BMS: Battery Management Systems

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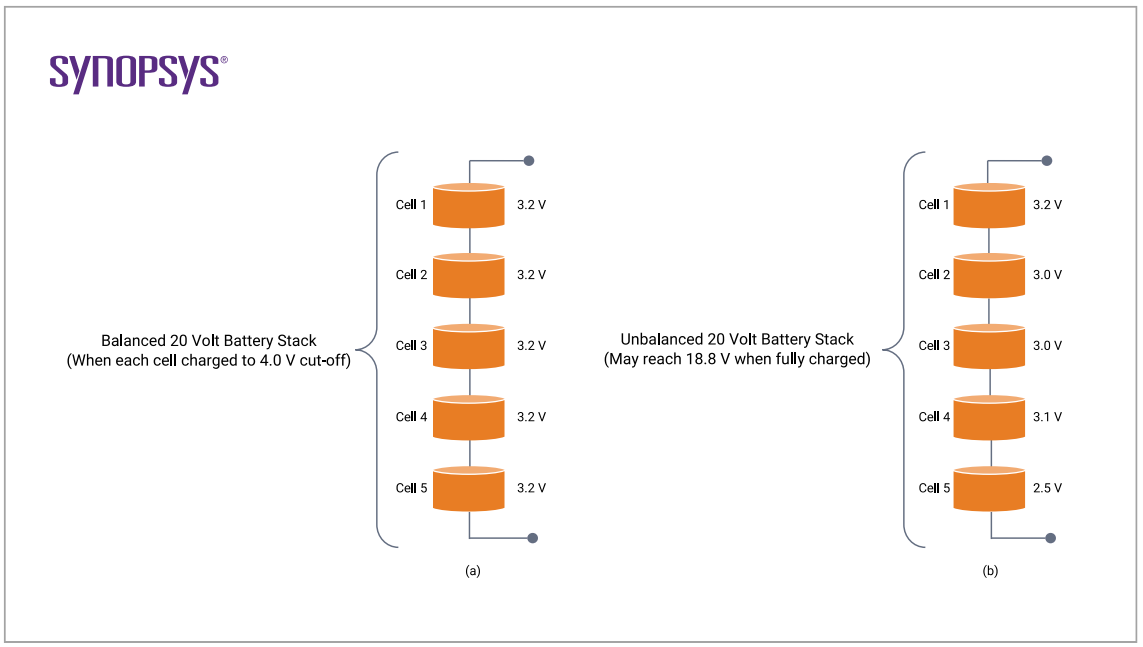
- Batteries need special monitoring, for example, during charging we are going to need to check if we are in a state of overvoltage, the overvoltage state leads to increase of temperature, causing increase of temperature therefore increase in internal resistance so power lost is increased.

Importance of BMS:

1. **Discharge control:** the primary goal of a BMS is to keep the battery away from operating out of its safety zone. The BMS must protect this cell during discharge.
2. **SOC Determination:** BMS keeps track of SOC (State of Charge) of a battery which is the current capacity inside it.
   There are several methods to determine SOC:
   I) Direct Voltage Measurement: The SOC is calculated based on the proportional relationships between the electromotive force (EMF) of a battery, its terminal voltage, and the state-of-charge. It is done using a voltmeter.
   II) Coulomb Counting: It is a method to measure how much current is going inside and outside the battery.
   III) Combination of Coulomb Counting and Direct Voltage Measurement.
3. **SOH Determination:** (State of Health is the battery's ability to store charge and deliver electrical energy compared to a new battery). SOH could be estimator for internal resistance or cell conductance.
4. **Cell Balancing:** BMS equalizes the charge level of individual cells within the battery to prevent overcharging or undercharging.
   - There are two techniques to balance the cells:

   I) Passive balancing: it allows the battery stack to look like every cell has the same capacity as the weakest cell. Using a relatively low current, it drains a small amount of energy from high SOC cells during the charging cycle so that all cells charge to their maximum SOC.
   II) Active Balancing: It is a more complex balancing technique that redistributes charge between battery cells during the charge and discharge cycles, thereby increasing system run time by increasing the total useable charge in the battery stack, decreasing charge time compared with passive balancing, and decreasing heat generated while balancing.



