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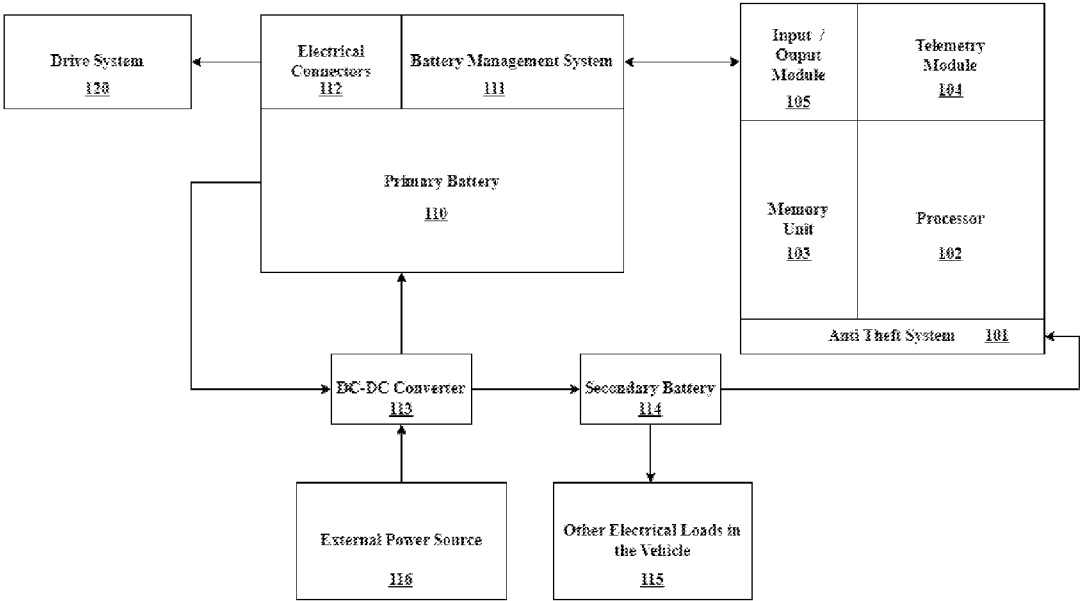


Figure 1

(57) Abstract: A battery management system 111 for dynamically managing a state of charge of a primary battery 110 of a vehicle during a distress state of the vehicle is disclosed. An electronic control unit of the vehicle is configured for monitoring a current state of the vehicle. If the current state is determined to be a distress state, the battery 5 management system 111 is configured to dynamically change to an alternate logic for charging the secondary battery 114 from the primary battery 110. This allows an anti theft system 101 of the vehicle to function beyond a benchmark time if the battery management system was functioning normally.

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TITLE OF INVENTION:**DYNAMIC BATTERY MANAGEMENT SYSTEM****Technical Field of Invention**

[0001] The present invention is generally related to energy management systems in
5 a vehicle. Particularly, the present invention is related to a dynamically managing
a primary and a secondary battery during a distress state of the vehicle.

Background

[0002] Security of one's belongings is a primary concern for any individual. A
10 conventional vehicle generally consists of one or more mechanical security locks.
These locks may be actuated by a physical key, or by electronic means, which is
usually provided in the form of a key fob to the user of the vehicle. The key fob
usually contains both the mechanical key and the electronic key. When a vehicle is
locked, there are multiple locks that are usually actuated. Generally, the steering is
15 locked, the ignition system is locked, and the doors and windows of the vehicle, if
any, are locked. However, a skilled and motivated person may find their way around
these multiple locks and compromise the vehicle, including theft, and damage. The
threat of theft and damage is even more sever in a two wheeled vehicle, since there
are no external doors and windows. When a vehicle is not in use by its authorized
20 user, it is usually in a parked state. During a parked state of the vehicle, the user of
the vehicle is usually away from the vicinity of the vehicle. in case there is any
incident involving the vehicle, there are no systems available which can update the
user in real time regarding the current state of the vehicle.

[0003] In conventional four wheeled vehicles, when the vehicle is put in a parked
25 state, there are several locks around the vehicles as indicated earlier. Similarly, in a
two wheeled vehicle, there is at least a steering lock and an ignition lock. Even if
these locks are designed to be unbreakable, it is still possible that the vehicle is
damaged by external conditions which are beyond the controls of the user of the
vehicle, or the entire vehicle is moved without any attempt at disabling any of the

locks. In such scenarios, having the vehicle locked is of no advantage to the user, who loses their belongings and their vehicle. Moreover, electronic locking mechanisms are often prone to hacking and cyber attacks, whereby a skilled hacker can copy the electronic signature of the key, and are able to access the vehicle.

5[0004] Systems exist whereby the vehicle is equipped with cameras and record any incident wherein the vehicle is potentially damaged. In such systems, when a suspicious activity is detected by the vehicle's internal systems, the cameras in the vehicle begin recording, and transmit the same to the user of the vehicle, who can then take appropriate action, including but not limited to flashing the lights, honking
10 the horns, and broadcasting messages remotely via speakers mounted in the vehicles. These systems are most commonly found in high end four wheeled vehicles, and add to the cost of the vehicle itself, due to the inherent cost of the equipment involved. Furthermore, the components involved imply that such a system is only suitable in a larger vehicle, such as a four wheeled vehicle.
15 Moreover, such systems are required to be proactively activated by the user of the vehicle when putting the vehicle in the parked condition. If the system is not activated, the benefits of the system are not available to the user in case of any occurrence of theft or any other kind of distress condition.

[0005] The same disadvantage needs to be addressed when the system is installed
20 and activated in the vehicle, however, the batteries in the vehicle are discharged. This is a problem that is typical to an electric vehicle, as an electric vehicle usually has one or more batteries for powering a drive unit and auxiliary electrical loads. On the other hand, a vehicle with an internal combustion engine will only have a 12 V battery, which cannot be charged using the engine and an integrated starter
25 generator, since automatically starting the engine would give access to the vehicle to unauthorized persons. An electric vehicle on the other hand usually has one or more primary high voltage batteries which powers one or more traction motors, and at least one low voltage auxiliary battery which is configured to provide electrical power to the other electrical loads in the vehicle. Typically, the auxiliary battery is
30 charged from the primary battiery(ies) through a voltage converter. However, when

the primary battery(ies) is itself in a discharged state, it cannot be used to charge the auxiliary battery.

[0006] Typically, the batteries in an electric vehicle are configured with a battery management system. The battery management system is configured to monitor the health of the battery, in order to prevent thermal runaway, or any other battery related issue. It monitors the state of charge of the battery, and controls the rate of charging and discharging the same to ensure safe operation of the battery. The commonly used battery management system however is not configured for ensuring that an auxiliary battery is charged from the primary battery even in case of an almost discharged state of the primary battery.

