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(54) **APPARATUS FOR DETECTING OVERHEATING OF BATTERY MODULE AND METHOD THEREOF**

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(52) **U.S. Cl.**

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(Continued)

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CPC B60L 3/0046; B60L 58/18; H01M 50/581; H01M 10/482; H01M 10/486; H01M 2200/103; H01M 2220/20
See application file for complete search history.

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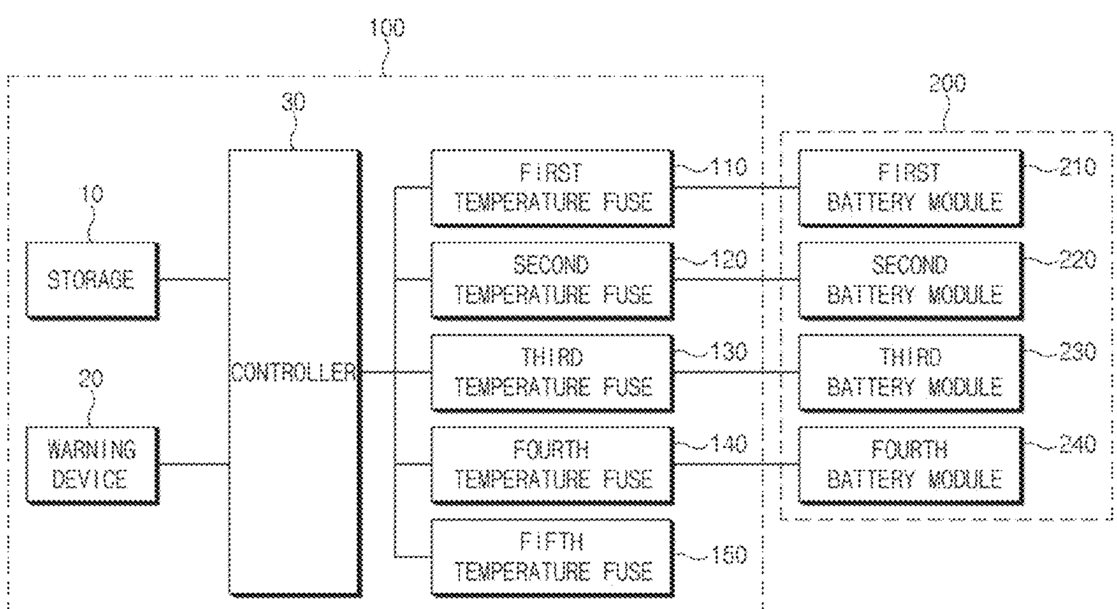
(57) **ABSTRACT**

An apparatus for detecting overheating of a battery module includes a battery pack including a first battery module and a second battery module, a first temperature fuse arranged on the first battery module and having a first resistance value, a second temperature fuse arranged on the second battery module and having a second resistance value, and a controller that detects an overheated battery module based on a total resistance value of the first and second temperature fuses, which are connected in parallel to each other.

7 Claims, 5 Drawing Sheets



(51) **Int. Cl.**
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H01M 50/581 (2021.01)

(52) **U.S. Cl.**
CPC ***H01M 10/486*** (2013.01); ***H01M 50/581*** (2021.01); *H01M 2200/103* (2013.01); *H01M 2220/20* (2013.01)

