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OPTIMUM POWER SOLUTION FOR BASE STATIONS

A Performance Testing on Amara Raja VRLA Battery for Quick Recharge performance and cyclic capability under PSOC operation

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Preface

Electrcial Power Storage in batteries play an important role in any infrastructure operations, especially in a situation where power-supply is erratic. Cellular base stations are no exception to this. These base stations in India have been using VRLA (Valve Regulated Lead Acid) batteries for years. However the limited number of charge-discharge cycles of these batteries have led to frequent replacements. As a result, there has been a serious interest in using Lithium Ion batteries, which promise much larger number of recharge cycles. However the initial cost of these Lithium Ion batteries is much higher and the higher cost of capital prevalent in India, comes in the way of their utilisation.

Recently Amara Raja Batteries Limited (ARBL) has developed a more promising AGM-VRLA (Absorbed Glass Mat – VRLA) battery. The cost of these batteries is similar to that of conventional VRLA batteries. At the same time, they promise to have much larger number of recharge cycles and ability of fast charge. To validate their claim, the Centre for Decentralized Power Systems (CDPS) and Telecom Centre of Excellence (TCOE) at IIT Madras took up the long term performance testing of these new VRLA batteries. While ARBL supplied the batteries, the tests were conducted by IITM team at IIT Madras. The results were shared and discussed with Amara Raja before publishing them in the report.

This is a follow-up report of the TCOE, IITM's earlier detailed analysis of energy sources and consumption by the loads at the BTS sites in the report titled "Powering Cellular Base Stations" (Reference]. This report had brought out the impact of the battery life on the overall running costs. Of particular interest is charging–discharging between 30% and 70% SOC with periodical boost charge. The results show that the life of the battery is not affected. Since the charging-discharging in this region is linear, it would be of high importance in battery-usage. The tests conducted, reported and analysed in this report would add considerable value to the subject.

We believe that these batteries could be of significant potential for usage not just in Base Station Applications, but other applications involving storage of electrical power, including solar PV systems. Lithium Ion batteries and these new AGM VRLA batteries may compete with each other depending upon applications.

Ashok Jhunjhunwala

References:

1. Powering Cellular Base Stations: A Quantitative Analysis of Energy Options- Prof. Ashok Jhunjhunwala,RITCOE-IIT Madras- Solar PV, Diesel Generators, Batteries and Electrical Grid
   - http://tcoe.in/doc_download.php?doc_id=100
2. Rural Base Station Powering: Ashok Jhunjhunwala, Bhaskar Ramamurthi, Sriram Narayanamurthy, SneharajRamdaspalli, Communications (NCC), 2012 National Conference

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1. Introduction

1.1 Transformation of Energy Scenario in Telecom

For the last two decades, telecom network has witnessed tremendous growth and expansions continue to happen at a rapid pace. While the growth is encouraging, the infrastructure and power quality is at a very nascent stage and the gap between power demands Vs power generation keeps increasing. Meanwhile, the cost of fuel (diesel) continues to skyrocket, with no signs of a decline in the future. The supply of electricity from the grid remains inadequate and unreliable, though there are signs that it may improve in the coming years. The depletion of fossil fuels and regulations on carbon foot prints add to the problems, thus shifting attention towards energy optimization. That said the potential for reducing energy usage and hence costs are significant.

While giving due importance to energy optimization and operational expenses, the energy storage systems are transforming from standby energy to primary source in the case of off-grid system and to secondary source in grid connected system apart from renewable energy sources. As this crucial change takes place, the batteries play a vital role and their design intent transforming from float application to cyclic application is being stressed for energy to have the BTS site connected.

Thereby it is essential for a battery and its system architecture to posses the following features to optimize the site operational expenses…

1. The battery should be able to perform under Partial State Of Charge (PSOC) without compromising on expected life.
2. The battery (Quick Recharge Series) should be able to attain sufficient charge at faster rate (with high Charge current) and be ready for next duty cycle of operation.
3. The battery should be able to perform consistently during charge/discharge cycles and deliver required back up in ambient room operating temperature conditions.
4. The battery should be competitive in initial CAPEX and be recyclable to gain scrap recovery benefit.
5. DG sets can be more efficient, with lower fuel consumption such as DC generator. Use of more advanced batteries can also reduce costs, especially in right combination with DG sets.
6. The design of shelters can help reduce energy usage. Network equipment also needs to be more energy efficient.
7. In totality, the selected battery should gain advantage on TCO when compared with any other matured storage technologies.

