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## (54) Title: A BATTERY CHARGING SYSTEM FOR A VEHICLE AND A METHOD THEREOF

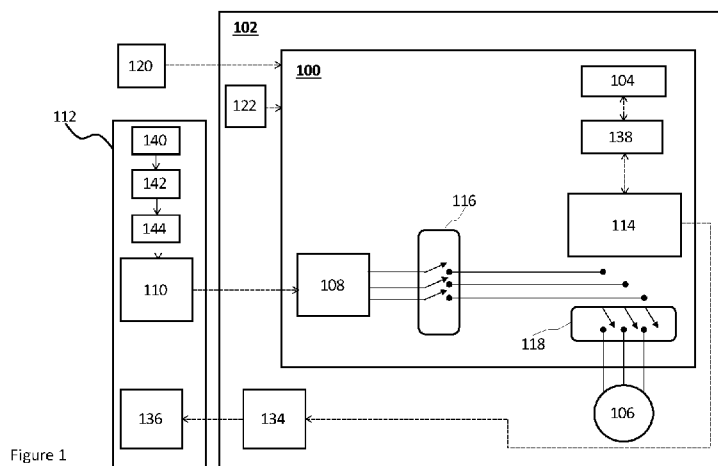


Figure 1

(57) Abstract: The present invention relates to a wireless battery charging system for an electric vehicle. The charging system (100) comprises a receiver unit (108) and communicably coupled to a transmitter unit (110) of a charging hub (112) disposed outside the vehicle (102). The system (100) comprises a control unit (114) coupled with the receiver unit (108), a battery pack (104), and a motor (106). The system comprises a first switch (116) connected between the receiver unit (108) and the control unit (114) to selectively supply power from the receiver unit (108) to the battery pack (104) for charging. The system comprises a second switch (118) connected between the control unit (114) and the motor (106). In battery charging mode, control unit (114) is configured to turn ON first switch (116) and turn OFF second switch (118) thereby charging battery pack (104). The charging system eliminates on-board charger in electric vehicles.



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**TITLE OF INVENTION****A Battery Charging System for a Vehicle and a Method thereof****FIELD OF THE INVENTION**

[001] The present invention generally relates to a battery charging system, and more particularly to a battery charging system for wirelessly charging an electric vehicle.

**5 BACKGROUND OF THE INVENTION**

[002] Present electric vehicles in the market use an on-board charger for charging a battery pack and a separate motor controller circuit for driving motor. Generally, rating and specifications of the on-board charger is found to be inferior when compared to a motor controller. It has also been observed that the vehicle's on-board charger could not be used while riding the vehicle and the motor controller could not be used while charging the vehicle. Thus, existing battery charging system involve two separate units for carrying out the functions of charging the battery of the vehicle and driving the vehicle. The use of two separate units for the two functions would increase an overall weight of the vehicle and also the associated cost. In addition to said limitations, it may result in obstructing an air flow that is intended for cooling the electric components in the vehicle and packaging would be difficult.

[003] Further, the existing charger configurations, where the chargers are external to the vehicle, the vehicles have used high cross section wires for connecting the battery and AC mains, resulting in routing issues of the wires. Also, connecting the AC mains to the vehicle may be difficult when ambient light is low, causing discomfort to the user.

[004] In the prior arts related to integrated on-board chargers, AC mains (220V) is used directly to charge EV (Electric Vehicle) battery which demands MOSFETs with higher breakdown voltages within the on-board chargers for applications involving low battery voltage (<100V). Further, in the prior arts related to wireless charging, HF Inverter in the external charging infrastructure/ charging hub is used for controlling current and voltage supplied to the battery by taking feedback from a controller of the on-board charger via a wireless communication channel.

[005] Wireless charging is emerging technology in the field of charging electric vehicles, although it has been used to charge low power devices earlier. So, topologies/schematics related to wireless charging are not typical.

[006] Thus, there is a need in the art for a wireless battery charging system for a vehicle which addresses at least the aforementioned problems.

