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INVESTIGATION ON ENHANCEMENT OF DYANMIC PERFORMANCE OF PV BASED SUPERCAPACITOR CONTROLLED EV SYSTEM

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ABSTRACT

Super capacitors are used as auxiliary elements beside batteries to increase peak power capability and battery life in hybrid electric vehicles. In such a configuration, a bidirectional high efficiency converter is required as an interface between super capacitors and batteries. Since the voltage level of super capacitors and batteries are different, the interface must be able to increase or decrease the voltage level in each power flow direction while limiting the current. All the switches in the proposed converter are soft switched to reduce switching losses and increase efficiency. Super capacitors (SCs) are characterized by its high power storage capacity, Low Equivalent Series Resistance (ESR) which leads to an efficient high charging / discharging current at a wide range of operating temperatures. SC is successfully utilized as a supplementary energy sources for electric vehicles (EVs). According to their high power densities they are adopted to operate in quick acceleration, hill-climbing and regenerative braking. So they have been considered for transient power supply and recovery in EVs. An SC-battery combination system can effectively smooth the power fluctuation caused by periodic acceleration and deceleration for different driving cycles.

Keywords: Battery, DC-DC Converter, DC Motor, Hybrid Electric Vehicle, Solar PV Panel, Super Capacitor.

I. INTRODUCTION

The SC is a promising energy storage device with behavior somewhere between rechargeable battery and traditional capacitor. It can be charged and discharged quickly like a capacitor, but exhibits 20-200 times greater capacitance than conventional capacitors. The advantages of SCs are: High energy storage due to activated carbon electrode to achieve a high surface area, Low Equivalent Series Resistance (ESR) providing high charging and discharging efficiency, Low temperature performance, so it can be used in a wide temperature range, and fast charge/discharge process. Comparing with batteries, SCs can accept a wide range of charging current and can be fully charged within a few minutes. High energy density batteries, like lithium-ion (Li-ion) and nickel metal hydride (Ni-MH) battery, and fuel cells have been developed for many years ago. They are successfully utilized as energy sources for electric vehicles (EVs). However, their power densities are inadequate under certain operation conditions, namely quick acceleration, hill climbing and regenerative braking. The SC is a high power density, so it has been considered for transient power supply and recovery in EVs. An SC-battery combination system can effectively smooth the power fluctuation caused by periodic acceleration and deceleration of different driving cycles. The SC supplies and absorbs and the large current pulses during high acceleration and braking conditions, and the battery provides the average power demand. This, in turn, allows for the size of the battery pack to be reduced and its life time to be increased .the performance characterization of an SC is modeled by measuring the capacitance (C), equivalent series resistance (ESR) and the output terminal voltage (V). The purpose of this model is to estimate the SC state of charge (SOC) which gives an indication of the available energy remained in the SC. The characterization is verified experimentally at different loading conditions in order to study the performance of the UC at different loads and temperatures.

II. SYSTEM CONFIGURATION

Super capacitor (SC) has many advantages such as high power density, quick charging and extended lifetime. Our research focuses on the application of super capacitor to electric vehicles. It can be driven for 20 minutes after one time quick charging in 30 seconds. Improving the energy system of EV is a usage of Hybrid Energy Storage Systems (HESS), which is based on the combination of the two energy storage devices. Electric vehicles, the application of super capacitor with battery has some remarkable advantages. The load stress of the battery can be released, so the battery life can be improved naturally. Super Capacitor can be used to improve the acceleration performance of EV and enlarge the range of driving capacity. Super capacitor is more effective during absorbing energy from the regenerative braking so that the energy system efficiency can be improved the hybrid energy system using super capacitor and low cost of the lead acid batteries is considered for the design of hybrid electric vehicle. The increasing popularity of electric vehicles is presenting the automotive industry with new challenges and the power density of super capacitor is higher than battery allowing the ultra capacitor providing peak power for the shorter duration.

