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Design and Implementation of State of Charge Management of Battery using Raspberry Pi

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***Abstract* - For reliable operation of the grid it is necessary that ancillary services are introduced in power system operation. Battery is one of the best choice among all ancillary services. In this paper we discussed thoroughly and implemented the strategy to increase life and performance of battery. To achieve this result, we did state of charge management of battery. State of charge (soc) is an important parameter which reflects the battery performance. As management of soc not only prevents over or under-charge but also improves the battery life and performance score.**

Aim of this paper is to manage the state of charge of battery within certain limit by using raspberry pi. A regional transmission organization provides a signal to the battery. By using raspberry pi, we have modified the signal given by rto which is send to the battery, by putting bias on battery's power output considering state of charge status so that performance score and battery life is improved.

Thus by using Raspberry Pi, we have successfully managed SOC of battery between prescribed limit and achieved the expected result of battery.

Keywords—Battery, State of Charge, RegD, Ancillary Service

I.INTRODUCTION

The ancillary power market, an alternative to the existing unscheduled interchange (UI) mechanism of power supply, is designed to handle real time active power supply demand imbalances of the users.

Power systems require ancillary services to maintain reliability and support their primary function of delivering energy to customers. Ancillary services are principally real-power generator control capacity services the system operator uses over various time frames to maintain the required instantaneous and continuous balance between aggregate generations and load. [1]

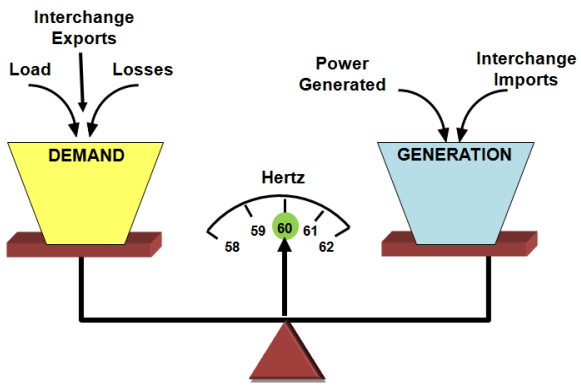
In this paper we will discuss strategy for State of charge management of battery where it is used as Ancillary Service for grid.

Without SOC management, comparatively more battery performance will be affected, Battery can undergo deep discharge and over discharge for longer time. Due to such conditions, battery response is unable to follow a signal. and it affects pay by performance of battery and Revenue generation by battery will be much more less. By managing SOC, we achieve quick response of battery for the changes in load, thus increasing revenue.

II.FREQUENCY REGULATION

Regulation is a variable amount of generation energy under automatic control. Regulation is Independent of economic cost signal also obtainable within five minutes and responds to frequency deviations. The generating units or Demand Response Resources (load resources that can reduce consumption when called upon) provide fine tuning that is necessary for effective system control. Regulating units correct for small load changes that cause the power system to operate out of balance (measured as "ACE"). [2]

Balancing Authority Goal:



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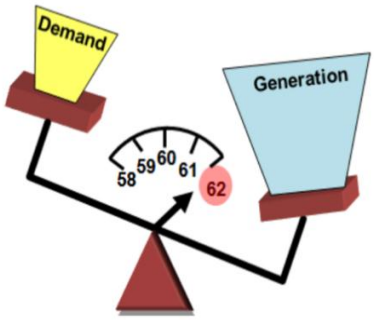
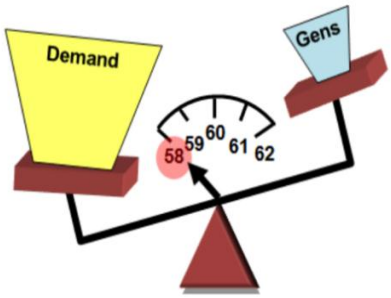
Imbalance Conditions:

1. Over Generation



- Total Generation > Total Demand
- Frequency > 60 Hertz
- Generators momentarily speed up

