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Solar Hybrid Accumulator and Kinesis Technique of Energy Efficient Storage System for Electric Vehicles (SHAKTEE)

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Abstract: Proper design and sizing of Energy Storage and management is a crucial factor in Electric Vehicle (EV). It will result into efficient energy storage with reduced cost, increase in lifetime and vehicle range extension. Design and sizing calculations presented in this paper is based on theoretical concepts for the selected vehicle. This article also presents power management between two different energy storage devices i.e dual energy device using the converter (Hybrid Energy Storage), a single energy storage device cannot fulfill all desirable characteristics. The main objective of Hybrid Energy Storage System and power management is to assist EV acceleration, capture regenerative braking. and the reduction of battery stress by maintaining battery current as constant as possible during transients and combining Supercapacitor (Ultracapacitor) to provide instanta- neous current during transients respectively and also the recovery of power during deceleration. Performance of Hybrid Energy Storage System is analyzed by experimental setup. It is clearly observed that after implementing power management algorithm battery current is maintained as constant as possible during acceleration i.e only average current is supplied by battery and during acceleration instantaneous current is supplied by supercapacitor.

I. INTRODUCTION

The possible increase in demand due to Electric vehicle has become a concern. However, recent studies have shown that EV's may be Beneficial in terms of grid, reliability and flexibility by using charging models such as vehicle to grid (V to G) energy transfer vehicle-home energy transfer, vehicle to vehicle energy transfer on the other hand these models may cause the comfort violation of EVs owner. The problem is associated with vehicle range in single charge. The range given by common electric vehicle is around 100-150 in single charge; and after the vehicle get discharged, the time associated with the charging of vehicle to 100% is around 5 to 6 hours, and for super charger it is around 2 to 3 hours.

In this study, the effect of energy transfer between hybrid storage system and solar panel on the comfort of electric vehicle's owners have been investigated.

Fast charging, instantaneous charging and on road regenerative braking system may affect the battery performance and battery life due to heating effect after instantaneous charging, the battery life may get reduced also the various load of electric vehicle are connected to the battery, therefore in the most cases battery get heated although there are various methods are present to save the battery life like battery management system (BMS), cooling of the battery pack, combination of the battery and capacitors, etc. There are various methods of EVs charging i.e. charging station, home EV charging kit, on-road charging etc. But there are some problems regarding algorithm used to charge the EVs and the method of charging. These algorithms and methods may affect the battery life, electric vehicle range and user experience. Also the various loads of electric vehicles are connected to the battery, therefore in the most of the cases battery get heated and may get damaged.

To solve the above problems, to increase the life of battery and increase the EVs range (Running) we come up with novel solution. The "SHAKTEE" architecture. This architecture will have the hybrid energy storage system associated with solar system. In this system, we used the super-capacitor to reduce the on-road electrical load about 50%, with the same power requirement.

II. NECESSITY

Hybridization in form of energy storage is one of the leading recent technologies and is a rapidly becoming megatrend.Energy storage offers us flexible way to make supply and demand meet by bridging the lag between power source and Consumption depending upon load Condition. A Hybrid energy Storage System, which consist of a battery and Supercapacitor presents good performance on both the Power density and the energy density when applying to the electric vehicle.

III. OBJECTIVE & SCOPE

1. Main objectives et an hybrid energy storage system is power management to increase the battery life
2. Improve the stability of storage of overall circuit.
3. Ultracapacitor charge quickly so it is reducing the time of changing
4. We can achieve the re-generative braking wingenergy storage system we can increase the range ofElectric vehicle (EV) in kilo-metes.
5. Promotes community awareness about on road charging system.
6. Use of new type of storage unit called supercapacitor.
7. Introducing central unit of shifting load to the two sources which means supercapacitor to battery & vice versa.
8. Introduced novel SHARTEE on road charging architecture.

IV. HARDWARE IMPLEMENTATION

1. Solar panel get output voltage 5v to increasing that it is connected to boost converter.
2. Boost converter give 13.5 v output voltage it connected to battery directly
3. Battery handle the all load of controller so it connected to main controller circuit with decreasing voltage upto 5v.
4. Super-capacitor bank get attached with chassis and it measuring voltage, voltage sensor is used.
5. To controlling both battery and capacitor relay module is used .
6. Relay is controlled by Arduino controller giving analog single.

