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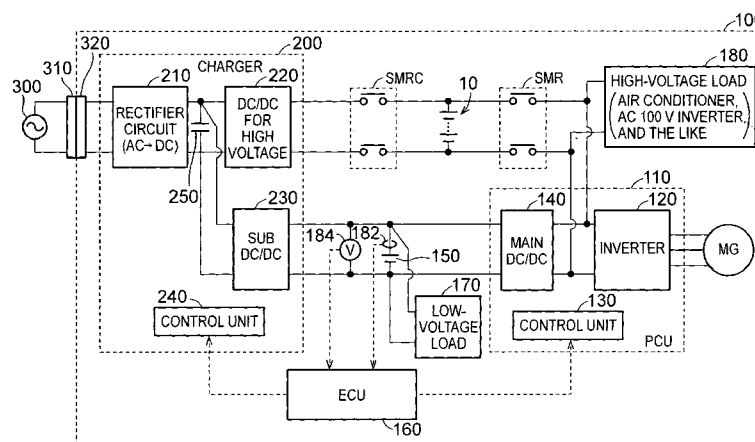
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(54) Title: CHARGING SYSTEM MOUNTED ON VEHICLE

FIG. 1



(57) Abstract: A charging system is mounted on a vehicle. The charging system includes an electric power receiving section, a main battery, an auxiliary battery, a main DC/DC converter, a sub DC/DC converter and an electronic control unit. The electronic control unit is configured to start the main DC/DC converter and perform charging of the auxiliary battery when following conditions i) to iii) are satisfied: i) the main battery is charged from outside the vehicle through the electric power receiving section; ii) the auxiliary battery is charged by the sub DC/DC converter; and iii) the electronic control unit detects a vehicle situation that causes a remaining capacity of the auxiliary battery to decrease.

CHARGING SYSTEM MOUNTED ON VEHICLE

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

[0001] The invention relates to a charging system mounted on a vehicle and, more particularly, to a charging system allowing a main battery and an auxiliary battery to be charged by using an electric power supply outside the vehicle.

10 2. Description of Related Art

[0002] Electric vehicle and plug-in hybrid vehicle are configured to allow main batteries for traveling to be charged by using electric power supplies outside the vehicles. Japanese Patent Application Publication No. 2012-244875 (JP 2012-244875 A) discloses a vehicle including a charger that supplies electric power from an electric power supply
15 outside the vehicle to a main battery and a DC/DC converter that receives electric power from the main battery and outputs the electric power to an auxiliary load and an auxiliary battery.

[0003] As described in JP 2012-244875 A, most hybrid vehicles mount the DC/DC converter that charges the auxiliary battery with electric power of the main battery.
20 In a case where the DC/DC converter has a small capacity, and when an auxiliary load is used and electric power consumption thereof increases, the auxiliary battery cannot be sufficiently charged and the auxiliary battery may be discharged. Accordingly, the DC/DC converter is designed to have a sufficient capacity.

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SUMMARY OF THE INVENTION

[0004] The invention provides a charging system mounted on a vehicle that is capable of suppressing a decrease in SOC of an auxiliary battery during external charging, and the charging system enables a reliable charge of the auxiliary battery.

30 [0005] A charging system according of the present invention is mounted on a vehicle. The vehicle is provided with a traveling motor and an auxiliary load. The charging system includes an electric power receiving section, a main battery, an auxiliary battery, a main DC/DC converter, a sub DC/DC converter and an electronic control unit.

The electric power receiving section is configured to receive electric power from outside the vehicle. The main battery is configured to supply electric power to the traveling motor. The auxiliary battery is configured to supply electric power to the auxiliary load. The main DC/DC converter is configured to perform voltage conversion of electric power supplied from the main battery and supply the electric power to the auxiliary battery. The sub DC/DC converter is configured to perform voltage conversion of electric power supplied from the electric power receiving section and supply the electric power to the auxiliary battery. The electronic control unit is configured to control the main DC/DC converter and the sub DC/DC converter. The electronic control unit is configured to start the main DC/DC converter and perform charging of the auxiliary battery when following conditions i) to iii) are satisfied: i) the main battery is charged from outside the vehicle through the electric power receiving section; ii) the auxiliary battery is charged by the sub DC/DC converter; and iii) the electronic control unit detects a vehicle situation that causes a remaining capacity of the auxiliary battery to decrease,

[0006] According to the configuration described above, the main DC/DC converter is started when the vehicle situation causing the decrease of the SOC of the auxiliary battery is detected, and thus a capacity of current supply to the auxiliary battery is enhanced. Accordingly, the decrease in the remaining capacity of the auxiliary battery can be prevented.

[0007] In other words, the charging system described above prevents from the decrease in the SOC of the auxiliary battery during external charging, and prevents a charging control system of the vehicle from being put into an OFF state and being stopped charging.

[0008] The main DC/DC converter may be higher in current supply capacity than the sub DC/DC converter. The electronic control unit may be configured to start the main DC/DC converter, perform the charging of the auxiliary battery, and stop the sub DC/DC converter when following conditions iv) to vi) are satisfied: iv) the main battery is being charged from outside the vehicle; v) the auxiliary battery is being charged by the sub DC/DC converter; and vi) the electronic control unit detects the vehicle situation.

[0009] In some cases, a DC/DC converter performs feedback processing so as to maintain a constant voltage. A problem such as feedback processing interference arises when a plurality of DC/DC converters are used in parallel for the same electric power supply, and measure should be taken to this problem. If the main DC/DC converter is

higher in current supply capacity than the sub DC/DC converter, the sub DC/DC converter can be stopped in most cases, and thus no measure may be needed and the control regulation may be simple.

