LETSGO DIGITAL

'METHOD FOR CONTROLLING A PLURALITY OF BATTERIES AND ELECTRONIC DEVICE THEREOF'

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This application is based on and claims priority under 35 U.S.C. § 119 to Korean Patent Application No. 10-2017-0081980, filed on Jun. 28, 2017, in the Korean Intellectual Property Office, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

1. Field

The present disclosure relates to a method and an electronic device for controlling a plurality of different batteries.

2. Description of the Related Art

Recently, with advances in digital technology, various electronic devices such as a mobile communication terminal, a personal digital assistant (PDA), an electronic note taking device, a smart phone, and a tablet personal computer (PC), capable of moving and processing communication and personal information are available. Such an electronic device uses a battery as its power supply means, for the sake of mobility. For a smooth supply of power to an electronic device, a plurality of batteries may be disposed in the electronic device.

If a plurality of batteries is disposed in an electronic device according to a limited battery capacity, the batteries may be used at the same time. To control the batteries which are charged or discharged together, charging circuits connected with each other may be disposed in the batteries. Since the charging circuits are connected, an electric current may flow between the batteries and a leakage current between the batteries may cause an overcharge or an overdischarge of the battery.

SUMMARY

An aspect of the present disclosure provides an apparatus and a method for controlling battery charging and discharging in an electronic device including a plurality of batteries.

According to an embodiment of the present disclosure, an electronic device is provided. The electronic device includes a power management circuit configured to supply power to the electronic device; a first battery electrically connected with a power input port of the power management circuit; a second battery electrically connected with the power input port; a first charging circuit configured to charge the first battery; a second charging circuit configured to charge the second battery; a first current control circuit electrically connected between the first charging circuit and the first battery, and configured to control a first charging current supplied from the first charging circuit to the first battery and a leakage current due to a voltage difference between the first battery and the second battery; and a second current control circuit electrically connected between the second charging circuit and the second battery, and configured to control a second charging current supplied from the second charging circuit to the second battery and the leakage current. According to an embodiment of the present disclosure, an electronic device is provided. The electronic device may include a power management circuit configured to supply power to the electronic device; a first battery electrically connected with a power input port of the power management circuit; a second battery electrically connected with the power input port; a first charging circuit configured to charge the first battery; a second charging circuit configured to charge the second battery; a first power supply control circuit electrically connected between the first charging circuit and the power management circuit, and configured to control a leakage current due to a voltage difference between the first battery and the second battery; and a second power supply control circuit electrically connected between the second charging circuit and the power management circuit and configured to control the leakage current.

BRIEF DESCRIPTION OF THE DRAWINGS

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:

FIGS. 1A and **1B** are illustrations of an electronic device according to various embodiments;

FIG. 1C is an illustration of an electronic device according to an embodiment;

FIG. 2 is a block diagram of a network environment including an electronic device according to an embodiment;

FIG. 3 is a block diagram of an electronic device for controlling a plurality of batteries according to an embodiment;

FIG. 4A is a block diagram of an electronic device for charging and discharging a plurality of batteries according to an embodiment;

FIG. 4B is a block diagram of an electronic device for discharging a plurality of batteries according to an embodiment;

FIG. 5 is a block diagram of a current control circuit according to an embodiment;

FIG. 6 is a block diagram of current control circuits according to an embodiment;

FIG. 7 is a block diagram of an electronic device for controlling a plurality of batteries according to an embodiment;

FIG. 8 is a block diagram of an electronic device according to an embodiment;

FIG. 9 is a block diagram of a program module according to an embodiment;

FIG. 10 is a flowchart of a method for charging batteries of an electronic device according to an embodiment;

FIG. 11 is a flowchart of a method for charging or discharging batteries of an electronic device according to an embodiment; and

FIG. 12 is a flowchart of a method for discharging batteries of an electronic device according to an embodiment.

DETAILED DESCRIPTION

Hereinafter, embodiments of the present disclosure are described with reference to the accompanying drawings. It should be understood that there is no intention of limiting the present disclosure to the particular forms disclosed herein, and the present disclosure should be understood to cover various modifications, equivalents, and/or alternatives of embodiments of the present disclosure. In describing the accompanying drawings, similar reference numerals may be used to designate similar elements. Singular forms may include plural forms as well unless the context clearly indicates otherwise. In the present disclosure, the expressions “A or B”, “at least one of A and/or B”, “A, B, or C”, and “at least one of A, B, or C” may include all possible combinations of the items listed. The expressions “a first”, “a second”, “the first”, or “the second” as used in an embodiment of the present disclosure may modify various components regardless of the order and/or the importance but do not limit the corresponding components. It should be understood that when an element (e.g., a first element) is referred to as being (operatively or communicatively) “connected,” or “coupled,” to another element (e.g., a second element), the element may be directly connected or directly coupled to the other element or any other element (e.g., a third element) may be interposed there between.

The expression “configured to” as used in the present disclosure may be used interchangeably with, for example, the expressions “suitable for”, “having the capacity to”, “designed to”, “adapted to”, “made to”, and “capable of” in hardware or in software according to the situation. In some situations, the expression “device configured to” may refer to a situation in which the device, together with other devices or components, “is able to”. For example, the expression “processor adapted (or configured) to perform A, B, and C” may refer, for example, to a dedicated processor (e.g., an embedded processor) only for performing the corresponding operations or a general-purpose processor (e.g., a central processing unit (CPU) or an application processor (AP) that may perform the corresponding operations by executing one or more software programs stored in a memory device.

An electronic device according to an embodiment of the present disclosure may include at least one of, for example, a smart phone, a tablet PC, a mobile phone, a video phone, an electronic book reader (e-book reader), a desktop PC, a laptop PC, a netbook computer, a workstation, a server, a PDA, a portable multimedia player (PMP), a moving picture experts group (MPEG-1) audio layer-3 (MP3) player, a mobile medical device, a camera, or a wearable device, but is not limited thereto. The wearable device may include at least one of an accessory type (e.g., a watch, a ring, a bracelet, an anklet, a necklace, glasses, a contact lens, or a head-mounted device (HMD)), a fabric or clothing integrated type (e.g., an electronic clothing), a body-mounted type (e.g., a skin pad or tattoo), and an implantable circuit, but is not limited thereto. According to an embodiment, an electronic device may include at least one of, for example, a television, a digital video disk (DVD) player, an audio player, a refrigerator, an air conditioner, a vacuum cleaner, an oven, a microwave oven, a washing machine, an air cleaner, a set-top box, a home automation control panel, a security control panel, a media box (e.g., Samsung HomeSync®, Apple TV®, or Google TV™), a game console (e.g., Xbox® and PlayStation®), an electronic dictionary, an electronic key, a camcorder, or an electronic photo frame, but is not limited thereto.

According to an embodiment, an electronic device may include at least one of various medical devices (e.g., various portable medical measuring devices (a blood glucose monitoring device, a heart rate monitoring device, a blood pressure measuring device, a thermometer, etc.), a magnetic resonance angiography (MRA) device, a magnetic resonance imaging (MRI) device, a computed tomography (CT) machine, or an ultrasonic machine)), a navigation device, a global navigation satellite system (GNSS), an event data recorder (EDR), a flight data recorder (FDR), a vehicle infotainment devices, an electronic device for a ship (e.g., a navigation device for a ship, and a gyro-compass), avionics, security devices, an automotive head unit, a robot for home or industry, a drone, an automated teller machine (ATM), a point of sales (POS) terminal, or an Internet of things (IoT) device (e.g., a light bulb, various sensors, a sprinkler device, a fire alarm, a thermostat, a streetlamp, a toaster, a sporting good, a hot water tank, a heater, a boiler, etc.), but is not limited thereto.

An electronic device may include at least one of a part of furniture, a building/structure or a vehicle, an electronic board, an electronic signature receiving device, a projector, and various kinds of measuring instruments (e.g., a water meter, an electric meter, a gas meter, and a radio wave meter), but is not limited thereto. An electronic device may be a flexible device or a combination of one or more of the aforementioned various devices. An electronic device is not limited to the aforementioned devices. As used herein, the term “user” may indicate a person who uses an electronic device or a device (e.g., an artificial intelligence electronic device) that uses an electronic device.

FIGS. 1A and 1B are illustrations of an electronic device **100** according to an embodiment. **FIG. 1C** is an illustrations of the electronic device **100** according to an embodiment.