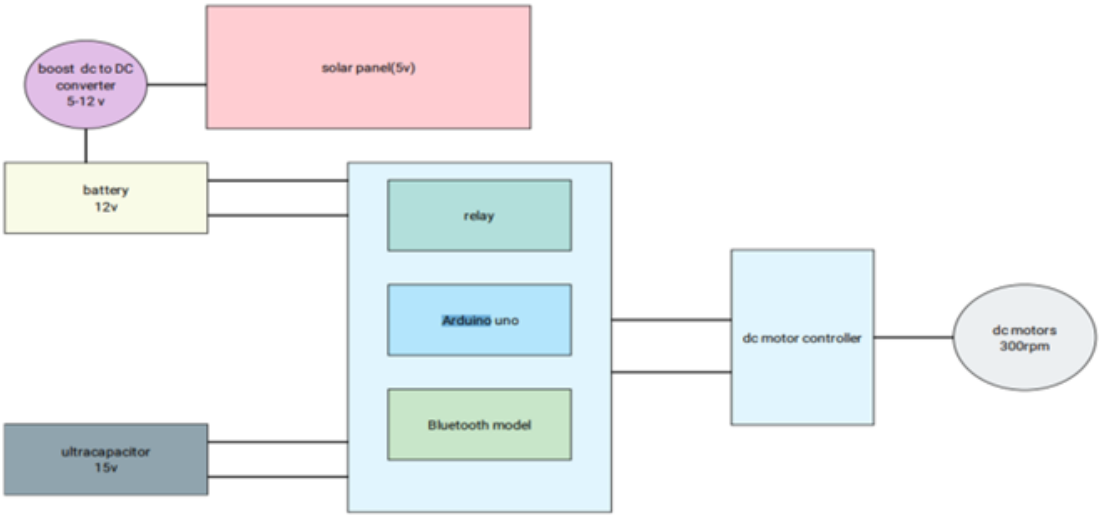

Fig.1.Block Diagram

7. Controlling Arduino board Arduino program is imported into the Arduino controller.
8. Getting output voltage from the system it connected to motor driver .motor driver is handle load by giving optimum voltage to dc motors.
9. Controlling Dc motors, Bluetooth model is connected to Arduino. And the analog signal controlled by Bluetooth .
10. Passing signal to Bluetooth module ,this module is connected to mobile which having application RC CAR.
11. And from the application we can change the signal
12. All component are attached with chassis and chassis having four wheels which diameter is 7 cm