But perhaps what is needed the most is a more holistic and proactive approach to energy management in telecom operations.

1.2 Objective

While understanding the transformation of energy needs in telecom, it was felt that it is important to verify the suitability of more promising lead acid technology (AGM VRLA) for above said requirements based on latest advancements in technology, change in usage patterns of the clients and green energy concepts. Hence, the performance tests to determine the suitability of lead acid battery (AGM VRLA) for PSOC operation and its ability to accept charge in shorter duration when compared with other emerging technologies such as Lithium, Fuel cell etc., for off grid or poor grid powered BTS applications need to be conducted.

Based on above needs, IIT-Madras (TCOE & DCSE) and M/s Amara Raja Jointly prepared a specification & test protocol to develop an appropriate battery and validate the design.

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2. Test Methodology

IIT Madras and ARBL undertook a joint project to develop the test procedure and conduct test on Amara Raja VRLA battery (for Quick Recharge Performance) by simulating BTS load through charge-discharge test with 40% DOD to determine

(i) The cyclic capability under PSOC and at **ambient room temperature** condition operation
   a. Discharge the battery up to 70% DOD or 30% SOC with a load of 60A for 3.0hrs
   b. Charge the batteries in CV mode with 2.32 to 2.35 V/cell at 25% Current limit for 110min, the battery will reach to 70% SOC.
   c. Discharge the batteries with 60A (20%) load for 96 mins., (96Ah out – 40% DOD), the battery will reach to 30%SOC

(ii) Recharge performance i.e. how good the charge acceptance in 110mins(1hr.50mins) from 30 – 70% SOC by providing 100% boost charge once in 2 weeks on 24V/300Ah battery.

Note: 30-70% SOC operation was chosen considering the Partial State of charge w.r.t best charge efficiency range for lead acid chemistry and worst situation in field operation due to poor EB availability& DG efficiency.

2.1 Requirement

Battery shall be able to accept charge sufficiently at faster rate in PSOC cycling and deliver >90% capacity (270Ah @ C_{10} rate) after completion of 1017 cycles under ambient conditions and when this trend is extrapolated, it is expected to give 3000 cycles when the capacity drops to 80% (240Ah).

2.2 Details of Tests Conducted

Phase –I : Test Started on Feb 27th 2013, 80 trial cycles werecompleted up to 1st April '13 data available with IIT).

Phase –II : From April 2nd 2013 to May 7th 2013, 280 cycles were completed (data shared with ARBL).

Phase – III : Conducted Boost charge on 8th May 2013 by ARBL.

Phase – IV : Cycling continued from 281 to 302 cycles up to 14th May 2013 (data shared with ARBL).

Phase – V : Due to AC failure (connected in control Unit & Load Bank Room) complete system was under shutdown for 8 days.

Phase – VI : Test resumed on 21st May 2013 and conducted the boost charge and followed with regular cycling.

Phase – VII : After 390 cycles (cumulative) were completed; test was stopped for a period of 10 days due to AC failure.

Phase – VIII : Test resumed on 15th June 2013 and continued upto 441 cycles.

Phase – IX : Test stopped due to data capturing issue for 4 – 5days in b/w (from 25th to 29th June '13) and resumed on 29th evening.

Phase – X : Continued the cycling and completed 1017 cycles.

Phase – XI : After completion of 1017 Cycles, Conducted Boost charge, followed by load test (C10) on 3rdFeb'14.

3. Observations

During the testing, it was observed that the battery was able to reach 70% SOC within 110min(1hr.50mins) charging as described in the test plan.

i.e. 99+/-3 Ah in within 110mins w.r.to Ah out of 96 +/-2Ah

** Conducted load test (C10 Capacity) after completion of 1017 cycles and found that the batteries delivered>92.5% of rated capacity i.e., 278Ahout.

