METHOD AND APPARATUS FOR CHARGING AN ELECTRIC VEHICLE WITH AN ON-BOARD CHARGING SYSTEM

TECHNICAL FIELD

[0001] The present disclosure relates to a method and apparatus for charging of an Electric Vehicle (EV). More particularly, the present disclosure relates to authentication or identification and implementing a feedback system to ensure integrity of the connector used.

BACKGROUND

[0002] The subject matter discussed in the background section should not be assumed to be prior art merely because of its mention in the background section. Similarly, a problem mentioned in the background section or associated with the subject matter of the background section should not be assumed to have been previously recognized in the prior art. The subject matter in the background section merely represents different approaches, which in and of themselves may correspond to implementations of the claimed technology.

[0003] Electric vehicles (EVs) are acquiring a center stage in the automobile industry and Increasingly getting popular among masses. With increasing demands, many private vendors are providing essential infrastructure such as charging stations etc. to ensure acceptability of EVs to a large section of the society. Among various kind of EVs, electric two-wheeler (E2W) contributes massively to the popularity of electric vehicles due to the many benefits and advantages provided. Some of the benefits accrued by users of electric two-wheeler vehicles include the low running cost, ease of maintenance, storage space, and low noise. In addition to the benefits provided to the users, electric vehicles are also environment-friendly as they do contribute to carbon emission.

[0004] Due to the increasing popularity of two-wheeler electric vehicles, there is an increasing need to provide sufficient public charging stations so that the same may be accessed by the user of an EV based upon his requirement. Due to the inherently small size of two-wheeler vehicles, there is limited battery capacity that is possible for electric two wheelers, and frequent charging is required so as to increase the range of the vehicle to an optimum level.

[0005] For optimum charging of EV vehicles, genuine charging cables should be provided with charging outlets. However, there are instances wherein the genuine charging cables may be replaced with low rated charging cables which pose significant risk to the charging circuits of the EV vehicles. The cable connecting the charging outlet can be swapped with unprotected or low rated charging cables, as this is freely available. These low rated charging cables present safety issues to the electronic control units (ECU's), battery pack, sensors and other equipment present in an electric vehicle.

[0006] Hence, there is a need for developing an authentication or identification method/system for cable of requisite standard provided by original equipment (OEMs) or proprietary cable so as to safeguard electronic control units (ECU's), battery pack, sensors and other equipment present in an electric vehicle.

OBJECTIVE OF THE INVENTION

[0007] An objective of the present invention is to provide an authentication/ identification system for Original Equipment (OE) cable or proprietary cable.

[0008] Another objective of the present invention is to optimize charging of electric vehicle in the absence of OE cable or proprietary cable.

[0009] Another objective of the present invention is to provide a feedback system to ensure the use of proprietary cable for charging an EV.

[0010] Yet another objective of the present invention in to increase longevity of on-board battery-pack and power train along with electronic control units of an electric vehicle.

SUMMARY OF THE INVENTION

[0011] The summary is provided to introduce aspects related to an electrical energy storage system. Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

[0012] In an embodiment, the present invention provides an on-boarding charging system, comprising an on-board charger coupled to one or more battery of a vehicle, a charger port coupled to the on-board charger and configured to be connected to a charging port, the charger

port includes one or more interlock switch and at least one proximity sensor, wherein the interlock switch is configured to detect interlocking of the charger port with the charging port, and the proximity sensor is configured to detect the proximity of the charging port with the charger port, and a vehicle controller coupled to the on-board charger and the charger port, wherein the vehicle controller is configured to: receive at least one feedback signal from the charging port, the feedback signal comprising at least one of successful detection of connection of charging port with charger port with the interlock switch, and proximity detection of the charging port with the charger port, and send an authentication feedback to the on-board charger, enabling operation of on-board charger in plurality of charging modes.

[0013] In an embodiment, the plurality of charging modes includes a first charging mode with 2.2Kw, 1.1Kw & variable current profile, and a second charging mode with 800W & variables current profile, to be supplied to on-board Battery Management System (BMS).

[0014] In an embodiment, the proximity sensor is a Magnetic Reed Switch Sensor.

[0015] In an embodiment, the BMS is operated at the first charging mode with 2.2Kw current profile when the vehicle control unit receives both mating connector engagement feedback and proximity sense feedback.

