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Optimizing EV Performance through supercapacitor-battery integration

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I. ABSTRACT

Theoretically the generation of battery innovation, as well as electric vehicles (EVs), has as of late picked up a parcel of consideration. In spite of major progressions in battery innovation, current batteries do not completely fulfil the vitality requests of EV power utilization. Non-monotonic vitality utilization taken after by rehashed alterations amid the battery releasing period is one of the major concerns. This is amazingly unsafe to the battery's electrochemical operation. Combining the battery with a supercapacitor, which is basically an electrochemical cell with a comparative plan but higher rate capability and more noteworthy cyclability, is an attainable elective. The supercapacitor will give the additional vitality required in this arrangement when the battery comes up short. In expansion to the battery and supercapacitor as isolated components, the development of the going with half breed gadget must be planned from an electrical building angle. So, the result of this framework in combination of battery and supercapacitor will be unrealistic the battery life cycle and superior execution of electrical vehicles.

Keywords : *Electrical Vehicles, Super capacitor, Battery, Control capacity framework, Regenerative braking.*

II.INTRODUCTION

Today we are witnessing how two-wheelers are making inter and intra-city travel easier. However, they make our lives much easier and have many advantages and some problems. In the original innovation, all vehicles ran using existing energy sources, primarily gasoline to power the engines and motors. Fortunately, after all the research and exploration, scientists were gradually able to use electricity as gasoline, and engines could run on electric batteries.

Traffic conditions in cities and urban areas typically consume significant amounts of power or energy due to the required speed changes. In this case, the driving distance can be increased only by applying a hybrid system to the vehicle. The electricity load profile includes high peaks and steep troughs, resulting in surges in generation and demand. This creates pressure in the battery, which increases internal heat generation and internal resistance, which reduces battery performance and ultimately leads to premature battery failure. The battery does not accept any form of renewable energy until it is fully charged. The performance of supercapacitors significantly exceeds that of batteries as they cope with current surges at some acceleration and deceleration points due to their higher intensity density limits and shorter charge-discharge capabilities. Supercapacitors are a recently invented method of energy storage. The application of supercapacitors can better replace the current power supply, and the application of supercapacitors can provide extensive work opportunities for experts and other people. Connecting a supercapacitor to a battery can be useful when high voltage and short dynamic response are required. This helps reduce battery load and maximize regenerative braking energy. Using supercapacitors in energy storage technology significantly reduces battery size because no chemical reactions occur. Therefore, there is no limit to the number of charge and discharge cycles.

Since no toxic substances are used, these devices do not require maintenance. However, although supercapacitors help reduce current surges, it is recommended to use supercapacitors to store energy in order to control it through a power electronics converter. This type of converter controls the power contained in the supercapacitor depending on the battery charge level. Battery performance analysis is performed by simulating a real system, connecting the battery directly to the supercapacitor, and using an appropriate power electronics converter. In 2013, India addressed national energy security issues in its National Electric Mobility Plan (NEMMP) 2020. The main objectives of the National Electric Mobility Mission (NMEM) are to provide national energy, reduce the unwanted impact of machinery such as vehicles on the environment and create a local industry in the automotive sector. Therefore, NEMMP 2020 is expected to impact the automotive sector for electric and hybrid vehicles. Various authors have described electric vehicles and battery storage technologies in the literature. In Reference [1], various authors reported literature on electric vehicles and battery technology. Link simulated and suggested a battery that would not be able to provide this kind of power and quick response to the vehicle.

[2] Electric vehicles require oscillating power loads, or waves, for which conventional batteries are unsuitable.

[3] Manufacturers are conducting research to create batteries with higher dynamic response for use in real-time environments. Pei et al. proposed a new technology that can increase the driving range of electric vehicle batteries.

[4] Regenerative braking increases the internal resistance of the battery, causing premature failure and reducing efficiency.

[5] To achieve this goal, the following application areas exist: Supercapacitors offer several advantages over traditional batteries, so mass market and manufacturing opportunities exist. Now electric car manufacturers are pinning their hopes on this technology.

[6] Much research has been conducted on this problem and several applications of supercapacitors have been studied.

[7] found that some applications require short-period power signals, requiring devices that can provide this power when needed. For example, transmitting electromagnetic waves or microwaves requires high voltage to generate powerful pulses in the device.