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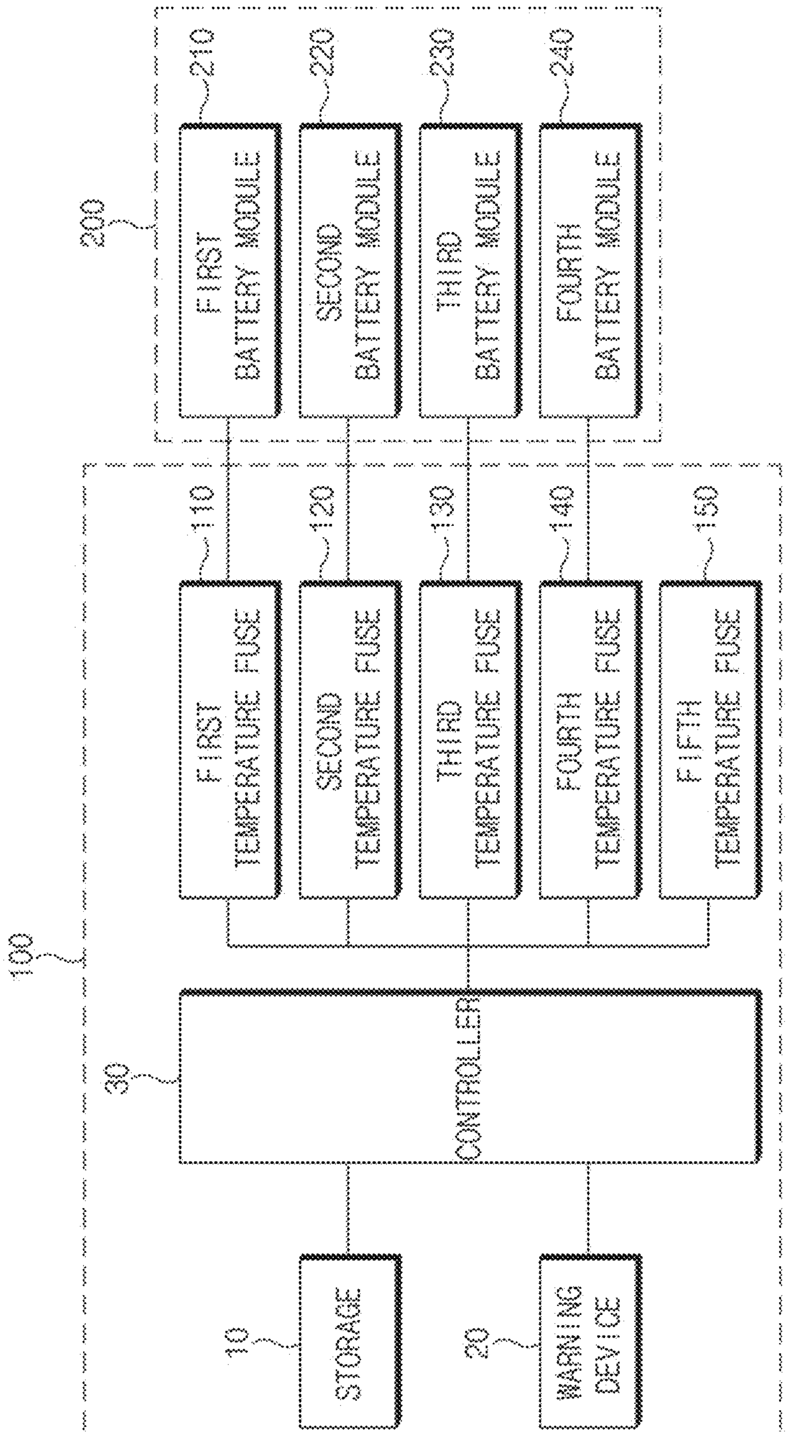
200
210
FIRST BATTERY MODULE
220
SECOND BATTERY MODULE
230
THIRD BATTERY MODULE
240
FOURTH BATTERY MODULE
100
110
FIRST TEMPERATURE FUSE
120
SECOND TEMPERATURE FUSE
130
THIRD TEMPERATURE FUSE
140
FOURTH TEMPERATURE FUSE
150
FIFTH TEMPERATURE FUSE
30
CONTROLLER
10
STORAGE
20
WARNING DEVICE

