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(54) **VEHICLE SPEED SENSOR DEVICE, ABS APPARATUS INCLUDING SAME, AND OPERATING METHOD THEREOF**

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(57) **ABSTRACT**

Provided are a vehicle speed sensor device, an ABS apparatus including the same, and an operating method thereof. The vehicle speed sensor device comprises: a rechargeable battery; a speed sensor for receiving power supplied from the battery and measuring a rotation speed of a wheel bearing to generate a speed signal; and a wireless signal transmitter for transmitting a speed signal to an electronic controller through wireless communication. Such a configuration enables the vehicle sensor device to be robust against an external damage, can remove the signal crosstalk problem due to complex cable connection, and can reduce the weight of a vehicle.

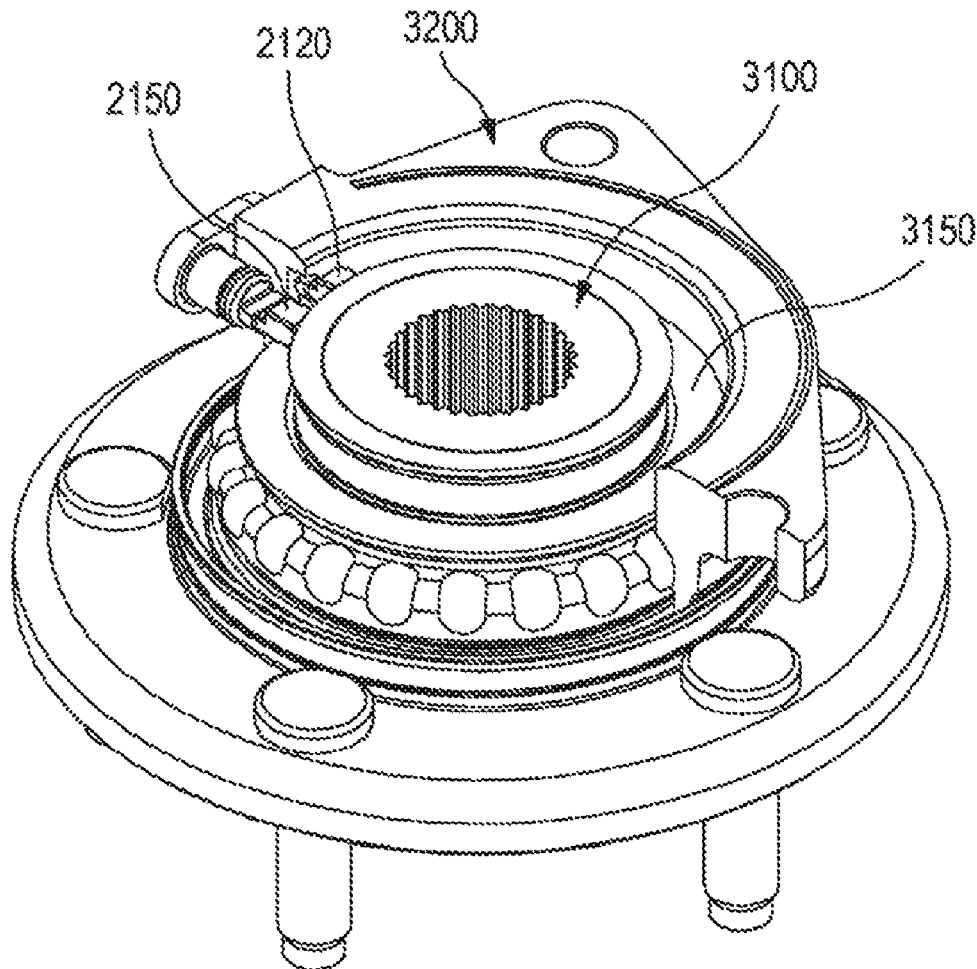
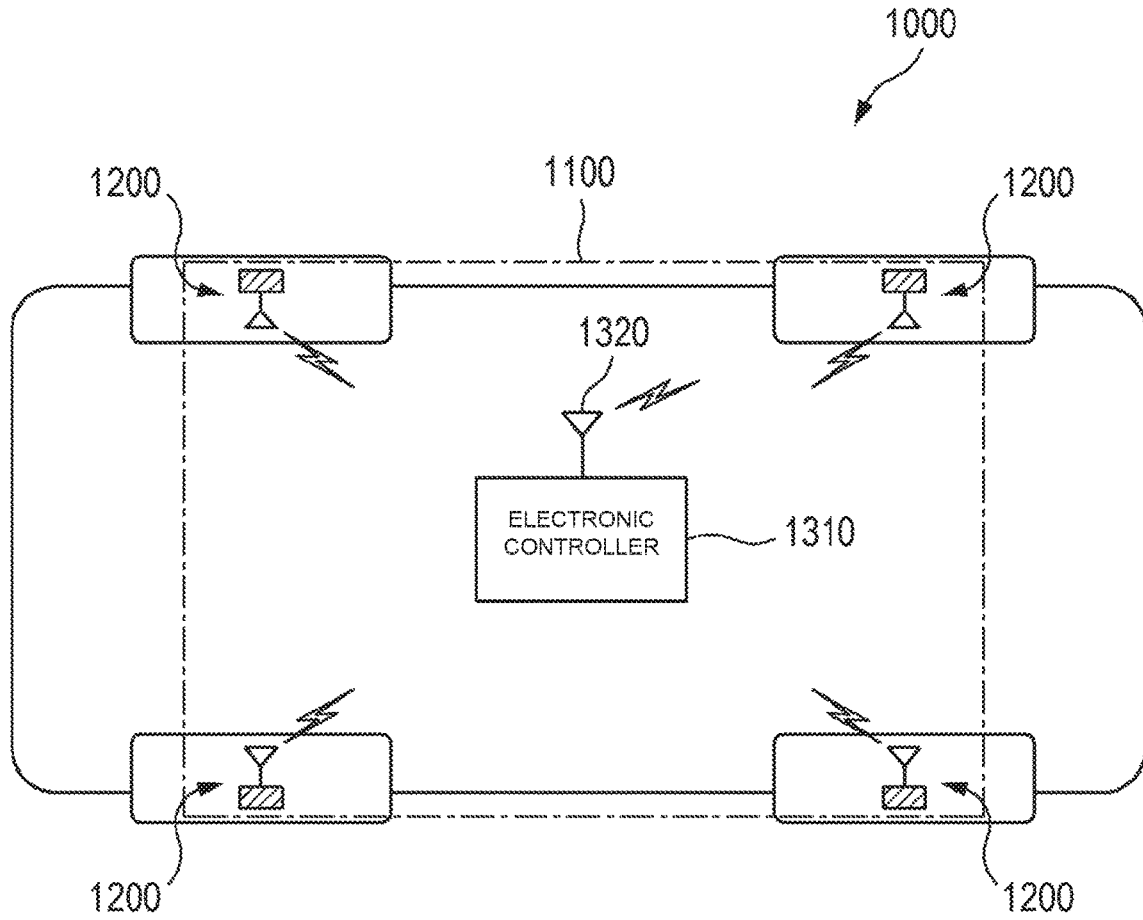


