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## ELECTRONIC DEVICE INCLUDING MULTI-CHANNEL GRIP SENSOR, AND METHOD FOR SENSING CAPACITANCE CHANGE USING MULTI-CHANNEL GRIP SENSOR


### Abstract

An electronic device includes: a first antenna; a second antenna; a first radio frequency (RF) front-end circuit configured to transmit a first RF signal to the first antenna via a first RF signal path; a second RF front-end circuit configured to transmit a second RF signal to the second antenna via a second RF signal path; and a multi-channel grip sensor including a first channel and a second channel, wherein the first channel is connected to the first antenna via a first grip sensing path, wherein the second channel is connected to the second antenna via a second grip sensing path, and wherein the multi-channel grip sensor is configured to sense a change in a first capacitance of the first antenna through the first channel and a change in a second capacitance of the second antenna through the second channel.



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## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation application of International Application No. PCT/KR2023/004691 designating the United States, filed on Apr. 7, 2023, in the Korean Intellectual Property Receiving Office and claiming priority to Korean Patent Application No. 10-2022-0076339, filed on Jun. 22, 2022, and Korean Patent Application No. 10-2022-0088562, filed on Jul. 18, 2022, in the Korean Intellectual Property Office, the disclosures of which are incorporated by reference herein in their entireties.

BACKGROUND
1. Field
[0002] The disclosure relates to a method and device for sensing capacitance using a multi-channel grip sensor.
2. Description of Related Art
[0003] Capacitance varies according to a distance between two conductors, their area, and a permittivity of a dielectric between the two conductors. In wireless communications, impedance matching of circuits used to transmit and/or receive a radio frequency (RF) signal may be necessary to transmit and/or receive an RF signal while reducing a loss.
SUMMARY
[0004] In accordance with an aspect of the disclosure, an electronic device includes: a first antenna; a second antenna; a first radio frequency (RF) front-end circuit configured to transmit a first RF signal to the first antenna via a first RF signal path; a second RF front-end circuit configured to transmit a second RF signal to the second antenna via a second RF signal path; a transceiver connected to the first RF front-end circuit and the second RF front-end circuit; and a multi-channel grip sensor including a first channel and a second channel, wherein the first channel is connected to the first antenna via a first grip sensing path, wherein the second channel is connected to the second antenna via a second grip sensing path, wherein the multi-channel grip sensor is configured to sense a change in a first capacitance of the first antenna through the first channel and a change in a second capacitance of the second antenna through the second channel.
[0005] The first RF signal path may include a coaxial cable or a flexible RF cable (FRC).
[0006] The electronic device may further include: a communication processor configured to control the transceiver; and a flexible printed circuit board (FPCB) connecting the multi-channel grip sensor to the communication processor.
[0007] The electronic device may further include a main board and a sub-board. The first RF front-end circuit, the second RF front-end circuit, and the transceiver may be provided on the main board of the electronic device, and the multi-channel grip sensor may be provided on the sub-board of the electronic device.

[0008] The first antenna may be provided adjacent to the sub-board, and the second antenna may be provided adjacent to the main board.
[0009] The electronic device may further include: a first isolation circuit connected between the first channel of the multi-channel grip sensor and the first antenna on the first grip sensing path; a second isolation circuit connected between the second channel and the first RF signal path on the second grip sensing path; and a third isolation circuit connected between the first RF signal path and the second antenna on the second grip sensing path.
[0010] Each of the first isolation circuit, the second isolation circuit, and the third isolation circuit may include either an inductor of 40 nH or greater or a resistor of 500 ohms or less.
[0011] The electronic device may further include: a first matching circuit on the first RF signal path; and a second matching circuit on the second RF signal path. The first matching circuit and the second matching circuit may be configured to perform impedance matching.
[0012] The electronic device may further include: a third antenna; and a third RF front-end circuit configured to transmit a third RF signal to the third antenna via a third RF signal path.
[0013] The third RF signal path may include a coaxial cable or an FRC.
[0014] In accordance with an aspect of the disclosure, an electronic device includes: a first antenna; a second antenna; a third antenna; a RF front-end circuit configured to transmit a first RF signal to the first antenna via a first RF signal path; a second RF front-end circuit configured to transmit a second RF signal to the second antenna via a second RF signal path; a third RF front-end circuit configured to transmit a third RF signal to the third antenna via a third RF signal path; a transceiver connected to the first RF front-end circuit, the second RF front-end circuit, and the third RF front-end circuit; and a multi-channel grip sensor including a first channel and a second channel, wherein the first channel is connected to the first antenna via a first grip sensing path, wherein the second channel is connected to the second antenna via a second grip sensing path, wherein the second channel is connected to the third antenna via the second channel, wherein the multi-channel grip sensor is configured to sense a change in a first capacitance of the first antenna through the first channel, a change in a second capacitance of the second antenna through the second channel and a chance in a third capacitance of the third antenna through the second channel.
[0015] The electronic device may further include a main board and a sub-board. The first RF front-end circuit, the second RF front-end circuit, the third RF front-end circuit, and the transceiver may be provided on the main board of the electronic device. The multi-channel grip sensor may be provided on the sub-board of the electronic device. The first antenna and the third antenna may be provided adjacent to the sub-board, and the second antenna may be provided adjacent to the main board.
[0016] The electronic device may further include: a first isolation circuit connected between the first channel of the multi-channel grip sensor and the first antenna on the first grip sensing path; a second isolation circuit connected between the second channel and the third RF signal path on the second grip sensing path; and a third isolation circuit connected between the third RF signal path and the second antenna on the second grip sensing path.
[0017] In accordance with an aspect of the disclosure, a method of sensing capacitance using a multi-channel grip sensor in an electronic device configured to perform wireless communication, includes: sensing, using a first channel of the multi-channel grip sensor connected to a first antenna of the electronic device, a change in a first capacitance of the first antenna; and sensing, using a second channel of the multi-channel grip sensor connected to a second antenna through a first RF signal path, a change in a second capacitance of the second antenna. An RF signal is transmitted through the first RF signal path between the first antenna and a first RF front-end circuit of the electronic device.
[0018] The method may further include: performing impedance matching of the first antenna based on the change in the first capacitance of the first antenna; and performing impedance matching of the second antenna based on the change in the second capacitance of the second antenna.

[0019] In accordance with an aspect of the disclosure, an electronic device includes: a first board; a second board connected to the first board via a flexible printed circuit board and a radio frequency cable; a processor provided on the first board; a first antenna; a second antenna; a first RF front-end circuit provided on the first board, and configured to transmit a first RF signal to the first antenna via a first RF signal path, wherein the first RF signal path includes the radio frequency cable; a second RF front-end circuit provided on the first board, and configured to transmit a second RF signal to the second antenna via a second RF signal path; and a multi-channel grip sensor provided on the second board, connected to the processor via the flexible printed circuit board, and including a first channel and a second channel, wherein the first channel is connected to the first antenna via a first grip sensing path, wherein the second channel is connected to the second antenna via a second grip sensing path, wherein the multi-channel grip sensor is configured to sense a change in a first capacitance of the first antenna through the first channel and a change in a second capacitance of the second antenna through the second channel.
[0020] The electronic device may further include a plurality of matching circuits, and the processor may be configured to, based on a change in capacitance of the first antenna or the second antenna, control the plurality of matching circuits to performance impedance matching.
[0021] The electronic device may further include a first matching circuit provided on the second board, and the processor may be configured to, based on a change in capacitance of the first antenna, control the first matching circuit to performance impedance matching.
[0022] The electronic device may further include a second matching circuit provided on the first board, and the processor may be configured to, based on a change in capacitance of the second antenna, control the second matching circuit to performance impedance matching.
[0023] The first RF front-end circuit may include a first duplexer and a first amplifier, and the second RF front-end circuit may include a second duplexer and a second amplifier.

