**Methods and systems for lifetime management of battery pack by creating a digital copy**

## CROSS REFERENCE TO RELATED APPLICATION

This application is based on and derives the benefit of Indian Provisional Application 201841042531 as filed on 12th November 2018, the contents of which are incorporated herein by reference.

## TECHNICAL FIELD

[001] Embodiments disclosed herein relate to management of battery packs and more particularly to managing, monitoring and tracking battery packs by creating digital copies of the battery packs.

## BACKGROUND

[002] A battery pack comprises modules such as battery cells, sensors for temperature, voltage, current, location sensing means, accelerometer, electronic control systems for battery management, telemetry and built-in-in modem with remote server systems for tracking and monitoring, and so on.

[003] Once the battery pack has been manufactured and deployed for use in field application, there could be performance related alerts and issues received by a server system to which the battery pack communicates. Ability to understand configuration of a given battery pack and identify which component is causing issues and how it tested during manufacturing can be critical.

[004] Further, existing solutions for manufacturing automation may not provide a hierarchical configuration to represent the battery pack and also with some of the components being ‘active’ and addressable remotely.

## SUMMARY

[004a] According to a first aspect, there is provided a battery pack management system including: a data storage, a battery pack assembly line, and a digital controller, wherein the digital controller is configured for: creating at least one digital copy of at least one battery pack, wherein the digital copy is stored in the data storage; and monitoring, tracing and managing the at least one battery pack using the created at least one digital copy after deploying the at least one battery pack in at least one field, wherein the battery pack

assembly line is configured for assembling at least one battery pack using at least one component of a plurality of components, wherein the battery pack assembly line is further configured for: performing a plurality of first level of tests on the plurality of components to be used for assembling the at least one battery pack using at least one threshold defined by the digital controller, wherein the plurality of first level of tests include assembly line tests and high rate discharge tests; receiving at least one indication from the digital controller upon communicating results of the plurality of first level of tests to the digital controller, wherein the indication includes information about the at least one component selected by the digital controller for assembling the at least one battery pack and at least one rule for assembling the at least one battery pack; and assembling the at least one battery pack using the at least one selected component based on the at least one indication received from the digital controller.

[004b] According to a second aspect, there is provided a method for lifetime management of battery packs, the method including: creating, by a digital controller, at least one digital copy of at least one battery pack, wherein the digital copy is stored in a data storage; monitoring, tracing and managing, by the digital controller, the at least one battery pack using the created at least one digital copy after deploying the at least one battery pack in at least one field; assembling, by a battery pack assembly line, at least one battery pack using at least one component of a plurality of components; performing, by the battery pack assembly line, a plurality of first level of tests on the plurality of components to be used for assembling the at least one battery pack using at least one threshold defined by the digital controller, wherein the plurality of first level of tests include assembly line tests and high rate discharge tests; receiving, by the battery pack assembly line, at least one indication from the digital controller upon communicating results of the plurality of first level of tests to the digital controller, wherein the indication includes information about the at least one component selected by the digital controller for assembling the at least one battery pack and at least one rule for assembling the at least one battery pack; and assembling, by the battery pack assembly line, the at least one battery pack using the at least one selected component based on the at least one indication received from the digital controller.

[005] Embodiments herein disclose methods and systems for creating at least one digital copy of at least one battery pack, wherein the at least one digital copy includes at least one of configuration information of the at least one battery pack and associated components, results of tests performed on the at least one battery pack and the associated components at various stages, unique identifiers of the at least one battery pack and the associated

components, thresholds used for performing the tests and rules defined for assembling the at least one battery pack.

[006] Embodiments herein disclose methods and systems for monitoring, tracing and managing the at least one battery pack using the at least one digital copy and data received from the at least one battery pack when the at least one digital copy is deployed in at least one field.

[007] These and other aspects and embodiments disclosed herein will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings. It should be understood, however, that the following descriptions, while indicating at least one embodiment and numerous specific details thereof, are given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the embodiments herein without departing from the spirit thereof, and the embodiments herein include all such modifications.

