[0451] In the touch driving/sensing mode, the control unit **300** may electrically connect the plurality of driving circuit units **310** to the plurality of first patterns **101A** of the sensor unit **100A**" for sensing a position of a touch of an object such as a finger. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of first patterns **101A** with the plurality of driving circuit units **310**.

[0452] Also, the control unit **300** may electrically connect the plurality of sensing circuit units **330** for sensing a position of a touch to the plurality of third patterns **103A** of the sensor unit **100A**". The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of third patterns **103A** with the plurality of sensing circuit units **330**.

[0453] In the driving/touch sensing mode, the control unit **300** simultaneously or sequentially applies a driving signal (or touch driving signal) for touch sensing to the plurality of first patterns **101A** and receives a sensing signal (or touch sensing signal) received from the plurality of third patterns **103A**. The plurality of sensing circuit units of the control unit **300** electrically connected to the plurality of third patterns **103A** may output information on capacitance variation contained in the input sensing signal as a predetermined voltage value. The control unit **300** may process the outputted voltage value to detect a touch position.

[0454] In the antenna driving mode (or stylus driving mode, or stylus uplink mode), the control unit **300** may electrically connect the plurality of driving circuit units **310** for antenna driving to the plurality of second patterns **102A**" of the sensor unit **100A**". The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of second patterns **102A**" with the plurality of driving circuit units **310**.

[0455] The control unit **300** may control a driving signal (or pen driving signal) outputted from each driving circuit unit **310** connected to the plurality of second patterns **102A**". The control unit **300** may control opposite pulse signals to be outputted from two random driving circuit units among the plurality of driving circuit units **310** electrically connected to the plurality of second patterns **102A**". Thus, the control unit **300** may variously change and set a size and a position of the current loop.

[0456] In the stylus sensing mode (or stylus downlink mode), the control unit **300** may electrically connect the plurality of sensing circuit units **330** for stylus sensing to the plurality of second patterns **101A**" and the plurality of third patterns **103A** of the sensor unit **100A**". This aspect is different from the stylus sensing mode of the touch input device in FIG. **12**.

[0457] The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of second patterns **101A**" and the plurality of third patterns **103A** with the plurality of sensing circuit units **330**.

[0458] When compared with the touch input device in FIG. **24**, the touch input device **500**" in FIG. **27** is different in that the plurality of second patterns **102A**" of the sensor unit **100A**" is connected to the control unit **300**. That is, the plurality of second patterns **102A** of FIG. **24** are connected to the control unit **300** through the second conductive pattern after two adjacent second patterns are electrically connected by the first conductive pattern, each of the plurality of second patterns **102A**" of FIG. **27** is connected to the control unit **300** by a conductive pattern. This configuration feature

has a disadvantage in that the number of channels of the touch input device **500**" in FIG. 27 increases compared to the touch input device **500** in FIG. 24, but has an advantage of reducing power consumption because the pen driving signal is applied only to a specific portion at which the stylus pen is disposed in the antenna mode for driving the stylus pen.

[0459] Also, while in the touch input device **500** in FIG. 24, in the stylus sensing mode, a pattern for sensing a signal emitted from the stylus pen is the plurality of first patterns **101A** in the major axis direction L and the plurality of third patterns **103A** in the minor axis direction S, in the touch input device **500**" in FIG. 27, in the stylus sensing mode, a pattern for sensing a signal emitted from the stylus pen is the plurality of second patterns **102A**" in the major axis direction L and the plurality of third patterns **103A** in the minor axis direction S.

[0460] When the in the touch input device **500**" in FIG. 27, in the stylus sensing mode, a pattern for sensing a signal emitted from the stylus pen is the plurality of second patterns **102A**" in the major axis direction L instead of the plurality of first patterns **101A**, coupling capacitance between the first patterns **101A** and the second patterns **102A**" may be reduced compared to the touch input device **500** in FIG. 24. Thus, an operating frequency bandwidth of the touch driving signal and the touch sensing signal for sensing a touch position may be improved, and an operating frequency bandwidth of the pen driving signal for driving the stylus pen may be improved.

[0461] Also, since the control unit **300** receives the pen sensing signal from the stylus pen through the plurality of second patterns **102A**" in the stylus pen sensing mode, a voltage value of the received pen sensing signal is relatively high. Particularly, since, in the major axis direction L, a voltage value of the pen sensing signal received from a point spaced farthest from the control unit **300** is relatively greater than that in case of FIG. 24, sensing sensitivity may be improved. This is because the capacitive coupling between the first pattern **101A** and the second pattern **102A** is unnecessary to be considered. Specifically, in case of FIG. 24, as described above in FIG. 26A, since current flows from the second pattern **102A** to the first pattern **101A** by the capacitive coupling between the first pattern **101A** and the second pattern **102A**, the pen sensing signal inputted to the control unit **300** through the first pattern **101A** is attenuated. However, since in the touch input device **500**" in FIG. 27, the pen sensing signal is directly inputted to the control unit **300** through the second pattern **102A**" instead of the first pattern **101A** without the capacitive coupling, the attenuation of the pen sensing signal caused by the capacitive coupling does not occur.

[0462] Also, since each of the plurality of second patterns **102A**" is one channel, when the plurality of second patterns **102A**" are used as the stylus driving electrode (Stylus TX), a distance between the channels is reduced by half, and the stylus driving resolution is improved.

[0463] FIG. 28 is a view illustrating the touch input device in FIG. 22 in detail;

[0464] Referring to FIG. 28, a touch input device **500**" may include a sensor unit **100A**" and a control unit **300** for controlling the sensor unit **100A**".

[0465] The sensor unit **100A**" includes a plurality of first to fourth patterns **101A**, **102A**", **103A**, and **104A**'. Here, since the plurality of first and third patterns **101A** and **103A** are the same as the plurality of first and third patterns **101A** and **103A** in FIG. 24, a description thereof will be omitted.

[0466] Hereinafter, while the plurality of second and fourth patterns **102A**" and **104A**' are described, a description on the same portions as the plurality of second and fourth patterns **102A** and **104A** of FIG. 24 will be omitted for convenience.

[0467] One ends of the plurality of second patterns **102A**" are floated, the other ends of the plurality of second pattern **102A**" may be electrically connected to each other through a conductive pattern. Here, each of the one ends is relatively close to the control unit **300**, and each of the other ends is relatively far from the control unit **300**.

[0468] Each of one ends of the plurality of fourth patterns **104A**' is electrically connected to the control unit **300** through a conductive pattern, the other ends of the plurality of fourth patterns **104A**' are electrically connected to each other through a conductive pattern. Here, each of the one

ends is relatively close to the control unit **300**, and each of the other ends is relatively far from the control unit **300**.

[0469] An operation mode of the touch input device **500''** in FIG. **28** will be described in detail.

[0470] In the touch driving/sensing mode, the control unit **300** may electrically connect the plurality of driving circuit units **310** to the plurality of first patterns **101A** of the sensor unit **100A''** for sensing a position of a touch of an object such as a finger. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of first patterns **101A** with the plurality of driving circuit units **310**.

[0471] Also, the control unit **300** may electrically connect the plurality of sensing circuit units **330** for sensing a position of a touch to the plurality of third pattern **103A** of the sensor unit **100A''**. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of third patterns **103A** with the plurality of sensing circuit units **330**.

[0472] In the driving/touch sensing mode, the control unit **300** simultaneously or sequentially applies a driving signal (or touch driving signal) for touch sensing to the plurality of first patterns **101A** and receives a sensing signal (or touch sensing signal) received from the plurality of third patterns **103A**. The plurality of sensing circuit units of the control unit **300** electrically connected to the plurality of third patterns **103A** may output information on capacitance variation contained in the input sensing signal as a predetermined voltage value. The control unit **300** may process the outputted voltage value to detect a touch position.

[0473] In the antenna driving mode (or stylus driving mode, or stylus uplink mode), the control unit **300** may electrically connect the plurality of driving circuit units **310** for antenna driving to the plurality of fourth patterns **104A'** of the sensor unit **100A'''**. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of fourth patterns **104A'** with the plurality of driving circuit units **310**.

[0474] The control unit **300** may control a driving signal (or pen driving signal) outputted from each driving circuit unit **310** connected to the plurality of fourth patterns **104A'**. The control unit **300** may control opposite driving signals to be outputted from two random driving circuit units among the plurality of driving circuit units **310** electrically connected to the plurality of fourth **104A'**. Thus, the control unit **300** may variously change and set a size and a position of the current loop.

[0475] In the stylus sensing mode (or stylus downlink mode), the control unit **300** may electrically connect the plurality of sensing circuit units **330** for stylus sensing to the plurality of first patterns **101A** of the sensor unit **100A''** and the plurality of fourth patterns **104A'**. This aspect is different from the stylus sensing mode of the touch input device in FIG. **24**.

[0476] The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of first patterns **101A** and the plurality of fourth patterns **104A'** with the plurality of sensing circuit units **330**.

[0477] When compared with the touch input device in FIG. **24**, the touch input device **500''** in FIG. **28** is different in that the plurality of second patterns **102A''** of the sensor unit **100A''** are not used to electrically float and drive the stylus pen through the plurality of fourth patterns **104A'**. This configuration has a disadvantage in that the number of channels of the touch input device **500''** in FIG. **28** increases compared to that of the touch input device **500** in FIG. **24**, but has an advantage in that conductive patterns connected to the one ends of the plurality of second patterns **102A** are not provided because the plurality of second patterns **102A** are not used. Thus, a thickness of the left/right bezel B may be remarkably reduced compared to that of FIG. **24**.

[0478] The touch input device in FIG. **28** has a disadvantage in that the number of total channels slightly increases compared to the touch input device in FIG. **24**, but has an advantage in that a voltage value of the stylus pen sensing signal received by the control unit **300** increases because the pen sensing signal emitted from the stylus pen is directly received through the plurality of fourth patterns **104A'**. The voltage value of the pen sensing signal received by the control unit **300** of the

touch input device in FIG. 24 increases by approximately two times.

[0479] Also, since each of the plurality of fourth patterns **104A'** is one channel, when the plurality of fourth patterns **104A'** are used as the stylus driving electrode (Stylus TX), a distance between the channels is reduced by half than the touch input device of FIG. 24, and the stylus driving resolution is improved.

[0480] Also, since the number of the TX trace channels may be reduced to $\frac{1}{4}$ to $\frac{1}{3}$ compared to the touch input device in FIG. 24, a thickness of a bezel B may be reduced.

[0481] FIG. 29 is a view illustrating the touch input device in FIG. 23 in detail;

[0482] Referring to FIG. 29, a touch input device **500'** may include a sensor unit **100A''** and the control unit **300** for controlling the sensor unit **100A'**

[0483] The sensor unit **100A''** includes the plurality of first to fourth patterns **101A'**, **102A'**, **103A**, and **104A**. Here, since the plurality of third and fourth patterns **103A** and **104A** are the same as the plurality of third and fourth patterns **103A** and **104A** in FIG. 24, a description thereof will be omitted.

[0484] Hereinafter, the plurality of second patterns **102A''** will be described, and a description on the same portion as the plurality of second patterns **101A**, **102A** of FIG. 24 will be omitted for convenience.

[0485] The first pattern **101A'** has a shape extending in the first direction. The first direction may be a major axis direction L of the screen of the touch input device. The first pattern **101A'** includes a first-a pattern **101a'** and a first-b pattern **101b'**. The first-a pattern **101a'** and the first-b **101b'** are arranged along the first direction and spaced a predetermined distance from each other. The first pattern **101A'** including the first-a pattern **101a'** and the first-b **101b'** may be referred to as Active TX (ATX).

[0486] The second pattern **102A'** has a shape extending in the first direction, is disposed adjacent to the first pattern **101A'** and is spaced a predetermined distance from the first pattern **101A'**. The second pattern **102A'** includes a second-a pattern **102a'** and a second-b pattern **102b'**. The second-a pattern **102a'** and the second-b **102b'** are arranged along the first direction and spaced a predetermined distance from each other. The second pattern **102A'** including the second-a pattern **102a'** and the second-b **102b'** may be referred to as Dummy TX (DTX).

[0487] In the plurality of first patterns **101A'**, a plurality of first-a patterns **101a'** have one ends electrically connected to the control unit **300** and the other ends that are electrically opened. Also, a plurality of first-b patterns **101b'** have one ends electrically connected to the control unit **300** and the other ends that are electrically opened. Here, each of the one ends is relatively close to the control unit **300**, and each of the other ends is relatively far from the control unit **300**.

[0488] The respective one ends of the plurality of first-a patterns **101a'** may be electrically connected to each other through the control unit **300** and a conductive pattern. The conductive patterns connecting the plurality of first-a patterns **101a'** and the control unit **300** may be arranged along a minor axis direction S in the bezel B of the touch input device **500'**.

[0489] The one ends of the plurality of first-b patterns **101b'** may be electrically connected to each other through the control unit **300** and a conductive pattern. The conductive patterns connecting the plurality of first-b patterns **101b'** and the control unit **300** may be arranged along the minor axis S in the bezel B of the touch input device **500**.

[0490] In the plurality of second patterns **102A'**, two adjacent one ends of the one ends of the plurality of second-a patterns **102a'** are electrically connected to each other by a first conductive pattern and then electrically connected to the control unit **300** through a second conductive pattern, and the other ends of the plurality of second-a patterns **102a'** are electrically connected to each other through the conductive pattern. Likewise, two adjacent one ends of the one ends of the plurality of second-b patterns **102b'** are electrically connected to each other and then electrically connected to the control unit **300** through the second conductive pattern, and the other ends of the plurality of second-b patterns **102b'** are electrically connected to each other through the conductive

pattern. Here, each of the one ends is relatively close to the control unit **300**, and each of the other ends is relatively far from the control unit **300**.

[0491] The second conductive patterns connecting the plurality of second-a and second-b patterns **102a'** and **102b'** and the control unit **300** are arranged along the minor axis direction S in the bezel B of the touch input device **500'**. Here, the second conductive patterns connecting the plurality of second-a and second-b patterns **102a'** and **102b'** and the control unit **300** may be arranged in the bezel B of the of the touch input device **500'** together with conductive patterns (not shown) connecting the plurality of first patterns **101A'** and the control unit **300**.

[0492] When the other ends of the plurality of second-a patterns **102a'** are electrically connected to each other, a total impedance is reduced because capacitances for respective second-a patterns **102a'** are added. Thus, an effect in which each of the other ends of the plurality of second-a patterns **102a'** is AC GND is obtained. Likewise, when the other ends of the plurality of second-b patterns **102b'** are electrically connected to each other, a total impedance is reduced because capacitances for respective second-b patterns **102b'** are added. Thus, an effect in which each of the other ends of the plurality of second-b patterns **102b'** is AC GND is obtained.

[0493] An operation mode of the touch input device **500'** in FIG. 29 will be described in detail.

[0494] In the touch driving/sensing mode, the control unit **300** may electrically connect the plurality of driving circuit units **310** to the plurality of first patterns **101A'** of the sensor unit **100A'** for sensing a position of a touch of an object such as a finger. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of first patterns **101A'** with the plurality of driving circuit units **310**.

[0495] Also, the control unit **300** may electrically connect the plurality of sensing circuit units **330** for sensing a position of a touch to the plurality of third patterns **103A** of the sensor unit **100A'**. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of third patterns **103A** with the plurality of sensing circuit units **330**.

[0496] In the touch driving/sensing mode, the control unit **300** simultaneously or sequentially applies a driving signal (or touch driving signal) for touch sensing to the plurality of first patterns **101A'** and receives a sensing signal (or touch sensing signal) received from the plurality of third patterns **103A**. The plurality of sensing circuit units of the control unit **300** electrically connected to the plurality of third patterns **103A** may output information on capacitance variation contained in the input sensing signal as a predetermined voltage value. The control unit **300** may process the outputted voltage value to detect a touch position.

[0497] In the antenna driving mode (or stylus driving mode, or stylus uplink mode), the control unit **300** may electrically connect the plurality of driving circuit units for antenna driving to the plurality of second a patterns **102a'** and the plurality of second b patterns **102b'** of the sensor unit **100A'**. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of second-a patterns **102a'** and the plurality of second-b patterns **102b'** with the plurality of driving circuit units **310**.

[0498] outputted from each driving circuit unit **310** connected to the plurality of second-a patterns **102a'** and the plurality of second-b patterns **102b'**. The control unit **300** may control opposite pulse signals to be outputted from two random driving circuit units among the plurality of driving circuit units **310** electrically connected to the plurality of second-a patterns **102a'** and the plurality of second-b patterns **102b'**. Thus, the control unit **300** may variously change and set a size and a position of the current loop.

[0499] In the stylus sensing mode (or stylus downlink mode), the control unit **300** may electrically connect the plurality of sensing circuit units **330** for stylus sensing to the plurality of first patterns **101A'** and the plurality of third patterns **103A'** of the sensor unit **100A'**. The control unit **300** may control a plurality of switches to electrically connect the conductive patterns connected to the plurality of first patterns **101A'** and the plurality of third patterns **103A** with the plurality of sensing circuit units **330**.

[0500] The touch input device **500'** in FIG. **29** is different from the touch input device in FIG. **24** in configuration of the plurality of first and second patterns **101A'** and **102A'** of the sensor unit **100A'**. That is, since the plurality of first and second patterns **101A'** and **102A'** are obtained by dividing the first and second patterns **101A** and **102A** of FIG. **24** into half, the number of the plurality of first and second patterns **101A'** and **103A'** is two times greater than that of the first and second patterns **101A** and **102A** of FIG. **24**.

[0501] This configuration feature has a disadvantage in that the number of channels of the touch input device **500'** in FIG. **29** increases compared to the touch input device **500** in FIG. **24**, but has an advantage of reducing power consumption because the pen driving signal is applied only to a specific portion at which the stylus pen is disposed in the antenna mode for driving the stylus pen.

[0502] The touch input device in FIG. **29** has a disadvantage in that the number of channels slightly increases compared to the touch input device in FIG. **24**, but has an advantage in that an operating frequency bandwidth of each of the touch driving signal applied to the touch driving electrode and the pen driving signal for driving the stylus pen is widened by reducing a resistance value and a capacitance value of the sensor unit **100'** because a length of each of the first pattern **101'** and the second pattern **102'** is reduced by half.

[0503] FIG. **30** is a schematic view illustrating a modified example of the sensor units **100** and **100'** in FIG. **16** or **19**.

[0504] A sensor unit **100B** in FIG. **30** may be used as the above-described sensor units of the touch input devices according to various embodiments of the present invention. Hereinafter, a specific structure and shape of the sensor unit **100B** will be described, and a description on a method for driving a touch input device including the sensor unit **100B** will be replaced by the above-described features.

[0505] Referring to FIG. **30**, the sensor unit **100B** includes a plurality of first to fourth patterns **101A**, **102A**, **103B**, and **104B**. The plurality of first to fourth patterns **101A**, **102A**, **103B**, and **104B** are arranged together on the same layer.

[0506] The first pattern **101A** has a shape extending in a first direction (width direction). The first direction may be a major axis direction of the screen of the touch input device. The first pattern **101A** may also be referred to as Active TX (ATX). The first pattern **101A** has a predetermined shape in which an electrical path is formed along the first direction (width direction).

[0507] The first pattern **101A** may include a plurality of main pattern parts and a connection pattern part connecting two adjacent main pattern parts among the plurality of main pattern parts. Here, although the main pattern part may have a diamond shape, the embodiment of the present invention is not limited thereto. For example, the main pattern part may have various shapes that are different from that of the connection pattern part.

[0508] The first pattern **101A** may have an opening in which the second pattern **102A** is disposed. The opening may have a shape corresponding to an outer shape of the first pattern **101A**. The first pattern **101A** may have a structure surrounding the second pattern **102A**. The first pattern **101A** is spaced a predetermined distance from the second pattern **102A**.

[0509] The second pattern **102A** has a shape extending in the first direction, is disposed adjacent to the first pattern **101A**, and is spaced a predetermined distance from the first pattern **101A**. The second pattern **102A** may also be referred to as Dummy TX (DTX). The second pattern **102A** may be disposed adjacent to the first pattern **101A** and have a predetermined shape in which an electrical path is formed along the first direction (width direction).

[0510] The second pattern **102A** is disposed in the first pattern **101A**.

[0511] The second pattern **102A** may include a plurality of main pattern parts and a connection pattern part connecting two adjacent main pattern parts among the plurality of main pattern parts. Here, although the main pattern part may have a diamond shape, the embodiment of the present invention is not limited thereto. For example, the main pattern part may have various shapes that are different from that of the connection pattern part.

[0512] The main pattern part of the second pattern **102A** may have a shape corresponding to that of the main pattern part of the first pattern **101A**, and the connection pattern part of the second pattern **102A** may have a shape corresponding to that of the connection pattern part of the first pattern **101A**.

[0513] The other ends (second ends) of the plurality of second patterns **102A** are electrically connected to each other by a second conductive pattern.

[0514] The third pattern **103B** is disposed on each of upper and lower portions based on one connection pattern part of the first pattern **101A**. Here, although the third pattern **103B** may have a diamond shape, the embodiment of the present invention is not limited thereto. For example, the third pattern **103B** may have various shapes that are different from that of the connection pattern part. The third pattern **103B** may have an opening in which the fourth pattern **104B** is disposed. The opening may have a shape corresponding to an outer shape of the third pattern **103B**. The third pattern **103B** may have a structure surrounding the fourth pattern **104B**. The third pattern **103B** is spaced a predetermined distance from the fourth pattern **104B**. The third pattern **103B** may also be referred to as Active RX (ARX), and the fourth pattern **104B** may also be referred to as Dummy RX (DRX).

[0515] The third patterns arranged along the second direction perpendicular to the first direction among the plurality of third patterns **103B** are electrically connected by a third conductive pattern D3. Thus, the third patterns arranged along the second direction may be electrically connected by a plurality of third conductive patterns D3 and equal to a electrical connection direction (electrical path) of the third pattern **103** in FIG. **16** or **19**.

[0516] The third conductive pattern D3 is arranged so as to cross the connection pattern part of the first pattern **101A** disposed between two adjacent third patterns. The third conductive pattern D3 may also be referred to a conductive bridge. Both ends of the third conductive pattern D3 are connected to a via connected to the third pattern **103B**.

[0517] The fourth patterns arranged along the second direction perpendicular to the first direction among the plurality of fourth patterns **104B** are electrically connected by a fourth conductive pattern D4. Accordingly, the fourth patterns arranged along the second direction may be electrically connected by a plurality of fourth conductive patterns D4 and equal to a electrical connection direction (electrical path) of the fourth pattern **104** in FIG. **16** or **19**.

[0518] The fourth conductive pattern D4 is arranged so as to cross the connection pattern part of the first pattern **101A** disposed between two adjacent fourth patterns. Also, the fourth conductive pattern D4 is disposed farthest from the control unit among the plurality of fourth patterns **104B** and electrically connect the fourth patterns **104B** arranged in the first direction. The fourth conductive pattern D4 may also be referred to a conductive bridge. Both ends of the fourth conductive pattern D4 are connected to a via connected to the fourth pattern **104B**.

[0519] The plurality of first to fourth patterns **101A**, **102A**, **103B**, and **104B** may be disposed on the same first layer, and the second to fourth conductive patterns D2, D3, and D4 may be disposed on the same second layer. Here, the first layer and the second layer are physically and electrically spaced apart from each other.

[0520] FIG. **31** is a view illustrating a modified example of the sensor unit in FIG. **30**.

[0521] Referring to FIG. **31**, in a sensor unit, first-1 pattern parts disposed on a first end and/or a second end of the plurality of first-1 pattern parts have a shape opened in the first direction (or horizontal direction). Thus, first-2 pattern parts disposed on the first end and/or the second end of the plurality of first-2 pattern parts may be exposed to the outside.

[0522] The first-2 pattern parts disposed on the second end of the plurality of first-2 pattern parts are electrically connected to each other through the connection pattern without the via. Here, the connection pattern may be a conductive trace. When compared with FIG. **30**, the first-2 pattern parts disposed on the second end of the plurality of first-2 pattern parts may be disposed on the same layer as the connection pattern instead of being connected through the via.

[0523] Also, in the sensor unit, second-1 pattern parts disposed on a first end and/or a second end of the plurality of second-1 pattern parts have a shape opened in the second direction (or vertical direction). Thus, second-2 pattern parts disposed on a first end and/or a second end of the plurality of second-2 pattern parts may be exposed to the outside.

[0524] The second-2 pattern parts disposed on the second end of the plurality of second-2 pattern parts are electrically connected to each other through the connection pattern without a via. Here, the connection pattern may be a conductive trace. When compared with FIG. 30, the second-2 pattern parts disposed on the second end of the plurality of second-2 pattern parts may be disposed on the same layer as the connection pattern instead of being connected through the via.

[0525] The sensor unit in FIG. 31 may be controlled by the control unit 300 and driven in one of the touch sensing mode, the antenna driving mode, and the stylus sensing mode. Specifically, in case of the touch sensing mode, the control unit 300 may control the touch driving signal to be applied to ATX1, ATX2, and ATX3 and sense a touch position by receiving a touch receiving signal from ARX1, ARX2, and ARX3. In case of the antenna driving mode, the control unit 300 may apply the pen driving signal to DTX1, DTX2, and DTX3 or DRX1, DRX2, and DRX3. In case of the stylus sensing mode, the control unit 300 may sense the position of the stylus pen by receiving the pen receiving signal from ATX1, ATX2, and ATX3 and ARX1, ARX2, and ARX3. Also, the various combinations of the <table 2> may be applied to the sensor unit 200' of FIG. 31. Thus, the sensor unit of FIG. 31 may be driven in one of the touch sensing mode, the antenna driving mode, and the stylus sensing mode through various methods by the control unit 300.