[8] The authors described the energy cycle and use cases of electric vehicles, as well as the increasing demand for electricity for safety and comfort. Describes the network or topology of the Solectra and DC 400 DC/DC converters.

[9] Following the study, research questions can be formulated to study the efficiency, battery life, and effectiveness of combining the two technologies. Supercapacitors and batteries for electric vehicles.

[10] The goal was to improve acceleration/deceleration performance and reduce cost and complexity by incorporating supercapacitors into the design.

III. PROBLEM ARTICULATION

In writing audit a few issues such as fabricating and plan of great capacity electrical gadgets to make strides the adequacy, execution and driving run of electrical vehicle have been considered. Hence, the issue articulation can be expressed as "Super capacitor-based battery life advancement in electric two-wheeler", considering improvement the framework by utilizing of MATLAB demonstrate and analysing the comes about. Scope of Work Hypothetical Foundation: Concurring to the information and earlier ponders hypothetical foundation of work, preferences and confinements of electrical vehicles will be created. Consequently, it will be utilized for planning the modern proposed show. Modelling: to create the demonstrate of a successful control capacity framework for live applications in mechanization segments we have to think almost the driving stack cycle of a two-wheeler vehicle first.

IV. DESCRIPTION OF FRAMEWORK

3.1 COMPONENTS OF FRAMEWORK

3.1.1 BATTERY

A battery for an electric bicycle is one that is utilized to create footing constrain. Charges are put away in a battery by a chemical response. Resistance, temperature, charging and releasing rates all have an effect on the battery's effectiveness. Thevenin's proportionate circuit, which puts the open circuit voltage in arrangement with a closely resembling resistance, is a broadly utilized uncertain demonstrate for batteries. The SOC of the batteries are characterized by the combination of resistance and voltage (State of Charge). After evacuating any Amp-Hr, the SOC is the volume of vitality cleared out in the battery. The voltage of the battery is seen as a work of the state of charge (SOC). $V_{oc}(t) = a1 + a2 * SOC(t)$, in particular temperature. In comparison to SLI batteries, deep-cycle batteries are frequently found in vehicle businesses. Profound cycle battery is outlined with an expansive charge unit estimate in intellect. The quality to weight proportion of batteries for electric vehicles must be tall. Electric and cross breed electric cars are getting to be more common in today's markets, so it's imperative to see at how they can be utilized in open travel systems. Lead Corrosive batteries have been the most prevalent vitality buffers being utilized in vehicle applications due to their moo fetched. Until presently, the chemical properties of lead acids have avoided quick charging or releasing without causing a temperature increment, bringing down its productivity and contributing to its long term weakening. Experts recommend matching the lead corrosive battery with the super capacitor to fathom this problem.

3.1.2 CHARGING AND RELEASING

On release, lithium particles (Li+) transport current from the negative to positive anodes of the battery, by means of a non-aqueous electrolyte and a separator stomach. An outside electrical control source applies higher voltage whereas charging, causing the charging current to stream from positive to negative anodes, in the inverse course of release current. Beneath intercalation, the lithium particle voyages from the positive to negative cathode, where it is implanted in the retentive anode substance. Electrical interaction resistance at the interfacing of cathode layers causes vitality misfortunes. Beneath standard working conditions, vitality misfortunes from current-collectors can be as much as 20% of the add up to vitality of the batteries. The charging component for a single Li-ion cell and a full Li-ion battery varies marginally. There are two stages for charging a single Li-ion cell:

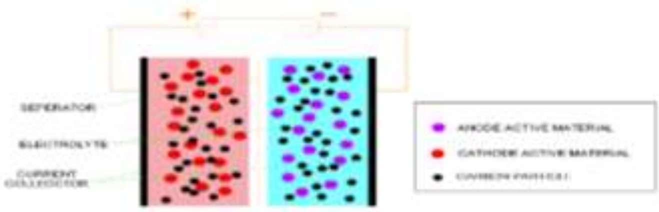


Fig.1: Lithium Ion Battery.