## BRIEF DESCRIPTION OF FIGURES

[008] Embodiments herein are illustrated in the accompanying drawings, throughout which like reference letters indicate corresponding parts in the various figures. The embodiments herein will be better understood from the following description with reference to the drawings, in which:

[009] FIG. 1 depicts a battery pack management system, according to embodiments as disclosed herein;

[0010] FIGs. 2a and 2b depict a battery pack management system, according to embodiments as disclosed herein;

[0011] FIG. 3 is an example diagram illustrating various modules of the digital controller for creating the digital copy of the battery pack and managing the battery pack when the battery pack is deployed in the at least one field, according to embodiments as disclosed herein; and

[0012] FIG. 4 is a flow diagram illustrating a method for lifetime management of the at least one battery pack, according to embodiments as disclosed herein.

## CLAIMS

1. A battery pack management system (100) comprising:

a data storage (206),

a battery pack assembly line (202),

and

a digital controller (204),

wherein the digital controller (204) is configured for:

creating at least one digital copy of at least one battery pack (100), wherein the digital copy is stored in the data storage (206); and

monitoring, tracing and managing the at least one battery pack (100) using the created at least one digital copy after deploying the at least one battery pack (100) in at least one field,

wherein the battery pack assembly line (202) is configured for assembling at least one battery pack using at least one component of a plurality of components, wherein the battery pack assembly line (202) is further configured for:

performing a plurality of first level of tests on the plurality of components to be used for assembling the at least one battery pack (100) using at least one threshold defined by the digital controller (204), wherein the plurality of first level of tests include assembly line tests and high rate discharge tests;

receiving at least one indication from the digital controller (204) upon communicating results of the plurality of first level of tests to the digital controller (204), wherein the indication includes information about the at least one component selected by the digital controller (204) for assembling the at least one battery pack (100) and at least one rule for assembling the at least one battery pack (100); and

assembling the at least one battery pack (100) using the at least one selected component based on the at least one indication received from the digital controller (204).

2. The battery pack management system of claim 1, wherein the digital controller (204) selects the at least one component for assembling the at least one battery pack (100) based on the results of the plurality of first level of tests.

3. The battery pack management system of claim 1, wherein the digital controller (204) defines the at least one rule for assembling the at least one battery pack (100) based on configuration information of the at least one selected component.

4. The battery pack management system of claim 1, wherein the digital controller (204) is further configured for:

performing a plurality of second level of tests on at least one of the assembled at least one battery pack (202) and the at least one component of the battery pack (100), wherein the plurality of second level of tests include at least one of insulation tests, communication tests, current calibration tests, End of Line (EOL) tests;

certifying the at least one battery pack (100) if results of the plurality of second level of tests satisfies with at least one threshold; and

creating the at least one digital copy of the at least one battery pack (100) after certifying the at least one battery pack (100).

5. The battery pack management system of claim 1, wherein the digital copy includes the configuration information of the at least one battery pack and the at least one component, the results of the plurality of first level of tests corresponding to the at least one component associated with the at least one battery pack (100), results of the plurality of second level of tests corresponding to the at least one battery pack and the associated at least one component, unique identifiers of the at least one battery pack and the associated at least one component, the at least one threshold used for performing the plurality of first level of tests and the plurality of second level of tests and the at least one rule defined for assembling the at least one battery pack (100).

6. The battery pack management system of claim 1, wherein the digital controller (204) is further configured for:

configuring the at least one battery pack (100) to operate in an field mode;

performing a plurality of third level of tests on the at least one battery pack (100) based on at least one alert condition received from the at least one battery pack (100), wherein the plurality of third level of tests include field diagnostic tests;

performing at least one correctional procedure on the at least one battery pack (100) based on a result of the plurality of third level of tests; and

updating the at least one digital copy corresponding to the at least one battery pack (100) based on the performed correctional procedure.