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## Description

BRIEF DESCRIPTION OF DRAWINGS
[0024] The above and other aspects, features, and advantages of certain embodiments of the present disclosure will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:
[0025] FIG. **1** is a block diagram illustrating an electronic device in a network environment, according to one or more embodiments;
[0026] FIG. **2** is a diagram illustrating a configuration of an electronic device including a multi-channel grip sensor, according to an embodiment;
[0027] FIG. **3** is a diagram illustrating a configuration of an electronic device including a multi-channel grip sensor, according to an embodiment;
[0028] FIG. **4** is a diagram illustrating an exemplary arrangement of a configuration for communication within an electronic device, according to an embodiment;
[0029] FIG. **5** is a diagram illustrating a configuration of an electronic device including a multi-channel grip sensor, according to an embodiment; and
[0030] FIG. **6** is a flowchart of a method of sensing a change in capacitance using a multi-channel grip sensor, according to an embodiment.
DETAILED DESCRIPTION
[0031] Hereinafter, embodiments are described in detail with reference to the accompanying drawings. Like reference numerals refer to like components and a repeated description related thereto is omitted.
[0032] In a portable electronic device including an antenna for wireless communication, when a user holds the portable electronic device, impedance of the antenna may change due to a hand of

the user, and the changed impedance may affect communication performance. A grip sensor may be connected to the antenna and may detect a change in a capacitance of the antenna. When a change in the capacitance is detected, the portable electronic device may perform impedance matching, which may be used to improve communication performance. Portable electronic devices are increasingly required to be slimmer and smaller in size for easier portability by users. However, due to such slimming and miniaturization, difficulties are increasing in arranging or designing antennas and grip sensors within portable electronic devices.

[0033] An electronic device including a multi-channel grip sensor according to an embodiment and a method of sensing a change in capacitance using the multi-channel grip sensor may improve performance degradation of the multi-channel grip sensor in a limited mounting space of a portable electronic device. Hereinafter, the electronic device and the method of sensing a change in capacitance are described in detail.

[0034] FIG. **1** is a block diagram illustrating an electronic device **101** in a network environment **100**, according to various embodiments. Referring to FIG. **1**, the electronic device **101** in the network environment **100** may communicate with an electronic device **102** via a first network **198** (e.g., a short-range wireless communication network), or communicate with at least one of an electronic device **104** or a server **108** via a second network **199** (e.g., a long-range wireless communication network). According to an embodiment, the electronic device **101** may communicate with the electronic device **104** via the server **108**. According to an embodiment, the electronic device **101** may include a processor **120**, a memory **130**, an input module **150**, a sound output module **155**, a display module **160**, an audio module **170**, a sensor module **176**, an interface **177**, a connecting terminal **178**, a haptic module **179**, a camera module **180**, a power management module **188**, a battery **189**, a communication module **190**, a subscriber identification module (SIM) **196**, or an antenna module **197**. In some embodiments, at least one of the components (e.g., the connecting terminal **178**) may be omitted from the electronic device **101**, or one or more other components may be added to the electronic device **101**. In some embodiments, some of the components (e.g., the sensor module **176**, the camera module **180**, or the antenna module **197**) may be integrated as a single component (e.g., the display module **160**).

[0035] The processor **120** may execute, for example, software (e.g., a program **140**) to control at least one other component (e.g., a hardware component) of the electronic device **101** connected to the processor **120** and may perform various data processing or computation. According to an embodiment, as at least a part of data processing or computation, the processor **120** may store a command or data received from another component (e.g., the sensor module **176** or the communication module **190**) in a volatile memory **132**, process the command or the data stored in the volatile memory **132**, and store resulting data in a non-volatile memory **134**. According to an embodiment, the processor **120** may include a main processor **121** (e.g., a central processing unit (CPU) or an application processor (AP)), or an auxiliary processor **123** (e.g., a graphics processing unit (GPU), a neural processing unit (NPU), an image signal processor (ISP), a sensor hub processor, or a communication processor (CP)) that is operable independently from, or in conjunction with the main processor **121**. For example, when the electronic device **101** includes the main processor **121** and the auxiliary processor **123**, the auxiliary processor **123** may be adapted to consume less power than the main processor **121** or to be specific to a specified function. The auxiliary processor **123** may be implemented separately from the main processor **121** or as a part of the main processor **121**.

[0036] The auxiliary processor **123** may control at least some of functions or states related to at least one (e.g., the display module **160**, the sensor module **176**, or the communication module **190**) of the components of the electronic device **101**, instead of the main processor **121** while the main processor **121** is in an inactive (e.g., sleep) state or along with the main processor **121** while the main processor **121** is in an active state (e.g., executing an application). According to an embodiment, the auxiliary processor **123** (e.g., an ISP or a CP) may be implemented as a portion of another component (e.g., the camera module **180** or the communication module **190**) that is functionally related to the auxiliary processor **123**. According to an embodiment, the auxiliary processor **123** (e.g., an NPU) may include a hardware structure specialized for artificial intelligence model processing. An artificial intelligence model may be generated through machine learning. Such learning may be performed, for example, by the electronic device **101** in which the artificial intelligence model is executed, or via a separate server (e.g., the server **108**). Learning algorithms may include, but are not limited to, for example, supervised learning, unsupervised learning, semi-supervised learning, or reinforcement learning. The artificial intelligence model may include a plurality of artificial neural network layers. An artificial neural network may include, for example, a deep neural network (DNN), a convolutional neural network (CNN), a recurrent neural network (RNN), a restricted Boltzmann machine (RBM), a deep belief network (DBN), a bidirectional recurrent deep neural network (BRDNN), a deep Q-network, or a combination of two or more thereof, but is not limited thereto.

[0037] The memory **130** may store various pieces of data used by at least one component (e.g., the processor **120** or the sensor module **176**) of the electronic device **101**. The various pieces of data may include, for example, software (e.g., the program **140**) and input data or output data for a command related thereto. The memory **130** may include the volatile memory **132** or the non-volatile memory **134**.

[0038] The program **140** may be stored as software in the memory **130** and may include, for example, an operating system (OS) **142**, middleware **144**, or an application **146**.

[0039] The input module **150** may receive a command or data to be used by another component (e.g., the processor **120**) of the electronic device **101**, from the outside (e.g., a user) of the electronic device **101**. The input module **150** may include, for example, a microphone, a mouse, a keyboard, a key (e.g., a button), or a digital pen (e.g., a stylus pen).

