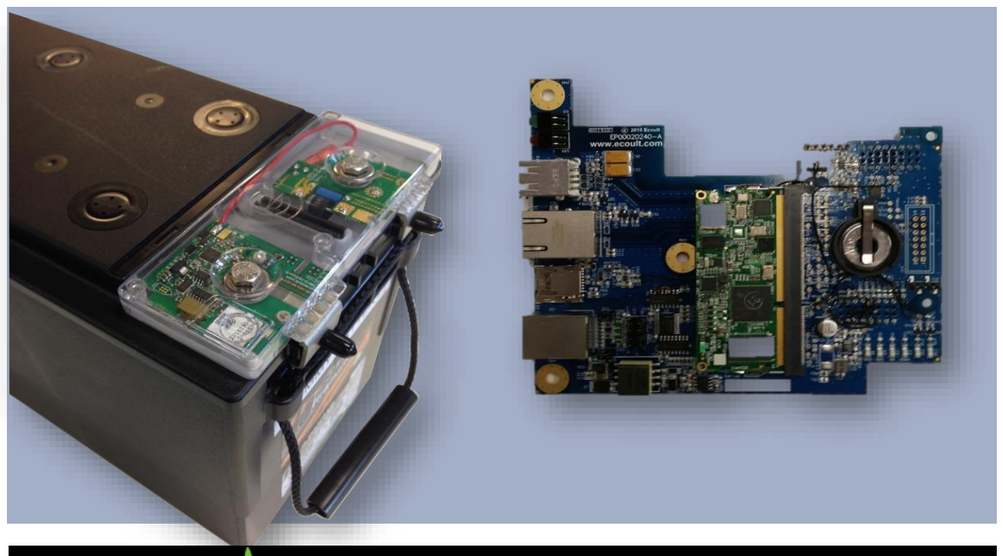
Lead-Acid Batteries in Megawatt-Scale Multi-Purpose Applications

By: Marc Pelletier

Application Challenges of using UltraBattery® for Frequency Regulation, Demand Response, and Microgrid Operation



The UltraBattery Advantage

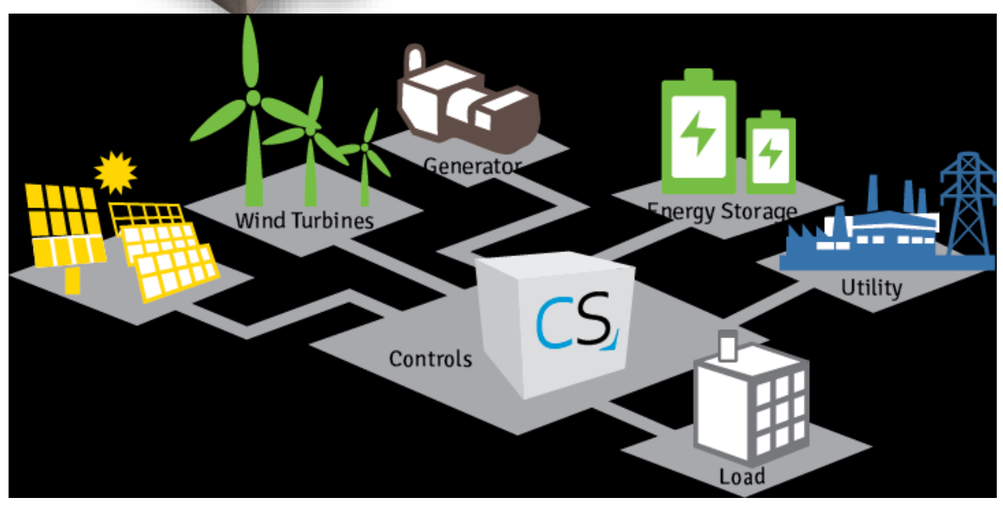
UltraBattery (UB) is a Partial State of Charge (PSoC) advanced Lead-Acid battery that combines ultracapacitor and lead-acid chemistries in a single electrolyte, overcoming the limitations of typical VRLAs with continuous PSoC operation while retaining advantages such as flexible over-voltage and high temperature limits. Significantly reduced internal resistance allows it to charge and discharge at much higher rates ($1.4C_1$) than typical VRLA.

UB in Microgrids & Ancillary Services

This allows for a battery system that can not only provide a UPS back up but also the following:

- Microgrid Operation with distributed renewables and DGs
- Frequency regulation Ancillary Service while connected on grid
- Demand Response while connected on grid.

The presentation will cover techniques Ecoult has adapted to achieve systems that have now demonstrated very high reliability in the field over many years.