3.1.3 CHARGING

The battery of an electric two-wheeler needs to be charged. The most popular way to charge an electric vehicle is through the distribution network at home or at a charging station. Using the right power source can extend the battery life. It takes 2-3 hours to fully charge the battery, but faster charging is possible without affecting the battery life. Figure 2 shows how to use a home charger for this reason. Chargers must have complex control systems to regulate current and voltage. Without this advanced care, your battery life may be shortened. An electric vehicle battery consists of multiple cells connected in series. Due to charging imbalance, battery cells may have different amounts of charge when charging and discharging. Temperature is also an important factor in these cases. To prevent battery failure and shortened service life, battery cells must be regularly charged at full SOC. The main requirement for a charger is that it must be fast. Due to lack of network capabilities, no one can charge their bikes at home. Therefore, an external charging station must be available. Otherwise, the use of electric bicycles will be limited to some extent. The problem with fast charging is that fast mode can only charge up to 80% SOC and the rest of the charging must be done in slow mode. Therefore, it is necessary to consider the load required for the vehicle and prepare/select parts that can meet these requirements. Simulation: MATLAB is used to develop simulations after selecting appropriate components for the Steady Current 2. Consistent Voltage There are three stages for charging an arrangement of Li-ion cells:

1. Constant Current
2. Balance
3. Constant Voltage

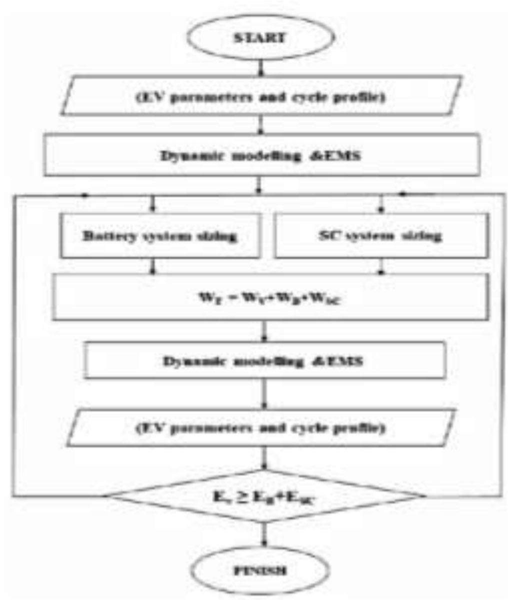
Analysis of results: Once the simulation is complete, it should be compared and analysed to verify completion of calculations and tasks.

Fig.2 : EV Household Charger.

IV. SYSTEM SIMULATION

4.1 SYSTEM SIZING ALGORITHM

Appropriate part sizes are required to meet the desired load and make the device most affordable in size and cost. The efficiency of the system is determined by the selection of components. Because



cost and functionality determine the dynamics and economy of the entire vehicle.

Fig.3 : System Assortment Algorithm.

4.2 SYSTEM SPECIFICATIONS

The battery system creates two parallel banks. Each battery pack consists of 24 VRLA (Valve Regulated Lead Acid) battery cells connected in cascade.

The total power consumption Pmax of the buck-boost converter and the thermal performance of the system determine the size of the switches and diodes used for freewheeling.

Table 1 : Battery Description

Rated voltage	24 V
Capacity	14 Ah
Recharge rate current	14.5 A
Static recharge internal resistance	(SOC $\leq$ 50%)

Table 2 : Super capacitor Cell Description

Rate voltage	2.7 Volt
Capacitance	350 F
Peak voltage	2.9 V
Series Resistance	1 mΩ

Table 3 : Super capacitor Subsystem Description

Rated voltage	32 V
Capacitance	29 F
Peak Voltage	34 V
Energy stored capacity	1.17 MJ

