Reliability Testing of Lead Acid Battery Module for grid services

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Introduction:

The advanced or carbon-enhanced negative electrode lead acid battery modules are used for renewable Energy Storage Applications due to their high cycle life, low cost and sustainability, However, there is still a lot to understand in terms of reliability for grid services. A lead acid battery modules has been tested for grid services such as frequency regulation. Test procedure and results are shown below.

Figure 1: Carbon Battery (Ref: C&D technologies)

Measurements :

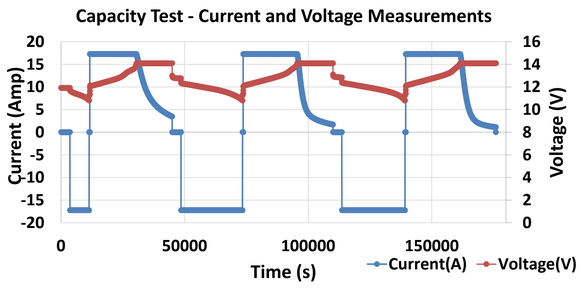
- Voltage
- Current
- Charge and Discharge Capacity
- Charge and Discharge Energy
- Cumulative Discharge Energy
- Round-trip efficiency (RTE),
- Internal Resistance

Objectives of the Project

- Develop a reliable testing protocol for lead acid battery module for grid services.
- Gain fundamental understanding of degradation mechanism of Lead Acid Battery module while used for grid services.
- Compare results with other battery chemistries to determine a reliable application specific battery technology for grid services.

Testing Procedure

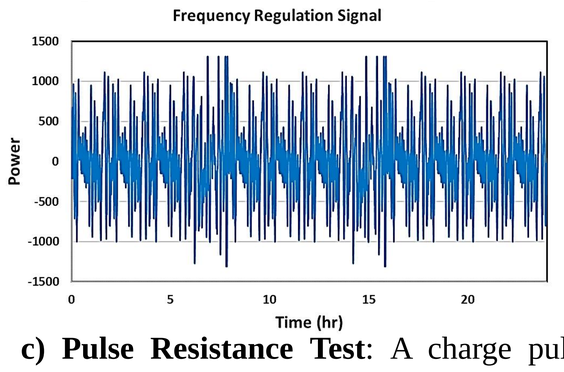
a) Capacity Test: It measures the battery capacity per cycling conditions described. Capacity test has been performed periodically to determine the capacity degradation of battery.



1. CC/CV charge to 100% SOC at C/10 rate to 14.1 V, hold till I < C/40 , Rest 1 hour
2. Discharge at 10-hour rate (17.24 amperes) to 10.8V, Rest 1 hour
3. Charge to 100% SOC , Rest 1 hour

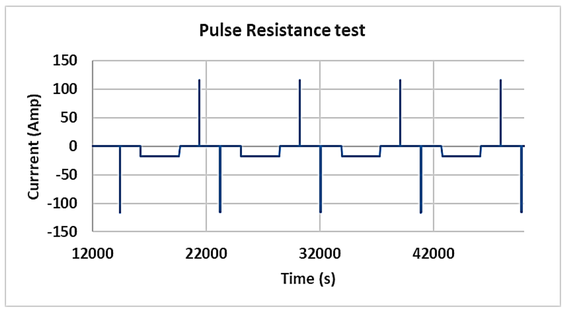
Repeat steps 2-3 thrice.

b) Frequency Regulation Test: The frequency regulation(FR) signal from the US DOE-OE Energy Storage Performance Protocol is applied. Power is normalized with respect to the rated power over a 24-hour time period.