[0010] The vehicle situation may include at least one of the following situations
5 vii) to x): vii) an abnormality occurs in the sub DC/DC converter; viii) an amount of discharge of the auxiliary battery is higher than or equal to a threshold; ix) a voltage of the auxiliary battery is lower than a threshold; and x) the charging system further comprising an electric load using electric power of the main battery and a relay configured to connect the electric load to the main battery, and a connection request for the relay is present.

10 [0011] In these vehicle situations, the discharge of the auxiliary battery surpasses the charging of the auxiliary battery, and the remaining capacity of the auxiliary battery is highly likely to decrease. Accordingly, any of the detected situations can be used as a trigger for starting the main DC/DC converter without calculating the actual remaining capacity of the auxiliary battery with accuracy.

15 [0012] The connection request may be given by selecting a my room mode when the vehicle is stopped, and the my room mode is a mode in which the electric load can be used.

[0013] In the my room mode, for example, a user operates an air conditioner, operates an audio instrument, or connects an electric appliance to an outlet provided in the
20 car and uses the electric appliance, in a passenger compartment. The electric appliance is brought in to the car by the user. Accordingly, in most cases, the discharge of the auxiliary battery significantly increases during the my room mode compared to the discharge of the auxiliary battery during a normal external charging. However, designing a capacity of the sub DC/DC converter in accordance with the my room mode may results
25 in an excess capacity and may degrades efficiency of the charging of the auxiliary battery during the external charging. The my room mode may be set infrequently. Accordingly, the capacity of the sub DC/DC converter is designed on the assumption that the my room mode is not selected, and the main DC/DC converter is configured to be started when the my room mode is selected. As a result, the efficiency of the external charging can be
30 improved and a depletion of the auxiliary battery during the my room mode can be prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is an overall block diagram of an electric vehicle 100 on which a charging system according to an embodiment of the invention is mounted;

FIG. 2 is a block diagram showing an electric power supply path between a charger and a PCU and an ECU and a command system;

FIG. 3 is a state transition diagram illustrating an operation mode transition during external charging;

FIG. 4 is a flowchart of control for executing control based on the state transition diagram in FIG. 3; and

FIG. 5 is an overall block diagram of an electric vehicle 100A on which a charging system modified from the charger is mounted.

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DETAILED DESCRIPTION OF EMBODIMENTS

[0015] Improvement of energy efficiency of hybrid vehicle and electric vehicle has been required and various studies have been carried out. For charging of the main battery by using the electric power supply outside the vehicle (hereinafter, referred to as external charging), the inventors of the invention examined the use of an automotive DC/DC converter, which has a small capacity and is designed to be reserved for the external charging, apart from a DC/DC converter of the related art. During the external charging, most of the auxiliary load is not used, and thus energy efficiency is degraded if the charging of the auxiliary battery is performed by using a DC/DC converter having an excess capacity. In JP 2012-244875 A, two DC/DC converters are mounted so as to perform electric power exchange with two auxiliary batteries. However, in JP 2012-244875 A, no detailed study is carried out concerning charging of the auxiliary battery during the external charging.

[0016] As a result of extensive studies, the inventors of the invention found out that a remaining capacity (state of charge: SOC) of the auxiliary battery may decrease in certain vehicle situations if the auxiliary battery is charged by using the DC/DC converter for the external charging having the small capacity. If the SOC of the auxiliary battery is at or below a predetermined value during the external charging, a charging control system of the vehicle that receives electric power from the auxiliary battery is turned OFF, and

thus it may become impossible to continue the external charging. The capacity of the DC/DC converter for the external charging may be uniformly increased as a countermeasure for this measure. However this is not an appropriate measure when energy efficiency during the external charging is taken into account. Accordingly, it is desirable to enhance a capacity of current supply to the auxiliary battery before an actual SOC decrease, in a case where the vehicle situation which may result in the decrease of the SOC of the auxiliary battery is detected during the external charging.

[0017] Hereinafter, embodiments of the invention will be described in detail with reference to accompanying drawings. The same reference numerals will be used to refer to the same or corresponding parts in the drawings and description thereof will be omitted.

[0018] FIG. 1 is an overall block diagram of an electric vehicle 100 on which a charging system according to an embodiment of the invention is mounted. Referring to FIG. 1, the electric vehicle 100 includes an electric power receiving section 320, a charger 200, a main battery 10, an auxiliary battery 150, a power control unit (PCU) 110, an electronic control unit (ECU) 160, a high-voltage load 180, a low-voltage load 170, and a motor generator MG. The PCU 110 includes a main DC/DC converter 140, an inverter 120, and a control unit 130 that controls the main DC/DC converter 140 and the inverter 120. The charger 200 includes a rectifier circuit 210, a DC/DC converter 220 for high voltage, a smoothing capacitor 250, a sub DC/DC converter 230, and a control unit 240.

[0019] During vehicle traveling, a system main relay SMR is connected, electric power from the main battery 10 is supplied to the high-voltage load 180 and the PCU 110, and the motor (motor generator) MG that drives a drive wheel can be driven.

[0020] The electric power receiving section 320 is also referred to as an inlet and receives electric power from outside the vehicle. During external charging, a charging connector 310 is connected to the electric power receiving section 320 and electric power is supplied from an external electric power supply 300.

