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Magnetic Field Assisted Smart Nano Fluids for Electric Vehicle (EV) Performance Test for Defence Application

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Abstract
Modern days electric vehicle (EV) technology is moving towards in the research and development area and also it can be more useful in upcoming years. The research paper is based on intelligent EV which is using smart nanofluid in its braking system. The smart fluid can substantially change the EV break, clutch and damping system. The EV moves through lot of obstacles in its path, the EV can adaptively change its position without getting disturbed to reach its destination. The regenerative braking system (RBS) is developed for EV using electrical energy storage system and run by brushless DC (BLDC) motor. While run-time of EV when it takes brake, the BLDC acts as a generator. A magneto-sensitive fluid (MSF) is a stable colloidal suspension of magnetic particles in a carrier fluid. A wide selection of liquid bases and magnetic particles is available: e.g. hydrocarbons, fluorocarbons, esters, organometallics, polyphenol ethers; and magnetic particles like metallic oxides (Fe_3O_4, Fe_2O_3), metals and their alloys (Fe, Co, Ni). Brownian motion keeps the particles suspended indefinitely, so that there is no precipitation under gravity or a magnetic field. Because the particle concentrations are only about 3-10% by volume, there is little effect on the physical and chemical characteristics of the fluid. Particles are stabilized with an absorbent coating, and various proprietary fluids have been tailored using specific particles and liquid bases. At this time fluid will play vital role during stoppage it will be easier stability and more smooth braking of the system without disturbances (like slippage and too much time in stop). To provide a reliable and smooth braking regeneration system, the braking force distribution is realized through a soft computing technique. The EV experiment result confirms high capacity of the future smart nanofluid technology.

Keywords: Electric vehicle (EV), Regenerative braking system (RBS), Smart Nanofluid, Modelling simulation

1 Introduction

This paper discusses about intelligent electric moving machine technology and development a high gain performance during run-time and also increasing attention for having distinctive features as efficiency is high, low emission, pollution free, cost-effective technology [1]. In EV technology the batteries are based on different type of chemical that has been used as the main source of energy storage system in many EV systems. However, the lead acid batteries have limited life cycle and this is known for shortcomings, such as limited density of electrical energy as well as market price is very high [2-3-4]. The electric capacitors those have double layer are known as super capacitors, are high capacitance capacitors that suggest several exceptional features such as power density is high, battery life is long, and high temperature operating range. Here the lead-acid batteries and super capacitors is compared on the basis of quality shown in figure 1, by the sun shape chart [5-6]. As shown, although the super capacitor provides better outcome in most of the situations, it cannot be used as the important energy store system since its energy density is comparatively down. Similarly, the technology of the super capacitors is developed; they are not as consistent as the conventional batteries. Additional benefits of lead- acid batteries and super capacitors can be used in an intelligent moving machine energy storage system [7-8]. There is different kind application of EV has discussed in detail.

1) Super capacitors have high power density that can be utilised to effectively control the kinetic energy of the EV.
2) Rheological fluid is using in EV which is capable to increase the life-cycle of battery but also changes in the acceleration of EV.
3) EV drive range can be significantly increased using smart fluid and regeneration braking energy could be effectively stored in battery.

During earlier innovation in EV technology, there are several techniques has been developed for automatic and smart vehicles. Here, the discussion for the efficient braking system with use of smart fluid or rheological fluid. The backup and the use of super capacitors in development of EV to rise above the drawback of the batteries. One of the most important terms of research and development in EV, the battery life and Fluid which is increasing the range of backup power of the system [9]. Thus, two topology is used in individual energy storage systems and a supportive power converter are needed for moving machine they are generally costly. The paper discusses about the novel structure is design for desirable interface between the super capacitor and battery is proposed. The research on saving the electrical energy and more storage as compared to other techniques which are available in market [10-11]. There are various operation modes of the

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proposed intelligent moving machine discussed in detail. Moreover, for the proposed electrical storage system for EV, a new regenerative braking system (RBS) is developed and also added the feature of smart fluid [12]. RBS perform during the braking process, using a suitable switching algorithm for the inverter, the dc-link voltage is boosted. Hence, the modes of operation are forward biased and the regeneration braking energy is directly harvested by the battery and the circuit module of capacitors without employing an additional converter