2. Under Generation



- Total Generation < Total Demand
- Frequency < 60 Hertz
- Generators momentarily slow down

PJM is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia in USA. [3]

Battery of kW/ MW energy storage tied to the local grid that stored energy is sold daily into PJM's fast response regulation market. The system is used to help balance the frequency on PJM's network. [4]

III.PAY FOR PERFORMANCE

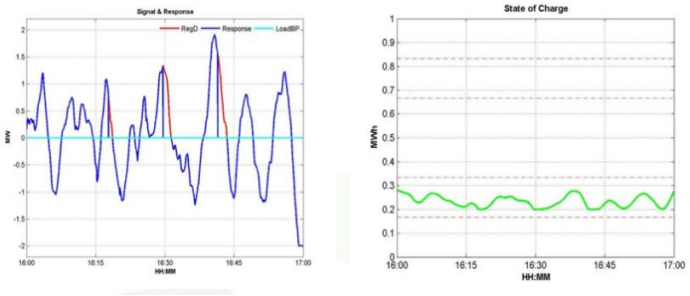
PJM judges the frequency regulation market participants largely, on how quickly and accurately those participants are able to respond to a PJM provided signal.

Frequency variations on the grid are usually fast, therefore battery asset response can follow more accurately the correcting signal given by the network operator than the other assets. It will have a stronger impact on the grid frequency and thus on the grid safety. Pay for performance is introduced in PJM for frequency regulation according to which a fast asset likes battery supplies more power to grid and therefore gets paid more. [5]

IV. STATE OF CHARGE

The SOC is defined as the available capacity expressed as a percentage of some reference, sometimes it is rated capacity but more likely it is current (i.e. at the latest charge-discharge cycle) capacity. It is very important parameter for a control strategy. As a SOC is important parameter which reflects the battery performance so management of SOC can not only protect the battery, prevent the over discharge and improve the battery life but also allow the application to make rational control strategies to save energy.

V.PERFORMANCE WITHOUT SOC MANAGEMENT



RegD(Regulation Dynamic) Signal:

- It is a Control signal sent by Regional Transmission Organization to Resource owner.
- This Signal is short-term and balanced around a zero state.
- It is a Dynamic signal which moves with the frequency deviation component of Area Control Error.
- It increases the "utilization" of the energy storage devices.
- When RegD is positive, battery is discharging putting power onto the grid and when RegD is negative, battery is charging acting as load and absorbing power from the grid. [6]

Above figure shows RegD signal and corresponding battery response and State of charge of Battery respectively.

Thus from figure it is clear that without SOC management, response signal does not follow RegD signal at some time intervals. Hence, Battery reaches lower threshold of SOC and is unable to respond. Thus Battery runs at High Depth of Discharge (DOD) which tends to shorten battery life significantly.

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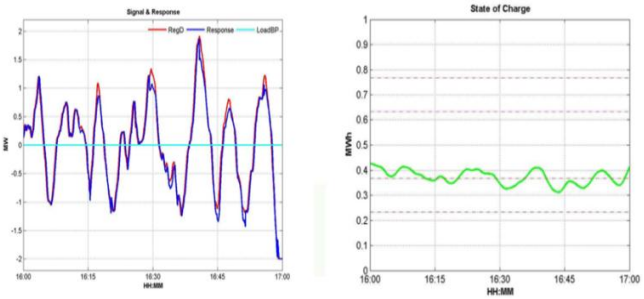
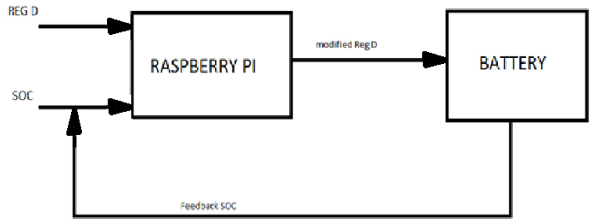
VI.PERFORMANCE WITH SOC MANAGEMENT



Above figure shows RegD signal and corresponding battery response and State of charge of Battery respectively.