[0040] The sound output module **155** may output a sound signal to the outside of the electronic device **101**. The sound output module **155** may include, for example, a speaker or a receiver. The speaker may be used for general purposes, such as playing multimedia or playing a record. The receiver may be used to receive an incoming call. According to an embodiment, the receiver may be implemented separately from, or as part of, the speaker.

[0041] The display module **160** may visually provide information to the outside (e.g., a user) of the electronic device **101**. The display module **160** may include, for example, a display, a hologram device, or a projector and control circuitry to control a corresponding one of the display, the hologram device, and the projector. According to an embodiment, the display module **160** may include a touch sensor adapted to sense a touch, or a pressure sensor adapted to measure the intensity of force incurred by the touch.

[0042] The audio module **170** may convert a sound into an electrical signal or vice versa. According to an embodiment, the audio module **170** may obtain the sound via the input module **150** or output the sound via the sound output module **155** or an external electronic device (e.g., the electronic device **102** such as a speaker or headphones) directly or wirelessly connected to the electronic device **101**.

[0043] The sensor module **176** may detect an operational state (e.g., power or temperature) of the electronic device **101** or an environmental state (e.g., a state of a user) external to the electronic device **101** and may generate an electrical signal or data value corresponding to the detected state. According to an embodiment, the sensor module **176** may include, for example, a gesture sensor, a gyro sensor, an atmospheric pressure sensor, a magnetic sensor, an acceleration sensor, a grip sensor, a proximity sensor, a color sensor, an infrared (IR) sensor, a biometric sensor, a temperature sensor, a humidity sensor, or an illuminance sensor.

[0044] The interface **177** may support one or more specified protocols to be used for the electronic device **101** to be coupled with the external electronic device (e.g., the electronic device **102**) directly (e.g., by wire) or wirelessly. According to an embodiment, the interface **177** may include, for example, a high-definition multimedia interface (HDMI), a universal serial bus (USB) interface, a secure digital (SD) card interface, or an audio interface.

[0045] The connecting terminal **178** may include a connector via which the electronic device **101** may be physically connected to an external electronic device (e.g., the electronic device **102**). According to an embodiment, the connecting terminal **178** may include, for example, an HDMI connector, a USB connector, an SD card connector, or an audio connector (e.g., a headphones connector).

[0046] The haptic module **179** may convert an electrical signal into a mechanical stimulus (e.g., a vibration or a movement) or an electrical stimulus which may be recognized by a user via their tactile sensation or kinesthetic sensation. According to an embodiment, the haptic module **179** may include, for example, a motor, a piezoelectric element, or an electric stimulator.

[0047] The camera module **180** may capture a still image and moving images. According to an embodiment, the camera module **180** may include one or more lenses, image sensors, ISPs, or flashes.

[0048] The power management module **188** may manage power supplied to the electronic device **101**. According to an embodiment, the power management module **188** may be implemented as, for example, at least a part of a power management integrated circuit (PMIC).

[0049] The battery **189** may supply power to at least one component of the electronic device **101**. According to an embodiment, the battery **189** may include, for example, a primary cell which is not rechargeable, a secondary cell which is rechargeable, or a fuel cell.

[0050] The communication module **190** may support establishing a direct (e.g., wired) communication channel or a wireless communication channel between the electronic device **101** and the external electronic device (e.g., the electronic device **102**, the electronic device **104**, or the server **108**) and performing communication via the established communication channel. The communication module **190** may include one or more CPs that are operable independently of the processor **120** (e.g., an AP) and that support direct (e.g., wired) communication or wireless communication. According to an embodiment, the communication module **190** may include a wireless communication module **192** (e.g., a cellular communication module, a short-range wireless communication module, or a global navigation satellite system (GNSS) communication module) or a wired communication module **194** (e.g., a local area network (LAN) communication module or a power line communication (PLC) module). A corresponding one of these communication modules may communicate with the external electronic device **104** via the first network **198** (e.g., a short-range communication network, such as Bluetooth™, wireless fidelity (Wi-Fi) direct, or infrared data association (IrDA)) or the second network **199** (e.g., a long-range communication network, such as a legacy cellular network, a 5G network, a next-generation communication network, the Internet, or a computer network (e.g., a LAN or a wide area network (WAN)). These various types of communication modules may be implemented as a single component (e.g., a single chip), or may be implemented as multi components (e.g., multi chips) separate from each other. The wireless communication module **192** may identify and authenticate the electronic device **101** in a communication network, such as the first network **198** or the second network **199**, using subscriber information (e.g., international mobile subscriber identity (IMSI)) stored in the SIM **196**.

[0051] The wireless communication module **192** may support a 5G network after a 4G network, and next-generation communication technology, for example, new radio (NR) access technology. The NR access technology may support enhanced mobile broadband (eMBB), massive machine type communications (mMTC), or ultra-reliable and low-latency communications (URLLC). The wireless communication module **192** may support a high-frequency band (e.g., a mmWave band) to achieve, e.g., a high data transmission rate. The wireless communication module **192** may support various technologies for securing performance on a high-frequency band, such as, e.g., beamforming, massive multiple-input and multiple-output (MIMO), full dimensional MIMO (FD-

MIMO), an array antenna, analog beam-forming, or a large scale antenna. The wireless communication module **192** may support various requirements specified in the electronic device **101**, an external electronic device (e.g., the electronic device **104**), or a network system (e.g., the second network **199**). According to an embodiment, the wireless communication module **192** may support a peak data rate (e.g., 20 Gbps or more) for implementing eMBB, loss coverage (e.g., 164 dB or less) for implementing mMTC, or U-plane latency (e.g., 0.5 ms or less for each of downlink (DL) and uplink (UL), or a round trip of 1 ms or less) for implementing URLLC.

[0052] The antenna module **197** may transmit or receive a signal or power to or from the outside (e.g., the external electronic device) of the electronic device **101**. According to an embodiment, the antenna module **197** may include an antenna including a radiating element including a conductive material or a conductive pattern formed in or on a substrate (e.g., a printed circuit board (PCB)). According to an embodiment, the antenna module **197** may include a plurality of antennas (e.g., array antennas). In such a case, at least one antenna appropriate for a communication scheme used in a communication network, such as the first network **198** or the second network **199**, may be selected by, for example, the communication module **190** from the plurality of antennas. The signal or power may be transmitted or received between the communication module **190** and the external electronic device via the at least one selected antenna. According to one or more embodiments, another component (e.g., a radio frequency integrated circuit (RFIC)) other than the radiating element may be additionally formed as a part of the antenna module **197**.

[0053] According to embodiments, the antenna module **197** may form a mmWave antenna module. According to an example embodiment, the mmWave antenna module may include a PCB, an RFIC provided on a first surface (e.g., a bottom surface) of the PCB or adjacent to the first surface and capable of supporting a designated high-frequency band (e.g., the mmWave band), and a plurality of antennas (e.g., array antennas) provided on a second surface (e.g., a top or a side surface) of the PCB, or adjacent to the second surface and capable of transmitting or receiving signals in the designated high-frequency band.