[0526] FIG. 32 is a view illustrating another modified example of the sensor unit.

[0527] Referring to FIG. 32, a structure of a main pattern part of each of first to fourth pattern parts 101', 102', 103', and 104' is different from those of FIG. 24.

[0528] In FIG. 32, the second pattern 102' or the fourth pattern 104' has an external shape of an uneven structure, and an opening of the first pattern 101' or the fourth pattern 104' has a shape corresponding to the external structure of the second pattern 102' or the fourth pattern 104'.

[0529] This structure may improve a mutual capacitance value C_m between the first pattern 101' and the second pattern 102' on the same layer and a mutual capacitance value C_m between the third pattern 103' and the fourth pattern 104' on the same layer. As the mutual capacitance C_m is improved, a voltage value outputted from the sensing circuit unit of the control unit 300 in the stylus sensing mode may increase. Thus, stylus sensing sensitivity may be improved.

[0530] Here, the modified example in FIG. 32 may be directly applied to the sensor units according to the above-described various embodiments.

[0531] FIG. 33 is another modified example of the sensor unit.

[0532] When compared with the sensor unit 100A in FIG. 24, a sensor unit 100'' in FIG. 33 further includes a plurality of fifth patterns 105 and a plurality of sixth patterns 106.

[0533] The plurality of fifth patterns 105 are disposed on the same layer (2nd layer) as the plurality of first patterns 101 and arranged in the first direction and the second direction.

[0534] Each of the fifth patterns 105 has a shape corresponding and overlapping a portion of a main pattern part of the third pattern 103 disposed on another layer (1st layer). Also, the fifth pattern 105 is electrically connected through the via and the fourth pattern 104 disposed on another layer (1st layer).

[0535] The plurality of fifth patterns 105 and the plurality of third patterns 103 may form the mutual capacitance C_m in the vertical direction. Also, since the fifth pattern 105 is electrically connected to the fourth pattern 104 in the third pattern 103, the third pattern 103 may form the mutual capacitance C_m with the fifth pattern 105 in addition to the fourth pattern 104.

[0536] The plurality of sixth patterns 106 are disposed on the same layer (first layer) as the plurality of third patterns 103 and arranged in the first direction and the second direction.

[0537] Each of the sixth patterns 106 has a shape corresponding and overlapping a portion of the main pattern part of the first pattern 101 disposed on another layer (second layer). Also, the sixth

pattern **106** is electrically connected through the via and the second pattern **102** disposed on another layer (second layer).

[0538] The plurality of sixth patterns **106** and the plurality of first patterns **101** may form the mutual capacitance C_m in the vertical direction. Also, since the sixth pattern **106** is electrically connected to the second pattern **102** in the first pattern **101**, the first pattern **101** may form the mutual capacitance C_m with the sixth pattern **106** in addition to the second pattern **102**.

[0539] As described above, the sensor unit **100''** in FIG. **33** may form the mutual capacitance in the vertical direction as well as the horizontal direction of the first pattern **101** and the mutual capacitance in the vertical direction as well as the horizontal direction of the third pattern **103**.

Thus, in the stylus sensing mode, the voltage value outputted from the sensing circuit unit of the control unit **300** may increase to improve the stylus sensing sensitivity.

[0540] Here, the modified example in FIG. **33** may be directly applied to the sensor units according to the above-described various embodiments.

[0541] FIG. **34** is a view illustrating another modified example of the sensor unit.

[0542] When compared with the sensor unit **100A** in FIG. **24**, in a sensor unit **100''** of FIG. **34**, a portion of a second pattern **102'** is disposed on a different layer from the rest portion. Specifically, the second pattern **102'** includes a plurality of main pattern parts and a connection pattern part connecting two adjacent main pattern parts of the plurality of main pattern parts, and the plurality of main pattern parts of the second pattern **102'** are disposed on a different layer from the plurality of connection pattern parts of the second pattern **102'**.

[0543] The plurality of main pattern parts of the second pattern **102'** are disposed on the same layer as the third pattern **103** and the fourth pattern **104**, and the plurality of connection pattern parts of the second pattern **102'** are disposed on the same layer as the first pattern **100** as with FIG. **24**.

[0544] The sensor unit **100'''** in FIG. **34** may be also driven in the touch sensing mode, the antenna driving mode, and the stylus sensing mode by the control unit **300** as with the sensor unit **100A** in FIG. **24**. Also, the various combinations of the <table 2> may be applied to the sensor unit **100'''** of FIG. **34**. Thus, the sensor unit **100'''** of FIG. **34** may be driven in one of the touch sensing mode, the antenna driving mode, and the stylus sensing mode through various methods by the control unit **300**.

[0545] FIG. **35** is a view illustrating another modified example of the sensor unit.

[0546] When compared with the sensor unit **100'''** in FIG. **34**, in a sensor unit **100''''** in FIG. **35**, a portion of a fourth pattern **104'** is disposed on a different layer from the rest portion. Specifically, the fourth pattern **104'** includes a plurality of main pattern parts and a connection pattern part connecting two adjacent main pattern parts of the plurality of main pattern parts, and the plurality of main pattern parts of the fourth pattern **104'** are disposed on a different layer from the plurality of connection pattern parts of the fourth pattern **104'**. The plurality of main pattern parts of the fourth pattern **104'** are disposed on the same layer as the first pattern **101**, and the plurality of connection pattern parts of the fourth pattern **104'** are disposed on the same layer as the plurality of main pattern parts of the second pattern **102'** and the third pattern **103**.

[0547] In summary, in the sensor unit **100''''** in FIG. **35**, the first pattern **101**, the plurality of connection pattern part of the second pattern **102**, and the plurality of main pattern parts of the fourth pattern **104'** are disposed on the first layer, and the third pattern **103**, the plurality of connection pattern part of the fourth pattern **104'**, and the plurality of main pattern part of the second pattern **102'** are disposed on the second layer. Here, the first layer and the second layer are different from each other, and a position relationship is that one is disposed on the other.

[0548] The sensor unit **100''''** in FIG. **35** may be also driven in the touch sensing mode, the antenna driving mode, and the stylus sensing mode by the control unit **300** as with the sensor unit **100A** in FIG. **24**. Also, the various combinations of the <table 2> may be applied to the sensor unit **100''''** of FIG. **35**. Thus, the sensor unit **100''''** of FIG. **35** may be driven in one of the touch sensing mode, the antenna driving mode, and the stylus sensing mode through various methods by the control unit

300.

[0549] FIG. 36 is a view illustrating another modified example of the sensor unit.

[0550] A sensor unit **100'''** in FIG. 36 is a modified from the sensor unit **100'''** in FIG. 35. When compared with the sensor unit **100'''** in FIG. 35, the sensor unit **100'''** in FIG. 36 is different in a second pattern **102''** and a fourth pattern **104''**.

[0551] Specifically, the second pattern **102''** includes a plurality of main pattern parts **102a''** and a plurality of connection pattern parts **102b'**, and the main pattern part **102a''** has a size greater than that the main pattern part of the second pattern **102'** of the sensor unit **100'''** in FIG. 35. The main pattern part **102a''** may have a size and a shape corresponding to those of the main pattern part of the first pattern **101**.

[0552] Also, the fourth pattern **104''** includes a plurality of main pattern parts **104a''** and a plurality of connection pattern parts **104b'**, and the main pattern part **104a''** has a size greater than that of the main pattern part of the fourth pattern **104'** of the sensor unit **100'''** in FIG. 35. The main pattern part **104a''** may have a size and a shape corresponding to those of the main pattern part of the third pattern **103**.

[0553] Since the main pattern part **102a''** of the second pattern **102''** has a size greater than that of the main pattern part of the second pattern **102'** in FIG. 35, an area corresponding to the first pattern **101** may increase to further improve the mutual capacitance C_m between the second pattern **102''** and the first pattern **101**. Thus, the stylus sensing sensitivity may be further improved in the stylus sensing mode.

[0554] Since the main pattern part **104a''** of the fourth pattern **104''** has a size greater than that of the main pattern part of the fourth pattern **104'** in FIG. 35, an area corresponding to the third pattern **103** may increase to further improve the mutual capacitance C_m between the fourth pattern **104''** and the third pattern **103**. Thus, the stylus sensing sensitivity may be further improved in the stylus sensing mode.

[0555] FIG. 37 is a view illustrating another modified example of the sensor unit.

[0556] When compared with the sensor unit **100A** in FIG. 24, a sensor unit **100''''** in FIG. 37 is different in that the other ends (second ends) of the plurality of second patterns **102** are electrically connected to the other ends (second ends) of the plurality of fourth patterns **104**.

[0557] This configuration has an advantage of reducing an impedance because the plurality of second patterns **102** as well as other fourth patterns are electrically connected to one fourth pattern **104** when the sensor unit **100'** is driven in the stylus sensing mode.

[0558] The sensor unit **100''''** in FIG. 37 may be also driven in the touch sensing mode, the antenna driving mode, and the stylus sensing mode by the control unit **300** as with the sensor unit **100A** in FIG. 24. Also, the various combinations of the <table 2> may be applied to the sensor unit **100''''** of FIG. 37. Thus, the sensor unit **100''''** of FIG. 37 may be driven in one of the touch sensing mode, the antenna driving mode, and the stylus sensing mode through various methods by the control unit **300**.

[0559] FIG. 38 is a view illustrating another modified example of the sensor unit.

[0560] When compared with the sensor unit **100A** in FIG. 24, a sensor unit **100''''** in FIG. 38 is different in a second pattern **102'** and a fourth pattern **104'** and further includes a plurality of fifth patterns **105'**, a plurality of sixth patterns **106'**, and a capacitor cap electrically connected to the fifth patterns **105'** and the sixth patterns **106'**. Since the rest components are the same as each other, different portions will be described in detail below.

[0561] The second pattern **102'** may be a bar pattern disposed in the first pattern **101** and extending in the second direction. Here, the second pattern **102'** may have a constant width. The second pattern **102'** is disposed on the same layer (2nd layer) as the first pattern **101**.

[0562] The fourth pattern **104'** may be a bar pattern disposed in the third pattern **103** and extending in the first direction. Here, the fourth pattern **104'** may have a constant width. The fourth pattern **104'** is disposed on the same layer (1st layer) as the third pattern **103**.

[0563] The plurality of fifth patterns **105'** are disposed on the same layer (2nd layer) as the plurality of first patterns **101** and arranged in the first direction and the second direction. The plurality of fifth patterns **105'** may be arranged between the plurality of first patterns **101**.

[0564] Each of the fifth patterns **105'** has a shape corresponding to and overlapping a main pattern part of the third pattern **103** disposed on a different layer (1st layer). Also, the fifth pattern **105'** is electrically connected through the via and the fourth pattern **104'** disposed on another layer (1st layer).

[0565] The fifth patterns **105'** electrically connected to one fourth pattern **104'** among the plurality of fifth patterns **105'** are arranged in the second direction. Here, a predetermined capacitor cap is connected to the fifth pattern **105'** disposed at the other edge among the fifth patterns **105'** arranged in the second direction. Also, the capacitor cap may be grounded. Here, the fifth pattern **105'** disposed at the other edge among the fifth patterns **105'** arranged in the second direction represents a pattern electrically connected to and spaced farthest from the control unit **300** in FIG. 24

Although not shown in the drawing, the capacitor cap may be connected between the fifth pattern **105'** and ELVSS of a display panel (not shown). Also, the capacitor cap may have one end connected to the fifth pattern **105'** and the other end connected to another layer (1st layer) on which the third pattern **103**, the fourth pattern **104'**, and sixth pattern **106'** are disposed.

[0566] The plurality of fifth patterns **105'** may form the mutual capacitance C_m in the vertical direction with the plurality of third patterns **103**. Also, since the fifth pattern **105'** is electrically connected to the fourth pattern **104'** in the third pattern **103**, the third pattern **103** may form the mutual capacitance C_m with the fifth pattern **105'** in addition to the fourth pattern **104'**.

[0567] The plurality of sixth patterns **106'** are disposed on the same layer (1st layer) as the plurality of third patterns **103** and arranged in the first direction and the second direction. The plurality of sixth patterns **106'** may be arranged between the plurality of third patterns **103**.

[0568] Each of the sixth patterns **106'** has a shape corresponding to and overlapping the main pattern part of the first pattern **101** disposed on another layer (2nd layer). Also, the sixth pattern **106'** is electrically connected through the via and the second pattern **102'** disposed on another layer (2nd layer).

[0569] The sixth patterns **106'** electrically connected to one second pattern **102'** among the plurality of sixth patterns **106'** are arranged in the first direction. Here, a predetermined capacitor cap is connected to the sixth pattern **106'** disposed at the other edge among the sixth patterns **106'** arranged in the first direction. Also, the capacitor cap may be grounded. Here, the sixth pattern **106'** disposed at the other edge among the sixth patterns **106'** arranged in the first direction represents a pattern electrically connected to and spaced farthest from the control unit **300** in FIG. 24 Although not shown in the drawing, the capacitor cap may be connected between the sixth pattern **106'** and the ELVSS of the display panel (not shown). Also, the capacitor cap may have one end connected to the sixth pattern **106'** and the other end connected to another layer (2nd layer) on which the third pattern **101**, the second pattern **102'**, and the fifth pattern **105'** are disposed.

[0570] The plurality of sixth patterns **106'** may form the mutual capacitance C_m in the vertical direction with the plurality of first patterns **101**. Also, since the sixth pattern **106'** is electrically connected to the second pattern **102'** in the first pattern **101**, the first pattern **101** may form the mutual capacitance C_m with the sixth pattern **106'** in addition to the second pattern **102'**.

[0571] As described above, the sensor unit **100''''''** in FIG. 38 may form the mutual capacitance in the vertical direction as well as the horizontal direction of the first pattern **101** and the mutual capacitance in the vertical direction as well as the horizontal direction of the third pattern **103**. Thus, in the stylus sensing mode, the voltage value outputted from the sensing circuit unit of the control unit **300** may increase to improve the stylus sensing sensitivity.

[0572] Since each of the second pattern **102'** and the fourth pattern **104'** does not have a diamond-shaped main pattern part unlike the second pattern **102** and the fourth pattern **104** of the sensor unit **100A** of FIG. 24, when the display panel is disposed below the sensor unit **100''''''**, visibility may

be further improved in comparison with the sensor unit **100A** of FIG. **24**.

[0573] The sensor unit **100** in FIG. **38** may be also driven in the touch sensing mode, the antenna driving mode, and the stylus sensing mode by the control unit **300** as with the sensor unit **100A** in FIG. **24**. Also, the various combinations of the <table 2> may be applied to the sensor unit **100** of FIG. **38**. Thus, the sensor unit **100** of FIG. **38** may be driven in one of the touch sensing mode, the antenna driving mode, and the stylus sensing mode through various methods by the control unit **300**.

[0574] Although not shown in the drawing, the capacitor cap may be electrically connected to the other ends of the plurality of second and fourth patterns **102** and **104** without the fifth and sixth patterns **105'** and **106'**. Furthermore, in the above-described sensor units according to various embodiments, the other ends of the plurality of second and fourth patterns may be connected to the capacitor instead of being connected to each other.

[0575] FIG. **39** is a view illustrating another modified example of the sensor unit.

[0576] In case of the sensor unit **100A** of FIG. **24**, when the stylus pen **10** is disposed on a right edge (or left edge) of the sensor unit **100A**, the stylus pen **10** may not provide a sufficient magnetic field, and a magnitude of a signal emitted from the stylus pen **10** is not large enough. In order to solve the above-described problem, a sensor unit **100** in FIG. **39** further includes a first trace t1 and a second trace t2 in comparison with the sensor unit **100A** in FIG. **24**.

[0577] The first trace t1 and the second trace t2 are directly connected to a conductive trace t0 electrically connecting the other end of the plurality of second patterns **102** to each other and disposed on a non-active area outside an active area tp (or touch area) of the touch input device. Here, at least a portion of the conductive trace t0 may be disposed outside the active area tp. The active area tp represents an area that is directly touched by an object, e.g., a finger or the stylus pen **10**, and the non-active area is disposed around the active area tp. The non-active area may be, e.g., a bezel area.

[0578] Specifically, the first trace t1 may be disposed on the non-active area outside the active area tp, and have one end directly connected to the conductive trace t0 and the other end connected to the driving circuit unit of the control unit **300** through a switch sw in one of the touch driving mode, the touch sensing mode, the antenna driving mode, and the stylus sensing mode.

[0579] The second trace t2 may be disposed on the non-active area outside the active area tp and have one end directly connected to the conductive trace t0 and the other end connected to the driving circuit unit of the control unit **300** through a switch sw in the antenna driving mode.

[0580] The first trace t1 may be disposed on the non-active area while surrounding one side of both left and right sides of the active area tp, and the second trace t2 may be disposed on the non-active area while surrounding the other side of the active area tp.

[0581] Although the stylus pen **10** is disposed at one edge of the active area tp when the first trace t1, the second trace t2, and the sensor unit **100** are driven in the antenna driving mode as with FIG. **25**, the stylus pen may provide a sufficient magnetic field signal. Thus, in the touch input device including the sensor unit **100** in FIG. **39**, the stylus pen **10** may receive a sufficient magnetic field signal and emit a sufficient signal although the stylus pen **10** is disposed on any portion of the active area tp.

[0582] Each of the first and second traces t1 and t2 of the sensor unit **100** in FIG. **39** may correspond to one channel in FIG. **25**, and the driving method such as that in FIG. **25** may be directly used.

[0583] The sensor unit **100** in FIG. **39** may be also driven in the touch sensing mode, the antenna driving mode, and the stylus sensing mode by the control unit **300** as with the sensor unit **100A** in FIG. **24**. Also, the various combinations of the <table 2> may be applied to the sensor unit **100** of FIG. **39**. Thus, the sensor unit **100** of FIG. **39** may be driven in one of the touch sensing mode, the antenna driving mode, and the stylus sensing mode through various methods by the control unit **300**.

[0584] FIG. 40 is a view for explaining a first modified example of the fifth pattern 105 in FIG. 33.

[0585] Referring to FIG. 40, a fifth pattern 105' is disposed on a layer different from a layer on which the third pattern 103 and the fourth pattern 104 are disposed.

[0586] The fifth pattern 105' may have a shape corresponding to the third pattern 103. For example, the fifth pattern 105' may have a diamond shape and a diamond-shaped opening therein.

[0587] The fifth pattern 105' may have one portion overlapping the third pattern 103 in the vertical direction and the other portion overlapping the fourth pattern 104 in the vertical direction. For example, an outer edge of the fifth pattern 105' may overlap an inner edge of the third pattern 103 disposed on another layer. Also, an inner edge of the fifth pattern 105' may overlap an outer edge of the fourth pattern 104 disposed on another layer.

[0588] The fifth pattern 105' is electrically connected to the fourth pattern 104 disposed on another layer through a conductive via v. Here, the via v may be provided in plurality, and a plurality of vias v may be arranged on outer edge of the fourth pattern 104.

[0589] The plurality of fifth patterns 105' may form the mutual capacitance C_m in the vertical direction with the third patterns 103 disposed on another layer. Also, since the fifth pattern 105' is electrically connected to the fourth pattern 104 in the third pattern 103 through the via v, the third pattern 103 may form a mutual capacitance C_{c_tx} with the fifth pattern 105' in addition to the fourth pattern 104.

[0590] Although not shown in the drawing, the sixth pattern 106 in FIG. 33 may have the same shape as the fifth pattern 105' in FIG. 40. Here, a sixth pattern (not shown) may have an outer edge overlapping an inner edge of the first pattern 101 disposed on another layer and an inner edge overlapping an outer edge of the second pattern 102 disposed on another layer. Also, the sixth pattern (not shown) may be electrically connected to the second pattern 102 disposed on another layer through the conductive via. Likewise, the sixth pattern (not shown) may form the mutual capacitance in the vertical direction with the first pattern 101. Since the sixth pattern (not shown) is electrically connected to the second pattern 102 in the first pattern 101, the first pattern 101 may form the mutual capacitance C_{c_tx} with the sixth pattern (not shown) in addition to the second pattern 102.

[0591] As described above, the sensor unit including the modified example of the fifth pattern 105' in FIG. 40 may form the mutual capacitance in the vertical direction as well as the horizontal direction of the third pattern 103, and the sensor unit including the modified example of the sixth pattern (not shown) may also form the mutual capacitance in the vertical direction as well as the horizontal direction of the first pattern 101. Thus, in the stylus sensing mode, the voltage value outputted from the sensing circuit unit of the control unit may increase to improve the stylus sensing sensitivity.

[0592] FIG. 41 is a view illustrating a modified example of FIG. 40; and

[0593] FIG. 40 is a view illustrating a state in which the fifth pattern 105' is disposed below the third and fourth patterns 103 and 104, and on the contrary, FIG. 41 is a view illustrating a state in which the fifth pattern 105' is disposed on the third and fourth patterns 103 and 104.

[0594] A structure of the fifth pattern 105'' in FIGS. 40 and 41 may be applied to the above-described sensor units according to various embodiments.

[0595] FIG. 42 is a view for explaining a modified example of the fifth pattern 105' in FIG. 40.

[0596] Referring to FIG. 42, a fifth pattern 105'' has the same shape and position as the fifth pattern 105' in FIG. 40. The fifth pattern 105'' is different from the fifth pattern 105' in FIG. 40 in that the fifth pattern 105'' is electrically connected to the third pattern 103 disposed on another layer through the conductive via v. Also, the via v is disposed on an inner edge of the third pattern 103.

[0597] Since the fifth pattern 105'' is electrically connected to the third pattern 103 disposed on another layer, the fourth pattern 104 may form a mutual capacitance C_{c_Tx} in the vertical direction with the fifth pattern 105''.

[0598] Also, the sensor unit including the modified example of the fifth pattern 105'' in FIG. 42

may form the mutual capacitance in the vertical direction as well as the horizontal direction.

[0599] FIG. **43** is a view illustrating a modified example of FIG. **42**.

[0600] FIG. **42** is a view illustrating a state in which the fifth pattern **105''** is disposed below the third and fourth patterns **103** and **104**, and on the contrary, FIG. **43** is a view illustrating a state in which the fifth pattern **105''** is disposed on the third and fourth patterns **103** and **104**.

[0601] A structure of the fifth pattern **105''** in FIGS. **42** and **43** may be applied to the above-described sensor units according to various embodiments.

[0602] FIGS. **44** and **45** are views for explaining modified examples of the third pattern **103** and the fourth pattern **104** in the sensor unit in FIG. **34** or **35**.

[0603] Referring to FIGS. **44** and **45**, the third pattern **103** and the fourth pattern **104** according to a modified example are disposed on different layers, and a portion of the third pattern **103** and a portion of the fourth pattern **104** overlap each other in the vertical direction. For example, an inner edge of the third pattern **103** may overlap an outer edge of the fourth pattern **104** in the vertical direction. FIG. **44** is a view illustrating a state in which the third pattern **103** is disposed on the fourth pattern **104**, and FIG. **45** is a view illustrating a state in which the third pattern **103** is disposed below the fourth pattern **104**.

[0604] A sensor unit including the third and fourth patterns **103** and **104** in FIGS. **44** and **45** may form the mutual capacitance C_{c_Tx} in the vertical direction instead of the horizontal direction. Although not shown in the drawing, the first and second patterns **101** and **102** in FIGS. **34** and **35** may have the same structures as that in FIGS. **44** and **45**.

[0605] A structure according to the modified example in FIGS. **44** and **45** may be applied to the above-described various embodiments.

[0606] FIG. **46** is a schematic view illustrating a portion of a touch input device according to another embodiment.

[0607] A touch unit **260** (or touch device) contained in the touch input device according to another embodiment includes a touch panel **261** and a touch controller **262** controlling the touch panel **261**. The touch controller **262** may include a first driver/receiver **2620** and a second driver/receiver **2622** that transmits and receives a signal with the touch panel **261** and a control unit **2624**.

[0608] The touch panel **261** may include a plurality of first touch electrodes **111-1** to **111-m** for detecting touch coordinates in a first direction and a plurality of second touch electrodes **121-1** to **121-n** for detecting touch coordinates in a second direction crossing the first direction. For example, the plurality of first touch electrodes **111-1** to **111-m** may each have a shape extending in the second direction, and the plurality of second touch electrodes **121-1** to **121-n** may each have a shape extending in the first direction. In the touch panel **261**, the plurality of first touch electrodes **111-1** to **111-m** may be arranged in the first direction, and the plurality of second touch electrodes **121-1** to **121-n** may be arranged in the second direction.

[0609] The first driver/receiver **2620** may apply a driving signal to the plurality of first touch electrodes **111-1** to **111-m**. The second driver/receiver **2622** may receive a sensing signal from the plurality of second touch electrodes **121-1** to **121-n**.