[0007] Therefore, there is a requirement for a dynamic battery management system, wherein the battery management system can charge the auxiliary battery in cases where the vehicle has been stolen, or tampered with, and it is vital to keep the owner of the user apprised of the current state of the vehicle as long as possible.

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Summary of the Invention

[0008] This summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described below, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

[0009] In an aspect, a method for dynamically managing a state of charge of a battery of a vehicle during a distress state is disclosed. The method comprises determining, by a battery management system, a state of charge of a primary and a secondary battery in the vehicle. The method further comprises receiving, by the battery management system, a current state of the vehicle from an electronic control unit of the vehicle. The method further comprises comparing, by the battery management system, the state of charge of the secondary battery with a first pre-defined threshold and the state of charge of the primary battery with a second pre-defined threshold. The method further comprises charging, by the battery management system, the secondary battery from the primary battery when the state of charge of the secondary battery is below the first pre-defined threshold, and the

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state of charge of the primary battery is above the second pre-defined threshold. The method further comprises disabling, by the battery management system, discharging of the primary battery when the state of charge of the secondary battery is above the first pre-determined threshold.

5[00010] In an embodiment, the method further comprises receiving, by the battery management system, the current state of the vehicle being an alert state. The method further comprises transmitting, by the battery management system, a first warning to the electronic control unit of the vehicle when the state of charge of the secondary battery is below the first pre-defined threshold, and the state of charge of the primary battery is below the second pre-defined threshold. The method further comprises enabling, by the battery management system, discharging the primary battery when the state of charge of the secondary battery is below a first ultra low threshold. The method further comprises charging, by the battery management system, the secondary battery from the primary battery after the first warning maintaining the state of charge of the secondary battery above the first ultra low threshold. The method further comprises disabling, by the battery management system, discharging the primary battery when the state of charge of the secondary battery is above the first ultra low threshold. The method further comprises transmitting, by the battery management system, a second warning to the electronic control unit of the vehicle when the state of charge of the secondary battery is below a third pre-defined threshold, and the state of charge of the primary battery is below a fourth pre-defined threshold. The method further comprises enabling, by the battery management system, discharging the primary battery when the state of charge of the secondary battery is below a second ultra low threshold. The method further comprises charging, by the battery management system, the secondary battery from the primary battery after the second warning maintaining the state of charge of the primary battery above the second ultra low threshold. The method further comprises disabling, by the battery management system, discharging the primary battery when the state of charge of the secondary battery is above the second ultra low threshold.

[00011] In an embodiment, the electronic control unit of the vehicle is configured to send a current state of the vehicle to the battery management system. The electronic control unit is further configured to operate one or more sensors, and one or more telemetry modules to determine a change in the current state of the vehicle. The electronic control unit is further configured to determine a current state of the vehicle being changed to an alert state when one or more pre-defined conditions are satisfied. The electronic control unit is further configured to transmit one or more alerts to a remote server during the alert state of the vehicle. The electronic control unit is further configured to determine one of a first warning and a second warning being received from the battery management system. The electronic control unit is further configured to disabling one or more electrical loads in the vehicle when the first warning is received from the battery management system. The electronic control unit is further configured to enabling the one or more electrical loads intermittently at a first pre-defined frequency of time interval vehicle when the first warning is received from the battery management system. The electronic control unit is further configured to updating a remote server when the second warning is received from the battery management system. The electronic control unit is further configured to enabling the one or more electrical loads intermittently at a second pre-defined frequency of time interval vehicle when the second warning is received from the battery management system. In an embodiment, the second pre-defined frequency of time is proportional to the state of charge of the primary battery.

[00012] In an embodiment, the battery management system is configured to charge the secondary battery above the second ultra low threshold from the primary battery until the state of charge of the primary battery is below a third pre-defined threshold.

25 [00013] In an embodiment, the current state of the vehicle being one of the parked state, the alert state, and an usage state.

[00014] In an embodiment, first ultra low threshold is less than the first pre-defined threshold, and the second ultra low threshold is less than the first ultra low threshold. In an embodiment, each of the thresholds being a state of charge of the secondary battery.

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[00015] In an embodiment, the one or more sensors include an inertial measurement unit (IMU) sensor, at least one positioning sensor, at least one position accuracy correction sensor, and at least one radio frequency identification (RFID) sensor.

[00016] In an embodiment, the one or more telemetry modules includes one or more
5 of wireless transceivers, cellular network transceivers, a global navigation satellite system (GNSS) transceiver, a Wireless Fidelity (WiFi) transceiver, and a Bluetooth transceiver.

[00017] In an embodiment, the primary battery is a high voltage battery, and the secondary battery is a low voltage battery. In an embodiment, the primary battery
10 is a 52 volts battery and the secondary battery is a 12 volts battery.

[00018] In an embodiment a mobile device of a user of the vehicle is configured to receive the updates from the remote server uploaded by the electronic control unit.

[00019] In an embodiment, charging the secondary battery from the primary battery by the battery management system comprises sending, by the battery management
15 system, to a charging controller to enable a charging circuit between the primary battery and the secondary battery. In an embodiment, the charging circuit includes a DC-DC converter.

[00020] In an aspect, a battery management system for dynamically managing a state of charge of a battery of a vehicle during a distress state of the vehicle is disclosed.
20 The battery management system is configured to determine a state of charge of the primary battery and a state of charge of the secondary battery in the vehicle. The battery management system is further configured to receive a current state of the vehicle from the at least one electronic control unit of the vehicle. The battery management system is configured to compare the state of charge of the secondary
25 battery with a first pre-defined threshold and the state of charge of the primary battery with a second pre-defined threshold. The battery management system is configured to charge the secondary battery from the primary battery when the state of charge of the secondary battery is below the first pre-defined threshold, and the state of charge of the primary battery is above the second pre-defined threshold.
30 The battery management system is configured to disable discharging of the primary

battery when the state of charge of the secondary battery is above the first pre-determined threshold.

[00021] In an embodiment, the battery management system is further configured to receive the current state of the vehicle being an alert state. The battery management system is configured to transmit a first warning to the at least one electronic control unit of the vehicle when the state of charge of the secondary battery is below the first pre-defined threshold, and the state of charge of the primary battery is below the second pre-defined threshold. The battery management system is configured to enable discharging the primary battery when the state of charge of the secondary battery is below a first ultra low threshold. The battery management system is configured to charge the secondary battery from the primary battery after the first warning maintaining the state of charge of the secondary battery above the first ultra low threshold. The battery management system is configured to disable discharging the primary battery when the state of charge of the secondary battery is above the first ultra low threshold. The battery management system is configured to transmit a second warning to the electronic control unit of the vehicle when the state of charge of the secondary battery is below a third pre-defined threshold, and the state of charge of the primary battery is below a fourth pre-defined threshold. The battery management system is configured to enable discharging the primary battery when the state of charge of the secondary battery is below a second ultra low threshold. The battery management system is configured to charge the secondary battery from the primary battery after the second warning maintaining the state of charge of the primary battery above the second ultra low threshold. The battery management system is configured to disable discharging the primary battery when the state of charge of the secondary battery is above the second ultra low threshold.