[0021] The main battery 10 is an electric power supply that supplies electric power to the traveling motor MG. The auxiliary battery 150 is an electric power supply that supplies electric power to an auxiliary load (low-voltage load 170). The main DC/DC converter 140 supplies the electric power from the main battery 10 to the auxiliary battery 150 after voltage conversion. The sub DC/DC converter 230 supplies the electric power that is supplied from the electric power receiving section 320 to the auxiliary battery 150 after voltage conversion. The ECU 160 transmits commands for controlling the main

DC/DC converter 140 and the sub DC/DC converter 230 to the control unit 130 and the control unit 240, respectively. The control unit 130 controls the main DC/DC converter 140, and the control unit 240 controls the sub DC/DC converter 230 based on the commands received from the ECU 160. In this embodiment, the control unit 130 and the control unit 240 are provided as different units from the ECU 160. The following description is described as the control unit 130 controls the main DC/DC converter 140 and the control unit 240 controls the sub DC/DC converter 230 by receiving the commands from the ECU 160. Therefore, the actual control can be regarded as being performed by the ECU 160.

[0022] The electric power that is received by the electric power receiving section 320 is transmitted to the charger 200. During the external charging, a charging relay SMRC is connected. The rectifier circuit 210 converts the AC electric power that is received by the electric power receiving section 320 to DC electric power. The DC/DC converter 220 for high voltage converts a voltage from the rectifier circuit 210 to a voltage (for example, 200 V) that is suitable for charging the main battery 10. The sub DC/DC converter 230 converts the voltage from the rectifier circuit 210 to a voltage (for example, 14 V) that is suitable for charging the auxiliary battery 150.

[0023] During the external charging, the ECU 160 performs charging control by transmitting a control signal to the control unit 240 of the charger 200. The ECU 160 receives outputs from a current sensor 182 and a voltage sensor 184 and monitors a current and a voltage of the auxiliary battery 150. In a case where discharge of the auxiliary battery 150 occurs and in a case where the voltage of the auxiliary battery 150 decreases to a lower voltage than a threshold, the ECU 160 performs charging of the auxiliary battery 150 and electric power supply to the low-voltage load 170 by using the sub DC/DC converter 230.

[0024] In a case where charging is performed on the main battery 10 from outside the vehicle through the electric power receiving section 320 and the auxiliary battery 150 is charged by the sub DC/DC converter 230, and when a vehicle situation that causes a remaining capacity of the auxiliary battery 150 to decrease is detected, the ECU 160 starts the main DC/DC converter 140 and performs charging on the auxiliary battery 150.

[0025] Such a vehicle situation that causes the remaining capacity of the auxiliary battery 150 to decrease may include at least one of following situations: an abnormality occurs in the sub DC/DC converter 230; an amount of the discharge of the auxiliary battery

150 is higher than or equal to a threshold; a voltage of the auxiliary battery 150 is lower than the threshold; and input of a connection request for the system main relay SMR is present, the system main relay SMR connects an electric load (high-voltage load 180) using a voltage of the main battery 10 to the main battery 10.

5 **[0026]** According to the configuration described above, the main DC/DC converter 140 is started when the vehicle situation that causes the remaining capacity of the auxiliary battery 150 to decrease is detected, and thus a capacity of current supply to the auxiliary battery 150 is enhanced. Accordingly, the decrease in the remaining capacity (SOC) of the auxiliary battery 150 can be prevented.

10 **[0027]** In the vehicle situation exemplified above, the discharge of the auxiliary battery 150 surpasses the charging of the auxiliary battery 150, and the remaining capacity of the auxiliary battery 150 is highly likely to decrease. Accordingly, any of the detected situations can be used as a trigger for starting the main DC/DC converter 140 without calculating the actual remaining capacity of the auxiliary battery 150 with accuracy.

15 **[0028]** The system main relay SMR may be configured to connect the main battery 10 to the high-voltage load 180 in a passenger compartment as well as the traveling motor MG. The connection request for the system main relay SMR is given when a my room mode is selected. More specifically, the connection request for the system main relay SMR is given when an instruction for transition to the my room mode is input into
20 the ECU 160. The my room mode is a mode in which loads (low-voltage load 170 and high-voltage load 180) in the passenger compartment can be used.

[0029] In the my room mode, for example, a user operates an air conditioner, operates an audio instrument, or connects an electric appliance to an outlet provided in the car and uses the electric appliance, in the passenger compartment. The electronic
25 appliance is brought in to the car by the user. In FIG. 1, the air conditioner, a 100 V inverter for the outlet provided in the car, and the like correspond to the high-voltage load 180 and the audio instrument and the like correspond to the low-voltage load 170. Accordingly, the discharge of the auxiliary battery 150 significantly increases during the my room mode, compared to that during a normal external charging. However, designing
30 a capacity of the sub DC/DC converter 230 in accordance with the my room mode may results in an excess capacity and may degrades efficiency of the charging of the auxiliary battery 150 during the external charging. The my room mode may be selected infrequently. If the capacity of the sub DC/DC converter 230 is designed to be suitable

for a vehicle situation in which the my room mode is not selected and electric power consumption is low, and the main DC/DC converter 140 is configured to be started when the my room mode is selected, the efficiency of the external charging can be improved and a depletion of the auxiliary battery 150 during the my room mode can be prevented.

5 **[0030]** The main DC/DC converter 140 may be higher in current supply capacity than the sub DC/DC converter 230. When the main battery 10 is charged from outside the vehicle, the auxiliary battery 150 is charged by the sub DC/DC converter 230, and the vehicle situation that causes the remaining capacity of the auxiliary battery 150 to decrease is detected, the ECU 160 starts the main DC/DC converter 140, performs the charging on
10 the auxiliary battery 150, and stops the sub DC/DC converter 230.