Table 4 : Converter Description

Switching Frequency	1 KHz
Inductance	100 mH
Resistance	10 mΩ
Capacitance	100 mF

4.3 SYSTEM SIMULATION

4.3.1 DIRECT CONNECTION OF SUPERCAPACITOR

The integration of supercapacitors with battery-powered load circuits has become more complex to simplify and improve the convenience of the supercapacitor subsystem. The easiest way to turn on a supercapacitor is to connect it in parallel with a battery. First, it is charged to the same voltage as the battery terminals. The load current is provided by il flowing down. This means that it becomes negative during regenerative braking and positive during acceleration, as shown in Figure 4. The supercapacitor current ic and battery current ib are measured using the following simple www.ijera.com rule circuit: Kirchhoff's current and voltage laws reduce to a specific load that reflects all driving cycles of the vehicle. The optimal components will have higher energy density and higher power density than current batteries and capacitors. This part does not exist at the moment, but supercapacitors are under development. Supercapacitors are devices that increase the power density of batteries or the energy density of conventional capacitors. Now, supercapacitors have half the power density and 100 times the energy density of the best tantalum capacitors. The source and load are always imperfect, and the allowable output depends on the application. The supercapacitor connects the source and the load. When used in parallel with a battery, it equalizes the load on the battery while improving the source impedance seen by the load. This shows that the battery provides energy and the supercapacitor provides short-term power.

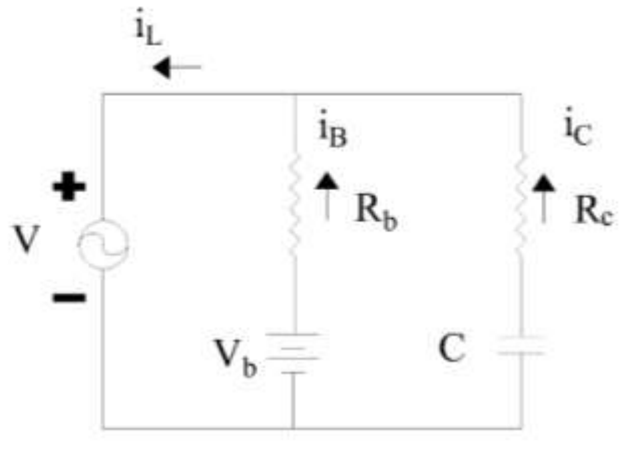


Fig .04: Network Circuit.

4.3.2 CONNECTING THE SUPERCAPACITOR THROUGH THE POWER CONTROLLER

Fully utilizing supercapacitor banks requires direct integration with power flow controllers between storage subsystems . The purpose of these power converters is to provide a constant current to the battery to keep it from overheating. During peak power consumption, the supercapacitor charged rapidly in the generation direction, destroying and discharging almost all of the power processed.

4.4 RECREATION

The recreation is carried out utilizing the MATLAB/SIMULINK computer program. For specialized work, MATLAB is a higher-performance verbal. For control estimations, recreation models are arranged. The yield of the combined gadget with buck and buck/boost control converter is moreover illustrated utilizing a vehicle demonstrate with control converter.

V. EVALUATION AND OUTCOME

5.1 MATLAB SIMULATION AND RESULTS

Figure 5 shows the power curve of the electric vehicle along with the current and voltage parameters MATLAB model with a supercapacitor and battery connected in parallel through a DC-DC converter. reenactments are run in discrete mode and the comes about are plotted. The control bend of an electric two wheeler, as well as voltage / current characteristics, are appeared in the fig. 5, which was gotten from a MATLAB show in which the super capacitors and batteries are associated in parallel as well as by means of a DC-DC control converter. Agreeing to the comes about of reenactments on sudden stack increments to DC frameworks at conventional substations and recreations on sudden stack increments, a crossover vitality capacity gadget for super capacitors and batteries will accomplish buffered quick release of the super capacitor and buffered moderate release of the battery, empowering them to both advantage from their individual points of interest. We made different scenarios for both immaculate electric and bunch half breed vehicles to examine the impact of super capacitors with lead-acid batteries on battery factors and fuel utilization, altering parameters such as capacitance esteem and battery charge for ideal working points.