## **SUMMARY OF THE INVENTION**

[007] In one aspect, the present invention is directed to a battery charging system for a vehicle. The battery charging system includes a wireless power receiver unit disposed on the vehicle and communicably coupled to a wireless power transmitter unit of a charging hub disposed outside the vehicle. The receiver unit configured to receive wireless power from the transmitter unit and supply the power for charging a battery pack of the vehicle, a control unit electrically coupled with the receiver unit, the battery pack, and a motor; a first switch connected between the receiver unit and the control unit to selectively supply power from the receiver unit to the battery pack for charging the battery pack; and a second switch connected between the control unit and the motor; wherein, in a battery charging

mode of the vehicle, the control unit is configured to turn ON the first switch and turn OFF the second switch thereby charging the battery pack; and in a drive mode of the vehicle, the control unit is configured to turn ON the second switch and turn OFF the first switch thereby supplying power to the motor.

5 [008] In an embodiment, the control unit is configured to receive a battery charging mode signal from a user wherein the battery charging mode signal requests the control unit to charge the battery pack.

[009] In another embodiment, the system includes a first communication module disposed on the vehicle and in communication with the control unit; and a second communication  
10 module disposed with the charging hub and in communication with the first communication module. In an embodiment, the first communication module is configured to receive the charging mode signal and transmit the charging mode signal to the second communication module. The second communication module is configured to receive the charging mode signal and generate an authorization signal whereby the charging hub initiates  
15 transmission of wireless power. In a further embodiment, the first communication module is configured to: receive control parameters from the control unit; and transmit the control parameters to the second communication module. In an embodiment, the control parameters include a duty ratio, a phase shift and frequency of operation required for charging the battery pack.

20 [010] In an embodiment, the system includes a switch disposed on the vehicle for generating the charging mode signal. In another embodiment, the system includes a handheld device configured for generating the charging mode signal.

[011] In one embodiment, the receiver unit includes a receiver coil configured for wireless power transmission, the receiver coil disposed at any one of a front wheel mudguard, a rear wheel mudguard, a top of a number plate, side panels of the vehicle and on one or more locations where EMI / EMC interference is not observed.

5 [012] In another embodiment, the charging hub includes an AC power supply; an AC-DC converter connected to the AC power supply; an inverter connected to the AC-DC converter for converting the DC to a high frequency AC; and the wireless power transmitter unit.

[013] In a further embodiment, the system includes a stepdown transformer and a power  
10 factor correction circuit electrically coupled with the control unit for charging the battery pack from the AC power supply.

[014] In another aspect, the present invention relates to a method for charging a battery pack of a vehicle, including the steps of: receiving, by a control unit, a battery charging mode signal requesting the control unit to charge the battery pack; turning ON a first  
15 switch, by the control unit, connected between a wireless power receiver unit and the control unit; turning OFF a second switch, by the control unit, connected between the control unit and a motor; transmitting, by the control unit, the battery charging mode signal to a charging hub; receiving, by the charging hub, the battery charging mode signal; generating, by the charging hub, an authorization signal to initiate wireless power  
20 transmission; initiating, by the charging hub, transmission of wireless power; receiving, by the receiver unit, the wireless power; and supplying, by the control unit through the first switch, the power to the battery pack thereby charging the battery pack.

[015] In an embodiment, the method includes the step of generating the battery charging mode signal by a user using a switch or a handheld device.

[016] In another embodiment, the method includes the step transmitting control parameters from a first communication module to a second communication module.

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## BRIEF DESCRIPTION OF THE DRAWINGS

[017] 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.

Figure 1 illustrates a schematic block diagram of a battery charging system of a vehicle, in accordance with an embodiment of the invention.

Figure 2 illustrates a schematic diagram of an electric vehicle incorporating the battery charging system of Figure 1, in accordance with an embodiment of the invention.

Figure 3 illustrates a flowchart of method for charging a battery pack of the electric vehicle, in accordance with another embodiment of the invention.