[0054] At least some of the above-described components may be coupled mutually and communicate signals (e.g., commands or data) therebetween via an inter-peripheral communication scheme (e.g., a bus, general purpose input and output (GPIO), serial peripheral interface (SPI), or mobile industry processor interface (MIPI)).

[0055] According to an example embodiment, commands or data may be transmitted or received between the electronic device **101** and the external electronic device **104** via the server **108** coupled with the second network **199**. Each of the external electronic devices **102** or **104** may be a device of the same type as or a different type from the electronic device **101**. According to an embodiment, all or some of operations to be executed by the electronic device **101** may be executed by one or more external electronic devices (e.g., the external electronic devices **102** or **104**, or the server **108**). For example, if the electronic device **101** needs to perform a function or a service automatically, or in response to a request from a user or another device, the electronic device **101**, instead of, or in addition to, executing the function or the service, may request the one or more external electronic devices to perform at least part of the function or the service. The one or more external electronic devices receiving the request may perform the at least part of the function or the service requested, or an additional function or an additional service related to the request and may transfer an outcome of the performing to the electronic device **101**. The electronic device **101** may provide the outcome, with or without further processing of the outcome, as at least part of a reply to the request. To this end, cloud computing, distributed computing, mobile edge computing (MEC), or client-server computing technology may be used, for example. The electronic device **101** may provide ultra-low-latency services using, e.g., distributed computing or MEC. In an embodiment, the external electronic device **104** may include an Internet-of-things (IoT) device. The server **108** may be an intelligent server using machine learning and/or a neural network. According to an embodiment, the external electronic device **104** or the server **108** may be included in the second

network **199**. The electronic device **101** may be applied to intelligent services (e.g., a smart home, a smart city, a smart car, or healthcare) based on 5G communication technology or IoT-related technology.
[0056] FIG. **2** is a diagram illustrating a configuration of an electronic device including a multi-channel grip sensor, according to an embodiment.
[0057] Referring to FIG. **2**, an electronic device **200** may include a processor **205**, a transceiver **210** controlled by the processor **205** and configured to perform wireless communication, a radio frequency (RF) front-end circuit (e.g., a first RF front-end circuit **215** and a second RF front-end circuit **220**) connected to the transceiver **210** and configured to perform preprocessing of RF transmission/reception signals, and an antenna (e.g., a first antenna **230** and a second antenna **235**) connected to the RF front-end circuit and configured to transmit and receive an RF signal. The RF front-end circuit may include a duplexer (e.g., a first duplexer **260** and a second duplexer **270**) and an amplifier (e.g., a first amplifier **265** and a second amplifier **275**). The processor **205** may be a main processor or a communication processor. The transceiver **210** may be controlled by the processor **205** or the transceiver **210** via a mobile industry processor interface (MIPI) interface (e.g., a first MIPI interface **280** and a second MIPI interface **285**). The electronic device **200** may include matching components (i.e., matching circuits) **245** and **250** used for impedance matching for RF transmission and reception and isolation components (i.e., isolation circuits) **240** and **255** for reducing an influence of capacitance change sensing of a multi-channel grip sensor **225** on an RF signal.
[0058] The electronic device **200** may further include a grip sensor to detect a change in a capacitance of the antenna due to a grip (i.e., a hand) of the user on the electronic device **200**. The electronic device **200** may include a plurality of antennas to improve communication performance, and in order to detect a change in capacitance of each of the antennas, the electronic device **200** may include the multi-channel grip sensor **225** that detects a change in capacitance through a plurality of channels (e.g., a first channel **223** and a second channel **227**). The multi-channel grip sensor **225** may be controlled by the processor **205**. Each channel of the multi-channel grip sensor **225** may be connected to each antenna, and the multi-channel grip sensor **225** may detect a change in the capacitance of the antenna connected to each channel.
[0059] In the electronic device **200**, each of the channels of the multi-channel grip sensor **225** may be connected to each of the antennas of the electronic device **200**. When the electronic device **200** includes a plurality of antennas, the antennas may be provided at positions spaced apart from each other. For example, a portion of the plurality of antennas may be provided close to a main board of the electronic device **200**, and another portion may be provided close to a sub-board of the electronic device **200**. In order to connect the channels of the multi-channel grip sensor **225** to different antennas, the electronic device **200** may need to further include a circuit for connecting some of the channels of the multi-channel grip sensor **225** between the main board and the sub-board. When the electronic device **200** includes an additional circuit to connect the multi-channel grip sensor **225**, it may be difficult to efficiently utilize a space in the electronic device **200**. In addition, depending on a placement of the multi-channel grip sensor **225**, when the multi-channel grip sensor **225** is close to a heat source such as the processor **205**, a performance of the multi-channel grip sensor **225** may be degraded by heat.
[0060] FIG. **3** is a diagram illustrating a configuration of an electronic device including a multi-channel grip sensor, according to an embodiment.
[0061] Referring to FIG. **3**, an electronic device **300** (e.g., the electronic device **101** of FIG. **1**) may include a processor **305** (e.g., the processor **120** of FIG. **1**), a transceiver **310** controlled by the processor **305** and configured to perform wireless communication, RF front-end circuits (e.g., a first RF front-end circuit **315** or a second RF front-end circuit **320**) connected to the transceiver **310** and configured to perform preprocessing of RF transmission/reception signals, and/or an antenna (e.g., a first antenna **350** or a second antenna **355**) connected to the RF front-end circuit