Fig.1

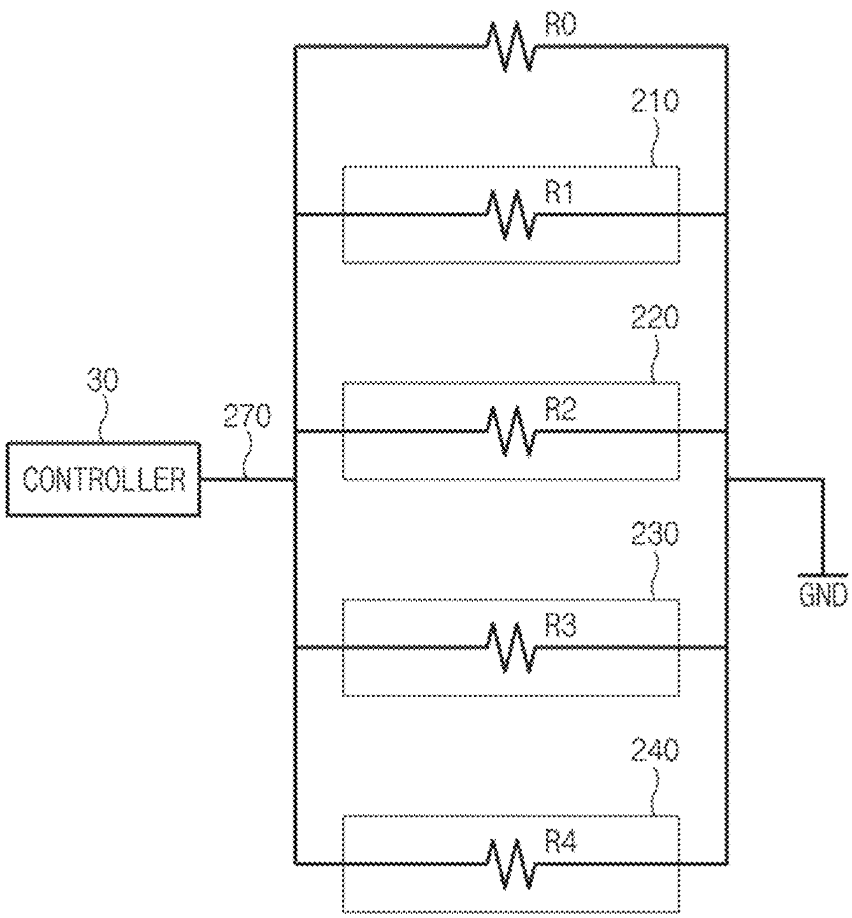

Fig.2

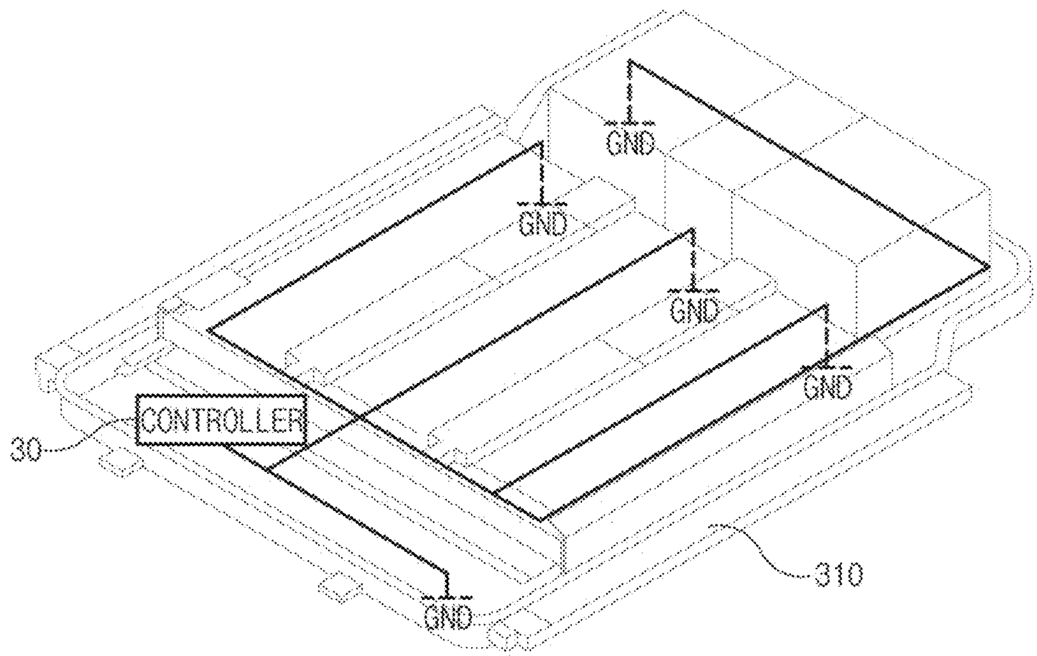

Fig.3

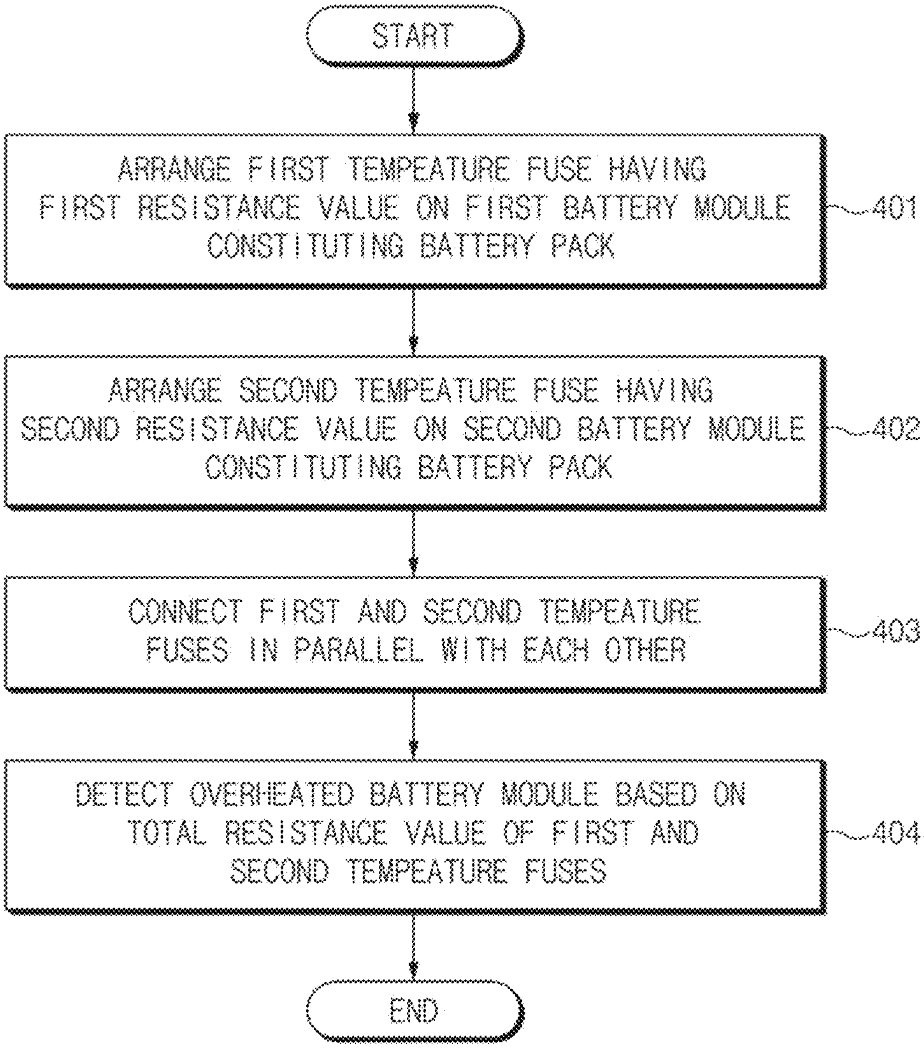
START
ARRANGE FIRST TEMPEATURE FUSE HAVING FIRST RESISTANCE VALUE ON FIRST BATTERY MODULE CONSTITUTING BATTERY PACK
401
ARRANGE SECOND TEMPEATURE FUSE HAVING SECOND RESISTANCE VALUE ON SECOND BATTERY MODULE CONSTITUTING BATTERY PACK
402
CONNECT FIRST AND SECOND TEMPEATURE FUSES IN PARALLEL WITH EACH OTHER
403
DETECT OVERHEATED BATTERY MODULE BASED ON TOTAL RESISTANCE VALUE OF FIRST AND SECOND TEMPEATURE FUSES
404
END