3.1 Glimpses of 'Ah in' and 'Ah out' data

Sl. No.	Cycle No.	'Ah out' before cycle	'Ah in' at this cycle	Remarks
1	100	97.56	99.33	Batteries are found to be capable to accept 'Ah in' more than 'Ah out' within 110 Min duration; 'Ah in' value, is varying from 40.5% to 42.7 % against 'Ah out' of 40+/-1%. This minor variation could be due to delay in boost charging, fluctuations in charger, changes in operating temperature and measurement error & aging of cells.
2	200	95.15	97.14	
3	300	97.67	101.69	
4	430	96.55	100.75	
5	490	95.51	99.87	
6	600	93.86	98.63	
7	700	96.1	101.92	
8	800	95.02	102.59	
9	900	95.27	101.00	
10	1000	95.61	102.07	

Table:1

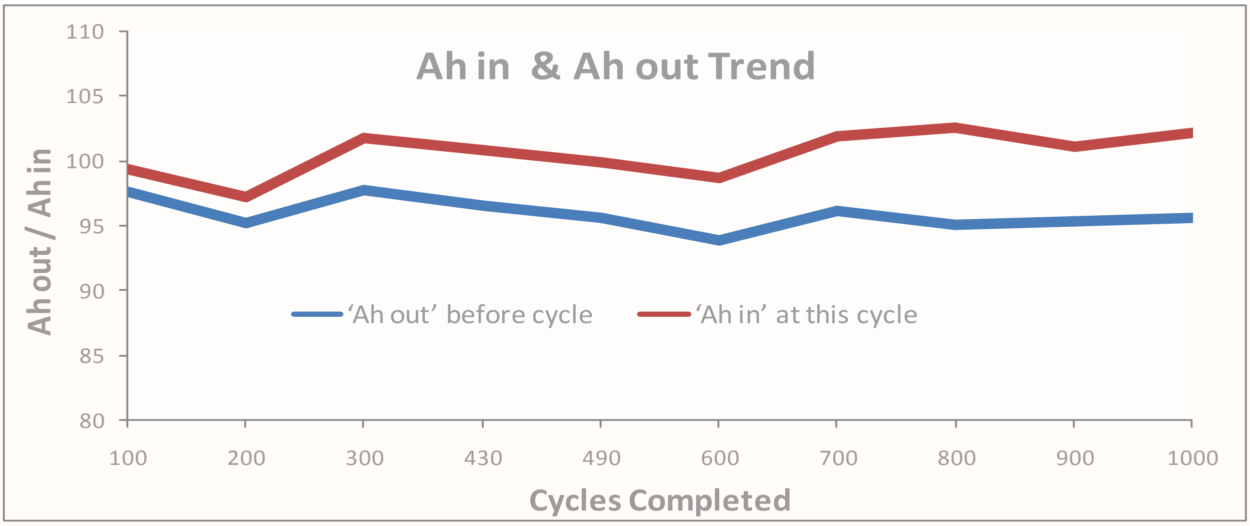

Fig: 1a

3.2 Ah in and Ah out Trend during cycling operation

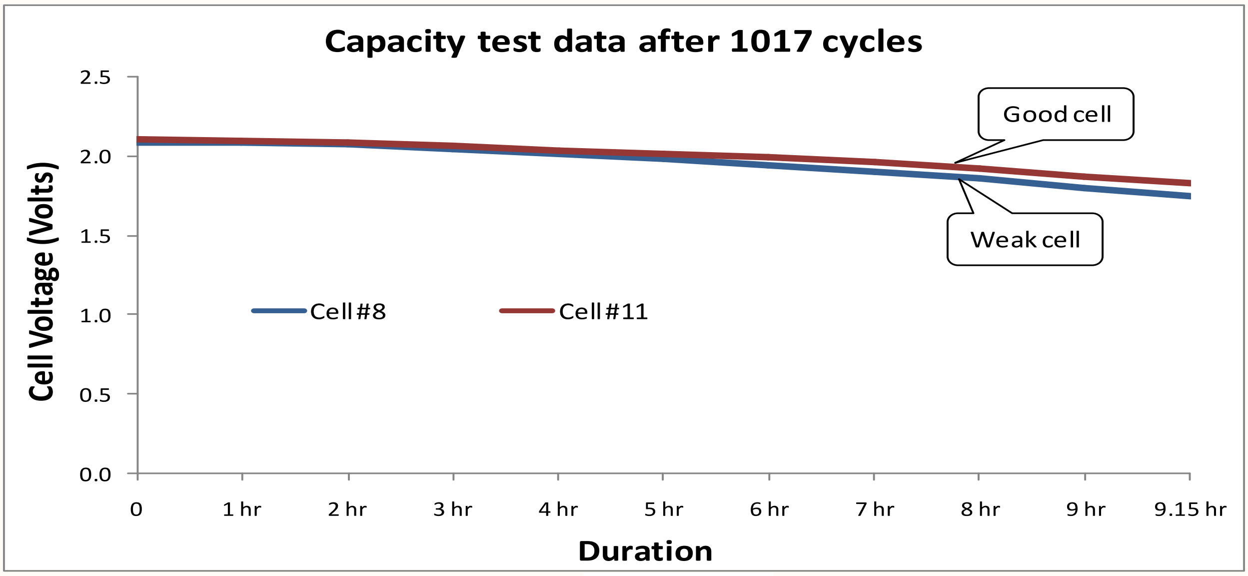

Fig: 1b

3.3 Load test Graph after 1017 cycles (Shown weak Cell &Good Cell)

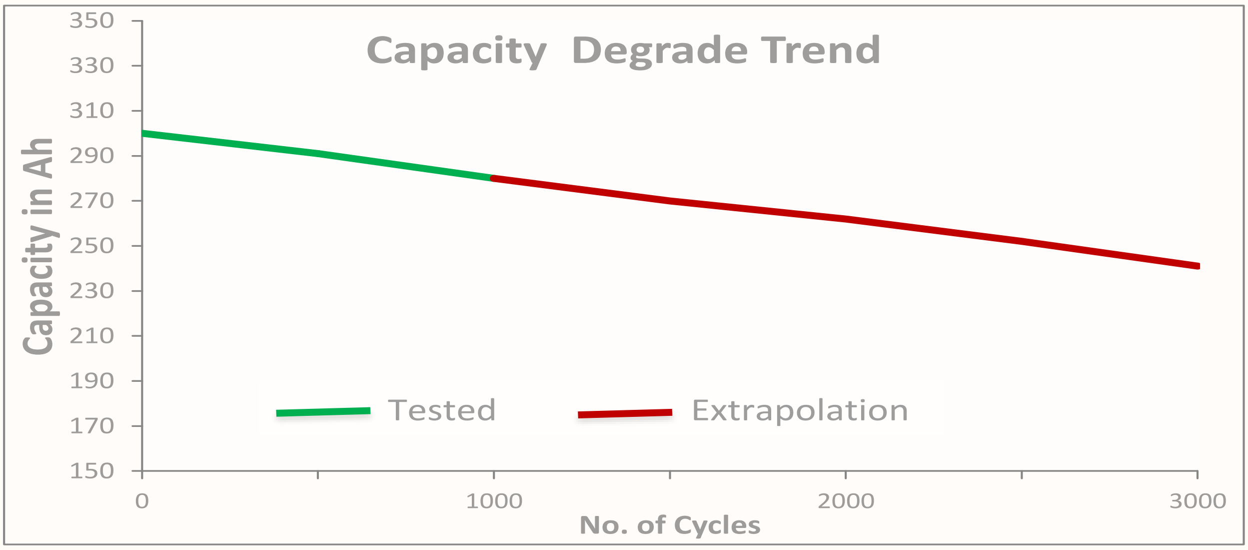

Fig: 1c

3.4 Glimpses of Current trend and 'Ah in'

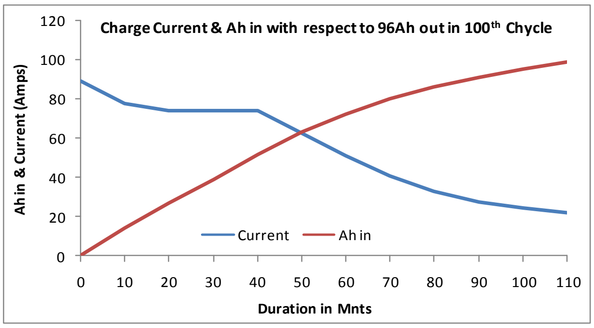

Fig: 2a

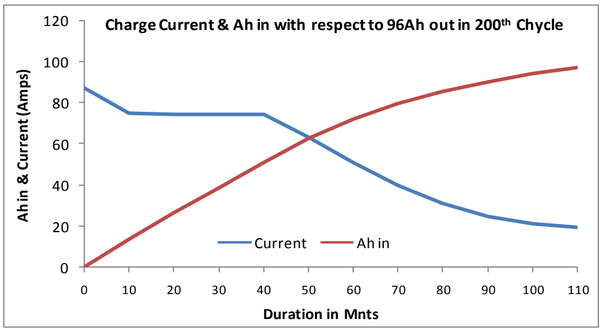

Fig: 2b

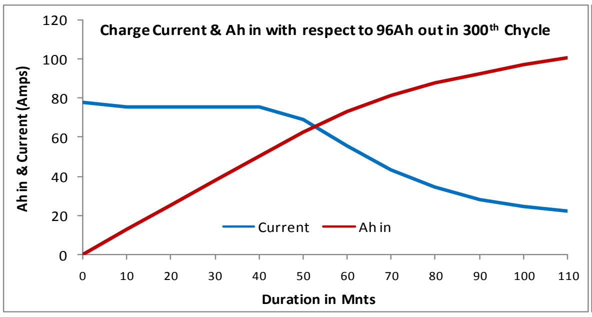

Fig: 2c

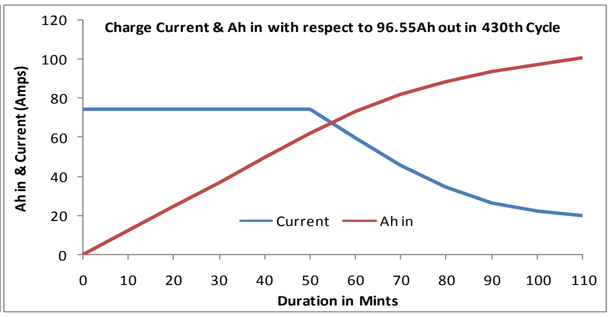

Fig: 2d