and configured to transmit and receive an RF signal. An RF front-end circuit may include a duplexer (e.g., a first duplexer **325** or a second duplexer **335**) and an amplifier (e.g., a first amplifier **330** and a second amplifier **340**). The processor **305** may include an application processor (e.g., a main processor **121**) or a communication processor (e.g., the auxiliary processor **123**). The transceiver **310** may be controlled by, for example, the processor **305** or the transceiver **310** via a MIPI interface. The electronic device **300** may include matching components (i.e., matching circuits) **370**, **380**, and **390** used for impedance matching for RF transmission and reception and isolation components (i.e., isolation circuits) **365**, **375**, and **385** for reducing an influence of capacitance change sensing of a multi-channel grip sensor **345** on an RF signal. For example, the electronic device **300** may include a first isolation component (i.e., a first isolation circuit) **365** provided between a first channel **343** of the multi-channel grip sensor **345** and a first antenna **350** on a first grip sensing path **357**, a second isolation component (i.e., a second isolation circuit) **375** provided between section **371** of a first RF signal path **367** and a second channel **347** on a second grip sensing path **363**, and a third isolation component (i.e., a third isolation circuit) **385** provided between a first RF signal path **367** and a second antenna **355** on the second grip sensing path **363**. The isolation components **365**, **375**, and **385** may include, for example, either an inductor of about 40 nH or greater or a resistor of about 500 ohms or less. The term “signal path” in this specification may be replaced with (i.e., may refer to), for example, “signal line.”
[0062] In an embodiment, the transceiver **310**, the first RF front-end circuit **315**, the second RF front-end circuit **320**, the matching components **370**, **380**, and **390**, and the isolation components **365**, **375**, and **385** may be included in the wireless communication module **192** of FIG. **1**.
[0063] The electronic device **300** may further include a grip sensor to detect a change in a capacitance of the antenna due to a grip (i.e., a hand) of the user on the electronic device **300**. The electronic device **300** may include the first antenna **350** or the second antenna **355** to improve communication performance, and in order to detect a change in capacitance of each of the first antenna **350** or the second antenna **355**, the electronic device **300** may include the multi-channel grip sensor **345** that detects a change in capacitance through the first channel **343** or the second channel **347**. The multi-channel grip sensor **345** may be controlled by the processor **305**. Each channel of the multi-channel grip sensor **345** may be connected to each antenna, and the multi-channel grip sensor **345** may detect a change in the capacitance of the antenna connected to each channel.
[0064] In an embodiment, the electronic device **300** may include the first RF signal path **367** through which a first RF signal is transmitted between the first RF front-end circuit **315** and the first antenna **350**, a second RF signal path **369** through which a second RF signal is transmitted between the second RF front-end circuit **320** and the second antenna **355**, the first grip sensing path **357** connecting the first channel **343** of the multi-channel grip sensor **345** to the first antenna **350**, and the second grip sensing path **363** connecting the second channel **347** of the multi-channel grip sensor **345** to the second antenna **355**.
[0065] For example, the electronic device **300** may include a main board **304** and a sub-board **302** on which components of the electronic device **300** are to be mounted. The processor **305**, the transceiver **310**, the first RF front-end circuit **315**, and the second RF front-end circuit **320** may be provided on the main board **304**, and the multi-channel grip sensor **345** may be provided on the sub-board **302**. By providing the multi-channel grip sensor **345** on the sub-board **302** spaced apart from the processor **305**, which may be a heat source, performance degradation of the multi-channel grip sensor **345** due to the heat source may be reduced. Because the multi-channel grip sensor **345** is located on the sub-board **302**, a path connecting the sub-board **302** to the main board **304** is needed to connect the second antenna **355** located close to the main board **304** to the second channel **347** of the multi-channel grip sensor **345**. When the path connecting the sub-board **302** to the main board **304** is added to connect the second channel **347** to the second antenna **355**, an ability to mount within the electronic device **300** may deteriorate. For example, each path

connecting the sub-board **302** to the main board **304** occupies physical space within the electronic device **300**, and thereby limits space for other components.

[0066] In an embodiment, the second grip sensing path **363** may connect the second channel **347** of the multi-channel grip sensor **345** to the second antenna **355** via the first RF signal path **367**. In an embodiment, the first RF signal path **367** may include a coaxial cable or a flexible RF cable (FRC) to reduce a signal loss. For example, a coaxial cable or an FRC may be used to transmit an RF signal with a small loss in the section **371** of the first RF signal path **367** that is between the sub-board **302** and the main board **304**. In an embodiment, the electronic device **300** may save a mounting space by using the first RF signal path **367**, without forming a separate channel, to connect the second channel **347** of the multi-channel grip sensor **345** between the sub-board **302** and the main board **304**.

[0067] FIG. **4** is a diagram illustrating an exemplary arrangement of a configuration for communication within an electronic device, according to an embodiment.

[0068] Referring to FIG. **4**, an example of locations of the main board **304**, a sub-board **302**, components provided on the main board **304**, components provided on the sub-board **302**, and antennas (the first antenna **350** and the second antenna **355**) in the electronic device **300** is illustrated.

[0069] In an embodiment, the multi-channel grip sensor **345** may be provided on the sub-board **302** and spaced apart from a heat source. When the multi-channel grip sensor **345** is provided on the sub-board **302**, the first antenna **350** located close to the sub-board **302** may be connected to the first channel **343** of the multi-channel grip sensor **345** using a relatively short wire. In an embodiment, the second antenna **355** located close to the main board **304** may be connected to the second channel **347** of the multi-channel grip sensor **345** via the first RF signal path **367**, through which an RF signal is transmitted from the first RF front-end circuit **315** to the first antenna **350**.

[0070] In an embodiment, the multi-channel grip sensor **345** may be controlled by the processor **305** provided on the main board **304**. Control of the multi-channel grip sensor **345** may be performed using a digital signal. Because a digital signal is relatively less affected by heat than an RF signal, which is an analog signal, a coaxial cable and an FRC cable may be omitted. Control of the multi-channel grip sensor **345** may be performed via a separate electrical signal path **349** connecting the main board **304** to the sub-board **302**. For example, the electrical signal path **349** connecting the main board **304** to the sub-board **302** may include a flexible printed circuit board (FPCB). For example, the FPCB may occupy less space than a coaxial cable or an FRC.

[0071] In an embodiment, the electronic device **300** may further include a third antenna, a third RF front-end circuit connected to the third antenna, and a third RF signal path through which a third RF signal is transmitted between the third RF front-end circuit and the third antenna. The third antenna may be provided at a location adjacent to the sub-board **302**. The third RF signal path may include a coaxial cable or an FRC.

[0072] FIG. **5** is a diagram illustrating a configuration of an electronic device including a multi-channel grip sensor, according to an embodiment.

[0073] Referring to FIG. **5**, an electronic device **500** (e.g., the electronic device **101** of FIG. **1**) may include a processor **505** (e.g., the processor **120** of FIG. **1**), a transceiver **510** controlled by the processor **505** and configured to perform wireless communication, RF front-end circuits (e.g., a first RF front-end circuit **515**, a second RF front-end circuit **520**, or a third RF front-end circuit **525**) connected to the transceiver **510** and configured to perform preprocessing of RF transmission/reception signals, and an antenna (e.g., a first antenna **545**, a second antenna **550**, or a third antenna **555**) connected to the RF front-end circuit and configured to transmit and/or receive an RF signal. Each of the first RF front-end circuit **515**, the second RF front-end circuit **520**, or the third RF front-end circuit **525** may include, for example, a duplexer and an amplifier. The processor **505** may be an application processor or a communication processor. The transceiver **510** may be controlled by the processor **505** or the transceiver **510** via a MIPI interface. The electronic device

**500** may include matching components (i.e., matching circuits) **577**, **587**, **593**, **568**, and **598** used for impedance matching for RF transmission and reception and/or isolation components (i.e., isolation circuits) **573**, **563**, **553**, and **558** for reducing an influence of capacitance change sensing of a multi-channel grip sensor **530** on an RF signal. In an embodiment, the transceiver **510**, the first RF front-end circuit **515**, the second RF front-end circuit **520**, the third RF front-end circuit **525**, the matching components **577**, **587**, **593**, **568**, and **598**, and the isolation components **573**, **563**, **553**, and **558** may be included in the wireless communication module **192** of FIG. **1**.