Referring to **FIGS. 1A, 1B, and 1C**, the electronic device **100** is disclosed in various embodiments. The electronic device **100** may include a housing **130** for accommodating internal electronic parts, a first touch screen **110**, and a second touch screen **120**. For example, the electronic device **100** may be folded like a foldable device or a wearable device, and the first touch screen **110** and the second touch screen **120** may be disposed on a right side and a left of a folding axis. The first touch screen **110** and the second touch screen **120** may display images and receive a touch input. The first touch screen **110** and the second touch screen **120** may include a display, a touch panel, a pen sensor (e.g., a digitizer), and so on.

According to an embodiment, the electronic device **100** may include an integrated touch screen **140** as shown in **FIG. 1B**. For example, the integrated touch screen **140** may display an image and receive a touch input. For example, the integrated touch screen **140** may be a flexible display. Hence, if the electronic device **100** is folded, the integrated touch screen **140** may also be bent.

The electronic device **100** according to an embodiment may include a housing **130**, a first circuit board **150**, a first charging circuit **151**, a first battery **152**, a second circuit board **160**, a second charging circuit **161**, a second battery **162**, a connecting wiring **170**, a first hinge **181**, and a second hinge **182**.

The housing **130** may provide a space for mounting internal electronic parts of the electronic device **100** and protect the internal electronic parts from the outside. For example, the housing **130** may be folded using the first hinge **181** and the second hinge **182**.

The first circuit board **150** and the second circuit board **160** may include the first charging circuit **151** and the second charging circuit **161** respectively, and may further include a current control circuit and a power supply control circuit. For example, the first circuit board **150** and the second circuit board **160** may employ a printed circuit board (PCB).

The first charging circuit **151** and the second charging circuit **161** may provide at least some of the power supplied from one or more external power supply devices to the first battery **152** and the second battery **162**, and supply at least some of the supplied power to a system. For example, the first charging circuit **151** and the second charging circuit **161** may be connected to the first battery **152** and the second battery **162**, respectively. The first charging circuit **151** and the second charging circuit **161** may be connected to each other using the connecting wiring **170**. Operations of the first charging circuit **151** and the second charging circuit **161** are described below.

The first battery **152** and the second battery **162** may be mounted in the housing **130** of the electronic device **100** and charged through the first charging circuit **151** and the second charging circuit **161**. The first battery **152** and the second battery **162** may have difference capacities and impedances. The first battery **152** and the second battery **162**may include, for example, a rechargeable battery and/or a solar battery.

A connector **131** may be disposed, for example, in the housing **130**. For example, the electronic device **100** may be connected to one or more external power supply devices. For example, the one or more external power supply devices may each be a wireless charging device or a wired charging device For example, the wired charging device may include a travel adaptor (TA) or an on-the-go (OTG) power supply device, and the wireless charging device may include a wireless power supply device or a wireless power transceiving device. According to an embodiment, the one or more external power supply devices may each be connected to the first charging circuit **151** and the second charging circuit **161**.

FIG. 2 is a block diagram of a network environment **200** including an electronic device **201** according to an embodiment.

Referring to **FIG. 2**, the electronic device **201** is disposed in the network environment **200**. The electronic device **201** may include a bus **210**, a processor **220**, a memory **230**, an input/output interface **250**, a display **260**, a communication interface **270**, a battery control module **280**, and a battery **290**. According to an embodiment, the electronic device **201** may omit at least one of the components, or may further include another component. The bus **210** may include a circuit which interconnects the components **210**through **280** and delivers communications (e.g., a control message and/or data) between the components **210** through **280**. The processor **220** may include one or more of a CPU, an AP, a communication processor (CP), and a touch screen processor (TSP). The processor **220** may, for example, carry out calculation or data processing relating to control and/or communication of at least one other component of the electronic device **201**.

The processor **220** may detect a connection of an external charging device. For example, the processor **220** may detect the connection of the external charging device and detect a charging current flowing into the battery control module **280**.

The processor **220** may identify and compare power levels of the battery **290**. For example, the battery **290** may include a plurality of batteries, and the processor **220** may determine which battery has a higher power level by comparing the power levels of the battery **290**.

If one of the plurality of batteries in the battery **290** has the highest power level, the processor **220** may connect only the corresponding battery to the system and disconnect the other batteries from the system.

If an external power supply device is connected and the power supply to the system is required, the processor **220** may discharge the battery with the highest power level and charge the other batteries.

The processor **220** may identify a setting current of the battery control module **280**. For example, the processor **220** may identify the setting currents corresponding to the plurality of batteries in the battery **290**.

The processor **220** may determine whether battery state information satisfies an update condition. For example, the battery state information may include a battery power level, a battery temperature, a current of the battery, and so on. The update condition may include a case where a battery power level difference exceeds a threshold, or a case where the battery temperature exceeds a reference temperature.

If the battery state information satisfies the update condition, the processor **220** may change the setting current of the battery control module **280**. For example, the processor **220** may increase the setting current of a battery with a high power level, and decrease the setting current of a battery with a low power level. For example, the processor **220**may decrease a setting current of a battery exceeding a reference temperature, and increase a setting current of a battery falling below the reference temperature.

The memory **230** may include a volatile memory and/or a non-volatile memory. The memory **230** may store, for example, commands or data relevant to at least one other component of the electronic device **201**. According to an embodiment, the memory **230** may store software and/or a program **240**.

The program **240** may include, for example, a kernel **241**, middleware **243**, an application programming interface (API) **245**, and/or an application program (or application) **247**. At least some of the kernel **241**, the middleware **243**, and the API **245** may be referred to as an operating system (OS). For example, the kernel **241** may control or manage system resources (e.g., the bus **210**, the processor **220**, or the memory **230**) used for performing an operation or a function implemented in the other programs (e.g., the middleware **243**, the API **245**, or the application **247**). Furthermore, the kernel **241** may provide an interface through which the middleware **243**, the API **245**, and the application **247** may access individual components of the electronic device **201** to control or manage the system resources.

The middleware **243**, for example, may serve as an intermediary for allowing the API **245** or the application **247** to communicate with the kernel **241** to exchange data. The middleware **243** may process one or more task requests received from the application **247** according to priorities thereof. For example, the middleware **243** may assign priorities for using the system resources (e.g., the bus **210**, the processor **220**, or the memory **230**) of the electronic device **201**, to at least one of the application **247**, and process the one or more task requests. The API **245** is an interface through which the application **247** controls functions provided from the kernel **241** or the middleware **243**, and may include, for example, at least one interface or function (e.g., an instruction) for file control, window control, image processing, character control, and the like. The input/output interface **250**, for example, may transfer commands or data input from a user or another external device to the other element(s) of the electronic device **201**, or output the commands or data received from the other element(s) of the electronic device **201** to a user or another external device.

The display **260** may include a liquid crystal display (LCD), a light-emitting diode (LED) display, an organic light-emitting diode (OLED) display, a micro electromechanical Systems (MEMS) display, and an electronic paper display, but is not limited thereto. The display **260** may display, for example, various types of content (e.g., text, images, videos, icons, or symbols) to the user. The display **260** may include a touch screen, and may receive, for example, a touch input, a gesture input, a proximity input, or a hovering input using an electronic pen or a part of a user's body.

The communication interface **270** may establish communication, for example, between the electronic device **201** and an external device (e.g., a first external electronic device **202**, a second external electronic device **204**, or a server **206**). For example, the communication interface **270** may access a network **262** through wireless or wired communication, and communicate with the second external electronic device **204** or the server **206**.

The battery control module **280** may control the charging and the discharging of the battery **290**. For example, the battery control module **280** may include a charging circuit, a current control circuit, a power supply control circuit, and the like.

The battery **290** may supply the power to the system through the battery control module **280**. The battery **290** may include a plurality of batteries having different capacities and impedances. The battery **290** may include, for example, a rechargeable battery and/or a solar battery.

The wireless communication **264** may include cellular communication using at least one of, for example, long term evolution (LTE), LTE-advance (LTE-A), code division multiple access (CDMA), wideband CDMA (WCDMA), universal mobile telecommunications system (UMTS), wireless broadband (WiBro), or global system for mobile communications (GSM). According to an embodiment, the wireless communication **264** may include at least one of, for example, wireless fidelity (WiFi), light fidelity (LiFi), Bluetooth, Zigbee, near field communication (NFC), magnetic secure transmission (MST), radio frequency (RF), or body area network (BAN). The wireless communication**264** may include GNSS. The GNSS may include, for example, a global positioning system (GPS), a global navigation satellite system (Glonass), a Beidou navigation satellite system (Beidou) or the European global satellite-based navigation system (Galileo). Hereinafter, in the present disclosure, the term “GPS” may be used interchangeably with the term “GNSS”. The wired communication may include, for example, at least one of a universal serial bus (USB), a high definition multimedia interface (HDMI), recommended standard 232 (RS-232), power line communication, or a plain old telephone service (POTS).