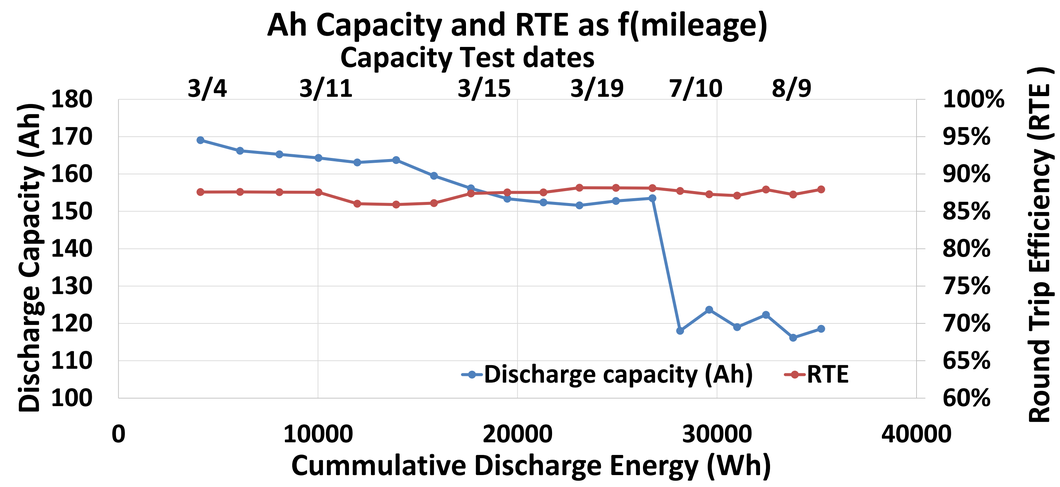
- Rated Power 1240 Watt
- Initial SOC 80%
- The SOC is reduced by 23% in one FR cycle
- The Battery module is charged back to initial SOC after one FR cycle.

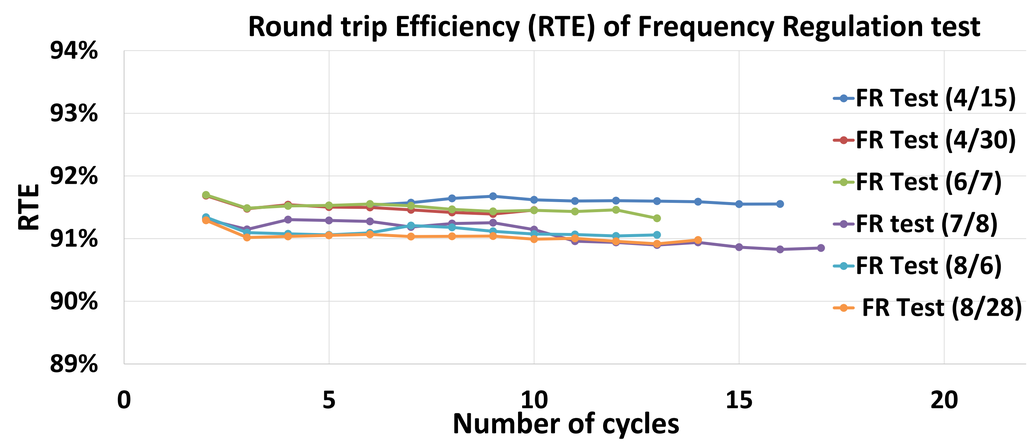
c) Pulse Resistance Test: A charge pulse and discharge pulse is applied. The internal resistance is calculated as the ratio of the change in voltage and current at the end of pulse.



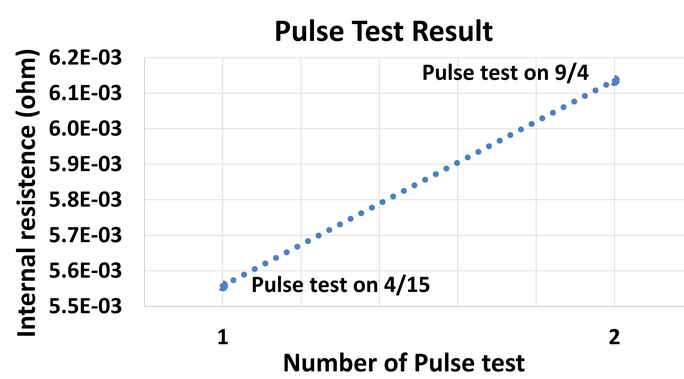
- Resistance is measured in every 10% ΔSOC decrementing from 100% SOC
- 6 second pulse width
- During pulse ΔSOC = 0.1%
- $Internal\ resistance = \Delta V / \Delta A$

Results and Discussion:





- Rated Capacity is 172 Ah while measured initial capacity was 169 Ah
- Round Trip Efficiency (RTE) is constant for all capacity tests. The FR RTE changed only 1% over the entire test duration.
- 30% decrease in Ah capacity. Capacity loss due to loss of active material; resistance increase of 10% does not play a major role (RTE unchanged).



- Internal Resistance increased 10% with time.
- Further pulse test will be done to determine the degradation profile of lead acid battery module.

Future Work:

- Peak shaving grid service testing will be performed.
- Degradation will be compared with that for volatile FR signal
- The results will be analyzed to characterize the performance reliability of lead acid battery module for grid services.
- The same tests will be conducted for other battery chemistry modules and the results will compared.

Acknowledgements

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