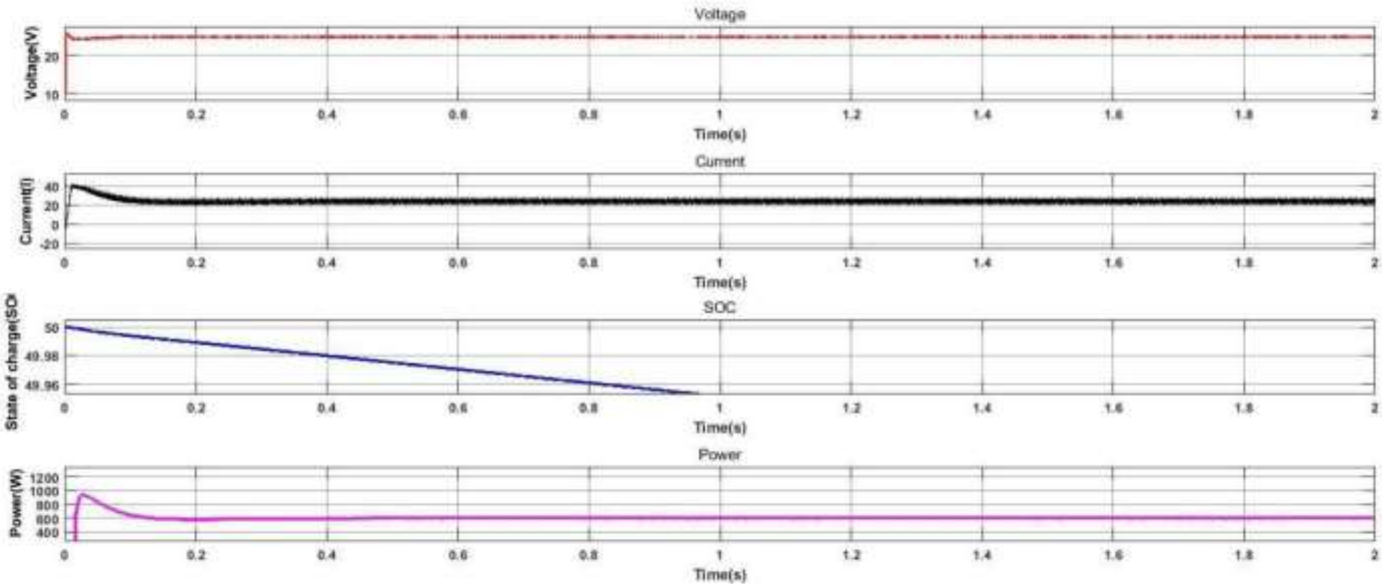


Fig 05: Electric Vehicles Battery Specifications**.**

Since the battery voltage is 24V, the state of charge (SOC) of the battery decreases as shown in Figure 5. No supercapacitors are used for battery electric drive. Without the peak power output of the supercapacitor bank, the peak power of the battery should be 800 W, as shown in Figure 09.

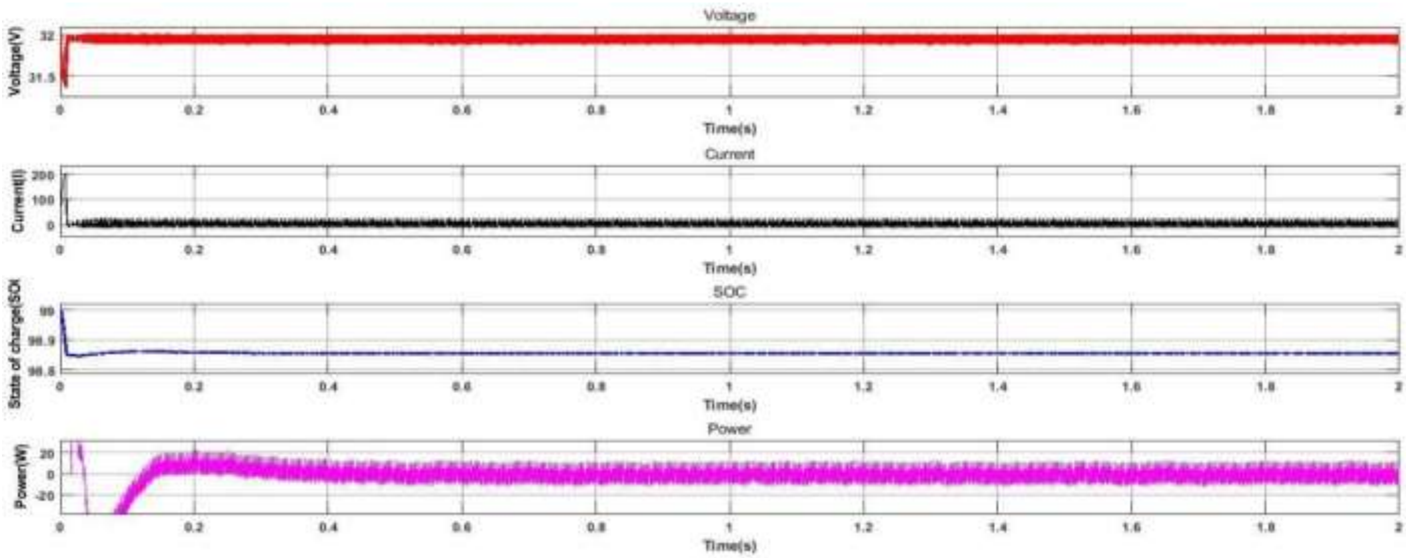


Fig.06 : Parallel Properties of Supercapacitor.

