Testing And Analysis Of Li-Ion Battery For Electric Vehicles Application

Dr. P. S. Raghavendran, T. Abinaya, P. Karthikeyan

Abstract: Lithium-ion batteries are ordinarily used for moveable physics and electrical vehicles and are growing in quality for military and part applications. Over the past many decades, the quantity of electric vehicles has continued to extend. Projections estimate that worldwide quite a hundred twenty-five million electrical vehicles are going to be on the road by our future generations. At the guts of those advanced vehicle is that the lithium-particle [Li-ion] battery that provides to needed energy storage. This project gift Li-ion batteries and their associated battery management systems, similarly as approaches to enhance overall battery potency, state of charge, voltage and current analysis, life span. The planned work helps to analysis the battery that aims to develop the Li-ion battery performs higher in action. Additionally, the interior resistance of the battery is going to be analyzed for the longer-term scope for increasing the generation, similarly as opportunities to repurpose and recycle the batteries.

Index Terms : Current, Life Span, State Of Charge (SOC), Voltage

1 INTRODUCTION

Batteries give the most supply of electricity before the event of electrical grids around the finish of the nineteenth century. Most of the vehicles, during these times still exploitation fuel. High usage of fuel, produce the matter atmospheric phenomenon and additionally shortage of fossil energy. So most of the country inspired the realize the new renewable power energy automotive company for substitution. One of the choices of energy for the work unit is a battery. Batteries are classified into 2 varieties. They are primary battery and secondary battery. The first battery is additionally known as a non-reversible battery and therefore and the secondary battery is also called a rechargeable battery.

2 LITHIUM-ION BATTERY FAILURE

This section describes the Lithium-ion battery failure. This will be mainly happened due to overvoltage, improper lithium plating, overheating, under-voltage/over-discharge, temperature effects[4]

COMMON REASONS FOR BATTERY SULFATION

1. Batteries sit excessively long between charges. As little as 24 hours in hot climate and few days in a cooler climate. Sulfations develop on the battery plates.
2. The battery is put away without some kind of energy input.
3. Incorrect charging levels and settings. For example, the undercharging of a battery to just 90% of limit will permit sulfation of the battery utilizing the 10% battery not reactivated and not finishing the charging cycle.
4. Low electrolyte level battery plates laid open to air will promptly sulfate.

3 OPERATION OF LITHIUM-ION BATTERY

During charging lithium ions (yellow circles) flow from the positive electrode (red) to the negative electrode (blue) through the electrolyte (gray). Electrons also flow from the positive electrode to the negative electrode and deposit lithium there. When no more ions will flow the battery is fully charged and ready to use. When all the ions have moved back, the battery is fully discharged and needs charging up again[4].

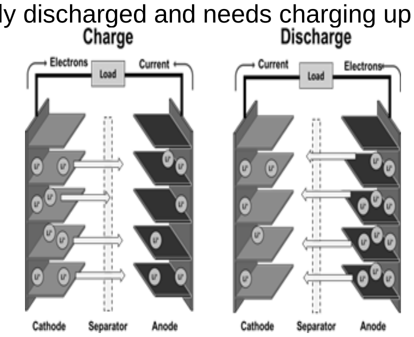

Fig1.*Process of charging and discharging*

4 CHARGING PROFILE

The charging profile based on four different stages
1. Trickle-charge
2. Constant current charge
3. Constant voltage
4. Charge termination

TRICKLE CHARGE

The cell voltage is approximately 3V. The cell is charged with a constant current of a maximum 0.1C.

CONSTANT CHARGING CURRENT

The range is between 0.2C to 0.1C. Constant current rates above 1C.

CONSTANT VOLTAGE

The voltage regulation tolerance should be better than +1%. Voltage state is invoked and cell voltage reaches 4.2V.

CHARGE TERMINATION

The minimum current senses the charging current during the constant voltage stage diminishes in the range of 0.002c to 0.007c. It will depleted in 2.5 hours to 3 hours.