[0016] In yet another embodiment, the BMS is operated at the second charging mode with 800W current profile when the vehicle control unit receives only mating connector engagement feedback.

[0017] In an embodiment, the authentication feedback to the on-board charger includes indicating of original equipment (OE) charging cable.

[0018] In a further embodiment, the charging port includes a magnet to be detected by the proximity sensor.

[0019] In yet another embodiment, the charging port is a C13 universal charging plug and the charger port is a C14 connector.

[0020] In yet another embodiment, the charging port is a male connector, and the charger port is a female connector fixed on the body of the vehicle.

[0021] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The accompanying drawings constitute a part of the description and are used to provide further understanding of the present invention. The drawings illustrate exemplary embodiments of the present disclosure and, together with the description, serve to explain the principles of the present disclosure.

[0023] **Fig. 1** illustrate a perspective view of charging an electric vehicle, according to a prior art; and

[0024] **Fig. 2** illustrates a perspective view of on-board charging system for an electric two-wheeler vehicle, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0025] The description set forth below in connection with the appended drawings is intended as a description of various embodiments of the present disclosure and is not intended to represent the only embodiments in which the present disclosure may be practiced. Each embodiment described in this disclosure is provided merely as an example or illustration of the present disclosure, and should not necessarily be construed as preferred or advantageous over other embodiments. The description includes specific details for the purpose of providing a thorough understanding of the present disclosure. However, it will be apparent to those skilled in the art that the present disclosure may be practiced without these specific details.

[0026] Exemplary embodiments now will be described with reference to the accompanying drawings. The disclosure may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey its scope to those skilled in the art. The terminology used in the detailed description of the particular exemplary embodiments illustrated in the accompanying drawings is not intended to be limiting. In the drawings, like numbers refer to like elements.

[0027] It is to be noted, however, that the reference numerals used herein illustrate only typical embodiments of the present subject matter, and are therefore, not to be considered for limiting its scope, for the subject matter may admit to other equally effective embodiments.

[0028] The specification may refer to "an", "another", "one" or "some" embodiment(s) in several locations.

[0029] This does not necessarily imply that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments.

[0030] As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless expressly stated otherwise. It will be further understood that the terms "includes", "comprises", "including" and/or "comprising" when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. Furthermore, "connected" or "coupled" as used herein may include operatively connected or coupled. As used herein, the term "and/or" includes any and all combinations and arrangements of one or more of the associated listed items.

[0031] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure pertains. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0032] The detailed description includes specific details for the purpose of providing a thorough understanding of the present disclosure. However, it will be apparent to those skilled in the art that the present disclosure may be practiced without these specific details.

[0033] Electric vehicles, especially two-wheeler vehicles have been growing in popularity and demand due to the several benefits and advantages offered by such vehicles. EV's not only help to curb vehicular tailpipe pollution but also to minimize the noise pollution. However, providing a robust charging infrastructure within a city and on highways have till date remained a challenge for the Government and automobile manufacture. In recent years, Government and private bodies have taken measures to install charging station at strategic locations within a city where a EV user can charge his vehicle; however, standardization of parameters for charging cable still remains a challenge. In order to reduce overall cost of installation and operation of a charging station, often universal charging cable are provided, which are low quality or does not meet the requirements of a vehicle manufacturer. It becomes difficult for an EV user to identify these sub-standard charging cables or even if identified, it becomes impossible to avoid the use of such a cable because of non-availability of any other option.

[0034] The cable available at the electric vehicle charging outlets may be low rated charging cables as these are freely/ universally available. These cables are provided with universal plug which get connected with charger vehicle port forming a male-female connection. Subsequently, charging of the battery of an electric vehicle rakes place.

[0035] Charging of battery of an electric vehicle with sub-standard charging cable pose a serious concern to the safety of battery, ECU's, on-board electric equipment (EE) and to the vehicle as a whole. There are often cases of overheating of the cable during charging at charging stations which case extensive damage to the vehicle in general and on-bard equipment in particular.