FIG. 1



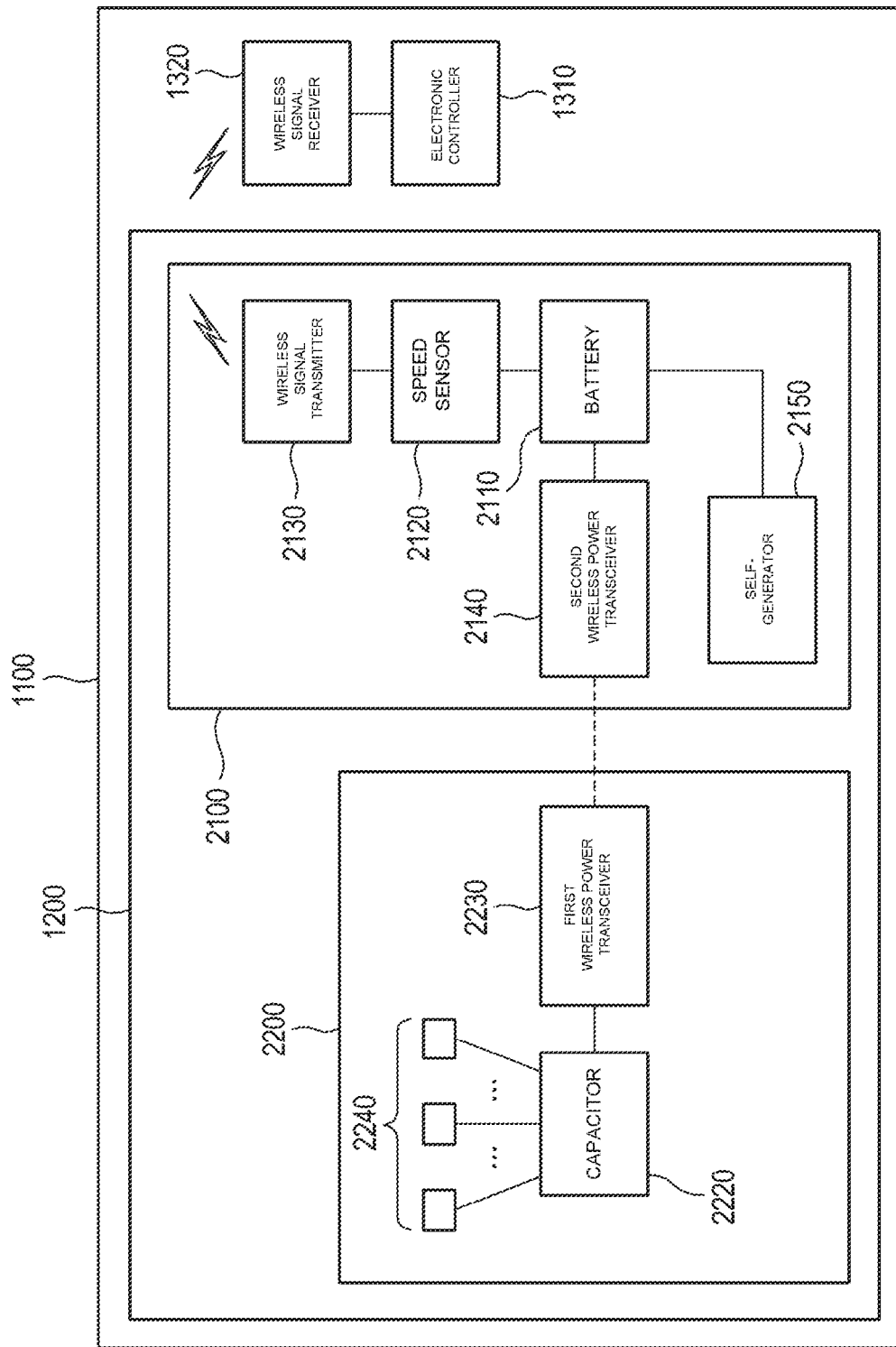


FIG. 2

FIG. 3

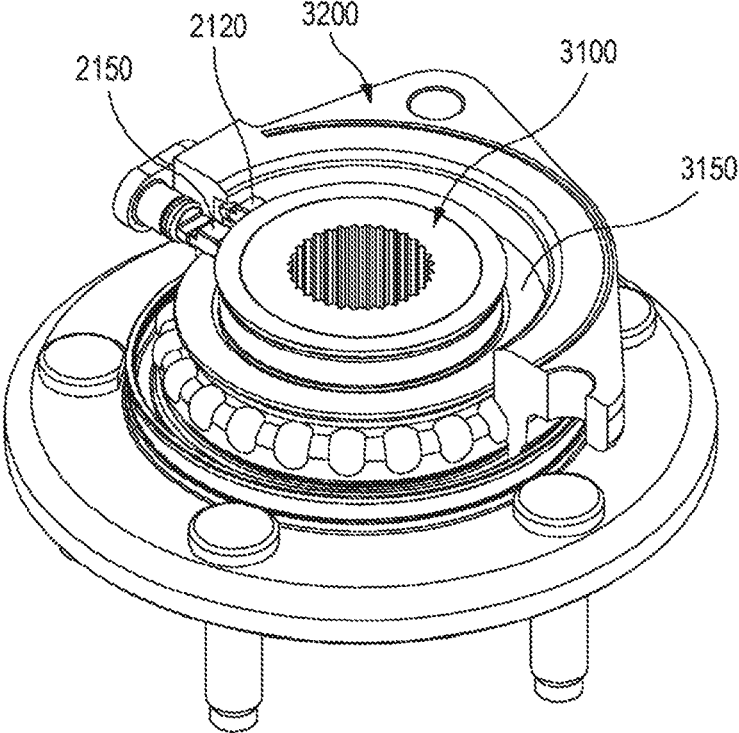


FIG. 4

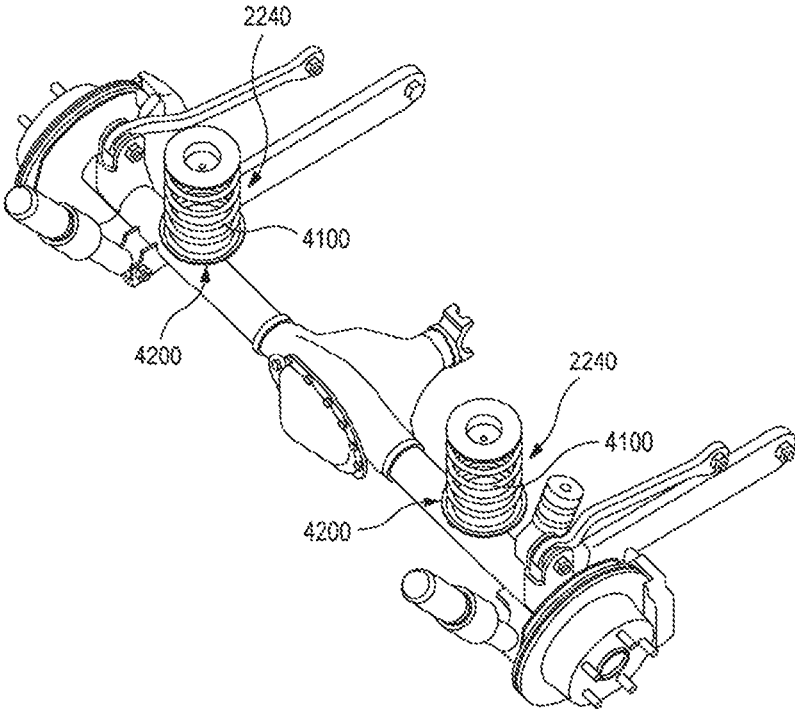


FIG. 5A

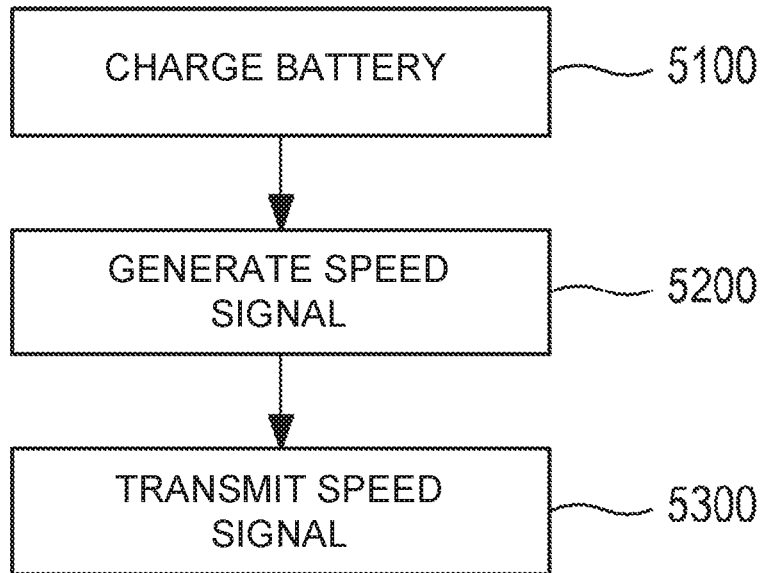


FIG. 5B

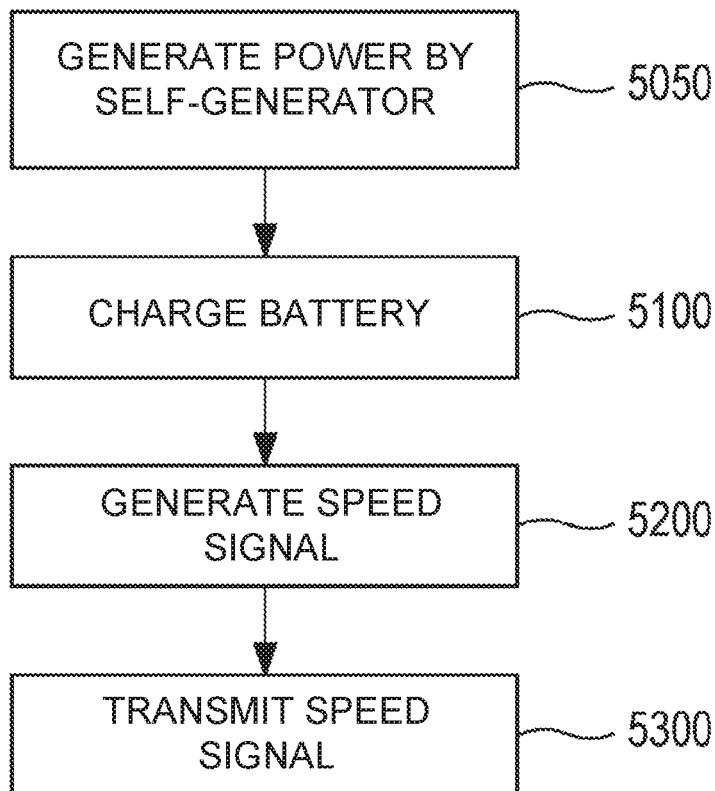


FIG. 6A

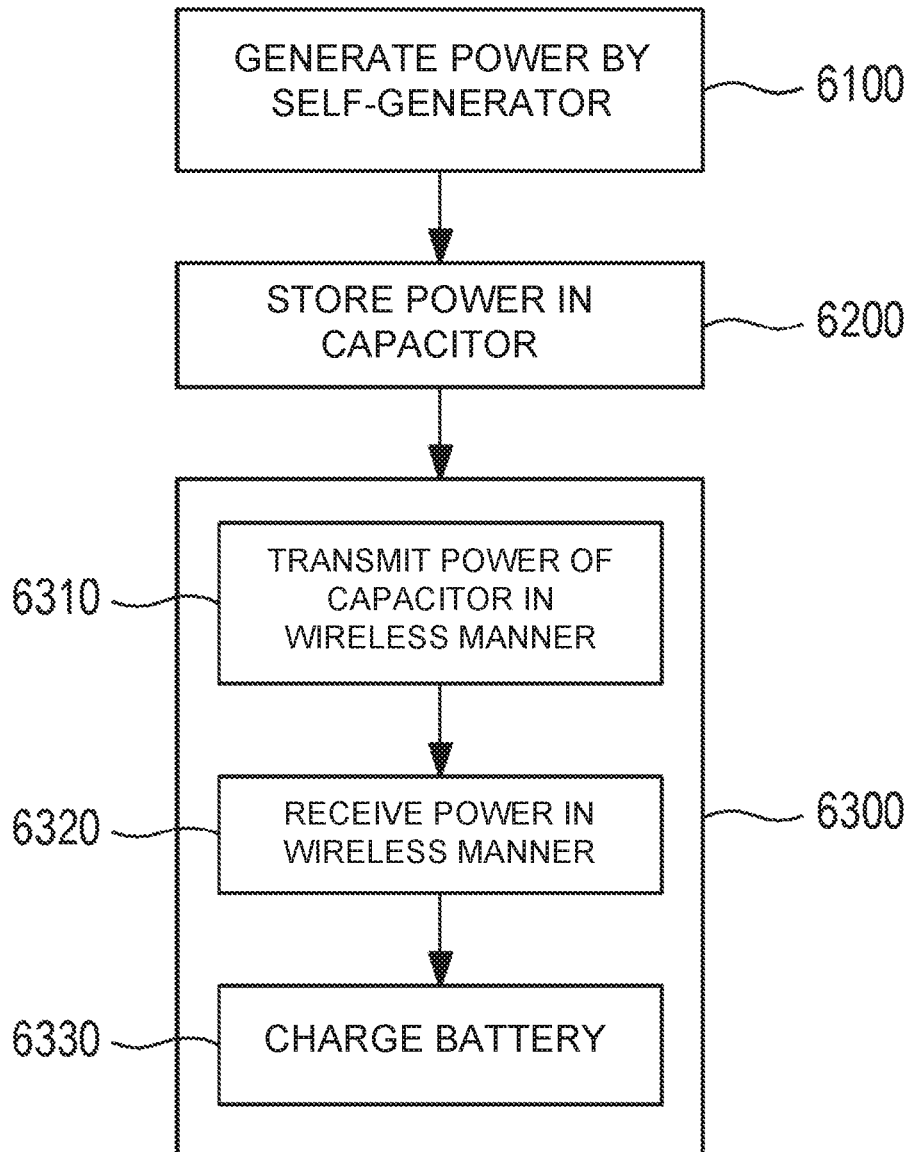


FIG. 6B

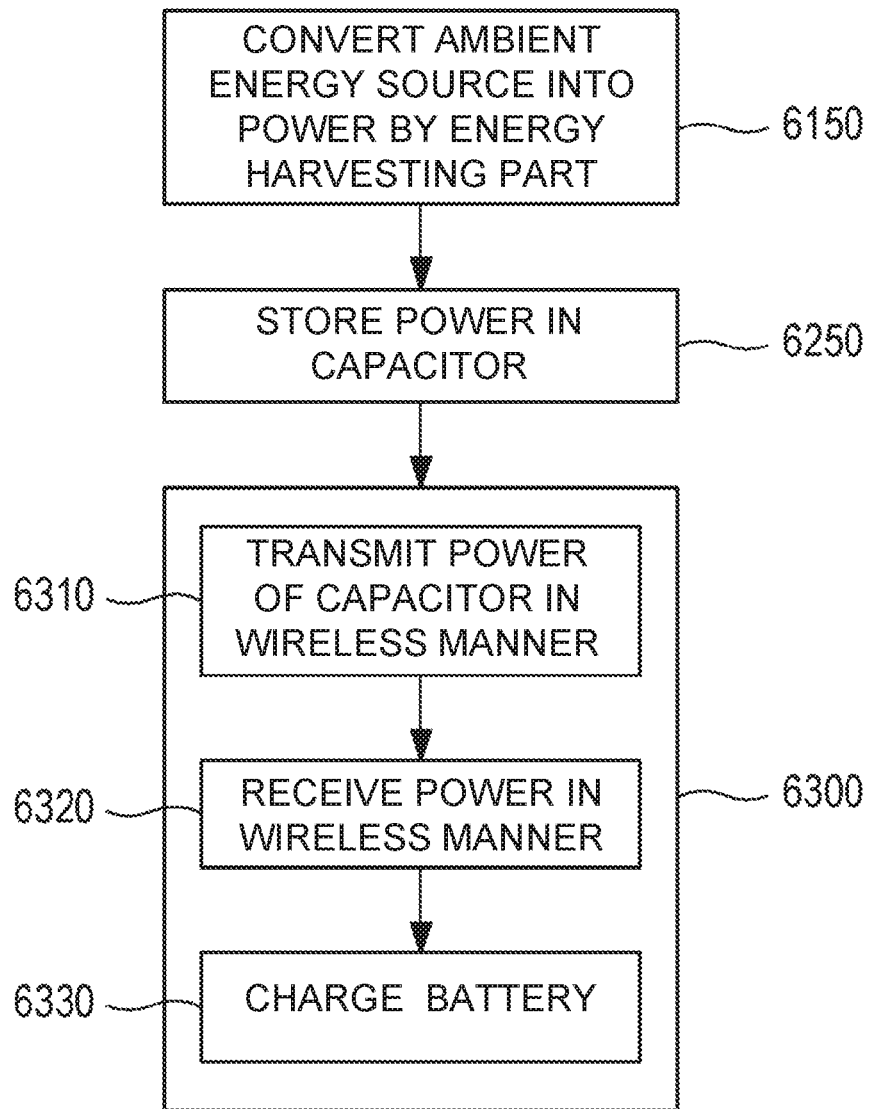


FIG. 7

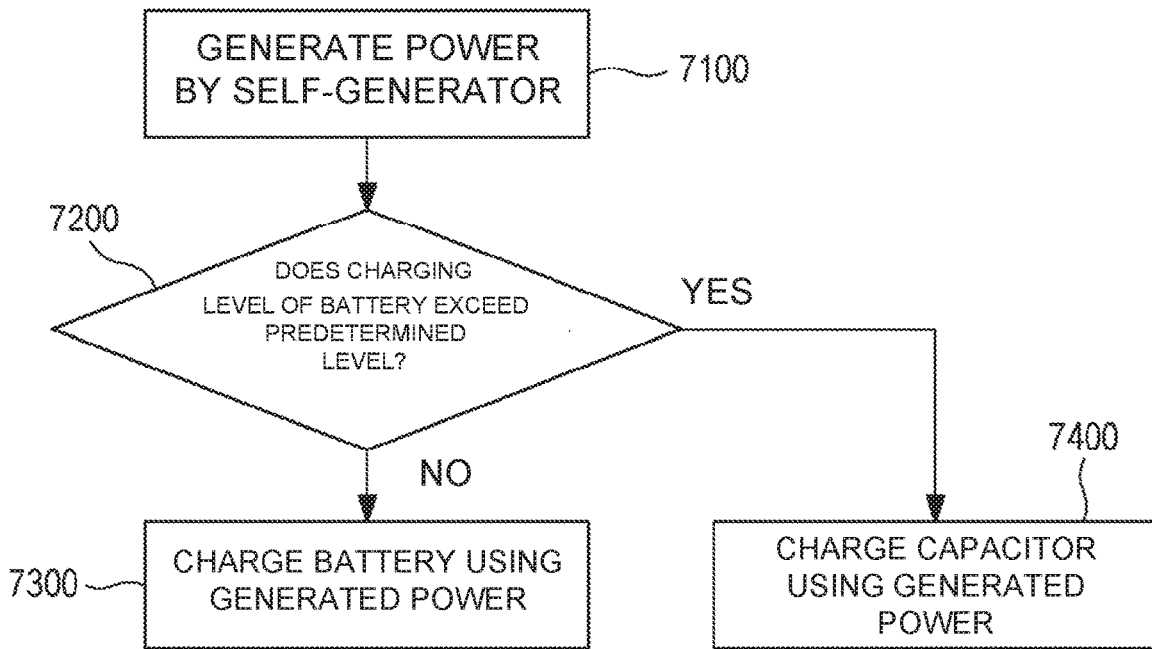
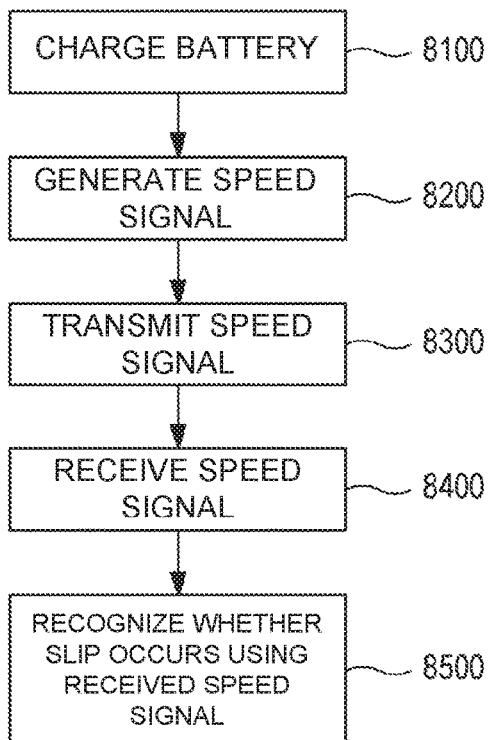


FIG. 8



VEHICLE SPEED SENSOR DEVICE, ABS APPARATUS INCLUDING SAME, AND OPERATING METHOD THEREOF

TECHNICAL FIELD

[0001] The present disclosure relates to a vehicle speed sensor device, an anti-lock brake system (ABS) apparatus including the same and an operating method thereof. Specifically, the present disclosure relates to a speed sensor device located on a vehicle wheel and configured to measure a rotational speed of the wheel and an ABS apparatus configured to detect slip of the wheel using the speed information measured from the speed sensor device and control a braking force of the vehicle.

BACKGROUND ART

[0002] Generally, a speed sensor for measuring a speed of a vehicle is provided in each of tires of the vehicle to measure a rotational speed of the tires. The speed sensor is electrically connected to an electronic control unit (ECU) through a wiring to transmit speed information of each of tires to the ECU in real time. Further, the speed sensor receives power from the ECU through the wiring.

[0003] Furthermore, the ECU controls a braking force of the vehicle using the speed information from the speed sensor. Particularly, in a situation that a road surface is slippery or sudden braking is performed, the ECU controls the braking force of the vehicle using the speed information received in real time to prevent a lock-up phenomenon that a wheel is stopped by the braking force before the vehicle is stopped and a vehicle body slips. Such a system is called an anti-lock brake system (ABS).

DISCLOSURE

Technical Problem

[0004] A conventional speed sensor is electrically connected to an electronic control unit (ECU) via a wired connection (wiring). However, such a wired connection has problems as described below.