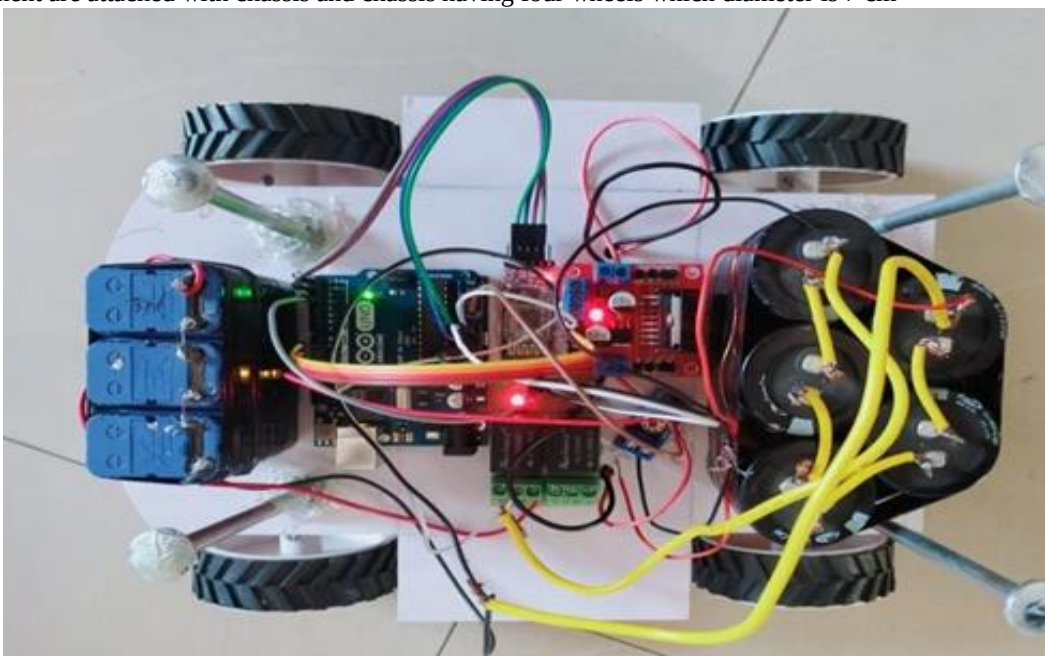

Fig.2.Top View of Car

3.1 Flow of Hardware Model (Working)

In SHAKTEE architecture we have two systems

1. The kinesis technique of the hybrid storage and
2. The re-changing Architecture system.

The Kmeals technique of the hybrid Energy Storage system:

In the SHAKLEE Energy storage system, we use Supercapacitors as well as batteries. In This architecture, The main focus is on the supercapacitor; while the battery is for a backup system.The kinesis of the hybrid energy storage system is controlled by an Arduino controller. In the Kinesis, In the supercapacitor is charged fully and the vehicles at that time the source of the energy for the vehicle is the supercapacitors.

After discharging the supercapacitor, the supercapacitor gets fully discharged, the source. the source of energy to the vehicle is shifted on the battery and this time the battery is the energy source of the Vehicle till the rechanging of the supercapacitor is done. After recharging the supercapacitor, again the source of energy of the vehicle shifted to the supercapacitor and the supercapacitor is now, the energy source of the vehicle.

Sr. No	Speed Condition	Speed (r/m)	Power(watt)
1	Residential Speed	250	7.2
2	Moderate Speed	270	6.5
3	High Speed	300	6

Table.1. Different power requirement

3.2 SHAKTEE CHARGING ARCHITECTURE

1. When Supercapacitor get discharged, the vehicle will run on the battery pack.
2. From the place where the Supercapacitor get discharged to the place where the high-power charger situated; the battery will work as a main source of the power to the vehicle.
3. When the vehicle is arrived at the charging station, the Supercapacitor bank will charge at high speed.
4. After completion of the charging of the Supercapacitor bank, the main source is shifted on the Supercapacitor from the battery. Now the Supercapacitor bank is main source of the power of the vehicle.
5. The SHAKTEE Architecture works on the frequent charging and discharging of the Supercapacitor bank charging station with in Supercapacitor charging and discharging period range.
6. We assume if the Supercapacitor bank will sustain 10 kms of distance, and discharges after 10 kms of the running of the vehicle: then we have to place charging stations every 10 kms of the distance. So that, this architecture will work properly.
7. Basically, this system will work within the city very well; also, on the highways for the long distance