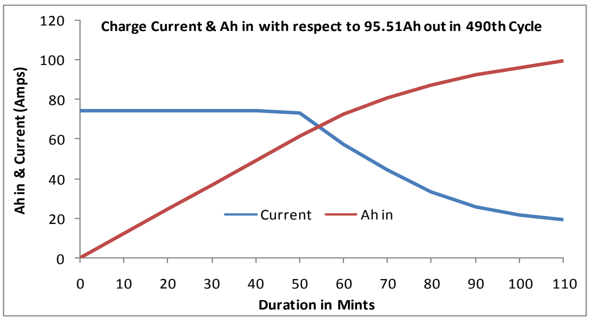

Fig: 2e

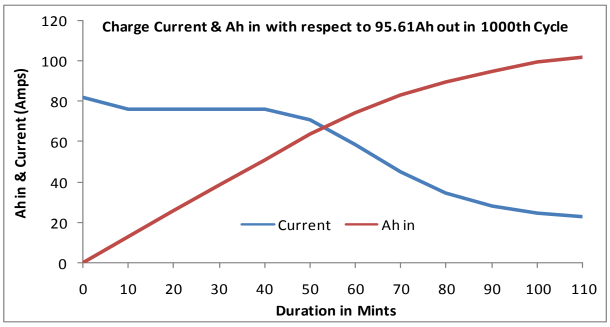

Fig: 2f

Note: Initially there was a variation in set current during beginning of charge (within 5-10 minutes). After replacement of CSU the current flow became normal.

i.e. it was starting with higher current than the set value and stabilizing in next few mins (5-10mins). This was corrected later. Since in Fig 2a and 2b, more current was found to flow initially and hence the current started falling down at 40th min. it is seen from Fig 2c & 2d that, the current starts falling from 50th min.