[0005] A first problem is vulnerability to external damage. In most vehicle designs, wired connection cables connecting a speed sensor to an ECU are located between a vehicle body structure and a wheel bearing at a vehicle floor in a state of being exposed to the outside without a separate housing. Consequently, the wired connection cable is vulnerable to damage due to external factors such as obstacles including stones on a road, irregularities on the road, and the like, and natural aging due to exposure to an external environment. When the wired connection cable is damaged, a supply of power to the speed sensor of the tire may be interrupted or the speed sensor may not be able to smoothly transmit a speed signal to the ECU. Accordingly, an error may occur in an entire operation of an anti-lock brake system (ABS) and safety of a driver may be threatened.

[0006] A second problem is possibility of signal crosstalk between wired connection cables. In addition to wired connection cables for the ABS, various cables are used in the vehicle and complicatedly connected to each other. Recently, installation of sensor products increases according to the advancement of the vehicle so that installation of wired connection cables is also increasing. When the signal crosstalk occurs between the wired connection cables, the

speed sensor may not be able to smoothly transmit the speed signal to the ECU. Accordingly, an error may occur in the entire operation of the ABS and the safety of the driver may also be threatened.

[0007] A third problem is weight of the wired connection cables. In light of the industry reality that weight reduction of the vehicle is required in conjunction with an energy consumption issue, it is necessary to reduce weight of the wired connection cables for connecting the speed sensors provided on the tires to the ECU.

[0008] Therefore, the present disclosure is directed to providing a vehicle speed sensor device, an ABS apparatus including the same, and an operating method thereof, which are capable of solving the above-described problems of a wired connection (i.e., vulnerability to external damage and probability of signal crosstalk) and reducing weight of a vehicle, by connecting the vehicle speed sensor device to an ECU to be communicatable in a wireless manner and transmitting a speed signal through the wireless communication.

Technical Solution

[0009] According to one embodiment of the present disclosure, a vehicle speed sensor device may be provided. The vehicle speed sensor device according to one embodiment of the present disclosure may comprise a rechargeable battery; a speed sensor configured to receive power from the battery measure a rotational speed of a wheel bearing to generate a speed signal; and a wireless signal transmitter configured to transmit the speed signal to an electronic controller through wireless communication.

