CLAIMS

What is claimed is:

1. A modular battery pack system controllable to supply power to a three phase motor of an electric vehicle (EV), the modular battery pack system comprising:

a first interconnection module comprising a first port, a second port, a first battery, and first switch circuitry; and

three converter module arrays, each array comprising at least three arrayed converter modules electrically coupled together to output an AC voltage signal comprising a superposition of output voltages from each of the at least three arrayed converter modules, wherein each of the three arrays is configured to output an AC voltage waveform having a different phase angle for the three phase motor, and wherein each of the arrayed converter modules comprises an energy source and is controllable to selectively output a positive DC output voltage, zero output voltage, or negative DC output voltage from the energy source; and

wherein the first port is electrically coupled with a first array of the three converter module arrays, the second port is electrically coupled to a second array of the three converter module arrays, and the first switch circuitry is controllable to selectively couple the first array or the second array to the first battery.

2. The system of claim 1, further comprising control circuitry communicatively coupled with the at least three arrayed converter modules of each array and with the first interconnection module.

3. The system of claim 2, wherein the control circuitry is configured to control, for each array, the at least three arrayed converter modules to balance intraphase state of charge.

4. The system of claim 3, wherein the control circuitry is configured to control the first interconnection module to balance interphase state of charge between the first and second array.

5. The system of claim 4, wherein the control circuitry is configured to control the first switch circuitry to exchange energy between the first array and the second array.

6. The system of claim 1, further comprising:

a plurality of local control devices configured to output switch signals to each of the at least three arrayed converter modules of each array and the first interconnection module; and

a master control device communicatively coupled with the plurality of local control devices.

7. The system of claim 6, wherein the master control device is configured to output information to the plurality of local control devices, wherein the information comprises normalized voltage reference waveforms and modulation indices, and wherein the plurality of local control devices are configured to generate pulse width modulated switch signals with the information received from the master control device.

8. The system of claim 6, wherein the plurality of local control devices are configured to output state of charge information, about the at least three arrayed converter modules of each array and the first interconnection module, to the master control device.

9. The system of claim 1, wherein a positive terminal of the first battery is electrically coupled with a first node and a negative terminal of the first battery is electrically coupled with a second node, and the first switch circuitry is configured to selectively couple the first port to either the first or second node, and configured to selectively couple the second port to either the first or second node.

10. The system of claim 1, further comprising a second interconnection module comprising a third port electrically coupled with a third array of the three converter module arrays, a second battery, and second switch circuitry, wherein the first and second batteries are electrically coupled in parallel.

11. The system of claim 10, wherein the first switch circuitry is electrically coupled between the first and second batteries and the first and second ports, and the second switch circuitry is electrically coupled between the first and second batteries and the third port.

12. A method of supplying power from a modular battery pack system of an electric vehicle (EV), the method comprising:

controlling a first, a second, and a third converter module array to output three phase voltage signals to a three phase motor of the EV, wherein each array comprises at least three arrayed converter modules electrically coupled together to output an AC voltage signal comprising a superposition of output voltages from each of the at least three arrayed converter modules, wherein each of the arrayed converter modules comprises an energy source and is controllable to selectively output a positive DC output voltage, zero output voltage, or negative DC output voltage from the energy source, and wherein the first array is electrically coupled to the first interconnection module, and the second array is electrically coupled to the first interconnection module; and

controlling the first interconnection module to selectively couple the first array or the second array to a first battery of the first interconnection module.

13. The method of claim 12, wherein controlling the first interconnection module comprises:

controlling first switch circuitry of the first interconnection module to selectively couple the first array or the second array to the first battery.

14. The method of claim 12, wherein controlling the first interconnection module comprises:

controlling the first interconnection module to balance interphase state of charge between the first array and the second array.

15. The method of claim 14, wherein controlling the first interconnection module to balance interphase state of charge between the first array and the second array comprises:

controlling first switch circuitry of the first interconnection module with a pulse width modulated switch signal to selectively couple the first array or the second array to the first battery.

16. The method of claim 12, wherein controlling the first interconnection module comprises:

controlling the first interconnection module to exchange energy between the first array and the second array.

17. The method of claim 12, wherein controlling the first, the second, and the third converter module array to output three phase voltage signals comprises:

controlling, for each array, the at least three arrayed converter modules to balance intraphase state of charge.

18. The method of claim 12, wherein controlling the first, the second, and the third converter module array to output three phase voltage signals comprises:

outputting information from a master control device to a plurality of local control devices, wherein the information comprises normalized voltage reference waveforms and modulation indexes;

generating, by the plurality of local control devices, pulse width modulated switch signals with the information received from the master control device; and

switching switch circuitry of each arrayed converter module of the first, second, and third arrays to selectively output the positive DC output voltage, zero output voltage, or negative DC output voltage.

19. The method of claim 18, further comprising determining the modulation indices based at least on state of charge information about the at least three arrayed converter modules of the first, second, and third arrays.

20. The method of claim 12, wherein the third array is electrically coupled to a second interconnection module comprising a second battery, wherein the second interconnection module is coupled to the first interconnection module such that the first battery and second battery are in parallel, the method further comprising:

controlling the second interconnection module to selectively couple the third array to the first and second batteries.