## DETAILED DESCRIPTION OF THE INVENTION

[018] The present invention generally relates to a battery charging system. Particularly, it relates to a wirelessly charging of a battery pack of an electric vehicle.

[019] Figure 1 illustrates a schematic block diagram of a battery charging system 100 of a vehicle 102, in accordance with an embodiment of the present invention. The schematic

block diagram illustrating the battery charging system 100 is an exemplary illustration. It is to be understood that the layout of the components of the battery charging system 100 as illustrated in Figure 1 should not be construed as the only possible layout. A person skilled in the art may propose one or more multiple ways or schematic layouts of the wireless charging system apart from the schematic layout depicted in Figure 1.

[020] As illustrated in the Figure 1, the battery charging system 100 has a charging hub 112 and a wireless power receiver unit 108. The wireless power receiver unit 108 is disposed on the vehicle 102. The terms 'wireless power receiver unit' and 'receiver unit' as mentioned hereinafter have been interchangeably used. In an embodiment, the receiver unit 108 includes a receiver coil. The receiver coil is made of metallic material known in the art. The receiver coil is configured to generate an AC power output based on induced electrons in the receiver coil due to a magnetic induction created by a wireless power transmitter unit 110. Thus, the receiver coil is configured to receive wireless power from the transmitter unit 110.

[021] The charging hub 112 has one or more components like an AC power supply 140, an AC-DC converter 142 connected to the AC power supply 140, an inverter 144 connected to the AC-DC converter 142 for converting the DC to a high frequency AC, and a wireless power transmitter unit 110. The terms 'wireless power transmitter unit' and 'transmitter unit' as mentioned hereinafter have been interchangeably used.

[022] In an embodiment, the transmitter unit 110 is provided outside the charging hub 112. Thus, the location of the transmitter unit 110 with respect to the charging hub 112 should not be limiting the scope of the present invention. However, it should be ensured that the

transmitter coil is placed outside the vehicle atop of the receiver coil with good alignment. As illustrated, the charging hub 112 is disposed outside the vehicle 102.

[023] In an embodiment, the transmitter unit 110 include a transmitter coil. The transmitter coil is configured to supply a power wirelessly through the receiver unit 108 of the vehicle 102 such that the power is supplied to a battery pack 104 of the vehicle 102 during a charging mode. The term 'charging mode' as used herein may be defined as a state of the vehicle 102 during which the battery pack 104 of the vehicle 102 is being electrically charged based on instructions of a control unit 114 of the system 100.

[024] In an embodiment of the present invention, the control unit 114 of the system 100 is electrically coupled with the receiver unit 108, the battery pack 104, and a motor 106 of the vehicle 102. In another embodiment, the control unit 114 includes a processor which may be required to process the received instructions / signals from one or more inputs device and process the same to communicate a set of predetermined or processed instructions. It is to be understood that the components are shown for exemplary purpose only and thus the system 100 may include fewer or additional components / modules than those depicted in the Figure 1. For example, the system 100 may include or may be in communication with an analytic module (not shown) which may be configured to perform additional analysis of the communication information received.

[025] In another embodiment, a memory unit (not shown) in communication with the control unit 114 may be capable of storing machine executable instructions. Further, the processor in the control unit 114 may be capable of executing the machine executable instructions to perform the functions described herein. The processor may embody or may be in communication with the components such as the pre-processing module and the

analytic module. In yet another embodiment, the processor is a multi-core processor, a single core processor, or a combination of one or more multi-core processors and one or more single core processors. For example, the processor may be embodied as one or more of various processing devices, such as a coprocessor, a microprocessor, a controller, a digital signal processor (DSP), a processing circuitry with or without an accompanying DSP, or various other processing devices including integrated circuits such as, for example, an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), a microcontroller unit (MCU), a hardware accelerator, a special-purpose computer chip, or the like.

[026] In yet another embodiment, the processor is configured to execute hard-coded functionality.

[027] In still another embodiment, the processor is embodied as an executor of instructions, where the instructions may be specifically configured to the processor to perform the steps or operations described herein when the instructions are executed for carrying wireless charging of the battery pack 104 of the vehicle 102.