If we connect a supercapacitor and a battery in parallel and perform a simulation with a specific load, the current and voltage will exhibit the characteristics shown in Figure 6. As you can see, the supercapacitor generates peak voltage when the car starts and protects the battery from high peak voltages and currents, thus extending its life.

The load torque and electromagnetic torque are shown in Figure 8. The motor load is 1Nm, which is the required torque, and our system provides approximately 1Nm. Because the torque characteristics of the starting section are high, starting the engine with a supercapacitor reduces the load on the battery and extends battery life.

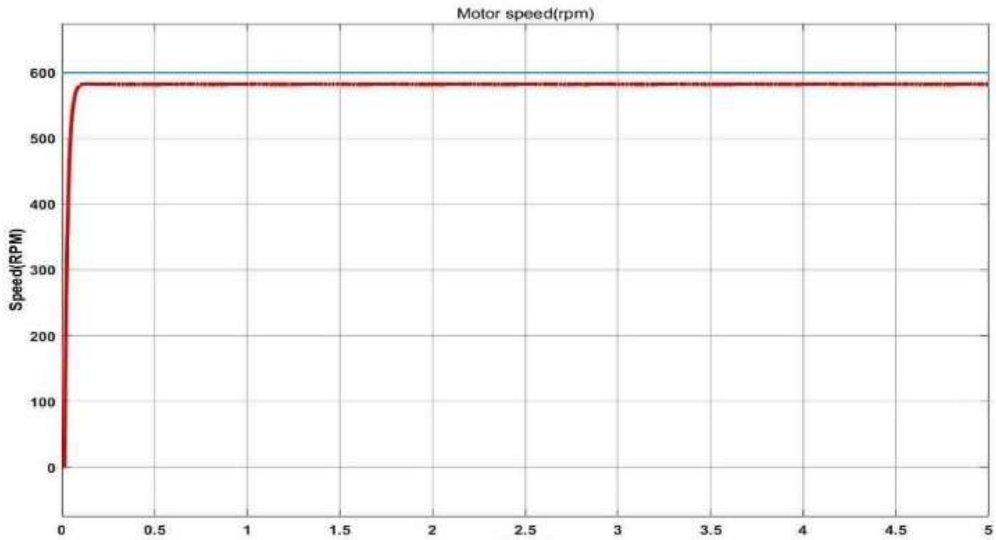


Fig .07:-Speed Attributes of Integrated Supercapacitor and DC-DC Converter.

Figure 8 shows the vehicle speed after adding a power controller to charge the supercapacitor. regulation. As shown in the blue line, the required speed is 600 rpm, and the delivered speed is approximately 580 rpm. As a result, the curve flattens out, indicating that the supercapacitor is being used at full capacity.