Fig.4

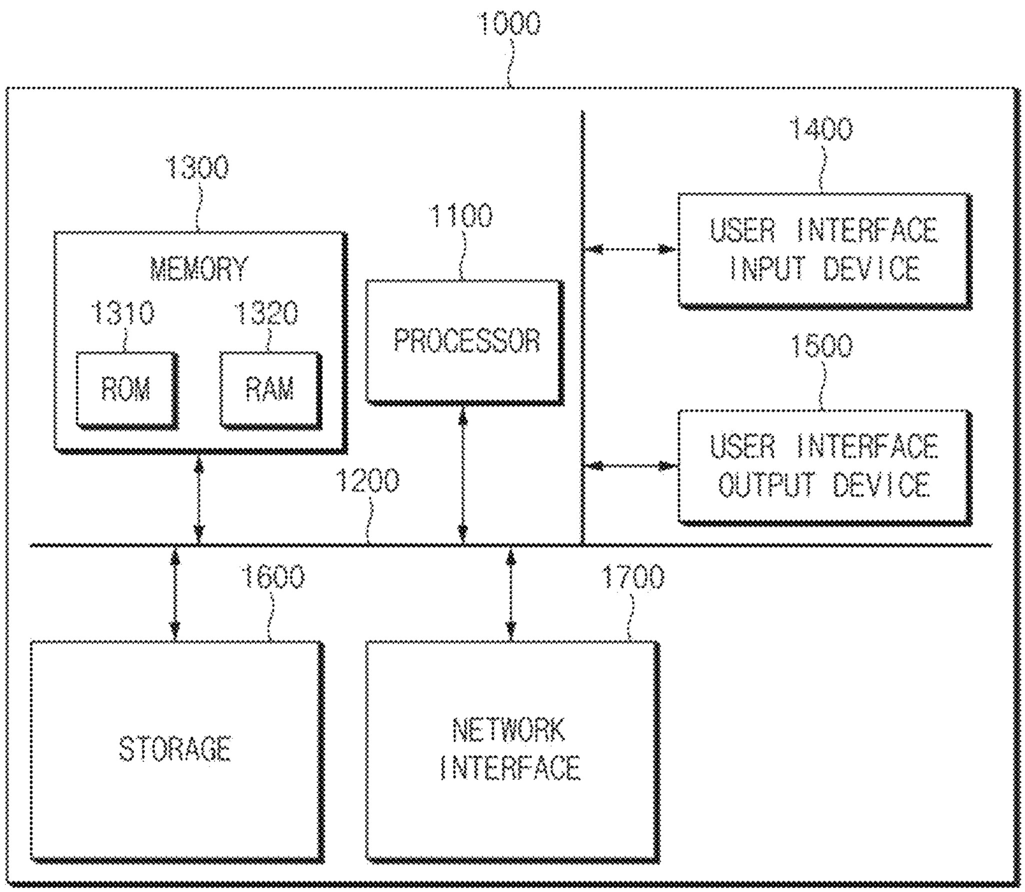
1000
1300
MEMORY
1310
1320
ROM
RAM
1100
PROCESSOR
1400
USER INTERFACE
INPUT DEVICE
1500
USER INTERFACE
OUTPUT DEVICE
1200
1600
1700
STORAGE
NETWORK
INTERFACE

Fig.5

APPARATUS FOR DETECTING OVERHEATING OF BATTERY MODULE AND METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This Application is a Division of application Ser. No. 17/020,295 filed on Sep. 14, 2020. Application Ser. No. 17/020,295 claims priority to Korean Patent Application No. 10-2020-0058456 filed on May 15, 2020. The entire contents of these applications are incorporated herein by reference in their entirety.

BACKGROUND

(a) Technical Field

The present disclosure relates to a technique for detecting if at least one battery module of a battery pack is overheated.

(b) Description of the Related Art

A battery (e.g., a lithium polymer battery) that supplies power to an electric vehicle includes a cell, a module, and a pack. In this case, the module includes a plurality of cells, and the pack includes a plurality of modules. For example, the battery of the BMW i3® includes one pack including 96 cells, where one pack includes 8 modules, each of which includes 12 cells.

When such a battery is overheated, it is important to understand in advance whether the battery is overheated because it may lead to a fire in the electric vehicle that would potentially affect the safety of passengers.

In general, because a battery management system (BMS) mounted on an electric vehicle detects whether a battery pack is overheated by using a temperature sensor, the BMS cannot specifically determine which battery module has overheated in the battery pack.

Therefore, even though a first battery module is overheated, when a temperature measured by the temperature sensor is normal, a driver of the electric vehicle cannot be warned of the possibility of fire in advance. In particular, when a fire occurs in a battery, it is impossible to know which battery module caused the fire.

Although a scheme of providing a temperature sensor for each battery module has been considered, it is necessary to provide additional temperature sensors as the battery module increases in size, and additional connectors (or pins) must be provided on the printed circuit board (PCB) as the number of temperature sensors increases, so that it is difficult to commercialize the scheme.

The matters described in this background section are intended to promote an understanding of the background of the disclosure and may include matters that are not already known to those of ordinary skill in in the art.