[028] In an embodiment of the present invention, the control unit 114 is configured to receive a battery charging mode signal from a user or an operator via operating an actuating device. The term 'user' or 'operator' as used herewith may be defined as a person who rides the vehicle or may be a technician who operates the battery charging system 100 during battery charging operation at a charging location.

[029] In an embodiment, the user may operate the actuating device like a switch 122 disposed on the vehicle 102 for generating the battery charging mode signal. In another embodiment, the user may operate another actuating device like a handheld device 120 for

generating the battery charging mode signal. The handheld device 120 may include mobile device or a tab which may be having an inbuilt or downloadable application and a user interface to activate the battery charging system 100. Thus, the system 100 can be activated for charging the battery pack 104 of the vehicle 102 via any of the activation devices like the switch 122 in the vehicle 102 or the handheld device 120 from outside of the vehicle 102. The control unit 114 of the system 100 receives the battery charging mode signal from any one of the switch 122 and the handheld device 120 for initiating the process of charging the battery pack 104 through a first switch 116 provided in the system 100.

[030] The first switch 116 of the system 100 is connected between the receiver unit 108 and the control unit 114. The first switch 116 is configured to selectively supply the power from the receiver unit 108 to the battery pack 104 for charging the battery pack 104. In an embodiment, a power distribution unit 138 may be provided between the battery pack 104 and the control unit 114. The power distribution unit 138 provided in the system 100 may be configured to allow power distribution. The power distribution unit 138 may also allow improved rationalisation of loads and thereby an improved charging in the battery charging system 100 of the vehicle 102.

[031] In another embodiment, the system 100 includes a stepdown transformer and a power factor correction circuit electrically coupled with the control unit 114 for charging the battery pack 104 from the AC power supply 140. By using this, additional circuitry in the external world charging infrastructure required for wireless charging can be eliminated.

[032] In an embodiment of the present invention, voltage supplied to MOSFETs in control unit 114 can be stepped down from 220V in the wireless charging mode, so that control

unit which is designed for propulsion or driving the vehicle can be used without any modifications. In another embodiment, with the advancements of GaN/SiC MOSFETs, switching frequency can be increased which increases efficiency and also decreases weight and size of passive components (inductor, capacitor) used.

5 [033] In the illustrated embodiment of Figure 1, a first communication module 134 is disposed on the vehicle 102 and in communication with the control unit 114. Further, the system 100 includes a second communication module 136 disposed with the charging hub 112 and in communication with the first communication module 134. The first communication module 134 is configured to receive the charging mode signal and transmit  
10 the charging mode signal to the second communication module 136, and the second communication module 136 is configured to receive the charging mode signal and generate an authorization signal whereby the charging hub 112 initiates transmission of wireless power through the transmitter unit 110 to the receiver unit 108.

[034] The first communication module 134 is configured to receive one or more control  
15 parameters from the control unit 114 and transmit the one or more control parameters to the second communication module 136. The one or more control parameters includes, but not limited to, a duty ratio, a phase shift and frequency of operation required for charging the battery pack 104.

[035] In an embodiment, the first communication module 134 and the second  
20 communication module 136 may be communication modules like a Wi-fi module or a Bluetooth module.

[036] As depicted in Figure 1, the system 100 further includes a second switch 118 which is connected between the control unit 114 and the motor 106. The control unit 114 is

configured to a circuit between the battery pack 104 and the motor 106 when the vehicle 102 is set to a drive mode by the user by operating the switch 122 or the handheld device 120.

[037] In an embodiment of the present invention, in a battery charging mode of the vehicle 102, the control unit 114 is configured to turn ON the first switch 116 and turn OFF the second switch 118. Thereby, charging the battery pack 104. In another embodiment of the present invention in a drive mode of the vehicle 102, the control unit 114 is configured to turn ON the second switch 118 and turn OFF the first switch 116, thereby supplying power to the motor 106. The term 'drive mode' as referred herein may be defined as a state of the vehicle 102, wherein the power from the battery pack 104 is being supplied to the motor 106 for movement of the vehicle 102.