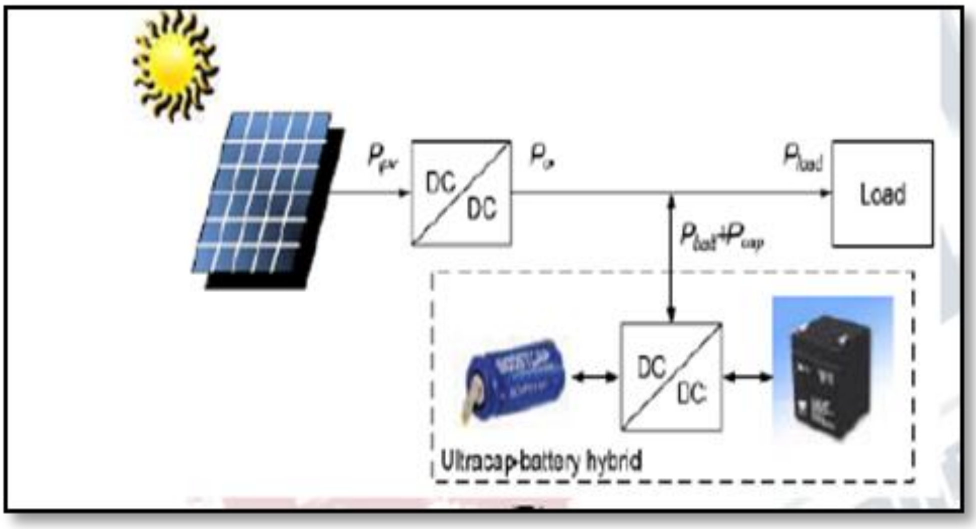

Figure : 1. Solar panel based supercapacitor using EV system

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Figure : 2. Electrical Department of electric vehicle

Table: 1 performance comparison between supercapacitor and Li-ion battery

Function	Supercapacitor	Lithium-ion battery
Charge time	1-10 seconds	10-60 minutes
Cycle life	1million or 30,000h	500 and higher
Cell voltage	2.3 to 2.75V	3.6 to 3.7V
Specific energy (Wh/kg)	5(typical)	100-200
Specific power (W/kg)	upto 10,000	1000 -3000
Service life (in vehicle)	10-15 year	5-10 years
Charge temperature	-40 to 65ºC	0-45ºC
Discharge temperature	-40 to 65ºC	-20 to 60ºC

III. MATRIALS AND METHODS

The following points will give an over view about the major parts of the proposed system.

A. Photovoltaic Solar Panels

Solar power is rapidly growing energy sources as it can be converted into electricity using Photovoltaic cells, offering, economic, and environmental benefits over fossil fuel generated electricity. Solar Photovoltaic (PV) systems are continuously increasing in efficiency and its recent advancements in manufacturing have decreased the initial cost of solar PV system. The photovoltaic solar panels are semiconductor devices that convert the solar illumination power directly to electricity. PV cells are made up of semiconductor materials and when such electrical conductors are connected to the positive and negative sides, they form an electrical circuit; these electrons are captured in the form of an electric current .i.e., electricity. This electricity can then can be used to power a load. PV cells are connected in series (for high voltage) and in the parallel (for high current) to form a PV module for desired output of the system. PV system offers several advantages such as, its generation is pollution free and environments friendly; simplicity of allocation for power transmission in remote and hilly areas; high dependability; low maintenance; and absence of fuel cost.

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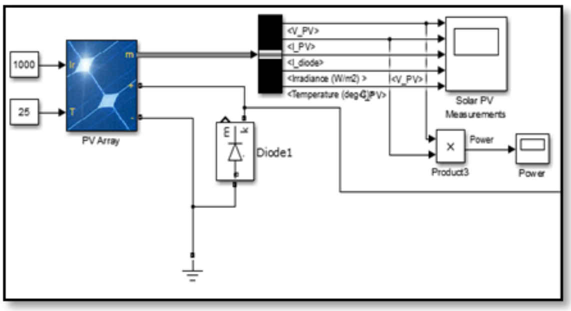

Figure: 3. Simulink model solar PV panel

B. Energy Storage System

The portable electrical energy storage presents the biggest obstacle in the commercialization of electric vehicles (EV) among the available choices of portable energy sources, batteries have been the most popular choice of energy sources for electric vehicles since the beginning of research and development programs in these vehicles. The lead acid battery has the longest development of all battery technology. The primary energy source for electric vehicle is the battery bank. A number of individual batteries connected in series or parallel. Each battery in the bank is consisting of 6v or 12V, and multiple batteries are connected in series or parallel to get the desired system voltage. The overall battery voltage is chosen as per the motor's EMF constant and the desired nominal cruising speed. However, the battery voltage, especially for lead-acid batteries, fluctuates from full charge to maximum discharge.