SUMMARY

An aspect of the present disclosure provides an apparatus for detecting overheating of a battery module which includes a plurality of thermal fuses having different resistance values and is capable of detecting an overheated battery module based on a resistance value due to disconnection of at least one temperature fuse, where one thermal fuse is arranged on

one battery module constituting one battery pack, and the thermal fuses are connected in parallel with each other, and a method thereof.

The technical problems to be solved by the present inventive concept are not limited to the aforementioned problems, and any other technical problems not mentioned herein will be clearly understood from the following description by those skilled in the art to which the present disclosure pertains.

According to an aspect of the present disclosure, an apparatus for detecting overheating of a battery module includes a battery pack including a first battery module and a second battery module, a first temperature fuse arranged on the first battery module and having a first resistance value, a second temperature fuse arranged on the second battery module and having a second resistance value, and a controller that detects an overheated battery module based on a total resistance value of the first and second temperature fuses, which are connected in parallel to each other.

The apparatus may further include a storage that stores a reference table in which a reference resistance value is recorded corresponding to disconnection of the first temperature fuse or the second temperature fuse.

The controller may measure the total resistance value of the first and second temperature fuses, search the reference table for a temperature fuse in which disconnection has occurred, based on the measured total resistance value, and determine that a battery module corresponding to the searched temperature fuse is overheated.

The apparatus may further include a third temperature fuse spaced apart from the first and second battery modules and having a third resistance value, wherein the third temperature fuse is connected in parallel with the first and second temperature fuses.

The controller may determine whether disconnection of the first and second temperature fuses was caused due to overheating or defective connector connections, based on the resistance value of the third temperature fuse when the disconnection occurred in the first and second temperature fuses.

The controller may warn of a possibility of fire when the overheated battery module is detected.

The controller may cut off power of the battery pack when the overheated battery module is detected.

The first and second temperature fuses may include wires that are melted at or above a threshold temperature, and wherein melting occurs throughout the wires.

The first temperature fuse may be arranged in a portion of the first battery module where a highest heat is generated.

The second temperature fuse may be arranged in a portion of the second battery module where a highest heat is generated.

According to another aspect of the present disclosure, a method of detecting overheating of a battery module includes arranging a first temperature fuse having a first resistance value on a first battery module constituting a battery pack, arranging a second temperature fuse having a second resistance value on a second battery module constituting the battery pack, connecting the first temperature fuse and the second temperature fuse in parallel with each other, and detecting an overheated battery module based on a total resistance value of the first and second temperature fuses.

The detecting of the overheated battery module may include storing a reference table in which a reference resistance value is recorded corresponding to disconnection of the first temperature fuse or the second temperature fuse, measuring the total resistance value of the first and second temperature fuses, searching the reference table for a temperature fuse in which disconnection has occurred, based on the measured total resistance value, and determining that a battery module corresponding to the searched temperature fuse is overheated.

The method may further include arranging a third temperature fuse having a third resistance value to be spaced apart from the first and second battery modules, connecting the third temperature fuse in parallel with the first and second temperature fuses, and determining whether disconnection of the first and second temperature fuses was caused due to overheating or defective connector connections, based on the resistance value of the third temperature fuse when the disconnection occurred in the first and second temperature fuses.

The method may further include warning of a possibility of fire when the overheated battery module is detected.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present disclosure will be more apparent from the following detailed description taken in conjunction with the accompanying drawings:

FIG. **1** is a block diagram of an apparatus for detecting overheating of a battery module according to an embodiment of the present disclosure;

FIG. **2** is a view illustrating a detailed structure of an apparatus for detecting overheating of a battery module according to an embodiment of the present disclosure;

FIG. **3** is a view illustrating a connection structure of a temperature fuse provided in an apparatus for detecting overheating of a battery module according to an embodiment of the present disclosure;

FIG. **4** is a flowchart illustrating a method of detecting overheating of a battery module according to an embodiment of the present disclosure; and

FIG. **5** is a block diagram illustrating a computing system for executing a method of detecting overheating of a battery module according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

It is understood that the term "vehicle" or "vehicular" or other similar term as used herein is inclusive of motor vehicles in general such as passenger automobiles including sports utility vehicles (SUV), buses, trucks, various commercial vehicles, watercraft including a variety of boats and ships, aircraft, and the like, and includes hybrid vehicles, electric vehicles, plug-in hybrid electric vehicles, hydrogen-powered vehicles and other alternative fuel vehicles (e.g. fuels derived from resources other than petroleum). As referred to herein, a hybrid vehicle is a vehicle that has two or more sources of power, for example both gasoline-powered and electric-powered vehicles.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Throughout the specification, unless explicitly described to the contrary, the word "comprise" and variations such as "comprises" or "comprising" will be understood to imply the inclusion of stated elements but not the exclusion of any other elements. In addition, the terms "unit", "-er", "-or", and "module" described in the specification mean units for processing at least one function and operation, and can be implemented by hardware components or software components and combinations thereof.

Further, the control logic of the present disclosure may be embodied as non-transitory computer readable media on a computer readable medium containing executable program instructions executed by a processor, controller or the like. Examples of computer readable media include, but are not limited to, ROM, RAM, compact disc (CD)-ROMs, magnetic tapes, floppy disks, flash drives, smart cards and optical data storage devices. The computer readable medium can also be distributed in network coupled computer systems so that the computer readable media is stored and executed in a distributed fashion, e.g., by a telematics server or a Controller Area Network (CAN).