[00022] In an embodiment, the vehicle comprises a primary battery, a secondary battery, one or more battery management controllers, at least one charging system, at least one electronic control unit, one or more sensors, and one or more actuators.

[00023] In an embodiment, the at least one electronic control unit of the vehicle is configured to send a current state of the vehicle to the battery management system. The at least one electronic control unit is further configured to operate one or more

sensors, and one or more telemetry modules to determine a change in the current state of the vehicle. The at least one electronic control unit is further configured to determine a current state of the vehicle being changed to an alert state when one or more pre-defined conditions are satisfied. The at least one electronic control unit is further configured to transmit one or more alerts to a remote server during the alert state of the vehicle. The at least one electronic control unit is further configured to determine one of a first warning and a second warning being received from the battery management system. The at least one electronic control unit is further configured to disabling one or more electrical loads in the vehicle when the first warning is received from the battery management system. The at least one electronic control unit is further configured to enabling the one or more electrical loads intermittently at a first pre-defined frequency of time interval vehicle when the first warning is received from the battery management system. The at least one electronic control unit is further configured to updating a remote server when the second warning is received from the battery management system. The at least one electronic control unit is further configured to enabling the one or more electrical loads intermittently at a second pre-defined frequency of time interval vehicle when the second warning is received from the battery management system. In an embodiment, the second pre-defined frequency of time is proportional to the state of charge of the primary battery.

[00024] In an embodiment, the battery management system is configured to charge the secondary battery above the second ultra low threshold from the primary battery until the state of charge of the primary battery is below a third pre-defined threshold.

[00025] In an embodiment, the current state of the vehicle being one of the parked state, the alert state, and an usage state.

[00026] In an embodiment, the first ultra low threshold is less than the first pre-defined threshold, and the second ultra low threshold is less than the first ultra low threshold. In an embodiment, each of the thresholds being a state of charge of the secondary battery.

[00027] In an embodiment, the one or more sensors include an inertial measurement unit (IMU) sensor, at least one positioning sensor, at least one position accuracy correction sensor, and at least one radio frequency identification (RFID) sensor.

[00028] In an embodiment, the one or more telemetry modules includes one or more
5 of wireless transceivers, cellular network transceivers, a global navigation satellite system (GNSS) transceiver, a Wireless Fidelity (WiFi) transceiver, and a Bluetooth transceiver.

[00029] In an embodiment, the primary battery is a high voltage battery, and the secondary battery is a low voltage battery. In an embodiment, the primary battery
10 is a 52 volts battery and the secondary battery is a 12 volts battery.

[00030] In an embodiment, a mobile device of a user of the vehicle is configured to receive the updates from the remote server uploaded by the electronic control unit.

[00031] In an embodiment, charging the secondary battery from the primary battery by the battery management system comprises sending, by the battery management
15 system, to a charging controller to enable a charging circuit between the primary battery and the secondary battery. In an embodiment, the charging circuit includes a DC-DC converter.

Brief Description of Drawings

20[0010] Reference will be made to embodiments of the invention, examples of which may be illustrated in accompanying figures. These figures are intended to be illustrative, not limiting. Although the invention is generally described in context of these embodiments, it should be understood that it is not intended to limit the scope of the invention to these particular embodiments.

25[0011] Figure 1 is an exemplary diagram showing the interconnectivity and the communication between an anti-theft system in the vehicle, and the battery management system.

[0012] Figures 2(a) and 2 (b) are exemplary flow charts showing the method being implemented by the battery management system when the vehicle is in a distress
30 mode.

Detailed Description

[0013] Various features and embodiments of the present invention here will be discernible from the following description thereof, set out hereunder.

[0014] Figure 1 exemplarily shows the battery management system 111 and an anti-theft system 101 in the vehicle. The anti-theft system 101 is configured to raise a distress state alert depending upon one or more conditions being satisfied, as provided in the description below. The vehicle, being an electric vehicle according to the exemplary embodiment, consists of a primary battery 110 and a secondary battery 114. The primary battery 110 is a high voltage battery, which is primarily configured to provide power the drive system 120 of the vehicle. The primary battery 110 is equipped with a battery management system 111. The primary battery 110 generally consists of multiple lithium ion cells, arranged in series and parallel connections to provide a high output voltage from the battery 110. As per an embodiment, the output voltage of the primary battery is 52 Volts. As per another embodiment, the output voltage of the primary battery is 48 Volts. The output current is usually a direct current (DC) output. The battery management system 111 is configured for monitoring the health of the individual cells of the primary battery 110. Lithium ion cells are generally prone to heating while charging and discharging. If the heat of the cells increases beyond a threshold, the cells go into thermal runaway, where surrounding cells fail due the heat generated by the overheating cells. The battery management system 111 is therefore configured to monitor the temperature of each of the cells, and control the rate of charge and discharge in case it is determined that one or more of the cells are overheating. In case the primary battery 110 is equipped with cooling means, the battery management system 111 may also be configured to control such a cooling system to maintain the temperatures of all the cells in the primary battery 110. The drive system of an electric vehicle generally consists of one or more traction motors. The traction motors may be hub mounted on the driven wheel of the vehicle, or on the frame of the vehicle and connected to the driven wheel using one or more transmission means. The anti theft system 101 comprises at least one processor 102,

at least one memory unit 103, at least one telemetry module 104, and at least one input / output module 104. The at least one processor 102 is also referred to as an electronic control unit of the vehicle. The input / output module 105 is configured to be communicatively coupled to one or more sensors in the vehicle. The input /
5 output module 105 is also configured to be communicatively coupled to the battery management system 111 of the primary battery 110. The vehicle also includes a secondary battery 114. The secondary battery 114 is configured to power the anti theft system 101 in the vehicle. The secondary battery is also configured to power other one or more electrical loads in the vehicle, including, but not limited to, the
10 instrument cluster of the vehicle, the headlamp assembly, the cornering lamps, the front turn signal lamps, the rear turn signal lamps, the rear lamp assembly, etc. In an embodiment, the anti theft system 101 may be configured within the instrument cluster of the vehicle.

[0015] The secondary battery 114 is usually a low voltage battery. In an
15 embodiment, the secondary battery 114 has an output voltage of 12 Volts. as per an embodiment, the charge in the secondary battery is always maintained above a threshold state of charge (SOC), so that the output voltage is maintained above a corresponding threshold voltage, to ensure that all the other electrical loads in the
vehicle 115 are functioning properly. This can be done by charging the secondary
20 battery 114 from the primary battery 110 through a DC-DC converter 113. The DC-DC converter 113 is required because of the difference in the voltage ratings of the two batteries 110 and 114. The same DC-DC converter may be used to charge the primary battery 110 as well. The primary battery 110 is further equipped with electrical connectors 112, which provide the current output to the drive system 120,
25 as well as facilitate charging of the primary battery 110 from an external power source 116. Since the voltage rating of the external power source 116 may be different from the voltage rating of the primary battery 110, the external power source 116 is first connected to the DC-DC converter 113, the output of which is then sent to the primary battery 110. The vehicle may also include a system wherein
30 the external power source 116 may charge the secondary battery 114 directly through the DC-DC converter 113.