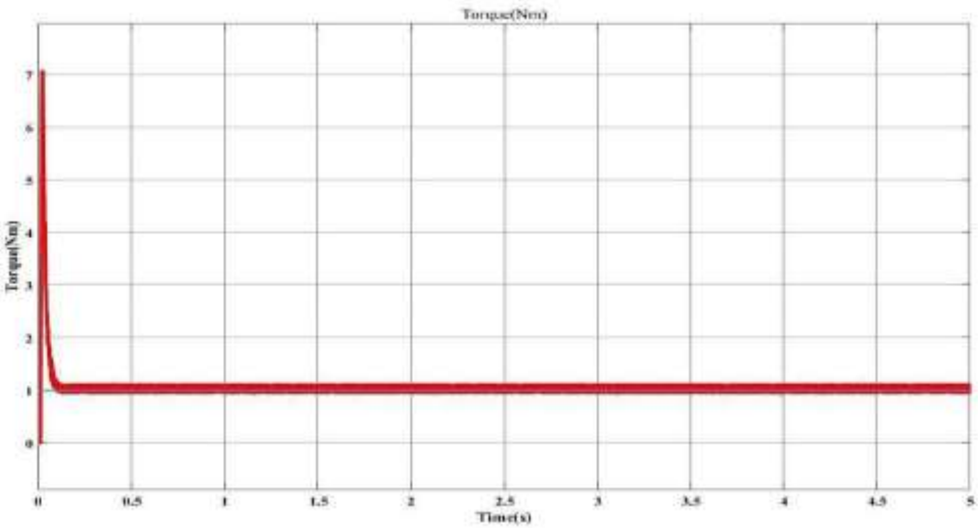


Fig.08 : Torque Attributes of Motor.

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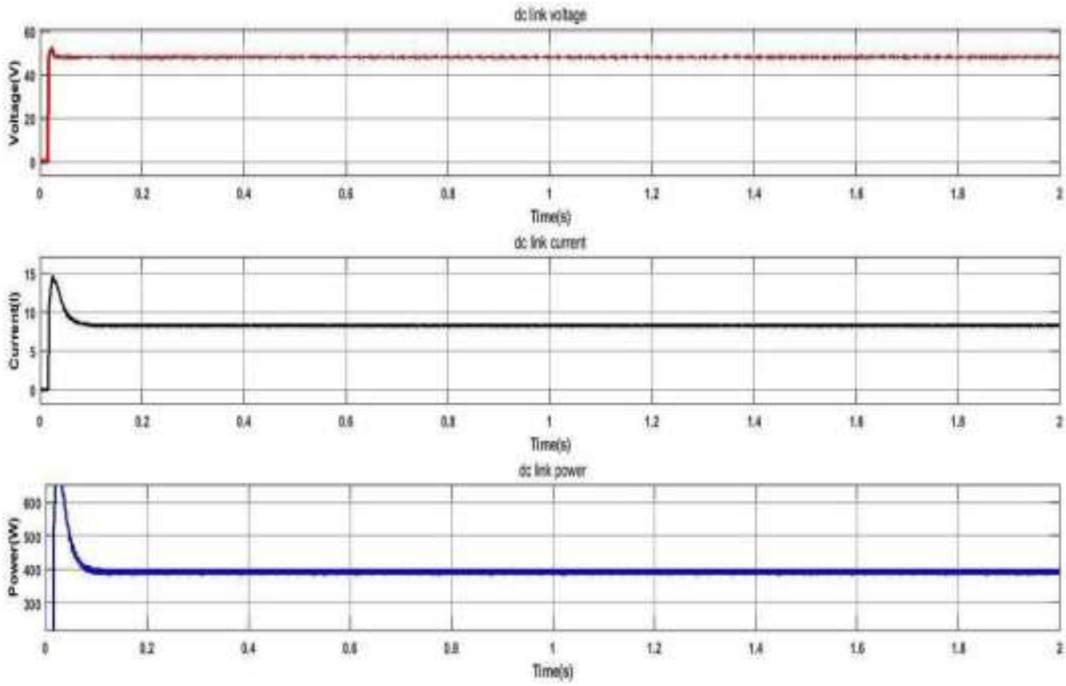

Fig 09:- Attributes of Electric Car Engine

Figure 09 shows the vehicle engine characteristics. Our batteries provide 24V to the system and the required electricity is supplied via supercapacitors. The voltage extracted from this figure is 48V required for PMSM motor. This voltage is provided by supercapacitor. Otherwise, the battery will not be supplied with electricity, thus reducing the peak current of the battery.

VII. Conclusion

For the control stream control of a half breed vitality capacity gadget comprising of batteries and supercapacitors for electric vehicles, a demonstrate prescient controller has been created. The controller's objectives are to keep up a characterized vehicle speed profile by appropriate control dissemination inside the battery and supercapacitors, as well as to anticipate sudden changes in the battery's control stream to secure it. Future endeavours will be cantered on the development of a capacity gadget that will work in all driving modes. Progressed observing instruments, such as fluffy control, will improve our vitality administration control. Advancements to the vehicle-to-grid course of action may be a potential project.

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