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REGENERATIVE BRAKING USING SUPER CAPACITOR

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Abstract— A super Capacitor Simulink model was first analyzed for calculating the effectiveness of certain parameters with respect to battery. Supercapacitor has high power density and can accept charge at a faster rate than counterpart battery, thus it was considered for the application. For reference Tata NEXON was considered and how much energy does braking generate was calculated wth help of formulas . A Block diagram of prospective Regenerative system with Supercapacitor is also included and explained in this paper.

Keywords— Regenerative Braking, Super Capacitor, Electric vehicle, storing.

INTRODUCTION

In recent years there has been a dramatic increase in the use of electric vehicles, mainly due to the increase in fuel capacity, the rise of alternative fuels, improved battery storage, and growing investment, and many other factors. Increased fuel efficiency, the rise of alternative fuels, increased battery storage, increasing investment and a various of these reasons have had a good full of hand in use of electric vehicles. Batteries are one of the most widely spread and has good application in use in electric vehicles. The supercapacitor provides good probability of energy as its capacity make use and supply of energy is good. However, there are other features that use supercapacitors are yet to examined.

Literature Review

In terms of vehicle use there are tons of paper that suggest the use of SC in car installations. Very few of supercapacitor applications are used, at least in some part, for reconstruction of purposes due to the very good compression features that are well arranged with refreshing brake feature. Apart from electric vehicles there are a limited number of paper reviewing the use of supercapacitor as source of energy. Super capacitors have been widely regarded as electric devices that close the gap between conventional low-power capacitors, and fuel cells and batteries suffer from low power congestion. The electrostatic and reversible supercapacitor charging system, which forms two parallel plate and the electrolyte, make the doublelayer capacitor electric capacitor competitive with conventional capacitor, due to the high electrode material, separation. . The distance between the electrodes and the range of electrolytes tested and still being tested.

PROBLEM STATEMENT

In a typical electric car system we use a battery to save and provide energy. In this process, when the regenerative braking occurs from Electric vehicles when the kinetic energy created during braking is lost to collisions . We are able to find good output capacity than battery by using supercapacitor setup.
The kinetic energy produced can be calculated as –
This are the given calculations for TATA Nexon on regular basis , We can calculate the values by using supercapacitor setup to improve energy and feasible use of energy in electric vehicle system and make it more viable.

Solution Strategy

- For energy saving purposes this supercapacitor setup is good solution as it will save energy as well as reduce wastage of energy.
- Use of Supercapacitors for energy saving applications reduce wastage of energy in existence. It does energy saving and use of energy tasks at a time, it also provides proper use of energy in small applications like light,radio,etc.
- Regenerative Braking creates lots of kinetic energy that gets wasted due to improper management and lost energy during this process.

I. OBJECTIVES OF THE PROJECT

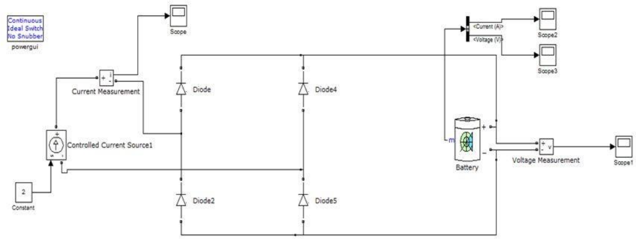
Objective of this project is to compare the amount of energy saved by using the supercapacitor instead of a battery in a TATA Nexon car module. To develop a setup which utilizes the energy created during Regenerative braking process and use that energy to store and perform different tasks in a system. The outcomes of the charge / discharge fee on the SC cell quantity is normally made below regular situations. In original, when the supercapacitor charging cycle at some point of regenerative braking will no longer have this kind of charging cycle. the biggest challenge for all transportation is to lessen energy consumption and reduce CO emissions. Acquisition of braking power (recovery or renewal) helps with both. This requires components that can quickly store and release energy over long periods of time at a high cycle rate. Supercapacitor meet those requirements and are consequently utilized in numerous travel load structures. ESR, which involves the resistance of molecular components, for example, electrolyte resistance and call resistance with ultra capacitors, or super capacitors as it's also recognized, is a strength-saving generation that offers high energy density, fast prices and really lengthy life. . Because they conserve energy in the electric field, instead of reacting to chemicals, they can survive hundreds of thousands of charge and discharge cycles.