[0016] As per an embodiment of the present invention, the anti theft system 101 is configured to determine a distress state of the vehicle. While in the distress state, the anti theft system is configured to raise an alert, and apprise the owner of the vehicle regarding the current location of the vehicle. The anti theft system 101 is configured to communicate with one or more electronic control units in the vehicle. The one or more other electronic control units may include a vehicle control unit, one or more microcontroller in the instrument cluster of the vehicle, and one or more microcontrollers for controlling one or more actuators in the vehicle. The anti theft system 101, through the input / output module 105, is configured to receive data of each of the sensors of the vehicle, through the one or more electronic control units of the vehicle. The anti theft system 101, in order to provide the current vehicle location to the owner of the vehicle, requires to draw electrical power, which is provided by the secondary battery 114.

[0017] As per an embodiment, the processor 102 in the anti theft system 101 is configured to send a current state of the vehicle to the battery management system 111. The the processor 102 in the anti theft system 101 is further configured to operate one or more sensors, and the telemetry module 104 to determine a change in the current state of the vehicle. The one or more sensors include an inertial measurement unit (IMU), a camera, a global navigation satellite system (GNSS) module, motion sensors, etc. The camera can detect when the vehicle has been tampered with using one or more image processing means. The GNSS module can track the location of the vehicle in case it has been moved, or towed without the consent of the owner of the vehicle. The same may be achieved by the IMU sensor as well, which is configured to determine the orientation of the vehicle with respect to a base condition. The following description is descriptive of the anti theft system 101 determining vehicle being in a distress state. The vehicle being in a distress state is indicative of the anti theft system 101 receiving one or more signals from the one or more sensors mentioned above, and determining that the vehicle is being tampered with externally, and raising one or more alerts and being in an alert state. As per an embodiment, the distress state is triggered from either a parked state. While in the distress state of the vehicle, the anti-theft system 101 is in an alert state.

The processor 102 in the anti theft system 101 is further configured to determine a current state of the vehicle being changed to an distress state when one or more pre-defined conditions are satisfied. The pre-defined conditions include the vehicle being moved while in a parked state, the vehicle having fallen down while in the parked state, etc. The processor 102 in the anti theft system 101 is further configured to be in the alert state, and transmit one or more alerts to a remote server during the alert state of the vehicle. The telemetry module 104 includes one or more wireless communication means, such as cellular, wireless fidelity (Wi-Fi), Bluetooth, GNSS. When the system detects that the vehicle is being moved while in a parked state, the remote server then transmits the alert to a registered device of the user, and further provide the user with a current location of the vehicle in case the vehicle has been moved, for easier tracking and retrieval. Continuous monitoring of the location of the vehicle however consumes a lot of power. Since the secondary battery 114 is configured to supply electrical power to the anti-theft system 101, the state of charge of the secondary battery 114 is also monitored by the battery management system 111 of the primary battery 110 when the anti theft system 101 raises the alert state. In order to prolong the life of the batteries 110 and 114 while in the alert state, the battery management system 111 changes the protocols for maintaining the state of charge of the batteries 110 and 114. While the alert state has not been raised, the battery management system 111 is configured for comparing the state of charge of the secondary battery 114 with a first pre-defined threshold and the state of charge of the primary battery 110 with a second pre-defined threshold. In an embodiment, the first pre-defined threshold being the output voltage of the secondary battery 114 at 14 Volts. In an embodiment, the second pre-defined threshold being the state of charge of the primary battery 110 is above 15 % - 20 %. The battery management system 111 is further configured for charging the secondary battery 114 from the primary battery 110 when the state of charge of the secondary battery 114 is below the first pre-defined threshold, and the state of charge of the primary battery 110 is above the second pre-defined threshold. The battery management system 111 is further configured for disabling the discharging of the primary battery 110 when the state of charge of the secondary

battery 114 is above the first pre-determined threshold. However, while in the alert state, the battery management system 111 is configured for transmitting a first warning to the processor 102 when the state of charge of the secondary battery 114 is below the first pre-defined threshold, and the state of charge of the primary battery 110 is below the second pre-defined threshold. The battery management system 111 is further configured for enabling discharging of the primary battery 110 when the state of charge of the secondary battery 114 is below a first ultra low threshold. In an embodiment, the first ultra low threshold being when the output voltage of the secondary battery 114 at 11.5 Volts. The battery management system 111 is further configured for charging the secondary battery 114 from the primary battery 110 after the first warning, maintaining the state of charge of the secondary battery 114 above the first ultra low threshold. The battery management system 111 is further configured for disabling discharging of the primary battery 110 when the state of charge of the secondary battery 114 is above the first ultra low threshold. This process is repeated until the state of charge of the secondary battery 114 falls below a third pre-defined threshold, and the state of charge of the primary battery 110 falls below a fourth pre-defined threshold. In an embodiment, the third pre-defined threshold is lower than the first pre-defined threshold, and the fourth pre-defined threshold is lower than the second pre-defined threshold. In an embodiment, the fourth pre-defined threshold being the state of charge of the primary battery at 10 % - 12 % of the full charge capacity of the primary battery 110. The battery management system 111 is further configured for transmitting a second warning to the processor 102 when the state of charge of the secondary battery 114 is below the third pre-defined threshold, and the state of charge of the primary battery 110 is below the fourth pre-defined threshold. The battery management system 111 is further configured for enabling discharging the primary battery 110 when the state of charge of the secondary battery 114 is below a second ultra low threshold. In an embodiment, the second ultra low threshold being the output voltage of the secondary battery 114 at 10.5 Volts. When the output of the secondary battery 114 falls below the second ultra low threshold, the battery management system 111 is further configured for charging the secondary battery 114 from the primary battery

110 after the second warning maintaining the state of charge of the secondary battery 114 above the second ultra low threshold. The battery management system 111 is further configured for disabling discharging of the primary battery 110 when the state of charge of the secondary battery 114 is above the second ultra low
5 threshold. This process is repeated by the battery management system 111 until the primary battery 110 is at 0 % state of charge, i.e., completely depleted, or the vehicle is connected to a charging port for recharging of the primary battery 110.