3.5 Average Charge Discharge Voltage at each cycle.

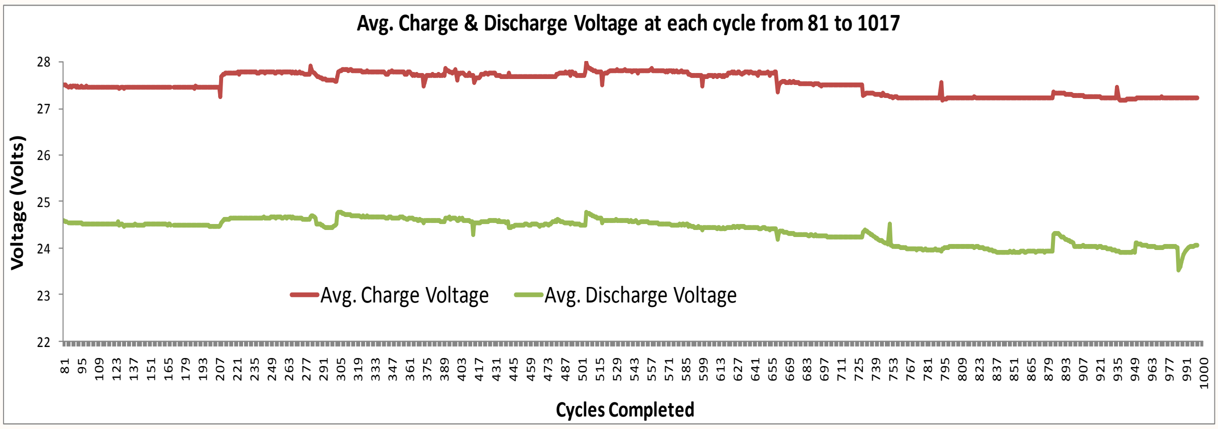

Fig: 3

3.6 Ah in & Ah-out Trend cycle wise

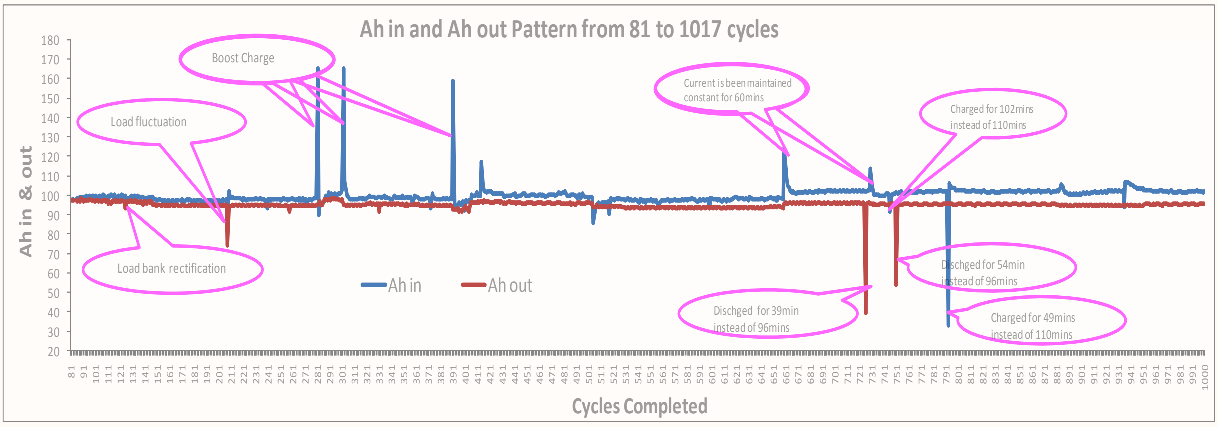

Fig: 4

3.7 Average Charge Voltage levels (min & max)

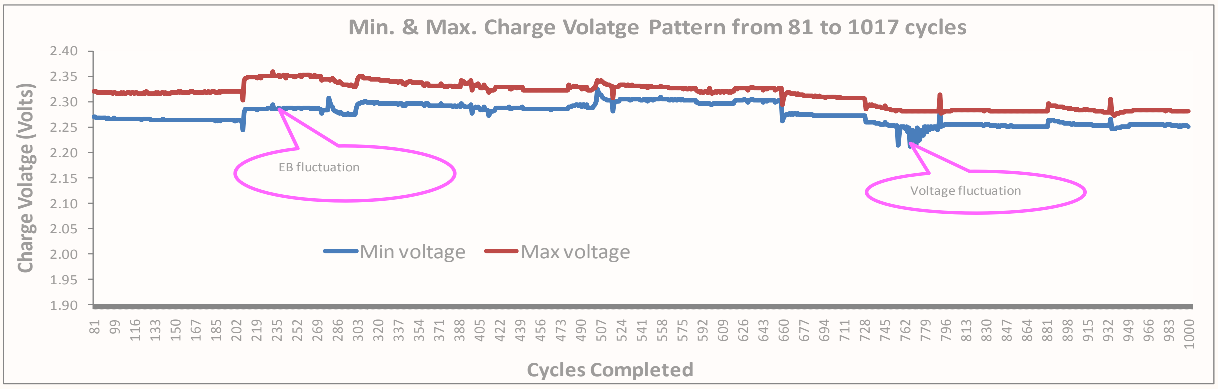

Fig: 5

There are changes in voltage levels after cycle 202. Recommended set Voltage is 2.32 – 2.35 Vpc andinitially the charging voltage was set at 2.32V. The charge voltages were changed to 2.35 after 202 cycles and, this might have happened during resetting of test after load disturbance.

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3.8 Average Discharge Voltage levels (min & max)