The network **262** may include a telecommunication network, for example, at least one of a computer network (e.g., a local area network (LAN) or a wide area network (WAN)), the Internet, or a telephone network.

The first and second external electronic devices **202** and **204** may each be the same as or different from the electronic device **201**. According to an embodiment, all or some of the operations performed at the electronic device **201** may be executed in another one or a plurality of the electronic devices **202** and **204** or the server **206**. If the electronic device **201** must perform some functions or services automatically or in response to a request, the electronic device **201** may request the electronic device **102**, the electronic device **104**, or the server **106** to execute at least some functions relating thereto instead of or in addition to autonomously performing the functions or services. The electronic device **102**, the electronic device **104**, or the server **106** may execute the requested functions or the additional functions, and may deliver a result of the execution to the electronic device **201**. The electronic device **201** may process the received result as is or additionally processed, and may provide the requested functions or services. In this case, for example, cloud computing, distributed computing, or client-server computing technologies may be used.

FIG. 3 is a block diagram of an electronic device **300** for controlling a plurality of batteries according to an embodiment. The battery control module **280** and the battery **290**of **FIG. 2** are described below in greater detail. For example, two charging circuits and two batteries are disposed. The battery control module **280** may include a first charging circuit **320**, a second charging circuit **330**, a first power supply control circuit **340**, a second power supply control circuit **350**, a first current control circuit **360**, a second current control circuit **370**, a third current control circuit **380**, and a fourth current control circuit **390**. The battery **290** may include a first battery **301** and a second battery **302**.

Referring to **FIG. 3**, the electronic device **300** (e.g., the electronic device **201** of **FIG. 2**) according to an embodiment may include a system **310**, the first charging circuit **320**, the second charging circuit **330**, the first power supply control circuit **340**, the second power supply control circuit **350**, the first current control circuit **360**, the second current control circuit **370**, the third current control circuit **380**, the fourth current control circuit **390**, the first battery **301**, and the second battery **302**.

The system **310** may be, for example, at least one electronic part which operates with power in the electronic device **300**, or a module which supplies power to at least one electronic part in the electronic device **300**. For example, the system **310** may include the bus **210**, the processor **220**, the memory **230**, the input/output interface **250**, the display **260**, and the communication interface **270** of **FIG. 2**.

The first charging circuit **320** may, for example, control charging of the first battery **301** and monitor capacity information (e.g., a battery power level) of the first battery **301**. In an embodiment, the first charging circuit **320** may be connected to the system **310** through the first power supply control circuit **340**, connected to the second charging circuit **330** through the first power supply control circuit **340** and the second power supply control circuit **350**, and connected to the first battery **301** through the first current control circuit **360** and the third current control circuit **380**.

The second charging circuit **330** may, for example, control charging of the second battery **302** and monitor capacity information (e.g., a battery power level) of the second battery **302**. In an embodiment, the second charging circuit **330** may be connected to the system **310** through the second power supply control circuit **350**, connected to the first charging circuit **320** through the first power supply control circuit **340** and the second power supply control circuit **350**, and connected to the second battery **302** through the second current control circuit **370** and the fourth current control circuit **390**.

According to an embodiment, the power supplied to the first charging circuit **320** or the second charging circuit **330** may be supplied only to the first battery **301** or the second battery **302**, and some of the power may be supplied to the system **310**.

The first power supply control circuit **340** may control, for example, whether to supply the power from the first battery **301** to the system **310**. In an embodiment, the first power supply control circuit **340** may be electrically connected between the system **310** and the first charging circuit **320**, and may control a leakage current due to a voltage difference between the first battery **301** and the second battery **302**. For example, the first power supply control circuit **340** may include a switch. For example, the processor **220** may turn on the first power supply control circuit **340** and thus supply the power from the first battery **301** to the system **310**. In addition, by turning off the first power supply control circuit **340**, the processor **220** may cut off the power supplied from the first battery **301** and block the leakage current which flows from the second battery **302** to the first battery **301**.

The second power supply control circuit **350** may control, for example, whether to supply the power from the second battery **302** to the system **310**. In an embodiment, the second power supply control circuit **350** may be electrically connected between the system **310** and the second charging circuit **330**, and may control a leakage current due to a voltage difference between the first battery **301** and the second battery **302**. For example, the second power supply control circuit **350** may include a switch. For example, the processor **220** may turn on the second power supply control circuit **350** and thus supply the power from the second battery **302** to the system **310**. In addition, by turning off the second power supply control circuit **350**, the processor **220** may cut off the power supplied from the second battery **302** and block the leakage current which flows from the first battery **301** to the second battery **302**.

The first current control circuit **360** may, for example, control a charging current to be below an allowable current of the first battery **301**. In an embodiment, the first current control circuit **360** may be electrically connected between the first charging circuit **320** and the first battery **301**, control a first charging current **360***a* flowing from the first charging circuit **320** to the first battery **301**, and control a leakage current due to a voltage difference between the first battery **301** and the second battery **302**. For example, if a first current that is greater than the allowable current of the first battery **301** flows through the first battery **301**, the first current control circuit **360** may lower the first current to below the allowable current. In this case, the first current may be at least one of the first charging current **360***a* and the leakage current. For example, the processor **220** may control a setting current of the first current control circuit **360**. For example, the processor **220** may change the setting current of the first current control circuit **360**, based on a state of the system **310**, power levels of the first battery **301** and the second battery **302**, and temperatures of the first battery **301** and the second battery **302**.

The second current control circuit **370** may, for example, control a charging current to be below an allowable current of the second battery **302**. In an embodiment, the second current control circuit **370** may be electrically connected between the second charging circuit **330** and the second battery **302**, control a second charging current **370***a* flowing from the second charging circuit **330** to the second battery **302**, and control a leakage current due to a voltage difference between the first battery **301** and the second battery **302**. For example, if a second current that is greater than the allowable current of the second battery **302** flows through the second battery **302**, the second current control circuit **370** may lower the second current to be below the allowable current. In this case, the second current may be at least one of the second charging current **370***a* and the leakage current. For example, the processor **220** may control a setting current of the second current control circuit **370**. For example, the processor **220** may change the setting current of the second current control circuit **370**, based on the state of the system **310**, the power levels of the first battery **301** and the second battery **302**, and the temperatures of the first battery **301** and the second battery **302**.

The third current control circuit **380** may, for example, control a discharging current to be below the allowable current of the first battery **301**. In an embodiment, the third current control circuit **380** may be electrically connected between the first charging circuit **320** and the first battery **301**, control a first discharging current **380***a* flowing from the first battery **301** to the first charging circuit **320**, and control a leakage current due to a voltage difference between the first battery **301** and the second battery **302**. For example, if a third current that is greater than the allowable current of the first battery **301** flows through the first battery **301**, the third current control circuit **380** may decrease the third current to be below the allowable current. In this case, the third current may be at least one of the first discharging current **380***a* and the leakage current. For example, the processor **220** may control a setting current of the third current control circuit **380**. For example, the processor **220** may change the setting current of the third current control circuit **380**, based on the state of the system **310**, the power levels of the first battery **301** and the second battery **302**, and the temperatures of the first battery **301** and the second battery **302**.

The fourth current control circuit **390** may, for example, control a discharging current to be below the allowable current of the second battery **302**. In an embodiment, the fourth current control circuit **390** may be electrically connected between the second charging circuit **330** and the second battery **302**, control a second discharging current **390***a* flowing from the second battery **302** to the second charging circuit **330**, and control a leakage current due to a voltage difference between the first battery **301** and the second battery **302**. For example, if a fourth current that is greater than the allowable current of the second battery **302** flows through the second battery **302**, the fourth current control circuit **390** may decrease the fourth current to be below the allowable current. In this case, the fourth current may be at least one of the second discharging current **390***a* and the leakage current. For example, the processor **220** may control a setting current of the fourth current control circuit **390**. For example, the processor **220** may change the setting current of the fourth current control circuit **390**, based on the state of the system **310**, the power levels of the first battery **301** and the second battery **302**, and the temperatures of the first battery **301** and the second battery **302**.