[0018] The processor 102 in the anti theft system 101 is further configured to determine one of the first warning and the second warning being received from the
10 battery management system 111. The processor 102 in the anti theft system 101 is further configured to disable one or more electrical loads in the vehicle when the first warning is received from the battery management system 111. The processor 102 in the anti theft system 101 is further configured to enable the one or more electrical loads intermittently at a first pre-defined frequency of time interval
15 vehicle when the first warning is received from the battery management system 111. The one or more electrical loads may be the various wireless communication systems in the telemetry module. In an embodiment, the default frequency of activating the one or more electrical loads 1 – 120 times per minute. When the first warning is received, the anti theft system 101 switches to the first pre-defined
20 frequency, which is lesser than the default frequency. In an embodiment, the first pre-defined frequency is 1 – 120 times per hour. The processor 102 in the anti theft system 101 is further configured to update a remote server when the second warning is received from the battery management system 111. The update contains the warning that the state of charge of the primary battery 110 has fallen below the
25 fourth pre-defined threshold, and that the location data may not be transmitted as frequently. The processor 102 in the anti theft system 101 is further configured to enable the one or more electrical loads intermittently at a second pre-defined frequency of time interval when the second warning is received. In an embodiment, the second pre-defined frequency is lesser than the first pre-defined frequency. In
30 another embodiment, the second pre-defined frequency is proportional to the state

of charge of the primary battery 110, wherein the second pre-defined frequency reduces as the state of charge of the primary battery keeps reducing.

[0019] Figure 2A-2B represent an exemplary flow chart showing the method of dynamically managing the state of charge of the battery 110 by the battery management system 111 before and during the distress state, while the vehicle is in a parked condition. The method comprises determining 201, by the battery management system 111, a state of charge of the primary battery 110 and the secondary battery 114 in the vehicle. The method further comprises receiving 202, by the battery management system 111, a current state of the vehicle from an electronic control unit of the vehicle, which according to the present embodiment, in the anti-theft system 101 of the vehicle. The method further comprises comparing 203, by the battery management system 111, the state of charge of the secondary battery 114 with the first pre-defined threshold, and the state of charge of the primary battery 110 with the second pre-defined threshold. The values of the first pre-defined threshold and the second pre-defined threshold, according to an embodiment, are given in the paragraphs above. The method further comprises charging 204, by the battery management system 111, the secondary battery 114 from the primary battery 110 when the state of charge of the secondary battery 114 is below the first pre-defined threshold, and the state of charge of the primary battery 110 is above the second pre-defined threshold. The method further comprises disabling 205, by the battery management system 111, discharging of the primary battery 110 when the state of charge of the secondary battery 114 is above the first pre-determined threshold. The method further comprises receiving 206, by the battery management system 111, the current state of the vehicle being an alert state. In an embodiment, the alert state is a heightened state of the distress state. As per this embodiment, the distress state may be raised, however the battery management system 111 may not be dynamically configured to respond to it. Only when the current state of the vehicle is determined as an alert state, the battery management system 111 is configured to dynamically respond according to the present description. The method further comprises transmitting 207, by the battery management system 111, a first warning to the anti theft system 101 of the vehicle

when the state of charge of the secondary battery 114 is below the first pre-defined threshold, and the state of charge of the primary battery 110 is below the second pre-defined threshold. The method further comprises enabling 208, by the battery management system 111, discharging the primary battery 110 when the state of charge of the secondary battery 114 is below a first ultra low threshold. The method further comprises charging 209, by the battery management system 111, the secondary battery 114 from the primary battery 110 after the first warning for maintaining the state of charge of the secondary battery 114 above the first ultra low threshold. The method further comprises disabling 210, by the battery management system 111, discharging the primary battery 110 when the state of charge of the secondary battery 114 is above the first ultra low threshold. The method further comprises transmitting 211, by the battery management system 111, a second warning to the anti-theft system 101 of the vehicle when the state of charge of the secondary battery 114 is below a third pre-defined threshold, and the state of charge of the primary battery 110 is below a fourth pre-defined threshold. The method further comprises enabling 212, by the battery management system 111, discharging of the primary battery 110 when the state of charge of the secondary battery 114 is below a second ultra low threshold. The method further comprises charging 213, by the battery management system 111, the secondary battery 114 from the primary battery 110 after the second warning maintaining the state of charge of the secondary battery 114 above the second ultra low threshold. The method further comprises disabling 214, by the battery management system 111, discharging the primary battery 110 when the state of charge of the secondary battery 114 is above the second ultra low threshold.

25[0020] Accordingly, the advantages associated with the method as described above are that the remaining charge in the primary battery 110, which is the high voltage battery, is prolonged. The secondary battery 114 is usually charged by drawing electrical power from the primary battery 110. During the distress state of the vehicle, or when the anti theft system 101 has raised the alert state, the battery management system changes to a modified logic, which allows the anti theft system 101 to function beyond a benchmark time if the battery management system was

functioning normally. This translates to a better possibility of locating the vehicle if it has been moved without the owner's consent. By changing the frequency of transmission to the remote server, the anti-theft system 101 also contributes to preserving the battery life under the distress state, upon receiving the first and
5 second warning. Upon receiving the second warning, the anti theft system 101 switches to a second pre-defined frequency of time interval of transmission, wherein the second pre-defined frequency is inversely proportional to the state of charge of the primary battery 110. The output voltage of the secondary battery also reduces to the minimum output voltage required for functioning of the one or more
10 electrical loads in the telemetry module, which also decreases the charge consumption.

We claim:

1. A method for dynamically managing a state of charge of a battery of a vehicle during a distress state, the method comprising steps of:
 - determining, by a battery management system, a state of charge of a primary
5 battery and a secondary battery in the vehicle;
 - receiving, by the battery management system, a current state of the vehicle from an electronic control unit of the vehicle;
 - comparing, by the battery management system, the state of charge of the secondary battery with a first pre-defined threshold and the state of charge of
10 the primary battery with a second pre-defined threshold;
 - charging, by the battery management system, the secondary battery from the primary battery when the state of charge of the secondary battery is below the first pre-defined threshold, and the state of charge of the primary battery is above the second pre-defined threshold; and,
 - 15 disabling, by the battery management system, discharging of the primary battery when the state of charge of the secondary battery is above the first pre-determined threshold.
2. The method as claimed in claim 1, further comprising the steps of:
 - 20 receiving, by the battery management system, the current state of the vehicle being an alert state;
 - transmitting, by the battery management system, a first warning to the electronic control unit of the vehicle when the state of charge of the secondary battery is below the first pre-defined threshold, and the state of charge of the
25 primary battery is below the second pre-defined threshold;
 - enabling, by the battery management system, discharging the primary battery when the state of charge of the secondary battery is below a first ultra low threshold;
 - 30 charging, by the battery management system, the secondary battery from the primary battery after the first warning maintaining the state of charge of the secondary battery above the first ultra low threshold;

disabling, by the battery management system, discharging the primary battery when the state of charge of the secondary battery is above the first ultra low threshold;

5 transmitting, by the battery management system, a second warning to the electronic control unit of the vehicle when the state of charge of the secondary battery is below a third pre-defined threshold, and the state of charge of the primary battery is below a fourth pre-defined threshold;

10 enabling, by the battery management system, discharging the primary battery when the state of charge of the secondary battery is below a second ultra low threshold;

charging, by the battery management system, the secondary battery from the primary battery after the second warning maintaining the state of charge of the primary battery above the second ultra low threshold; and,

15 disabling, by the battery management system, discharging the primary battery when the state of charge of the secondary battery is above the second ultra low threshold.