- *Dr. P S Raghavendran, Assistant Professor (Sr.Grade), Kongu Engineering College, Perundurai*
- *T. Abinaya, PG Scholar, Department of EEE, Kongu Engineering College, Perundurai*
- *P Karthikeyan, Assistant Professor Department of EEE, Kongu Engineering College, Perundurai*

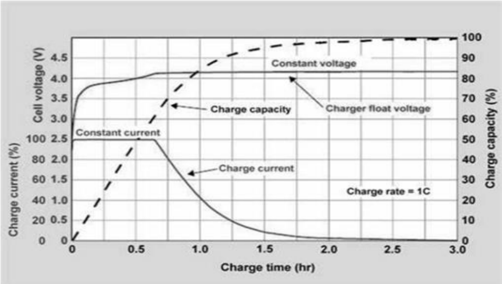

Fig2.*Charging Profile*

5 PROCEDURE FOR CHARGING LITHIUM-ION BATTERY

1. Charge the battery when the temperature is 50-86ºF (10-30ºC).
2. Lithium-ion batteries run the most effective within the recommended temperature range.
3. However, lithium-ion batteries can be charged at temperature between 32-113ºF (0-45ºC) if necessary.
4. Lithium-ion does not need to be fully charged: a partial charge is better.
5. Over discharged batteries can be "boosted" to life again. Discard pack if the voltage does not rise to a normal level within a minute while on boost.

6 BATTERY STATE OF CHARGE

SOC is the level of charge of an electric battery relative to its capacity. The units SOC are percentage points (0% = empty; 100% = full).SOC is normally used when discussing the current state of a battery in use. The battery desires to be charged and discharged at a constant rate such as coulomb-counting.[6]
In general, there are five methods to determine SOC indirectly:

1. Chemical
2. Voltage integration
3. Kalman filtering
4. Pressure

7 DEPTH OF DISCHARGE

For example, if you have a 100amp hour battery and use 50amp hours you have discharged the battery 50%. The same battery discharged it only 20amp hours or 20% of the battery, your depth of discharge will be 20 %, 50% can result in less than 300 total cycles. 100% DOD and there is no long term effect. You can expect to get 3000 cycles or more at this depth of discharge.

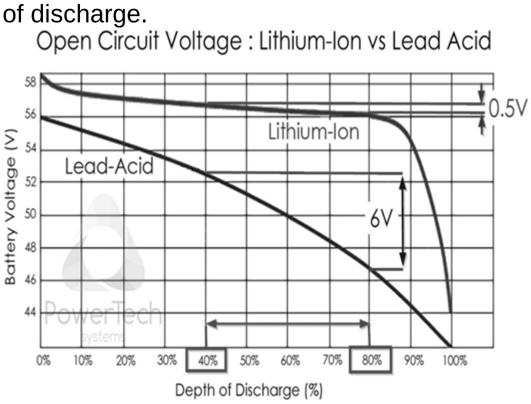

Fig3.*Depth of Discharge*

8 BATTERY DISCHARGE CYCLE

Batteries are seldom fully discharged and often use the 80 percent DOD formula to rate a battery. The 80% of available energy is delivered and 20% remains in reverse.

BATTERY SPECIFICATION

Voltage : 60V
Capacity : 32Ah
Nominal drop voltage : 3.7V
Maximum voltage : 4.2V
Minimum drop voltage : 3V
Full charge voltage : 67.2V

8.1 PRACTICALLY TESTED

In table 1 the battery 1 is discharged. The discharging current is 35 amps. It is tested for four cycles with the same battery. It is analyzed that the battery having a different capacity.

Table.1 *Battery 1 discharge cycle*

CYCLE	SPEC	I	FCV	CV	Ah
1	60V/30Ah	35	66.67	52.89	29.03
2	60V/30Ah	35	66.85	51.73	30.03
3	60V/30Ah	35	66.67	50.89	28.63
4	60V/30Ah	35	66.67	51.49	27.65

BAT- Battery, SPEC-Specification, I-Current, FCV- Full charge voltage, CV- Cut-off voltage, Ah- Capacity