[0031] In most cases, a DC/DC converter performs feedback processing so as to maintain a constant voltage. A problem such as feedback processing interference arises when a plurality of DC/DC converters are used in parallel in order to control a voltage of a single electric power supply line, and measure should be taken to this problem. If the
15 main DC/DC converter 140 is higher in current supply capacity than the sub DC/DC converter 230, the sub DC/DC converter 230 can be stopped in most cases, and thus no measure may be needed and the control regulation may be simple.

[0032] FIG. 2 is a block diagram showing an electric power supply path between the charger and the PCU and the ECU and a command system.

20 **[0033]** The electric power supply path will be described first. The auxiliary battery 150 can be charged by both the main DC/DC converter 140 in the PCU 110 and the sub DC/DC converter 230 in the charger 200. A fuse F1 and a fuse F2 are disposed in these charging paths. In a case where the fuse F2 is opened by an overcurrent or the like, the auxiliary battery 150 cannot be charged by the sub DC/DC converter 230.
25 Furthermore, the ECU 160 receives operating supply voltage from the auxiliary battery 150. When the charging of the auxiliary battery 150 becomes impossible and a drop in the voltage of the auxiliary battery 150 occurs, an operation of the ECU 160 may stop and the vehicle cannot be charged. In this embodiment, switching is carried out in this case so that the charging of the auxiliary battery is performed by the main DC/DC converter 140.

30 **[0034]** Next, the command system will be described. The ECU 160 includes an auxiliary control unit 162 and a system control unit 164. The auxiliary control unit 162 calculates a discharge current from the auxiliary battery 150 by receiving a detected value from the current sensor 182, and the auxiliary control unit 162 transmits a result of a

discharge determination for the auxiliary battery 150 to the system control unit 164. In the discharge determination for the auxiliary battery 150, the auxiliary battery 150 is determined to discharge when a current outflow from the auxiliary battery 150 becomes higher than or equal to the predetermined threshold. The system control unit 164 receives a detected value of the voltage of the auxiliary battery 150 from the voltage sensor 184, receives the result of the discharge determination for the auxiliary battery 150 from the auxiliary control unit 162, and receives status information from the charger 200 for monitoring whether an operation of the charger 200 is properly performed according to a drive command. The system control unit 164 performs auxiliary low voltage determination, DC/DC mode determination, and high-voltage system connection determination based on the detected value of the voltage of the auxiliary battery 150, the result of the discharge determination for the auxiliary battery 150, and the status information. .

[0035] A DC/DC mode is set to one of a main DC/DC mode and a sub DC/DC mode. The main DC/DC mode is a mode in which the charging of the auxiliary battery 150 is performed by using the main DC/DC converter 140. The sub DC/DC mode is a mode in which the charging of the auxiliary battery 150 is performed by using the sub DC/DC converter 230.

[0036] In a case where the DC/DC mode is the main DC/DC mode, the system control unit 164 transmits the drive commands to the control units 130, 240 to stop the sub DC/DC converter 230 and operate the main DC/DC converter 140. In a case where the DC/DC mode is the main DC/DC mode, the auxiliary control unit 162 transmits a voltage command of the main DC/DC converter 140 to the control unit 130.

[0037] In a case where the DC/DC mode is the sub DC/DC mode, the system control unit 164 transmits the drive commands to the control units 130, 240 to stop the main DC/DC converter 140 and operate the sub DC/DC converter 230. In a case where the DC/DC mode is the sub DC/DC mode, the auxiliary control unit 162 transmits a voltage command of the sub DC/DC converter 230 to the control unit 240 of the charger 200.

[0038] In a case where the amount of the discharge current of the auxiliary battery is large, a command for increasing a voltage of the DC/DC converter is performed by the auxiliary control unit 162 and feedback control is performed.

[0039] FIG. 3 is a state transition diagram illustrating an operation mode

transition during the external charging. FIG. 4 is a flowchart of control for executing control based on the state transition diagram in FIG. 3.

[0040] Referring to FIGS. 3 and 4, the processing is initiated in initial state ST0. Firstly, in Step S1, it is determined whether or not an operation mode of the vehicle is a charging mode. For example, when the charging connector 310 is connected to the electric power receiving section 320 of the vehicle, the ECU 160 determines that the operation mode of the vehicle is the charging mode. In the charging mode, the charging relay SMRC is connected while the system main relay SMR is normally disconnected. When the charging connector 310 is not connected to the electric power receiving section 320, the ECU 160 determines that the operation mode of the vehicle is a non-charging mode. In the non-charging mode, the vehicle is set in a traveling mode that allows traveling when, for example, a driver operates a vehicle start switch (not illustrated). In the traveling mode, the charging relay SMRC is disconnected and the system main relay SMR is connected.

[0041] In a case where the operation mode of the vehicle is determined to be the charging mode, the processing proceeds from Step S1 to Step S2 and the ECU 160 sets the DC/DC mode to the sub DC/DC mode. As a result, as described in the state transition diagram in FIG. 3, a state transition from initial state ST0 to state ST1 occurs. In state ST1, the sub DC/DC converter 230 is driven and the main DC/DC converter 140 is stopped.

[0042] In Step S3, the ECU 160 determines whether or not the abnormality is present in the sub DC/DC converter 230. The sub DC/DC converter 230 has a self-diagnosis function and when malfunction occurs due to an overcurrent, an overvoltage, or the like, a diagnosis result is transmitted to the ECU 160 through the control unit 240. The ECU 160 determines whether or not the abnormality is present in the sub DC/DC converter 230 based on the diagnosis result.