3. The method as claimed in claim 1, wherein the electronic control unit of the vehicle is configured to:

20 send a current state of the vehicle to the battery management system;
operate one or more sensors, and one or more telemetry modules to determine a change in the current state of the vehicle;

determine a current state of the vehicle being changed to the distress state when one or more pre-defined conditions are satisfied ;

25 transmit one or more alerts to a remote server during the distress state of the vehicle, and change to an alert state;

determine one of a first warning and a second warning being received from the battery management system;

30 disabling one or more electrical loads in the vehicle when the first warning is received from the battery management system;

enabling the one or more electrical loads intermittently at a first pre-defined frequency of time interval vehicle when the first warning is received from the battery management system;

5 updating a remote server when the second warning is received from the battery management system; and,

enabling the one or more electrical loads intermittently at a second pre-defined frequency of time interval vehicle when the second warning is received from the battery management system;

10 wherein, the second pre-defined frequency of time is proportional to the state of charge of the primary battery.

4. The method as claimed in claim 1, wherein the battery management system is configured to charge the secondary battery above the second ultra low threshold from the primary battery until the state of charge of the primary battery is below
15 a third pre-defined threshold.

5. The method as claimed in claim 1, wherein the current state of the vehicle being one of a parked state, a distress state, and an usage state, wherein the electronic control unit of the vehicle is configured to switch to an alert state when the
20 distress state is determined, and transmit one or more alerts to a remote server.

6. The method as claimed in claim 1, wherein the first ultra low threshold is less than the first pre-defined threshold, and the second ultra low threshold is less than the first ultra low threshold, wherein each of the thresholds being a state of
25 charge of the secondary battery.

7. The method as claimed in claim 2, wherein the one or more sensors include an inertial measurement unit (IMU) sensor, at least one positioning sensor, at least one position accuracy correction sensor, and at least one radio frequency
30 identification (RFID) sensor.

8. The method as claimed in claim 2, wherein the one or more telemetry modules includes one or more of wireless transceivers, cellular network transceivers, a global navigation satellite system (GNSS) transceiver, a Wireless Fidelity (WiFi) transceiver, and a Bluetooth transceiver.

5

9. The method as claimed in claim 1,
wherein the primary battery is a high voltage battery, and the secondary battery is a low voltage battery, wherein the primary battery is a 52 volts battery and the secondary battery is a 12 volts battery; and

10 wherein charging the secondary battery from the primary battery by the battery management system comprises sending, by the battery management system, to a charging controller to enable a charging circuit between the primary battery and the secondary battery, wherein the charging circuit includes a DC-DC converter.

15

10. The method as claimed in claim 3, wherein a mobile device of a user of the vehicle is configured to receive the updates from the remote server uploaded by the electronic control unit.

- 20 11. A battery management system for dynamically managing a state of charge of a battery of a vehicle during a distress state of the vehicle, the battery management system is configured to:

determine a state of charge of the primary battery and a state of charge of the secondary battery in the vehicle;

25 receive a current state of the vehicle from the at least one electronic control unit of the vehicle;

compare the state of charge of the secondary battery with a first pre-defined threshold and the state of charge of the primary battery with a second pre-defined threshold;

30 charge the secondary battery from the primary battery when the state of charge of the secondary battery is below the first pre-defined threshold, and the

state of charge of the primary battery is above the second pre-defined threshold;
and,

disable discharging of the primary battery when the state of charge of the
secondary battery is above the first pre-determined threshold.

5

12. The battery management system as claimed in claim 11, wherein the battery
management system is further configured to:

receive the current state of the vehicle being an alert state;

10 transmit a first warning to the at least one electronic control unit of the
vehicle when the state of charge of the secondary battery is below the first pre-
defined threshold, and the state of charge of the primary battery is below the
second pre-defined threshold;

enable discharging of the primary battery when the state of charge of the
secondary battery is below a first ultra low threshold;

15 charge the secondary battery from the primary battery after the first warning
maintaining the state of charge of the secondary battery above the first ultra low
threshold;

disable discharging of the primary battery when the state of charge of the
secondary battery is above the first ultra low threshold;

20 transmit a second warning to the electronic control unit of the vehicle when
the state of charge of the secondary battery is below a third pre-defined
threshold, and the state of charge of the primary battery is below a fourth pre-
defined threshold;

25 enable discharging the primary battery when the state of charge of the
secondary battery is below a second ultra low threshold;

charge the secondary battery from the primary battery after the second
warning maintaining the state of charge of the primary battery above the second
ultra low threshold; and,

30 disable discharging the primary battery when the state of charge of the
secondary battery is above the second ultra low threshold.

13. The battery management system as claimed in claim 11, wherein the vehicle comprises a primary battery, a secondary battery, one or more battery management controllers, at least one charging system, at least one electronic control unit, one or more sensors, and one or more actuators.

5

14. The battery management system as claimed in claim 11, wherein the at least one electronic control unit of the vehicle is configured to:

send a current state of the vehicle to the battery management system,

operate one or more sensors, and one or more telemetry modules to

10 determine a change in the current state of the vehicle,

determine a current state of the vehicle being changed to an alert state when one or more pre-defined conditions are satisfied,

transmit one or more alerts to a remote server during the alert state of the vehicle,

15 determine one of a first warning and a second warning being received from the battery management system,

disabling one or more electrical loads in the vehicle when the first warning is received from the battery management system,

20 enabling the one or more electrical loads intermittently at a first pre-defined frequency of time interval vehicle when the first warning is received from the battery management system,

updating a remote server when the second warning is received from the battery management system,

25 enabling the one or more electrical loads intermittently at a second pre-defined frequency of time interval vehicle when the second warning is received from the battery management system,

wherein, the second pre-defined frequency of time is proportional to the state of charge of the primary battery.

30 15. The battery management system as claimed in claim 11, wherein the battery management system is configured to charge the secondary battery above the

second ultra low threshold from the primary battery until the state of charge of the primary battery is below a third pre-defined threshold.

16. The battery management system as claimed in claim 11, wherein the current
5 state of the vehicle being one of a parked state, a distress state, and an usage state, wherein the electronic control unit of the vehicle is configured to switch to an alert state when the distress state is determined, and transmit one or more alerts to a remote server.

10 17. The battery management system as claimed in claim 12, wherein the first ultra low threshold is less than the first pre-defined threshold, and the second ultra low threshold is less than the first ultra low threshold, wherein each of the thresholds being a state of charge of the secondary battery.

15 18. The battery management system as claimed in claim 13, wherein the one or more sensors include an inertial measurement unit (IMU) sensor, at least one positioning sensor, at least one position accuracy correction sensor, and at least one radio frequency identification (RFID) sensor.