The first battery **301** and the second battery **302** may supply power to the system **310** and have different characteristics (e.g., capacity and impedance). The first battery **301**and the second battery **302** may include a rechargeable battery and/or a solar battery.

According to an embodiment, an output port of the first current control circuit **360** and an output port of the third current control circuit **380** may be connected, and an output port of the second current control circuit **370** and an output port of the fourth current control circuit **390** may be connected, which is described below in greater detail with reference to **FIG. 6**.

The first current control circuit **360** and the third current control circuit **380** may be configured as a single circuit, and the second current control circuit **370** and the fourth current control circuit **390** may be configured as a single circuit.

The first current control circuit **360** through the fourth current control circuit **390** of the electronic device **300** may be omitted.

FIG. 4A is a block diagram of an electronic device **400** for charging and discharging a plurality of batteries according to an embodiment. In **FIG. 4A**, a first power supply control circuit **440**, a second power supply control circuit **450**, and a first current control circuit **460**, a second current control circuit **470**, a third current control circuit **465**, and a fourth current control circuit **475** may be controlled by the processor **220** of **FIG. 2**. In **FIG. 4A**, an external charging device **402** is connected to the electronic device **400**.

Referring to **FIG. 4A**, the electronic device **400** may further include a power management system **410**. In an embodiment, the power management system **410** may provide power from batteries to components of a system **401**, and include a power management integrated circuit (PMIC). For example, an input port of the power management system **410** may be connected to a first battery **480** through the first power supply control circuit **440**, a first charging circuit **420**, the first current control circuit **460**, and the third current control circuit **465**, and connected to a second battery **490** through the second power supply control circuit **450**, a second charging circuit **430**, the second current control circuit **470**, and the fourth current control circuit **475**.

In an embodiment, the first charging circuit **420** and the second charging circuit **430** may monitor the power level of the first battery **480** and the second battery **490** using their internal power or fuel gauges **421** and **431**, respectively. For example, the processor **220** may continually update the power level of the first battery **480** and the second battery **490** through the first charging circuit **420** and the second charging circuit **430**.

The processor **220** may detect a connection of the external charging device **402**. The external charging device **402** may be a wireless charging device or a wired charging device. For example, the wired charging device may include a TA or OTG power supply device, and the wireless charging device may include a wireless power supply device or a wireless power transceiving device.

If the external charging device **402** is connected to the input port CHG_IN of the first charging circuit **420**, the processor **220** may control the first power supply control circuit **440** and the second power supply control circuit **450**, based on the power levels of the first battery **480** and the second battery **490**. For example, the processor **220** may identify the power levels of the first battery **480** and the second battery **490**, and determine which one of the first battery **480** and the second battery **490** has a greater power level. If the first battery **480** has a greater power level than the second battery **490**, the processor **220** may turn on the first power supply control circuit **440** and turn off the second power supply control circuit **450**. In contrast, if the second battery **490** has a greater power level than the first battery **480**, the processor **220** may turn off the first power supply control circuit **440** and turn on the second power supply control circuit **450**.

If the first power supply control circuit **440** is turned on and the second power supply control circuit **450** is turned off, the second battery **490** may only perform discharging and the first battery **480** may perform either charging or discharging. For example, the first charging circuit **420** may supply a first charging current b to the first battery **480** with power from the external electronic device **402**, and the second charging circuit **430** may supply a second charging current a to the second battery **490** with power supplied through the input port CHG_IN.

If the external electronic device **402** is connected and the system **401** requires the power supply, the processor **220** may control to discharge the first battery **480**. That is, if the first power supply control circuit **440** is turned on and the second power supply control circuit **450** is turned off, the first battery **480** may be connected to the system **401** and the processor **220** may stop charging the first battery **480** and supply a first discharging current c of the first battery **480** to the system **401**. In this case, the first discharging current c from the first battery **480** may only be supplied to the system **401** and block the leakage current to the second battery **490**. That is, if the second power supply control circuit **450** is turned on, the first discharging current c from the first battery **480** may be leaked to the second battery **470** via the second charging circuit **430** due to a voltage difference between the first battery **480** and the second battery **490**, which may overcharge and damage the second battery **490**. However, the present disclosure may prevent the first discharging current c from leaking to the second battery **490** by turning off the second power supply control circuit **450**. Thus, even if discharging of the first battery **480**and charging of the second battery **490** are performed at the same time, battery overcharge may be prevented.

According to an embodiment, the electronic device **400** may include a plurality of batteries. If the electronic device **400** includes a plurality of batteries, the electronic device **400** may include a charging circuit for each of the plurality of batteries, where the charging circuits may be interconnected, and a power supply control circuit may be disposed between the system **401** and a charging circuit. If one of the plurality of batteries stops charging and supplies a discharging current to the system **401**, the discharging current may flow into another charging circuit rather than the system **401**, because the charging circuits are interconnected. A leakage current to another charging circuit may cause an overcharge of a battery which is charging. For example, if a first discharging current c of the first battery **480** of **FIG. 4A** is supplied to the second charging circuit **430**, the second battery **490** may be overcharged. Thus, to block the battery discharging current from flowing into another battery which is charging, the electronic device **400** which is charging through an external electronic device **402** may turn on only the power supply control circuit connected with the battery with the greater power level and turn off all the power supply control circuits connected with the other batteries. That is, with multiple batteries, the electronic device **400** may limit the number of batteries supplying power during battery charging to one. In this case, it is possible to prevent a discharging current of one of the batteries from leaking to another battery while the batteries are charging.

The first current control circuit **460** may prevent the current of the first battery **480** from exceeding an allowable current of the first battery **480**. For example, if a current over an allowable current flows in the first battery **480** due to various reasons such as malfunction of the first power supply control circuit **440** or the first charging circuit **420**, the first current control circuit **460** may lower the current below the allowable current. In the same manner as the first current control circuit **460**, the second charging circuit **470**may prevent the current of the second battery **490** from exceeding an allowable current of the second battery **490**.

To charge the first battery **480** or the second battery **490**, the processor **220** may control the setting currents of the first current control circuit **460** and the second current control circuit **470**, based on the power levels and the temperature of the first battery **480** and the second battery **490**. For example, if the power level of the first battery **480** is greater than the power level of the second battery **490**, the processor **220** may lower the setting current of the first current control circuit **460** and increase the setting current of the second current control circuit **470**. Thus, more charging current may be supplied to the second battery **490** than the first battery **480** with the greater power level. For example, if the temperature of the first battery **480** exceeds a reference temperature, the processor **220** may lower the setting current of the first current control circuit **460** and increase the setting current of the second current control circuit **470**. Hence, the charging current to the first battery **480** with the greater temperature may be limited, and more charging current may be supplied to the second battery **490**.

The first battery **480** and the second battery **490** may each include a separate overcharge/overcurrent protect circuit module (PCM).

FIG. 4B is a block diagram of the electronic device **400** for discharging a plurality of batteries according to an embodiment. The first power supply control circuit **440**, the second power supply control circuit **450**, and the first current control circuit **460**, the second current control circuit **470**, the third current control circuit **465**, and the fourth current control circuit **475** may be controlled by the processor **220** of **FIG. 2**. In **FIG. 4B**, the plurality of the batteries supply power to the system **401** at the same time.

Referring to **FIG. 4B**, the first battery **480** and the second battery **490** may supply power to the system **401** at the same time. Either the first battery **480** or the second battery **490** may supply power to the system **401**.

In an embodiment, if power is supplied to the system **401**, the processor **220** may monitor the currents flowing in the third current control circuit **465** and the fourth current control circuit **475**, and change the setting current if a current greater than the setting current flows in the third current control circuit **465** or the fourth current control circuit **475**. For example, the processor **220** may control the third current control circuit **465** to flow a first discharging current e that is less than the allowable current of the first battery **480**, and control the fourth current control circuit **475** to flow a second discharging current d that is less than the allowable current of the second battery **490**.