[038] Figure 2 illustrates a schematic diagram of the electric vehicle 102 incorporating the battery charging system 100 shown in Figure 1, in accordance with an embodiment of the invention. The receiver unit 108 (shown in Figure 1), more particularly the receiver coil can be disposed at any one of the locations on the vehicle 102, including, but not limited to, a front wheel mudguard 124, a rear wheel mudguard 126, a top 128 of a number plate 130, side panels 132 or any other location in the vehicle 102. It is to be understood that the location of receiver coil in the vehicle 102 should be such that there is no EMI / EMC interference is observed.

[039] Figure 3 illustrates a flowchart of a method 300 for charging the battery pack 104 of the electric vehicle 102, in accordance with another aspect of the invention. When the user operates the activation device (the switch 122 or the handheld device 120), the battery

charging mode signal is generated. At a step 302, the generated battery charging mode signal is received by the control unit 114 for charging the battery pack 104.

[040] Upon receiving the battery charging mode signal by the control unit 114, at a step 304, the control unit 114 communicates to the first switch 116 connected between the receiver unit 108 and the control unit 114 of the system 100 to turn ON.

[041] At a step 306, the control unit 114 communicates to the second switch 118 connected between the motor 106 and the control unit 114 to turn OFF.

[042] At a step 308, the control unit 114 transmits the battery charging mode signal to the charging hub 112 via the first communication module 134 disposed on the vehicle 102. In other words, the first communication module 134 is configured to receive the charging mode signal from the control unit 114 at the step 308 and transmit the charging mode signal to the second communication module 136 disposed at the charging hub 112.

[043] At a step 310, the charging hub 112 receives the battery charging mode signal via the second communication module 136.

[044] Upon the second communication module 136 receiving the charging mode signal, at a step 312, the charging hub 112 generates the authorization signal to initiate the wireless power transmission.

[045] Once the authorization signal is generated, at a step 314, the charging hub 112 initiates transmission of wireless power through the transmitter unit 110 to the receiver unit 108. The authorization signal from the charging hub 112 is transmitted to the control unit 114 via the communication between the second communication module 136 and the first communication module 134.

[046] In an embodiment of the method of present invention, control parameters of a duty ratio, a phase shift and frequency of operation are transmitted from the first communication module 134 to the second communication module 136.

[047] At a step 316, the receiver unit 108 receives the wireless power from the transmitter unit 110.

[048] At a step 318, the control unit 114 supplies the power to the battery pack 104 through the first switch 116, thereby charging the battery pack 104 of the vehicle 102 during the charging mode. Once the battery pack is fully charged, the control unit 114 communicates to the charging hub 112 to stop the transmission of the power from the transmitter unit 110, thereby to turn OFF the first switch 116.

[049] Upon turning OFF the first switch 116, the control unit 114 is configured to turn ON the second switch 118 so that the vehicle 102 is brought to the drive mode. In the drive mode, the power is derived from the battery pack 104 and supplied to the motor 106 for driving the vehicle 102.

[050] Advantageously, the present invention uses reduced number of components in the electric vehicle since the motor controller is utilized to perform both charging of the battery pack during charging mode and to drive the vehicle during the drive mode. This makes a space required for accommodating other vehicle components, thereby increasing space utilization in the electric vehicle. Owing to reduction in number of components, reduced amount of heat generation can be achieved. Also, the present invention involves less damage to wiring harness and do not involve wear and tear of socket connection / wires. Further, the system and method disclosed in the present invention can be used even in wet environments and thus provides a safety advantage.

[051] The data in the system and method disclosed in the present invention is communicated via wireless channel. While the wireless charging is going on, the control unit communicates to high frequency inverter in transmission side wirelessly about the duty ratio, phase shift and frequency of operation depending on the control strategy being used via the Bluetooth channel / module. This eliminates a need for a controller in the on-board charger.

[052] The system and method disclosed in the present invention also eliminates gun and socket which are used in wired charging and providing isolation from grid to battery. The gun and socket appear to be not reliable and not cost effective.