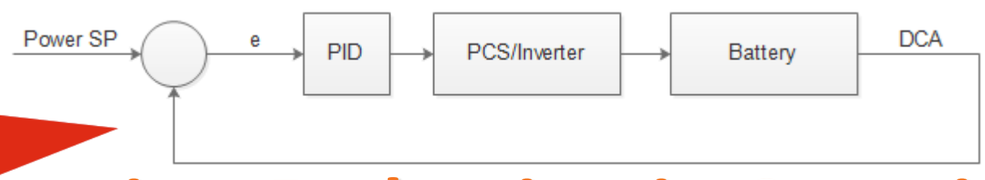
Dynamic Charge Acceptance

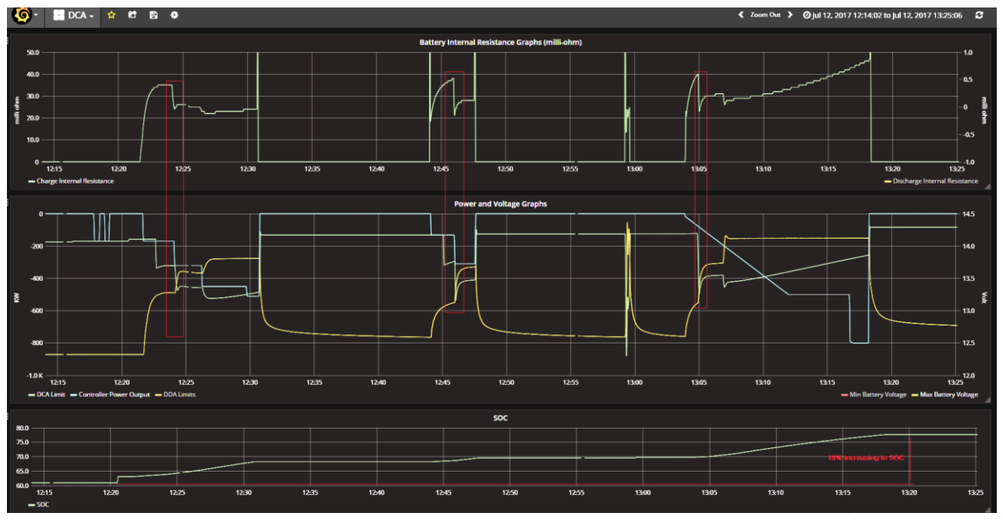
One of the best revenue streams for PSoC batteries, is frequency regulation in the electricity market. The UltraBattery shines most when regulating an energy neutral power signal received from the grid operator. One challenge faced is at the outer edges of operation: 80%<SoC<30% where the battery may increase in impedance, unexpectedly causing a rise in voltage which can approach the inverter voltage trip levels. Predictive algorithms as shown below can prevent a potential voltage trip should the voltage rise too quickly.

Overall Internal Resistance OIR = (OCV - V)/I

I_Chrg_Limit = (Vmax - Vmax_Limit)/OIR for one string of batteries where

DCA = I_Char_Limit * Vmax_Limit or a more conservative DCA can be gained by DCA = (I_Char_Limit * V_string) for a string of batteries