20 19. The battery management system as claimed in claim 14, wherein the one or more telemetry modules includes one or more of wireless transceivers, cellular network transceivers, a global navigation satellite system (GNSS) transceiver, a Wireless Fidelity (WiFi) transceiver, and a Bluetooth transceiver.

25 20. The battery management system as claimed in claim 11,

wherein the primary battery is a high voltage battery, and the secondary battery is a low voltage battery, wherein the primary battery is a 52 volts battery and the secondary battery is a 12 volts battery; and

30

wherein charging the secondary battery from the primary battery by the battery management system comprises sending, by the battery management system, to a charging controller to enable a charging circuit between the primary battery and the secondary battery, wherein the charging circuit includes a DC-
5 DC converter.

21. The battery management system as claimed in claim 14, wherein a mobile device of a user of the vehicle is configured to receive the updates from the remote server uploaded by the electronic control unit.
10

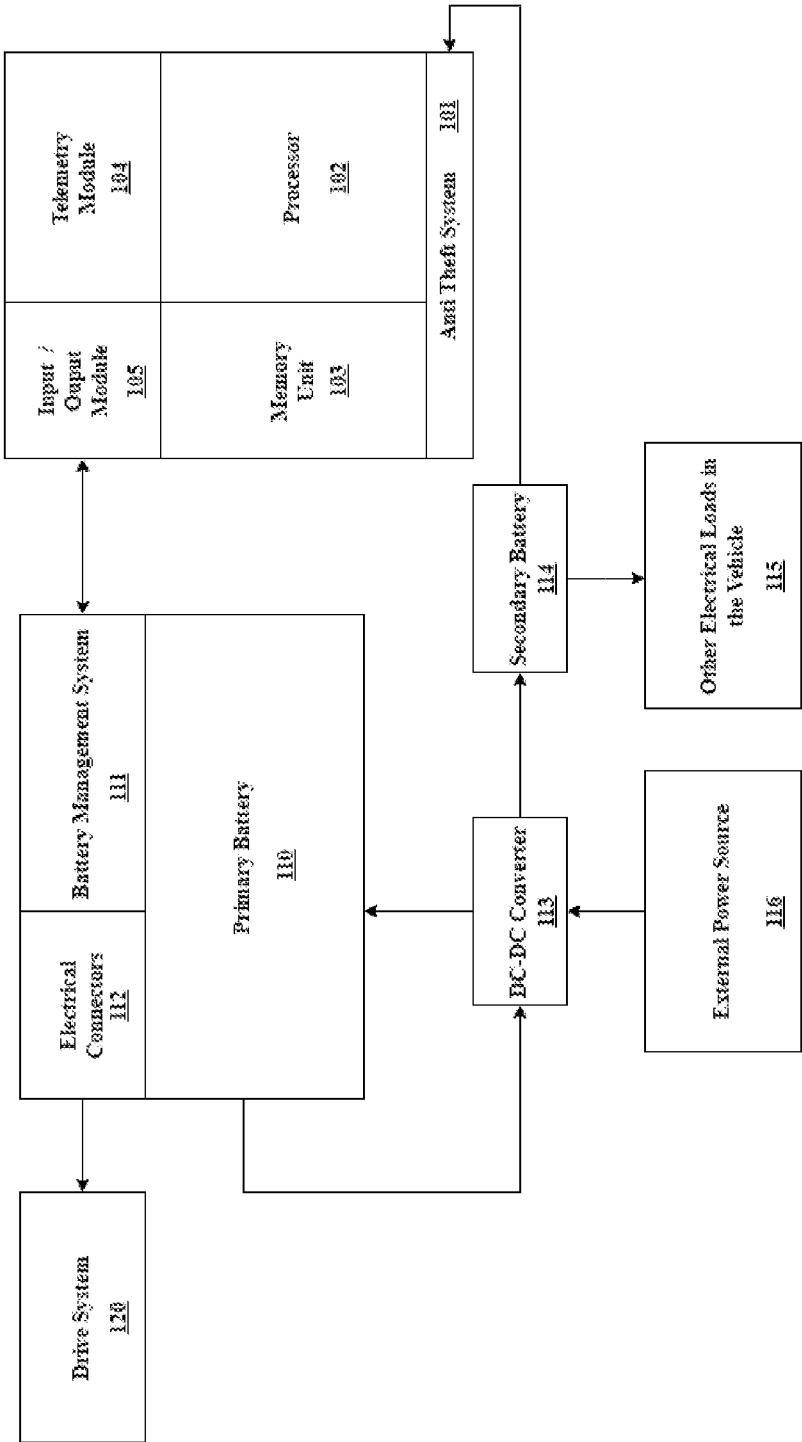


Figure 1

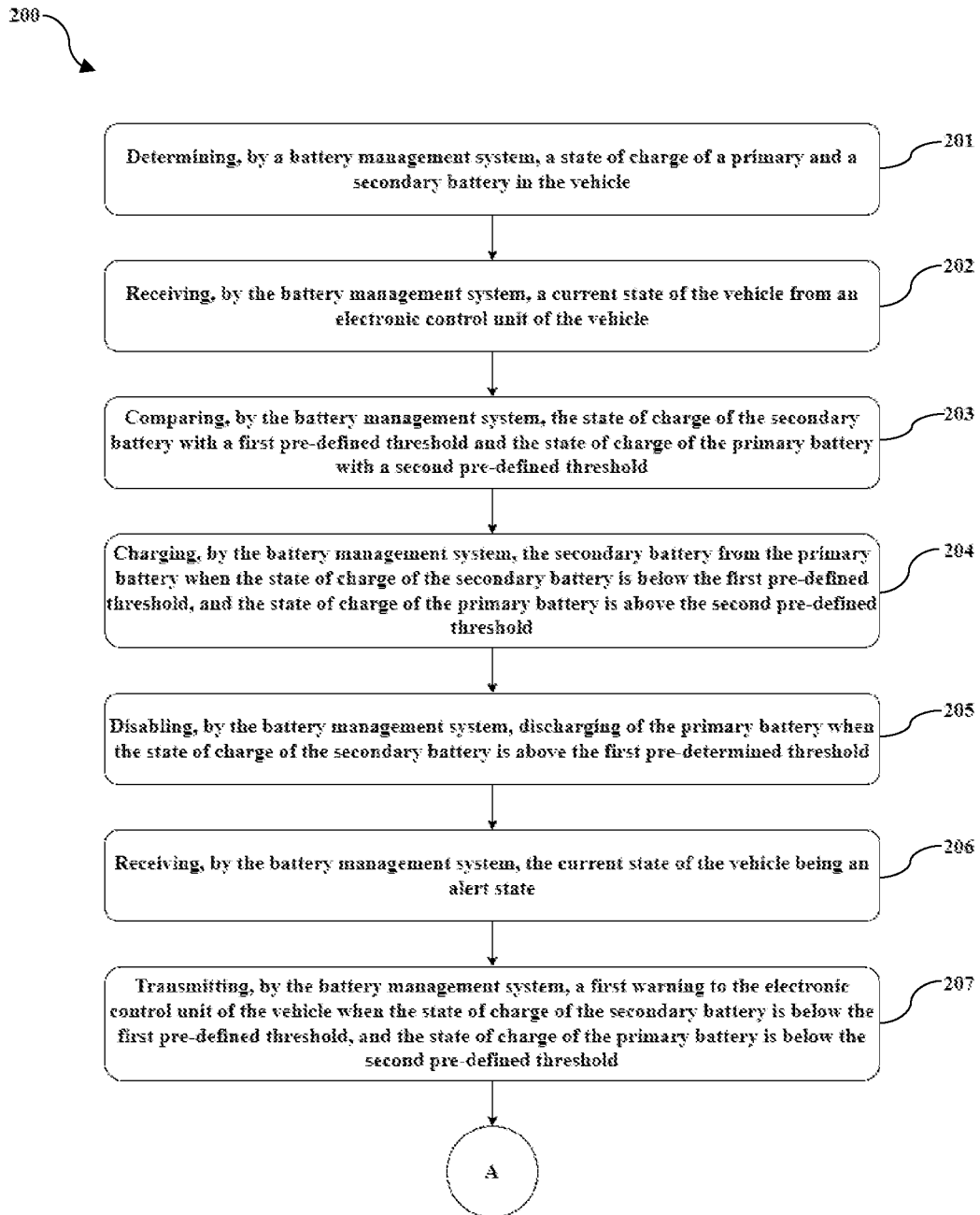


Figure 2A