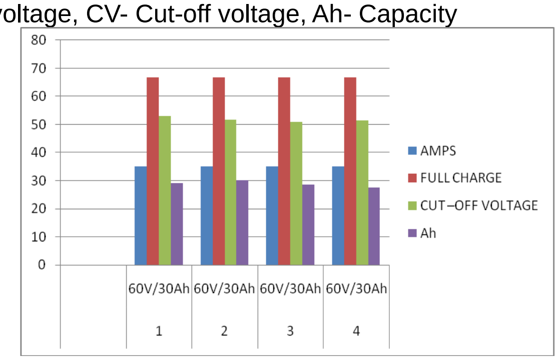

Fig4.*Battery 1 Discharge cycle*

In the table2 the battery 2 is discharged. The discharging current is 35 amps. It is tested for four cycles with the same battery. It is analyzed that the battery having a different capacity.

Table.*2 Battery 2 discharge cycle*

CYCLE	SPEC	I	FCV	CV	Ah
1	60V/30Ah	35	66.36	47.28	30.16
2	60V/30Ah	35	66.77	47.17	30.83
3	60V/30Ah	35	66.53	52.57	27.68
4	60V/30Ah	35	66.86	51.48	29.92

BAT- Battery, SPEC-Specification, I-Current, FCV- Full charge voltage, CV- Cut-off voltage, Ah- Capacity

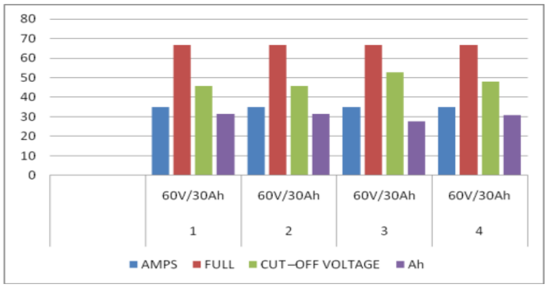

Fig5.*Battery 2 Discharge cycle*

In table 3 the battery 3 is discharged. The discharging current is 35 amps. It is tested for four cycles with the same battery. It is analyzed that the battery having a different capacity.

Table3 *Battery 3 discharge cycle*

CYCLE	SPEC	I	FCV	CV	Ah
1	60V/30Ah	35	66.36	47.28	30.16
2	60V/30Ah	35	66.77	47.17	30.83
3	60V/30Ah	35	66.53	52.57	27.68
4	60V/30Ah	35	66.86	51.48	29.92

BAT- Battery, SPEC-Specification, I-Current, FCV- Full charge voltage, CV- Cut-off voltage, Ah- Capacity

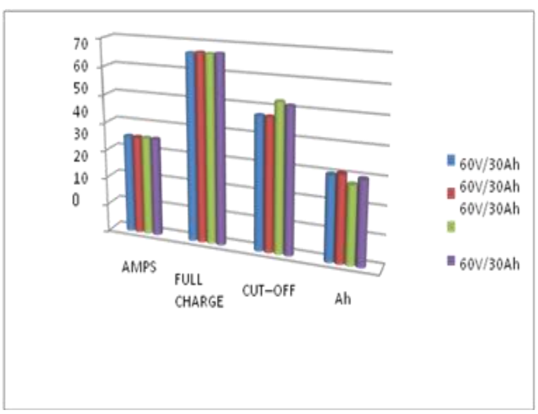

Fig6.*Battery 3 Discharge cycle*

In table 4 the battery 1, battery 2, battery 3, battery 4, battery 5 is discharged. The discharging current is 25 amps. It is tested for five cycles with different batteries. It is analyzed that the battery having a different capacity.

Table 4 *Different Battery discharge cycle*

CYCLE	BAT	SPEC	I	FCV	CV	Ah
1	BAT 1	60V/30AH	25	66.81	46.87	31.24
2	BAT 2	60V/30AH	25	66.74	47.23	31.48
3	BAT 3	60V/30AH	25	66.85	46.81	31.71
4	BAT 4	60V/30AH	25	66.74	48.00	30.73
5	BAT 5	60V/30AH	25	66.81	46.87	31.24

BAT- Battery, SPEC-Specification, I-Current, FCV- Full charge voltage, CV- Cut-off voltage, Ah- Capacity