Hereinafter, some embodiments of the present disclosure will be described in detail with reference to the exemplary drawings. In adding the reference numerals to the components of each drawing, it should be noted that the identical or equivalent component is designated by the identical numeral even when they are displayed on other drawings. Further, in describing the embodiment of the present disclosure, a detailed description of well-known features or functions will be ruled out in order not to unnecessarily obscure the gist of the present disclosure.

In describing the components of the embodiment according to the present disclosure, terms such as first, second, "A", "B", (a), (b), and the like may be used. These terms are merely intended to distinguish one component from another component, and the terms do not limit the nature, sequence or order of the constituent components. Unless otherwise defined, all terms used herein, including technical or scientific terms, have the same meanings as those generally understood by those skilled in the art to which the present disclosure pertains. Such terms as those defined in a generally used dictionary are to be interpreted as having meanings equal to the contextual meanings in the relevant field of art, and are not to be interpreted as having ideal or excessively formal meanings unless clearly defined as having such in the present application.

FIG. **1** is a block diagram of an apparatus for detecting overheating of a battery module according to an embodiment of the present disclosure. Although five temperature fuses are described as an example to help understanding, the number of temperature fuses can be changed according to the designer's intention, and even if the number of temperature fuses is changed, there is no difficulty in applying the present disclosure.

As shown in FIG. **1**, an apparatus **100** for detecting overheating of a battery module according to an embodiment of the present disclosure may include a storage **10**, a warning device **20**, a controller **30**, and first to fifth temperature fuses **110** to **150**. In this case, according to a scheme of implementing the apparatus **100** for detecting overheating of a battery module according to an embodiment of the present disclosure, each component may be combined with each other to be implemented together, and some components may be omitted.

Regarding each component, first, the storage **10** may store a reference table in which a reference resistance value is recorded corresponding to disconnection of at least one of the first to fifth temperature fuses **110** to **150**. For example, the reference table is shown in following Table 1.

TABLE 1

Disconnection location	R0	R1	R2	R3	R4	Reference resistance value
case 1	○	○	○	○	○	0.0
case 2						43.8
case 3					○	48.0
case 4				○		49.2
case 5			○			51.3
case 6				○	○	54.5
case 7		○				56.1
case 8			○		○	57.1
case 9			○	○		58.8
case 10		○			○	63.2
case 11		○		○		65.2
case 12			○	○	○	66.7
case 13		○	○			69.0
case 14		○		○	○	75.0
case 15	○					77.9
case 16		○	○		○	80.0
case 17		○	○	○		83.3
case 18	○				○	92.3
case 19	○			○		100.0
case 20		○	○	○	○	105.3
case 21	○		○			120.0
case 22	○			○	○	127.7
case 23	○	○				133.3
case 24	○		○		○	142.9
case 25	○		○	○		142.9
case 26	○	○			○	171.4
case 27	○	○		○		187.5
case 28	○		○	○	○	200.0
case 29	○	○	○			222.2
case 30	○	○		○	○	300.0
case 31	○	○	○		○	400.0
case 32	○	○	○	○		500.0

In Table 1, "○" represents a case where disconnection occurs. For example, the first temperature fuse **110** may have a resistance value R1 of 200Ω, the second temperature fuse **120** may have a resistance value R2 of 300Ω, the third temperature fuse **130** may have a resistance value R3 of 400Ω, the fourth temperature fuse **140** may have a resistance value R4 of 500Ω, and the fifth temperature fuse **150** may have a resistance value R0 of 100Ω.

For example, in case **7** where disconnection occurs in the first temperature fuse **110**, the reference resistance value is 56.1Ω. Thus, when the measured resistance value of the entire temperature fuse satisfies 56.1Ω, the controller **30** may determine that overheating has occurred in the first temperature fuse **110**.

As another example, in case **20** where disconnection occurred in the first to fourth temperature fuses **110** to **140**, because any disconnection did not occur in the temperature fuse **150**, when the measured total resistance value of the temperature fuses satisfies 105.3Ω, the controller **30** may determine that all the first to fourth temperature fuses **110** to **140** are overheated.

As another example, in case **1** where disconnection occurred in all the first to fifth temperature fuses **110** to **150**, when the measured total resistance value of the temperature fuses satisfies 0Ω, considering that the fifth temperature fuse **150** is arranged spaced apart from a battery module, the controller **30** may determine that disconnection (or defective PCB connector connection) has occurred on the connection line with the controller **30**.

Therefore, when the first to fourth temperature fuses **110** to **140** are all disconnected, the resistance value R0 of the fifth temperature fuse **150** may be used to detect whether disconnection was caused by overheating or disconnection on the connection line with the controller **30**.

The storage **10** may store various logic, algorithms and programs required in the processes of measuring the total resistance value of the first to fourth temperature fuses **110** to **140** and an auxiliary temperature fuse **150** and detecting which temperature fuse is disconnected, that is, which battery module is overheated, based on the reference table.

The storage **10** may include at least one type of a storage medium of memories of a flash memory type, a hard disk type, a micro type, a card type (e.g., a secure digital (SD) card or an extreme digital (XD) card), and the like, and a random access memory (RAM), a static RAM (SRAM), a read-only memory (ROM), a programmable ROM (PROM), an electrically erasable PROM (EEPROM), a magnetic memory (MRAM), a magnetic disk, and an optical disk type memory.

The warning device **20** may warn of the possibility of fire due to overheating of each battery module under control of the controller **30**.