Cell Balancing Example

5. **BMS can act like a logbook:** Monitoring and storing the battery's history is another possible function of the BMS. This is needed to estimate the State of Health of the battery, but also to determine whether it has been subject to abuse. Parameters such as number of cycles, maximum and minimum voltages and temperatures and maximum charging and discharging currents can be recorded for subsequent evaluation.
6. **Overvoltage/Undervoltage Protection:** BMS prevents the battery from operating outside of its safe voltage range.
7. **Overcurrent/Short-Circuit Protection:** BMS prevents excessive current flow, which can damage the battery or other components.
8. **Temperature Monitoring:** BMS monitors the temperature of the battery to prevent overheating, which can damage the battery or cause a safety hazard.
9. **Communication:** BMS gives precise and detailed information about SOH, SOC and much more details for service and maintenance. BMS also incorporates some form of communication between the battery and the charger or test equipment.

BMS Topologies:

1. **Distributed Topology:**
   - A distributed BMS incorporates all the electronic hardware on a control board placed directly on the cell or module that is being monitored.
   - It is simple and reliable. However, it requires a large number of small PCBs so it is difficult for mounting.

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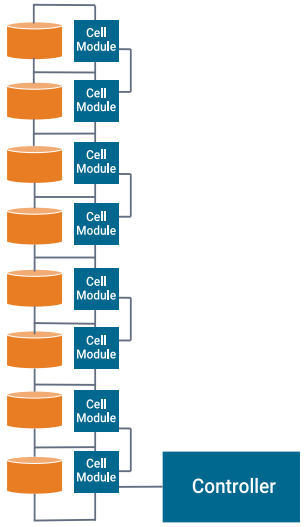
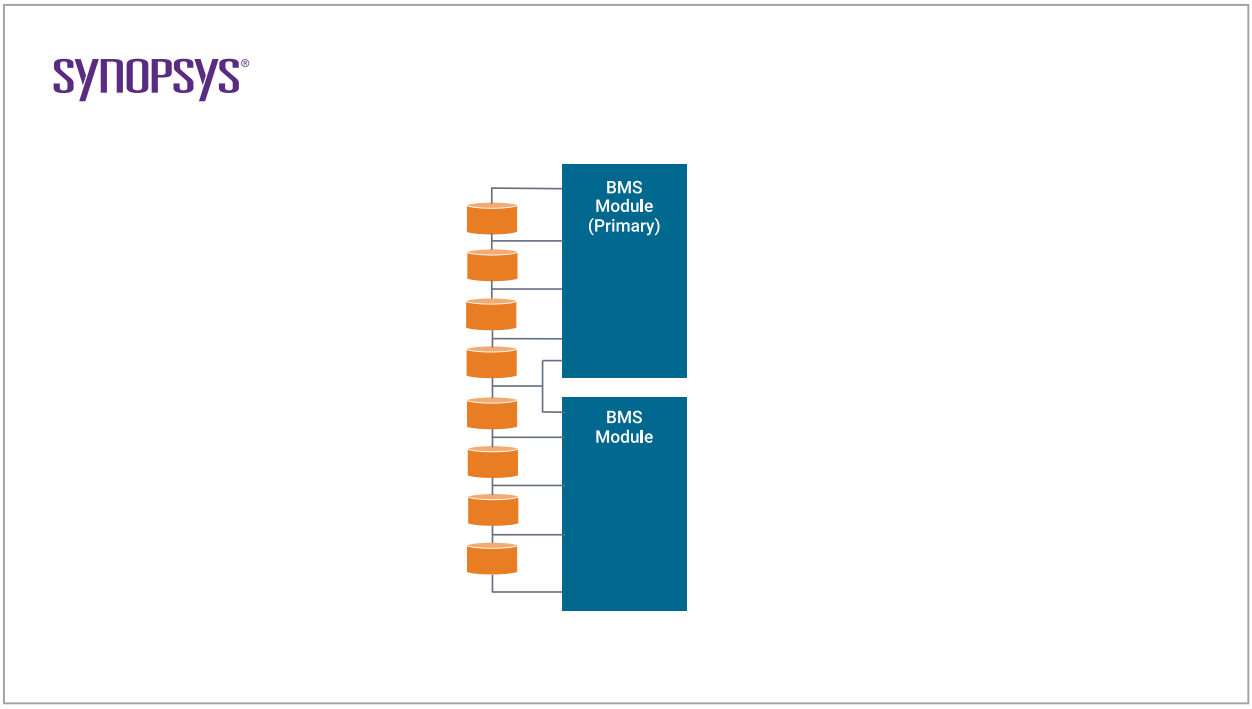