[0010] According to one embodiment of the present disclosure, a transmission period of the speed signal may be 50 μ s or less.

[0011] According to one embodiment of the present disclosure, the vehicle speed sensor device may further comprise a self-generator configured to be able to generate power from rotation of the wheel bearing and charge the battery using the generated power.

[0012] According to one embodiment of the present disclosure, the vehicle speed sensor device may further comprise an external power supply module configured to supply the power to the battery.

[0013] According to one embodiment of the present disclosure, the external power supply module may comprise a capacitor capable of storing the power generated by the self-generator and the capacitor may be configured to charge the battery when an output current of the self-generator is less than or equal to a predetermined value.

[0014] According to one embodiment of the present disclosure, the external power supply module may further comprise a first wireless power transceiver connected to the capacitor and configured to transmit the power of the capacitor in a wireless manner, and the vehicle speed sensor device may further comprise a second wireless power transceiver configured to receive the power from the first wireless power transceiver provided in the external power supply module in a wireless manner and charge the battery using the received power.

[0015] According to one embodiment of the present disclosure, the self-generator may be configured to charge the battery using the generated power when a charging level of the battery is less than or equal to a predetermined level and

charge the capacitor using the generated power when the charging level of the battery exceeds the predetermined level.

[0016] According to one embodiment of the present disclosure, the external power supply module may comprise one or more energy harvesting parts configured to convert an ambient energy source into power and store the converted power in the capacitor.

[0017] According to one embodiment of the present disclosure, the energy harvesting part may comprise a piezoelectric element installed at a suspension and configured to generate power from a displacement of the suspension.

[0018] According to one embodiment of the present disclosure, the energy harvesting parts may comprise a photovoltaic element installed on an outer surface of the vehicle and configured to generate power from sunlight.