[0610] Although the touch panel **261** is implemented in a mutual capacitance method as described above, the touch panel **261** may be implemented in a self-capacitance method. Here, a person skilled in the art may easily modify the mutual capacitance method into the self-capacitance method by appropriately changing the touch electrodes **111-1** to **111-m** and **121-1** to **121-n**, the first driver/receiver **2620**, and the second driver/receiver **2622** in the mutual capacitance method, adding new components, or omitting some components.

[0611] That is, the touch panel **261** may include a plurality of self-capacitance type touch electrodes (or touch patterns). In this case, the touch electrodes (or touch patterns) may be arranged in a dot shape or arranged in a shape extending in one direction as described above.

[0612] Next, the electrode (or pattern) and the trace will be described with reference to FIG. **47**.

[0613] FIG. **47** is a view illustrating an example of an arrangement form of the trace and the

electrode (or pattern) of the touch unit according to an embodiment.

[0614] The sensor unit of the touch unit may include touch electrodes **111** and **121** and an antenna connected to a dummy electrode. For example, a plurality of dummy electrodes **121D** and the touch electrodes are disposed on the same layer, and some of the plurality of the dummy electrodes **121D** are connected to each other by a bridge **121B**. The bridge **121B** may be connected to pads **113a** and **113b** through a trace **112**.

[0615] The touch controller **262** may apply a driving signal to an antenna **121A** in order to resonate the stylus pen **10**. The driving signal may include a signal (e.g., sine wave or square wave) having a frequency corresponding to a resonance frequency of the resonance circuit unit **12** and may be an AC voltage or AC current having a predetermined frequency. The driving signal may have a frequency and a magnitude that are changed according to control of the control unit **2624**. Specifically, the touch controller **262** may apply a driving signal to one of two adjacent bridges **121B** and allow the other to be grounded.

[0616] The touch electrodes **111** and **121** are connected to the pads **113a** and **113b** through the traces **112**, **122a**, and **122b** disposed on a peripheral area disposed on an edge of the touch area. First touch electrodes **111-1**, **111-2**, **111-3**, . . . are respectively connected to the traces **112** in a corresponding manner, and second touch electrodes **121-1**, **121-2**, **121-3**, . . . are respectively connected to the traces **122a** and **122b**.

[0617] The touch electrodes **111** and **121** and the traces **112**, **122a**, and **122b** may be formed on the same layer. The touch electrodes **111** and **121** and the traces **112**, **122a**, and **122b** may be made of a conductive material having a high transmittance and a low impedance as with a metal mesh and a silver nanowire. Alternatively, the touch electrodes **111** and **121** and the traces **112**, **122a**, and **122b** may be disposed on different layers and made of ITO and graphene. However, the embodiment of the present invention is not limited thereto.

[0618] The pads **113a** and **113b** are connected to the touch controller **262**. The pads **113a** and **113b** transmit a signal (e.g., driving signal) of the touch controller **262** to the touch electrodes **111** and **121** and a signal (e.g., sensing signal) from the touch electrodes **111** and **121** to the touch controller **262**.

[0619] FIG. **48** is a view illustrating another example of the arrangement form of the trace and the electrode (or pattern) of the touch unit according to an embodiment.

[0620] As with FIG. **47**, the touch electrodes **111** and **121** are connected to the pads **113a** and **113b** through the traces **112**, **122a**, and **122b** disposed on a peripheral area disposed the edge of the touch area.

[0621] One touch electrode has two signal input terminals, and the two signal input terminals are connected to correspond to two traces in a corresponding manner. For example, the second touch electrode **121-9** that is a “U”-shaped electrode has a first signal input terminal **TE1** disposed at an upper side and a second signal input terminal **TE2** disposed at a lower side.

[0622] One of the two signal input terminals may be connected to the ground or the driver/receiver **2620** through a switch. For example, the first signal input terminal **TE1** is connected to the driver/receiver **2620**, and the second signal input terminal **TE2** is connected to a switch **SW**. The switch **SW** connects the second signal input terminal **TE2** to the ground or the driver/receiver **2620**.

[0623] The touch controller **262** may connect one signal input terminal to the ground and apply a driving signal to resonate the stylus pen **10**. The touch controller **262** may simultaneously receive sensing signals from two signal input terminals. Also, the touch controller **262** may apply driving signals having the same phase to two signal input terminals in case of driving for a general finger touch.

[0624] Although one signal input terminal is connected to the ground and the driving signal is applied as described above, the touch controller **262** may apply driving signals having opposite phases to the two signal input terminals.

[0625] Next, signals induced to the touch electrodes **111** and **121** and the traces **112**, **122a** and **122b**

when the stylus pen **10a** or **10b** is disposed on the touch screen **20** will be described with reference to FIG. **49**.

[0626] FIG. **49** is a view illustrating a case in which the stylus pen is disposed on the sensor unit of the touch unit according to an embodiment.

[0627] As illustrated in FIG. **49**, the inductor unit **14** of the stylus pen **10a** and **10b** is disposed between first touch electrodes **111-5** and **111-6** and between second touch electrodes **121-8** and **121-9** on the touch screen **20**.

[0628] The stylus pens **10a** and **10b** are resonated by a driving signal applied to the touch electrodes **111** and **121** having the antenna **121A** of two signal input terminals. A current I_r flowing through the coil of the inductor unit **14** flows by resonance. The current I_r causes an eddy current to the touch electrodes **111** and **121** and the traces **112**, **122a** and **122b**. The eddy current is formed in a direction opposite to the direction of the current I_r .

[0629] Therefore, currents I_{a1} and I_{a2} are formed in the first touch electrodes **111-4** and **111-5** disposed at a left side ($-X$ -axis direction) of the inductor unit **14** in a $-Y$ -axis direction, and currents I_{a3} and I_{a4} are formed in the first touch electrodes **111-6** and **111-7** disposed at a right side ($+X$ -axis direction) of the inductor unit **14** in a $+Y$ -axis direction. That is, directions of the currents induced to the first touch electrodes **111-1** to **111-5** and directions of currents induced to the first touch electrodes **111-6** to **111-10** are opposite to each other.

[0630] Currents I_{b1} and I_{b2} are formed in the second touch electrodes **121-7** and **121-8** disposed at an upper side ($+Y$ -axis direction) of the inductor unit **14** in the $-X$ -axis direction, and currents I_{b3} and I_{b4} are formed in the second touch electrodes **121-9** and **121-10** disposed at a lower side ($-Y$ -axis direction) of the inductor unit **14** in the $+X$ -axis direction. That is, directions of currents induced to the second touch electrodes **121-1** to **121-8** and directions of currents induced to the second touch electrodes **121-9** to **121-16** are opposite to each other.

[0631] Currents I_{c1} and I_{c2} are formed in the traces **122a** disposed at a left side of the inductor unit **14** in the $-Y$ -axis direction, and currents I_{c3} and I_{c4} are formed in the traces **122b** disposed at a right side of the inductor unit **14** in the $+Y$ -axis direction. That is, directions of currents induced to the traces **122a** and directions of currents induced to the traces **122b** are opposite to each other.

[0632] Also, directions of currents induced to the second touch electrodes **121-1** to **121-8** and directions of currents induced to the traces **122a** connected to the second touch electrodes **121-1** to **121-8** are the same as each other. Directions of currents induced to the second touch electrodes **121-9** to **121-16** and directions of currents induced to the traces **122b** connected to the second touch electrodes **121-9** to **121-16** are opposite to each other.

[0633] In terms of a direction of a current at one point based on the pads **113a** and **113b**, a current may flow from the second touch electrodes **121-1** to **121-8** to the pad **113a**. The current may flow from the pad **113b** to the second touch electrodes **121-9** to **121-16** and the traces **122b** or flow from the second touch electrodes **121-9** to **121-16** to the pad **113b** according to a magnitude of the current induced to the second touch electrodes **121-9** to **121-16** and the traces **122b** connected thereto. However, since the inductor unit **14** of the stylus pen **10** is disposed closer to the second touch electrodes **121-9** to **121-16** than the traces **122b** in FIG. **49**, a current may flow to the pads **113b** from the second touch electrodes **121-9** to **121-16**.

[0634] Besides, since the stylus pen **10b** of FIG. **4B** outputs an electric field signal E to the touch electrodes **111** and **121**, a sensing signal caused by the electric field signal E applied to the first touch electrodes **111-5** and **111-6** and the second touch electrodes **121-8** and **121-9** is received.

[0635] In relation to this, a method for measuring a signal of the touch unit **260** will be described with reference to FIG. **50**.

[0636] FIG. **50** is a graph representing a method for measuring a signal of the touch unit according to embodiments in FIGS. **48** and **49**.

[0637] FIG. **50** shows a voltage variation V_8 of the second touch electrode **121-8** and a voltage variation V_9 of the second touch electrode **121-9**, in which currents are induced in opposite

directions.

[0638] The first driver/receiver **2620** and the second driver/receiver **2622** perform sampling of the voltage variation corresponding to a frequency of the driving signal in order to measure a sensing signal according to the voltage variation. At least one sampling time point (I, Q, IB, and QB) may be an arbitrary timing that is periodically set in relation to the frequency of the driving signal. For example, a period between I and I is equal to a half of the frequency of the driving signal.

[0639] The sensing signal includes a difference (AI) between voltage values measured at a time point I and at a time point IB and/or a difference (ÄQ) between voltage values measured at a time point Q and at a time point QB.

[0640] Next, a sensing signal caused by the touch screen **10b** of FIG. **4B** will be described in detail with reference to FIGS. **51** and **52**.

[0641] FIGS. **51** and **52** are graphs representing a sensing signal caused by the stylus pen according to an embodiment.

[0642] FIG. **51** is a graph representing a sensing signal received from the first touch electrodes **111-1** to **111-10**.

[0643] As illustrated in FIG. **51**, since directions of currents between the first touch electrodes **111-1** to **111-5** and the first touch electrodes **111-6** to **111-10** are induced in opposite directions, a sensing signal AB1 measured thereby has opposite signs in the first touch electrode **111-5** and the first touch electrode **111-6**. Also, since the induced current gradually increases in a direction toward the inductor unit **14**, a magnitude of the current induced to the first touch electrode **111-5** and the first touch electrode **111-6** is greater than that of current induced to the other first touch electrode **111-1** to **111-4** and **111-7** to **111-10**.

[0644] Since the stylus pen **10b** outputs the electric field signal E to the first touch electrode **111-5** and the first touch electrode **111-6** through the conductive tip **11b**, a sensing signal AE1 generated thereby is received.

[0645] A sensing signal AC1 received by the first driver/receiver **2620** has a shape in which a sensing signal AB1 and a sensing signal AE1 are combined. In this case, the control unit **2624** may determine, as a touch point, a position between the two first touch electrodes **111-5** and **111-6** at which a difference in magnitude of the sensing signal AC1 is maximum, and an exact touch point may be calculated by interpolation or the like.

[0646] FIG. **52** is a graph representing a sensing signals received from the second touch electrodes **121-1** to **121-16**.

[0647] As illustrated in FIG. **52**, since directions of currents between the second touch electrodes **121-1** to **121-8** and the second touch electrodes **121-9** to **121-16** are induced in opposite directions, a sensing signal AB2 measured thereby has opposite signs in the second touch electrode **121-8** and the second touch electrode **121-9**. Also, since the induced current gradually increases in the direction toward the inductor unit **14**, a magnitude of the current induced to the first touch electrode **121-8** and the first touch electrode **121-9** is greater than that of current induced to the other first touch electrode **121-2** to **121-7** and **121-10** to **121-16**.

[0648] Since the stylus pen **10b** outputs the electric field signal E to the second touch electrode **121-8** and the second touch electrode **121-9** through the conductive tip **11b**, a sensing signal AE2 generated thereby is received.

[0649] A sensing signal AC2 received by the second driver/receiver **2622** has a shape in which the sensing signal AB2 and the sensing signal AE2 are combined. In this case, the control unit **2624** may determine, as a touch point, a position between the two second touch electrodes **121-8** and **121-9** at which a difference in magnitude of the sensing signal AC2 is maximum, and an exact touch point may be calculated by interpolation or the like.

[0650] Next, a sensing signal caused by the stylus pen **10a** of FIG. **4A** will be described in detail with reference to FIGS. **53** and **54**.

[0651] FIGS. **53** and **54** are graphs representing a sensing signal caused by the stylus pen according

to another embodiment.

[0652] FIG. 53 is a graph representing a sensing signal received from the first touch electrodes **111-1** to **111-10**.

[0653] As illustrated in FIG. 53, since directions of currents between the first touch electrodes **111-1** to **111-5** and the first touch electrodes **111-6** to **111-10** are induced in opposite directions, a sensing signal **AB3** received by the first driver/receiver **2620** has opposite signs in the first touch electrode **111-5** and the first touch electrode **111-6**. Also, since the induced current gradually increases in the direction toward the inductor unit **14**, a magnitude of the current induced to the first touch electrode **111-5** and the first touch electrode **111-6** is greater than that of current induced to the other first touch electrode **111-1** to **111-4** and **111-7** to **111-10**.

[0654] In this case, the control unit **2624** may determine a touch point between the two first touch electrodes **111-5** and **111-6** in which sensing signals **AB3** have opposite signs and each have a great magnitude, and an exact touch point may be calculated by using interpolation. In this case, the control unit **2624** may determine, as a touch point, an area having a maximum value obtained by differentiating the sensing signal **AB3**. Alternatively, the control unit **2624** may receive a differential signal from two adjacent first touch electrodes among the first touch electrodes **111-1** to **111-10** and determine a touch point of the stylus pen based on a maximum value or a minimum value in the received differential signal. For example, an area having the maximum value or the minimum value in the received differential signal may be determined as the touch point. Here, the two adjacent first touch electrodes may be two adjacent first touch electrodes **111-1** and **111-2** or **111-2** and **111-3**. Alternatively, the two adjacent first touch electrodes are two first touch electrodes **111-1** and **111-3** or **111-2** and **111-4** that are not neighbored to each other, and at least one another first touch electrode **111-2** or **111-3** may be disposed between the first touch electrodes **111-1** and **111-3** or **111-2** and **111-4**.

[0655] FIG. 54 is a graph representing a sensing signal received from the second touch electrodes **121-1** to **121-16**.

[0656] As illustrated in FIG. 54, since directions of currents between the second touch electrodes **121-1** to **121-8** and the second touch electrodes **121-9** to **121-16** are induced in opposite directions, a sensing signal **AB4** received by the second driver/receiver **2622** has opposite signs in the second touch electrode **121-8** and the second touch electrode **121-9**. Also, since the induced current gradually increases in the direction toward the inductor unit **14**, a magnitude of the current induced to the second touch electrode **121-8** and the second touch electrode **121-9** is greater than that of current induced to the other second touch electrodes **121-1** to **121-7** and **121-10** to **121-16**.

[0657] In this case, the control unit **2624** may determine, as a touch point, a point between the two second touch electrodes **121-8** and **121-9** each having a great magnitude because a sign of the sensing signal **AB4** is converted, and an exact touch point may be calculated by using interpolation. In this case, the control unit **2624** may determine, as a touch point, an area having a maximum value obtained by differentiating the sensing signal **AB4**. Alternatively, the control unit **2624** may receive a differential signal from two adjacent second touch electrodes among the second touch electrodes **121-1** to **121-8** and determine a touch point of the stylus pen based on a maximum value or a minimum value in the received differential signal. For example, an area having the maximum value or the minimum value in the received differential signal may be determined as the touch point. Here, the two adjacent second touch electrodes may be two adjacent second touch electrodes **121-1** and **121-2** or **121-2** and **121-3**. Alternatively, the two adjacent second touch electrodes are two second touch electrodes **121-2** and **121-3** or **121-2** and **121-4** that are not neighbored to each other, and at least one another second touch electrode **121-2** or **121-3** may be disposed between the second touch electrodes **121-2** and **121-3** or **121-2** and **121-4**.

[0658] Next, a signal induced to the touch electrodes **111** and **121** and the traces **112**, **122a** and **122b** when the stylus pen **10a** or **10b** is disposed on the touch screen **20** will be described with reference to FIG. 55.

[0659] FIG. 55 is a view illustrating a case in which the stylus pen is disposed on the sensor unit of the touch unit according to an embodiment.

[0660] As illustrated in FIG. 55, the inductor unit **14** of the stylus pen **10a** and **10b** is disposed between first touch electrodes **111-2** and **111-3** and between second touch electrodes **121-2** and **121-3** on the touch screen **20**.

[0661] The stylus pens **10a** and **10b** are resonated by a driving signal applied to the touch electrodes **111** and **121** having the antenna **121A** of two signal input terminals. A current I_r flowing through the coil of the inductor unit **14** flows by resonance. The current I_r causes an eddy current to the touch electrodes **111** and **121** and the traces **112**, **122a** and **122b**. The eddy current is formed in a direction opposite to the direction of the current I_r .

[0662] Therefore, currents I_{a1} and I_{a2} are formed in the first touch electrodes **111-1** and **111-2** disposed at a left side ($-X$ -axis direction) of the inductor unit **14** in a $-Y$ -axis direction, and currents I_{a3} and I_{a4} are formed in the first touch electrodes **111-3** and **111-4** disposed at a right side ($+X$ -axis direction) of the inductor unit **14** in a $+Y$ -axis direction. That is, directions of currents induced to the first touch electrodes **111-1** to **111-2** and directions of currents induced to the first touch electrodes **111-3** to **111-10** are opposite to each other.

[0663] Currents I_{b1} and I_{b2} are formed in the second touch electrodes **121-1** and **121-2** disposed at an upper side ($+Y$ -axis direction) of the inductor unit **14** in the $-X$ -axis direction, and currents I_{b3} , I_{b4} , I_{b5} and I_{b6} are formed in the second touch electrodes **121-3**, **121-4**, **121-9**, and **121-10** disposed at a lower side ($-Y$ -axis direction) of the inductor unit **14** in the $+X$ -axis direction. That is, directions of currents induced to the second touch electrodes **121-1** and **121-2** and directions of currents induced to the second touch electrodes **121-3** to **121-16** are opposite to each other.

[0664] Currents I_{c1} to I_{c4} are formed in the traces **122a** disposed at the left side of the inductor unit **14** in the $-Y$ -axis direction, and currents I_{c5} and I_{c6} are formed in the traces **122b** disposed at the right side of the inductor unit **14** in the $+Y$ -axis direction. That is, directions of currents induced to the traces **122a** and directions of currents induced to the traces **122b** are opposite to each other.

[0665] Also, directions of currents induced to the second touch electrodes **121-1** and **121-2** and directions of currents induced to the traces **122a** connected to the second touch electrodes **121-1** and **121-2** are the same as each other. Directions of currents induced to the second touch electrodes **121-3** to **121-8** and directions of currents induced to the traces **122a** connected to the second touch electrodes **121-3** to **121-8** are opposite to each other. Directions of currents induced to the second touch electrodes **121-9** to **121-16** and directions of currents induced to the traces **122b** connected to the second touch electrodes **121-9** to **121-16** are opposite to each other.

[0666] In terms of a direction of a current at one point based on the pads **113a** and **113b**, a current may flow from the second touch electrodes **121-1** and **121-2** to the pad **113a**. The current may flow from the pad **113a** and **113b** to the second touch electrodes **121-3** to **121-16** or flow from the second touch electrodes **121-3** to **121-16** to the pad **113a** and **113b** according to a magnitude of the current induced to the second touch electrodes **121-3** to **121-16** and the traces **122a** and **122b** connected thereto.

[0667] Besides, since the stylus pen **10b** of FIG. 4B outputs an electric field signal E to the touch electrodes **111** and **121**, a sensing signal caused by the electric field signal E applied to the first touch electrodes **111-2** and **111-3** and the second touch electrodes **121-2** and **121-3** is received.

[0668] Next, a sensing signal caused by the stylus pen **10b** of FIG. 4B will be described in detail with reference to FIGS. 56 and 57.

[0669] FIGS. 56 and 57 are graphs representing a sensing signal caused by the stylus pen according to an embodiment.

[0670] As illustrated in FIG. 56, since directions of currents between the first touch electrodes **111-1** and **111-2** and the first touch electrodes **111-3** to **111-10** are induced in opposite directions, a sensing signal $AB5$ measured thereby has opposite signs in the first touch electrode **111-2** and the first touch electrode **111-3**. Also, since the induced current gradually increases in the direction

toward the inductor unit **14**, a magnitude of the current induced to the first touch electrode **111-2** and the first touch electrode **111-3** is greater than that of current induced to the other first touch electrode **111-1** and **111-4** to **111-10**.

[0671] Since the stylus pen **10b** outputs the electric field signal **E** to the first touch electrode **111-2** and the first touch electrode **111-3** through the conductive tip **11b**, a sensing signal **AE5** generated thereby is received.

[0672] A sensing signal **AC5** received by the first driver/receiver **2620** has a shape in which a sensing signal **AB5** and a sensing signal **AE5** are combined. In this case, the control unit **2624** may determine, as a touch point, a position between the two first touch electrodes **111-2** and **111-3** at which a difference in magnitude of the sensing signal **AC5** is maximum, and an exact touch point may be calculated by interpolation or the like.

[0673] FIG. **57** is a graph representing a sensing signal received from the second touch electrodes **121-1** to **121-16**.

[0674] As illustrated in FIG. **57**, since directions of currents between the second touch electrodes **121-1** and **121-2** and the second touch electrodes **121-3** to **121-16** are induced in opposite directions, a sensing signal **AB6** measured thereby has opposite signs in the second touch electrode **121-2** and the second touch electrode **121-3**. Also, since the induced current gradually increases in the direction toward the inductor unit **14**, a magnitude of the current induced to the second touch electrode **121-2** and the second touch electrode **121-3** is greater than that of current induced to the other second touch electrodes **121-1** and **121-4** to **121-16**.

[0675] Since the stylus pen **10b** outputs the electric field signal **E** to the second touch electrode **121-2** and the second touch electrode **121-3** through the conductive tip **11b**, a sensing signal **AE6** generated thereby is received.

[0676] A sensing signal **AC6** received by the second driver/receiver **2622** has a shape in which the sensing signal **AB6** and the sensing signal **AE6** are combined. In this case, the control unit **2624** may determine, as a touch point, a point between the two second touch electrodes **121-2** and **121-3** at which a difference in magnitude of the sensing signal **AC6** is maximum, and an exact touch point may be calculated by interpolation or the like.

[0677] Next, a sensing signal caused by the stylus pen **10a** of FIG. **4A** will be described in detail with reference to FIGS. **58** and **59**.

[0678] FIGS. **58** and **59** are graphs representing a sensing signal caused by the stylus pen according to another embodiment.

[0679] FIG. **58** is a graph representing a sensing signal received from the first touch electrodes **111-1** to **111-10**.

[0680] As illustrated in FIG. **58**, since directions of currents between the first touch electrodes **111-1** and **111-2** and the first touch electrodes **111-3** to **111-10** are induced in opposite directions, a sensing signal **AB7** received by the first driver/receiver **2620** has opposite signs in the first touch electrode **111-2** and the first touch electrode **111-3**. Also, since the induced current gradually increases in the direction toward the inductor unit **14**, a magnitude of the current induced to the first touch electrode **111-2** and the first touch electrode **111-3** is greater than that of current induced to the other first touch electrode **111-1** and **111-4** to **111-10**.

[0681] In this case, the control unit **2624** may determine, as a touch point, a position between the two first touch electrodes **111-2** and **111-3** each having a great magnitude because a sign of the sensing signal **AB7** is converted, and an exact touch point may be calculated by using interpolation.

[0682] FIG. **59** is a graph representing a sensing signal received from the second touch electrodes **121-1** to **121-16**.

[0683] As illustrated in FIG. **59**, since directions of currents between the second touch electrodes **121-1** and **121-2** and the second touch electrodes **121-3** to **121-16** are induced in opposite directions, a sensing signal **AB8** received by the second driver/receiver **2622** has opposite signs in the second touch electrode **121-2** and the second touch electrode **121-3**. Also, since the induced

current gradually increases in the direction toward the inductor unit **14**, a magnitude of the current induced to the second touch electrode **121-2** and the second touch electrode **121-3** is greater than that of current induced to the other second touch electrodes **121-1** and **121-4** to **121-16**.

[0684] In this case, the control unit **2624** may determine, as a touch point, a position between the two second touch electrodes **121-2** and **121-3** each having a great magnitude because a sign of the sensing signal **AB8** is converted, and an exact touch point may be calculated by using interpolation.

[0685] The method for measuring the signal of the touch unit in FIGS. **49** to **59** may be applied to the sensor unit and control unit in FIGS. **16** to **45**. Specifically, one of the first to fourth patterns **101**, **102**, **103**, and **104** in FIG. **16** may correspond to the first touch electrode **111-1** to **111-10** or the second touch electrodes **121-1** to **121-16** in FIG. **49**. For example, one of the first pattern **101** and the second pattern **102** in FIG. **16** may correspond to the first touch electrodes **111-1** to **111-10** in FIG. **49**, and one of the third pattern **103** and the fourth pattern **104** in FIG. **16** may correspond to the second touch electrodes **121-1** to **121-16** in FIG. **49**.