[053] While the present invention has been described with respect to certain embodiments, it will be apparent to those skilled in the art that various changes and modification may be made without departing from the scope of the invention as defined in the following claims.

**CLAIMS:**

1. A battery charging system (100) for a vehicle (102) comprising:

a wireless power receiver unit (108) disposed on the vehicle and communicably coupled to a wireless power transmitter unit (110) of a charging hub (112) disposed outside the vehicle (102), the receiver unit (108) configured to receive wireless power from the transmitter unit (110) and supply the power for charging a battery pack (104) of the vehicle (102);

a control unit (114) electrically coupled with the receiver unit (108), the battery pack (104), and a motor (106);

a first switch (116) connected between the receiver unit (108) and the control unit (114) to selectively supply power from the receiver unit (108) to the battery pack (104) for charging the battery pack (104); and

a second switch (118) connected between the control unit (114) and the motor (106);

wherein, in a battery charging mode of the vehicle (102), the control unit (114) is configured to turn ON the first switch (116) and turn OFF the second switch (118) thereby charging the battery pack (104); and in a drive mode of the vehicle (102), the control unit (114) is configured to turn ON the second switch (118) and turn OFF the first switch (116) thereby supplying power to the motor (106).

2. The system (100) as claimed in claim 1, wherein the control unit (114) is configured to

receive a battery charging mode signal from a user, the battery charging mode signal requests the control unit (114) to charge the battery pack (104).

3. The system (100) as claimed in claim 1 comprising a first communication module (134) disposed on the vehicle (102) and in communication with the control unit (114); and a second communication module (136) disposed with the charging hub (112) and in communication with the first communication module (134).

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4. The system (100) as claimed in claim 2 or 3, wherein the first communication module (134) is configured to receive the charging mode signal and transmit the charging mode signal to the second communication module (136), and the second communication module (136) is configured to receive the charging mode signal and generate an authorization signal whereby the charging hub (112) initiates transmission of wireless power.

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5. The system (100) as claimed in claim 4, wherein the first communication module (134) is configured to:

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receive control parameters from the control unit (114); and  
transmit the control parameters to the second communication module (136).

6. The system (100) as claimed in claim 5, wherein the control parameters comprise a duty ratio, a phase shift and frequency of operation required for charging the battery pack (104).

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7. The system (100) as claimed in claim 2 comprising a switch (122) disposed on the vehicle (102) for generating the charging mode signal.

8. The system (100) as claimed in claim 2 comprising a handheld device (120) configured for generating the charging mode signal.
9. The system (100) as claimed in claim 1, wherein the receiver unit (108) comprises a receiver coil configured for wireless power transmission, the receiver coil disposed at any one of a front wheel mudguard (124), a rear wheel mudguard (126), a top (128) of a number plate (130), side panels (132) of the vehicle (102) and on one or more locations where EMI / EMC interference is not observed.
10. The system (100) as claimed in claim 1, wherein the charging hub (112) comprises an AC power supply (140); an AC-DC converter (142) connected to the AC power supply (140); an inverter (144) connected to the AC-DC converter (142) for converting the DC to a high frequency AC; and the wireless power transmitter unit (110).
11. The system (100) as claimed in claim 1 comprising a stepdown transformer and a power factor correction circuit electrically coupled with the control unit (114) for charging the battery pack (104) from the AC power supply (140).
12. A method (300) for charging a battery pack (104) of a vehicle (102), comprising the steps of:
- receiving (302), by a control unit (114), a battery charging mode signal requesting the control unit (114) to charge the battery pack (104);
- turning ON (304) a first switch (116), by the control unit (114), connected between a wireless power receiver unit (108) and the control unit (114);

turning OFF (306) a second switch (118), by the control unit (114), connected between the control unit (114) and a motor (106);

transmitting (308), by the control unit (114), the battery charging mode signal to a charging hub (112);

5 receiving (310), by the charging hub (112), the battery charging mode signal;

generating (312), by the charging hub (112), an authorization signal to initiate wireless power transmission;

initiating (314), by the charging hub (112), transmission of wireless power;

receiving (316), by the receiver unit (108), the wireless power; and

10 supplying (318), by the control unit (114) through the first switch (116), the power to the battery pack (104) thereby charging the battery pack (104).