[0019] According to one embodiment of the present disclosure, an anti-lock brake system (ABS) apparatus may be provided. The ABS apparatus according to one embodiment of the present disclosure may comprise the above-described vehicle speed sensor device and the electronic controller, wherein the electronic controller may recognize whether slip of a vehicle occurs using the speed signal transmitted from the wireless signal transmitter of the vehicle speed sensor device through wireless communication and control a braking force of the vehicle based on whether the slip occurs.

[0020] According to one embodiment of the present disclosure, an operating method of a vehicle speed sensor device may be provided. The operating method according to one embodiment of the present disclosure may comprise charging a rechargeable battery; measuring a rotational speed of a wheel bearing via a speed sensor receiving power supplied from the battery and then generating a speed signal; and transmitting the speed signal to an electronic controller via a wireless signal transmitter through wireless communication.

[0021] According to one embodiment of the present disclosure, a transmission period of the speed signal may be 50 μ s or less.

[0022] According to one embodiment of the present disclosure, the operating method may further comprise generating power from rotation of the wheel bearing through a self-generator; and charging the battery using the power.

[0023] According to one embodiment of the present disclosure, the operating method may further comprise supplying the power to the battery through an external power supply module.

[0024] According to one embodiment of the present disclosure, the operating method may further comprise storing the power generated by the self-generator in a capacitor provided in the external power supply module; and charging the battery by the capacitor when an output current of the self-generator is less than or equal to a predetermined value.

[0025] According to one embodiment of the present disclosure, charging the battery by the capacitor comprises transmitting the power of the capacitor in a wireless manner by a first wireless power transceiver connected to the capacitor and provided in the external power supply module; receiving the power from the first wireless power transceiver in a wireless manner by a second wireless power transceiver; and charging the battery using the received power.

[0026] According to one embodiment of the present disclosure, the operating method may further comprise charging the battery using the power generated by the self-

generator when a charging level of the battery is less than or equal to a predetermined level; and charging the capacitor using the power generated by the self-generator when the charging level of the battery exceeds the predetermined level.

[0027] According to one embodiment of the present disclosure, the operating method may further comprise converting an ambient energy source into power by one or more energy harvesting parts provided in the external power supply module and storing the converted power in the capacitor.

[0028] According to one embodiment of the present disclosure, converting of the ambient energy source into power by one or more energy harvesting and storing the converted power in the capacitor comprises generating power from a displacement of the suspension by a piezoelectric element installed at a suspension; and storing the generated power in the capacitor.

[0029] According to one embodiment of the present disclosure, converting of the ambient energy source into power by one or more energy harvesting and storing the converted power in the capacitor comprises generating power from sunlight by a photovoltaic element installed on an outer surface of a vehicle; and storing the generated power in the capacitor.

[0030] According to one embodiment of the present disclosure, an operating method of an anti-lock brake system (ABS) apparatus having the operations of the above-described operating method of a vehicle speed sensor device. According to one embodiment of the present disclosure, the ABS apparatus may comprise an electronic controller and the operating method for the ABS apparatus may comprise recognizing whether slip of a vehicle using the speed signal transmitted from the wireless signal transmitter of the vehicle speed sensor device through wireless communication; and controlling a braking force of the vehicle based on whether the slip occurs.

Advantageous Effects

[0031] In a vehicle speed sensor device according to one embodiment of the present disclosure, wireless communication is employed for transmitting a speed signal to an electronic controller such that vulnerability to external damage and signal crosstalk due to a complicated cable connection, which are problems of a conventional wired connection, can be solved and a weight of a vehicle can be reduced.

[0032] Further, power can be stably supplied to the vehicle speed sensor device not only which is important for vehicle safety but also which requires high power, and power can be optionally stored for driving any other electronic component in the vehicle.

[0033] Furthermore, the vehicle speed sensor device according to one embodiment of the present disclosure can utilize extra energy, which is not effectively used in each of parts of the vehicle, as electric power.

DESCRIPTION OF DRAWINGS

[0034] FIG. 1 is a schematic diagram of an anti-lock brake system (ABS) apparatus according to one embodiment of the present disclosure.

[0035] FIG. 2 is a block diagram of the ABS apparatus according to one embodiment of the present disclosure.

[0036] FIG. 3 is a perspective view illustrating a position of each component of a vehicle speed sensor device according to one embodiment of the present disclosure in a vehicle wheel.

[0037] FIG. 4 is a schematic diagram of a suspension comprising energy harvesting parts with a piezoelectric element according to one embodiment of the present disclosure.

[0038] FIG. 5A is a flowchart illustrating an operating method of a vehicle speed sensor device according to one embodiment of the present disclosure.

[0039] FIG. 5B is a flowchart illustrating an operating method of a vehicle speed sensor device according to one embodiment of the present disclosure.

[0040] FIG. 6A is a flowchart illustrating an operating method of a vehicle speed sensor device according to one embodiment of the present disclosure.

[0041] FIG. 6B is a flowchart illustrating an operating method of a vehicle speed sensor device according to one embodiment of the present disclosure.

[0042] FIG. 7 is a flowchart illustrating a charging operation performed by a self-generator according to one embodiment of the present disclosure.

[0043] FIG. 8 is a flowchart illustrating an operating method of an ABS apparatus according to one embodiment of the present disclosure.

[0044] [Modes of the Invention]

[0045] Embodiments of the present disclosure are exemplified for the purpose of describing the technical spirit of the present disclosure. The scope of the claims according to the present disclosure is not limited to the embodiments described below or to the detailed descriptions on these embodiments.

[0046] Unless otherwise defined, all technical and scientific terms used herein have the same meaning commonly understood by those skilled in the art to which the present disclosure pertains. All terms used herein are selected for the purpose of more clearly describing the present disclosure and not limiting the scope of the present disclosure defined by appended claims.

[0047] Unless the phrase or sentence clearly indicates otherwise, terms “comprising,” “including,” “having,” “taking,” and the like used herein should be construed as open-ended terms encompassing the possibility of including other embodiments.

[0048] The singular form described herein may include the plural form unless the context clearly dictates otherwise, and this is equally applied to the singular form set forth in the claims.

[0049] Terms a “first,” a “second,” and the like are used to distinguish a plurality of components, and the order or importance of corresponding components is not limited by these terms.

[0050] The term a “module” or “part” used herein refers to software or a hardware component such as a field-programmable gate array (FPGA), an application specific integrated circuit (ASIC), or the like. However, the “module” or “part” is not limited to hardware and software. The “module” or “part” may be configured to reside on an addressable storage medium or may be configured to playback one or more processors. Accordingly, for example, the “module” or “part” includes components, such as software components, object oriented software components, class components, and task components, processes, functions, attributes, proce-

dures, subroutines, segments of a program code, drivers, firmwares, microcodes, circuits, data, databases, data structures, tables, arrays, and variables. The components and functions provided in the “module” or “part” may be combined to a smaller number of components and the “module” or “part,” or may be further divided into additional components and an additional “module” or “part.”

[0051] In this disclosure, the expression “based on” or “due to” is used to describe one or more factors affecting an action or an operation of a decision or a determination, which are described in a phrase or sentence in which the expression is contained, and such a expression does not exclude additional factors affecting the action or the operation of the decision or the determination.

[0052] Throughout this disclosure, when a component is referred to as being “connected” or “coupled” to another component, the component can be directly connected or coupled to another component or can be indirectly connected or coupled to another component by intervening yet another component therebetween.

[0053] Hereinafter, exemplary embodiments of the present disclosure will be described in detail with reference to the accompanying drawings.

[0054] FIG. 1 is a schematic diagram of an anti-lock brake system (ABS) apparatus 1100 installed in a vehicle 1000 according to one embodiment of the present disclosure. The ABS apparatus 1100 comprises a vehicle speed sensor device 1200, an electronic controller 1310, and a wireless signal receiver 1320. In one embodiment of the present disclosure, the vehicle speed sensor device 1200 is located on each of wheels. Although the vehicle speed sensor device 1200 has been shown as being provided on all four wheels of the vehicle in FIG. 1, the vehicle speed sensor device 1200 may be provided on only two front or rear wheels of the vehicle 1000 or on only one of the four wheels thereof.

[0055] The vehicle speed sensor device 1200 measures the rotational speed of the wheel to generate a speed signal and transmits the generated speed signal to the wireless signal receiver 1320 through wireless communication. The wireless signal receiver 1320 receives the speed signal of each of wheels, and the received speed signal is used to control the vehicle 1000 (e.g., control of a braking force of the vehicle) by the electronic controller 1310.