[0686] For example, when the first pattern **101** in FIG. **16** corresponds to the first touch electrodes **111-1** to **111-10** in FIG. **49**, and the third pattern **103** in FIG. **16** corresponds to the second touch electrodes **121-1** to **121-16** in FIG. **49**, the plurality of first patterns **101** of the sensor unit **100** of FIG. **16** may be the pen sensing patterns in a horizontal axis direction, and the plurality of third patterns **103** may be the pen sensing patterns in a vertical axis direction. In this case, the control unit for controlling the sensor unit **100** receives stylus pen sensing signals from the plurality of first patterns **101**. The control unit may determine, as a touch point of the stylus pen in the horizontal axis direction, a position between two pen sensing patterns that output two pen sensing signals having a maximum value and a minimum value among the stylus pen sensing signals received from the plurality of first patterns **101**. The control unit may determine, as a touch point of the stylus pen in the vertical axis direction, a position between two pen sensing patterns that output two pen sensing signals each having a maximum magnitude because signs of the signals are converted among the stylus pen sensing signals received from the plurality of third patterns **103**.

[0687] Alternatively, the control unit may determine, as a touch point of the stylus pen in the horizontal axis direction, a position between two adjacent patterns having opposite signs among the stylus pen sensing signals received from the plurality of first patterns **101**. Alternatively, the control unit may determine, as a touch point of the stylus pen in the vertical axis direction, a position between two adjacent patterns having opposite signs among the stylus pen sensing signals received from the plurality of third patterns **103**.

[0688] Alternatively, the control unit may determine, as a touch point of the stylus pen in the horizontal axis direction, a position on the pen sensing patterns, which has a maximum differential value by differentiating the stylus pen sensing signals received from the plurality of first patterns **101**. Alternatively, the control unit may determine, as a touch point of the stylus pen in the horizontal axis direction, a position on the pen sensing patterns, which has a maximum differential value by differentiating the stylus pen sensing signals received from the plurality of third patterns **103**.

[0689] Alternatively, the control unit may receive a differential signal from two adjacent first patterns among the plurality of first patterns **101** and determine a touch point of the stylus pen based on a maximum value or a minimum value in the received differential signal. For example, a position on the pen sensing patterns having the maximum value or the minimum value in the received differential signal may be determined as the touch point. Here, the two adjacent first patterns may be two neighboring first patterns. Alternatively, the two adjacent first patterns may be two first patterns that are not neighbored to each other, and at least one another first pattern may be disposed between the two first patterns.

[0690] Alternatively, the control unit may receive a differential signal from two adjacent third patterns among the plurality of third patterns **103** and determine a touch point of the stylus pen based on a maximum value or a minimum value in the received differential signal. For example, a

position on the pen sensing patterns having the maximum value or the minimum value in the received differential signal may be determined as the touch point. Here, the two adjacent third patterns may be two neighboring third patterns. Alternatively, the two adjacent third patterns may be two third patterns that are not neighbored to each other, and at least one another third pattern may be disposed between the two third patterns.

[0691] Next, the touch input device **2** having the touch screen **20c** of (c) of FIG. **2A** will be described with reference to FIG. **60**.

[0692] FIG. **60** is a schematic block diagram representing the touch input device.

[0693] The touch input device of FIG. **60** further includes a loop coil **264** and a coil driver **263** applying a driving signal to the loop coil **264** in comparison with the touch input device of FIG. **4**.

[0694] The loop coil **264** may be disposed around the touch screen **20** or disposed at an arbitrary position in the touch input device **2**. The loop coil **264** may also be configured as an antenna of a short-range communication module **212** such as RFID or NFC. The driving signal includes an AC voltage or an AC current having a predetermined frequency.

[0695] FIG. **61** is a schematic view illustrating a portion of the touch unit according to an embodiment.

[0696] The touch unit of FIG. **61** further includes a loop coil **264** and a coil driver **263** applying a driving signal to the loop coil **264** in comparison with the touch unit of FIG. **46**.

[0697] The coil driver **263** applies a driving signal to the loop coil **264**. The driving signal may include a signal (e.g., sine wave or square wave) having a frequency corresponding to a resonance frequency of the resonance circuit unit **12** and may be an AC voltage or AC current having a predetermined frequency. The driving signal may have a frequency and a magnitude that are changed according to control of the control unit **2624**.

[0698] The stylus pen **10a** and **10b** is resonated by the driving signal applied to the loop coil **264**. A current I_r flowing through the coil of the inductor unit **14** flows by resonance.

[0699] FIG. **62** is a view illustrating an example of an arrangement form of a trace and an electrode (or pattern) of a touch unit according to another embodiment.

[0700] The touch electrodes **111** and **121** in the sensor unit of the touch unit are connected to the pads **113a** and **113b** through the traces **112**, **122a** and **122b** of a peripheral area disposed on an edge of the touch area. First touch electrodes **111-1**, **111-2**, **111-3**, . . . are respectively connected to the traces **112** in a corresponding manner, and second touch electrodes **121-1**, **121-2**, **121-3**, . . . are respectively connected to the traces **122a** and **122b**.

[0701] The touch electrodes **111** and **121** and the traces **112**, **122a**, and **122b** may be formed on the same layer. The touch electrodes **111** and **121** and the traces **112**, **122a**, and **122b** may be made of a conductive material having a high transmittance and a low impedance as with a metal mesh and a silver nanowire. Alternatively, the touch electrodes **111** and **121** and the traces **112**, **122a**, and **122b** may be disposed on different layers and made of ITO and graphene. However, the embodiment of the present invention is not limited thereto.

[0702] The pads **113a** and **113b** are connected to the touch controller **262**. The pads **113a** and **113b** transmit a signal (e.g., driving signal) of the touch controller **262** to the touch electrodes **111** and **121** and a signal (e.g., sensing signal) from the touch electrodes **111** and **121** to the touch controller **262**.

[0703] FIG. **63** is a schematic view for explaining a method for driving the stylus pen in the touch input device **2** or the stylus driving device according to the present invention, and FIGS. **64A** and **64B** is a view for explaining a method for activating the stylus pen in the touch input device **2** or the stylus driving device in detail according to the present invention.

[0704] As illustrated in FIG. **63**, the touch input device **2** according to the present invention generates a magnetic field by using the touch panel **261**, and the magnetic field allows the resonance circuit **12** of a stylus **10c** to operate. The resonance circuit **12** of the stylus **10c** includes a capacitor and an inductor, and a current is generated in the resonance circuit **12** of the stylus **10c** by

electromagnetic induction caused by an electromagnetic field generated by the touch panel **261**.

[0705] FIG. **64A** illustrates a method for generating a magnetic field by controlling a direction of a current flowing through a plurality of first electrodes each extending in the Y-axis, and FIG. **64B** illustrates a method for generating an electromagnetic field by controlling a direction of a current flowing through a plurality of second electrodes each extending in the X-axis.

[0706] In another embodiment, a magnetic field may be generated by simultaneously controlling directions of currents flowing through the first electrode and the second electrode. As with illustrated coordinates, in FIG. **64**, a horizontal direction of the drawing indicates the Y-axis, and a vertical direction of the drawing indicates the X-axis.

[0707] The directions of the currents flowing through the plurality of first electrodes may be individually controlled. Here, directions of currents flowing through the electrodes disposed at left and right sides based on a position P of the tip of the stylus **10c** is controlled in opposite directions. Based on the position of the first electrode with respect to the tip of the stylus **10c**, the direction of the current flowing through each of the plurality of first electrodes of the touch panel **261** is controlled. Since the plurality of first electrodes that are adjacent to each other and arranged in parallel do not form a closed loop, individual current control is required to be performed on each of the plurality of first electrodes.

[0708] When the electromagnetic field is generated in a method that does not form a closed loop as with the embodiment of the present invention, a typical touch sensor may be directly used. Thus, the embodiment of the present invention may be immediately applied to various types of electronic devices such as foldable or rollable (smartphones, TVs, etc.) to achieve the same function. Also, since production may be performed by using typical production facilities and methods, economic feasibility in manufacturing may be promoted, and from a different point of view, existing products that detects only touches caused by fingers may use the stylus through firmware upgrade. Thus, a function of the existing product may be expanded.

[0709] Referring to FIG. **64B** again, directions of currents flowing through the first electrode disposed at a left side and the first electrode disposed at a right side based on a virtual line passing through the tip of the stylus **10c** and parallel to the Y-axis are driven in opposite directions. Although the position of the tip of the stylus **10c** may be determined in advance to control the directions of currents of the both electrodes, an entire surface of the touch panel **261** may be divided into a plurality of areas, and directions of currents of the electrodes contained in each of the plurality of areas may be controlled, so that the stylus **10c** may react to the electromagnetic field although the stylus **10c** is disposed at any position on the touch panel **261**. Although the directions of the currents of the electrodes disposed at the left and right sides of the divided areas are controlled in opposite directions as an example, the embodiment of the present invention is not limited thereto. For example, various applications and modifications may be considered.

[0710] As illustrated in FIG. **64B**, directions of currents flowing through the plurality of second electrodes may also be individually controlled. Here, directions of currents flowing through the electrodes disposed at upper and lower sides with respect to the position P of the tip of the stylus **10c** is controlled in opposite directions. In other words, the direction of the current flowing through the second electrode is controlled based on the position of the second electrode with respect to the tip of the stylus **10c**.

[0711] Since the plurality of second electrodes that are adjacent to each other and arranged in parallel do not form a closed loop, individual current control is required to be performed on each of the plurality of second electrodes.

[0712] More specifically, directions of currents flowing through the second electrodes disposed at upper and lower sides based on a virtual line passing through the tip of the stylus **10c** and parallel to the X-axis are driven in opposite directions. Here, in relation to current direction control of each electrode, although directions of currents flowing through all of the first electrodes and/or the second electrodes contained in the touch panel **261** may be controlled, only electrodes within a

predetermined distance from the tip of the stylus may be controlled when the position of the tip of the stylus **10c** is recognized in advance.

[0713] Likewise, an entire surface of the touch pad **261** may be divided into a plurality of areas, and directions of currents of the electrodes contained in each of the plurality of areas may be controlled, so that the stylus **10c** may react to the electromagnetic field although the stylus **10c** is disposed at any position on the touch panel **261**. For example, the directions of the currents flowing through the electrode disposed at upper and lower edges of the divided areas may be controlled in opposite directions.

[0714] An electromagnetic field is formed because currents flowing opposite directions flow through left and right sides and/or upper and lower sides with respect to the tip of the stylus **10c**, and as a result, the currents are induced to the resonance circuit **12** of the stylus **10c**, so that the stylus **10c** generates an electromagnetic field signal. The current generated in the resonance circuit **12** of the stylus **10c** forms an electromagnetic field around the coil of the inductor, and thus a current signal is generated around the tip of the stylus **10c**. The current signal rotates clockwise or counterclockwise around the tip of the stylus **10c**.

[0715] The touch input device **2** according to an embodiment of the present invention uses at least one electrode (or pattern) of the touch panel **261** to receive the current signal generated from the stylus **10c**, thereby determining coordinates at which the tip of the stylus **10c** is disposed.

Hereinafter, a method for determining touch coordinates by receiving a signal generated by the stylus **10c** activated by the touch panel **261** will be described in detail.

Detecting Signal from Stylus Pen

[0716] The touch input device according to an embodiment of the present invention detects a signal emitted from the stylus pen by using the touch panel **261**.

[0717] FIGS. **65A** and **65B** are a schematic view for explaining a method for detecting a signal emitted from the stylus pen **2** in the touch input device **2** according to the present invention, and FIGS. **66A** to **68B** are views for explaining the method for detecting a signal emitted from the stylus pen in the touch input device **2** in detail according to the present invention.

[0718] When current is induced to the resonance circuit **12** of the stylus **10c** by the magnetic field generated by individually controlling the directions of the currents flowing in the electrodes contained in the touch panel **261** (the current has a maximum value at the resonance frequency), an electromagnetic field is induced around the coil of the inductor by the current generated in the resonance circuit **12** of the stylus **10c** as illustrated in FIG. **65A**, and the electromagnetic field allows the stylus pen **2** to generate a current signal again as illustrated in FIG. **65B**. Hereinafter, a method for obtaining touch coordinates by receiving a magnetic field signal of the stylus **10c** will be described.

[0719] FIGS. **66A** and **66B** are a view illustrating a current signal generated by a magnetic field generated by the stylus **10c**. The electromagnetic field generated by the current induced to the resonance circuit **12** of the stylus **10c** generates a current signal rotating in a counterclockwise direction around the tip of the stylus **10c** as illustrated in FIGS. **66A** and **66B**. In another embodiment, a current signal rotating clockwise may be generated. Although the current signal rotating in the clockwise or counterclockwise direction may be an eddy current, the embodiment of the present invention is not limited thereto.

[0720] The current signal rotating in the counterclockwise direction causes current flow to first electrodes **121Y-1** to **121Y-m** of the touch panel **261** as illustrated in FIG. **66A**. That is, the current signal rotating counterclockwise based on the position P of the tip of the stylus **10c** form opposite current flows in a first electrode disposed at a left side and a first electrode disposed at a right side based on a virtual line passing through the tip of the stylus **10c** and parallel to the Y-axis. The current signal rotating in the clockwise direction may generate a current signal opposite to the first electrode of the touch panel **261**.

[0721] Likewise, the current signal rotating in the counterclockwise direction causes a current flow

to second electrodes **121X-1** to **121X-n** of the touch panel **261** as illustrated in FIG. **66B**. That is, the current signal rotating in the counterclockwise direction based on the position P of the tip of the stylus **10c** form opposite current flows in a second electrode disposed at an upper side and a second electrode disposed at a lower side based on a virtual line passing through the tip of the stylus **10c** and parallel to the X-axis. The current signal rotating in the clockwise direction may generate a current signal opposite to the second electrode of the touch panel **261**.

[0722] In a portion A of FIG. **66B**, the current signal rotating in the counterclockwise direction by the stylus forms a predetermined current flow to the second electrodes as described above.

However, since a predetermined current flow is formed in a wire (trace) connected to each second electrode by the current signal rotating in the counterclockwise direction, a current flow of some second electrodes contained in the portion A and a current flow of a wire connected to the some second electrodes may flow in opposite directions, and a magnitude of the current outputted from the wire may be relatively reduced. In a portion B of FIG. **66B**, since a current flow of the other second electrodes contained in the portion B and a current flow of a wire connected to the other second electrodes may flow in the same direction, and a magnitude of the current outputted from the wire may relatively increase. This is because a wire is connected to one side of each of the some second electrodes and a wire is connected to the other side of each of the other second electrodes.

[0723] FIGS. **67A** and **67B** are a view for explaining a current signal detected in the first electrode extending in the Y-axis direction when a signal of the stylus is received. A direction of the current flowing through the first electrode varies according to a position relationship with the tip of the stylus **10c** by a current signal (here, rotates around the tip in the clockwise direction) generated by the stylus **10c**.

[0724] Specifically, when a current rotating in the clockwise direction is generated by a current signal generated by the stylus **10c** as illustrated in FIG. **67A**, directions of currents flowing through the first electrodes disposed at left and right sides with respect to the tip of the stylus **10c** vary in correspondence to a movement direction (rotation direction) of the current signal generated by the stylus **10c**. The current flowing through the first electrode disposed at a left side of a virtual line CLy passing through the tip of the stylus **10c** and parallel to the Y-axis flows in a direction opposite to that of the current flowing through the first electrode disposed at a right side.

[0725] As shown in a lower graph of FIG. **67B**, a signal received from each of n first electrodes shows a rapid current change at a position of the tip of the stylus **10c**. When differentiating this and then obtaining coordinates corresponding to a peak value, a X-coordinate value of the touch position caused by the stylus **10c** may be obtained. Alternatively, the control unit may receive a differential signal from two adjacent first electrodes among the n first electrodes and determine a touch point of the stylus pen based on a maximum value or a minimum value in the received differential signal. For example, a coordinate corresponding to the maximum value or the minimum value in the received differential signal may be a X-coordinate value of the touch position caused by the stylus pen **2**. Here, the two adjacent first electrodes may be two neighboring first electrodes. Alternatively, the two adjacent first electrodes may be two first electrodes that are not neighbored to each other, and at least one another first electrode may be disposed between the two first electrodes.

[0726] Here, a feature in which the direction of the current flowing through the first electrode of the touch panel **261** corresponds to the rotation (movement) direction of the current signal represents that, e.g., when a current signal rotates clockwise around the tip of the stylus, a current flows upward in the electrode disposed at the left side of the tip of the stylus among the first electrodes, and a current flows downward in the electrode disposed at the right side. On the contrary, when the current signal rotates counterclockwise around the tip of the stylus, a current flows downward in the electrode disposed at the left side of the tip of the stylus among the first electrodes, and a current flows upward in the electrode disposed at the right side.

[0727] When a current performs a circular movement around the tip of the stylus in the clockwise direction, the current flows upward in correspondence to a tangential vector at a 180° point in a circular movement path in the electrode disposed at the left side of the tip of the stylus among the first electrodes, and the current flows downward in correspondence to a tangential vector at a 0° point in the electrode disposed at the right side.

[0728] FIGS. **68A** and **68B** is a view for explaining a current signal detected in the second electrode extending in the X-axis direction when a signal of the stylus is received. A direction of the current flowing through the second electrode varies according to a position relationship with the tip of the stylus **10c** by a current signal generated by the stylus **10c**.

[0729] That is, the current flowing through the second electrodes disposed at the upper and lower sides of the tip of the stylus **10c** has a directivity corresponding to the rotation direction of the current signal induced by the electromagnetic field of the stylus. Specifically, currents flowing through the second electrodes disposed at the upper and lower sides based on the virtual line Clx passing through the tip of the stylus **10c** and parallel to the X-axis flow in opposite directions in correspondence to the rotation direction of the current signal.

[0730] When a signal detected from each of m second electrodes is analyzed, a rapid current change occurs at the tip of the stylus **10c**. After differentiating the detected current value, a coordinate corresponding to a peak value is determined as a Y-coordinate value of the touch position caused by the stylus **10c**. Here, a differential signal may be received from two adjacent second electrodes among the m second electrodes, and the touch point of the stylus pen may be determined based on a maximum value or a minimum value in the received differential signal. For example, a coordinate corresponding to the maximum value or the minimum value in the received differential signal may be a Y-coordinate value of the touch position caused by the stylus pen **2**. Here, the two adjacent second electrodes may be two neighboring second electrodes. Alternatively, the two adjacent second electrodes may be two second electrodes that are not neighbored to each other, and at least one another second electrode may be disposed between the two second electrodes.

[0731] Here, a feature in which the direction of the current flowing through each of the plurality of second electrodes of the touch panel **261** corresponds to a rotation (movement) direction of the current signal caused by the stylus **10c** represents that, e.g., when a current signal rotates clockwise around the tip of the stylus, a current flows rightward in the electrode disposed at the upper side of the tip of the stylus among the second electrodes, and a current flows leftward in the electrode disposed at the lower side. Alternatively, when the rotation direction is reversed, the direction of the current flowing in each electrode will also be reversed.

[0732] When a current performs a circular movement around the tip of the stylus in the clockwise direction, the current flows rightward in correspondence to a tangential vector at a 90° point in a circular movement path in the electrode disposed at the upper side of the tip of the stylus among the second electrodes, and the current flows leftward in correspondence to a tangential vector at a 270° point in the electrode disposed at the lower side.

[0733] According to an embodiment of the present invention, the stylus **10c** may be activated by using the electrode (or pattern) of the touch panel, which is not contained in the closed loop, and an electromagnetic field signal of the stylus may be detected. That is, since the n first electrodes arranged in parallel and the m second electrodes perpendicular thereto and arranged in parallel each individually receive the electromagnetic field signal of the stylus, the touch position of the stylus may be more accurately detected.

[0734] FIGS. **69A** and **69B** are a view illustrating various wiring structures of the second electrode in the touch input device according to an embodiment of the present invention. FIG. **69A** illustrates a structure in which a wire (or trace) of the plurality of second electrodes extending in parallel to the X-axis is connected to a right side of the second electrode disposed at an upper side, and a wire is connected to a right side of the second electrode disposed at a lower side based on the touch

panel **261**.

[0735] The wiring of the electrode may be variously changed, and the wire may be connected to only the left side of the touch panel or only the right side of the touch panel as illustrated in FIG. **69B**. In this case, a shape of the graph shape of the received signal may be varied. However, in any case, the signal pattern rapidly changes by using a point at which the tip of the stylus **10c** is disposed as a boundary, and based on this, the touch coordinates may be determined.

[0736] FIGS. **70A** to **71C** are view illustrating experiment processes for verifying a signal detection capability of the stylus pen by using the touch input device and results thereof according to an embodiment of the present invention.

[0737] This experiment is conducted by using an EMR pen in which a resonance frequency is adjusted to 400 kHz. As illustrated in FIG. **70A**, a signal is detected after the EMR pen is disposed at a first position **P1** and a second position **P2** of a touch surface of the touch input device **2**. As a result, it is confirmed that the EMR pen is activated by the touch input device **2** to emit a signal. This represents that a current is induced to a resonance circuit of the EMR pen by the electromagnetic field generated by the touch panel **261**. A graph as shown in FIG. **70B** is obtained by analyzing the signal received through the first electrode of the touch pad **261** when the EMR pen is disposed at the first position (**P1**). When a X-coordinate of the EMR pen obtained by analyzing a point at which the signal rapidly changes is compared with that of the first position **P1** of the EMR, the X-coordinates coincide with each other.

[0738] The signal received by the touch panel **261** from the EMR pen at the second position **P2** is shown in FIG. **70C**. As a result of comparison, the X-coordinate of the EMR pen at the point at which the signal changes rapidly coincides with the X-coordinate of the second position **P2** of the EMR pen.

[0739] Graphs of FIGS. **70B** and **70C** represents IQ sampling signals. Each of lines represents a AI signal and a AQ signal, a vertical axis represents a magnitude of a signal value, and a horizontal axis represents a number of an arrangement order of eighteen first electrodes.

[0740] FIGS. **71A** to **71C** show a signal received through the second electrode of the touch pad **261** in the same experiment. As illustrated in FIG. **71A**, a signal is detected after the EMR pen is disposed at the first position **P1** and the second position **P2** of the touch surface of the touch input device. A signal generated by the EMR pen is received through the second electrode of the touch pad **261**. This represents that the current is induced to the resonance circuit of the EMR pen by the electromagnetic field generated by the touch panel **261**. Here, a graph of FIG. **70B** is obtained by analyzing the signal received through the second electrode of the touch pad **261** when the EMR pen is disposed at the first position **P1**. When a Y-coordinate of the EMR pen obtained by analyzing a point at which the signal rapidly changes is compared with that of the first position **P1** of the EMR pen, the Y-coordinates coincide with each other.

[0741] Thereafter, the signal received by the second electrode of the touch panel **261** at the second position **P2** is shown in FIG. **70C**. As a result of comparison, the Y-coordinate of the EMR pen at the point at which the signal changes rapidly coincides with the Y-coordinate of the second position **P2** of the EMR pen. Graphs of FIGS. **70B** and **70C** represents IQ sampling signals. Each of lines represents a AI signal and a AQ signal, a vertical axis represents a magnitude of a signal value, and a horizontal axis represents a number of an arrangement order of forty second electrodes.

[0742] It is confirmed through the experiments of FIGS. **70A** to **71C** that the stylus **10c** is driven by the touch input device **2** according to an embodiment of the present invention, and the signal thereof is accurately detected.

[0743] The touch input device according to an embodiment of the present invention may receive various types of stylus signals and determine the touch position of the stylus. As described above, since the touch input device according to an embodiment of the present invention receives the signal of the stylus by using the touch panel having at least one electrode (or pattern) that is not contained in the closed loop, existing touch sensors may be directly used, and existing products that

detects only touches caused by fingers may use the stylus through firmware upgrade. Thus, a function of the existing product may be expanded.

[0744] The touch input device according to an embodiment of the present invention includes the touch panel including the plurality of first electrodes each extending in the Y-axis and the plurality of second electrodes each extending in the X-axis and the control unit (or touch controller) determining the touch coordinates based on the signal received from the stylus. Here, as described above, each of the plurality of first electrodes and the plurality of second electrodes may not form the closed loop.

[0745] Here, the current signal rotating clockwise or counterclockwise around the tip of the stylus is induced by the electromagnetic field generated by the current induced to the resonance circuit of the stylus, and the control unit determines the touch coordinates based on the current signal.

[0746] Specifically, the current signal is generated by the magnetic field generated by the stylus. The electromagnetic field generated by the current induced to the resonance circuit of the stylus generates the current signal rotating counterclockwise around the tip of the stylus. In another embodiment, a current signal rotating clockwise may be generated. Although the current signal rotating in the clockwise or counterclockwise direction may be an eddy current, the embodiment of the present invention is not limited thereto.

[0747] Here, the direction of the current flowing through the first electrode or the second electrode of the touch panel disposed at the upper, lower, left, and right sides around the tip of the stylus is determined in correspondence to the rotation direction of the current signal, and the current signal generated by the stylus allows currents to flow through the first electrode disposed at the left side and the first electrode disposed at the right side based on the virtual line parallel to the Y-axis in opposite directions or allows currents to flow through the second electrode disposed at the upper side and the second electrode disposed at the lower side based on the virtual line parallel to the X-axis in opposite directions.

[0748] The coordinates at which the tip of the stylus is disposed may be accurately detected by detecting the current induced to the first electrode and the second electrode, and in relation to this, redundant description will be omitted because of the detailed descriptions above.

