Design of real-time balance criterion

- Another question is, “what should be the real-time criterion for determining which cells to balance?”
  - Which balancer circuits should be “switched on” at any instant?
- We might choose to balance based on SOC estimates (until ΔSOC at the balance setpoint is small)
  - But, if SOC estimates are poor, can balance “wrong” cells
- Could also choose to balance based on voltage measurements (until Δv, as continuously monitored, small), especially if using fast active balancing
  - Simpler, but voltage is a poor indicator of SOC
  - Wasteful since often balancing “wrong” cells when pack under load

Design of real-time balance criterion

- Could even balance based on total available energy (SOCs never exactly equal at any point when balancing this way)
  - Maximizes energy that can be extracted from battery pack before a design limit (usually on minimum cell voltage) is exceeded
  - Can improve total available energy by moving charge from low-resistance cells to high-resistance cells to bolster their SOC (and hence their voltage)
  - Need an accurate cell model and state estimate for every cell

Design of balance activity

- Another question we need to consider is, when to balance?

ON CHARGE ONLY:

- Can be used for EV/PHEV/E-REV
  - Maximizes range: Dissipates charge only when plugged in
  - But, charging times must be larger to allow full balance

CONTINUOUSLY:

- Needed for HEV and if fast active balancing used to maximize energy and power
- Harder to do “right” for SOC-based balance as SOC estimates must be accurate

PREDICTIVE:

- Predict where the end point will be on charge (etc)
  - Proactively balance even when otherwise not obvious that balancing is needed

Summary

- Need to determine when a pack is balanced, when to balance
- Can choose different criteria for a “balanced” battery
- Can decide a pack is balanced if all voltages are within Δv of each other right now
- Can decide a pack is balanced if all SOCs are within Δz of each other, either at some design setpoint or continuously
- Can decide a pack is balanced if all cells hold same total or available energy, either at some design setpoint or continuously
- Can balance continuously, only while charging, or even predictively