[0056] FIG. 2 is a block diagram of the ABS apparatus 1100 according to one embodiment of the present disclosure. According to one embodiment of the present disclosure, the vehicle speed sensor device 1200 comprises a sensing module 2100 and an external power supply module 2200. The sensing module 2100 may comprise a battery 2110, a speed sensor 2120, a wireless signal transmitter 2130, a second wireless power transceiver 2140, and a self-generator 2150. The external power supply module 2200 may comprise a capacitor 2220, a first wireless power transceiver 2230, and an energy harvesting part 2240. Further, the vehicle speed sensor device 1200 may communicate with the wireless signal receiver 1320 in the vehicle 1000 through the wireless signal transmitter 2130, and a signal received by the wireless signal receiver 1320 may be transmitted to the electronic controller 1310 so as to control the vehicle 1000.

[0057] The battery 2110 is a component for supplying power to a speed sensor 2120 and may be a rechargeable battery (e.g., a lithium ion battery). The speed sensor 2120 is configured to measure a rotational speed of a wheel bearing and generate a speed signal based on the measured

rotational speed. For example, the speed sensor 2120 may comprise a Hall integrated circuit (IC) having a Hall element or the like. The Hall element may be made of InSb, GaAs, or the like. The wireless signal transmitter 2130 is configured to transmit the speed signal generated by the speed sensor 2120 to the electronic controller 1310 through wireless communication. According to one embodiment of the present disclosure, the speed signal is transmitted to the electronic controller 1310 via the wireless signal receiver 1320.

[0058] A transmission period for transmitting the speed signal to the electronic controller 1310 via wireless communication may be designed differently as necessary. However, since rotational speed information of the wheel is important for controlling the vehicle, particularly, for controlling the ABS apparatus 1100 directly connected to safety of a driver, the transmission period is usually short. For example, as compared with a case in which a different kind of vehicle information signal is transmitted, such as a case in which an air pressure in a wheel is monitored and air pressure information is provided (a tire pressure sensor), a transmission period of a signal may be relatively shorter. Ideally, a signal may be transmitted in real time. Alternatively, a transmission period of a speed signal may be designed to be 50 μ s or less, more preferably, 10 μ s or less in practical applications.

[0059] Power consumption of the speed sensor 2120 is relatively larger than that of other sensors (e.g., the tire pressure sensor) since a period for which a speed signal is sensed and then transmitted to the electronic controller 1310 is required to be shorter in order for a proper operation of the ABS apparatus 1100. Further, it is an important requirement to stably supply power to the speed sensor 2120 since an operation of the speed sensor 2120 is directly connected to stable control of the vehicle and further to the safety of the driver, as described above.

[0060] According to one embodiment of the present disclosure, the vehicle speed sensor device 1200 is not electrically connected to the electronic controller 1310 through a wired connection (wiring). The vehicle speed sensor device 1200 communicates with the electronic controller 1310 in a wireless manner and comprises a component for stably supplying power to the speed sensor 2120 therein. This will be described in more detail below.

[0061] The sensing module 2100 comprises the battery 2110 connected to the speed sensor 2120, and the battery 2110 may be a rechargeable battery. When a charging level of the battery 2110 is low, the battery 2110 is recharged. That is, the battery 2110 is maintained at a predetermined charging level or higher, and thus power may be stably supplied to the speed sensor 2120.

[0062] The sensing module 2100 may comprise the self-generator 2150 as a component for charging the battery 2110. The self-generator 2150 generates power due to rotation of the wheel bearing and charges the battery 2110 using the generated power. According to one embodiment of the present disclosure, the self-generator 2150 is wired connected to the battery 2110.

[0063] The external power supply module 2200 may comprise a capacitor 2220 as a component for storing the power generated by the self-generator 2150. For example, according to one embodiment of the present disclosure, the capacitor 2220 may be installed on each of wheels and may be wired connected to the self-generator 2150 of a correspond-

ing wheel. Alternatively, the number of capacitors 2220 provided in the vehicle 1000 may be less than the number of wheels, and one or more capacitors 2220 may be configured to be connected to a plurality of self-generators 2150. Further, the capacitor 2220 may be configured to supply power not only to the vehicle speed sensor device 1200 according to the present disclosure but also to other electronic components of the vehicle 1000.

[0064] As shown in FIG. 2, according to one embodiment of the present disclosure, the capacitor 2220 may be configured to charge the battery 2110 when an output current of the self-generator 2150 is less than or equal to a predetermined value. Since the self-generator 2150 generates power due to rotation of the wheel bearing, the self-generator 2150 may not be able to supply sufficient power to the battery 2110 when a rotation speed of the wheel is low. However, if the capacitor 2220 is configured to charge the battery 2110 when the output current of the self-generator 2150 is less than or equal to a predetermined value, power supplied from the capacitor 2220 to the battery 2110 may act to “wake-up” the speed sensor 2120. For example, when the vehicle 1000 is driven after not driven for a long time, a charging level of the battery 2110 may be low. In this case, when the vehicle 1000 is driven at a low speed, an amount of power supplied from the self-generator 2150 may be insufficient for driving the speed sensor 2120. At this point, the capacitor 2220 may supply power to the speed sensor 2120 through the battery 2110, i.e., the capacitor 2220 may wake-up the speed sensor 2120. Accordingly, even when the output current of the self-generator 2150 is low, the speed sensor 2120 may be operated while receiving the power stably.

[0065] According to one embodiment of the present disclosure, charging of the battery 2110 by the capacitor 2220 of the external power supply module 2200 may be performed using the first wireless power transceiver 2230 and the second wireless power transceiver 2140. For example, the first wireless power transceiver 2230 and the second wireless power transceiver 2140 are each formed of a coil such that power may be transmitted in a wireless manner by a magnetic induction method or a magnetic resonance method. In addition to a case in which the first wireless power transceiver 2230 charges the second wireless power transceiver 2140, it is also possible for the second wireless power transceiver 2140 to transmit power to the first wireless power transceiver 2230 as necessary.

[0066] According to one embodiment of the present disclosure, when the vehicle speed sensor device 1200 comprises all of the self-generator 2150, the capacitor 2220, and the battery 2110, the self-generator 2150 may be connected to each of the capacitor 2220 and the battery 2110. Accordingly, the vehicle speed sensor device 1200 may be configured to determine whether power generated by the self-generator 2150 is used for charging the capacitor 2220 or is used for charging the battery 2110 based on a predetermined criterion. In this case, the battery 2110 may comprise a configuration for transmitting information on a charging level of the battery 2110 to the self-generator 2150, and the self-generator 2150 may comprise a configuration for receiving the information on the charging level of the battery 2110 therefrom. For example, the self-generator 2150 may be configured to charge the battery 2110 using the generated power when the charging level of the battery 2110 is less than or equal to a predetermined level (e.g., a predetermined current value or voltage value), whereas the self-generator

2150 may be configured to charge the capacitor **2220** using the generated power when the charging level exceeds the predetermined level. In this case, the self-generator **2150** may be configured to primarily charge the battery **2110** since power consumption of the speed sensor **2120** is relatively large as described above, and then configured to charge the capacitor **2220** when the charging level of the battery **2110** exceeds the predetermined level so as to prepare for discharging of the battery **2110** or to store power for driving any other electronic components in the vehicle **1000** in a case that the capacitor **2220** also supplies power to other electronic components of the vehicle **1000**.

[**0067**] The predetermined level may be differently designed in consideration of a relationship between components. According to one embodiment of the present disclosure, when the capacitor **2220** also supplies power to other electronic components of the vehicle **1000**, the predetermined level may be designed to be low so that the capacitor **2220** stably supplies the power to the other electronic components, since power consumption of other electronic components in the vehicle **1000** may be large. Alternatively, when the power consumption of the speed sensor **2120** is large and thus consumption of the battery **2110** is expected to be relatively fast becoming, the predetermined level may be designed to be high to increase power supply stability to the speed sensor **2120**.

[**0068**] The external power supply module **2200** may further comprise one or more energy harvesting parts **2240** as components for converting an ambient energy source into power and storing the power in the capacitor **2220**. The one or more energy harvesting parts **2240** may utilize an ambient energy source to contribute to enhancement of power supply stability for the speed sensor **2120**. Further, when the capacitor **2220** is configured to also supply power to other electronic components of the vehicle **1000**, the energy harvesting parts **2240** may be used to reserve power for driving any other electronic components in the vehicle **1000**.