[0036] **Fig. 1** illustrates charging of the vehicle as present in the state of art. An electric vehicle, which include electric two-wheeler E2W, is essentially fitted with an on-board charging (OBC) system **101**, a battery-pack and a power train along with electronic control units (ECU's). During the process the OBC **101** is connected via cable **102** with a mating connector **103** toward the OBC side and the cable **102** is connected to the power source **104** at the charging outlet. The cable **102** connecting the charging outlet can be swapped with unprotected or low rated charging cables, as this is freely available. These low rated charging cables present safety issues to the electronic control units (ECU's), battery pack, sensors and other equipment present in an electric vehicle.

[0037] The present invention provides an on-board system for charging an electric vehicle including a E2Ws. The present disclosure provides a feedback system with authentication or identification to ensure the safe proprietary of the connector which has been used. The feedback system ensures that current which is flowing across the connector is minimized so that no extra amount of heat is generated leading to the damage of on-board electrical equipment. The feedback system further ensures that the male-female connectors are present in close proximity so as to minimize the chance of short circuit during charging.

[0038] **Fig. 2** illustrates a perspective view of on-board charging system **200** for an electric two-wheeler vehicle, in accordance with an embodiment of the present invention. The on-board charging system **200** of a vehicle comprises an on-board charger **205**, a vehicle controller/control unit (VCU) **204** and a charger vehicle port **203** forming a female connector. In an embodiment, the charger vehicle port **203** is connected to a charging plug **202** forming a male connector. In an embodiment, the charger vehicle port **203** is a C14 connector. The vehicle controller **204** is in communication with on-board charger **205** to exchange data/information in real time.

[0039] In an embodiment, the connectors **202, 203** are configured to implement proximity detection with the help of a magnetic sensor **206** & a micro switch **207** (*also referred to as interlock switch*) for two charging modes (or profiles) in the on-board changer for the vehicle. In an embodiment, the vehicle is at least one of two wheeler electric vehicle, or four wheeler electric vehicle.

[0040] In an embodiment, the first profile (or mode) allows for the 2.2Kw & variable current profile. In another embodiment, the second profile (or mode) allows 800W current profile to be supplied to the on-board Battery Management System (BMS). The present system allows optimum charging of the battery of an electric vehicle so as to provide required motive force to the motor for displacement of the vehicle. In an exemplary embodiment, with the original cable, charger will charge with 2.2 kW (20A) and with other cable charger will charge with sun 1 kW (<10A) charge. The sensor inputs provided by sensor **206** and micro switch **207** are sensed by the Vehicle Control Unit **204** and follows the charging process as defined in the charging software logic of the battery management system (BMS). The customized cable input will be available only when the correct charge cable is used, otherwise vehicle control units will detect that the proper charge cable is not used and restrict the vehicle charging.

[0041] In a preferred embodiment, the charging system works on a mating connectors engagement feed-back system. Once the male **202** and female portions **203** of the connector are connected, a feedback is sent to the VCU (vehicle control unit) **204**. The VCU authenticate the nature of the cable connected from the charging point. If the cable connected is a proprietary cable than the controller allows optimum charging of the battery allowing the 2.2Kw current profile. If the authentication fails, the VCU still allows charging of the battery but with reduced flow of current, preferably with the 800W current profile.

[0042] In order to initiate the process of charging, the male part of the connector is connected with female portion of the connector to form the electrical connection. In an exemplary embodiment, the male part of the connector is a C13 universal charging plug and the female portion of connector is a C14 socket.

[0043] In an exemplary embodiment, the charger vehicle port **203** may include at least one Magnetic Reed switch sensor **206** and one or more interlock/micro switch **207.** In an exemplary embodiment, the charger plugs **202** includes a magnet **208.** When the connectors **202, 203** are connected to form an electrical connection, the micro switch **207** ensures proper connection of the connector **203** with charging plug **202.** Improper connection will lead to heating up the connectors and eventually leading to fire.

[0044] When an electrical connection is established by connecting the male and the female connectors, the sensor **206** present on the connector **203** sends signal to the vehicle control unit (VCU) **204** leading to two scenarios. In one scenario, once the charger plug **202** is inserted into the vehicle charger port connector **203**, the micro switch **207** gets closed and the proximity sensed by the both inputs will be sent to VCU (vehicle control unit) **204** and allowing the 2.2Kw current profile. In an alternative scenario, when the VCU (vehicle control unit) **204** has not received the proximity connector sensor feedback from the sensor **206** and only the micro switch (MSW) input has been received, then the VCU (vehicle control unit) **204** will communicate with on-board charger OBC **205** to proceed with the 800W current profile to BMS (Battery Management System). In an embodiment, the VCU 204 sends an authentication feedback to the on-board charger indicating the originality of the charging cable.