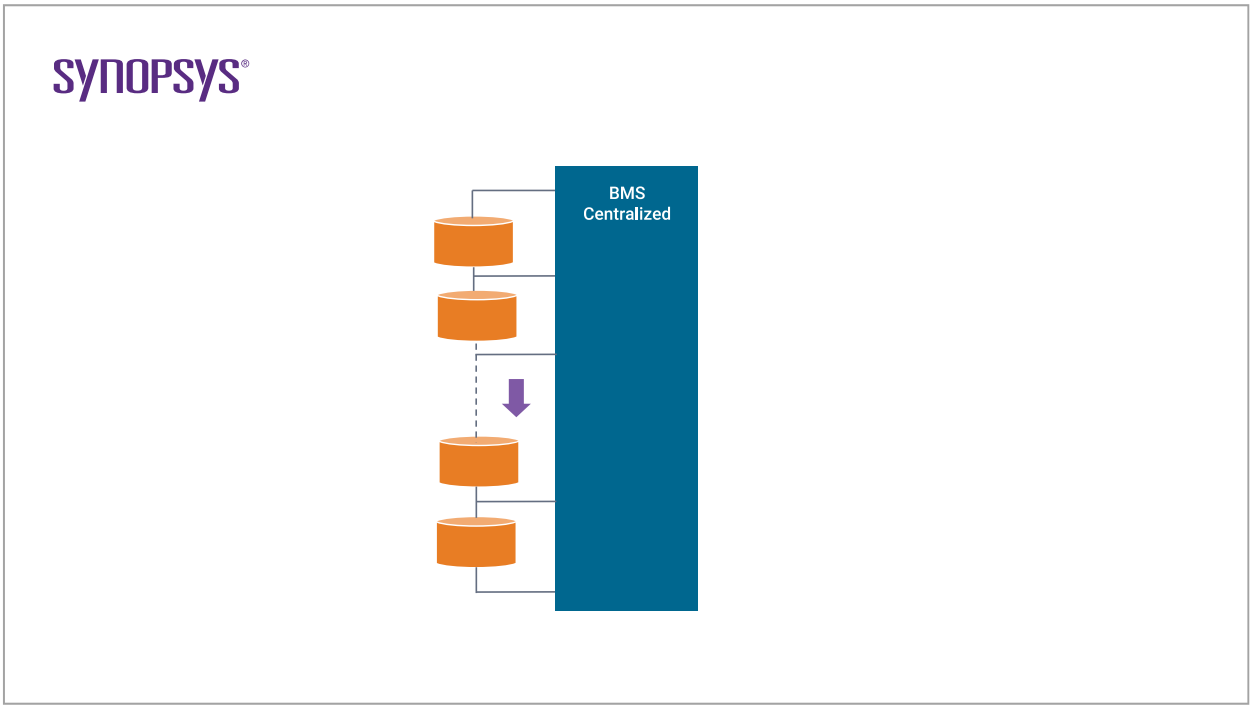
Distributed Topology

2. **Modular Topology:**
   - A distributed BMS incorporates all the electronic hardware on a control board placed directly on the cell or module that is being monitored.
   - No special PCBs are necessary to connect the individual cells. However, communication is difficult.



