

CLAIMS

1. A modular energy system controllable to supply power to a load, comprising:
a plurality of modules connected together to output an AC voltage signal comprising a superposition of first output voltages from each module, wherein each module comprises an energy source and converter electronics connected to the energy source and configured to generate the first output voltage from the energy source; and
an enclosure for the plurality of modules, wherein the enclosure is configured to pass coolant to cool the plurality of modules.
2. The system of claim 1, wherein the enclosure comprises a conduit section configured to pass the coolant.
3. The system of claim 2, wherein the enclosure comprises a channel having a shape corresponding to a shape of the conduit section, wherein the conduit section is located within the channel.
4. The system of claim 3, wherein the conduit section is press fit within the channel.
5. The system of claim 2, wherein a first module of the plurality of modules has the converter electronics mounted on a substrate, and wherein the substrate is positioned between the conduit section and the converter electronics of the first module.
6. The system of claim 5, wherein the substrate and converter electronics are positioned between the energy source of the first module and the conduit section.
7. The system of claim 5, further comprising a heatsink positioned between the conduit section and the substrate.
8. The system of claim 7, further comprising an interface layer positioned between the conduit section and the heatsink.

9. The system of claim 8, wherein the interface layer is deformable.
10. The system of claim 8, wherein the conduit section is in contact with the interface layer, the interface layer is in contact with the heatsink, and the heatsink is in contact with the substrate.
11. The system of claim 5, wherein each of the plurality of modules has the converter electronics mounted on a substrate, and wherein the substrate is positioned between the conduit section and the converter electronics of each module.
12. The system of any of claims 2-9, wherein the enclosure comprises a first base section, a second section opposing the base section, and a sidewall section.
13. The system of claim 12, wherein the conduit section is within at least one of the first base section, the second section, and the sidewall section.
14. The system of claim 13, wherein the second section is a lid of the enclosure and wherein the conduit section is within the lid.
15. A method of cooling a modular energy system of an electric vehicle, the method comprising:
pumping coolant through a cooling apparatus in proximity with the modular energy system such that the coolant cools modules of the modular energy system;
then pumping the coolant in proximity with a motor of the EV to cool the motor; and
then pumping the coolant through a heat exchanger to cool the coolant.
16. The method of claim 15, wherein pumping coolant through the cooling apparatus comprises:
pumping coolant in proximity with at least one battery of a module of the modular energy system to cool the at least one battery;
then pumping coolant in proximity with electronics of the module to cool the electronics.

17. The method of claim 15, wherein pumping coolant through the cooling apparatus comprises pumping coolant through a section of an enclosure of the modular energy system.

18. The method of claim 17, wherein the section is at least one of a base section, a second section opposing the base section, and a sidewall section.

19. The method of claim 15, wherein pumping coolant through the cooling apparatus comprises pumping coolant through a base section of an enclosure of the modular energy system and then through a second section of the enclosure that opposes the base section.

20. The method of claim 19, wherein batteries of modules of the modular energy system are located adjacent the base section, and electronics of the modules of the modular energy system are located adjacent the second section.

21. The method of claim 17, wherein pumping coolant through the cooling apparatus comprises pumping coolant through only one of the base section, the second section, and the sidewall section.

22. A modular energy system controllable to supply power to a motor of an electric vehicle, comprising:

at least three arrays, each array comprising a plurality of modules connected together to output an AC voltage signal comprising a superposition of first output voltages from each module, wherein each module comprises an energy source and converter electronics configured to generate the first output voltage from the energy source, wherein the AC voltage signals output by the three arrays supply three-phase power to the motor, wherein the energy source is releasably connectable to the converter electronics.

23. The system of claim 22, further comprising a latch mechanism configured to releasably connect the energy source to the converter electronics.

24. The system of claim 23, wherein each module comprises a housing for holding the converter electronics.

25. The system of claim 24, wherein the housing is coupled to a guide rail for the energy source.

26. The system of claim 25, wherein the energy source is slidable along the guide rail.

27. The system of any of claims 22-26, wherein the energy source has a width, a length, and height, wherein the length is at least twice the width.

28. The system of claim 27, wherein the length is at least three times the width.

29. The system of claim 27, wherein the length is at least four times the width.

30. The system of claim 23, wherein the latch mechanism comprises a power connector for connecting the energy source to the converter electronics.

31. The system of any of claims 22-30, wherein the system comprises at least one interconnection module comprising an energy source and a converter, wherein the converter of the interconnection module is coupled to at least two of the arrays.

32. The system of claim 31, wherein the interconnection module comprises a housing that holds the converter of the interconnection module, wherein the housing comprises a control port, at least two connectors for coupling the converter to the at least two of the arrays, and at least two connectors for coupling the energy source or the converter of the interconnection module to at least one auxiliary load.

33. The system of any of claims 24-32, wherein the energy source is a battery module.

34. The system of claim 33, wherein the housing of each module comprises a connector for connecting a battery management system of the battery module to a local control device housed within the housing.

35. The system of any of claims 22-34, comprising a control system for controlling the converters of the modules.

36. The system of claim 35, wherein the control system is configured to control intraphase balancing within each array.

37. The system of claim 36, wherein the control system is configured to control interphase balancing across the arrays.

38. An electric vehicle, comprising:
an electric motor;
a modular energy system configured in accordance with any of claims 22-37 to supply power for the electric motor; and
at least one access panel configured to move between a first position that covers energy sources of the modular energy system and a second position that exposes the energy sources for removal.

39. The electric vehicle of claim 38, wherein the at least one access panel is a door configured to pivot.

40. A method of managing power for an electric vehicle comprising a modular energy system having at least three arrays, each array comprising a plurality of modules connected together in a cascaded fashion to generate an AC voltage signal for a motor of the electric vehicle, wherein each module comprises a battery module and converter electronics, the method comprising:

removing a first battery module from a first position within the electric vehicle; and

inserting a second battery module into the first position within the electric vehicle, wherein the second battery module has a relatively higher state of charge than the first battery module.

41. The method of claim 40, wherein removing the first battery module comprises unlocking the first battery module from a locked state within the electric vehicle.

42. The method of claim 41, further comprising locking the second battery module in the first position.

43. The method of any of claims 40-42, further comprising moving an access panel of the electric vehicle from a closed position that covers the first battery module to an open position that exposes the first battery module prior to removing the first battery module.

44. The method of claim 43, wherein the access panel is beneath a passenger door.

45. The method of any of claims 40-44, further comprising removing all battery modules from the electric vehicle and inserting different battery modules having relatively higher states of charge than the removed battery modules.

46. The method of any of claims 40-45, wherein removing the first battery module from the first position within the electric vehicle comprises removing the first battery module from electrical contact with first converter electronics associated with the first battery module.

47. The method of claim 46, inserting the second battery module into the first position within the electric vehicle comprises inserting the second battery module into electrical contact with the first converter electronics.

48. The method of any of claims 40-47, wherein removing the first battery module from the first position within the electric vehicle comprises sliding the first battery module along a guide rail.

49. The method of any of claims 40-47, wherein inserting the second battery module into the first position within the electric vehicle comprises sliding the second battery module along a guide rail.

50. The method of any of claims 40-49, wherein the modular energy system is configured in accordance with any of claims 22-37.