[0749] Here, the stylus may be an active stylus including a resonance circuit and a power supply to resonate itself. The active stylus includes the resonance circuit and the power supply therein. The power supply may be a battery, but may be a module (wired connection terminal or wireless charging module) that receives power from the outside by a wired or wireless manner. The active stylus may provide various additional functions such as pen pressure, hovering, and buttons.

[0750] In another embodiment, the stylus may be a passive stylus including a resonant circuit to resonate by an external signal. The passive stylus may be driven by various methods such as an inductive resonance method, an electro magnetic resonance (EMR) method, and a capacitive resonance method.

[0751] In case of the passive stylus, since the passive stylus does not include a built-in power supply such as a battery, the pen has a light weight and operates anytime and anywhere.

[0752] When the passive stylus operates in the EMR method, the stylus may be activated by the electromagnetic field generated by the panel **261** as described above. When the passive stylus operates in the electrically coupled resonance (ECR) method, the stylus may be activated by a signal transmitted by the electrode of the panel **261**.

[0753] A method for controlling the touch input device according to an embodiment of the present invention drives the stylus by using the touch panel having the plurality of first electrodes each extending in the Y-axis and the plurality of second electrodes each extending in the X-axis and receives the signal from the stylus. Here, the plurality of first electrodes contained in the touch panel may not form a closed loop, and the plurality of second electrodes may also not form a closed loop. Also, the first electrodes and the second electrodes may not form a closed loop.

[0754] The method for controlling the touch input device according to an embodiment of the

present invention includes a driving process of individually controlling a direction of a current flowing through the plurality of first electrodes or the plurality of second electrodes to generate an electromagnetic field and activate the stylus and a determination process of determining touch coordinates based on a signal generated by the stylus.

[0755] The driving process individually adjust the directions of the currents flowing through the first electrode or the second electrode to generate the electromagnetic field based on the position of the first electrode or the second electrode around the tip of the stylus, thereby driving the stylus.

The driving of the stylus represents that a current is induced or resonance occurs in the internal resonance circuit. Alternatively, the electromagnetic field may be generated by simultaneously adjusting the directions of the currents flowing through the first electrode and the second electrode.

[0756] Although the plurality of first electrodes and the plurality of second electrodes contained in the touch panel do not form the closed loop, the stylus may be driven by only the controlling of the directions of the currents. That is, since the stylus may be activated by generating the electromagnetic field using the touch panel including only open-loop electrodes (i.e., ends of the plurality of first electrodes are not directly connected, and ends of the plurality of second electrodes are not directly connected), a typical touch panel may be directly used, and a component such as an expensive digitizer is not required.

[0757] The driving process generates the electromagnetic field by driving currents flowing through the first electrode disposed at the left side and the first electrode disposed at the right side based on the virtual line passing through the tip of the stylus and parallel to the Y-axis in opposite directions or currents flowing through the second electrode disposed at the upper side and the second electrode disposed at the lower side based on the virtual line passing through the tip of the stylus and parallel to the X-axis in opposite directions, so that the current is induced to or resonated in the resonance circuit of the stylus.

[0758] When the stylus is activated by the driving process, a receiving process is performed.

[0759] The current is induced to the resonance circuit of the stylus by the electromagnetic field, and the magnetic field generated by the current induced to the resonance circuit induces the current signal rotating clockwise or counterclockwise around the tip of the stylus. In the receiving process, the touch coordinates is determined by receiving the current signal.

[0760] Here, the directions of the currents flowing through the first electrode or the second electrode disposed at the upper, lower, left, and right sides around the tip of the stylus are determined in correspondence to the rotation direction of the current signal. Specifically, the currents flowing through the first electrode disposed at the left side and the first electrode disposed at the right side based on the virtual line passing through the tip of the stylus and parallel to the Y-axis may flow in opposite directions, and the currents flowing through the second electrode disposed at the upper side and the second electrode disposed at the lower side based on the virtual line passing through the tip of the stylus and parallel to the X-axis may flow in opposite directions.

[0761] The method for measuring the signal of the touch unit in FIGS. **66A** to **71C** may be applied to the sensor unit and control unit in FIGS. **16** to **45**. Specifically, one of the first to fourth patterns **101**, **102**, **103**, and **104** in FIG. **16** may correspond to the first touch electrode **121-1Y** to **121Y-m** or the second touch electrodes **121X-1** to **121X-n** in FIGS. **66A** and **66B**. For example, one of the first pattern **101** and the second pattern **102** in FIG. **16** may correspond to the first touch electrodes **121-1Y** to **121Y-m** in FIGS. **66A** and **66B**, and one of the third pattern **103** and the fourth pattern **104** in FIG. **16** may correspond to the second touch electrodes **121X-1** to **121X-n** in FIGS. **66A** and **66B**.

[0762] For example, when the first pattern **101** in FIG. **16** corresponds to the first touch electrodes **121-1Y** to **121Y-m** in FIGS. **66A** and **66B**, and the third pattern **103** in FIG. **16** corresponds to the second touch electrodes **121X-1** to **121X-n** in FIGS. **66A** and **66B**, the plurality of first patterns **101** of the sensor unit **100** of FIG. **16** may be the pen sensing patterns in the horizontal axis direction, and the plurality of third patterns **103** may be the pen sensing patterns in the vertical axis direction. In this case, the control unit for controlling the sensor unit **100** receives the stylus pen sensing

signal from the plurality of first patterns **101**. The control unit may determine, as a touch point of the stylus pen in the horizontal axis direction, a position between two pen sensing patterns that output two pen sensing signals having a maximum value and a minimum value among the stylus pen sensing signals received from the plurality of first patterns **101**. Alternatively, the control unit may determine, as a touch point of the stylus pen in the vertical axis direction, a position between two pen sensing patterns that output two pen sensing signals having a maximum value and a minimum value among the stylus pen sensing signals received from the plurality of third patterns **103**.

[0763] Alternatively, the control unit may determine, as a touch point of the stylus pen in the horizontal axis direction, a position between two adjacent patterns having opposite signs among the stylus pen sensing signals received from the plurality of first patterns **101**. Alternatively, the control unit may determine, as a touch point of the stylus pen in the vertical axis direction, a position between two adjacent patterns having opposite signs among the stylus pen sensing signals received from the plurality of third patterns **103**.

[0764] Alternatively, the control unit may determine, as a touch point of the stylus pen in the horizontal axis direction, a predetermined position on the plurality of first patterns **101**, which has a maximum differential value by differentiating the stylus pen sensing signals received from the plurality of first patterns **101**. Alternatively, the control unit may determine, as a touch point of the stylus pen in the horizontal axis direction, a predetermined position on the plurality of third patterns **103**, which has a maximum differential value by differentiating the stylus pen sensing signals received from the plurality of third patterns **103**.

[0765] Alternatively, the control unit may receive a differential signal from two adjacent first patterns among the plurality of first patterns **101** and determine a touch point of the stylus pen based on a maximum value or a minimum value in the received differential signal. For example, a predetermined position on the plurality of first patterns **101** having the maximum value or the minimum value in the received differential signal may be determined as the touch point. Here, the two adjacent first patterns may be two neighboring first patterns. Alternatively, the two adjacent first patterns may be two first patterns that are not neighbored to each other, and at least one another first pattern may be disposed between the two first patterns.

[0766] Alternatively, the control unit may receive a differential signal from two adjacent third patterns among the plurality of third patterns and determine a touch point of the stylus pen based on a maximum value or a minimum value in the received differential signal. For example, a predetermined position on the plurality of third patterns **103** having the maximum value or the minimum value in the received differential signal may be determined as the touch point. Here, the two adjacent third patterns may be two neighboring third patterns. Alternatively, the two adjacent third patterns may be two third patterns that are not neighbored to each other, and at least one another third pattern may be disposed between the two third patterns.

[0767] FIG. **72** is a block diagram representing a touch unit and a host, and FIG. **73** is a view representing an example of touch data provided from the touch unit to the host.

[0768] Referring to FIG. **72**, a host **270** may receive touch data from a touch controller **262** contained in the touch unit **260**. For example, the host **270** may be a mobile system-on-chip (SoC), an application processor (AP), a media processor, a microprocessor, a central processing unit (CPU), or a device similar thereto.

[0769] The touch unit **260** may generate touch data by using information on touches inputted during one frame after one frame is finished and transmit the touch data to the host **270**.

[0770] Referring to **72** and **73**, touch data **600** may be transmitted from the touch unit **260** to the host **270**, and the touch data **600** may include a touch count field **610** and at least one touch entity field **612** and **614**. In addition, the touch data **600** may further include sensor input data from the stylus pen **10** and data representing a resonance signal change.

[0771] A value representing the number of touches input during one frame period may be written in

a touch count field **610**. The touch entity field **612** and **614** includes a field representing information on each touch input. For example, the touch entity field **612** and **614** includes a flag field **620**, an X-axis coordinate field **621**, a Y-axis coordinate field **622**, a Z-value field **623**, an area field **624**, and a touch action field **625**.

[0772] The number of touch entity fields **612** and **614** may be the same as values written in the touch count field **610**.

[0773] A value representing a touch object may be written in the flag field **620**. For example, different values for a finger, a palm, and a stylus pen may be written in the flag field **620**. Values representing calculated touch coordinates may be written in the X-axis coordinate field **621** and the Y-axis coordinate field **622**. A value corresponding to a signal intensity of the sensing signal may be written in the Z-value field **623**. A value corresponding to a touch area may be written in the area field **624**.

[0774] According to embodiments, the host **270** receiving the touch data **600** uses a value of the area field **624** to determine that the touch object is a finger when the touch area is greater than a threshold value and determine that the touch object is the stylus pen **10** when the touch area is less than or equal to the threshold value.

[0775] According to embodiments, the host **270** receiving the touch data **600** may use a value of the flag field **620** to determine whether the touch object is a finger or the stylus pen **10**.

[0776] Hereinafter, various embodiments of the stylus pen **10** illustrated in FIG. **4** will be described with reference to the accompanying drawings.

[0777] FIG. **74** is a view illustrating an embodiment of the resonant circuit unit **12** of the stylus pen illustrated in FIG. **4**.

[0778] As illustrated in FIG. **74**, the inductor unit **14** includes a coil **116** wound around the ferrite core **115**, and the capacitor unit **13** includes a first electrode **117**, a second electrode **118**, and a dielectric material **119**. The coil **116** of the inductor unit **14** is electrically connected to the electrodes **117** and **118** of the capacitor unit **13**.

[0779] The core **11** is inserted into the through-hole of the ferrite core **115**. One end of the core **11** may serve as a pen tip of the stylus pen **10**, and the first electrode **117** of the capacitor unit **13** may be disposed at the other end of the core **11**. The first electrode **117** may move in the Z-axis direction by pressure of the core **11** in the Z-axis direction.

[0780] The second electrode **118** and the dielectric **119** are disposed on a movement path of the first electrode **117** in the Z-axis direction. That is, the first electrode **117**, the second electrode **118**, and the dielectric material **119** are disposed so that the capacitance is varied as the first electrode **117** moves. Although the first electrode **117** has a cylindrical shape, and each of the second electrode **118** and the dielectric material **119** has a ring shape in the drawing, the embodiment of the present invention is not limited to the shapes of the first electrode **117**, the second electrode **118**, and the dielectric material **119**. In addition, each of the first electrode **117**, the second electrode **118**, and the dielectric material **119** may have a cylindrical shape, a polygonal shape, a column shape in which at least a portion is a curved surface, an entasis column shape, a truncated pyramid shape, a truncated cone shape, and a toroid shape.

[0781] Although not shown in the drawing, the first electrode **117** may be disposed at a position at which the first electrode **117** operates with the core **11** instead of being disposed at the other end of the core **11**. That is, the first electrode **117** may move along a movement of the core **11**.

Alternatively, at least a portion of the first electrode **117** may operate with the core **11**.

[0782] The dielectric material **119** may be disposed in the second electrode **118**, and a through-hole H1 through which the first electrode **117** moves may be defined in the dielectric material **119**. The first electrode **117** having the cylindrical shape may move in the Z-axis direction through the through-hole H1 to form a capacitance with the second electrode **118** and the dielectric material **119**.

[0783] Although the dielectric material **119** may have a constant thickness, the dielectric material

119 may have various thicknesses or shapes in case of the stylus pen **10** according to a fifth aspect that will be described later.

[0784] Here, a capacitance may be calculated as in equation 2 below.

[00002] $C = \frac{A}{d}$ [Equation2]

[0785] Here, C is a capacitance, A is an overlap area of the first electrode **117** and the second electrode **118**, d is a distance between the first electrode **117** and the second electrode **118**, and ϵ is a dielectric constant of the dielectric material **119**.

[0786] The first electrode **117** moves in the Z-axis direction as the pressure applied to the one end of the core **11** increases. As the first electrode **117** moves in the z-axis direction, an overlap area of the second electrode **118** and the first electrode **117** increases. Accordingly, the capacitance C of the capacitor unit **13** increases.

[0787] Hereinafter, various modified examples of the stylus pen illustrated in FIG. **74** according to an embodiment of the present invention will be described in detail.

[0788] FIGS. **75A** and **75B** are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a first aspect.

[0789] FIGS. **75A** and **75B** illustrate a side surface of the resonant circuit unit **12** and a cross-section obtained by cutting the ring-shaped second electrode **118** and dielectric material **119** along a XZ plane.

[0790] As illustrated in FIG. **75A**, a support member **120** is disposed at the other end of the core **11**. An elastic member **121** is disposed between the support member **120**, the second electrode **118**, and the dielectric material **119**. The elastic member **121** is supported by the support member **120**.

[0791] As illustrated in FIG. **75B**, as the core **11** moves in the Z-axis direction, the support member **120** may also move in the Z-axis direction. The elastic member **121** may be compressed in the Z-axis direction as the support member **120** moves in the Z-axis direction. As the first electrode **117** moves by a distance L1 in the Z-axis direction, the second electrode **118** and the first electrode **117** overlap each other.

[0792] Here, a direction of elastic force of the elastic member **121** is opposite to a Z-axis. Thus, when the pressure applied to the core **11** is removed, the elastic member **121** is restored by the elastic force as illustrated in FIG. **75A**.

[0793] FIGS. **76A** and **76B** are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a second aspect.

[0794] FIGS. **76A** and **76B** illustrate a side surface of the resonant circuit unit **12** and a cross-section obtained by cutting the ring-shaped second electrode **118** and dielectric material **119** along the XZ plane.

[0795] As illustrated in FIG. **76A**, the elastic member **121** is disposed between the first electrode **117** and the support member **120**. The support member **120** is fixed to the housing. The elastic member **121** is supported by the support member **120**. Here, the housing may be also referred to as a body unit.

[0796] As illustrated in FIG. **76B**, as the core **11** moves in the Z-axis direction, the elastic member **121** may be compressed in the Z-axis direction. As the first electrode **117** moves by a distance L1 in the Z-axis direction, the second electrode **118** and the first electrode **117** overlap each other.

[0797] Here, a direction of elastic force of the elastic member **121** is opposite to the Z-axis. Thus, when the pressure applied to the core **11** is removed, the elastic member **121** is restored by the elastic force as illustrated in FIG. **76A**.

[0798] FIGS. **77A** and **77B** are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a third aspect.

[0799] FIGS. **77A** and **77B** illustrate a side surface of the resonant circuit unit **12** and a cross-section obtained by cutting the ring-shaped second electrode **118** and dielectric material **119** along the XZ plane.

[0800] The second electrode **118** may have a cylindrical shape having a cavity therein. The dielectric material **119** may be disposed on an inner wall of the cavity.

[0801] As illustrated in FIG. 77A, the support member **120** is disposed at the other end of the core **11**. The elastic member **121** is disposed between the support member **120**, the second electrode **118**, and the dielectric material **119**. The elastic member **121** is supported by the support member **120**.

[0802] As illustrated in FIG. 77B, as the core **11** moves in the Z-axis direction, the support member **120** may also move in the Z-axis direction. The elastic member **121** may be compressed in the Z-axis direction as the support member **120** moves in the Z-axis direction. As the first electrode **117** moves by a distance **L1** in the Z-axis direction, the second electrode **118** and the first electrode **117** overlap each other. Here, a capacitance is also formed by the first electrode **117** and the second electrode **118** and dielectric **119** disposed in the Z-axis direction of the first electrode **117**.

[0803] Here, a direction of elastic force of the elastic member **121** is opposite to the Z-axis. Thus, when the pressure applied to the core **11** is removed, the elastic member **121** is restored by the elastic force as illustrated in FIG. 77A.

[0804] FIGS. 78A to 78C are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a fourth aspect, and FIG. 79 is a graph showing a variation of a capacitance value of the stylus pen according to the fourth aspect.

[0805] As illustrated in FIG. 78A, when compared with the stylus pen according to the first aspect, the stylus pen according to this aspect includes dielectric materials **119a** and **119b** having different dielectric constants. The dielectric materials **119a** and **119b** may be disposed at different positions along the Z-axis direction. The first dielectric material **119a**, which is closer to the first electrode **117**, has a dielectric constant greater than that of the second dielectric material **119b**.

[0806] As illustrated in FIG. 78B, when the stylus pen **10** contacts the touch screen **20** with weak pen pressure (equal to or less than a (gf) of FIG. 79), since the first electrode **117** moves within a length **L1** of the dielectric material **119a**, increase in capacitance caused by pressure increase is relatively large.

[0807] As illustrated in FIG. 78C, when the stylus pen **10** contacts the touch screen **20** with strong pen pressure (equal to or less than a (gf) of FIG. 79), since the first electrode **117** moves between the length **L1** of the dielectric material **119a** and a total length **L2** of the first and second dielectric materials **119a** and **119b**, increase in capacitance caused by pressure increase is relatively small.

[0808] That is, there is a big difference between a capacitance of the stylus pen **10** that is not in contact with the touch screen **20** and a capacitance of the stylus pen **10** in contact with the touch screen **20**. Thus, the touch screen **20** may determine whether the stylus pen **10** is in contact or not by recognizing a signal variation caused by a significant variation in capacitance of the stylus pen **10**.

[0809] FIGS. 80A to 80C are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a fifth aspect, and FIG. 82 is a graph showing a variation of a capacitance value of the stylus pen according to the fifth aspect.

[0810] As illustrated in FIG. 80A, when compared with the stylus pen according to the first aspect, the stylus pen according to this aspect includes a dielectric material **119** having a different distribution. The dielectric material **119a** may be disposed with the different distribution along the Z-axis direction. The distribution of the dielectric material **119** in a region **S1** adjacent to the first electrode **117** is high. For example, the dielectric material **119** in the region **S1** has a thickness greater than that of the dielectric material **119** in a region **S2** spaced apart from the first electrode **117**. In addition, the distribution of the dielectric material **119** will be described with reference to FIGS. 81A and 81B.

[0811] Referring to FIG. 81A, a plurality of dielectric materials **1190** to **1195** are disposed on the second electrode **118**, and each of the dielectric materials **1190** to **1195** in the region **S1** has an area greater than that of each of the dielectric materials **1190** to **1195** in the region **S2**.

[0812] Referring to FIG. 81B, a plurality of dielectric materials **119a** to **119e** are disposed on the

second electrode **118**, and each of the dielectric materials **119a** to **119e** adjacent to the region **S1** has an area greater than that of each of the dielectric materials **119a** to **119e** in the region **S2**.
[0813] In addition, the dielectric material **119** may be disposed in various manners so that the distribution of the dielectric material **119** in the region **S1** adjacent to the first electrode **117** is greater than other regions.

[0814] As illustrated in FIG. **80B**, when the stylus pen **10** contacts the touch screen **20** with weak pen pressure (equal to or less than a (gf) of FIG. **82**), since the first electrode **117** moves within a length **L1** of an area on which the dielectric material **119** having a great thickness is disposed, increase in capacitance caused by pressure increase is relatively large.

[0815] As illustrated in FIG. **80C**, when the stylus pen **10** contacts the touch screen **20** with weak pen pressure (greater than a (gf) of FIG. **82**), since the first electrode **117** moves within a total length **L2** of the dielectric material **119**, increase in capacitance caused by pressure increase is relatively small.

[0816] That is, there is a big difference between a capacitance of the stylus pen **10** that is not in contact with the touch screen **20** and a capacitance of the stylus pen **10** in contact with the touch screen **20**. Thus, the touch screen **20** may determine whether the stylus pen **10** is in contact or not by recognizing a signal variation caused by a significant variation in capacitance of the stylus pen **10**.

[0817] FIGS. **83A** and **83B** is a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a sixth aspect, and FIGS. **83A** and **83B** are a graph showing a variation of a capacitance value of the stylus pen according to the sixth aspect.

[0818] As illustrated in FIG. **83A**, when compared with the stylus pen according to the first aspect, the stylus pen according to this aspect further includes an additional capacitor unit **131**. The additional capacitor unit **131** and the capacitor unit **13** of the first electrode **117a** and the second electrode **118** are connected in parallel to each other.

[0819] The additional capacitor unit **131** is electrically connected to the first electrode **117b** as the first electrode **117b** moves in the Z-axis direction. The additional capacitor unit **131** includes two electrodes **1310** and **1312** and a dielectric material **1314** between the two electrodes **1310** and **1312**. The additional capacitor unit **131** may be disposed on a PCB **130**. For example, the additional capacitor unit **131** is disposed on a first surface of the PCB **130**. One of the two electrodes **1310** and **1312** is connected to a wire **132** passing through the first and second surfaces of the PCB **130**.

[0820] As illustrated in FIG. **83A**, when pressure is not applied to the core **11**, the additional capacitor unit **131** is not electrically connected to the first electrode **117b**. Here, the capacitance caused by the first electrode **117a** and the second electrode **118** is extremely small or is not formed (less than a (gf) in FIG. **84**).

[0821] As illustrated in FIG. **83B**, when pressure is applied to the core **11**, the first electrodes **117a** and **117b** move in the X-axis direction. Accordingly, the first electrode **117b** is electrically connected to the additional capacitor unit **131**, and the capacitance generated by the first electrode **117a** and the second electrode **118** increases.

[0822] For example, the first electrode **117b** is electrically connected to the additional capacitor unit **131**, and when the first electrode **117a** moves by a predetermined length **L3**, the first electrode **117a** overlaps the second electrode **118** in the Z-axis direction. Accordingly, the capacitance of the first electrode **117a** and the second electrode **118** is formed based on equation 1, and the total capacitance of the capacitor unit **13** rapidly increases by the additional capacitor unit **131** connected in parallel thereto (a (gf) of FIG. **84**).

[0823] Thereafter, as the pressure applied to the core **11** increases, the overlap area between the first electrode **117a** and the second electrode **118** increases, and thus the capacitance therebetween also increases.

[0824] As described above, since the stylus pen **10** illustrated in FIGS. **74** to **84** according to the embodiments uses a simple structure to vary the capacitance of the resonant circuit unit **12**, the pen

pressure of the stylus pen may be detected, and costs for manufacturing the stylus pen may be reduced. Also, the precise pen pressure caused by the stylus pen may be measured.

[0825] FIG. **85** is a view illustrating another embodiment of the resonant circuit unit **12** of the stylus pen illustrated in FIG. **4**.

[0826] As illustrated in FIG. **85**, a stylus pen **10** includes a core **11** and a ferrite core **115** disposed in a housing **16**, a coil **116** wound around the ferrite core **115**, and a magnetic material **117** disposed in the housing **16**. Here, the housing **16** may be also referred to as a body unit.

[0827] The core **11** is inserted into a through-hole of the ferrite core **115**. One end of the core **11** serves as a pen tip of the stylus pen **10**. The ferrite core **115** may move in the Z-axis direction by pressure of the core **11** in the Z-axis direction.

[0828] When the ferrite core **115** moves in the Z-axis direction, a relative position between the ferrite core **115** and the magnetic material **117** is changed, and accordingly, a magnetic flux density is varied. An inductance of an inductor unit **14** is varied by a variation of the magnetic flux density. When a distance between the ferrite core **115** and the magnetic material **117** decreases, the inductance increases, and when the distance between the ferrite core **115** and the magnetic material **117** increases, the inductance decreases.

[0829] The magnetic material **117** may have a magnetic permeability equal to or different from that of the ferrite core **115**. The variation in magnetic flux density caused by the change in relative position between the ferrite core **115** and the magnetic material **117** is greater when the magnetic permeability of the magnetic material **117** is greater than that of the ferrite core **115** than when the magnetic permeability of the magnetic material **117** is less than that of the ferrite core **115**.

[0830] Although the ferrite core **115** has a cylindrical shape, and the magnetic material **117** has a ring shape surrounding the ferrite core **115** in this drawing, the embodiment of the present invention is not limited to the shapes of the ferrite core **115** and the magnetic material **117**. For example, each of the ferrite core **115** and the magnetic material **117** may have a cylindrical shape, a polygonal shape, a column shape in which at least a portion is a curved surface, an entasis column shape, a truncated pyramid shape, a truncated cone shape, and a toroid shape. The sheet-type magnetic material **117** may be attached to the housing **16** or the powder-type magnetic material **17** may be applied to the housing **16**.

[0831] The ferrite core **115** moves in the Z-axis direction as pressure applied to one end of the core **11** increases. As the ferrite core **115** moves in the Z-axis direction, a distance between the ferrite core **115** and the magnetic material **117** increases. Accordingly, an inductance value of the inductor unit **14** decreases.

[0832] Hereinafter, various modified examples of the stylus pen illustrated in FIG. **85** according to another embodiment of the present invention will be described in detail.