[0074] In an embodiment, the electronic device **500** may further include a grip sensor to detect a change in a capacitance of the antenna due to a grip (i.e., a hand) of the user on the electronic device **500**. For example, the electronic device **500** may include the first antenna **545**, the second antenna **550**, or the third antenna **555** to improve communication performance, and in order to detect a change in capacitance of the first antenna **545**, the second antenna **550**, or the third antenna **555**, the electronic device **500** may include the multi-channel grip sensor **530** that detects a change in capacitance through a first channel **533** or a second channel **527**. The multi-channel grip sensor **530** may be controlled by the processor **505**. Each channel (e.g., the first channel **533** or the second channel **527**) of the multi-channel grip sensor **530** may be connected to an antenna (e.g., the first antenna **545**, the second antenna **550**, or the third antenna **555**), and the multi-channel grip sensor **530** may detect a change in the capacitance of the antenna connected to each channel.

[0075] In an embodiment, the electronic device **500** may include a first RF signal path **560** through which a first RF signal is transmitted between the first RF front-end circuit **515** and the first antenna **545**, a second RF signal path **565** through which a second RF signal is transmitted between the second RF front-end circuit **520** and the second antenna **550**, a third RF signal path **570** through which a third RF signal is transmitted between the third RF front-end circuit **525** and the third antenna **555**, a first grip sensing path **535** connecting the first channel **533** of the multi-channel grip sensor **530** to the first antenna **545**, and a second grip sensing path **540** connecting the second channel **527** of the multi-channel grip sensor **530** to the second antenna **550**.

[0076] For example, the electronic device **500** may include a main board **504** and a sub-board **502** on which components of the electronic device **500** are provided. For example, the processor **505**, the transceiver **510**, the first RF front-end circuit **515**, the second RF front-end circuit **520**, and the third RF front-end circuit **525** may be provided on the main board **504**, and the multi-channel grip sensor **530** may be provided on the sub-board **502**. By providing the multi-channel grip sensor **530** on the sub-board **502** spaced apart from the processor **505**, which may be a heat source, performance degradation of the multi-channel grip sensor **530** due to the heat source may be reduced. Because the multi-channel grip sensor **530** is located on the sub-board **502**, a path connecting the sub-board **502** to the main board **504** may be included to connect the second antenna **550** located close to the main board **504** to the second channel **527** of the multi-channel grip sensor **530**. When the path connecting the sub-board **502** to the main board **504** is added to connect the second channel **527** to the second antenna **550**, an ability to mount within the electronic device **300** may deteriorate.

[0077] In an embodiment, the second grip sensing path **540** may connect the second channel **527** of the multi-channel grip sensor **530** to the second antenna **550**, while including at least a portion of the third RF signal path **570**. In an embodiment, the third RF signal path **570** may include a coaxial cable or an FRC to reduce a signal loss. A coaxial cable or an FRC may be used to transmit an RF signal with a small loss in a section **575** of the third RF signal path **570** that is between the sub-board **502** and the main board **504**. The electronic device **500** may save a mounting space by using the third RF signal path **570** without forming a separate channel for connecting the second channel **527** of the multi-channel grip sensor **530** between the sub-board **502** and the main board **504**.

[0078] In an embodiment, the multi-channel grip sensor **530** may be controlled by the processor **505** provided on the main board **504**. Control of the multi-channel grip sensor **530** may be performed using a digital signal. Because a digital signal is relatively less affected by heat than an

RF signal, which is an analog signal, a coaxial cable and an FRC cable may be omitted. Control of the multi-channel grip sensor **530** may be performed via a separate electrical signal path **580** connecting the main board **504** to the sub-board **502**. For example, the electrical signal path **580** connecting the main board **504** and the sub-board **502** may include an FPCB.

[0079] FIG. **6** is a flowchart of a method of sensing a change in capacitance using a multi-channel grip sensor, according to an embodiment.

[0080] Referring to FIG. **6**, in operation **605**, the electronic device **300** may sense a change in a capacitance of the first antenna **350** by using the first channel **343** of the multi-channel grip sensor **345** connected to the first antenna **350** of the electronic device **300**.

[0081] The electronic device **300** may perform impedance matching of the first antenna **350** based on the sensed change in the capacitance of the first antenna **350**. In an embodiment, the first antenna **350** may be an antenna provided at a location adjacent to the sub-board **302** of the electronic device **300** in the electronic device **300**.

[0082] In operation **610**, the electronic device **300** may sense a change in a capacitance of the second antenna **355** by using the second channel **347** of the multi-channel grip sensor **345** connected to the second antenna **355** through at least the section **371** of the first RF signal path **367** through which an RF signal is transmitted between the first antenna **350** and the first RF front-end circuit **315** of the electronic device **300**.

[0083] The electronic device **300** may perform impedance matching of the second antenna **355** based on the sensed change in the capacitance of the second antenna **355**. In an embodiment, the second antenna **355** may be an antenna provided at a location adjacent to the main board **304** of the electronic device **300** in the electronic device **300**. The multi-channel grip sensor **345** may be provided on the sub-board **302**.

[0084] In an embodiment, the electronic device **500** may sense a change in a capacitance of the first antenna **545** using the first channel **533** of the multi-channel grip sensor **530** connected to the first antenna **545** of the electronic device **500**, and may sense a change in a capacitance of the second antenna **550** using the second channel **527** of the multi-channel grip sensor **530** connected to the second antenna **550** through at least a portion of the third RF signal path **570** through which an RF signal is transmitted between the third antenna **555** and the third RF front-end circuit **525** of the electronic device **500**.

[0085] The electronic device **500** may perform impedance matching of the first antenna **545** based on the sensed change in the capacitance of the first antenna **545**, and may perform impedance matching of the second antenna **550** based on the sensed change in the capacitance of the second antenna **550**.

[0086] The first antenna **545** may be an antenna provided at a location adjacent to the sub-board **502** of the electronic device **500** in the electronic device **500**. The second antenna **550** may be an antenna provided at a location adjacent to the main board **504** of the electronic device **500** in the electronic device **500**. The third antenna **555** may be an antenna provided at a location adjacent to the sub-board **502** of the electronic device **500** in the electronic device **500**. The multi-channel grip sensor **530** may be provided on the sub-board **502**.

[0087] The electronic device **300** according to an embodiment may include the first antenna **350**, the second antenna **355**, the first RF front-end circuit **315** connected to the first antenna **350**, the second RF front-end circuit **320** connected to the second antenna **355**, the transceiver **310** connected to the first RF front-end circuit **315** and the second RF front-end circuit **320** and configured to perform wireless communication, the multi-channel grip sensor **345** including two or more channels for sensing a change in a capacitance of an antenna, wherein, among the channels, the first channel **343** is connected to the first antenna **350** and the second channel **347** is connected to the second antenna **355**, the first RF signal path **367** through which a first RF signal is transmitted between the first RF front-end circuit **315** and the first antenna **350**, the second RF signal path **369** through which a second RF signal is transmitted between the second RF front-end circuit **320** and the second antenna **355**, the first grip sensing path **357** connecting the first channel **343** of the multi-channel grip sensor **345** to the first antenna **350**, and the second grip sensing path **363** connecting the second channel **347** of the multi-channel grip sensor **345** to the second antenna **355**, while including at least a portion of the first RF signal path **367**.

[0088] The first RF signal path **367** may include a coaxial cable or an FRC.

