

CLAIMS

What is claimed is:

1. A battery module, comprising:
 - a first set of power contacts;
 - a first set of signal contacts;
 - a battery pack operable to deliver electrical power to the set of power contacts;
 - an electronic isolation system operable to electrically disconnect and electrically connect the battery pack and the first set of power contacts; and
 - an electronic control system electrically connected to the electronic isolation system and to at least one of the first set of signal contacts or the first set of power contacts, the electronic control system being operable to:
 - obtain a first comparison between a state of charge of the battery module and an electrical device, obtain a second comparison between a state of health of the battery module and the electrical device, obtain a third comparison between a temperature of the battery module and the electrical device and obtain a fourth comparison between a power of the battery module and the electrical device,
 - calculate a closing parameter based on at least one of the first comparison, the second comparison, the third comparison or the fourth comparison, and
 - compare the closing parameter to a predefined closing parameter value to result in a connect determination as to whether it is desirable to connect the first battery module to the electrical device; and
 - wherein the electronic isolation system connects the battery pack to the first set of power contacts based on a positive result of the connect determination, and the electronic isolation system disconnects the battery pack and the first set of power contacts based on a negative result of the connect determination.
2. The battery module of claim 1, wherein the electrical device comprises a second battery module.
3. The battery module of claim 2, comprising:

the first comparison comprising a difference between a state of charge of the battery module and the second battery module;

the second comparison comprising a difference between a state of health of the battery module and the second battery module;

the third comparison comprising a difference between a temperature of the battery module and the second battery module; and

the fourth comparison comprising a difference between a power of the battery module and the second battery module.

4. The battery module of claim 3, comprising:
the battery module and the second battery module comprising at least a portion of a plurality of battery modules of a battery module system, the battery module system including a power bus operable to be connected to the first set of power contacts of the battery module.
5. The battery module of claim 4, wherein the closing parameter comprises:
an absolute value of a difference between a closing voltage and a sag voltage, the sag voltage comprising a measured voltage on the power bus prior to the power contacts of the battery module being connected to the power bus, and the closing voltage being a predicted value of what the sag voltage will become if the power contacts of the battery module are connected to the power bus.
6. The battery module of claim 5, wherein the predefined closing parameter value is less than 5 volts.
7. The battery module of claim 5, wherein the predefined closing parameter value is less than 2 volts.
8. The battery module of claim 1, wherein the electronic isolation system comprises:
a temperature sensor, a current sensor and a voltage sensor; and

a microprocessor in communication with the temperature sensor, the current the sensor and the voltage sensor, the microprocessor comprising:

a memory, and

instructions stored in the memory for execution by the microprocessor for performing a method comprising:

measuring the temperature of the battery module and the electrical device with the temperature sensor,

measuring a current of the battery module and the electrical device with current sensor,

measuring voltage of the battery module and the electrical device with the voltage sensor,

calculating the state of charge, the state of health and the power with the temperature, the current and the voltage,

utilizing the temperature, the power, the state of charge and the state of health to obtain the first, second, third and fourth comparisons,

calculating, the closing parameter based on the first, second, third and fourth comparisons, and

comparing, the closing parameter to the predefined closing parameter value to result in a connect determination.

9. The battery module of claim 8, wherein the method comprises:

determining the running state of the battery module, the running state comprising: a before power draw state, a during power draw state and an after power draw state; and

utilizing the running state to calculate the closing parameter.

10. A battery module system, comprising:

a battery module system power bus; and

a plurality of battery modules, a first battery module of the plurality of battery modules, the first battery module comprising:

a first set of power contacts electrically connected to the power bus,

a first set of signal contacts,

a first battery pack operable to deliver electrical power to the first set of power contacts,

a first electronic isolation system operable to electrically disconnect and connect the first battery pack and the first set of power contacts, and

a first electronic control system electrically connected to the electronic isolation system and to at least one of the first set of signal contacts or the first set of power contacts, the electronic control system being operable to:

obtain a first comparison between a state of charge of the first battery module and a second battery module of the plurality of battery modules, obtain a second comparison between a state of health of the first battery module and the second battery module, obtain a third comparison between a temperature of the first battery module and the second battery module and obtain a fourth comparison between a power of the first battery module and the second battery module,

calculate a closing parameter based on at least one of the first comparison, the second comparison, the third comparison or the fourth comparison, and

compare the closing parameter to a predefined closing parameter value to result in a connect determination as to whether it is desirable to connect the first battery module to the second battery module;

wherein the electronic isolation system connects the battery pack to the first set of power contacts based on a positive result of the connect determination, and the electronic isolation system disconnects the battery pack and the first set of power contacts based on a negative result of the connect determination.

11. The battery module system of claim 10, comprising:

the first comparison comprising a difference between a state of charge of the first battery module and the second battery module;

the second comparison comprising a difference between a state of health of the first battery module and the second battery module;

the third comparison comprising a difference between a temperature of the first battery module and the second battery module; and

the fourth comparison comprising a difference between a power of the first battery module and the second battery module.

12. The battery module system of claim 11, wherein the closing parameter comprises:

an absolute value of a difference between a closing voltage and a sag voltage, the sag voltage comprising a measured voltage on the power bus prior to the first power contacts of the first battery module being connected to the power bus, and the closing voltage being a predicted value of what the sag voltage will become if the first power contacts of the first battery module are connected to the power bus.

13. The battery module system of claim 12, wherein the predefined closing parameter value is less than 5 volts.

14. The battery module system of claim 12, wherein the predefined closing parameter value is less than 2 volts.

15. The battery module of claim 10, wherein the electronic isolation system comprises:

a temperature sensor, a current sensor and a voltage sensor; and

a microprocessor in communication with the temperature sensor, the current sensor and the voltage sensor, the microprocessor comprising:

a memory, and

instructions stored in the memory for execution by the microprocessor for performing a method comprising:

measuring the temperature of the battery module and the electrical device with the temperature sensor,

measuring a current of the battery module and the electrical device with the current sensor,

measuring voltage of the battery module and the electrical device with the at least voltage sensor,

calculating the state of charge, the state of health and the power with the measured temperature, current and voltage,
utilizing the temperature, power, state of charge and state of health to obtain the first, second, third and fourth comparisons,
calculating, the closing parameter based on the first comparison, second comparison, third comparison and fourth comparison, and
comparing, the closing parameter to the predefined closing parameter value to result in a connect determination.

16. The battery module system of claim 15, wherein the method comprises:
determining a running state of the battery module, the running state comprising: a before power draw state, a during power draw state and an after power draw state; and
utilizing the running state to calculate the closing parameter.

17. A computer implemented method of connecting a battery module to an electrical device, the method comprising:
measuring a temperature of a battery module and an electrical device with the at least one temperature sensor;
measuring a current of the battery module and the electrical device with the at least one current sensor;
measuring a voltage of the battery module and the electrical device with the at least voltage sensor;
calculating a state of charge, a state of health and a power of the battery module from at least one of the current, temperature or voltage of the battery module;
calculating a state of charge, a state of health and a power of the electrical device from at least one of the current, temperature or voltage of the electrical device;
obtaining a first comparison between a state of charge of the battery module and the electrical device, a second comparison between a state of health of the battery module and the electrical device, a third comparison between a temperature of the battery module and the electrical device and a fourth comparison between a power of the battery module and the electrical device;

calculating, a closing parameter based on the first, second, third and fourth comparisons; and
comparing, the closing parameter to a predefined closing parameter value to result in a connect determination.

18. The method of claim 17, comprising:

connecting the battery module to the electrical device, based on a positive result of the connect determination; and

disconnecting the battery pack from the electrical device based on a negative result of the connect determination.

19. The method of claim 17, comprising:

determining the running state of the battery module, the running state comprising: a before power draw state, a during power draw state and an after power draw state; and

utilizing the running state to calculate the closing parameter.

20. The method of claim 17, wherein the electrical device as a second battery module.