- **AID TO MANKIND**

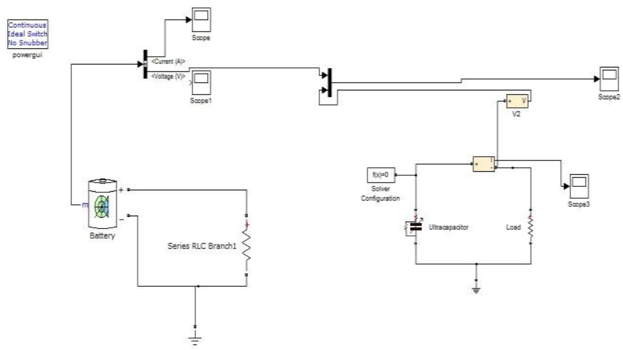
i. Provides efficient use of power rather than battery.
ii. This supercapacitor braking system can restore power faster than normal.
iii. It provides a higher level of discharge than battery with battery supply.

DESIGN AND SIMULATION

All the design process was done on MATLAB SIMULINK R2021a.



Battery charging circuit



Supercapacitor charging circuit

MOTOR SPECIFICATIONS

Motor Type:	Permanent Magnet Synchronous Motor
Fuel Type	Electric
Transmission Type:	Automatic
Maximum Torque:	250 Nm

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Maximum Power	141.04 bhp
Body type	SUV
Battery capacity	30.2 kwh

PARAMETERS

PARAMETERS	Battery (10 Ah, 2.7 V)	Supercapacitor (1800 F, 2.7 V)
R_i	5.02	1.03
C_{i0}	110F	5202F
C_{i1}	Remove	-
R_d	4.2	0.48
C_d	432.62	292.8F
R_l	1.8	1.2
C_l	22.44	3F

Regenerative Braking Calculations :

Mass of car = 1400 kg

Expected Velocity = 50 km/hr

Brake time = 10 se

The Kinetic energy generated can be calculated –

K.E = $\frac{1}{2} M * V^2$

Kinetic energy = $\frac{1}{2} * 1400 * 50^2$

= 135.885 kJ

This is the amount of energy that can be got by Regenerative Braking at 100% Efficiency.

Medium power during braking can be provided by-

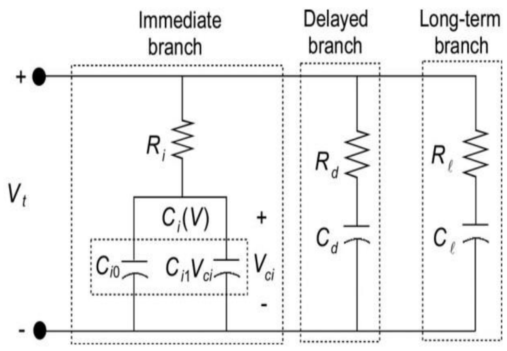
P = $\frac{K.E}{T}$

Average power = $\frac{K.E}{T}$

= $\frac{135.88}{10}$

= 13.49 kwatts

- **Supercapacitor Calculations:**



Immediate Branch :
The immediate branching parameter identifies both devices by charging them with DC. The parameter is calculated from the current relationship with the power supply of the branch according to formula 1..

$$R_i = \frac{V_1}{I_{ch}} \quad (1)$$

where V1 is the voltage at time t1 after power-up. Flexible Charger Ich. V1 is the reference point for determining Ci0 and Ci1. Ci0 is calculated using the voltage difference from ΔV to V2 = V1 + ΔV. The charging time (t2) is calculated such that the battery or supercapacitor voltage reaches V2 and the time difference is Δt = t2 t1. Ci0 is calculated according to the equation 2

$$C_{io} = I_{ch} \frac{\Delta t}{\Delta V} \quad (2)$$

Charging time (t3) is the time required to gain total power (V3), for Ci1 to be calculated using Equation 3.

$$C_i = \frac{2}{V_4} \cdot \left(\frac{Q_{tot}}{V_4} - C_{i0}\right) \tag{3}$$

where Qtot = Ich x(t4 t1) and t4 = t3 + t1. V4 is the remove voltage of the battery or supercapacitor after a long discharge process t1.