[0089] The electronic device **300** may further include the processor **305** configured to control the transceiver **310**, and an electrical signal path **349** connecting the multi-channel grip sensor **345** to the processor **305**, wherein the electrical signal path **349** may include an FPCB.

[0090] The first RF front-end circuit **315**, the second RF front-end circuit **320**, and the transceiver **310** may be provided on the main board **304** of the electronic device **300**, and the multi-channel grip sensor **345** may be provided on the sub-board **302** of the electronic device **300**.

[0091] The first antenna **350** may be provided at a location adjacent to the sub-board **302**, and the second antenna **355** may be provided at a location adjacent to the main board **304**.

[0092] The first isolation component **365** provided between the first channel **343** of the multi-channel grip sensor **345** and the first antenna **350** on the first grip sensing path **357**, the second isolation component **375** provided between the second channel **347** and the first RF signal path **367** on the second grip sensing path **363**, and the third isolation component **385** provided between the first RF signal path **367** and the second antenna **355** on the second grip sensing path **363** may be further included.

[0093] Each of the first isolation component **365**, the second isolation component **375**, and the third isolation component **385** may include either an inductor of 40 nH or greater or a resistor of 500 ohms or less.

[0094] The electronic device **300** may further include matching components provided on the first RF signal path **367** and the second RF signal path **369** and configured to perform impedance matching.

[0095] The electronic device **300** may further include the third antenna, the third RF front-end circuit connected to the third antenna, and the third RF signal path through which the third RF signal is transmitted between the third RF front-end circuit and the third antenna.

[0096] The third RF signal path may be formed using a coaxial cable or an FRC.

[0097] The electronic device **500** according to an embodiment may include the first antenna **545**, the second antenna **550**, the third antenna **555**, the first RF front-end circuit **515** connected to the first antenna **545**, the second RF front-end circuit **520** connected to the second antenna **550**, the third RF front-end circuit **525** connected to the third antenna **555**, a transceiver **510** connected to the first RF front-end circuit **515**, the second RF front-end circuit **520**, and the third RF front-end circuit **525** and configured to perform wireless communication, the multi-channel grip sensor **530** including two or more channels for sensing a change in capacitance of the antenna, wherein, among the channels, the first channel **533** and the second channel **527** are connected to the first antenna **545** and the second antenna **550**, respectively, the first RF signal path **560** through which a first RF signal is transmitted between the first RF front-end circuit **515** and the first antenna **545**, the second RF signal path **565** through which a second RF signal is transmitted between the second RF front-end circuit **520** and the second antenna **550**, the third RF signal path **570** through which a third RF signal is transmitted between the third RF front-end circuit **525** and the third antenna **555**, the first grip sensing path **535** connecting the first channel **533** of the multi-channel grip sensor **530** to the first antenna **545**, and the second grip sensing path **540** connecting the second channel **527** of the multi-channel grip sensor **530** to the second antenna **550** through the third RF signal path **570**.

[0098] The third RF signal path **570** may include a coaxial cable or an FRC.

[0099] The electronic device **500** may further include the processor **505** configured to control the transceiver **510**, and an electrical signal path **580** connecting the multi-channel grip sensor **530** to the processor **505**, wherein the electrical signal path **580** may include an FPCB.

[0100] The first RF front-end circuit **515**, the second RF front-end circuit **520**, the third RF front-end circuit **525**, and the transceiver **510** may be provided on the main board **504** of the electronic device **500**, and the multi-channel grip sensor **530** may be provided on the sub-board **502** of the electronic device **500**.

[0101] The first antenna **545** and the third antenna **555** may be provided at a location adjacent to the sub-board **502**, and the second antenna **550** may be provided at a location adjacent to the main board **504**.

[0102] The electronic device **500** may further include the first isolation component **573** provided between the first channel **533** of the multi-channel grip sensor **530** and the first antenna **545** on the first grip sensing path **535**, the second isolation component **553** provided between the second channel **527** and the third RF signal path **570** on the second grip sensing path **540**, and the third isolation component **558** provided between the third RF signal path **570** and the second antenna **550** on the second grip sensing path **540**.

[0103] According to an electronic device including a multi-channel grip sensor according to various embodiments disclosed in this document and a method of sensing a change in capacitance using the multi-channel grip sensor, it is possible to reduce performance degradation of the multi-channel grip sensor due to a limited mounting space by using an RF signal path used for RF signal transmission in the electronic device for sensing of a change in capacitance using the multi-channel grip sensor.

[0104] The electronic device according to various embodiments disclosed herein may be one of various types of electronic devices. The electronic device may include, for example, a portable communication device (e.g., a smartphone), a computer device, a portable multimedia device, a portable medical device, a camera, a wearable device, or a home appliance device. According to an embodiment of the present disclosure, the electronic device is not limited to the devices described above.

[0105] It should be appreciated that various embodiments of the disclosure and the terms used therein are not intended to limit the technological features set forth herein to particular embodiments and include various changes, equivalents, or replacements for a corresponding embodiment. With regard to the description of the drawings, similar reference numerals may be used to refer to similar or related components. It is to be understood that a singular form of a noun corresponding to an item may include one or more of the item, unless the relevant context clearly indicates otherwise. As used herein, “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 any one of the items listed together in the corresponding one of the phrases, or all possible combinations thereof. Terms such as “1st” and “2nd,” or “first” and “second” may be used to simply distinguish a corresponding component from other components, and do not limit the components in other aspects (e.g., importance or order). It is to be understood that if an element (e.g., a first element) is referred to, with or without the term “operatively” or “communicatively”, as “coupled with,” “coupled to,” “connected with,” or “connected to” another element (e.g., a second element), it means that the element may be coupled with the other element directly (e.g., wiredly), wirelessly, or via a third element.

[0106] As used in connection with embodiments of the disclosure, the term “module” may include a unit implemented in hardware, or firmware, and may interchangeably be used with other terms, for example, “logic,” “logic block,” “part,” “circuit,” or “circuitry.” A module may be a single integral component or a minimum unit or part thereof, adapted to perform one or more functions. For example, according to an embodiment, the module may be implemented in a form of an application-specific integrated circuit (ASIC).

[0107] Various embodiments as set forth herein may controlled using software (e.g., the program **140**) including one or more instructions that are stored in a storage medium (e.g., an internal memory **136** or an external memory **138**) that is readable by a machine (e.g., the electronic device **101**). For example, a processor (e.g., the processor **120**) of the machine (e.g., the electronic device

**101**) may invoke at least one of the one or more instructions stored in the storage medium, and execute it. This allows the machine to be operated to perform at least one function according to the at least one instruction invoked. The one or more instructions may include code generated by a compiler or code executable by an interpreter. The machine-readable storage medium may be provided in the form of a non-transitory storage medium. Here, the term “non-transitory” simply means that the storage medium is a tangible device, and does not include a signal (e.g., an electromagnetic wave), but this term does not differentiate between where data is semi-permanently stored in the storage medium and where the data is temporarily stored in the storage medium.

