Title: Smart Battery Gauge

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Problem:
Utilities: Stationary energy storage devices can play critical roles in handling powerline congestion, safety and reliability in renewable energy systems. There is a large opportunity for deployment of stationary energy storage systems if real-time, accurate battery management systems are available, thereby reducing capital expenditure, operational cost, and uncertainty in performance of the battery systems.
Battery Manufacturers: While battery manufacturing costs are expected to drop below $100/kWh, the inability of current battery gauges to accurately estimate the SOH and the RUL of batteries while they are in-use is still a major concern. A battery gauge that can provide real-time, accurate estimation of an energy storage system's performance while in use can increase the penetration of stationary energy storage devices in utility grids and broaden the market for battery manufacturers.

Solution: The SBG, developed at ADAC lab, NCSU, can provide an accurate real-time estimate of the SOH and RUL of a battery of any chemistry while in use to prolong battery life and enable efficient management and use of batteries as alternative energy sources to the grid. Competing systems require batteries to be taken offline for significant periods of time to make measurements resulting in more cumbersome integration and increased costs – labor, maintenance, capital, etc. The benefits of integrating the SBG into batteries at utility and manufacturer level are:
Utilities: SBG can ensure successful and profitable utilization of the stationary energy storage devices by the utilities and high returns for initial investment.
Battery Manufacturers: Integrating the SBG on the energy storage devices, can help vendors provide improved reliability and support to their customers. SBG's chemistry agnostic ability can help vendors minimize expenditure on multiple technologies for different chemistries.
The SBG uses the Co-Estimation Algorithm, a combination of an adaptive parameter identification technique and an observer-based estimation method. Using these techniques, the Co-Estimation algorithm is able to acquire the terminal voltage, current and temperature of operation and identify the SOC and SOH in real-time and provide feedback on the RUL of the battery. Figure 1 shows the block diagram of the SBG.

Results: The SBG is able to adapt to real world operating conditions and battery aging and provide live and accurate assessment of the SOC of the battery within an error margin of 5%. The SBG has been successfully implemented in a Raspberry Pi and deployed at two working microgrids in North Carolina. Figure 2 shows the pilot implementation of the SBG at two microgrid facilities in North Carolina. The innovation of the SBG is discussed in 25 journal and conference papers and 3 patents. The SBG has also generated 4 simulation software products and 3 hardware products.

Impact: The SBG can be applied to any battery. Renewable energy is a rapidly growing market, the SBG will have the greatest benefits in stationary energy storage systems, such as power generation applications where batteries are used for storage and other ancillary applications such as frequency regulation.
The current energy storage market stands at nearly 4.9GW and is expected to grow to 100GW by 2024 because the cost of battery manufacturing expected to decrease below $100/kWh, an increase from nearly $22B to $100B as per BloombergNEF(1). The adoption of battery into the power grid is a critical step towards a more resilient power infrastructure with renewable energy integration, and the SBG could be a key driver of that adoption. The key players in this market are utility companies such as Duke Energy, Pacific Gas & Energy, cooperative organizations, etc. The value proposition for stationary energy storage vendors is lowering the total cost of ownership by maximizing the useful life of batteries, increasing battery system uptime, reducing required maintenance and improving the reliability and safety of their products. Potential markets include utility scale storage, microgrids, solar + storage installations and electric vehicles. The SBG has been deployed in a pilot project and has a Technology Readiness Level of 8. NC State has also partnered with multiple battery manufacturers to develop custom battery monitoring solutions. The SBG is in the technology transfer stage and is ready for commercialization.

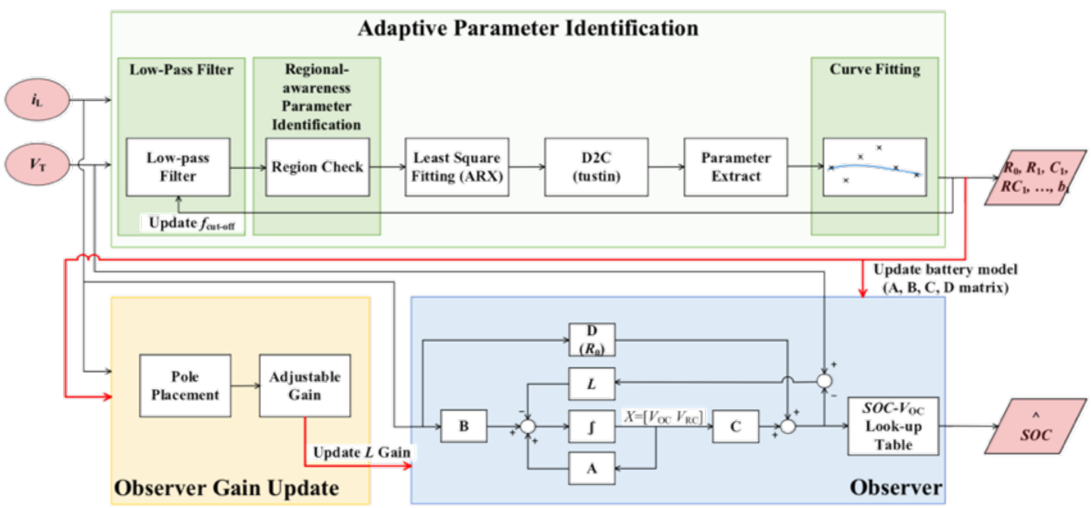

Figure 1. The block diagram of operation for the SBG

Figure 2. Pilot implementation of the SBG in a Raspberry Pi at Microgrid facilities in North Carolina.

(1) https://about.bnef.com/blog/energy-storage-620-billion-investment-opportunity-2040/