[0833] FIGS. **86A** and **86B** are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a first aspect, and FIG. **87** is a graph showing a variation of an inductance value of the stylus pen according to the first aspect.

[0834] FIGS. **86A** and **86B** illustrate a cross-section obtained by cutting the stylus pen **10** along the XZ plane.

[0835] As illustrated in FIG. **86A**, the core **11** is coupled with the ferrite core **115**. Accordingly, the ferrite core **115** moves by the pressure applied to the core **11**.

[0836] A first member **111** is disposed at the other end of the ferrite core **115** having one end at which the core **11** is disposed. When the ferrite core **115** moves in the Z-axis direction, the first member **111** may also move in the Z-axis direction. An elastic member **121** is disposed between the first member **111** and the support member **161** disposed in the housing **16**. The elastic member **121** is supported by the support member **161**. A second member **120** may be disposed at one end of the first member **111**. The second member **120** may be fastened to a catching member **162** disposed on an inner surface of the housing **16**. The catching member **162** prevents the core **11** from being separated to the outside of the housing **16** by the elastic member **121** pressing the first member **111**

in a direction opposite to the Z-axis.

[0837] As illustrated in FIG. **86B**, as the core **11** moves in the Z-axis direction, the ferrite core **115** and the first member **111** may also move in the Z-axis direction. The elastic member **121** may be compressed in the Z-axis direction as the first member **111** moves in the Z-axis direction. Here, a direction of elastic force of the elastic member **121** is opposite to the Z-axis. Thus, when the pressure applied to the core **11** is removed, the elastic member **121** is restored by the elastic force as illustrated in FIG. **86A**.

[0838] As the ferrite core **115** moves in the Z-axis direction, the distance between the ferrite core **115** and the magnetic material **117** increases.

[0839] Accordingly, as illustrated in FIG. **87**, when the stylus pen **10** contacts the touch screen **20**, since the ferrite core **115** is spaced apart from the magnetic material **117**, the inductance decreases. Also, as the pen pressure increases, the distance between the ferrite core **115** and the magnetic material **117** further increases, and thus the inductance further decreases.

[0840] FIGS. **88A** and **88B** are a view illustrating a structure of the magnetic material of FIGS. **86A** and **86B**.

[0841] The magnetic material **117** may have a different distribution in the housing **16**. The magnetic material **117** may be disposed with the different distribution along the Z-axis direction. For example, the magnetic material **117** may have a different thickness and/or area along the Z-axis direction.

[0842] Referring to FIG. **88A**, a shape of each of magnetic materials **1170** to **1175** on the inner surface of the housing **16** has a different X-directional length along the Z-axis direction. Accordingly, as the ferrite core **115** moves in the Z-axis direction, a variation amount of a magnetic flux density is changed.

[0843] Referring to FIG. **88B**, the magnetic material **117** includes a plurality of magnetic materials **117a** to **117e**, and areas of the plurality of magnetic materials **117a** to **117e** gradually decreases in the Z-axis direction.

[0844] In addition, the magnetic material **117** may be disposed in various manners so that a distribution of the magnetic material **117** is different in the Z-axis direction.

[0845] For example, referring to FIGS. **86A** and **86B** again, when the stylus pen **10** contacts the touch screen **20** with weak pen pressure, the ferrite core **115** moves within an area on which the magnetic material **117** is disposed with a high distribution, and thus decrease in inductance caused by pressure increase is large.

[0846] When the stylus pen **10** contacts the touch screen **20** with strong pen pressure, the ferrite core **115** moves within an area on which the magnetic material **117** is disposed with a low distribution, and thus the decrease in inductance caused by the pressure increase is small.

[0847] That is, there is a big difference between an inductance of the stylus pen **10** that is not in contact with the touch screen **20** and an inductance of the stylus pen **10** in contact with the touch screen **20**.

[0848] Thus, the touch screen **20** may determine whether the stylus pen **10** is in contact or not by recognizing a signal variation caused by a significant variation in inductance of the stylus pen **10**.

[0849] FIGS. **89A** and **89B** are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a second aspect.

[0850] As illustrated in FIG. **89A**, when compared with the stylus pen illustrated in FIG. **86A** according to the first aspect, the stylus pen according to this aspect may include the magnetic material **117** protruding by a predetermined height from an inner surface of the housing **16**.

[0851] As illustrated in FIG. **89B**, as the core **11** moves in the Z-axis direction, the ferrite core **115** and the first member **111** may also move in the Z-axis direction. The elastic member **121** may be compressed in the Z-axis direction as the first member **111** moves in the Z-axis direction. Here, a direction of elastic force of the elastic member **121** is opposite to the Z-axis. Thus, when the pressure applied to the core **11** is removed, the elastic member **121** is restored by the elastic force

as illustrated in FIG. **89A**.

[0852] As the ferrite core **115** moves in the Z-axis direction, the distance between the ferrite core **115** and the magnetic material **117** increases. When the stylus pen **10** contacts the touch screen **20**, since the ferrite core **115** is spaced apart from the magnetic material **117**, the inductance decreases. Also, as the pen pressure increases, the distance between the ferrite core **115** and the magnetic material **117** further increases, and thus the inductance further decreases.

[0853] FIGS. **90A** and **90B** are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a third aspect, and FIG. **91** is a graph showing a variation of a capacitance value of the stylus pen according to the third aspect.

[0854] As illustrated in FIG. **90A**, when compared with the stylus pen according to the first aspect, the stylus pen according to this aspect includes the magnetic material disposed adjacent to the first member **111**.

[0855] As illustrated in FIG. **90B**, as the core **11** moves in the Z-axis direction, the ferrite core **115** and the first member **111** may also move in the Z-axis direction. The elastic member **121** may be compressed in the Z-axis direction as the first member **111** moves in the Z-axis direction. Here, a direction of elastic force of the elastic member **121** is opposite to the Z-axis. Thus, when the pressure applied to the core **11** is removed, the elastic member **121** is restored by the elastic force as illustrated in FIG. **90A**.

[0856] As the ferrite core **115** moves in the Z-axis direction, the distance between the ferrite core **115** and the magnetic material **117** decreases.

[0857] When the stylus pen **10** contacts the touch screen **20**, since the ferrite core **115** is disposed adjacent to the magnetic material **117**, the inductance increases. Also, as the pen pressure increases, the distance between the ferrite core **115** and the magnetic material **117** further decreases, and thus the inductance further increases.

[0858] FIGS. **92A** and **92B** are a view illustrating a portion of a structure of the resonant circuit unit of the stylus pen according to a fourth aspect.

[0859] As illustrated in FIG. **92A**, when compared with the stylus pen according to the third aspect, the stylus pen according to this aspect may include the magnetic material **117** protruding by a predetermined height from an inner surface of the housing **16**.

[0860] As illustrated in FIG. **92B**, as the core **11** moves in the Z-axis direction, the ferrite core **115** and the first member **111** may also move in the Z-axis direction. The elastic member **121** may be compressed in the Z-axis direction as the first member **111** moves in the Z-axis direction. Here, a direction of elastic force of the elastic member **121** is opposite to the Z-axis. Thus, when the pressure applied to the core **11** is removed, the elastic member **121** is restored by the elastic force as illustrated in FIG. **92A**.

[0861] As the ferrite core **115** moves in the Z-axis direction, the distance between the ferrite core **115** and the magnetic material **117** decreases. When the stylus pen **10** contacts the touch screen **20**, since the ferrite core **115** is disposed adjacent to the magnetic material **117**, the inductance increases. Also, as the pen pressure increases, the distance between the ferrite core **115** and the magnetic material **117** further decreases, and thus the inductance further increases.

[0862] As described above, since the stylus pen **10** illustrated in FIGS. **85** to **92B** according to the embodiments uses a simple structure to vary the capacitance of the resonant circuit unit **12**, the pen pressure of the stylus pen may be detected, and the costs for manufacturing the stylus pen may be reduced. Also, the precise pen pressure caused by the stylus pen may be measured.

[0863] FIG. **93** is a view illustrating another embodiment of the resonant circuit unit **12** of the stylus pen illustrated in FIG. **4**.

[0864] Referring to FIG. **93**, a resonant circuit unit **12** of a stylus pen **10c** may include a capacitor unit **13** and an inductor unit **14**. The inductor unit **14** may include a ferrite core **115** and a coil **116** wound around the ferrite core **115**. The inductor unit **14** may further include a magnetic material **117**.

[0865] A through-hole may be formed in the ferrite core **115** along an axial direction (not shown) (Z-axis direction of FIG. **93**). The through-hole may be formed to allow the core **11** to be inserted thereto, and the core **11** may be inserted into the through-hole. Thus, replacement may be easily performed by separating and replacing only the core **11** from the ferrite core **115** when the core **11** is required to be replaced.

[0866] One end of the core **11** serves as a pen tip of the stylus pen **10c**. The one end of the core **11**, which serves as the pen tip, may be exposed to the outside of the ferrite core **115** through an opening of the through-hole formed in one surface of the ferrite core **115**. When pressure is applied in the axial direction to the one end that serves as the pen tip, the core **11** may move along the through-hole of the ferrite core **115**, i.e., along the Z-axis direction. In contrast, a position of the ferrite core **115** in the housing **15** of the stylus pen **10c** may be fixed. That is, the ferrite core **115** may be fixed at a specific position in the housing **15** regardless of the pen pressure applied to the core **11**. In this embodiment, the ferrite core **115** and the coil **116** are fixed below the magnetic material **117**, i.e., fixed adjacent to the pen tip of the core **11**, to improve a performance and secure mass production. Here, the housing **15** may be also referred to as a body unit.

[0867] The magnetic material **117** may be coupled to the other end of the core **11**. The other end of the core **11** may pass through the opening of the through-hole formed in the other surface of the ferrite core **115** to contact the magnetic material **117**. When the core **11** moves in the Z-axis direction, the magnetic material **117** may move in the Z-axis direction along a movement of the core **11**.

[0868] A fixing member **119** may be disposed in the housing **15**. The fixing member **119** may be fixed to the inside of the housing **15** to restrict a displacement amount of each of the core **11** and the magnetic material **117**. An elastic member **118** may be disposed between the fixing member **119** and the magnetic material **117**. The elastic member **118** may be supported by the fixing member **119**. When pressure in the Z-axis direction is applied to the core **11** and the magnetic material **117** moves toward the fixing member **119**, the elastic member **118** may be compressed in the Z-axis direction. When the pressure applied to the core **11** in the Z-axis direction is not provided or when the pressure applied to the core **11** in the Z-axis direction is less than elastic force of the elastic member **118**, the magnetic material **117** and the core **11** may move to an initial position thereof by the elastic force of the elastic member **118** or maintain the initial position. The elastic member **118** may be made of a material having elastic force such as a spring or elastic rubber.

[0869] When the core **11** moves in the Z-axis direction, the magnetic material **117** may move in the Z-axis direction together with the core **11** and be spaced apart from the ferrite core **115** in the Z-axis direction. Thus, a relative position between the ferrite core **115** and the magnetic material **117** may be changed.

[0870] FIGS. **94A** to **94C** are a view for explaining an operation according to the pen pressure of the stylus pen of FIG. **93**.

[0871] Referring to FIG. **94A**, each of the core **11** and the magnetic material **117** may maintain the initial position without moving in a state ('(a) Hover' state) in which the core **11** is not in contact with the touch screen (refer to reference numeral **20** of FIG. **1**). Accordingly, the ferrite core **115** and the magnetic material **117** may contact each other or maintain an extremely small spaced distance therebetween.

[0872] Referring to FIG. **94B**, when one end of the core **11** contacts the touch screen **20** ('(b) Contact' state), the core **11** and the magnetic material **117** may move in the Z-axis direction by pressure applied to the core **11** in the contact state. Here, since the ferrite core **115** maintains a fixed position in the housing **15** regardless of the pen pressure, the ferrite core **115** and the magnetic material **117** may be spaced apart from each other or the spaced distance between the ferrite core **115** and the magnetic material **117** may increase.

[0873] Referring to FIG. **94C**, the core **11** and the magnetic material **117** may additionally move in the Z-axis direction by the pen pressure applied to the core **11** when the pen pressure gradually

increases after the one end of the core **11** contacts the touch screen **20** ('(c) Pressure' state). That is, the core **11** and the magnetic material **117** may further move in the Z-axis direction as the pen pressure increases. Thus, the spaced distance between the ferrite core **115** and the magnetic material **117** may also increase as the pen pressure increases.

[0874] The magnetic material **117** may be made of a material having the same or different magnetic permeability as or from the ferrite core **115**. For example, the magnetic material **117** may be made of ferrite having the same magnetic permeability as the ferrite core **115**. The magnetic material **117** may give an influence on the inductance of the coil **116**, and change in relative position between the ferrite core **115** and the magnetic material **117** may change a variation amount of the magnetic flux density to vary the inductance of the resonant circuit unit **12**.

[0875] FIG. **95** is a schematic view illustrating an equivalent circuit of the resonant circuit unit of the stylus pen of FIG. **93**.

[0876] Referring to FIGS. **93** and **95** together, when the magnetic material **117** moves according to the pen pressure, an inductance L of the inductor unit **14** may be varied according to the pen pressure. This variable inductance (L) may gradually decrease as the separation distance between the ferrite core **115** and the magnetic material **117** increases. That is, as the pen pressure applied to the core **11** increases and the spaced distance between the ferrite core **115** and the magnetic material **117** increases, an inductance value of the resonant circuit unit **12** may gradually decrease.

[0877] When the inductance L of the inductor unit **14** is varied, a resonant frequency of the resonant circuit unit **12** is varied. Thus, in this embodiment, when the pen pressure is applied to the stylus pen **10c**, the resonant frequency of the resonant circuit unit **12** may be varied due to a variation of the inductance. When the resonant frequency of the resonant circuit unit **12** is varied, a phase of an electromagnetic signal output from the stylus pen **10c** in response to a driving signal of the touch screen (refer to reference numeral **20** of FIG. **1**) is changed. Accordingly, the touch controller (refer to reference numeral **262** of FIG. **4**) may detect the pen pressure by calculating the variation amount of the inductance of the resonant circuit unit **12** from the changed phase of the electromagnetic signal output from the stylus pen **10c**.

[0878] FIG. **96** is a view illustrating another embodiment of the resonant circuit unit **12** of the stylus pen illustrated in FIG. **4**.

[0879] Referring to FIG. **96**, a resonant circuit unit **12** of a stylus pen **10d** may include a capacitor unit **13** and an inductor unit **14**. The capacitor unit **13** may include at least one resonant capacitors C that are electrically connected to a coil **116** of the inductor unit **14**. The capacitor unit **13** may further include an additional capacitor CP that is selectively connected to the coil **116** and connected in parallel to the resonant capacitor C when connected to the coil **116**.

[0880] A through-hole, which allows a core **11** to be inserted thereto, may be formed in a ferrite core **115** along an axial direction (Z-axis direction of FIG. **96**), and the core **11** may be inserted to the through-hole. A position of the ferrite core **115** in a housing **15** of the stylus pen **10d** may be fixed. In this embodiment, the ferrite core **115** and the coil **116** are fixed below a switching member **120**, i.e., fixed adjacent to a pen tip of the core **11**, to improve a performance and secure mass production.

[0881] One end of the core **11** serves as the pen tip of the stylus pen **10d**. The one end of the core **11**, which serves as the pen tip, may be exposed to the outside of the ferrite core **115** through an opening of the through-hole formed in one surface of the ferrite core **115**. When pressure in the axial direction is applied to the one end that serves as the pen tip, the core **11** may move along the through-hole of the ferrite core **115**, i.e., along the Z-axis direction.

[0882] The stylus pen **10d** may further include a switching member **20** including a movable unit **121** and a fixing unit **122**. The movable unit **121** may be coupled to the other end of the core **11**. The other end of the core **11** may pass through the opening of the through-hole formed in the other surface of the ferrite core **115** to contact the movable unit **121**. When the core **11** moves in the Z-axis direction, the movable unit **121** may move in the Z-axis direction along a movement of the

core **11**. The fixing unit **122** may be disposed between the ferrite core **115** and the movable unit **121** and maintain a fixed position. For example, the position of the fixing unit **122** may be fixed to an end of the ferrite core **115**, which faces the movable unit **121**. In the switching member **120** having the above-described structure, the movable unit **121** may contact the fixing unit **122** or be spaced apart from the fixing unit **122** according to a movement of the core **11**.

[0883] A fixing member **119** may be disposed between the capacitor unit **13** and the inductor unit **14** in the housing **15** to restrict a displacement amount of each of the core **11** and the movable unit **121**. An elastic member **118** may be disposed between the fixing member **119** and a magnetic material **117**. The elastic member **118** may be supported by the fixing member **119**. When the pressure in the Z-axis direction is applied to the core **11** and the core **11** and the movable unit **121** move toward the fixing member **119**, the elastic member **118** may be compressed in the Z-axis direction. When the pressure applied to the core **11** in the Z-axis direction is not provided or when the pressure applied to the core **11** in the Z-axis direction is less than elastic force of the elastic member **118**, each of the movable unit **121** and the core **11** may move to an initial position thereof by the elastic force of the elastic member **118** or maintain the initial position.

[0884] FIGS. **97A** and **97B** are a view for explaining an operation according to the pen pressure of the stylus pen of FIG. **96**.

[0885] Referring to FIG. **97A**, the pressure applied to the core **11** in the Z-axis direction may not be provided, and each of the core **11** and the magnetic material **117** may maintain the initial position without moving in a state ('Hover' state) in which the core **11** is not in contact with the touch screen **20**. Accordingly, the movable unit **121** may maintain a state of being in contact with the fixing unit **122**.

[0886] Referring to FIG. **97B**, when one end of the core **11** contacts the touch screen **20** ('Contact' state), the core **11** and the magnetic material **121** may move in the Z-axis direction by pressure applied to the core **11** in the contact state. Accordingly, the movable unit **121** may be spaced apart from the fixing unit **122**.

[0887] Each of the movable unit **121** and the fixing unit **122** may include a substrate and at least one conductive contact **125** and **126** formed on the substrate. The movable unit **121** may include at least one conductive contact **125** electrically connected to the additional capacitor CP. The fixing unit **122** may include at least one contact **126** electrically connected to the coil **116**. The contacts **125** and **126** may be formed to face each other on surfaces of the substrate of the movable portion **121** and the substrate of the fixed portion **122**. Accordingly, the contacts **125** and **126** may be in contact with each other or spaced apart from each other depending on a contact state between the movable unit **121** and the fixing unit **122** to switch an electrical connection between the additional capacitor CP and the coil **116**.

[0888] FIG. **98** is a schematic view illustrating an equivalent circuit of the resonant circuit unit of the stylus pen of FIG. **96**. Referring to FIG. **98**, for example, contacts **125-1** and **125-2** of the movable unit **121** are connected to both ends of the additional capacitor CP, respectively, and contacts **126-1** and **126-2** of the fixing unit **122** are connected to both ends of the coil **116**, respectively. Accordingly, when the movable unit **121** and the fixing unit **122** contact each other, the contact **125-1** of the movable unit **121** and the contact **126-1** of the fixing unit **122** contact each other. When the contact **125-2** of the movable unit **121** and the contact **126-2** of the fixing unit **122** contact each other, the additional capacitor CP may be connected in parallel to the coil **116** together with the resonant capacitor C. On the other hand, when electrical connections between the contact **125-1** of the movable unit **121** and the contact **126-1** of the fixing unit **122** and between the contact **125-2** of the movable unit **121** and the contact **126-2** of the fixing unit **122** are disconnected as the movable unit **121** and the fixing unit **122** are spaced apart from each other, the additional capacitor CP may be electrically separated from the resonant capacitor C and the coil **116**, and thus a capacitance of the resonant circuit unit **12** may decrease.

[0889] When the capacitance of the resonant circuit unit **12** is varied, the resonant frequency of the

resonant circuit unit **12** is varied. Accordingly, in this embodiment, the resonant frequency of the resonant circuit unit **12** may be varied by connection release of the additional capacitor CP when the stylus pen **10d** contacts the touch screen **20**. When the resonant frequency of the resonant circuit unit **12** is varied, a phase of an electromagnetic signal output from the stylus pen **10d** in response to a driving signal of the touch screen (refer to reference numeral **20** of FIG. **1**) is changed. Accordingly, the touch controller (refer to reference numeral **262** of FIG. **4**) may detect whether the stylus pen **10d** contacts the touch screen **20** by detecting a variation in capacitance of the resonant circuit unit **12** from the changed phase of the electromagnetic signal output from the stylus pen **10d**.

[0890] FIG. **99** is a view illustrating another embodiment of the resonant circuit unit **12** of the stylus pen illustrated in FIG. **4**.

[0891] Referring to FIG. **99**, a resonant circuit unit **12** of a stylus pen **10e** may include a capacitor unit **13** and an inductor unit **14**. The inductor unit **14** may include a ferrite core **115** and a coil **116** wound around the ferrite core **115** and further include a magnetic material **117**. The capacitor unit **13** may include at least one resonant capacitor C and further include an additional capacitor CP.

[0892] A through-hole, which allows a core **11** to be inserted thereto, may be formed in a ferrite core **115** along an axial direction (Z-axis direction of FIG. **99**), and the core **11** may be inserted to the through-hole. A position of the ferrite core **115** in a housing **15** of the stylus pen **10e** may be fixed. In this embodiment, the ferrite core **115** and the coil **116** are fixed below the magnetic material **117** and a switching member **120**, i.e., fixed adjacent to a pen tip of the core **11**, to secure mass production.

[0893] One end of the core **11** serves as the pen tip of the stylus pen **10e**. The one end of the core **11**, which serves as the pen tip, may be exposed to the outside of the ferrite core **115** through an opening of the through-hole formed in one surface of the ferrite core **115**. When pressure in the axial direction is applied to the one end that serves as the pen tip, the core **11** may move along the through-hole of the ferrite core **115** (i.e., along the Z-axis direction).

[0894] The magnetic material **117** may be coupled to the other end of the core **11**. When the core **11** moves in the Z-axis direction, the magnetic material **117** may move in the Z-axis direction along a movement of the core **11**.

[0895] The stylus pen **10e** may further include the switching member **20** including a movable unit **121** and a fixing unit **122**. The movable unit **121** may be coupled to the other end of the core **11** and disposed between the magnetic material **117** and the ferrite core **115**. The other end of the core **11** may pass through the opening of the through-hole formed in the other surface of the ferrite core **115** to contact the movable unit **121**. The movable unit **121** may move in the axial direction (Z-axis direction in FIG. **11**) together with the magnetic material **117** according to a movement of the core **11**. The fixing unit **122** may be disposed between the ferrite core **115** and the movable unit **121** and maintain a fixed position. For example, the fixing unit **122** may be coupled to an end of the ferrite core **115**, which faces the movable unit **121**. In the switching member **120** having the above-described structure, the movable unit **121** may contact the fixing unit **122** or be spaced apart from the fixing unit **122** according to the movement of the core **11**.

[0896] A fixing member **119** may be disposed between the capacitor unit **13** and the inductor unit **14** in the housing **15** to restrict a displacement amount of each of the core **11** and the movable unit **121**. An elastic member **118** may be disposed between the fixing member **119** and the magnetic material **117**. When the pressure applied to the core **11** in the Z-axis direction is not provided or when the pressure applied to the core **11** in the Z-axis direction is less than elastic force of the elastic member **118**, each of the core **11**, the magnetic material **117**, and the movable unit **121** may move to an initial position thereof or maintain the initial position through the elastic force.

[0897] FIGS. **100A** to **100C** are a view for explaining an operation according to the pen pressure of the stylus pen of FIG. **99**.

[0898] Referring to FIG. **100A**, the pressure applied to the core **11** in the Z-axis direction may not

be provided, and the core **11** may maintain the initial position without moving in a state ('(a) Hover' state) in which the core **11** is not in contact with the touch screen **20**. Accordingly, each of the movable unit **121** and the magnetic material **117** may also maintain an initial position thereof without moving. In the initial position, the movable unit **121** may be in contact with the fixing unit **122**, and the ferrite core **115** and the magnetic material **117** may maintain an extremely small spaced distance therebetween (corresponding to a height in the Z-axis direction of the movable unit **121** and the fixing unit **122**).

[0899] Referring to FIG. **100B**, when one end of the core **11** contacts the touch screen **20** ('(b) Contact' state), the core **11** may move in the Z-axis direction by pressure applied to the core **11** in the contact state. Accordingly, the movable unit **121** may be spaced apart from the fixing unit **122**, and the spaced distance between the magnetic material **117** and the ferrite core **115** may also increase as many as a moving distance of the core **11**.

[0900] Referring to FIG. **100C**, when the pen pressure gradually increases after the one end of the core **11** contacts the touch screen **20** ('(c) Pressure' state), the core **11** may additionally move in the Z-axis direction by the pen pressure. Accordingly, the movable unit **121** and the magnetic material **117** may also additionally move in the Z-axis direction as many as an additionally moving distance of the core **11**, and the spaced distance between the magnetic material **117** and the ferrite core **115** may also additionally increase.

[0901] Each of the movable unit **121** and the fixing unit **122** may include a substrate and at least one contact **125** and **126** formed on the substrate. The movable unit **121** may include at least one contact **125** electrically connected to the additional capacitor CP. The fixing unit **122** may include at least one contact **126** electrically connected to the coil **116**. The contacts **125** and **126** may be formed on surfaces, which face each other, of the substrate of the movable unit **121** and the substrate of the fixing unit **122** to face each other. Accordingly, the contacts **125** and **126** may be in contact with each other or spaced apart from each other depending on a contact state between the movable unit **121** and the fixing unit **122** to switch an electrical connection between the additional capacitor CP and the coil **116**.