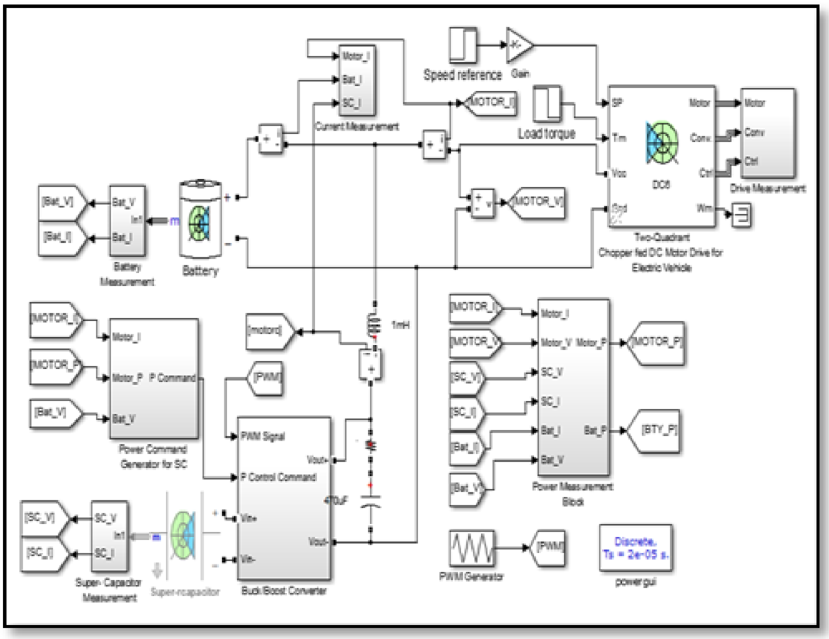

Figure: 4. Simulink model energy storage system

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IV. MATHEMATICAL MODEL OF BLDC MOTOR

The governing equation of the magnetic field is represented by Maxwell's equation in the form of a magnetic vector potential as

$$\nabla \times H = J + \frac{\partial D}{\partial t} \qquad (1)$$

D=0

$$\nabla \times H = J \qquad (2)$$

$$\nabla . B = 0 \qquad (3)$$

B =magnetic flux density

$$B = \mu H \qquad (4)$$

$$\mu = \frac{B}{H(B)} \qquad (5)$$

$$B = \nabla \times A$$

(6)

V. SIMULINK MODEL FOR ELECTRIC VEHICLE

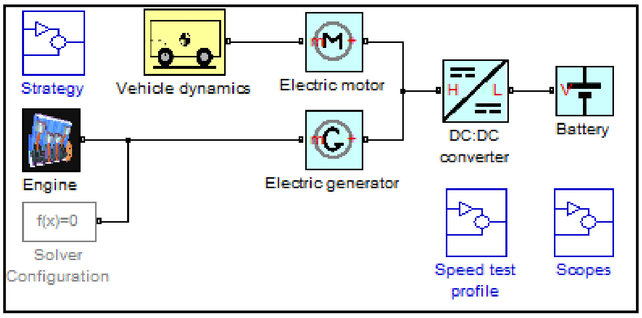

Figure: 5 Simulation With Electric Vehicle Subsystem

VI. RESULT AND DISCUSSION

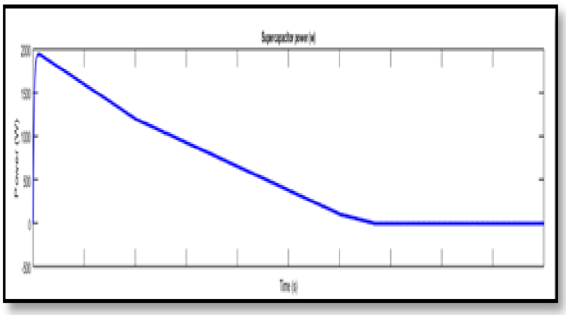

Figure: 6 supercapacitor and power

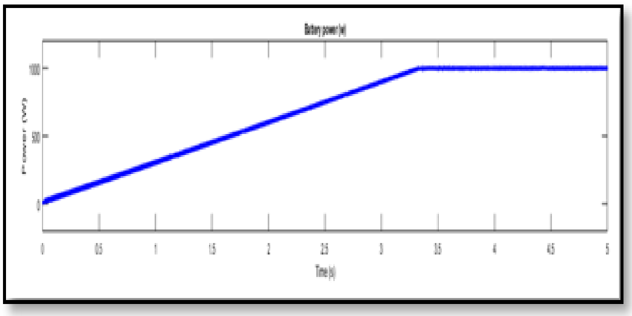

Figure:8 battery and power

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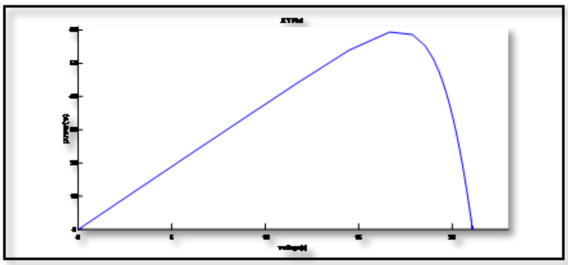