The processor **220** may supply power to the system **401** by controlling the third current control circuit **465** and the fourth current control circuit **475**, based on the state of the system **401**, the power levels of the first battery **480** and the second battery **490**, and the temperatures of the first battery **480** and the second battery **490**. For example, the processor **220** may identify the power levels of the first battery **480** and the second battery **490** through the first charging circuit **420** and the second charging circuit **430**, and compare the power levels of the first battery **480** and the second battery **490**. If the power level of the first battery **480** is greater than the power level of the second battery **490**, the processor **220** may increase the setting current of the third current control circuit **465** and decrease the setting current of the fourth current control circuit **475**. Hence, the first battery **480** may supply more first discharging current e to the system **401**, and the second battery **490** may supply less second discharging current d to the system **401**. For example, the processor **220** may identify the temperatures of the first battery **480** and the second battery **490** through the first charging circuit **420** and the second charging circuit **430**. If the temperature of the first battery **480** is greater than the reference temperature, the processor **220** may decrease the setting current of the third current control circuit **465** and increase the setting current of the fourth current control circuit **475**. Herein, the reference temperature may be the allowable temperature of the battery. Thus, the first discharging current e of the first battery **480** may be limited or reduced, and the second discharging current d of the second battery **490** may be increased.

In this case, even if the first battery **480** and the second battery **490** have different power levels, the third current control circuit **465** and the fourth current control circuit **475**may control the discharging current to exceed the allowable current all the time, which is shown in Table 1 below. As shown in Table 1 below, by means of the third current control circuit **465** and the fourth current control circuit **475**, the current over the allowable current may not flow in the battery with the greater power level.

FIG. 5 is a block diagram of a current control circuit **500** according to an embodiment. The current control circuit **500** may be identical to the first current control circuit through the fourth current control circuit of **FIGS. 3, 4A, and 4B**.

Referring to **FIG. 5**, the current control circuit **500** (e.g., the first current control circuit **360** or **460**, the second current control circuit **370** or **470**, the third current control circuit **380** or **480**, or the fourth current control circuit **390** or **490** of **FIG. 3, 4A**, or **4**B, respectively) may include a control unit **510**, a current limit setting unit **520** (e.g., a current limit unit), a comparing unit **530**, a reference voltage setting unit **540** (e.g., a charge pump), a variable resistance unit **550** (e.g., a true reverse-current blocking (TRCB) device), an overvoltage protection circuit **560** (e.g., an over voltage protection (OVP) device), a voltage input port **570** (e.g., Vin), a voltage output port **575** (e.g., a Vout), a current path setting input port **580** (e.g., ON), and a setting current input port **585** (e.g., Iset). The current control circuit **500** may supply a current to a load **590**. Herein, the load **590** may be the system **310** of **FIG. 3**.

The control unit **510** may, for example, control operations of the current control circuit **500** and control a current to be below a setting current. For example, in response to the current being below the setting current, the control unit **510** may control the current by minimizing a resistance of the variable resistance unit **550**. In contrast, in response to the current being over the setting current, the control unit **510** may control the current to be below the setting current by increasing the resistance of the variable resistance unit **550**. For example, if the setting current is 0.5 A, an input voltage is 5V, and the resistance of the load **590** is 5Ω, the control unit **510** may set the resistance of the variable resistance unit **550** to **51** and thus control a current of 0.5 A to flow from the voltage input port **570** to the voltage output port **575**.

The control unit **510** may, for example, receive an ON/OFF setting signal of a current path from the current path setting input port **580** through the processor **220**. For example, in response to the current path OFF signal received from the processor **220**, the control unit **510** may stop the current by setting the resistance of the variable resistance unit **550** to infinity.

The current limit setting unit **520** may, for example, store the setting current value received from the setting current input port **585**, and detect the current between the setting current input port **585** and the voltage output port **575**. For example, the current limit setting unit **520** may send the setting current value and the detected current to the comparing unit **530**.

The comparing unit **530** may, for example, compare the setting current value and the detected current, which are received from the current limit setting unit **520**, provide a comparison result to the control unit **510**, and provide an output voltage to a gate voltage of the variable resistance unit **550** under control of the control unit **510**.

By controlling the output voltage of the comparing unit **530**, the control unit **510** may, for example, adjust the resistance of the variable resistance unit **550** and control the current flowing between the voltage input port **570** and the voltage output port **575**.

The overvoltage protecting circuit **560** may, for example, identify the current being over an allowable current of the current control circuit **500**, and block the current path in response to the current being over the allowable current.

FIG. 6 is a block diagram of current control circuits according to an embodiment. Descriptions of a second charging circuit, a second current control circuit, a fourth current control circuit, and a second battery, which are connected in the same fashion as a first charging circuit, a first current control circuit, a third current control circuit, and a first battery, are omitted below.

Referring to **FIG. 6**, a first charging circuit **610** (e.g., the first charging circuit **320** of **FIG. 3** or the first charging circuit **420** of **FIGS. 4A and 4B**), a first current control circuit **620** (e.g., the first current control circuit **360** of **FIG. 3** or the first current control circuit **460** of FIGS. **4**A and **4**B), a third current control circuit **630** (e.g., the third current control circuit **380** of **FIG. 3** or the third current control circuit **465** of **FIGS. 4A and 4B**), and a first battery **640** (e.g., the first battery **301** of **FIG. 3** or the first battery **480** of **FIGS. 4A and 4B**) may be connected in order. For example, the first current control circuit **620** may control a charging current flowing from the first charging circuit **610**to the first battery **640**. To do so, a voltage output port (e.g., Vout) **621** may be connected to the third current control circuit **630** and the first battery **640**, and a voltage input port (e.g., Vin) **622** may be connected to the first charging circuit **610**. The third current control circuit **630** may control a discharging current flowing from the first battery **640** to the first charging circuit **610**. To do so, a voltage output port (e.g., Vout) **631** may be connected to the first current control circuit **620** and the first charging circuit **610**, and a voltage input port (e.g., Vin) **632** may be connected to the first battery **640**. The voltage output port **621** of the first current control circuit **620** may be connected with the voltage output port **631** of the third current control circuit **630**.

According to an embodiment, the first current control circuit **620** and the third current control circuit **630** may be configured as a single current control circuit, and the single current control circuit may control the charging and the discharging of the first battery **640**.

FIG. 7 is a block diagram of an electronic device **700** for controlling a plurality of batteries according to an embodiment. The battery control module **280** and the battery **290**of **FIG. 2** are described below. To facilitate understanding, a repeated description of **FIG. 3** is omitted below. A first power supply control circuit **740**, a second power supply control circuit **750**, a third current control circuit **780**, and a fourth current control circuit **790** may be controlled by the processor **220** of **FIG. 2**.

Referring to **FIG. 7**, the electronic device **700** may include a system **710**, a first charging circuit **720**, a second charging circuit **730**, the first power supply control circuit **740**, the second power supply control circuit **750**, the third current control circuit **780**, the fourth current control circuit **790**, a first battery **701**, and a second battery **702**.

If not separately supplying power to the system **710** during charging, the electronic device **700** may control to charge the first battery **701** and the second battery **702** using the first power supply control circuit **740**, the second power supply control circuit **750**, the first charging circuit **720**, and the second charging circuit **730**. For example, if the electronic device **700** is turned off, the electronic device **700** may turn off the first power supply control circuit **740** or the second power supply control circuit **750** during charging using an external charging device, and thus prevent a leakage current between the first battery **701** and the second battery **702**.

To supply the power to the system **710**, the electronic device **700** may prevent a leakage current between the first battery **701** and the second battery **702** by turning off the first power supply control circuit **740** or the second power supply control circuit **750** during charging using an external charging device, and control a first discharging current **780***a* or a second discharging current **790***a* to not exceed an allowable current of the first battery **701** and the second battery **702** using the third current control circuit **780** or the fourth current control circuit **790**, respectively. For example, if the first power supply control circuit **740** is turned off, the fourth current control circuit **790** may control the second discharging current **790***a* supplied from the second battery **702** to the system **710**. In contrast, if the second power supply control circuit **750** is turned off, the third current control circuit **780** may control the first discharging current **780***a* supplied from the first battery **701** to the system **710**.

If an external charging device is disconnected and the electronic device **700** is not charging, both of the first power supply control circuit **740** and the second power supply control circuit **750** may be turned on and the electronic device **700** may control the first discharging current **780***a* and the second discharging current **790***a* to not exceed an allowable current of the first battery **701** and the second battery **702** using the third current control circuit **780** and the fourth current control circuit **790**, respectively. The components of **FIG. 7** may perform the same operations as the components of **FIG. 3**.

According to an embodiment, the third current control circuit **780** and the fourth current control circuit **790** may be omitted in the electronic device **700**.

FIG. 8 is a block diagram of an electronic device **801** according to an embodiment.

The electronic device **801**, for example, may include all or part of the electronic device **201** of **FIG. 2**. The electronic device **801** includes one or more processors (e.g., an AP) **810**, a communication module **820**, a subscriber identification module (SIM) card **824**, a memory **830**, a sensor module **840**, an input device **850**, a display **860**, an interface **870**, an audio module **880**, a camera module **891**, a power management module **895**, a battery **896**, an indicator **897**, and a motor **898**.