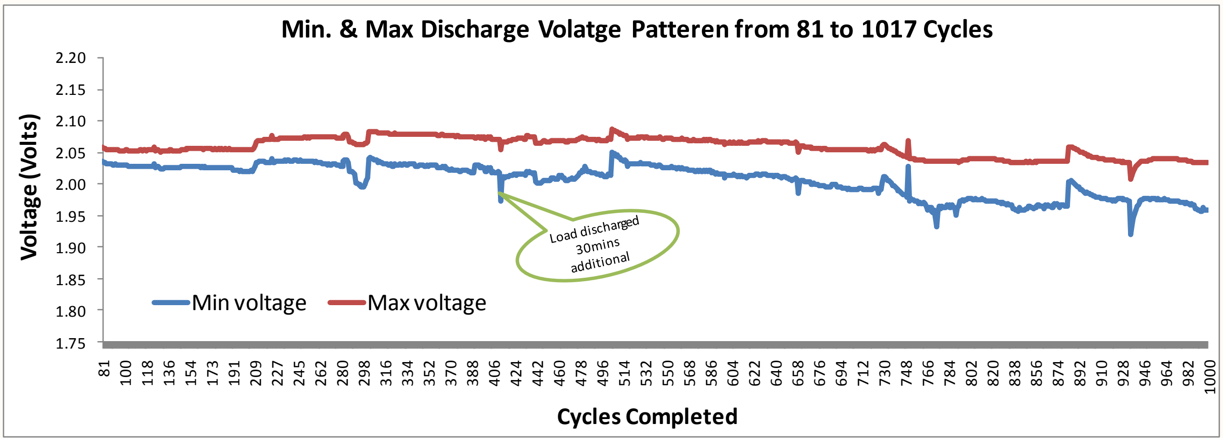

Fig: 6

3.9 Average Cell level voltages during Charge

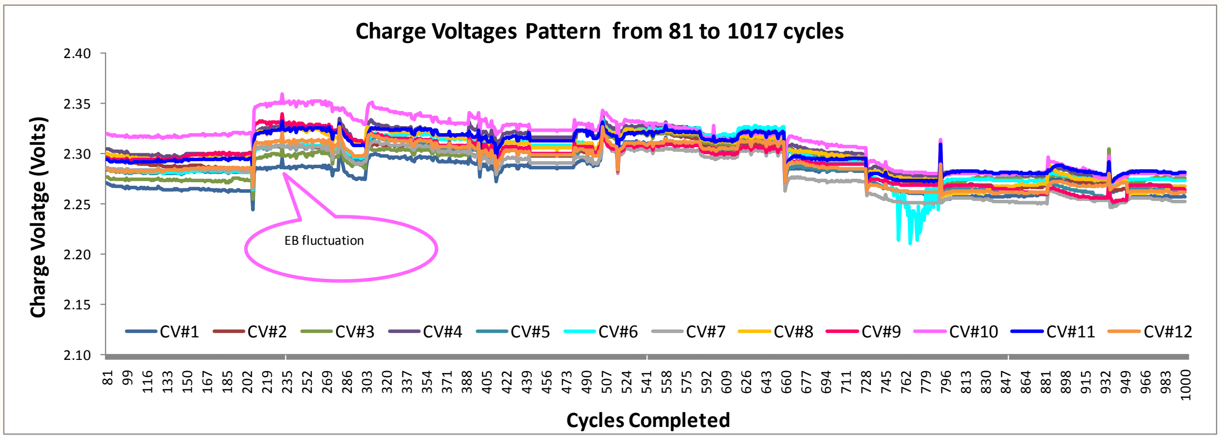

Fig: 7

3.10 Average Cell level voltages during Discharge

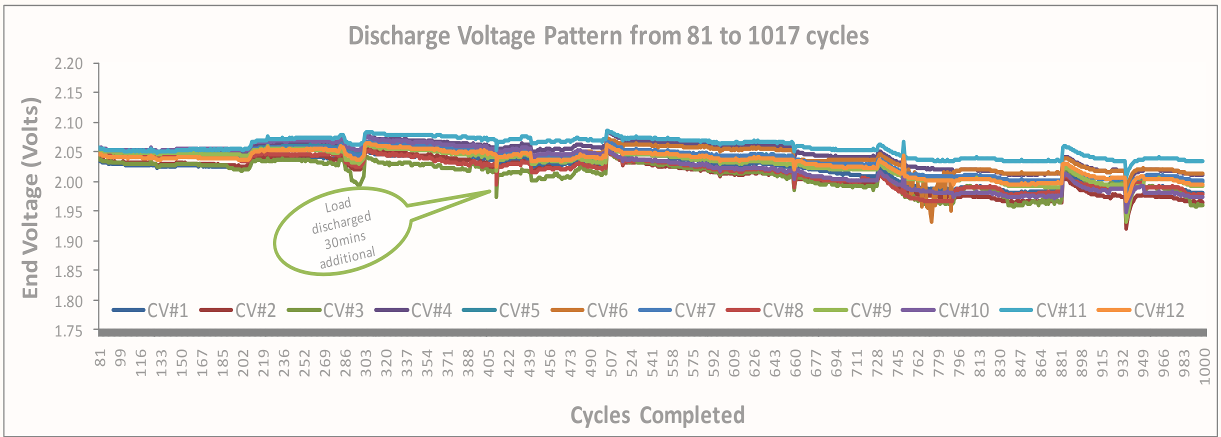

Fig: 8

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4. Summary

The test has progressed satisfactorily and 1017 cycles of 40% DOD was completed under partial state of charge operation in ambient conditions with charging time of 110mins(1hr.50mins) to pump in >96Ah (>40%SOC). During the cycling, it was observed that cells were accepting good charge within the considered time and cell charge/discharge voltages were found to be within the limits. Batteries were able to take the charge with >25% current limit comfortably with out any concerns.

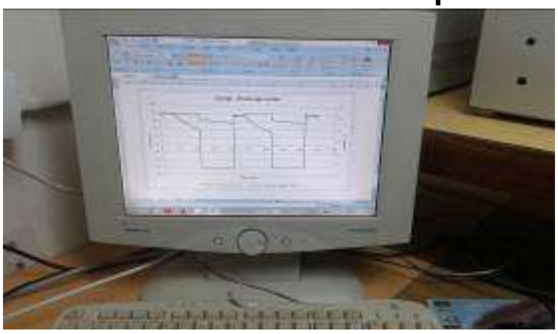
During the Capacity test after successful completion of 1017 cycles requitrement (as stated in test plan), the batteries delivered >92.5% capacity (as shown in Fig:1b to see the trend). With this trend (based on Test data) the battery is expected to give 3000 cycles **to 80% end** capacity when operated at about 30°C .

The results cyclic life test as well as fast recharge capability of these batteries point to their great potential. When used with cellular BTS, they would contribute significantly in reducing the operational expenditure, especially in the areas where the supply of electricity from the grid remains poor and unreliable.

5. Pictures of Experimental Setup

Battery and Battery Charger

Electronic Load Bank and Instrumentation setup



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