13. The method (300) as claimed in claim 12 comprising the step of generating the battery charging mode signal by a user using a switch or a handheld device.

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14. The method (300) as claimed in claim 12 comprising the step of transmitting control parameters from a first communication module (134) to a second communication module (136).

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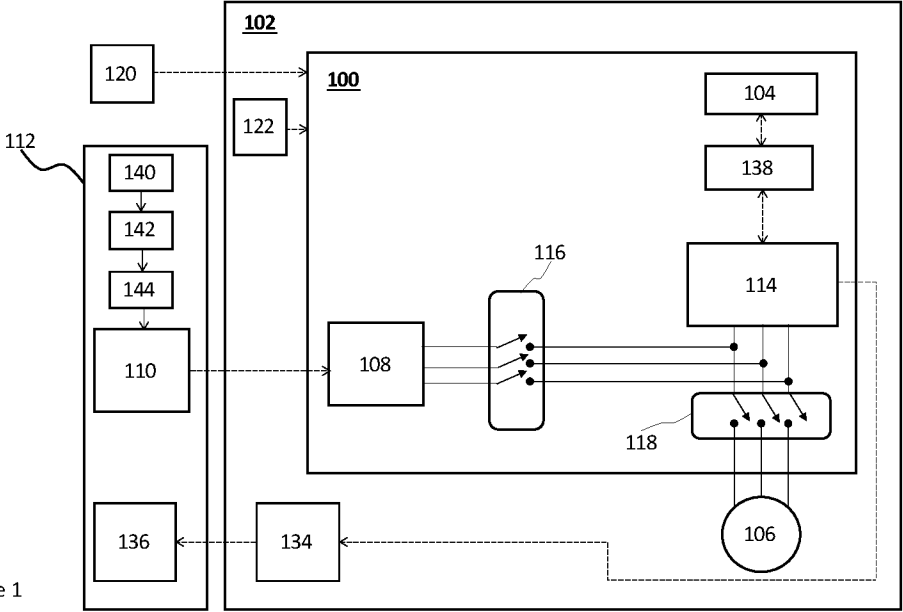