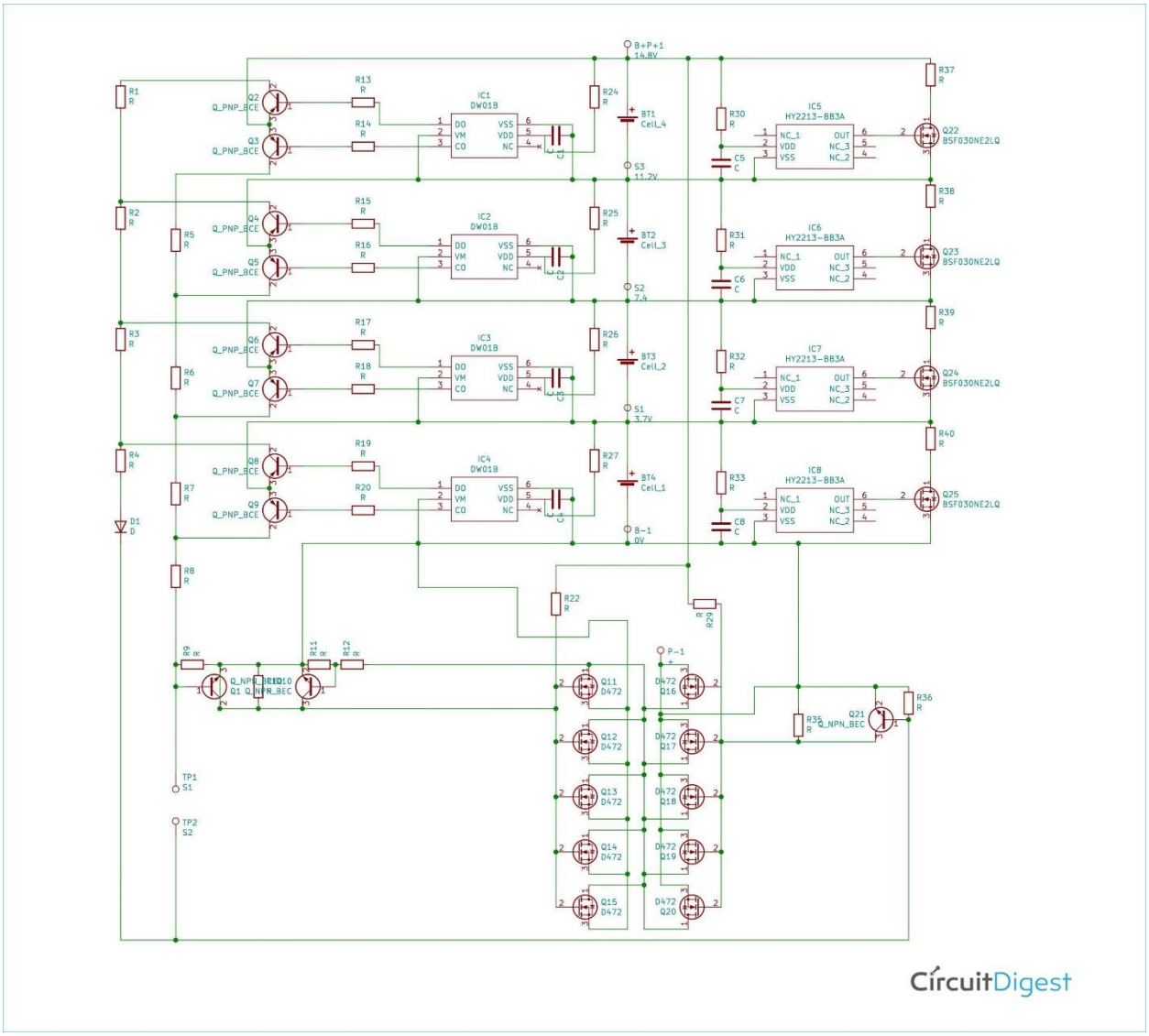
Modular Topology

3. **Centralized Topology:**
   - A distributed BMS incorporates all the electronic hardware on a control board placed directly on the cell or module that is being monitored.
   - It required less hardware, but excess heat could be generated because the controller is the only source for cell balancing. In addition, the cells are distributed within various locations which requires a lot of wiring.



Centralized Topology

Example: Circuit Diagram of a BMS



Lithium-Ion Battery Management and Protection Module (BMS)