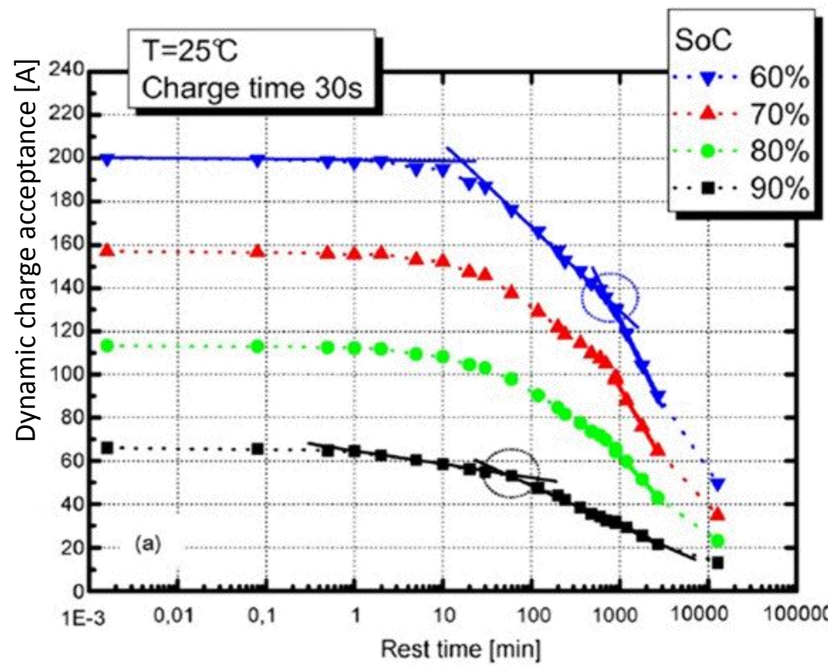




Idle batteries: Reduction in Capacity

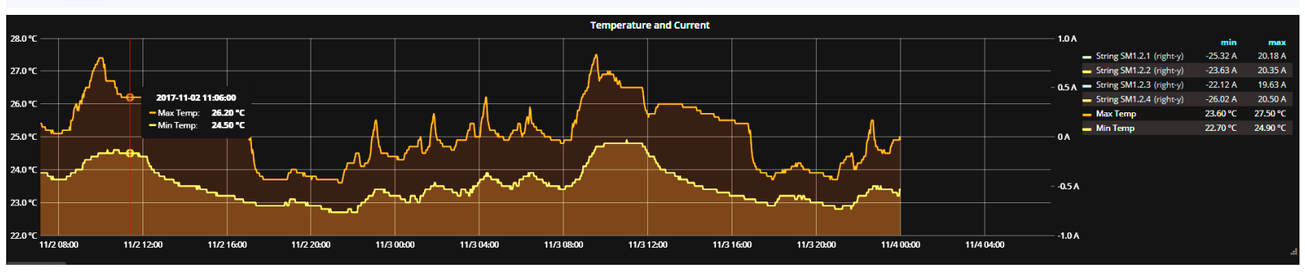
Idle batteries which have not run for over 24 hours have a reduced capacity when coming back into operation, particularly if the entry begins at full power. Typically a battery refresh would return power levels back to the mid-point to start in the frequency regulation market.

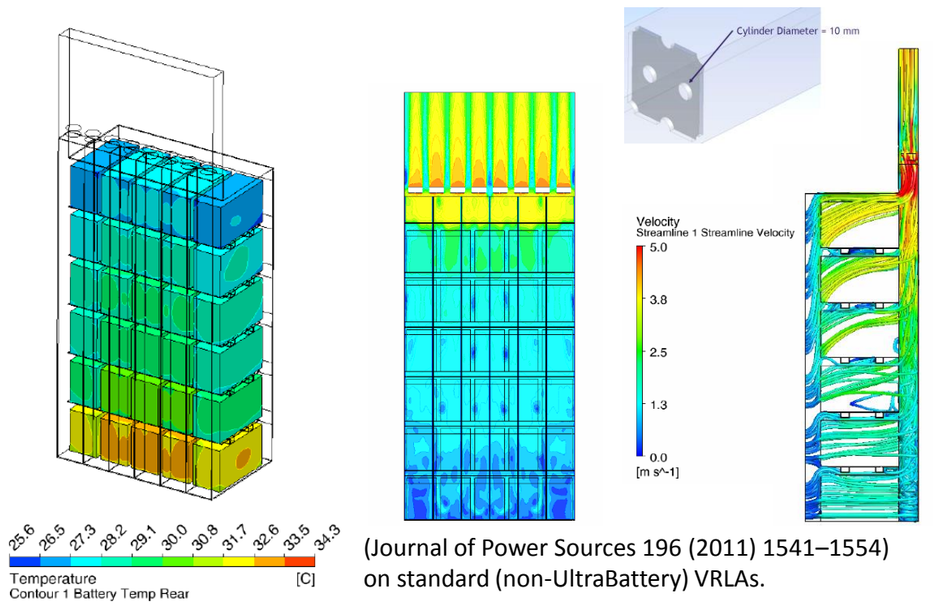
However Ecoult's approach has been to implement a light "exercise" regime to keep batteries in a running state, ready for next use. Instead of shutting down, inverter power is cycled at low levels to keep current flowing, avoiding the idle period altogether. UltraBattery chemistry prefers PSoC cycling over idling, but this causes none of the degradation that would occur in a standard VRLA.



Optimised Racks for Power Applications

Heat is an issue in high powered batteries. While lead-acid is able to operate at very high temperatures (up to 50°C) it is still a challenge to keep all batteries throughout the string at the same operating temperature. Deviation in temperature unbalances batteries within a string, which in turn causes limitations at the edges of SoC operation. Using CFD analysis, fan mountings, and specialised HVAC designs, we have optimised the battery racks to keep all batteries, from the top rack to the bottom rack within 3°C of one another.





(Journal of Power Sources 196 (2011) 1541–1554) on standard (non-UltraBattery) VRLAs.