21. A modular battery pack system controllable to supply power to an electric vehicle (EV), the modular battery pack system comprising:

three converter module arrays, each array comprising at least three arrayed converter modules electrically coupled together to output an AC voltage signal comprising a superposition of output voltages from each of the three arrayed converter modules, wherein each of the three arrays is configured to output an AC voltage signal having a different phase for a three phase motor of the EV, and wherein each of the arrayed converter modules comprises an energy source and is controllable to selectively output a positive DC output voltage, zero output voltage, or negative DC output voltage from the energy source; and

a first interconnection module electrically coupled with a first array of the three converter module arrays and a second array of the three converter module arrays, wherein the first interconnection module comprises a first battery and a port to supply power from the first battery to a first auxiliary load of the EV.

22. The system of claim 21, wherein the first battery is configured to output a first voltage, and wherein the first interconnection module is configured to supply the first voltage directly to the first auxiliary load.

23. The system of claim 21, wherein the first interconnection module comprises:

first switch circuitry electrically coupled with the first battery; and

a first inductor electrically coupled with the first switch circuitry such that the first inductor is switchably coupled to the first battery,

wherein the first inductor is electrically coupled with the port.

24. The system of claim 23, further comprising control circuitry configured to control the first switch circuitry to control the first voltage supplied to the first auxiliary load from the first battery.

25. The system of claim 24, wherein the control circuitry is configured to receive measurement signals from the first interconnection module and use the measurement signals to control the first switch circuitry to control the first voltage supplied to the first auxiliary load.

26. The system of claim 25, wherein the control circuitry is configured to use the measurement signals and to generate a pulse width modulated switch signal to control the first switch circuitry to control the first voltage supplied to the first auxiliary load.

27. The system of claim 21, wherein the port is a first port, and the first interconnection module comprises a second port to supply power from the first battery to a second auxiliary load of the EV.

28. The system of claim 27, wherein the first auxiliary load comprises an air conditioner of the EV, and the second auxiliary load is an on-board electrical network of the EV.

29. The system of claim 21, wherein the port is a first port, and the system further comprises a second interconnection module electrically coupled with a first array of the three converter module arrays, wherein the second interconnection module comprises a second port to couple to the first auxiliary load of the EV, and a second battery electrically coupled in parallel with the first battery.

30. The system of claim 29, wherein the first interconnection module comprises first switch circuitry electrically coupled with the first and second batteries, and a first inductor electrically coupled with the first switch circuitry such that the first inductor is switchably coupled to the first and second batteries, wherein the first inductor is electrically coupled with the first port.

31. The system of claim 30, wherein the second interconnection module comprises second switch circuitry electrically coupled with the first and second batteries, and a second inductor electrically coupled with the second switch circuitry such that the second inductor is

switchably coupled to the first and second batteries, wherein the second inductor is electrically coupled with the second port.

32. The system of claim 29, wherein the first interconnection module comprises a third port to supply power from the first and second batteries to a second auxiliary load of the EV.

33. The system of claim 32, wherein the second interconnection module comprises a fourth port to couple to a second auxiliary load of the EV.

34. The system of claim 33, wherein the first and second ports are electrically coupled together, and wherein the third and fourth ports are electrically coupled together.

35. A method of supplying power from a modular battery pack system to an electric vehicle (EV), the method comprising:

controlling three converter module arrays to output three phase voltage signals to a three phase motor of the EV, wherein each array comprises at least three arrayed converter modules electrically coupled together to output an AC voltage signal comprising a superposition of output voltages from each of the three arrayed converter modules, wherein each of the arrayed converter modules comprises an energy source and is controllable to selectively output a positive DC output voltage, zero output voltage, or negative DC output voltage from the energy source; and

controlling a first interconnection module to supply power from a first battery of the first interconnection module to a first auxiliary load of the EV, wherein the first interconnection module is electrically coupled with a first array of the three converter module arrays and a second array of the three converter module arrays, and wherein the first interconnection module comprises the first battery and a port to supply power from the first battery to the first auxiliary load.

36. The method of claim 35, wherein controlling the first interconnection module comprises:

controlling first switch circuitry of the first interconnection module to control the power supplied from the first battery to the first auxiliary load.

37. The method of claim 36, further comprising:

using measurement signals from the first interconnection module to control the first switch circuitry to control the power supplied from the first battery to the first auxiliary load.

38. The method of claim 37, wherein using the measurement signals from the first interconnection module comprises:

using the measurement signals as a basis to generate a pulse width modulated switch signal to control the first switch circuitry to control the power supplied to the first auxiliary load.

39. The method of claim 38, wherein the first interconnection module comprises:

a first inductor electrically coupled with the first switch circuitry such that the first inductor is switchably coupled to the first battery, wherein the first inductor is electrically coupled with the port and power is supplied from the first battery to the first auxiliary load through the first inductor.

40. The method of claim 39, further comprising controlling the first interconnection module to supply power from the first battery to a second auxiliary load of the EV, wherein the second interconnection module comprises a second port to supply power from the first battery to the second auxiliary load.