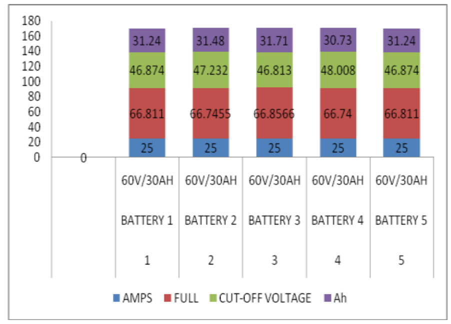

Fig7.*Battery 3 different batteries with the same discharge current ratings.*

8.2 BATTERY SOC Vs CAPACITY ANALYSIS

Battery capacity : 32Ah
Voltage : 60V
32Ah : 100 percent SOC
0.32 : 1 percent
10 percent: 3.2Ah

Table 5 *BATTERY SOC VS Ah*

STATE OF CHARGE (SOC)%	CAPACITY(AH)
100	32
90	28.8
80	25.6
70	22.4
60	19.2
50	16
40	12.8
30	9.6
20	6.4
10	3.2

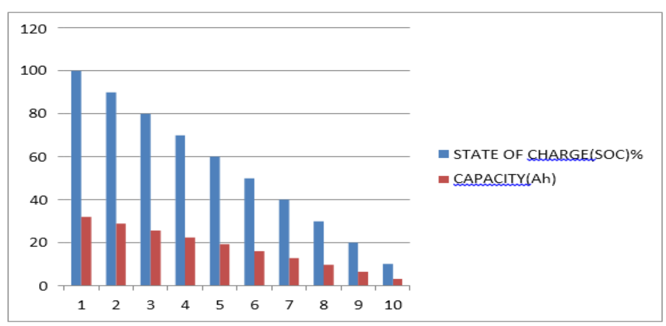

Fig8.*BATTERY SOC VS Ah*

BATTERY SPECIFICATION

Voltage: 48V
Capacity: 24Ah
Full charge : 54.6V
Output Current : 6A
Input current : max 4A
Maximum voltage : 4-2V

Nominal voltage : 3.7V

COMPARISION OF TWO BATTERIES
Current ratings: 15Amps, Full charge voltage: 54.6 V, Battery 1 and battery 2 voltage: 48V, Capacity: 24AhIn the table5 the battery is discharged. The discharging current is 15 amps... It is analyzed that the battery having a different capacity.

Table5 *COMPARISON OF TWO BATTERIES*

BAT	SPEC	I	FCV	CV	AH
1	48V/24AH	15	54.6	44.04	22.63
2	48V/24AH	15	54.6	41.05	22.89

BAT- Battery, SPEC-Specification, I-Current, FCV- Full charge voltage, CV- Cut-off voltage, Ah- Capacity

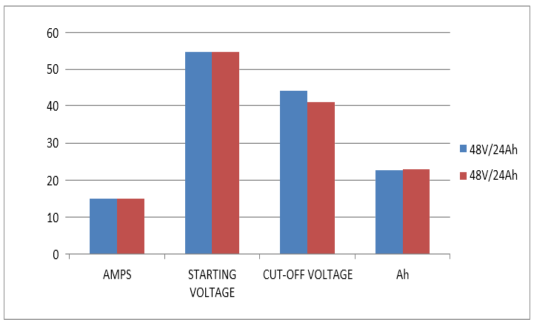

Fig9.*COMPARISION OF TWO BATTERIES*

9 SIMULATION MODEL OF BATTERY CIRCUIT

RC CIRCUIT
An RC circuit is a circuit with both a resistor (R) and capacitor (C). RC circuits are a frequent element in electronic devices. The crucial parameters that describe the time dependence are the time constant RC.[10]

CONSTANT CURRENT
A constant current(steady-state current, time-independent current, stationary current) is a type of direct current(DC) that does not change in its intensity with time.

CONSTANT VOLTAGE
Constant voltage refers to the ability to fluctuate output current to maintain a set voltage.