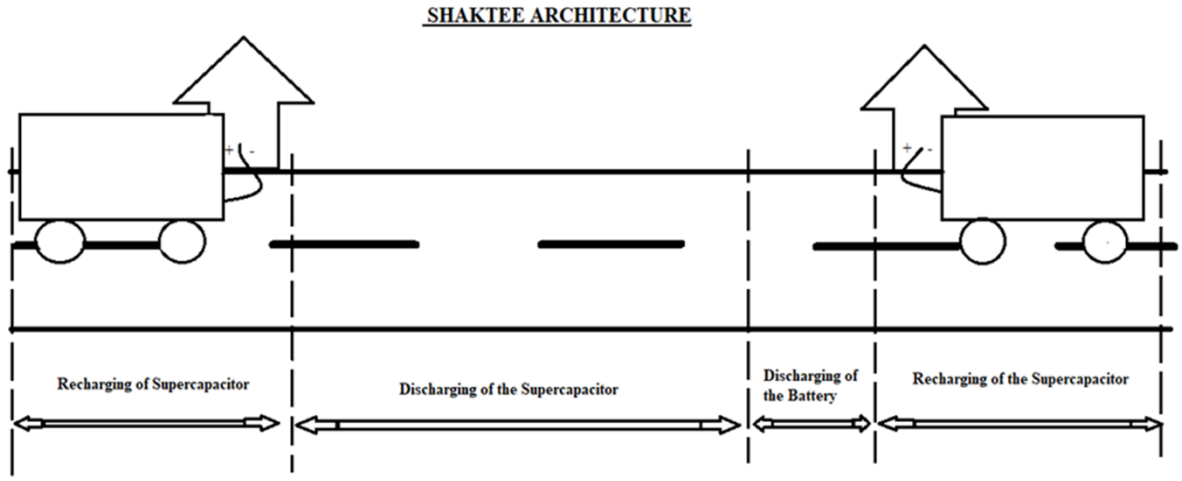

Fig.3.SHAKTEE Architecture

3.3. Hardware Calculation:

I. To calculating total capacitance of capacitor bank getting 5 supercapacitors

$$F = \frac{I*T}{V1-V2}$$

Where,

F = Supercapacitor Value (F)
I = Driving Current (A)
T = Load Applied Time (S)
V2 = Final Voltage (V)
V1 = Initial Voltage (V)F

II. Practical calculations:

Calculation 1: Discharging supercapacitor with voltage 11v to 10v with 1Amp load

So,

F = 11v to 10v $\xrightarrow{\text{discharge}}$ 59 Seconds

$$F = \frac{I*T}{V1-V2} = \frac{1*59}{11-10} = 59 \text{ F}$$

So average capacitance of each supercapacitance is **345F**

Calculation 2: Discharging supercapacitor with voltage 14v to 2v with 1Amp load.

So,

F = 14v to 2v $\xrightarrow{\text{discharge}}$ 11.14 minute

$$F = \frac{I*T}{V1-V2} = \frac{1*701}{14-2} = 59 \text{ F}$$

Calculation 3: Final voltage of supercapacitor 15v discharge with 1Amp load fully charged supercapacitor calculation getting 14 minutes.

15 Supercapacitor $\longrightarrow$ 2.6 watt load $\longrightarrow$ 0.1Ah = 100 mAh
So our load Specification
Dc motor-

RPM = 300
Operating voltage = 12v Dc
Torque = 2kg –cm
No load Current = 300 (Max)

So, converting into watt

P = 12 * 0.3
P = 3.6 watt for 300mA load

We are attach two dc motor For two loads. So it is get double power,

P = 3.6 * 2 = 7.2 watt

Calculation 4: Calculating time taken by capacitor to discharge 2 loads

$L_1 + L_2 = 600$ mA

$$\text{Time} = \frac{Ah \times 3600}{600 \times 10^{-3}}$$

$$\text{Time} = 100 \times 6$$

$\therefore$ Time = 600 second

Load handled by capacitor for 600 second ≅ 10 minute and calculation time for battery is battery specification

Voltage = 12 V ; Ah = 1

$$\text{Time (H)} = \frac{Ah(mA)}{Amp(mA)}$$

$$\text{Time (H)} = \frac{1000}{600} = 1.67 \text{ Hour}$$

Distance covered using battery is 4km.

$\therefore$ Time = 96 minutes.

Calculation 5: Calculating distance covered by wheels in one shot of charging super-capacitor

Wheel diameter = 3.5 * 2 = 7 cm
RPM of DC motor = No load => 300 RPM
Load => 200 RPM
Circumference = 23.5 cm
Distance = circumference * RPM * Time
= 23.5 * 200 * 10
= 4700 cm
Distance = 470 meters in 10 minutes