[0043] In Step S4, the ECU 160 determines whether or not the discharge determination for the auxiliary battery 150 is present based on the detected value from the current sensor 182. For example, when the discharge of the auxiliary battery 150 continues for a predetermined time, it is determined that the discharge determination for the auxiliary battery 150 is present.

[0044] In Step S5, the ECU 160 determines whether or not a low voltage determination for the auxiliary battery 150 is present based on the detected value from the

voltage sensor 184. For example, when the voltage of the auxiliary battery 150 is lower than the threshold for a predetermined time, it is determined that the low voltage determination is present.

5 [0045] In Step S6, the ECU 160 determines the presence or absence of a high-voltage system load connection request, that is, the presence or absence of the connection request for the system main relay SMR. For example, when the user selects the my room mode during the external charging, the system main relay SMR is connected so that the high-voltage load 180 such as the air conditioner and the 100 V inverter for the outlet provided in the car can be used during the charging. In this case, it is determined
10 that the high-voltage system load connection request is present, in other words, the connection request for the system main relay SMR is present.

[0046] When a YES determination is made in any one of Steps S3 to S6, the processing proceeds to Step S8 and the ECU 160 sets the DC/DC mode to the main DC/DC mode. As a result, a state transition from state ST1 to state ST2 in the state
15 transition diagram occurs. In state ST2, the system main relay SMR is connected, the sub DC/DC converter 230 is stopped, and the main DC/DC converter 140 is driven.

[0047] In a case where a NO determination is made in each of Steps S3 to S6, the processing proceeds to Step S7 and the ECU 160 sets the DC/DC mode to the sub DC/DC mode. As a result, no state transition from state ST1 in the state transition diagram occurs.
20 In state ST1, the system main relay SMR is disconnected, the main DC/DC converter 140 is stopped, and the sub DC/DC converter 230 is driven.

[0048] The configuration may be modified as illustrated in FIG. 5. FIG. 5 is an overall block diagram of an electric vehicle 100A on which a charging system modified from the charger is mounted.

25 [0049] Referring to FIG. 5, an inner portion of a charger 200A of the vehicle 100A differs from that of the charger 200 illustrated in FIG. 1. In the charger 200A, the sub DC/DC converter 230 receives a DC voltage from a path connecting the DC/DC converter for high voltage to the charging relay SMRC for supply to the auxiliary battery 150 after conversion. The other parts of FIG. 5 are identical to those in FIG. 1 and
30 description thereof will not be repeated.

[0050] A sub DC/DC converter 230A that is illustrated in FIG. 5 supplies at least one of the electric power supplied from the electric power receiving section 320 and the electric power supplied from the main battery 10 to the auxiliary battery 150 after voltage

conversion. In other words, the sub DC/DC converter 230A can perform the charging of the auxiliary battery 150 by using the electric power supplied from outside the vehicle through the electric power receiving section 320 or the electric power supplied from the main battery 10 through the charging relay SMRC.

5 **[0051]** In this case, the charging of the auxiliary battery 150 can be continuously performed even, for example, in a case where a power outage occurs during the external charging and in a case where control is performed to temporarily stop and resume the external charging.

10 **[0052]** According to both FIGS. 1 and 5, it is preferable that the sub DC/DC converter 230 is stopped in the main DC/DC mode. However, the sub DC/DC converter 230 may be in operation in the main DC/DC mode.

15 **[0053]** In this embodiment, an example in which the charging connector 310 is connected to the electric power receiving section 320 is illustrated in FIG. 1. However, the electric power receiving section 320 may be configured to be capable of receiving the electric power from outside on a non-contact basis.

[0054] It should be understood that the embodiments disclosed herein are illustrative in every aspect and do not limit the invention. The scope of the invention is clarified in the claims, not the description above, and any modification within the claims and equivalents thereof are included in the invention.

CLAIMS:

1. A charging system mounted on a vehicle, the vehicle being provided with a traveling motor and an auxiliary load,

5 the charging system comprising:

an electric power receiving section configured to receive electric power from outside the vehicle;

a main battery configured to supply electric power to the traveling motor;

an auxiliary battery configured to supply electric power to the auxiliary load;

10 a main DC/DC converter configured to perform voltage conversion of electric power supplied from the main battery and supply the electric power to the auxiliary battery;

a sub DC/DC converter configured to perform voltage conversion of electric power supplied from the electric power receiving section and supply the electric power to the auxiliary battery; and

15 an electronic control unit configured to control the main DC/DC converter and the sub DC/DC converter, the electronic control unit being configured to start the main DC/DC converter and perform charging of the auxiliary battery when following conditions i) to iii) are satisfied,

20 i) the main battery is charged from outside the vehicle through the electric power receiving section,

ii) the auxiliary battery is charged by the sub DC/DC converter, and

iii) the electronic control unit detects a vehicle situation that causes a remaining capacity of the auxiliary battery to decrease.

25 2. The charging system according to claim 1,

wherein the main DC/DC converter is higher in current supply capacity than the sub DC/DC converter, and

30 wherein the electronic control unit is configured to start the main DC/DC converter, perform the charging of the auxiliary battery, and stop the sub DC/DC converter when following conditions iv) to vi) are satisfied,

iv) the main battery is being charged from outside the vehicle,

v) the auxiliary battery is being charged by the sub DC/DC converter, and

vi) the electronic control unit detects the vehicle situation.