Figure 1

102

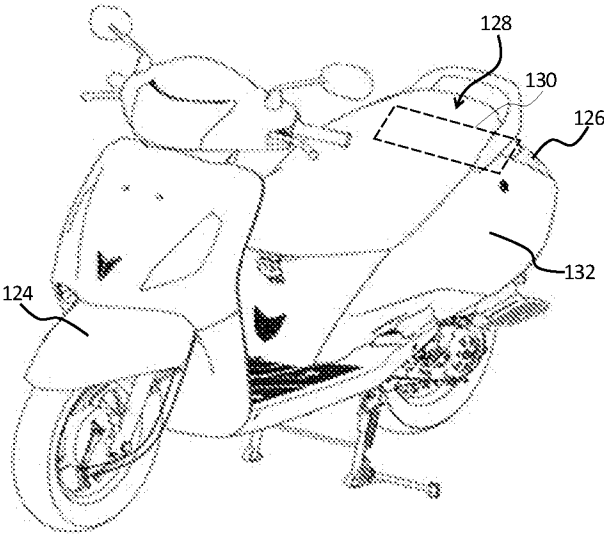


Figure 2

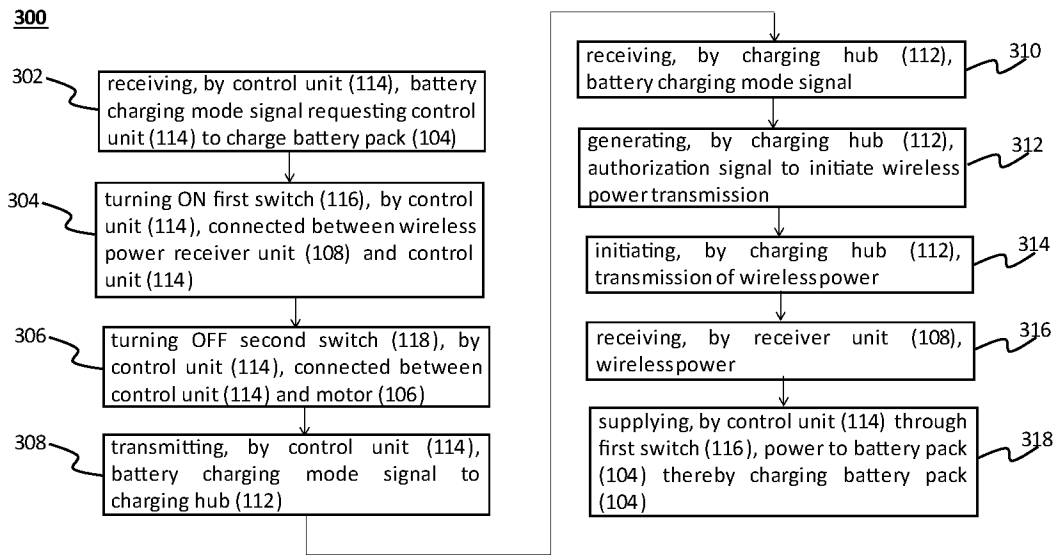


Figure 3

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/IN2022/050421

| <b>A. CLASSIFICATION OF SUBJECT MATTER</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                    |                                                                         |
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| <b>ADD.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                    |                                                                         |
| According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                    |                                                                         |
| <b>B. FIELDS SEARCHED</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                    |                                                                         |
| Minimum documentation searched (classification system followed by classification symbols)<br><b>B60L</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                    |                                                                         |
| 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)<br><b>EPO-Internal, WPI Data</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                    |                                                                         |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                    |                                                                         |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Citation of document, with indication, where appropriate, of the relevant passages                                                                                 | Relevant to claim No.                                                   |
| <b>X</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>US 2012/153717 A1 (OBAYASHI KAZUYOSHI [JP] ET AL) 21 June 2012 (2012-06-21) figures 1-3 paragraphs [0042], [0048], [0052], [0060], [0073] - [0091]</b><br>----- | <b>1-14</b>                                                             |
| <b>A</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>US 2018/194236 A1 (ELSHAER MOHAMED [US] ET AL) 12 July 2018 (2018-07-12) paragraphs [0034] - [0036]; figures 1-5</b><br>-----                                   | <b>2-6, 10, 11</b>                                                      |
| <b>A</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>US 2013/234675 A1 (KING ROBERT DEAN [US] ET AL) 12 September 2013 (2013-09-12) paragraphs [0016] - [0022]; figures 1-4</b><br>-----                             | <b>1-14</b>                                                             |
| <b>A</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>US 2018/015833 A1 (NAMOU ANDREW J [US] ET AL) 18 January 2018 (2018-01-18) paragraphs [0005] - [0009], [0021] - [0026]; figures 1-2</b><br>-----                | <b>1-14</b>                                                             |
| <input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                    |                                                                         |
| * Special categories of cited documents :<br>"A" document defining the general state of the art which is not considered to be of particular relevance<br>"E" earlier application or patent but published on or after the international filing date<br>"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)<br>"O" document referring to an oral disclosure, use, exhibition or other means<br>"P" document published prior to the international filing date but later than the priority date claimed<br>"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<br>"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<br>"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<br>"&" document member of the same patent family |                                                                                                                                                                    |                                                                         |
| Date of the actual completion of the international search<br><b>8 July 2022</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                    | Date of mailing of the international search report<br><b>18/07/2022</b> |
| Name and mailing address of the ISA/<br>European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                    | Authorized officer<br><b>Tzortzopoulos, O</b>                           |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IN2022/050421

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                               | Publication<br>date                    |
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