SIMULATION
CIRCUIT PARAMETER VALUES
Resistor (R) = 1000 ohm
Capacitor (C) = 0.2 mf
Amplitude = 20
Frequency = 500

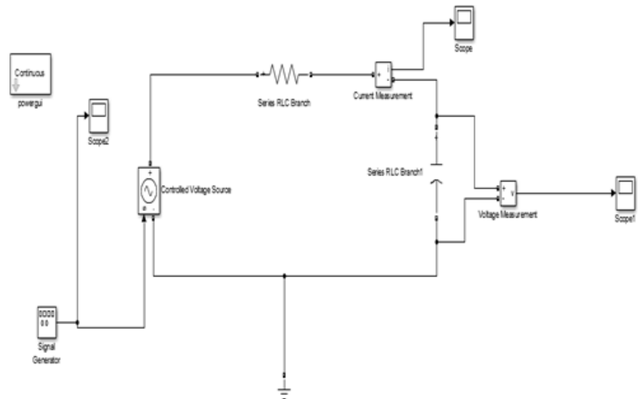

Fig10.*RC SIMULATION CIRCUIT*

OUTPUT

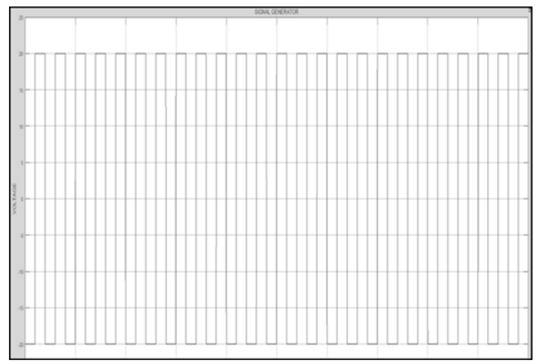

Fig11. *RC SIGNAL GENERATOR OUTPUT*

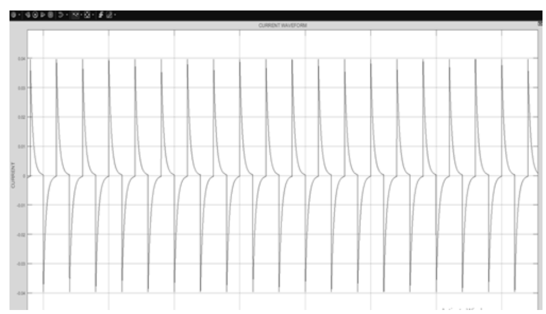

Fig12.*RC OUTPUT CURRENT*

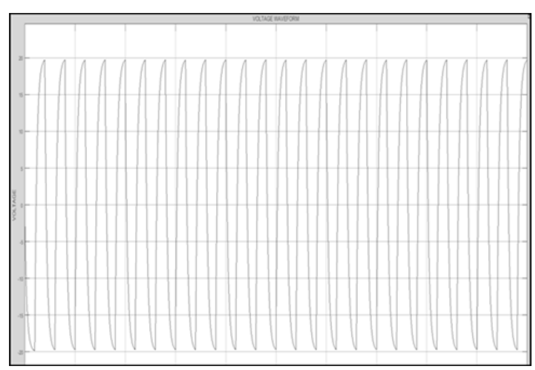

Fig13.*RC OUTPUT VOLTAGE*

10 RC CHARGING CIRCUIT

When a voltage source is applied to an RC circuit, the capacitor, C charges up through the resistance, R. When an increasing DC voltage is applied to a discharged capacitor the capacitor draws a charging current and charges up and when the voltage is reduced, the capacitor discharges in the opposite direction.[4]

SIMULATION
PARAMETER VALUES
Resistor = 1k
Capacitor = 9mf
Dc voltage source = 9V

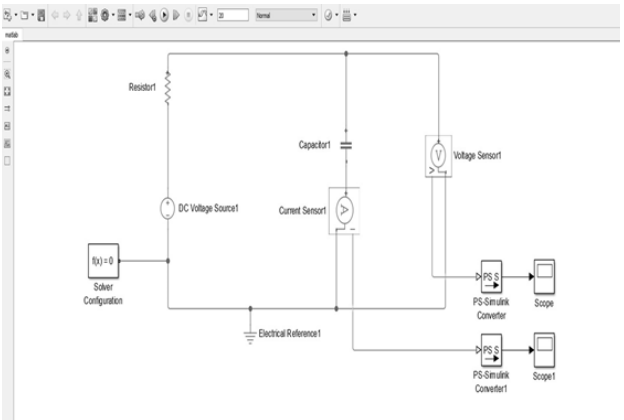

Fig14. *RC CHARGING CIRCUIT*

OUTPUT

The output of the RC charging circuit the output voltage increases.