3. The charging system according to claim 1 or 2,
wherein the vehicle situation includes at least one of the following situations vii) to
x),

- 5 vii) an abnormality occurs in the sub DC/DC converter,
 viii) an amount of discharge of the auxiliary battery is higher than or equal to a
threshold,
 ix) a voltage of the auxiliary battery is lower than a threshold, and
 x) the charging system further comprising an electric load using electric power of the
10 main battery and a relay configured to connect the electric load to the main battery, and a
connection request for the relay is present.

4. The charging system according to claim 3,
wherein the connection request is given by selecting a my room mode when the
15 vehicle is stopped, and
 wherein the my room mode is a mode in which the electric load can be used.

FIG. 2

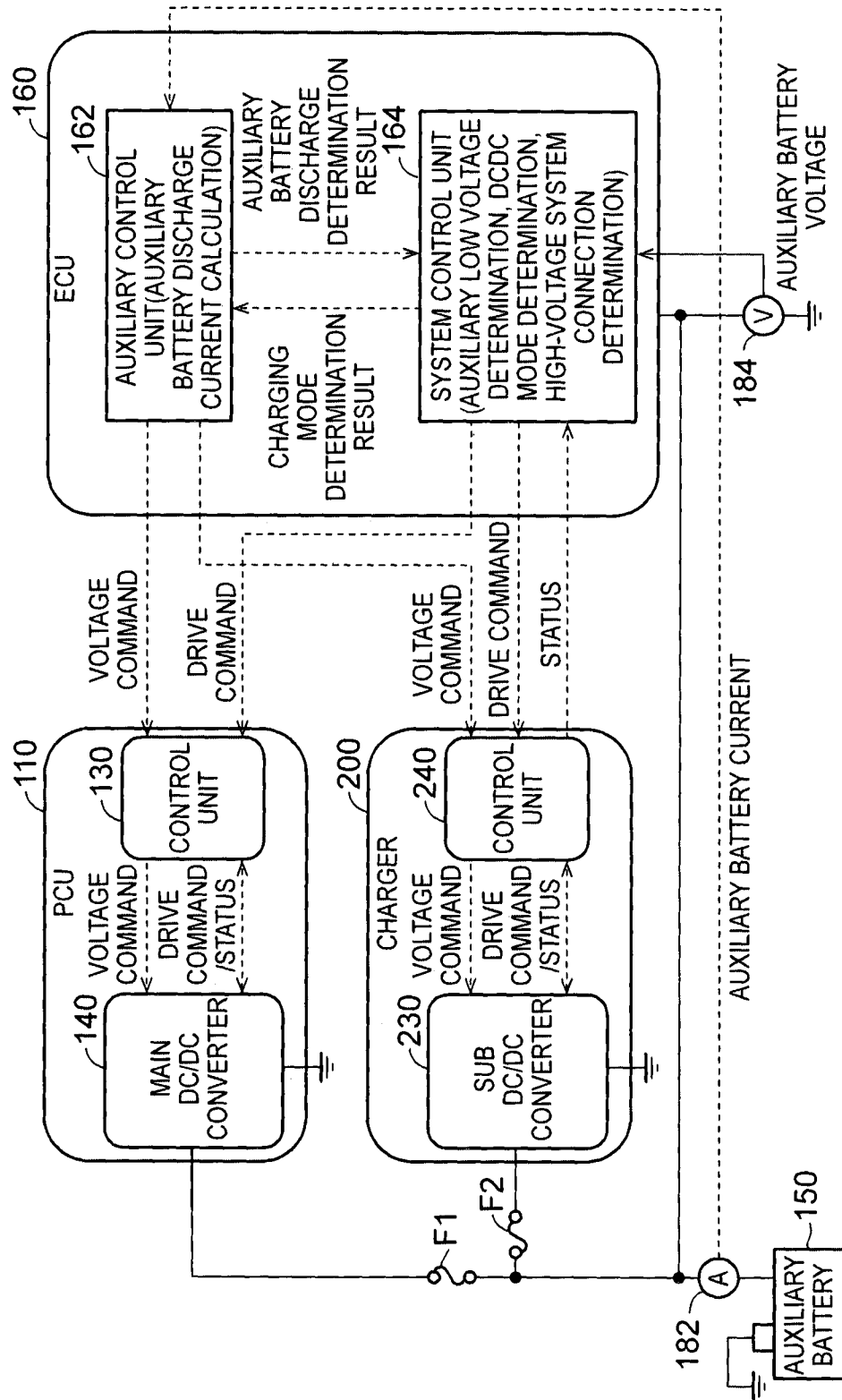


FIG. 3

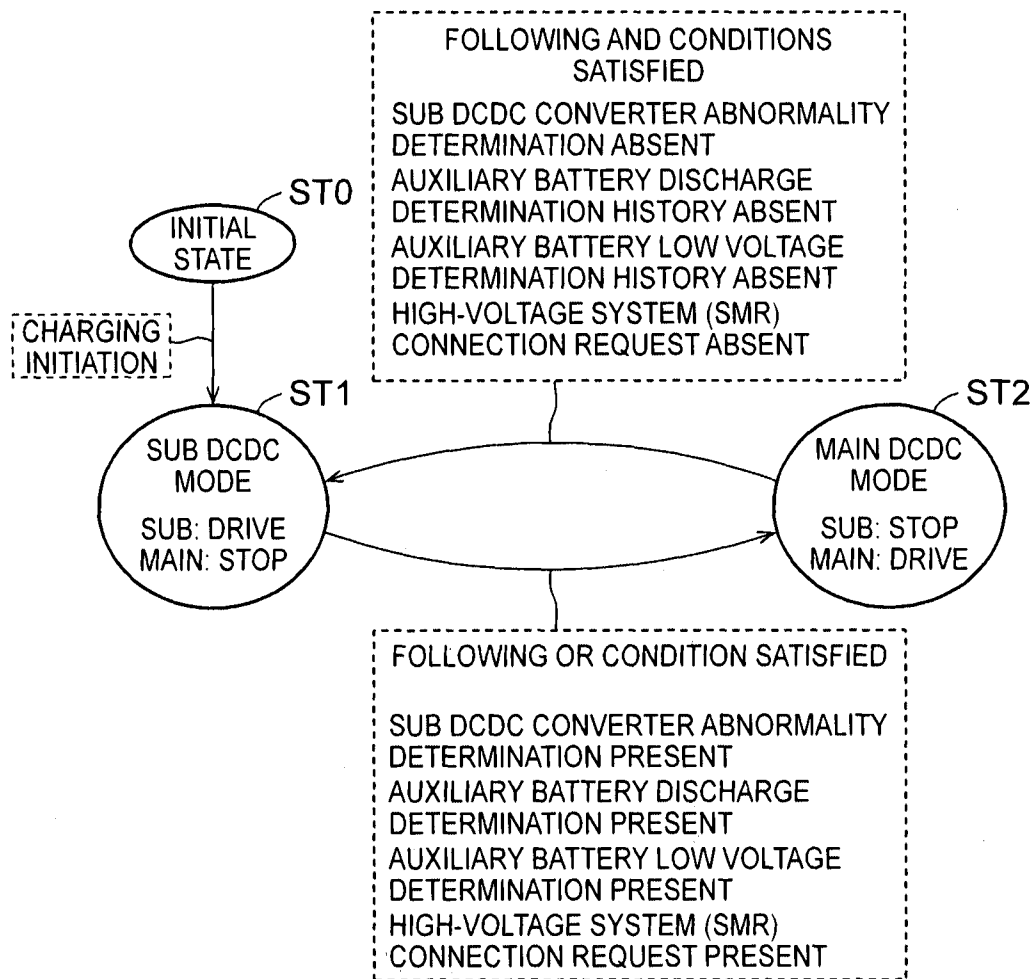


FIG. 4

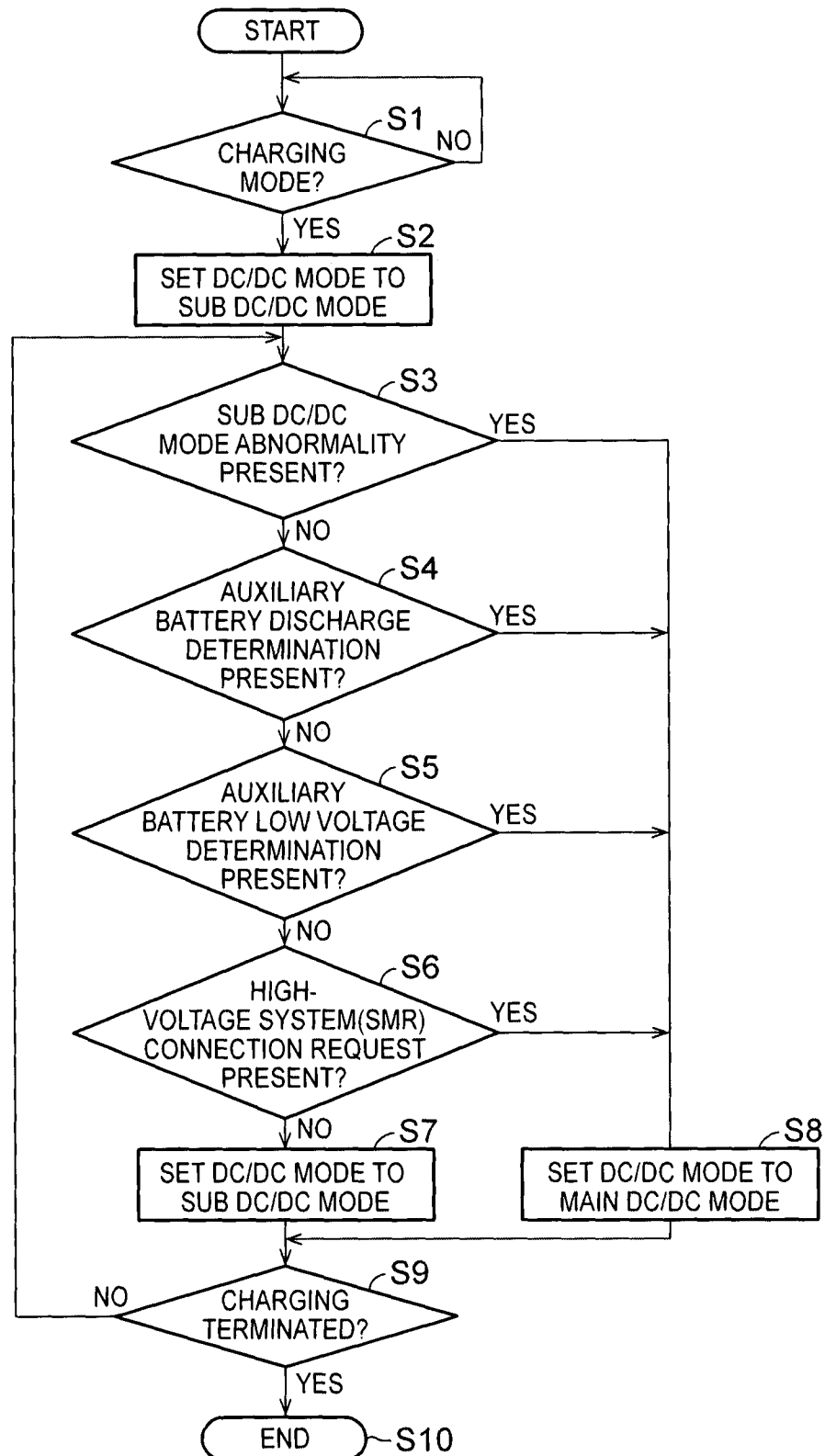
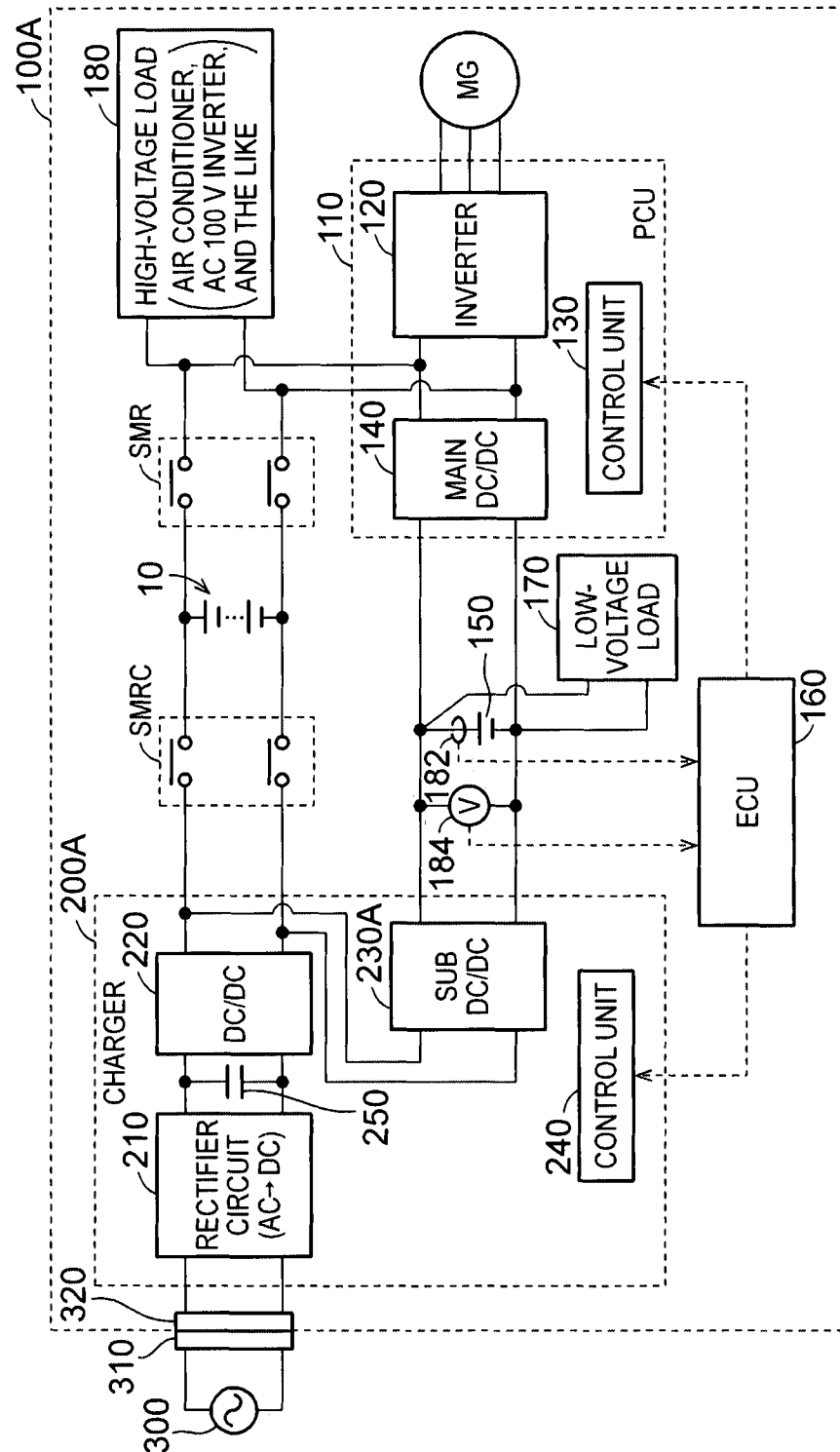


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/000330

A. CLASSIFICATION OF SUBJECT MATTER INV. B60L11/18 B60L3/00 B60L1/00 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B60L		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 463 138 A1 (TOYOTA MOTOR CO LTD [JP]) 13 June 2012 (2012-06-13)	1
Y	paragraph [0072] - paragraph [0073]; figure 1	2-4
Y	----- WO 2011/138648 A2 (TOYOTA MOTOR CO LTD [JP]; SUGIYAMA YOSHINOBU [JP]; ANG WANLENG [JP]) 10 November 2011 (2011-11-10) paragraph [0054] - paragraph [0054]; claim 1; figure 1	2-4
Y	----- EP 2 641 771 A1 (TOYOTA MOTOR CO LTD [JP]) 25 September 2013 (2013-09-25) claims 2,3 -----	3
<input style="width: 20px; height: 20px; margin-right: 5px;" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" style="width: 20px; height: 20px; margin-right: 5px;" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
Date of the actual completion of the international search 23 July 2015	Date of mailing of the international search report 03/08/2015	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Schury, Dominik	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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