[0108] According to an embodiment, a method according to various embodiments of the disclosure may be included and provided in a computer program product. The computer program product may be traded as a product between a seller and a buyer. The computer program product may be distributed in the form of a machine-readable storage medium (e.g., a compact disc read-only memory (CD-ROM)), or be distributed (e.g., downloaded or uploaded) online via an application store (e.g., PlayStore™), or between two user devices (e.g., smartphones) directly. If distributed online, at least part of the computer program product may be temporarily generated or at least temporarily stored in the machine-readable storage medium, such as memory of the manufacturer's server, a server of the application store, or a relay server.

[0109] According to various embodiments, each component of the above-described components may include a single entity or multiple entities, and some of the multiple entities may be separately provided in different components. According to various embodiments, one or more of the above-described components or operations may be omitted, or one or more other components or operations may be added. Alternatively or additionally, a plurality of components may be integrated into a single component. In such a case, the integrated component may still perform one or more functions of each of the plurality of components in the same or similar manner as they are performed by a corresponding one of the plurality of components before the integration. According to various embodiments, operations performed by the module, the or another component may be carried out sequentially, in parallel, repeatedly, or heuristically, or one or more of the operations may be executed in a different order or omitted, or one or more other operations may be added.

## Claims

**1**. An electronic device comprising: a first antenna; a second antenna; a first radio frequency (RF) front-end circuit configured to transmit a first RF signal to the first antenna via a first RF signal path; a second RF front-end circuit configured to transmit a second RF signal to the second antenna via a second RF signal path; a transceiver connected to the first RF front-end circuit and the second RF front-end circuit; and a multi-channel grip sensor comprising a first channel and a second channel, wherein the first channel is connected to the first antenna via a first grip sensing path, wherein the second channel is connected to the second antenna via a second grip sensing path, and wherein the multi-channel grip sensor is configured to sense a change in a first capacitance of the first antenna through the first channel and a change in a second capacitance of the second antenna through the second channel.

**2**. The electronic device of claim 1, wherein the first RF signal path comprises a coaxial cable or a flexible RF cable (FRC).

**3**. The electronic device of claim 2, wherein the electronic device further comprises: a communication processor configured to control the transceiver; and a flexible printed circuit board (FPCB) connecting the multi-channel grip sensor to the communication processor.

**4**. The electronic device of claim 3, further comprising a main board and a sub-board, wherein the first RF front-end circuit, the second RF front-end circuit, and the transceiver are provided on the main board of the electronic device, and wherein the multi-channel grip sensor is provided on the sub-board of the electronic device.

**5**. The electronic device of claim 4, wherein the first antenna is provided adjacent to the sub-board, and wherein the second antenna is provided adjacent to the main board.

**6**. The electronic device of claim 5, further comprising: a first isolation circuit connected between the first channel of the multi-channel grip sensor and the first antenna on the first grip sensing path; a second isolation circuit connected between the second channel and the first RF signal path on the second grip sensing path; and a third isolation circuit connected between the first RF signal path and the second antenna on the second grip sensing path.

**7**. The electronic device of claim 6, wherein each of the first isolation circuit, the second isolation circuit, and the third isolation circuit comprises either an inductor of 40 nH or greater or a resistor of 500 ohms or less.

**8**. The electronic device of claim 7, further comprising: a first matching circuit on the first RF signal path; and a second matching circuit on the second RF signal path, wherein the first matching circuit and the second matching circuit are configured to perform impedance matching.

**9**. The electronic device of claim 8, further comprising: a third antenna; and a third RF front-end circuit configured to transmit a third RF signal to the third antenna via a third RF signal path.

**10**. The electronic device of claim 9, wherein the third RF signal path comprises a coaxial cable or an FRC.

**11**. The electronic device of claim 1, further comprising: a first board; a second board connected to the first board via a flexible printed circuit board and a radio frequency cable; and a processor provided on the first board, and wherein the first RF front-end circuit provided on the first board, wherein the first RF signal path comprises the radio frequency cable, wherein the second RF front-end circuit provided on the first board, and wherein the multi-channel grip sensor provided on the second board, connected to the processor via the flexible printed circuit board.

**12**. The electronic device of claim 11, further comprising a plurality of matching circuits, wherein the processor is configured to, based on a change in capacitance of the first antenna or the second antenna, control the plurality of matching circuits to performance impedance matching.

**13**. The electronic device of claim 11, further comprising a first matching circuit provided on the second board, wherein the processor is configured to, based on a change in capacitance of the first antenna, control the first matching circuit to performance impedance matching.

**14**. The electronic device of claim 13, further comprising a second matching circuit provided on the first board, wherein the processor is configured to, based on a change in capacitance of the second antenna, control the second matching circuit to performance impedance matching.

**15**. The electronic device of claim 14, wherein the first RF front-end circuit comprises a first duplexer and a first amplifier, and wherein the second RF front-end circuit comprises a second duplexer and a second amplifier.

**16**. An electronic device comprising: a first antenna; a second antenna; a third antenna; a first radio frequency (RF) front-end circuit configured to transmit a first RF signal to the first antenna via a first RF signal path; a second RF front-end circuit configured to transmit a second RF signal to the second antenna via a second RF signal path; a third RF front-end circuit configured to transmit a third RF signal to the third antenna via a third RF signal path; a transceiver connected to the first RF front-end circuit, the second RF front-end circuit, and the third RF front-end circuit; and a multi-channel grip sensor comprising a first channel and a second channel, wherein the first channel is connected to the first antenna via a first grip sensing path, wherein the second channel is connected to the second antenna via a second grip sensing path, wherein the second channel is connected to the third antenna via the second channel, and wherein the multi-channel grip sensor is configured to sense a change in a first capacitance of the first antenna through the first channel, a change in a second capacitance of the second antenna through the second channel and a chance in a third capacitance of the third antenna through the second channel.

**17**. The electronic device of claim 16, further comprising a main board and a sub-board, wherein the first RF front-end circuit, the second RF front-end circuit, the third RF front-end circuit, and the transceiver are provided on the main board of the electronic device, wherein the multi-channel grip sensor is provided on the sub-board of the electronic device, wherein the first antenna and the third antenna are provided adjacent to the sub-board, and wherein the second antenna is provided adjacent to the main board.

**18**. The electronic device of claim 16, further comprising: a first isolation circuit connected between the first channel of the multi-channel grip sensor and the first antenna on the first grip sensing path; a second isolation circuit connected between the second channel and the third RF signal path on the second grip sensing path; and a third isolation circuit connected between the third RF signal path and the second antenna on the second grip sensing path.

**19**. A method of sensing capacitance using a multi-channel grip sensor in an electronic device configured to perform wireless communication, the method comprising: sensing, using a first channel of the multi-channel grip sensor connected to a first antenna of the electronic device, a change in a first capacitance of the first antenna; and sensing, using a second channel of the multi-channel grip sensor connected to a second antenna through a first radio frequency (RF) signal path, a change in a second capacitance of the second antenna, wherein an RF signal is transmitted through the first RF signal path between the first antenna and a first RF front-end circuit of the electronic device.

**20**. The method of claim 19, further comprising: performing impedance matching of the first antenna based on the change in the first capacitance of the first antenna; and performing impedance matching of the second antenna based on the change in the second capacitance of the second antenna.