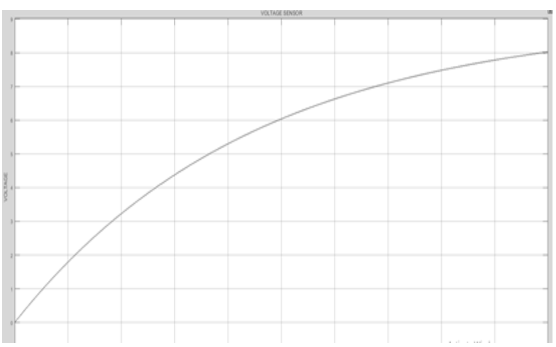

Fig15.*RC VOLTAGE WAVEFORM*

The output of the RC charging circuit the output current decreased.

Fig16.*RC CURRENT WAVEFORM*

11 RESULT AND CONCLUSION

From the above analysis, it is concluded that Li-ion battery is used in many electric vehicle applications. Because of their charging and discharging characteristics. In this paper, the different parameters are analyzed. The parameters are a state of charge, voltage, a current, capacity that is used to improve the performance and life span of the battery. The improvement in analysis gives the eco-friendly usage of lithium batteries.

REFERENCES

[1] Ranjbar, A. Banaei, A. Khoobroo, and B. Fahimi,(2012) "Online Estimation of State of Charge in Li-Ion Batteries Using Impulse Response Concept," IEEE Trans. on Smart Grid, vol. 3, no. 1, pp. 360–367

[2] Si Li, Ximing Cheng, (2014) "A comparative study on RC models of the lithium-ion battery," IEEE Conference and Expo Transportation Electrification Asia-Pacific (ITEC Asia-Pacific)

[3] El Mejdoubi, A. Oukaour, H. Chaoui, H. Gualous, J. Sabor, Y. Slamani,(2016) "State-of-Charge and State-of-Health Lithium-ion Batteries Diagnosis According to Surface Temperature Variation" IEEE Trans. Ind. Electron., vol. 63, no. 4, pp. 2391-2402

[4] Jiuchun Jiang, Caiping Zhang,(2015) "Fundamentals and Applications of Lithium-Ion Batteries in Electric Drive Vehicles," Edition John Wiley and Sons Singapore Pte. Ltd

[5] Guangming Liu, Language Lu , Hong Fu; Jianfeng Hua,(2014) "A comparative study of equivalent circuit models and enhanced equivalent circuit models of lithium-ion batteries with different model structures," IEEE Conference

[6] Haifeng Dai; Zechang Sun; Xuezhe Wei ,(2006) "Online SOC Estimation of High-power Lithium-ion- Batteries Used on HEVs," IEEE International Conference on Vehicular Electronics and Safety

[7]. J. Zhang, S. Ci, H. Sharif, M. Alahmad,(2010) "An enhanced circuit-based model for single-cell battery", Proc. IEEE Conf. Appl. Power Electron.Conf.Expo.,pp.672-675

[8] H. He, R. Xiong, X. Zhang, F. Sun and J. Fan, "State-of-charge estimation of the lithium-ion battery using an adaptive extended Kalman filter based on an improved Thevenin model," IEEE Transactions on Vehicular Technology, vol. 60, no. 4, pp. 1461-1469, May 2011.

[9] R. Rao, S. Vrudhula, and D. N. Rakhmatov, "Battery modeling for energy-aware system design," Computer, vol. 36, no. 12, pp.77-87, December 2003.

[10] M. R. Jongerden and B. R. Haverkort, "Which battery model to use?," IET Software, vol. 3, no. 6, pp. 445-457, December 2009

[11] L. Long, P. Bauer, and E. Kelder, "A practical circuit-based model for Li-ion battery cells in electric vehicle applications," IEEE Telecommunications Energy Conference (INTELEC), pp. 1-9, October 2011.