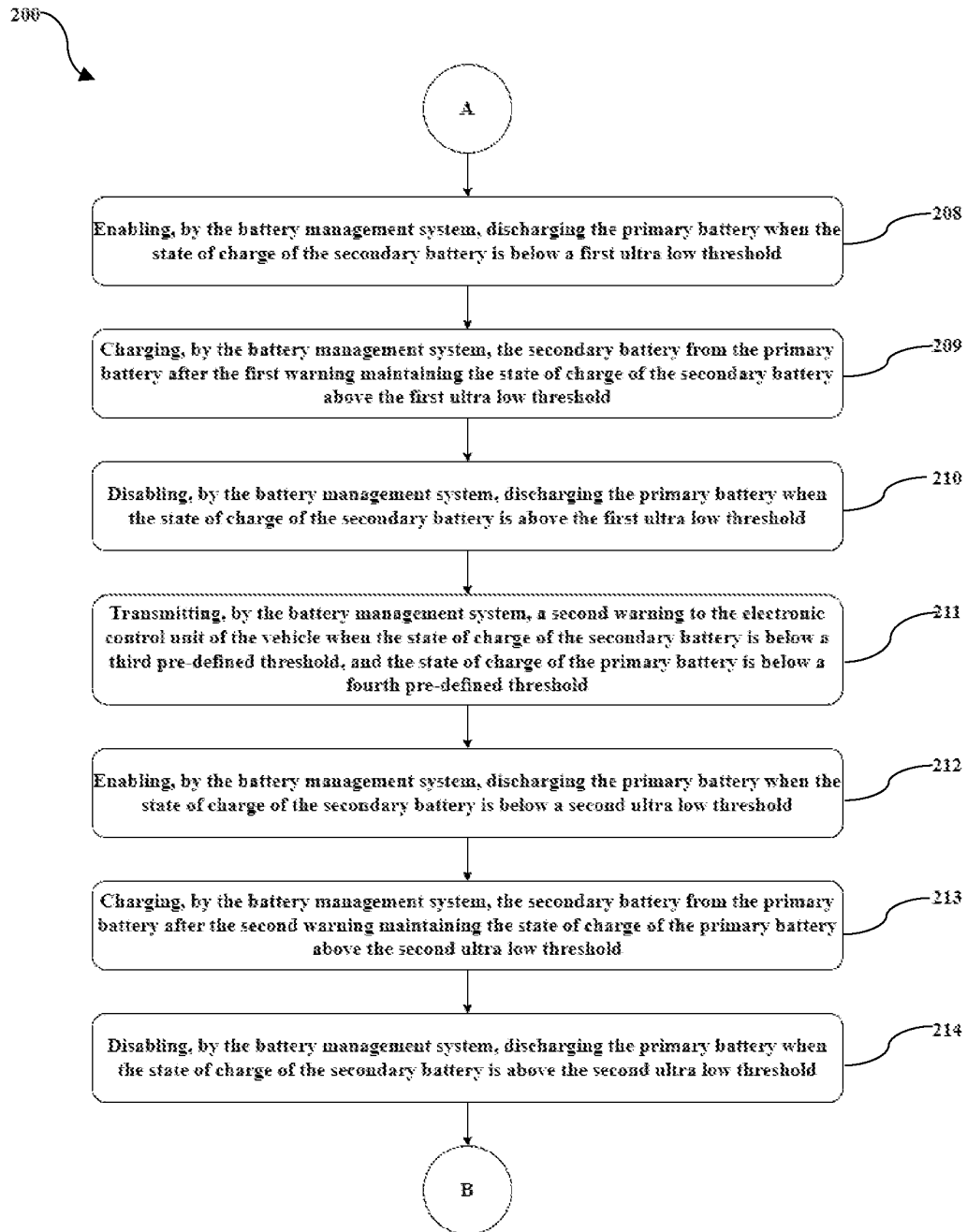


Figure 2B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2024/052350

A. CLASSIFICATION OF SUBJECT MATTER

B60L58/18, B60L58/13, H02J7/00, H02J7/34, G01R31/367, H01M10/48

Version=2025.01

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, H02J, G01R, H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

PatSeer, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US20220209544A1, (LG ENERGY SOLUTION, LTD.) 30 JUNE 2022 (30-06-2022) paragraphs [0055], [0075], [0131]-[0167], fig. 1, 10A, 10B, 11, 12	1, 11, 13
Y	paragraphs [0055], [0075], [0131]-[0167], fig. 1, 10A, 10B, 11, 12	2-10, 12, 14-21
Y	US20130221741A1, (FORD GLOBAL TECHNOLOGY LLC) 29 AUGUST 2013 (29-08-2013) paragraphs [0033]-[0064], fig. 10, 12, 13	2-10, 12, 14-21



Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"I" 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

07-04-2025

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IN2024/052350

Citation	Pub.Date	Family	Pub.Date
US 20220209544 A1	30-06-2022	EP 3960533 A1	02-03-2022
		KR 20210029895 A	17-03-2021
		JP 2022532515 A	15-07-2022
		WO 2021045539 A1	11-03-2021
US 2013221741 A1	29-08-2013	CN 103287279 A	11-09-2013
		DE 102013202725 A1	29-08-2013