The warning device **20** may warn of the possibility of fire in at least one of visual warning, audible warning, or tactile warning. For example, the warning device **20** may visually warn of the possibility of fire through a display (not shown), may audibly warn of the possibility of fire through a speaker (not shown), and may tactilely warn of the possibility of fire through a vibration element (not shown). When an embodiment of the present disclosure is applied to an electric vehicle, a display, a speaker, and a vibration element provided in the electric vehicle may be used.

The controller **30** performs overall control so that each of the components can perform its function normally. The controller **30** may be implemented in the form of hardware or software, or may be implemented in the form of a combination of hardware and software. Preferably, the controller **30** may be implemented with a microprocessor, but is not limited thereto.

The processor may include a single processor core, or may include a plurality of processor cores. For example, the processor may include multi-cores such as dual-core, quad-core, and hexa-core. According to embodiments, the processor may further include a cache memory located inside or outside. According to embodiments, the processor may be configured with one or more processors. For example, the processor may include at least one of an application processor, a communication processor, or a graphical processing unit (GPU).

The processor may receive an instruction of other components, interpret the received instruction, and perform calculation or process data corresponding to the interpreted instruction. The processor may interpret and process messages, data, instructions, or signals received from the storage **10**. The processor may generate a new message, data, instruction, or signal based on the received message, data, instruction, or signal. The processor may provide the storage **10** with processed or generated messages, data, instructions, or signals.

The processor may process data or signals generated or created in a program. For example, the processor may request instructions, data, or signals from the storage **10** to execute or control a program. The processor may record (or store) or update instructions, data, or signals to the storage **10** to execute or control a program.

The controller **30** may perform various control required in the processes of measuring the total resistance value of the first to fifth temperature fuses **110** to **150** connected in parallel with each other and detecting which temperature fuse is disconnected, that is, which battery module is overheated, based on the reference table.

Hereinafter, with reference to FIG. **2**, the arrangement structure between each battery module **210** to **240** and each temperature fuse **110** to **150** will be described in detail.

FIG. **2** is a view illustrating a detailed structure of an apparatus for detecting overheating of a battery module according to an embodiment of the present disclosure.

As shown in FIG. **2**, the first temperature fuse **110** may be arranged on the first battery module **210** and may be disconnected by overheating generated in the first battery module **210**. In this case, the first temperature fuse **110** may be installed in a portion of the first battery module **210** where the highest heat is generated. When the first temperature fuse **110** is disconnected, the total resistance value R measured by the controller **30** may be expressed as following Equation 1.

$$R = \left\{ \frac{1}{\frac{1}{R0} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4}} \right\} \quad \text{[Equation 1]}$$

Where R0 represents the resistance value of the fifth temperature fuse **150**, R2 represents the resistance value of the second temperature fuse **120**, R3 represents the resistance value of the third temperature fuse **130**, and R4 represents the fourth temperature fuse **140**.

The second temperature fuse **120** may be arranged on the second battery module **220** and may be disconnected by overheating caused in the second battery module **220**. In this case, the second temperature fuse **120** may be installed in a portion of the second battery module **220** where the highest heat is generated. When the second temperature fuse **120** is disconnected, the total resistance value R measured by the controller **30** may be expressed as following Equation 2.

$$R = \left\{ \frac{1}{\frac{1}{R0} + \frac{1}{R1} + \frac{1}{R3} + \frac{1}{R4}} \right\} \quad \text{[Equation 2]}$$

Where R1 represents the resistance value of the first temperature fuse **110**.

The third temperature fuse **130** may be arranged on the third battery module **230** and may be disconnected by overheating caused in the third battery module **230**. In this case, the third temperature fuse **130** may be installed in a portion of the third battery module **230** where the highest heat is generated. When the third temperature fuse **130** is disconnected, the total resistance value R measured by the controller **30** may be expressed as following Equation 3.

$$R = \left\{ \frac{1}{\frac{1}{R0} + \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R4}} \right\} \quad \text{[Equation 3]}$$

The fourth temperature fuse **140** is arranged on the fourth battery module **240** and may be disconnected by overheating caused in the fourth battery module **240**. In this case, the fourth temperature fuse **140** may be installed in a portion of the fourth battery module **240** where the highest heat is generated. When the fourth temperature fuse **140** is disconnected, the total resistance value R measured by the controller **30** may be expressed as following Equation 4.

$$R = \left\{ \frac{1}{\frac{1}{R0} + \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}} \right\} \quad \text{[Equation 4]}$$

Because the fifth temperature fuse **150** is installed spaced apart from the battery module, it may be utilized to detect whether the disconnection of the first to fourth temperature fuses **110** to **140** was caused due to overheating of the battery modules or disconnection (or defective PCB connector connections) on a connection line **270**.

The temperature fuses **110** to **150** include wires that are melted at or above a threshold temperature, so that melting may occur throughout the wires. As an example, the connection structure of each temperature fuse is shown in FIG. **3**.

Meanwhile, the controller **30** may control the warning device **20** to warn of a possibility of fire when an overheated battery module is detected.

When the overheated battery module is detected, the controller **30** may turn off a relay (not shown) such that the power of a battery pack **310** is not supplied to the load. That is, the controller **30** may cut off the power of the battery pack **310**.

FIG. **3** is a view illustrating a connection structure of a temperature fuse provided in an apparatus for detecting overheating of a battery module according to an embodiment of the present disclosure, where a temperature fuse having a wire shape is connected to each battery module provided in the battery pack **310**.