The processor **810** may, for example, control a plurality of hardware or software components connected to the processor **810** by driving an OS or an application program, and process various pieces of data and calculations. The processor **810** may be embodied as, for example, a system on chip (SoC). According to an embodiment, the processor **810** may further include a graphics processing unit (GPU) and/or an image signal processor. The processor **810** may include at least some (e.g., a cellular module **821**) of the components illustrated in **FIG. 7**. The processor **810** may load, into a volatile memory, commands or data received from at least one (e.g., a non-volatile memory) of the other components, process the loaded commands or data, and store various data in a non-volatile memory.

The communication module **820** may have a configuration equal or similar to that of the communication interface **270**. The communication module **820** may include, for example, a cellular module **821**, a WiFi module **823**, a Bluetooth (BT) module **825**, a BT low energy (BLE) module, a GPS module **827**, an NFC module **828**, and an RF module **829**. The cellular module **821**, for example, may provide a voice call, a video call, a text message service, or an Internet service through a communication network. According to an embodiment, the cellular module **821** may distinguish and authenticate the electronic device **801** in a communication network using the SIM (e.g., a SIM card) **824**. The cellular module **821** may perform at least some of the functions that the processor **810** may provide. The cellular module **821** may include a CP. At least some (e.g., two or more) of the cellular module **821**, the WiFi module **823**, the BT module **825**, the BLE module, the GPS module **827**, and the NFC module **828** may be included in one integrated circuit (IC) or IC package. The RF module **829**, for example, may transmit/receive a communication signal (e.g., an RF signal). The RF module **829** may include, for example, a transceiver, a power amplifier module (PAM), a frequency filter, a low noise amplifier (LNA), and an antenna. At least one of the cellular module **821**, the WiFi module **823**, the BT module **825**, the BLE module, the GPS module **827**, or the NFC module **828** may transmit/receive an RF signal through a separate RF module. The SIM card **824** may include, for example, an embedded SIM, and may contain unique identification information (e.g., an integrated circuit card identifier (ICCID)) or subscriber information (e.g., an international mobile subscriber identity (IMSI)).

The memory **830** may include, for example, an internal memory **832** or an external memory **834**. The internal memory **832** may include, for example, at least one of a volatile memory (e.g., a dynamic random access memory (DRAM), a static RAM (SRAM), a synchronous dynamic RAM (SDRAM), and the like) and a non-volatile memory (e.g., a one-time programmable read only memory (OTPROM), a programmable ROM (PROM), an erasable and programmable ROM (EPROM), an electrically erasable and programmable ROM (EEPROM), a mask ROM, a flash ROM, a flash memory, a hard disc drive, a solid state drive (SSD), and the like). The external memory **834** may further include a flash drive, for example, a compact flash (CF), a secure digital (SD) memory card, a micro secure digital (micro-SD) memory card, a mini secure digital (mini-SD) memory card, an extreme digital (xD) memory card, a multimedia card (MMC), a memory stick, and the like. The external memory **834** may be functionally and/or physically connected to the electronic device **801** through various interfaces.

The sensor module **840**, for example, may measure a physical quantity or detect an operational state of the electronic device **801**, and may convert the measured or detected information into an electrical signal. The sensor module **840** may include, for example, at least one of a gesture sensor **840**A, a gyro sensor **840**B, an atmospheric pressure sensor **840**C, a magnetic sensor **840**D, an acceleration sensor **840**E, a grip sensor **840**F, a proximity sensor **840**G, a color sensor **840**H (e.g., a red, green, and blue (RGB) sensor), a biometric sensor **840**I, a temperature/humidity sensor **840**J, an illumination sensor **840**K, an ultra violet (UV) light sensor **840**M, a pressure sensor, and a geomagnetic sensor. Additionally or alternatively, the sensor module **840** may include, for example, an electronic nose (E-nose) sensor, an electromyography (EMG) sensor, an electroencephalogram (EEG) sensor, an electrocardiogram (ECG) sensor, an infrared (IR) sensor, an iris scan sensor, and/or a finger scan sensor. The sensor module **840** may further include a control circuit for controlling one or more sensors included therein. The electronic device **801** may further include a processor configured to control the sensor module **840**, as a part of the processor **810** or separately from the processor **810**, and may control the sensor module **840** while the processor **810** is in a reduced power of sleeping mode. The electronic device **801** may detect a user wearing an HMD, using the gyro sensor **840**B, the acceleration sensor **840**E, the geomagnetic sensor, the proximity sensor **840**B, or the grip sensor **840**F.

The input device **850** may include, for example, a touch panel **852**, a (digital) pen sensor **854**, a key **856**, or an ultrasonic input device **858**. The touch panel **852** may use, for example, at least one of a capacitive type panel, a resistive type panel, an infrared type panel, or an ultrasonic type panel. The touch panel **852** may further include a control circuit. The touch panel **852** may further include a tactile layer, and provide a tactile reaction to a user. The (digital) pen sensor **854** may include, for example, a recognition sheet which is a part of the touch panel **852** or is separated from the touch panel **852**. The key **856** may include, for example, a physical button, an optical key or a keypad. The ultrasonic input device **858** may detect, through a microphone **888**, ultrasonic waves generated by an input tool and identify data corresponding to the detected ultrasonic waves.

The display **860** may include a panel **862**, a hologram unit **864**, a projector **866**, and/or a control circuit for controlling the same. The panel **862** may be implemented to be, for example, flexible, transparent, or wearable. The panel **862** may be implemented as one or more modules with the touch panel **852**. The panel **862** may include an LCD, an OLED, an electronic ink display, or an electro-wetting display (EWD). The display **860** may allow the light to pass (e.g., a display having light transmittance). For example, the display **860** having light transmittance may be implemented by mounting a plurality of transparent or translucent regions which transmit light with pixels. Alternatively, the display **860** having light transmittance may be implemented by mounting a plurality of through holes for transmitting light with pixels. The hologram device **864** may show a three dimensional (3D) image in the air by using an interference of light. The projector **866** may project light onto a screen to display an image. The screen may be located, for example, in the interior of or on the exterior of the electronic device **801**. The interface **870** may include, for example, and without limitation, an HDMI **872**, a USB **874**, an optical interface **876**, or a D-subminiature (D-sub) connector **878**. The interface **870** may be included in, for example, the communication interface **270** of **FIG. 2**. Additionally or alternatively, the interface **870** may include, for example, a mobile high-definition link (MHL) interface, an SD memory card/MMC interface, or an Infrared Data Association (IrDA) standard interface.

The audio module **880**, for example, may bilaterally convert a sound and an electrical signal. At least some components of the audio module **880** may be included in, for example, the input/output interface **245** of **FIG. 2**. The audio module **880** may process voice information input or output through, for example, a speaker **882**, a receiver **884**, earphones **886**, or the microphone **888**. The camera module **891** is, for example, a device which may photograph a still image and record a video. According to an embodiment, the camera module **891** may include one or more image sensors (e.g., a front sensor or a back sensor), a lens, an image signal processor (ISP), or a flash (e.g., an LED or a xenon lamp). The power management module **895** may manage, for example, the power of the electronic device **801**. The power management module **895** may include a PMIC, a charger IC, or a battery gauge. The PMIC may use a wired and/or wireless charging method. Examples of a wireless charging method may include, for example, a magnetic resonance method, a magnetic induction method, an electromagnetic wave method, and the like. Additional circuits such as a coil loop, a resonance circuit, or a rectifier for wireless charging may be further included. The battery gauge may measure, for example, a power level, a voltage, a current, or a temperature of the battery **896** while charging. The battery **896** may include, for example, a rechargeable battery and/or a solar battery.

The indicator **897** may display a particular state, for example, a booting state, a message state, a charging state, and the like of the electronic device **801** or a part (e.g., the processor **810**) of the electronic device **801**. The motor **898** may convert an electrical signal into a mechanical vibration, and may generate a vibration, a haptic effect, and the like. The electronic device **801** may include a mobile TV supporting device (e.g., a GPU) for processing, for example, media data according to digital multimedia broadcasting (DMB), digital video broadcasting (DVB), or MediaFlo™.

Each of the above-described component elements of hardware according to the present disclosure may be configured with one or more components, and the names of the corresponding component elements may vary based on the type of electronic device. In an embodiment, the electronic device (e.g., the electronic device **201**) may include some of the elements or further include some other elements. In addition, some of the components may be combined into one entity, which may perform functions identical to those of the relevant components before the combination.