Supercapacitor = 500 F & 2.2 v To calculating capacitance of capacitor bank

3.4 Flow of Simulation Models

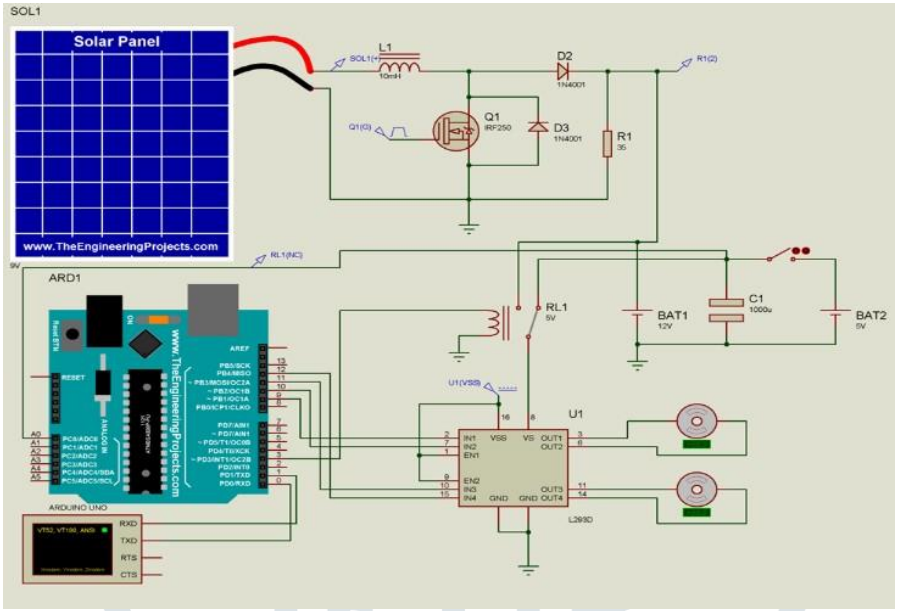

Fig.4. Simulation Circuit

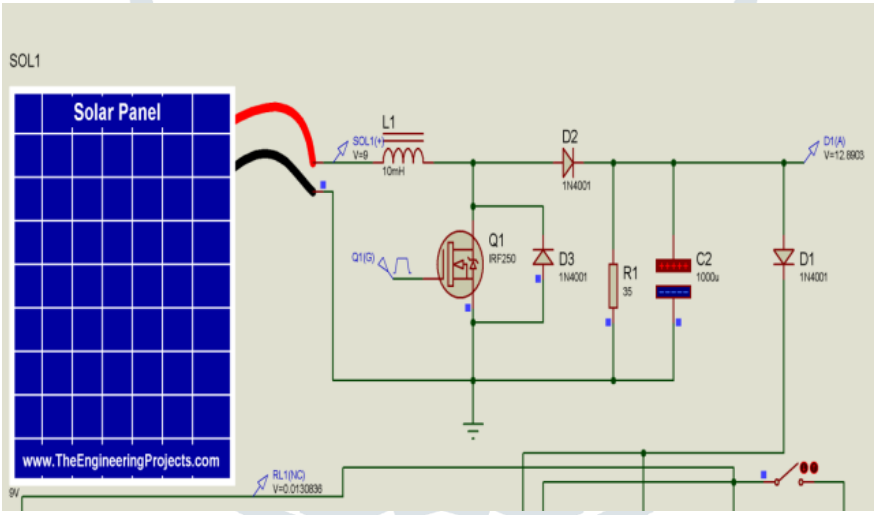

Fig.5.DC Output Voltage = 12.86 ≅ 13V @ PV Voltage =9V

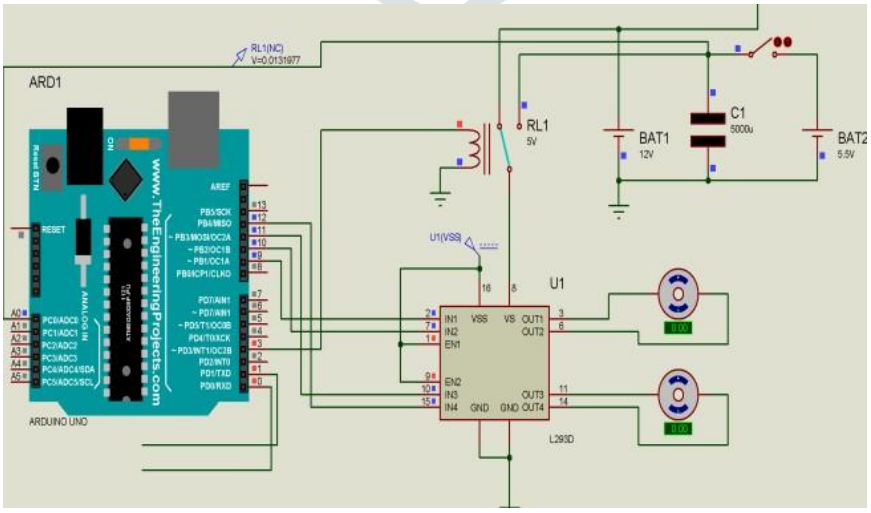

Fig.6. Capacitor Voltage Less Than Reference, Relay On

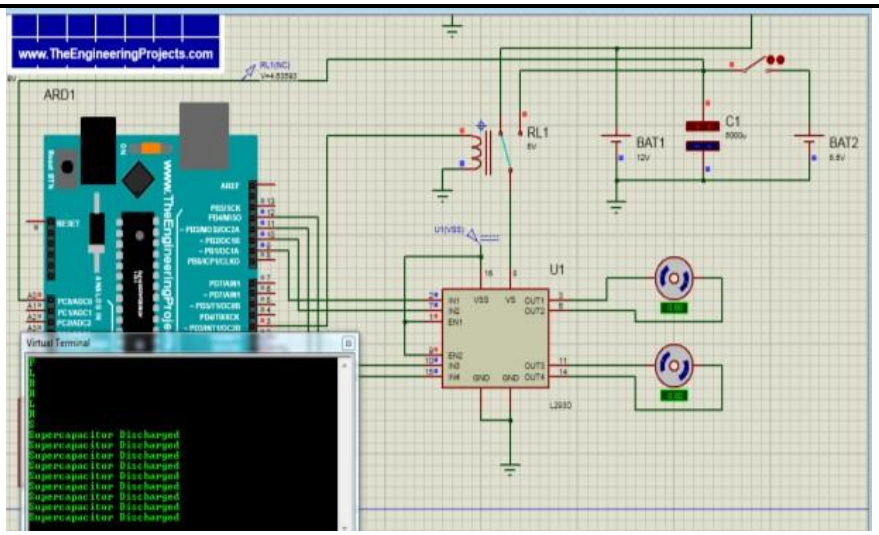

Fig.7. Serial Port Message For "SupercapacitorDischarged"

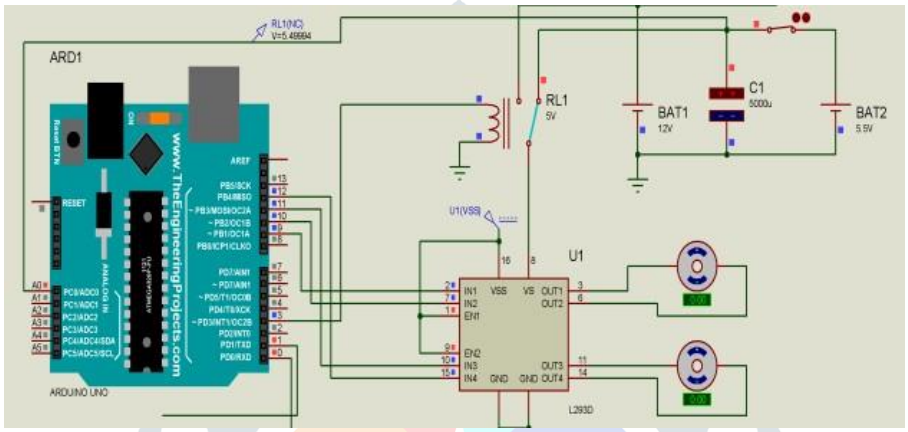

Fig.8. Capacitor Voltage Greater Than Reference, RelayOff

V. Conclusion

From the experimental and theoretical analysis of the HESS it is concluded that sizing of battery and super-capacitor in terms of combination with required power and energy plays important role while designing the actual battery powered electric vehicle. Power demand can be met by power management system discussed in this project and also load profile is satisfied. The battery current is maintained as constant as possible as peak current is supplied by auxiliary energy storage element i.e Super-capacitor so battery life is significantly increased.

Due to instant charging of the battery, the battery may get heated and damage early so by using our method of charging we can increase the battery life and reduce the losses due to heating effect of the battery. The range of electric vehicle increases and the stress on battery get reduced. Hybrid vehicles in most general terms can be described as vehicles comprising combination of energy producing and storing .Introducing SHKTEE architecture which will getting demand in future .

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