[**0069**] According to one embodiment of the present disclosure, the energy harvesting part **2240** may comprise a piezoelectric element installed at a suspension and configured to generate power from a displacement of the suspension. This energy harvesting part **2240** will be described in more detail below with reference to FIG. 4. Alternatively, the energy harvesting part **2240** may comprise a photovoltaic element installed on an outer surface of the vehicle **1000**. The photovoltaic element may be installed on a part or entirety of the outer surface of the vehicle **1000** and may generate power from the sunlight to charge the capacitor **2220**.

[**0070**] The wireless signal receiver **1320** is configured to receive a speed signal transmitted from the wireless signal transmitter **2130** of the sensing module **2100** through wireless communication. According to one embodiment of the present disclosure, the wireless signal receiver **1320** may use a low frequency (LF) signal, monitor a timing of signal transmission in real time, and receive a signal from each of the wheels without crosstalk using an identification (ID) assigned to each of the wheels. For example, a wireless frequency (RF) of a 2.4 GHz band, an 800 MHz band, a 400 MHz band, or the like may be used as a transmission frequency, and the transmission frequency may be differently applied according to a policy of each country. In order to avoid disturbance of a signal, which is transmitted from each of the wheels, due to an external ambient signal, a

technique such as a physical unclonable function (PUF) may be used. The received speed signal is transmitted to the electronic controller **1310**, and the electronic controller **1310** is configured to recognize whether slip of the vehicle **1000** occurs using the speed signal received from each of the wheels, and then control or adjust a braking force of the vehicle **1000** based on the recognition result.

[**0071**] FIG. 3 is a schematic diagram illustrating a position of each component of a vehicle speed sensor device according to one embodiment of the present disclosure in a vehicle wheel. According to one embodiment of the present disclosure, the wheel comprises a rotating member **3100** which is rotated during driving, and a fixed member **3200** which is fixed during driving. The speed sensor **2120** and the self-generator **2150** may be provided on the fixed member **3200** of the wheel. The rotating member **3100** comprises an encoder **3150** of forming a magnetic field required for power generation of the self-generator **2150**. For example, the encoder **3150** may comprise a magnetized rubber magnet in which N and S poles are alternatively formed. When a wheel bearing is rotated, the encoder **3150** is rotated and the speed sensor **2120** and the self-generator **2150** are fixed. The speed sensor **2120** detects a speed from variation in magnetic field formed by the encoder **3150**. According to one embodiment of the present disclosure, the self-generator **2150** comprises a coil, and a magnetic field formed by the encoder **3150** passes through a cross section of the coil. The variation in magnetic field formed by the encoder **3150** generates a potential difference proportional to a differential value with respect to time of a magnetic flux passing through the cross section of the coil at both ends of the coil due to electromagnetic induction. Alternatively, a tone wheel may be used instead of the encoder **3150**.

[**0072**] FIG. 4 is a schematic diagram of a suspension comprising the energy harvesting part **2240** with a piezoelectric element **4200** according to one embodiment of the present disclosure. According to one embodiment of the present disclosure, the energy harvesting part **2240** comprises the piezoelectric element **4200**. A spring **4100** is provided on the suspension so as to prevent impact from a road surface from being transmitted to the vehicle body. The spring **4100** repeats contraction and stretching and prevents the impact generated from the road surface from being directly transmitted to the vehicle body. The piezoelectric element **4200** is located at one or more of upper and lower portions of the spring **4100** to receive a displacement of the suspension, i.e., a mechanical pressure due to a load and a repulsive force which are generated by elastic deformation of the spring **4100**. The potential difference is generated as polarizability of molecules constituting the piezoelectric element **4200** is varied due to the mechanical pressure. The piezoelectric element **4200** may be connected to the capacitor **2220** to charge the capacitor **2220** using the generated power.

[**0073**] Although not shown in FIG. 4, a design of the energy harvesting part may be diversified in addition to the configuration shown in FIG. 4. In any case, a displacement of an elastic body may occur as long as the suspension acts to alleviate transmission of the impact from the road surface using an elastic force acting due to the displacement of the elastic body. The piezoelectric element is coupled to the elastic body such that a mechanical force is also applied to

the piezoelectric element, and the piezoelectric element may be configured to self-generate power based on such a mechanical force.

[0074] FIG. 5A is a flowchart illustrating an operating method of the vehicle speed sensor device 1200 according to one embodiment of the present disclosure. In the step 5100, the battery 2110 of the vehicle speed sensor device 1200 is charged. The battery 2110 may be a rechargeable battery, e.g., a lithium ion battery. Optionally, the step 5100 may comprise a step of supplying power to the battery 2110 through the external power supply module 2200. In the step S200, a speed signal including rotational speed data is generated. A rotational speed of the wheel bearing is measured by the speed sensor 2120 receiving power supplied from the battery 2110, and then the speed signal may be generated based on the measured rotational speed of the wheel bearing. For example, the speed sensor 2120 may comprise a Hall IC having a Hall element. In the step S300, the generated speed signal is transmitted to the electronic controller 1310 by the wireless signal transmitter 2130 through wireless communication.

[0075] A transmission period for transmitting the speed signal to the electronic controller 1310 through wireless communication may be differently designed as necessary. For example, the transmission period of the speed signal may be designed to be 50 μ s or less. Further, since a stable supply of power to the speed sensor 2120 and stable transmission of the speed signal are important requirements relating to safety of the vehicle 1000 or a user, the step 5100 may be employed for stably supplying the power to the speed sensor 2120.

[0076] FIG. 5B is a flowchart illustrating the operating method of the vehicle speed sensor device 1200 according to one embodiment of the present disclosure. The operating method of the vehicle speed sensor device 1200 according to this embodiment of the present disclosure further comprises the step S050 in the operating method of the vehicle speed sensor device 1200 described with reference to FIG. 5A. In the step 5050, the power is generated by the self-generator 2150. The self-generator 2150 is included in the sensing module 2100 and generates power due to the rotation of the wheel bearing. A coupling relationship of the self-generator 2150 in the wheel is the same as that described above with reference to FIG. 3. Descriptions on the steps 5100, 5200, and 5300 are the same as those described with reference to FIG. 5A, and thus duplicate descriptions thereof will be omitted.

[0077] FIG. 6A is a flowchart illustrating an operating method of the vehicle speed sensor device 1200 according to one embodiment of the present disclosure. In the step 6100, power is generated by the self-generator 2150. In the step 6200, the power generated by the self-generator 2150 is stored in the capacitor 2220 included in the external power supply module 2200. The self-generator 2150 may be wired connected to the capacitor 2220. For example, the capacitor 2220 may be installed on each of the wheels and may be connected to the self-generator 2150 of a corresponding wheel. Alternatively, the number of capacitors 2220 provided in the vehicle 1000 may be less than the number of wheels, and one or more capacitors 2220 may be configured to be connected to a plurality of self-generators 2150. In one embodiment of the present disclosure, the capacitor 2220 may be configured to supply power not only to the vehicle

speed sensor device 1200 according to the present disclosure but also to other electronic components of the vehicle 1000.

[0078] In the step 6300, the battery 2110 is charged using the power stored in the capacitor 2220. According to one embodiment of the present disclosure, when an output current of the self-generator 2150 is less than or equal to a predetermined value, the battery 2110 may be charged. In this case, even when the output current of the self-generator 2150 is low, the battery 2110 may be charged using the power stored in the capacitor 2220 so that the capacitor 2220 acts to “wake-up” the speed sensor 2120. Consequently, the speed sensor 2120 may stably receive the power.

[0079] Specifically, the step 6300 comprises the step 6310, the step 6320, and the step 6330. In the step 6310, the first wireless power transceiver 2230 included in the external power supply module 2200 transmits the power stored in the capacitor 2220 in a wireless manner. In the step 6320, the second wireless power transceiver 2140 receives the power transmitted in the step 6310. In the step 6330, the second wireless power transceiver 2140 charges the battery 2110 using the power received in the step 6320. For example, the wireless power transmission and reception in the steps 6310 and 6320 may be performed through a magnetic induction method or a magnetic resonance method.

[0080] FIG. 6B is a flowchart illustrating the operating method of the vehicle speed sensor device 1200 according to one embodiment of the present disclosure. In the step 6150, the energy harvesting part 2240 converts an ambient energy source into power. The energy harvesting part 2240 is a configuration included in the external power supply module 2200. The power converted by the energy harvesting part 2240 in the step 6150 is stored in the capacitor 2220 in the step 6250. The power converted by the energy harvesting part 2240 is stored in the capacitor 2220 so that the capacitor 2220 may contribute to enhancement of power supply stability to the speed sensor 2120. When the capacitor 2220 also supplies the power to other electronic components of the vehicle 1000, the capacitor 2220 may be used to reserve power for driving any other electronic component in the vehicle 1000. Descriptions of the step 6300 and the steps 6310, 6320, and 6330 included in the step 6300 are the same as those described with reference to FIG. 6A, and thus duplicate descriptions thereof will be omitted.