Thus from figure it is clear that with SOC management, RegD signal is almost followed by response signal. Hence, Battery does not reach at its lower threshold of SOC. So Battery never runs at high Depth Of Discharge which tends to increase in battery life significantly.

VII.PRODUCT DESIGN



BLOCK DIAGRAM OF SOC MANAGEMENT

This is a block diagram for state of charge management of battery. There are two input signals namely RegD and SOC which will be given to Raspberry Pi. Raspberry Pi is a series of credit card-sized single-board computer developed in UK by the Raspberry Pi foundation. [7]
According to the SOC, Raspberry pi will modify the RegD signal and that signal will be sent to the Battery. Thus as per modified RegD, Battery's SOC will be changed and input SOC signal of Raspberry Pi will get updated through closed loop system.

VIII.PAPER IMPLEMENTATION

The logic of this project is implemented by using JAVA programming language.
Server Client communication system is used to setup connection between Battery and raspberry pi. In this system there are two clients and one server. Raspberry Pi acts as a server and RegD and Battery act as clients.

IX.SIMULATION RESULTS

On the console screen of battery following parameters will be displayed.

```
Without SOC Management

RegD received from server 0.36459404

New Soc in percentage :
8.16

With SOC Management

RegDM received from server 0.14583762

New Soc in percentage :8.28

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-----------------------------------------------------

Without SOC Management

RegD received from server 0.34085003

New Soc in percentage :
8.09

With SOC Management

RegDM received from server 0.13634

New Soc in percentage :8.2

-----------------------------------------------------

-----------------------------------------------------

Without SOC Management

RegD received from server 0.31710598

New Soc in percentage :
8.02

With SOC Management

RegDM received from server 0.1268424

New Soc in percentage :8.13

-----------------------------------------------------
```

Where RegDM is Modified RegD send from Raspberry Pi to Battery.
So from the result it is cleared that when SOC is at critical value i.e below 10% Due to the biasing, power drawn from the battery is less, indicating that RegDM is less than RegD. Thus SOC percentage is more with SOC management as compared to without SOC management.

X.CONCLUSION

This paper examines the performance of battery without state of charge management and with state of charge management and focuses on corresponding Battery life and performance score. The paper also presents a output tables that incorporates potential scenarios regarding State of charge management of Battery. The output of the model also determines the overall revenue opportunity form ancillary services. Conclusions herein will facilitate the transition to a desired battery life and performance score of Battery by highlighting important synergies and related potential Ancillary services Revenue opportunities.

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XI. REFRENCES

[1] "Ancillary Services", www.pjm.com/markets-and-operations/ancillary-services.aspx

[2] "RES Powering Change supplies Renewable Energy Systems in America", http://www.res-americas.com/media/2301749/final_frequency-regulation-flyer_v5-26-15.pdf ,2015.

[3] "PJM supplies ancillary services in America", http://www.pjm.com/about-pjm/who-we-are/pjm-history.aspx ,1999-2015.

[4] sandcelectric,(2014,Oct 20) *"S&C's PJM Frequency Regulation Energy Storage Demonstration"*(Video File) ,https://www.youtube.com/watch?v=ncFYTVKlZPs

[5] "Application Case Study Frequency Regulation" , https://www.neces.com/assets/NEC_ApplicationCaseStudy-FrequencyRegulationR11.pdf

[6] "Case Study- PJM Frequency Regulation", "History of Regulation Signals", www.pjm.com/~/media/...groups/.../20150701-item-02-history-of-regulation-d.ashx ,Jul 2015

[7] "Raspberry Pi 2 Model B developed in UK by the Raspberry Pi foundation", http://www.raspberrypi.org/products/raspberry-pi-2-model-b Feb 2015.