FIG. 9 is a block diagram of a program module, according to an embodiment. The program module **910** may include an OS for controlling resources that are related to the electronic device **201** and/or various applications **247** that are operated under the OS. For example, the OS may be Android®, iOS®, Windows®, Symbian®, Tizen®, Bada™, or the like.

The program module **910** may include a kernel **920**, middleware **930**, an API **960**, and/or an application **970**. At least some of the program module **910** may be preloaded in the electronic device, or may be downloaded from external electronic devices **202** and **204**, or the server **206**.

The kernel **920**, for example, may include a system resource manager **921** and/or a device driver **923**. The system resource manager **921** may perform control, allocation, or collection of system resources. According to an embodiment, the system resource manager **921** may include a process management unit, a memory management unit, or a file system management unit. The device driver **923**, for example, may include a display driver, a camera driver, a Bluetooth driver, a shared memory driver, a USB driver, a keypad driver, a WiFi® driver, an audio driver, or an inter-process communication (IPC) driver.

In an embodiment, the display driver may control one or more display driver ICs (DDIs). The display driver may include functions for controlling a screen according to requests of the application **970**.

The middleware **930**, for example, may provide functions required in common for the application **970**, or may provide various functions to the application **970** through the API **960** in order to allow the application **970** to effectively use limited system resources in the electronic device. According to an embodiment, the middleware **930** may include at least one of a run time library **935**, an application manager **941**, a window manager **942**, a multimedia manager **943**, a resource manager **944**, a power manager **945**, a database manager **946**, a package manager **947**, a connectivity manager **948**, a notification manager **949**, a location manager **950**, a graphic manager **951**, or a security manager **952**.

The run time library **935**, for example, may include a library module that a compiler uses in order to add new functions through programming languages while the application **970** are executed. The run time library **935** may perform the input/output management, the memory management, or a function of an arithmetic calculation.

The application manager **941**, for example, may manage a life cycle of at least one of the application **970**. The window manager **942** may manage a graphical user interface (GUI) resource that is used in the screen. For example, in a case where two or more displays **860** are connected, the screen may be differently configured or managed according to a screen ratio or the operation of the application **970**. The multimedia manager **943** may identify formats for reproducing various media files, and may perform encoding or decoding of media files by using a codec that conforms to the corresponding format. The resource manager **944** may manage resources, such as source code, memories, or storage spaces of one or more application **970**.

The power manager **945**, for example, may manage a battery or power by operating in association with a basic input/output system (BIOS), and may provide power information that is necessary for the operation of the electronic device. The database manager **946** may create, retrieve, or change a database that is to be used in one or more application **970**. The package manager **947** may manage the installation or updating of the applications that are distributed in the form of a package file.

The connectivity manager **948**, for example, may manage a wireless connection, such as WiFi or Bluetooth. The notification manager **949** may display or notify of events (such as received messages, appointments, or proximity notifications) to a user without disturbance. The location manager **950** may manage location information of the electronic device. The graphic manager **951** may manage graphic effects to be provided to a user or user interfaces related thereto. The security manager **952** may provide a general security function that is required for the system security or user verification. According to an embodiment, in a case of the electronic device (for example, the electronic device **201**) adopting a phone call function, the middleware **930** may further include a telephony manager for managing the functions of a voice call or a video call of the electronic device.

The middleware **930** may include a middleware module that forms a combination of various functions of the above-described elements. The middleware **930** may provide a module that is specialized according to a type of OS in order to provide differentiated functions. In addition, the middleware **930** may dynamically exclude some of the typical elements or add new elements.

The API **960**, for example, may be a group of API programming functions, and may be provided as a different configuration according to an OS. For example, one set of APIs may be provided to each platform in the case of Android® or iOS®, and two or more sets of APIs may be provided to each platform in the case of Tizen®.

The application **970**, for example, may include one or more applications that may execute functions of a home application **971**, a dialer application **972**, a short message service/multimedia messaging service (SMS/MMS) application **973**, an instant message (IM) application **974**, a browser application **975**, a camera application **976**, an alarm application **977**, a contact application **978**, a voice dial application **979**, an e-mail application **980**, a calendar application **981**, a media player application **982**, an album application **983**, a watch application **984**, a healthcare application (for example, measuring an amount of exercise or a blood glucose level), providing environment information (for example, providing atmospheric pressure, humidity, or temperature information), or the like.

According to an example embodiment, the application **970** may include an information-exchange application that supports an exchange of information between the electronic device **201** and an external electronic device **202** or **204**. The information-exchange application, for example, may include a notification relay application for relaying certain information to the external electronic devices, or may include a device management application for managing the external electronic devices.

For example, the notification relay application may include a function of transferring notification information that is generated in other applications (for example, the SMS/MMS application **973**, the e-mail application **980**, the healthcare application, or the environment information application) of the electronic device to the external electronic device. In addition, the notification relay application, for example, may receive notification information from the external electronic device to then provide the same to the user.

The device management application, for example, may manage (for example, install, delete, or update) one or more functions {for example, turning on and off the external electronic device (or some equipped sensors) or adjusting the brightness (or resolution) of a display} of the external electronic device that communicates with the electronic device; applications that are executed in the external electronic device; or services (for example, a phone call service or a messaging service) that are provided by the external electronic device.

According to an example embodiment, the application **970** may include applications (for example, the healthcare application of a mobile medical device) that are designated according to the attribute of the external electronic device. The application **970** may include applications that are received from the external electronic device. The application **970** may include preloaded applications or third party applications that may be downloaded from a server. The names of the elements of the program module **910**, according to the illustrated embodiment, may vary depending on a type of OS.

According to an embodiment, at least some of the program module **910** may be implemented by software, firmware, hardware, or a combination thereof. At least some of the program module **910**, for example, may be implemented (for example, executed) by the processor **220**. At least some of the program module **910**, for example, may include modules, program routines, sets of instructions, or processors for executing one or more functions.

According to an embodiment, an electronic device may include a power management circuit for supplying power to the electronic device; a first battery electrically connected with a power input port of the power management circuit; a second battery electrically connected with the power input port; a first charging circuit for charging the first battery; a second charging circuit for charging the second battery; a first current control circuit electrically connected between the first charging circuit and the first battery, and configured to control a first charging current supplied from the first charging circuit to the first battery and a leakage current due to a voltage difference between the first battery and the second battery; and a second current control circuit electrically connected between the second charging circuit and the second battery, and configured to control a second charging current supplied from the second charging circuit to the second battery and the leakage current.

According to an embodiment, the first battery and the second battery may have different characteristics.

According to an embodiment, the first charging circuit may be connected to the second charging circuit.

According to an embodiment, if a first current greater than an allowable current of the first battery flows in the first battery, the first current control circuit may decrease the first current to below the allowable current, and if a second current greater than an allowable current of the second battery flows in the second battery, the second current control circuit may decrease the second current to below the allowable current.

According to an embodiment, the electronic device may further include a third current control circuit electrically connected between the first charging circuit and the first battery, and configured to control a first discharging current supplied from the first battery to the power management circuit and a leakage current due to a voltage difference between the first battery and the second battery; and a fourth current control circuit electrically connected between the second charging circuit and the second battery, and configured to control a second discharging current supplied from the second battery to the power management circuit and the leakage current.

According to an embodiment, an output port of the first current control circuit and an output port of the third current control circuit may be connected, and an output port of the second current control circuit and an output port of the fourth current control circuit may be connected.

According to an embodiment, the electronic device may further include a processor connected with the third current control circuit and the fourth current control circuit, wherein the processor may be configured to identify setting currents of the third current control circuit and the fourth current control circuit, determine whether battery state information satisfies an update condition, and if the battery state information satisfies the update condition, change the setting current of the third current control circuit or the fourth current control circuit.

According to an embodiment, the battery state information may include at least one of power levels of the first battery and the second battery, temperatures of the first battery and the second battery, or a current flowing in the first battery and the second battery.

According to an embodiment, the update condition may include at least one of a case where a power level difference of the first battery and the second battery exceeds a threshold, or a case where at least one temperature of the first battery and the second battery exceeds a reference temperature.

According to an embodiment, the electronic device may further include a first power supply control circuit electrically connected between the first charging circuit and the power management circuit, and configured to control a leakage current due to a voltage difference between the first battery and the second battery; and a second power supply control circuit electrically connected between the second charging circuit and the power management circuit and configured to control the leakage current.