[0081] In one embodiment of the present disclosure, the step 6150 may comprise a step of generating power from a mechanical pressure according to the variation in displacement of the suspension by the piezoelectric element 4200 installed at the suspension. In the step 6150, a mechanical force is applied to the piezoelectric element 4200 from the mechanical pressure according to the variation in displacement of the suspension, and polarizability of molecules constituting the piezoelectric element 4200 is varied due to the mechanical force such that a potential difference occurs. Alternatively, the step 6150 may comprise a step of generating power from the sunlight through a photovoltaic element installed on the outer surface of the vehicle 1000.

[0082] FIG. 7 is a flowchart illustrating a charging operation performed by the self-generator 2150 according to one embodiment of the present disclosure. In the operating method of the vehicle speed sensor device 1200 comprising all of the self-generator 2150, the capacitor 2220, and the battery 2110, a flowchart of an exemplary method of determining whether to use the power generated by the self-generator 2150 to charge the capacitor 2220 or the battery

2110 is illustrated in FIG. 7. In the step **7100**, power is generated by the self-generator **2150**. Then, in the step **7200**, it is determined whether a charging level of the battery **2110** exceeds a predetermined level. When the charging level of the battery **2110** is less than or equal to the predetermined level, the battery **2110** is charged using the generated power in the step **7300**. When the charging level of the battery **2110** exceeds the predetermined level, the capacitor **2220** is charged using the generated power in the step **7400**. As described with reference to FIG. 2, such a determination method is used such that potential degradation in charging level of the battery **2110** may be prepared or power for driving any other electronic components in the vehicle **1000** may be reserved. Further, the predetermined level may be differently designed as necessary, and the example of the predetermined level is the same as that described with reference to FIG. 2, and thus a duplicate description thereof will be omitted.

[0083] FIG. 8 is a flowchart illustrating an operating method of the ABS apparatus **1100** according to one embodiment of the present disclosure. Descriptions of the steps **8100**, **8200**, and **8300** are the same as those of the steps **5100**, **5200**, and **5300** described with reference to FIG. 5A, and thus duplicate descriptions thereof will be omitted. A speed signal transmitted in the step **8300** is received by the wireless signal receiver **1320** in the step **8400**. In the step **8500**, the electronic controller **1310** recognizes whether slip of the vehicle **1000** occurs using the received speed signal.

[0084] Although the above-described methods have been described with reference to the specific embodiments, the above-described methods may also be implemented as a computer-readable code in a computer-readable recording medium. The computer-readable recording medium includes all kinds of recording devices in which data readable by a computer system is stored. Examples of the computer-readable recording medium may comprise a read only memory (ROM), a random access memory (RAM), a compact disc ROM (CD-ROM), a magnetic tape, a floppy disk, an optical data storage device, and the like. The computer-readable recording medium may also be distributed in a computer system connected via a network so that a computer-readable code may be stored and executed in a distributed manner. Further, functional programs, codes, and code segments for implementing the exemplary embodiments may be easily deduced by programmers skilled in the art to which the present disclosure pertains.

[0085] Although the present disclosure has been described herein in conjunction with some exemplary embodiments, it should be noted that various modifications and alterations can be devised by those skilled in the art to which the present disclosure pertains without departing from the spirit and scope of the present disclosure. Further, it should be construed that these modifications and alterations are included within the scope of the appended claims.

What is claimed is:

1. A vehicle speed sensor device, comprising:

a rechargeable battery;

a speed sensor configured to receive power from the battery and measure a rotational speed of a wheel bearing to generate a speed signal; and

a wireless signal transmitter configured to transmit the speed signal to an electronic controller through wireless communication.

2. The vehicle speed sensor device according to claim 1, wherein a transmission period of the speed signal is 50 μ s or less.

3. The vehicle speed sensor device according to claim 1, further comprising:

a self-generator configured to be able to generate power from rotation of the wheel bearing and charge the battery using the generated power.

4. The vehicle speed sensor device according to claim 3, further comprising:

an external power supply module configured to supply power to the battery.

5. The vehicle speed sensor device according to claim 4, wherein:

the external power supply module comprises a capacitor capable of storing the power generated by the self-generator; and

the capacitor is configured to charge the battery when an output current of the self-generator is less than or equal to a predetermined value.

6. The vehicle speed sensor device according to claim 5, wherein:

the external power supply module further comprises a first wireless power transceiver connected to the capacitor and configured to transmit the power of the capacitor in a wireless manner; and

the vehicle speed sensor device further comprises a second wireless power transceiver configured to receive the power from the first wireless power transceiver provided in the external power supply module in a wireless manner and charge the battery using the received power.

7. The vehicle speed sensor device according to claim 5, wherein the self-generator is configured to charge the battery using the generated power when a charging level of the battery is less than or equal to a predetermined level and charge the capacitor using the generated power when the charging level of the battery exceeds the predetermined level.

8. The vehicle speed sensor device according to claim 5, wherein the external power supply module comprises one or more energy harvesting parts configured to convert an ambient energy source into power and store the converted power in the capacitor.

9. The vehicle speed sensor device according to claim 8, wherein the energy harvesting part comprises a piezoelectric element installed at a suspension and configured to generate power from a displacement of the suspension.

10. The vehicle speed sensor device according to claim 8, wherein the energy harvesting part comprises a photovoltaic element installed on an outer surface of the vehicle and configured to generate power from sunlight.

11. An anti-lock brake system (ABS) apparatus having the vehicle speed sensor device according to any one of claims 1 to 10, the ABS apparatus comprising:

the electronic controller,

wherein the electronic controller recognizes whether slip of a vehicle occurs using the speed signal transmitted from the wireless signal transmitter of the vehicle speed sensor device through wireless communication and controls a braking force of the vehicle based on whether the slip occurs.

12. An operating method of a vehicle speed sensor device, comprising:

charging a rechargeable battery;
 measuring a rotational speed of a wheel bearing via a speed sensor receiving power supplied from the battery and then generating a speed signal; and
 transmitting the speed signal to an electronic controller via a wireless signal transmitter through wireless communication.

13. The operating method according to claim **12**, wherein a transmission period of the speed signal is 50 μ s or less.

14. The operating method according to claim **12**, further comprising:
 generating power from rotation of the wheel bearing through a self-generator; and
 charging the battery using the power.

15. The operating method according to claim **14**, further comprising:
 supplying the power to the battery through an external power supply module.

16. The operating method according to claim **15**, further comprising:
 storing the power generated by the self-generator in a capacitor provided in the external power supply module; and
 charging the battery by the capacitor when an output current of the self-generator is less than or equal to a predetermined value.

17. The operating method according to claim **16**, wherein charging the battery by the capacitor comprises:
 transmitting the power of the capacitor in a wireless manner by a first wireless power transceiver connected to the capacitor and provided in the external power supply module;
 receiving the power from the first wireless power transceiver in a wireless manner by a second wireless power transceiver; and
 charging the battery using the received power.

18. The operating method according to claim **16**, further comprising:

charging the battery using the power generated by the self-generator when a charging level of the battery is less than or equal to a predetermined level; and
 charging the capacitor using the power generated by the self-generator when the charging level of the battery exceeds the predetermined level.

19. The operating method according to claim **16**, further comprising:
 converting an ambient energy source into power by one or more energy harvesting parts provided in the external power supply module and storing the converted power in the capacitor.

20. The operating method according to claim **19**, wherein converting of the ambient energy source into power by one or more energy harvesting and storing the converted power in the capacitor comprises:
 generating power from a displacement of the suspension by a piezoelectric element installed at a suspension; and
 storing the generated power in the capacitor.

21. The operating method according to claim **19**, wherein converting of the ambient energy source into power by one or more energy harvesting and storing the converted power in the capacitor comprises:
 generating power from sunlight by a photovoltaic element installed on an outer surface of a vehicle; and
 storing the generated power in the capacitor.

22. An operating method of an anti-lock brake system (ABS) apparatus having the operations of operating method of a vehicle speed sensor device according to any one of claims **12** to **21**, wherein the ABS apparatus comprises an electronic controller, the operating method comprising:
 recognizing whether slip of a vehicle using the speed signal transmitted from the wireless signal transmitter of the vehicle speed sensor device through wireless communication; and
 controlling a braking force of the vehicle based on whether the slip occurs.

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