[0902] FIG. **101** is a schematic view illustrating an equivalent circuit of the resonant circuit unit of the stylus pen of FIG. **99**. Also, FIG. **102** is a graph showing, e.g., a LC value variation according to the pen pressure of the stylus pen of FIG. **99**, and FIG. **103** is a graph showing, e.g., frequency response characteristics of the stylus pen of FIG. **99**.

[0903] Referring to FIG. **101**, for example, contacts **125-1** and **125-2** of the movable unit **121** are connected to both ends of the additional capacitor CP, respectively, and contacts **126-1** and **126-2** of the fixing unit **122** are connected to both ends of the coil **116**, respectively. Accordingly, when the movable unit **121** and the fixing unit **122** contact each other, the contact **125-1** and the contact **126-1** may contact each other, and as the contact **125-2** and the contact **126-2** contact each other, the additional capacitor CP may be connected in parallel to the coil **116** together with the resonant capacitor C. On the other hand, when electrical connections between the contact **125-1** and the contact **126-1** and between the contact **125-2** and the contact **126-2** are disconnected as the movable unit **121** and the fixing unit **122** are spaced apart from each other, the additional capacitor CP may be separated from the resonant capacitor C and the coil **116**, and thus a capacitance of the resonant circuit unit **12** may decrease.

[0904] Also, a variation of the distance between the ferrite core **115** and the magnetic material **117** may vary the inductance of the resonant circuit unit **12**. Accordingly, as illustrated in FIG. **101**, the resonant circuit unit **12** may include an inductor unit **14** having an inductance value that is varied according to the pen pressure. The inductance value of the inductor unit **14** may gradually decrease as the spaced distance between the ferrite core **115** and the magnetic material **117** increases.

[0905] Thus, the LC value of the resonant circuit unit **12** may gradually decrease as the pen pressure applied to the core **11** increases. FIG. **102** illustrates a variation in LC value according to a variation in pen pressure as an example. Here, a Th section represents a section ('Hover' state of

FIG. 100A) in which the core **11** of the stylus pen **10e** is not in contact with the touch screen **20**, a Tc point represents a point ('Contact' state of FIG. 100B) immediately after the core **11** of the stylus pen **10e** contacts the touch screen **20**, and a Tp section represents a section ('Pressure' state of FIG. 100C in which the pen pressure applied to the stylus pen **10e** gradually increases.

[0906] Referring to FIG. 102, the LC value of the resonant circuit unit **12** maintains a constant value Th before the core **11** of the stylus pen **10e** contacts the touch screen **20** and then rapidly decreases immediately after Tc the movable unit **121** and the fixing unit **122** are spaced apart from each other as the core **11** contacts the touch screen **20**. Also, in the section Tp in which the pen pressure is applied to the stylus pen **10e** after the stylus pen **10e** contacts the touch screen **20**, the LC value of the resonant circuit unit **12** may further decrease depending on the pen pressure. That is, in this section Tp, as the pen pressure applied to the stylus pen **10e** increases, the LC value of the resonant circuit unit **12** may gradually decrease. Referring to FIG. 102, the LC value of the resonant circuit unit **12** shows 'Hover' state > 'Contact' state > 'Pressure' state. Also, a variation amount of the LC value is greater in a state immediately after the core **11** contacts the touch screen **20** than in a state in which the pen pressure gradually increases.

[0907] When the inductance and capacitance of the resonant circuit unit **12** are varied, the resonant frequency and Q value of the resonant circuit unit **12** may also be varied. The resonant frequency of the resonant circuit unit **12** may gradually increase as the inductance of the resonant circuit unit **12** decreases and gradually decrease as the Q value decreases. Thus, as illustrated in FIG. 103, frequency characteristics of a resonant signal Vpen output from the resonant circuit unit **12** according to this embodiment may have a resonant frequency that gradually increases ('Hover' state < 'Contact' state < 'Press' state) and the Q value that gradually decrease ('Hover' state > 'Contact' state > 'Press' state) as a moving distance of the core **11** increases, i.e., as the pen pressure increases.

[0908] When the resonant frequency of the resonant circuit unit **12** is varied, a phase of an electromagnetic signal output from the stylus pen **10e** in response to a driving signal of the touch screen (refer to reference numeral **20** of FIG. 1) is changed. Accordingly, the touch controller (refer to reference numeral **262** of FIG. 4) may calculate a LC value variation of the resonant circuit unit **12** from the changed phase of the electromagnetic signal output from the stylus pen **10e** and, based on this, detect whether the stylus pen **10e** contacts the touch screen **20** and the pen pressure.

[0909] As described above, since the stylus pen **10c**, **10d**, and **10e** illustrated in FIGS. 93 to 103 according to the embodiments may use a simple structure to vary at least one or both of the inductance and capacitance of the resonant circuit unit **12**, thereby reducing the costs for manufacturing the stylus pen capable of detecting the pen pressure. Also, the precise pen pressure caused by the stylus pen may be measured.

[0910] On the other hand, a soldering process may be additionally required in a process of configuring a circuit that detects whether a touch occurs and a pen pressure in a manufacturing process of the stylus pen according to the above-described embodiments. However, as the soldering process increases, the manufacturing process may become complex, manufacturing costs may also increase due to the complex manufacturing process, and a possibility of contact failure due to poor soldering may also increase. Thus, a soldering connection is required to be minimized in a process of realizing a function of detecting the pen pressure of the stylus pen.

[0911] Hereinafter, embodiments of the stylus pen **10** for reducing complexity of an assembly process by minimizing the soldering connection will be described with reference to FIGS. 104A to 109. FIGS. 104A to 108 illustrate embodiments modified from the stylus pen **10e** according to the third embodiment described with reference to FIGS. 100 to 102. In FIGS. 104A to 108, the same reference numerals are used for the same components as those of the stylus pen **10e** according to the third embodiment, and overlap descriptions are omitted.

[0912] FIGS. 104A and 104B is a schematic view illustrating a stylus pen **10f** according to a fourth embodiment.

[0913] Referring to FIGS. **104A** and **104B**, in the stylus pen **10f** according to the fourth embodiment, one end of a core **11** may serve as a pen tip, and a magnetic material **117** may be disposed at the other end of the core **11**. When the core **11** moves in the Z-axis direction by pen pressure, the magnetic material **117** may move in the Z-axis direction according to a movement of the core **11**.

[0914] The stylus pen **10f** may further include a switching member **120** including a movable unit **121** and a fixing unit **122**.

[0915] The movable unit **121** may be disposed to contact the magnetic material **117** or structurally coupled to the magnetic material **117**. The movable unit **121** may be disposed between the elastic member **118** and the magnetic material **117**. The movable unit **121** may be installed to be movable in the Z-axis direction inside a housing **15**. When the core **11** and the magnetic body **117** move toward the elastic member **118** by the pen pressure, the movable unit **121** may also move toward the elastic member **118** to press the elastic member **118**. When pressure applied to the core **11** in the Z-axis direction is not provided or when the pressure applied to the core **11** in the Z-axis direction is less than elastic force of the elastic member **118**, the movable unit **121** may move to an initial position thereof together with the magnetic material **117** and the core **11** by the elastic force of the elastic member **118** or maintain the initial position.

[0916] The fixing unit **122** may be installed to maintain a fixed position (e.g., a position between a ferrite core **115** and the movable unit **121**) in the housing **15**. The fixing unit **122** may include a through-hole formed in a central portion of the fixing unit **122** in the Z-axis direction. The magnetic material **117** may be inserted into the through-hole of the fixing unit **122**, and the magnetic material **117** may move along the through-hole in the Z-axis direction.

[0917] In the switching member **120** having the above-described structure, the movable unit **121** may contact the fixing unit **122** or be spaced apart from the fixing unit **122** according to the movement of the core **11**. When the pressure applied to the core **11** in the Z-axis direction is not provided, the movable unit **121** may be disposed at the initial position at which the movable unit **121** is in contact with the fixing unit **122**. On the other hand, when the core **11** moves toward the elastic member **118** by the pressure applied in the Z-axis direction, the movable unit **121** may be spaced apart from the fixing unit **122**.

[0918] The stylus pen **10f** may include a plurality of conductive contacts CP**11** to CP**18** and a plurality of conductive wires W**11** to W**16** for electrical connection between the capacitor unit **13** (the resonant capacitor C and the additional capacitor Cp) and the inductor unit **14** (the coil **116**).

[0919] The contacts CP**11** and CP**12** may be disposed on the capacitor unit **13** and electrically connected to both ends of the additional capacitor Cp, respectively.

[0920] The contacts CP**13** and CP**14** may be disposed on the fixing member **119** or the capacitor unit **13**. The contacts CP**13** and CP**14** may be electrically connected to both ends of at least one resonant capacitor C, respectively. The contacts CP**13** and CP**14** may also be electrically connected to both ends of the coil **116**, respectively.

[0921] The contacts CP**15** and CP**16** may be disposed on the fixing member **120** or the capacitor unit **121**. The contacts CP**15** and CP**16** may be electrically connected to the contacts CP**13** and CP**14** through the wires W**13** and W**14**, respectively. Accordingly, the contacts CP**15** and CP**16** may be electrically connected to both the ends of the coil **16**, respectively.

[0922] The contacts CP**17** and CP**18** may be disposed on the fixing unit **122** of the switching member **120**. The contacts CP**17** and CP**18** may be electrically connected to the contacts CP**11** and CP**12** through the wires W**11** and W**12**, respectively. Accordingly, the contacts CP**17** and CP**18** may be electrically connected to both the ends of the additional capacitor Cp, respectively.

[0923] The contacts CP**11** to CP**18** may be realized in various shapes capable of allowing the electrical connection, such as a conductive pad, a conductive tab, or a conductive bar (e.g., a metal bar).

[0924] When the movable unit **121** of the switching member **120** contacts the fixing unit **122**, the

contacts CP15 and CP16 disposed on the movable unit 121 may be electrically connected to the contacts CP17 and CP18 disposed on the fixing unit 122, respectively. For example, when the movable unit 121 and the fixing unit 122 contact each other, the contact CP15 may be electrically connected to the contact CP17, and the contact CP16 may be electrically connected to the contact CP18. The contacts CP15 and CP16 and the contacts CP17 and CP18 may be electrically disconnected from each other when the movable unit 121 of the switching member 120 is spaced apart from the fixing unit 122.

[0925] When the movable unit 121 of the switching member 120 contacts the fixing unit 122, an additional conductive bar (not shown), a contact hole (not shown), and a via-hole (not shown) may be used to electrically connect the contacts CP15 and CP16 disposed on the movable unit 121 and the contacts CP17 and CP18 disposed on the fixing unit 122.

[0926] The above-described structure of the stylus pen 10f may switch the electrical connection between the additional capacitor Cp and the coil 116 according to a contact state between the movable unit 121 and the fixing unit 122 of the switching member 120.

[0927] Referring to FIG. 104A, since the pressure applied to the core 11 in the Z-axis direction is not provided in the state ('(a) hover' state) in which the core 11 is not in contact with the touch screen 20, the core 11 may maintain the initial position without moving. Accordingly, the movable unit 121 and the magnetic material 117 may also maintain initial positions thereof without moving, and the ferrite core 115 and the magnetic material 117 may be in contact with each other or maintain an extremely small spaced distance. At the initial position, the movable unit 121 may maintain a state of being in contact with the fixing unit 122. Thus, as the contacts CP15 and CP16 of the movable unit 121 maintains the electrical connection with the contacts CP17 and CP18 of the fixing unit 122, both ends of the additional capacitor Cp are electrically connected to both ends of the coil 116, respectively.

[0928] Referring to FIG. 104B, when the pen pressure is applied to the stylus pen 10f in a state in which one end of the core 11 is in contact with the touch screen 20 ('(b) Pressure' state), the core 11 may move in the Z-axis direction by the pen pressure. Accordingly, the movable unit 121 and the magnetic material 117 may also move in the Z-axis direction as many as a moving distance of the core 11, and a spaced distance between the magnetic material 117 and the ferrite core 115 may also increase.

[0929] When the movable unit 121 moves toward the elastic member 118 by the pen pressure, the movable unit 121 and the fixing unit 122 may be spaced apart from each other, and the electrical connection between the contacts CP15 and CP16 of the movable unit 121 and the contacts CP17 and CP18 of the fixing unit 122 may be disconnected. Accordingly, the electrical connection between the additional capacitor Cp and the coil 116 may be also disconnected.

[0930] In the stylus pen 10f of FIGS. 104A and 104B, both ends of each of the wires W11, W12, W13, and W14 may be coupled to corresponding respective contacts CP11, CP12, CP13, CP14, CP15, CP16, CP17, and CP18 by soldering. Also, both the ends of the coil 116 may be bonded to the corresponding respective contacts CP13 and CP14 by soldering. Thus, in the stylus pen 10f, the soldering may be performed on eight contacts CP11, CP12, CP13, CP14, CP15, CP16, CP17, and CP18 for the electrical connection between the capacitor unit 13 (the resonant capacitor C and the additional capacitor Cp) and the inductor unit 14 (the coil 116).

[0931] FIGS. 105A and 105B are a schematic view illustrating a stylus pen 10g according to a fifth embodiment.

[0932] Referring to FIGS. 105A and 105B, the stylus pen 10g according to the fifth embodiment may include a plurality of conductive contacts CP11, CP14, CP15, and CP17 and a plurality of conductive wires W11 and W13 for electrical connection between a capacitor unit 13 (a resonant capacitor C and an additional capacitor Cp) and an inductor unit 14 (a coil 116). The stylus pen 10g may have a shape in which some contacts and wires are omitted from the above-described stylus pen 10f according to the fourth embodiment.

[0933] The contact CP11 may be disposed on the capacitor unit 13 and electrically connected to one end of the additional capacitor Cp. The other end of the additional capacitor Cp may maintain a state of being electrically connected to the resonant capacitor C regardless of the movement of the core 11. Thus, when compared with the stylus pen 10g of FIGS. 104A and 104B, some contacts (CP12, CP16, and CP18 of FIG. 16) and wires (W12 and W14 of FIG. 16) for switching the electrical connection between the other end of the additional capacitor Cp and the coil 116, CP18 may be omitted from the stylus pen 10g.

[0934] The contacts CP13 and CP14 may be disposed on the fixing member 119 or the capacitor unit 13. The contacts CP13 and CP14 may be electrically connected to both ends of at least one resonant capacitor C, respectively. The contacts CP13 and CP14 may be also electrically connected to both ends of the coil 116, respectively. The contact CP14 may be in a state of being electrically connected to the other end of the additional capacitor Cp.

[0935] The contact CP15 may be disposed on the movable unit 121 of the switching member 120 and electrically connected to the contact CP13 through the wire W13. Accordingly, the contact CP15 may be electrically connected to one end of the coil 116.

[0936] The contact CP17 may be disposed on the movable unit 122 of the switching member 120 and electrically connected to the contact CP11 through the wire W11. Accordingly, the contact CP17 may be electrically connected to one end of the additional capacitor Cp.

[0937] The contacts CP11, CP13, CP14, CP15, and CP17 may be realized in various shapes capable of allowing the electrical connection, such as a conductive pad, a conductive tab, or a conductive bar (e.g., a metal bar).

[0938] When the movable unit 121 of the switching member 120 contacts the fixing unit 122, the contact CP15 disposed on the movable unit 121 may be electrically connected to the contact CP17 disposed on the fixing unit 122. The contacts CP15 and CP17 may be electrically disconnected from each other when the movable unit 121 of the switching member 120 is spaced apart from the fixing unit 122.

[0939] The above-described structure of the stylus pen 10g may switch the electrical connection between one end of the additional capacitor Cp and one end of the coil 116 according to whether the movable unit 121 of the switching member 120 contacts the fixing unit 122.

[0940] Referring to FIG. 105A, the movable unit 121 may maintain a state of being in contact with the fixing unit 122 in a state ('(a) Hover' state) in which the core 11 is not in contact with the touch screen 20. Thus, as the contact CP15 of the movable unit 121 maintains the electrical connection with the contact CP17 of the fixing unit 12, both ends of the additional capacitor Cp may be electrically connected to both ends of the coil 116, respectively.

[0941] Referring to FIG. 105B, when the pen pressure is applied to the stylus pen 10g in a state in which one end of the core 11 contacts the touch screen 20 ('(b) Pressure' state), the core 11 may move in the Z-axis direction by the pen pressure. Accordingly, the movable unit 121 and the magnetic material 117 may also move in the Z-axis direction as many as a moving distance of the core 11. When the movable unit 121 moves toward the elastic member 118 by the pen pressure, the movable unit 121 and the fixing unit 122 may be spaced apart from each other, and the electrical connection between the contact CP15 of the movable unit 121 and the contact CP17 of the fixing unit 122 may be disconnected. Thus, the one end of the additional capacitor Cp may be separated from the coil 116.

[0942] In the stylus pen 10g of FIGS. 105A and 105B, both ends of each of the wires W11 and W13 may be bonded to corresponding respective contacts CP11, CP13, CP15, and CP17 by soldering. Also, both the ends of the coil 116 may be bonded to the corresponding respective contacts CP13 and CP14 by soldering. Thus, in the stylus pen 10f, the soldering may be performed on five contacts CP11, CP13, CP14, CP15, and CP17 for the electrical connection between the capacitor unit 13 (the resonant capacitor C and the additional capacitor Cp) and the inductor unit 14 (the coil 116).

[0943] FIGS. **106A** and **106B** are a schematic view illustrating a stylus pen **10h** according to a sixth embodiment.

[0944] Referring to FIGS. **106A** and **106B**, the stylus pen **10h** according to the sixth embodiment may include a plurality of contacts **CP11**, **CP13**, **CP14**, and **CP16**, a wire **W21**, and a contact structure **CP20** for electrical connection between a capacitor unit **13** (a resonant capacitor **C** and an additional capacitor **Cp**) and an inductor unit **14** (a coil **116**). When compared with the above-described stylus pen **10f** according to the fourth embodiment, the stylus pen **10h** may have a shape in which some contacts and wires are omitted or replaced by the contact structure **CP20** or the wire **W21**.

[0945] The contact **CP11** may be disposed on the capacitor unit **13** and electrically connected to one end of the additional capacitor **Cp**. The other end of the additional capacitor **Cp** may maintain a state of being electrically connected to the resonant capacitor **C** regardless of a movement of the core **11**.

[0946] The contacts **CP13** and **CP14** may be disposed on the fixing member **119** or the capacitor unit **13**. The contacts **CP13** and **CP14** may be electrically connected to both ends of at least one resonant capacitor **C**, respectively. The contacts **CP13** and **CP14** may be also electrically connected to both ends of the coil **116**, respectively. The contact **CP14** may be in a state of being electrically connected to the other end of the additional capacitor **Cp**.

[0947] The contact **CP16** may be disposed on a movable unit **121** of a switching member **120** and electrically connected to the contact **CP11** through the wire **W21**. Accordingly, the contact **CP16** may be electrically connected to one end of the additional capacitor **Cp**.

[0948] The contacts **CP11**, **CP13**, **CP14**, and **CP16** may be realized in various shapes capable of allowing the electrical connection, such as a conductive pad, a conductive tab, or a conductive bar (e.g., a metal bar).

[0949] The contact structure **CP20** may perform a function of switching the electrical connection between one end of the additional capacitor **Cp** and one end of the coil **116**. The contact structure **CP20** may include a connection unit **130** that electrically connects two conductive contacts **CP21** and **CP22** to each other.

[0950] One end of the contact **CP21** may be disposed on the fixing unit **122** of the switching member **120**, and the other end may extend in the Z-axis direction to pass through a through-hole formed in the movable unit **121**. The other end of the contact **CP21** may further extend in the Z-axis direction and electrically connected to the contact **CP13**. Accordingly, the contact **CP21** may be electrically connected to one end of the coil **116** through the contact **CP13**. The contact **CP21** may be electrically connected to the contact **CP13** by a bonding method such as soldering or electrically connected to the contact **CP13** by a contact method. The contact **CP21** may be coupled through the through-hole formed in the movable unit **121** in the Z-axis direction and maintain a fixed position although the movable unit **121** moves in the Z-axis direction. The contact **CP21** may maintain a state of being electrically connected to the one end of the coil **116** although the movable unit **121** moves in the Z-axis direction.

[0951] The contact **CP22** may have one end disposed on the fixing unit **122** of the switching member **120** and the other end extending in the Z-axis direction. The contact **CP22** may be selectively electrically connected to the contact **CP16**. The contact **CP22** may be electrically connected to the contact **CP16** when the movable unit **121** contacts the fixing unit **122**. The electrical connection between the contact **CP22** and the contact **CP16** may be disconnected when the movable unit **121** is spaced apart from the fixing unit **122**. Thus, the contact **CP22** may be selectively electrically connected to the one end of the additional capacitor **Cp** according to a movement of the movable unit **121**.

[0952] The connection unit **130** may be disposed on the fixing unit **122** of the switching unit **120** and electrically connect the contact **CP21** to the contact **CP22**.

[0953] The above-described structure of the stylus pen **10h** may switch the electrical connection

between the one end of the additional capacitor Cp and the one end of the coil **116** according to whether the movable unit **121** of the switching member **120** contacts the fixing unit **122**.

[0954] Referring to FIG. **106A**, the movable unit **121** may maintain a state of being in contact with the fixing unit **122** in a state ('(a) Hover' state) in which the core **11** is not in contact with the touch screen **20**. Thus, as the contact CP**16** of the movable unit **121** maintains the electrical connection with the contact structure of the fixing unit **122**, both ends of the additional capacitor Cp may be electrically connected to both ends of the coil **116**, respectively.

[0955] Referring to FIG. **106B**, when the pen pressure is applied to the stylus pen **10h** in a state in which one end of the core **11** is in contact with the touch screen **20** ('(b) Pressure' state), the core **11** may move in the Z-axis direction by the pen pressure. Accordingly, the movable unit **121** and the magnetic material **117** may also move in the Z-axis direction as many as a moving distance of the core **11**. When the movable unit **121** moves toward the elastic member **118** by the pen pressure, the movable unit **121** and the fixing unit **122** may be spaced apart from each other, and the electrical connection between the contact CP**16** of the movable unit **121** and the contact CP**22** of the fixing unit **122** may be disconnected. Thus, the one end of the additional capacitor Cp may be separated from the coil **116**.

[0956] In the stylus pen **10h** of FIGS. **106A** and **106B**, both ends of the wire W**21** may be bonded to corresponding respective contacts CP**11** and CP**16** by soldering. Also, both the ends of the coil **116** may be bonded to the corresponding respective contacts CP**13** and CP**14** by soldering. Also, one end of the contact CP**21** may be additionally bonded to the contact CP**13** by soldering. Thus, in the stylus pen **10f**, the soldering may be performed on four contacts CP**11**, CP**13**, CP**14**, and CP**16** for the electrical connection between the capacitor unit **13** (the resonant capacitor C and the additional capacitor Cp) and the inductor unit **14** (the coil **116**).

[0957] FIGS. **107A** and **107B** are a schematic view illustrating a stylus pen **10i** according to a seventh embodiment.

[0958] Referring to FIGS. **107A** and **107B**, the stylus pen **10i** according to the seventh embodiment may include a plurality of contacts CP**13**, CP**14**, CP**16**, and CP**31**, a conductive elastic member **140**, and a contact structure CP**20** for electrical connection between a capacitor unit **13** (a resonant capacitor C and an additional capacitor Cp) and an inductor unit **14** (a coil **116**). When compared with the above-described stylus pen **10h** according to the sixth embodiment, the stylus pen **10i** may have a shape in which the wire is omitted and the conductive elastic member **140** is added.

[0959] The contact CP**31** may be disposed on the capacitor unit **13** or the fixing member **119** and electrically connected to one end of the additional capacitor Cp. The other end of the additional capacitor Cp may maintain a state of being electrically connected to the resonant capacitor C regardless of a movement of the core **11**.

[0960] The contacts CP**13** and CP**14** may be disposed on the fixing member **119** or the capacitor unit **13**. The contacts CP**13** and CP**14** may be electrically connected to both ends of at least one resonant capacitor C, respectively. The contacts CP**13** and CP**14** may be also electrically connected to both ends of the coil **116**, respectively. The contact CP**14** may be in a state of being electrically connected to the other end of the additional capacitor Cp.

[0961] The contact CP**16** may be disposed on a movable unit **121** of a switching member **120** and electrically connected to the contact CP**31** through the conductive elastic member, i.e., a conductive spring **140**. Accordingly, the contact CP**16** may be electrically connected to one end of the additional capacitor Cp. The conductive spring **140** may maintain a state in which both ends thereof are electrically connected to the contacts CP**31** and CP**16** regardless of a movement of the movable unit **122**.

[0962] The contacts CP**13**, CP**14**, CP**16**, and CP**31** may be realized in various shapes capable of allowing the electrical connection, such as a conductive pad, a conductive tab, or a conductive bar (e.g., a metal bar).

[0963] The contact structure CP**20** may perform a function of switching the electrical connection

between one end of the additional capacitor Cp and one end of the coil **116**. The contact structure CP**20** may include a connection unit **130** that electrically connects two conductive contacts CP**21** and CP**22**.