Figure: 7 PV Solar Panel for Power and voltage

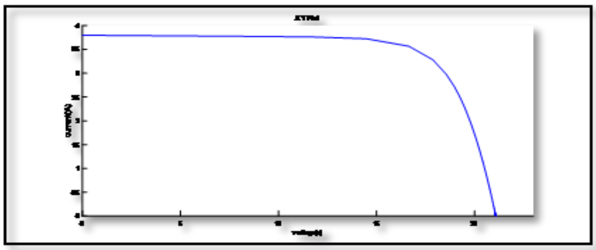

Figure: 9 PV Solar Panel for current and voltage

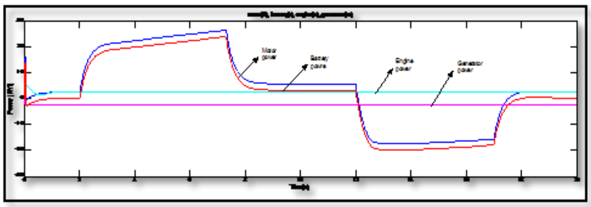

Figure: 10 simulated results motor, battery, engine, and generato

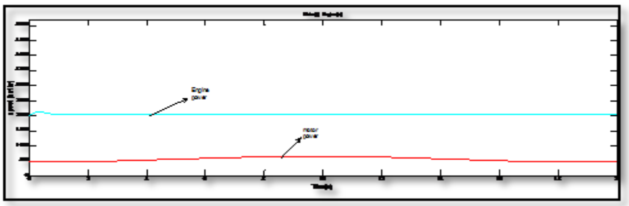

Figure: 13 motor, engine

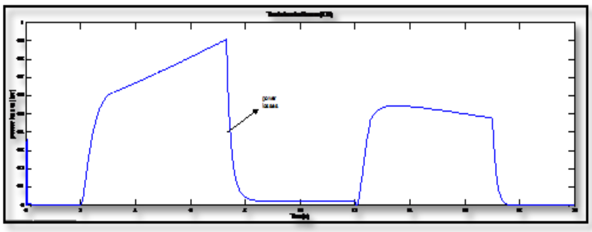

Figure: 11 total electrical losses

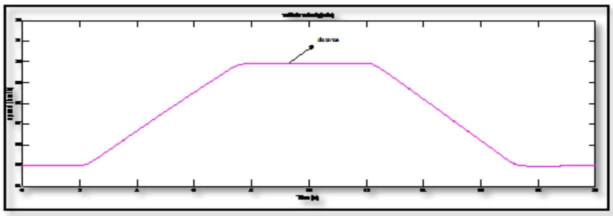

Figure: 14 vehicle velocity

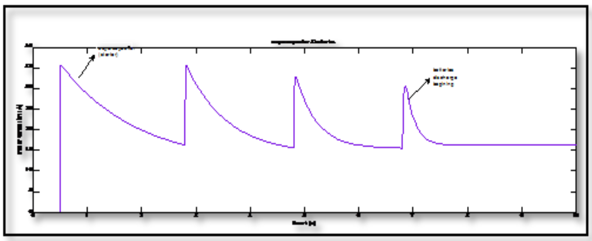

Figure 12 supercapacitor (starter) and battery discharging begining

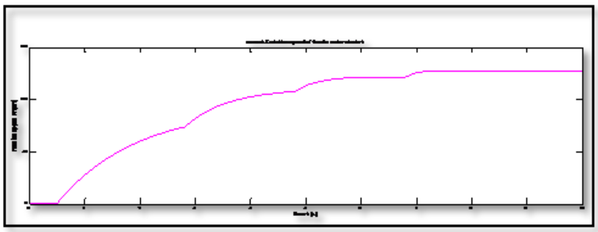

Figure: 15 current & rotation speed of the DC motor at start

VII. SCOPE OF FUTURE WORKS

1. Electric vehicles for charger controller battery-to- charge grid power applied to vehicles system. Series and parallels Hybrid vehicle which uses its excess rechargeable battery and capacity to provide power to the flow electric grid in response to peak load demands. A solar vehicle which uses its excess charging capacity fast for super capacitor used to provide power flow electric grid when the battery is fully charged. Otherwise battery discharged then super capacitor charging time fast so that continues power flow. Different charger technology used for vehicle-to-grid power can be done .The scheme will includes bidirectional energy meter.
2. Electric vehicles used for Regenerative Braking: A regenerative braking system used in energy recovery mechanism. Power can be improve the overall efficiency of the vehicle velocity. The battery and super

capacitor will get charged from the machines power and electric vehicle speed and acceleration better for long time future needed.

3. Possible innovation at later stage: Development of intelligent controller using neuro- fuzzy based technique

VIII. CONCLUSION

A simplified practical model based on simple tests for capacitance estimation at different charging/discharging current rates and different surrounding temperatures for the UC has been carried out. The latest technology used a super capacitor charging technique based hybrid provides a feasible method to improve the performances of the electric vehicles system. This helps in reducing the battery size. The results of the proposed systems paper show that the performance of the electric vehicle was improved in the PV source with storage devices like battery and SC. PV source helps to increase the range that the vehicle can travel rang and SC improves the system performance by contributing burst of power during vehicle acceleration and absorbing the regenerated energy while decelerating.

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