Delayed Branch:

Rd and Cd are calculated for branch shear delay. The charging times of both the battery and capacitor at Rd should be calculated at time t5 for a given voltage V5. where V5 = V4 ΔV. Rd is calculated using:

$$R_d = \frac{(V_4 - \frac{\Delta V}{2})\Delta t}{C_{diff} * \Delta t} \tag{4}$$

where Cdiff = Ci0 + (Ci1 x V3). After that, t6 is calculated using t6 = t5 + 3 (Rd x Cil), Cd is obtain by use of Equation 5

$$C_d = \frac{Q_{tot}}{V_6} - \left(C_{i0} + \left(\frac{C_{i1}}{2} * V_6\right)\right) \ldots\ldots\ldots\ldots\ldots (5)$$

Long-term Branch :

In the longterm branch with V7 = V6 ΔV, and t7 is the capacitor or battery charging time when the voltage drops to V7, and then, R1 is calculated using Equation 6.

$$R_l = \frac{\left(V_6 - \frac{\Delta V}{2}\right)\Delta t}{C_{diff} * \Delta t} \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where Δt = t7 – t6.

At the end of the measurement phase, charge the capacitor for 30 minutes to calculate Cl. Cl is calculated according to Equation 7.

$$C_l = \frac{Q_{tot}}{V_8} - \left(C_{i0} + \left(\frac{C_{i1}}{2} * V_8\right)\right) \ldots\ldots (7)$$

- **Braking power Calculations:**

Average braking power can be calculated as –

$$= \frac{K.E.}{V} = \frac{135.585 * 1000}{14} = 9684.642J = 9.64KJ$$

$$\text{CURRENT GENERATED} = \frac{9.6846 * 1000}{14}$$

$$= 691.71 \text{ Ampere}$$

If charging time for 9.4 ampere is 8 hours then 692 Amperes will take 588 hours .

- **Graphical Representations**

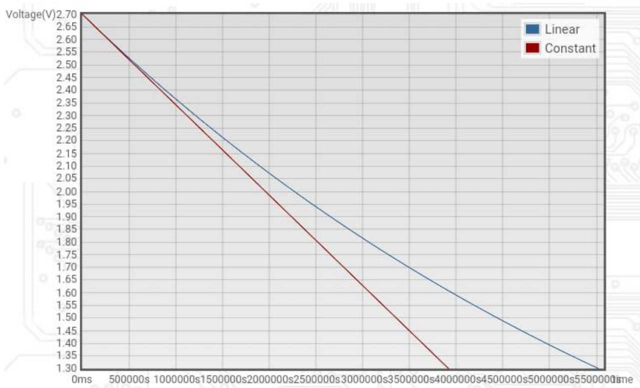


Fig. Discharging Graph

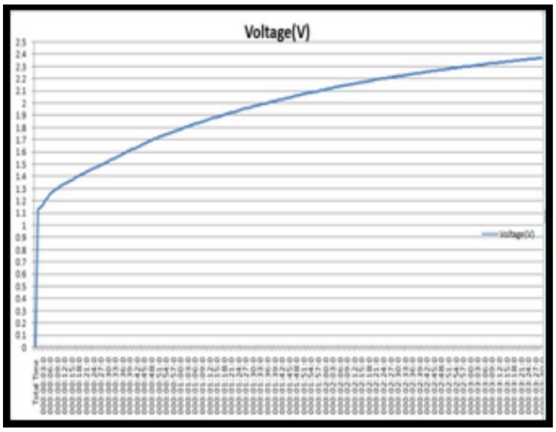


Fig. Charging Graph

CONCLUSION

The use of supercapacitor/ultracapacitor as part of this Regenerative braking system has shown to be very efficient. We calculated the three parameters of, immediate and delayed, and Long term branch parameter with values Ri=1.03, rd,0.48, R1=1.2, which show that it can absorb a greater amount of energy. However, a Supercapacitor's discharge time is large, with a significant decline. This must be addressed in future developments.

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