FIG. **4** is a flowchart illustrating a method of detecting overheating of a battery module according to an embodiment of the present disclosure. Although the following description will be made based on the first and second temperature fuses **110** and **120** to help understanding, the same may be applied to the case where the third temperature fuse **130** and the fourth temperature fuse **140** are included.

First, in operation **401**, the first temperature fuse **110** having the first resistance value is arranged on the first battery module **210** constituting the battery pack **310**.

Then, in operation **402**, the second temperature fuse **120** having the second resistance value is arranged on the second battery module **220** constituting the battery pack **310**.

Then, in operation **403**, the first and second temperature fuses **110** and **120** are connected in parallel with each other.

Thereafter, in operation **404**, the controller **30** detects an overheated battery module based on the total resistance value of the first and second temperature fuses **110** and **120**. That is, the controller **30** may store a reference table in which a reference resistance value is recorded corresponding to disconnection of the first or second temperature fuses **110** and **120**, measure the total resistance value of the first and second temperature fuses **110** and **120**, search the reference table for a temperature fuse in which disconnection has occurred, based on the measured total resistance value, and determine that a battery module corresponding to the searched temperature fuse is overheated.

FIG. **5** is a block diagram illustrating a computing system for executing a method of detecting overheating of a battery module according to an embodiment of the present disclosure.

Referring to FIG. **5**, as described above, a method of detecting overheating of a battery module according to an embodiment of the present disclosure may be implemented through a computing system. A computing system **1000** may include at least one processor **1100**, a memory **1300**, a user interface input device **1400**, a user interface output device **1500**, storage **1600**, and a network interface **1700** connected through a system bus **1200**.

The processor **1100** may be a central processing unit (CPU), or a semiconductor device that processes instructions stored in the memory **1300** and/or the storage **1600**. The memory **1300** and the storage **1600** may include various types of volatile or non-volatile storage media. For example, the memory **1300** may include a read only memory (ROM) **1310** and a random access memory (RAM) **1320**.

Accordingly, the processes of the method or algorithm described in relation to the embodiments of the present disclosure may be implemented directly by hardware executed by the processor **1100**, a software module, or a combination thereof. The software module may reside in a storage medium (that is, the memory **1300** and/or the storage **1600**), such as a RAM, a flash memory, a ROM, an EPROM, an EEPROM, a register, a hard disk, solid state drive (SSD), a detachable disk, or a CD-ROM. The exemplary storage medium is coupled to the processor **1100**, and the processor **1100** may read information from the storage medium and may write information in the storage medium. In another method, the storage medium may be integrated with the processor **1100**. The processor and the storage medium may reside in an application specific integrated circuit (ASIC). The ASIC may reside in a user terminal. In another method, the processor and the storage medium may reside in the user terminal as an individual component.

According to embodiments of the present disclosure, there are provided an apparatus for detecting overheating of a battery module which includes the plurality of thermal fuses having different resistance values and can detect an overheated battery module based on a resistance value due to disconnection of at least one temperature fuse, and a method thereof, where one thermal fuse is arranged on one battery module constituting one battery pack, and the thermal fuses are connected in parallel with each other.

The above description is a simple exemplification of the technical spirit of the present disclosure, and the present disclosure may be variously corrected and modified by those skilled in the art to which the present disclosure pertains without departing from the essential features of the present disclosure.

Therefore, the disclosed embodiments of the present disclosure do not limit the technical spirit of the present disclosure but are illustrative, and the scope of the technical spirit of the present disclosure is not limited by the embodiments of the present disclosure. The scope of the present disclosure should be construed by the claims, and it will be understood that all the technical spirits within the equivalent range fall within the scope of the present disclosure.

What is claimed is:

1. A method of detecting overheating of a battery module, comprising:

arranging a first temperature fuse having a first resistance value on a first battery module constituting a battery pack;

arranging a second temperature fuse having a second resistance value on a second battery module constituting the battery pack;

connecting the first temperature fuse and the second temperature fuse in parallel with each other; and

detecting an overheated battery module based on a total resistance value of the first and second temperature fuses;

further comprising:

arranging a third temperature fuse having a third resistance value to be spaced apart from the first and second battery modules;

connecting the third temperature fuse in parallel with the first and second temperature fuses; and

determining a defective connector connection has occurred connection line between the first, second, and third temperature fuses when a total resistance value of the first, second, and third temperature fuses is 0Ω.

2. The method of claim **1**, wherein detecting the overheated battery module includes:

storing a reference table in which a reference resistance value is recorded corresponding to disconnection of the first temperature fuse or the second temperature fuse;

measuring the total resistance value of the first and second temperature fuses;

searching the reference table for a temperature fuse in which disconnection has occurred, based on the measured total resistance value; and

determining that a battery module corresponding to the searched temperature fuse is overheated.

3. The method of claim **1**, further comprising:

warning of a possibility of fire when the overheated battery module is detected.

4. The method of claim **1**, further comprising:

cutting off power of the battery pack when the overheated battery module is detected.

5. The method of claim **1**, wherein the first and second temperature fuses include wires that are melted at or above a threshold temperature, and wherein melting occurs throughout the wires.

6. The method of claim **1**, wherein the first temperature fuse is arranged in a portion of the first battery module where a highest heat is generated.

7. The method of claim **1**, wherein the second temperature fuse is arranged in a portion of the second battery module where a highest heat is generated.

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