[0964] One end of the contact CP**21** may be disposed on the fixing unit **122** of the switching member **120**, and the other end may extend in the Z-axis direction to pass through a through-hole formed in the movable unit **121**. The other end of the contact CP**21** may further extend in the Z-axis direction and electrically connected to the contact CP**13**. Accordingly, the contact CP**21** may be electrically connected to one end of the coil **116** through the contact CP**13**. The contact CP**21** may be electrically connected to the contact CP**13** by a bonding method such as soldering or electrically connected to the contact CP**13** by a contact method. The contact CP**21** may be coupled through the through-hole formed in the movable unit **121** in the Z-axis direction and maintain a fixed position although the movable unit **121** moves in the Z-axis direction. The contact CP**21** may maintain a state of being electrically connected to the one end of the coil **116** although the movable unit **121** moves in the Z-axis direction.

[0965] The contact CP**22** may have one end disposed on the fixing unit **122** of the switching member **120** and the other end extending in the Z-axis direction. The contact CP**22** may be selectively electrically connected to the contact CP**16**. The contact CP**22** may be electrically connected to the contact CP**16** when the movable unit **121** contacts the fixing unit **122**. The electrical connection between the contact CP**22** and the contact CP**16** may be disconnected when the movable unit **121** is spaced apart from the fixing unit **122**. Thus, the contact CP**22** may be selectively electrically connected to the one end of the additional capacitor Cp according to a movement of the movable unit **121**.

[0966] The connection unit **130** may be disposed on the fixing unit **122** of the switching unit **120** and electrically connect the contact CP**21** electrically connected to the one end of the coil **116** and the contact CP**22** selectively electrically connected to the one end of the additional capacitor Cp.

[0967] The above-described structure of the stylus pen **10i** may switch the electrical connection between the one end of the additional capacitor Cp and the one end of the coil **116** according to whether the movable unit **121** of the switching member **120** contacts the fixing unit **122**.

[0968] Referring to FIG. **107A**, the movable unit **121** may maintain a state of being in contact with the fixing unit **122** in a state ('(a) Hover' state) in which the core **11** is not in contact with the touch screen **20**. Thus, as the contact CP**16** of the movable unit **121** maintains the electrical connection with the contact structure CP**20** of the fixing unit **122**, both ends of the additional capacitor Cp may be electrically connected to both ends of the coil **116**, respectively.

[0969] Referring to FIG. **107B**, when the pen pressure is applied to the stylus pen **10i** in a state in which one end of the core **11** is in contact with the touch screen **20** ('(b) Pressure' state), the core **11** may move in the Z-axis direction by the pen pressure. Accordingly, the movable unit **121** and the magnetic material **117** may also move in the Z-axis direction as many as a moving distance of the core **11**. When the movable unit **121** moves toward the elastic member **118** by the pen pressure, the movable unit **121** and the fixing unit **122** may be spaced apart from each other, and the electrical connection between the contact CP**16** of the movable unit **121** and the contact CP**20** of the fixing unit **122** may be disconnected. Thus, the one end of the additional capacitor Cp may be separated from the coil **116**.

[0970] In the stylus pen **10i** of FIGS. **107A** and **107B**, the conductive spring **140** may not require separate soldering. Also, both the ends of the coil **116** may be bonded to the corresponding respective contacts CP**13** and CP**14** by soldering. Also, one end of the contact CP**21** may be additionally bonded to the contact CP**13** by soldering. Thus, in the stylus pen **10i**, the soldering may be performed on two contacts CP**13** and CP**14** for the electrical connection between the capacitor unit **13** (the resonant capacitor C and the additional capacitor Cp) and the inductor unit **14** (the coil **116**).

[0971] FIGS. **108A** and **108B** are a schematic view illustrating a stylus pen **10j** according to an

eight embodiment.

[0972] Referring to FIGS. **108A** and **108B**, the stylus pen **10j** according to the eighth embodiment may include a plurality of contacts **CP13**, **CP14**, **CP31**, **CP41**, **CP42**, and **CP43** for electrical connection between a capacitor unit **13** (a resonant capacitor **C** and an additional capacitor **Cp**) and an inductor unit **14** (a coil **116**).

[0973] The contact **CP31** may be disposed on the capacitor unit **13** or the fixing member **119** and electrically connected to one end of the additional capacitor **Cp**. The other end of the additional capacitor **Cp** may maintain a state of being electrically connected to the resonant capacitor **C** regardless of a movement of the core **11**.

[0974] The contacts **CP13** and **CP14** may be disposed on the fixing member **119** or the capacitor unit **13**. The contacts **CP13** and **CP14** may be electrically connected to both ends of at least one resonant capacitor **C**, respectively. The contacts **CP13** and **CP14** may be also electrically connected to both ends of the coil **116**, respectively. The contact **CP14** may be in a state of being electrically connected to the other end of the additional capacitor **Cp**.

[0975] The contacts **CP41**, **CP42**, and **CP43** may perform a function of switching the electrical connection between one end of the additional capacitor **Cp** and one end of the coil **116**.

[0976] One end of the contact **CP41** may be disposed on the fixing unit **122** of the switching member **120**, and the other end may extend in the Z-axis direction to pass through a through-hole formed in the movable unit **121**. The other end of the contact **CP41** may further extend in the Z-axis direction and electrically connected to the contact **CP13**. Accordingly, the contact **CP41** may be electrically connected to one end of the coil **116** through the contact **CP13**. The contact **CP41** may be electrically connected to the contact **CP13** by a bonding method such as soldering or electrically connected to the contact **CP13** by a contact method. The contact **CP41** may be coupled through the through-hole formed in the movable unit **121** in the Z-axis direction and maintain a fixed position although the movable unit **121** moves in the Z-axis direction. Thus, the contact **CP41** may maintain a state of being electrically connected to the one end of the coil **116** although the movable unit **121** moves in the Z-axis direction.

[0977] One end of the contact **CP42** may be disposed on the fixing unit **122** of the switching member **120**, and the other end may extend in the Z-axis direction to pass through a through-hole formed in the movable unit **121**. The other end of the contact **CP42** may further extend in the Z-axis direction and electrically connected to the contact **CP31**. Accordingly, the contact **CP42** may be electrically connected to one end of the additional capacitor **Cp** through the contact **CP31**. The contact **CP42** may be electrically connected to the contact **CP31** by a bonding method such as soldering or electrically connected to the contact **CP31** by a contact method. The contact **CP42** may be coupled through the through-hole formed in the movable unit **121** in the Z-axis direction and maintain a fixed position although the movable unit **121** moves in the Z-axis direction. Thus, the contact **CP42** may maintain a state of being electrically connected to the one end of the additional capacitor **Cp** although the movable unit **121** moves in the Z-axis direction.

[0978] The contact **CP43** may be disposed on a surface facing the magnetic material **117** in the movable unit **121**. The contact **CP43** may be selectively electrically connected to the contact **CP41** and the contact **CP42** according to a position of the movable unit **121**.

[0979] At an initial position of the movable unit **121**, i.e., in a state in which the movable unit **121** is in contact with the fixing unit **122**, both ends of the contact **CP43** may maintain a state of being electrically connected to the contacts **CP41** and **C42**, respectively. When the movable unit **121** moves from the initial position toward the elastic member **118**, i.e., when the movable unit **121** and the fixed unit **122** are spaced apart from each other, the electrical connection between both ends of the contact **CP43** and the contacts **C41** and **CP42** may be disconnected.

[0980] The above-described structure of the stylus pen **10j** may switch the electrical connection between the one end of the additional capacitor **Cp** and the one end of the coil **116** according to whether the movable unit **121** of the switching member **120** contacts the fixing unit **122**.

[0981] Referring to FIG. **108A**, the movable unit **121** may maintain a state of being in contact with the fixing unit **122** in a state ('(a) Hover' state) in which the core **11** is not in contact with the touch screen **20**. Accordingly, both ends of the additional capacitor **Cp** may be electrically connected to the coil **116** by maintaining a state in which both ends of the contact **CP43** are electrically connected to the contacts **CP41** and **CP42**, respectively.

[0982] Referring to FIG. **108B**, when the pen pressure is applied to the stylus pen **10j** in a state in which one end of the core **11** is in contact with the touch screen **20** ('(b) Pressure' state), the core **11** may move in the Z-axis direction by the pen pressure. Accordingly, the movable unit **121** and the magnetic material **117** may also move in the Z-axis direction as many as a moving distance of the core **11**. When the movable unit **121** moves toward the elastic member **118** by the pen pressure, the movable unit **121** and the fixing unit **122** may be spaced apart from each other, and the electrical connection between the contact **CP43** of the movable unit **121** and the contacts **CP41** and **CP42** of the fixing unit **122** may be disconnected. Thus, the one end of the additional capacitor **Cp** may be separated from the coil **116**.

[0983] In the stylus pen **10j** of FIGS. **108A** and **108B**, electrical connection between the contacts **CP41**, **CP42**, and **CP43** may not require separate soldering. Both the ends of the coil **116** may be bonded to the corresponding respective contacts **CP13** and **CP14** by soldering. Thus, in the stylus pen **10j**, the soldering may be performed on two contacts **CP13** and **CP14** for the electrical connection between the capacitor unit **13** (the resonant capacitor **C** and the additional capacitor **Cp**) and the inductor unit **14** (the coil **116**). As necessary, additional soldering may be required to bond the contacts **CP41** and **CP42** to the contacts **CP13** and **CP14**, respectively.

[0984] FIGS. **109A** and **109B** are a schematic view illustrating a stylus pen **10k** according to a ninth embodiment.

[0985] Referring to FIGS. **109A** and **109B**, the stylus pen **10k** according to the ninth embodiment may include a plurality of contacts **CP11**, **CP13**, **CP14**, **CP15**, and **CP16**, a wire **W21**, and a contact structure **CP50** for electrical connection between a capacitor unit **13** (a resonant capacitor **C** and an additional capacitor **Cp**) and an inductor unit **14** (a coil **116**). When compared with the above-described stylus pen **10f** according to the fourth embodiment, the stylus pen **10k** may have a shape in which some contacts and wires are omitted or replaced by the contact structure **CP50** or the wire **W21**.

[0986] The contact **CP11** may be disposed on the capacitor unit **13** and electrically connected to one end of the additional capacitor **Cp**. The other end of the additional capacitor **Cp** may maintain a state of being electrically connected to the resonant capacitor **C** regardless of a movement of the core **11**.

[0987] The contacts **CP13** and **CP14** may be disposed on the fixing member **119** or the capacitor unit **13**. The contacts **CP13** and **CP14** may be electrically connected to both ends of at least one resonant capacitor **C**, respectively. The contacts **CP13** and **CP14** may be also electrically connected to both ends of the coil **116**, respectively. The contact **CP14** may be in a state of being electrically connected to the other end of the additional capacitor **Cp**.

[0988] The contacts **CP15** and **CP16** may be disposed on the movable unit **121** of the switching member **120**. The contact **CP15** may be electrically connected to the contact **CP13** through the wire **W13**. The contact **CP16** may be electrically connected to the contact **CP11** through the wire **W21**. Thus, the contact **CP15** may be electrically connected to one end of the coil **116**, and the contact **CP16** may be electrically connected to one end of the additional capacitor **Cp**.

[0989] The contacts **CP11**, **CP13**, **CP14**, **CP15**, and **CP16** may be realized in various shapes capable of allowing the electrical connection, such as a conductive pad, a conductive tab, or a conductive bar (e.g., a metal bar).

[0990] The contact structure **CP50** may perform a function of switching the electrical connection between one end of the additional capacitor **Cp** and one end of the coil **116**. The contact structure **CP50** may include a connection unit **150** that electrically connects two conductive contacts **CP51**

and CP52 to each other.

[0991] The contact CP51 may have one end disposed on the fixing unit 122 of the switching member 120 and the other end extending in the Z-axis direction. The contact CP51 may be selectively electrically connected to the contact CP15. The contact CP51 may be electrically connected to the contact CP15 when the movable unit 121 contacts the fixing unit 122. The electrical connection between the contact CP51 and the contact CP15 may be disconnected when the movable unit 121 is spaced apart from the fixing unit 122.

[0992] Thus, the contact CP51 may be selectively electrically connected to the one end of the coil 116 according to a movement of the movable unit 121.

[0993] The contact CP52 may have one end disposed on the fixing unit 122 of the switching member 120 and the other end extending in the Z-axis direction. The contact CP52 may be selectively electrically connected to the contact CP16. The contact CP52 may be electrically connected to the contact CP16 when the movable unit 121 contacts the fixing unit 122. The electrical connection between the contact CP52 and the contact CP16 may be disconnected when the movable unit 121 is spaced apart from the fixing unit 122. Thus, the contact CP52 may be selectively electrically connected to the one end of the additional capacitor Cp according to a movement of the movable unit 121.

[0994] The connection unit 150 may be disposed on the fixing unit 122 of the switching unit 120 and electrically connect the contact CP51 to the contact CP52.

[0995] The above-described structure of the stylus pen 10k may switch the electrical connection between the one end of the additional capacitor Cp and the one end of the coil 116 according to whether the movable unit 121 of the switching member 120 contacts the fixing unit 122.

[0996] Referring to FIG. 109A, the movable unit 121 may maintain a state of being in contact with the fixing unit 122 in a state ('(a) Hover' state) in which the core 11 is not in contact with the touch screen 20. Thus, as the contacts CP15 and CP16 of the movable unit 121 maintains the electrical connection with the contact structure CP50 of the fixing unit 122, both ends of the additional capacitor Cp may be electrically connected to both ends of the coil 116, respectively.

[0997] Referring to FIG. 109B, when the pen pressure is applied to the stylus pen 10k in a state in which one end of the core 11 is in contact with the touch screen 20 ('(b) Pressure' state), the core 11 may move in the Z-axis direction by the pen pressure. Accordingly, the movable unit 121 and the magnetic material 117 may also move in the Z-axis direction as many as a moving distance of the core 11. When the movable unit 121 moves toward the elastic member 118 by the pen pressure, the movable unit 121 and the fixing unit 122 may be spaced apart from each other, and the electrical connection between the contacts CP15 and CP16 of the movable unit 121 and the contact structure CP50 of the fixing unit 122 may be disconnected. Thus, the one end of the additional capacitor Cp may be separated from the coil 116.

[0998] In the stylus pen 10k of FIGS. 109A and 109B, both ends of each of the wires W13 and W21 may be bonded to corresponding respective contacts CP13 and CP15 or CP11 and CP16 by soldering. Also, both the ends of the coil 116 may be bonded to the corresponding respective contacts CP13 and CP14 by soldering. Thus, in the stylus pen 10k, the soldering may be performed on five contacts CP11, CP13, CP14, CP15, and CP16 for the electrical connection between the capacitor unit 13 (the resonant capacitor C and the additional capacitor Cp) and the inductor unit 14 (the coil 116).

[0999] The touch input device according to the various embodiments in this specification may include various types of devices. The touch input device may include, e.g., a portable communication device (e.g., a smart phone), a computer device, a portable multimedia device, a portable medical device, a camera, a wearable device, or a home appliance. The touch input device according to the embodiment of this specification is not limited to the above-described devices.

[1000] The various embodiments of this specification and the terms used herein are not intended to limit the technical features described in this document to specific embodiments, and should be

understood to include various modifications, equivalents, or substitutions of the embodiments. When the drawings are described, like reference numerals refer to like elements throughout. The singular form of the noun corresponding to the item may include one or more items, unless the relevant context clearly describes otherwise. As used herein, each of the phrases “A or B”, “at least one of A and B”, “at least one of A or B,” “A, B or C,” “at least one of A, B, and C,” and “at least one of A, B, or C” may include all possible combinations of the items listed together in the corresponding one of the phrases. Terms such as “1st”, “2nd”, “first”, or “second” may simply be used to distinguish a component from another component, and the component is not limited in another aspect (e.g., importance or order). When one (e.g., first) component is “coupled” or “connected” to another (e.g., second) component, with or without the terms “functionally” or “communicatively”, this indicates that one component may be connected to the other component directly (e.g., by wire), wirelessly, or through a third component.

[1001] As used herein, the term “module” may include a unit implemented in hardware, software, or firmware, and may be used interchangeably with terms such as, e.g., logic, logic block, component, or circuit. A module may be an integrally formed part or a minimum unit or a portion of the part that performs one or more functions. For example, according to an embodiment, the module may be implemented in the form of an application-specific integrated circuit (ASIC).

[1002] Various embodiments of the present specification may be implemented as software (e.g., a program) including one or more commands stored in a storage medium (e.g., internal memory or external memory) readable by a machine (e.g., an electronic device). For example, a processing unit (e.g., a processor) of a device (e.g., a touch input device) may call one or more commands stored from a storage medium and execute it. This makes it possible for the device to be operated to perform one or more functions depending on the called one or more commands. The one or more commands may include codes generated by a compiler or executable by an interpreter. The device-readable storage medium may be provided in the form of a non-transitory storage medium. Herein, the term ‘non-transitory’ only indicates that the storage medium is a tangible device and does not include a signal (e.g., electromagnetic wave), and this term does not distinguish a case in which data is stored semi-permanently in a storage medium from a case in which data is temporarily stored therein.

[1003] According to an embodiment, the method according to various embodiments disclosed in this document may be provided as being included in a computer program product. A computer program product may be traded between a seller and a buyer as a commodity. The computer program product may be distributed in the form of a machine-readable storage medium (e.g., compact disc read only memory (CD-ROM)), or may be distributed (e.g., downloaded or uploaded) via an application store (e.g., Play Store™), directly between two user devices (e.g., smart phones), or in an online manner. In the case of online distribution, at least a part of the computer program product may be at least temporarily stored or temporarily created in a machine-readable storage medium such as a memory of a server of a manufacturer, a server of an application store, or a memory of a relay server.

[1004] According to various embodiments, each component (e.g., a module or a program) of the above-described components may include a singular entry or a plurality of entities. According to various embodiments, one or more components or operations among the above-described corresponding components may be omitted, or one or more other components or operations may be added. Alternatively, or additionally, a plurality of components (e.g., a module or a program) may be integrated into one component. In this case, the integrated component may perform one or more functions of each component of the plurality of components identically or similarly to being performed by the corresponding component among the plurality of components prior to the integration. According to various embodiments, operations performed by a module, program, or other component may be executed sequentially, in parallel, repeatedly, or heuristically, one or more

of the operations may be executed in a different order or may be omitted, or one or more other operations may be added.

Claims

1-7. (canceled)

8. A pen and touch input system comprising: a touch input device comprising a sensor unit and a control unit configured to control the sensor unit; and a stylus pen configured to interact with the touch input device, wherein the sensor unit comprises: a plurality of first patterns each extending in a first direction and having first ends electrically connected to the control unit; and a plurality of third patterns each extending in a second direction different from the first direction and having first ends electrically connected to the control unit, wherein the control unit applies a touch driving signal to the plurality of first patterns and receives a touch sensing signal from the plurality of third patterns, and the control unit receives a stylus pen sensing signal from at least one pen-sensing-pattern of the plurality of first and third patterns, wherein the stylus pen comprises: a body unit having at least a portion extending in one direction; an inductor unit comprising a ferrite core disposed in the body unit and a coil wound in multiple layers around at least a portion of the ferrite core; a capacitor unit disposed in the body unit and comprising a capacitor electrically connected to the coil of the inductor unit; and a core having at least a portion disposed in the body unit to move in the one direction by pressure applied to one end thereof, and a capacitance of the capacitor unit and/or an inductance of the inductor unit are varied by the pressure applied to the one end of the core.

9. The pen and touch input system of claim 8, wherein the ferrite core is fixedly installed in the body unit and has a through-hole passing through in one direction, at least a portion of the core between one end and the other end is disposed in the through-hole of the ferrite core, the capacitor unit comprises: a first electrode connected to the other end of core to operate together with the core; and a second electrode fixedly installed on the first electrode, and an overlap area between the first electrode and the second electrode is varied when the first electrode moves in the one direction by the pressure applied to the one end of the core.

10. (canceled)

11. The pen and touch input system of claim 8, wherein the ferrite core is disposed in the body unit and has a through-hole passing through in one direction, at least a portion of the core between one end and the other end is disposed in the through-hole of the ferrite core, the ferrite core of the inductor unit is coupled with the core to operate together with the core, the inductor unit comprises a magnetic material fixedly installed in the body unit, and a spaced distance between the ferrite core and the magnetic material is changed when the ferrite core moves in the one direction by the pressure applied to the one end of the core.

12. The pen and touch input system of claim 8, wherein the capacitor unit comprises a first capacitor electrically connected to the coil of the inductor unit and a second capacitor electrically connected to the first capacitor, further comprising a switching member disposed in the body unit to switch electrical connection between the first capacitor and the second capacitor according to a movement of the core in the one direction, wherein a capacitance of the capacitor unit is varied by the pressure applied to the one end of the core.

13. The pen and touch input system of claim 8, wherein the ferrite core is fixedly disposed in the body unit, further comprising a magnetic material disposed in the body unit and operating with the core to move in the one direction, wherein an inductance of the inductor unit is varied by the pressure applied to the one end of the core.

14. The pen and touch input system of claim 8, wherein the ferrite core is fixedly installed in the body unit and has a through-hole passing through in one direction, the capacitor unit comprises a capacitor electrically connected to the coil of the inductor unit and an additional capacitor

electrically connected to the capacitor; at least a portion between one end and the other end of the core is disposed in the through-hole of the ferrite core, further comprising a switching member configured to switch electrical connection between the capacitor and the additional capacitor according to the pressure applied to the core, wherein the inductor unit comprises a magnetic material having a varied spaced distance from the ferrite core according to the pressure applied to the core.

15-56. (canceled)

57. The pen and touch input system of claim 9, wherein the second electrode has a through-hole or cavity into which the first electrode is inserted.

58. The pen and touch input system of claim 9, further comprising a dielectric material disposed in the through-hole or cavity of the second electrode, wherein the dielectric material has a through-hole or cavity having a size that allows the first electrode is inserted thereto.

59. The pen and touch input system of claim 58, wherein the dielectric material has different thicknesses or areas along the one direction.

60. The pen and touch input system of claim 58, wherein the dielectric comprises a first dielectric material and a second dielectric material, which are sequentially arranged along the one direction, and the first dielectric material has a dielectric constant greater than that of the second dielectric material.

61. The pen and touch input system of claim 9, further comprising an additional capacitor electrically connected to the first electrode when the first electrode moves by a predetermined distance in the one direction by the pressure applied to the one end of the core.

62. The pen and touch input system of claim 11, wherein the spaced distance between the ferrite core and the magnetic material increases or decreases when the pressure applied to the one end of the core increases.

63. The pen and touch input system of claim 11, wherein the magnetic material has different thicknesses or areas along the one direction.

64. The pen and touch input system of claim 11, wherein the magnetic material is disposed on an inner surface of the body unit or protrudes from the inner surface of the body unit.

65. The pen and touch input system of claim 12, wherein the switching member comprises a movable unit coupled to the other end of the core to operate together with the core and a fixing unit fixedly installed between the movable unit and the ferrite core, the movable unit of the switching member comprises a movable electrode electrically connected to the capacitor unit, and the fixing unit of the switching member comprises a fixing electrode electrically connected to the capacitor unit, and a contact state between the movable unit and the fixing unit is varied by the pressure applied to the core.

66. The pen and touch input system of claim 65, wherein, when the pressure is not applied to the one end of the core, the movable unit maintains the contact state with the fixing unit, so that the movable electrode is electrically connected to the fixing electrode, and when the pressure is applied to the one end of the core, the movable electrode is electrically separated from the fixing electrode as the movable unit moves, so that the movable electrode is electrically separated from the fixing electrode.

67. The pen and touch input system of claim 66, wherein as the pressure applied to the one end of the core increases after the movable electrode is electrically separated from the fixing electrode, the spaced distance between the ferrite core and the magnetic material increases.

68. The pen and touch input system of claim 14, wherein the switching member comprises a movable unit couple to the other end of the core to operate together with the core and fixing unit fixedly installed between the movable unit and the ferrite core, the movable unit of the switching member comprises a movable electrode electrically connected to the capacitor unit, and the fixing unit of the switching member comprises a fixing electrode electrically connected to the capacitor unit, and a contact state between the movable unit and the fixing unit is varied by the pressure

applied to the core.

69. The pen and touch input system of claim 68, wherein, when the pressure is not applied to the one end of the core, the movable unit maintains the contact state with the fixing unit, so that the movable electrode is electrically connected to the fixing electrode, and when the pressure is applied to the one end of the core, the movable electrode is electrically separated from the fixing electrode as the movable unit moves, so that the movable electrode is electrically separated from the fixing electrode.

70. The pen and touch input system of claim 1, wherein the sensor unit further comprises: a plurality of second patterns each extending in the first direction and disposed adjacent to the first patterns; and a plurality of fourth patterns each extending in the second direction and disposed adjacent to the third patterns, wherein second ends of at least a portion of the plurality of second patterns are electrically connected to each other, and second ends of at least a portion of the plurality of fourth patterns are electrically connected to each other, wherein the control unit applies a stylus pen driving signal to at least one pattern of the plurality of first to fourth patterns, and the control unit receives stylus pen sensing signals from at least one pattern of the plurality of first to fourth patterns.