7. The battery pack management system of claim 6, wherein the digital controller (204) is further configured for:

monitoring performance of the at least one battery pack (100) and the associated at least one component to determine performance degradation in the at least one battery pack (100) and the associated at least one component;

identifying at least one malfunctioning component within the at least one battery pack (100) on receiving the at least one alert condition from the at least one battery pack (100), wherein the at least one malfunctioning component is identified using the at least one digital copy and data received from the at least one battery pack (100); and

addressing the at least one malfunctioning component within the at least one battery pack (100) if the at least one malfunctioning component is an active component.

8. A method for lifetime management of battery packs, the method comprising:

creating, by a digital controller (204), at least one digital copy of at least one battery pack (100), wherein the digital copy is stored in a data storage (206);

monitoring, tracing and managing, by the digital controller (204), the at least one battery pack (100) using the created at least one digital copy after deploying the at least one battery pack (100) in at least one field;

assembling, by a battery pack assembly line (202), at least one battery pack using at least one component of a plurality of components;

performing, by the battery pack assembly line (202), a plurality of first level of tests on the plurality of components to be used for assembling the at least one battery pack (100) using at least one threshold defined by the digital controller (204), wherein the plurality of first level of tests include assembly line tests and high rate discharge tests;

receiving, by the battery pack assembly line (202), at least one indication from the digital controller (204) upon communicating results of the plurality of first level of tests to the digital controller (204), wherein the indication includes information about the at least

one component selected by the digital controller (204) for assembling the at least one battery pack (100) and at least one rule for assembling the at least one battery pack (100); and

assembling, by the battery pack assembly line (202), the at least one battery pack (100) using the at least one selected component based on the at least one indication received from the digital controller (204).

9. The method of claim 8, further comprises: selecting, by the digital controller (204), the at least one component for assembling the at least one battery pack (100) based on the results of the plurality of first level of tests.

10. The method of claim 8, further comprises: defining, by the digital controller (204) the at least one rule for assembling the at least one battery pack (100) based on configuration information of the at least one selected component.

11. The method of claim 8, wherein creating, by the digital controller (204), the at least one digital copy includes:

performing a plurality of second level of tests on at least one of the assembled at least one battery pack (202) and the at least one component of the battery pack (100), wherein the plurality of second level of tests include at least one of insulation tests, communication tests, current calibration tests, End of Line (EOL) tests;

certifying the at least one battery pack (100) if results of the plurality of second level of tests satisfies with at least one threshold; and

creating the at least one digital copy of the at least one battery pack (100) after certifying the at least one battery pack (100).

12. The method of claim 11, wherein the digital copy includes the configuration information of the at least one battery pack and the at least one component, the results of the plurality of first level of tests corresponding to the at least one component associated with the at least one battery pack (100), results of the plurality of second level of tests corresponding to the at least one battery pack and the associated at least one component, unique identifiers of the at least one battery pack and the associated at least one component, the at least one threshold used for performing the plurality of first level of tests and the plurality of second level of tests and the at least one rule defined for assembling the at least one battery pack (100).

13. The method of claim 8, wherein monitoring, tracing and managing, by the digital controller (204), the at least one battery pack (100) includes:

configuring the at least one battery pack (100) to operate in an field mode;

performing a plurality of third level of tests on the at least one battery pack (100) based on at least one alert condition received from the at least one battery pack (100), wherein the plurality of third level of tests include field diagnostic tests;

performing at least one correctional procedure on the at least one battery pack (100) based on a result of the plurality of third level of tests; and

updating the at least one digital copy corresponding to the at least one battery pack (100) based on the performed correctional procedure.

14. The method of claim 1, further comprises:

monitoring performance of the at least one battery pack (100) and the associated at least one component to determine performance degradation in the at least one battery pack (100) and the associated at least one component;

identifying at least one malfunctioning component within the at least one battery pack (100) on receiving the at least one alert condition from the at least one battery pack (100), wherein the at least one malfunctioning component is identified using the at least one digital copy and data received from the at least one battery pack (100); and

addressing the at least one malfunctioning component within the at least one battery pack (100) if the at least one malfunctioning component is an active component.