According to an embodiment, an electronic device may include a power management circuit for supplying power to the electronic device; a first battery electrically connected with a power input port of the power management circuit; a second battery electrically connected with the power input port; a first charging circuit for charging the first battery; a second charging circuit for charging the second battery; a first power supply control circuit electrically connected between the first charging circuit and the power management circuit, and configured to control a leakage current due to a voltage difference between the first battery and the second battery; and a second power supply control circuit electrically connected between the second charging circuit and the power management circuit and configured to control the leakage current.

According to an embodiment, the first battery and the second battery may have different characteristics.

According to an embodiment, the first charging circuit may be connected to the second charging circuit.

According to an embodiment, the electronic device may further include a first current control circuit electrically connected between the first charging circuit and the first battery, and configured to control a first charging current supplied from the first charging circuit to the first battery and a leakage current due to a voltage difference between the first battery and the second battery; and a second current control circuit electrically connected between the second charging circuit and the second battery, and configured to control a second charging current supplied from the second charging circuit to the second battery and the leakage current.

According to an embodiment, the electronic device may further include a third current control circuit electrically connected between the first charging circuit and the first battery, and configured to control a first discharging current supplied from the first battery to the power management circuit and a leakage current due to a voltage difference between the first battery and the second battery; and a fourth current control circuit electrically connected between the second charging circuit and the second battery, and configured to control a second discharging current supplied from the second battery to the power management circuit and the leakage current.

According to an embodiment, the processor may be configured to determine whether to supply power to the electronic device if the first power supply control circuit is turned on, and to discharge the first battery if the electronic device requires the power supply.

According to an embodiment, the processor may be configured to determine whether to supply power to the electronic device if the second power supply control circuit is turned on, and to discharge the second battery if the electronic device requires power.

According to an embodiment, the processor may be configured to discharge the first battery and charge the second battery if the second power supply control circuit is turned off and the electronic device requires power, and to charge the first battery and discharge the second battery if the first power supply control circuit is turned off and the electronic device requires power.

FIG. 10 is a flowchart of a method for charging batteries of an electronic device according to an embodiment. The electronic device may include the electronic device **201**of **FIG. 2** or at least part (e.g., the processor **220**) of the electronic device **201**.

Referring to **FIG. 10**, the electronic device **201** may detect a connection of an external charging device through the first charging circuit **320** or the second charging circuit **330** in step **1001**. For example, the processor **220**, which detects the connection of the external charging device, may detect a charging current flowing through an input port of the first charging circuit **320**.

In step **1003**, the electronic device **201** may identify battery power levels through the first charging circuit **320** and the second charging circuit **330**. For example, the processor **220** may identify the power level of the first battery **301** based on information received from the first charging circuit **320**, and identify the power level of the second battery **302** based on information received from the second charging circuit **330**.

In step **1005**, the electronic device **201** may compare the power levels of the first battery **301** and the second battery **302**. For example, the processor **220** may determine which battery has a greater power level by comparing the power levels of the first battery **301** and the second battery **302**.

If the power level of the first battery **301** is greater than the power level of the second battery **302**, the electronic device **201** may turn off the second power supply control circuit **350** in step **1007** and turn on or keep turned on the first power supply control circuit **340**. For example, to disconnect the second battery **302** of the lesser power level from the system **310**, the processor **220** may turn off the second power supply control circuit **350**.

In step **1011**, the electronic device **201** may charge the battery. For example, the processor **220** may control the second charging circuit **330** to charge the second battery **302**and control the first charging circuit **320** to charge the first battery **301**. If the system **310** requires power, the processor **220** may supply power to the system **310** using only the first battery **301**.

In contrast, if the power level of the first battery **301** is less than the power level of the second battery **302**, the electronic device **201** may turn off the first power supply control circuit **340** in step **1009** and turn on or keep turned on the second power supply control circuit **350**. For example, to disconnect the first battery **302** of the lesser power level from the system **310**, the processor **220** may turn off the first power supply control circuit **340**.

In step **1011**, the electronic device **201** may charge the battery. For example, the processor **220** may control the second charging circuit **330** to charge the second battery **302**and control the first charging circuit **320** to charge the first battery **301**. If the system **310** requires power, the processor **220** may supply the power to the system **310** using only the second battery **302**.

FIG. 11 is a flowchart of a method for charging and discharging batteries of an electronic device according to an embodiment. For example, charging the battery in step **1011** of **FIG. 10** is described below.

Referring to **FIG. 11**, in step **1101**, the electronic device **201** may detect charging from an external charging device. For example, the processor **220** may detect a charging current after a connection to the external charging device is detected.

In step **1103**, the electronic device **201** may identify the power supply control circuit in an ON state. For example, the processor **220** may identify whether the power supply control circuit operating in the ON state is the first power supply control circuit **340** or the second power supply control circuit **350** by comparing the power levels of the first battery **301** and the second battery **302**.

In step **1105**, the electronic device **201** may identify whether the system **310** requires additional power. For example, if the external charging device may not supply all the power required by the system **310**, the processor **220** may identify that the system **310** requires additional power.

If the system **310** requires additional power, the electronic device **201** may discharge the battery in step **1107**. For example, if the first power supply control circuit **340** is turned on, the processor **220** may supply additional power from the first battery **301** to the system **310** by discharging the first battery **301** and continuing to charge the second battery **302**. In contrast, if the second power supply control circuit **350** is turned on, the processor **220** may supply additional power from the second battery **302** to the system **310** by discharging the second battery **302** and continuing to charge the first battery **301**. Next, the electronic device **201** may return to the operations of **FIG. 10**.

If there is no need to supply additional power to the system **310**, the electronic device **201** may charge the battery in step **1109**. For example, the processor **220** may charge the first battery **301** and the second battery **302** regardless of the ON/OFF state of the power supply control circuit. Next, the electronic device **201** may return to the operations of **FIG. 10**.

FIG. 12 is a flowchart of a method for discharging batteries of an electronic device according to an embodiment.

Referring to **FIG. 12**, the electronic device **201** may identify the setting current of the current control circuit in step **1201**. For example, the processor **220** may identify the setting current of the third current control circuit **380** or the fourth current control circuit **390**.

In step **1203**, the electronic device **201** may determine whether battery state information satisfies an update condition. For example, the battery state information may include a battery power level, a battery temperature, a current of the battery, and so on. The update condition may include a case where a battery power level difference exceeds a threshold, or a case where the battery temperature exceeds a reference temperature. For example, the processor **220** may determine whether the state information of the first battery **301** and the second battery **302** satisfy the update condition through the first charging circuit **320** and the second charging circuit **330**, respectively.

If the battery state information satisfies the update condition, the electronic device **201** may change the setting current of the current control circuit in step **1205**. For example, the processor **220** may compare the power levels of the first battery **301** and the second battery **302**, and if the power level of the first battery **301** is greater than the power level of the second battery **302** by more than the threshold, increase the setting current of the third current control circuit **380** and decrease the setting current of the fourth current control circuit **390**. Hence, the first battery **301** may supply more discharging current to the system **310**, and the second battery **302** may supply less discharging current to the system **310**. Herein, the threshold may be a value more than half of the full battery capacity. For example, the processor **220** may identify the temperatures of the first battery **301** and the second battery **302** through the first charging circuit **320** and the second charging circuit **330**. If the temperature of the first battery **301** is greater than the reference temperature, the processor **220** may lower the setting current of the third current control circuit **380** and increase the setting current of the fourth current control circuit **390**. Herein, the reference temperature may be the allowable temperature of the battery. Thus, the discharging current of the first battery **301** may be limited or reduced, and the discharging current of the second battery **302** may be increased.

In contrast, if the battery state information does not satisfy the update condition, the electronic device **201** may discharge the batteries in step **1207**. For example, if the currents flowing through the first battery **301** and the second battery **302** fall below the setting current, the processor **220** may continuously supply the power of the first battery **301** and the second battery **302** to the system **310**.

The method and the electronic device according to an embodiment may, if some of the batteries are discharged during charging, prevent a discharging current of a battery from leaking to the charging battery and thus improve the lifetime and the safety of the battery.

In addition, the method and the electronic device according to an embodiment may, if the batteries are discharging, control the discharging current of the batteries to not exceed an allowable battery current and thus improve the lifetime and the safety of the battery.

While the present disclosure has been shown and described with reference to various embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the present disclosure as defined by the appended claims and their equivalents.