[0045] In an embodiment, the above mechanism may also be implemented on non-electric vehicles. A person skilled in the art may implement the above logic in an electronic control unit (ECU) based on vehicle software architecture.

[0046] Hence, the disclosed on-board charging system for charging an electric vehicle proposed in the present invention acts as a safety mechanism for the on-board battery management system, sensors, ECUs and other electrical equipment, particularly in a two-wheeler electric vehicle.

[0047] The on-board charging system for charging an electric vehicle proposed in the present invention, hence ensures the authentication and/or identification of the proprietary cable for charging at a charging station leading to enhance safety of electrical equipment present in a two-wheeler vehicle. It further ensures proximity of male and female parts of the connector so as to ensure tight connection while in an on-going charging process. The disclosed feedback loop system allows charging of the electric vehicle both with proprietary and non-proprietary cables, however, allowing lesser current profile with the non-proprietary cable. This ensures optimum charging of the battery of an EV leading to increased longevity of the same and thus, minimizing overall cost of operation over the entire life cycle.

[0048] The figures of the disclosure are provided to illustrate some examples of the disclosure described. The figures are not to limit the scope of the depicted embodiments or the appended claims. Aspects of the disclosure are described herein with reference to the disclosure to example embodiments for illustration. It should be understood that specific details, relationships, and method are set forth to provide a full understanding of the example embodiments. One of ordinary skill in the art recognize the example embodiments can be practiced without one or more specific details and/or with other methods.

[0049] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

[0050] It is to be understood that the disclosure is not to be limited to the specific embodiments disclosed, and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation, unless described otherwise.

WE CLAIM:

1. An on-boarding charging system, comprising:

an on-board charger **205** coupled to one or more battery of a vehicle;

a charger port **203** coupled to the on-board charger **205** and configured to be connected to a charging port **202**, the charger port **203** includes one or more interlock switch **207** and at least one proximity sensor **206**, wherein the interlock switch **207** is configured to detect interlocking of the charger port **203** with the charging port **202**, and the proximity sensor **206** is configured to detect the proximity of the charging port **202** with the charger port **203**; and

a vehicle controller **204** coupled to the on-board charger **205** and the charger port **203**, wherein the vehicle controller **204** is configured to:

receive at least one feedback signal from the charging port **203**, the feedback signal comprising at least one of successful mating of charging port **202** with charger port **203** with the interlock switch **207**, and proximity detection of the charging port **202** with the charger port **203**; and

send an authentication feedback to the on-board charger **205**, enabling charging of batteries in plurality of charging modes.

2. The system as claimed in claim 1, wherein the plurality of charging modes includes a first charging mode with 2.2Kw, 1.1 Kw & variable current profile, and a second charging mode with 800W & variable current profile, to be supplied to on-board Battery Management System (BMS).

3. The system as claimed in claim 1, wherein the proximity sensor **206** is a Magnetic Reed Switch Sensor.

4. The system as claimed in claim 2, wherein the BMS is operated at the first charging mode with 2.2Kw current profile when the vehicle control unit **204** receives both mating connector engagement feedback and proximity sense feedback.

5. The system as claimed in claim 2, wherein the BMS is operated at the second charging mode with 800W current profile when the vehicle control unit **204** receives only mating connector engagement feedback.

6. The system as claimed in claim 1, wherein the authentication feedback to the on-board charger **205** includes indicating of original equipment (OE) charging cable.

7. The system as claimed in claim 3, wherein the charging port **202** includes a magnet **208** to be detected by the proximity sensor **206**.

8. The system as claimed in claim 1, wherein the charging port **202** is a C13 universal charging plug and the charger port **203** is a C14 connector.

9. The system as claimed in claim 1, wherein the charging port **202** is a male connector.

10. The system as claimed in claim 1, wherein the charger port **203** is a female connector fixed on the body of the vehicle.