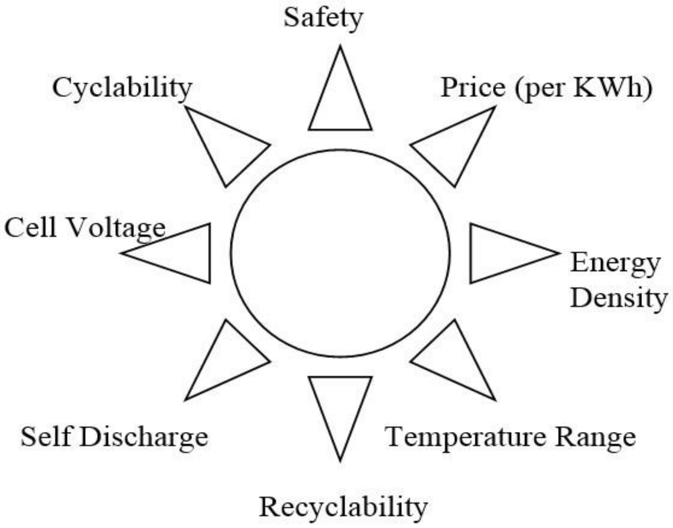

Fig.1. Qualitative Comparison of the Lead Acid battery and super capacitor

The DC-link is connected by the signal variations of cycle to pulse width modulation (PWM) in the inverter. Thus, when the conductor circuit module is approximately charged, the battery is realized as regenerative braking. In this method, the EV regenerative braking system efficiency is higher due to the removal of the utilized converters for this system performance [13]. Furthermore, an artificial neural network (ANN) is used with Simulink to complete braking energy force circulation. Meanwhile, a proportional integrator (PI) controller is used to set the braking current to make braking torque is kept constant [14].

Magnetic Field Smart Fluid (MSF) mechanisms: Particles in suspension remain randomly oriented in the absence of an applied magnetic field. A magnetic field induces a dipole in each particle, and the interaction of the applied field with the resultant dipoles causes the particles to form columnar structures parallel to the magnetic field. Figure2is a schematic of the change in internal structure of the suspension when applying a magnetic field H [15].
The columnar structures restrict the motion of the fluid and therefore increase the viscosity and yield stress [16]. This is called the magnetorheological (MR) effect. Improvement of the MR effect and/or reduction of the sizes of MR devices are important challenges for their use. One possible solution is to use anisotropic particles: rod and cube-like particles give higher MR response compared with spherical ones [17-18].

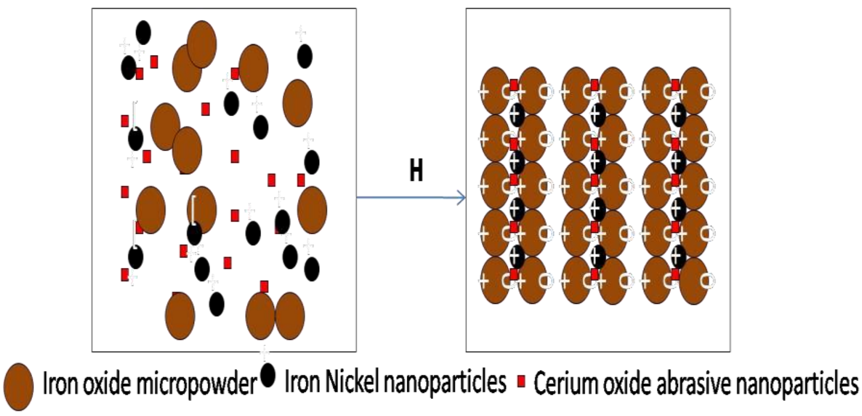

Fig 2. (a) Suspension droplets without external magnetic field where the droplets are randomly oriented; **(b)** Long chains formed by the droplets when subjected to a magnetic field H**.**

MSF applications: There are many applications of MSFs**.** Various people target specific applications and develop fluids for themselves**.** There are various tests available to the specific application. With respect to these applications most of the

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devices using MSFs can be classified into three groups: (i) devices with fixed poles, also referred toas the Pressure Driven Flow mode (PDF), e.g. servo valves, actuators, dampers and vibration/shock absorbers; (ii) relatively moveable or transferable poles also referred to as Direct Shear (DS) mode, e.g. clutches, brakes and locking devices; (iii) the Squeeze Film (SF) mode, which is rarely used and is the biaxial elongated mode for high force and slow motion applications,

The most extensive use of MSF fluids is most probably in the automobile and aircraft industries, e.g. for semi-active dampers. The benefit of using MSF fluids instead of conventional oils lies in their ability to rapidly respond to large dynamic forces. Furthermore, MSF dampers do not require mechanical valves to restrict flow, contrary to hydraulic dampers. Typical and widespread applications are for automotive suspension systems, and rotary brakes for exercise equipment, pneumatic actuators and steer-by-wire systems. MSF dampers are also used in civil engineering applications, in seismic protection, cable stayed bridges, and biomedical applications (e.g. a prosthetic leg developed by Biedermann Motet GmbH). MSF fluids also find use in the polishing of optical lenses (QED technologies) and impact or shock loading applications such as active recoil of large calibre gun systems and bullet-proof vests.

The MSFs developed by the R&D lab have a unique application in optical surface finishing at then a no meter level, using a magnetorheological nano finishing instrument. We have used water as the suspension medium, which has several advantages for nano finishing up-to about 10nm: water is reusable and has a self-cleaning characteristic since it removes the polishing debris.

Magneto-Sensitive Fluids (MSFs)

Composition	**Yield stress (kPa)**
Silicone oil + Iron oxide (10%)	2.33
Silicone oil + Iron oxide (20%)	3.12
Silicone oil + Iron oxide (30%)	4.19

Table-1. For MSF Composition and Yield Stress

2 Control Approach of Regenerative Braking

Control strategy of regenerative braking is discussed in detail. The braking force distribution, of braking energy in systematic way using ANN, and PID controller are foremost section of planned system arrangement, which is discussed here,

2.1 Control algorithm for the EV based on ANN technique:

The idea of the ANN controller technique is shown below in figure 3. When the brake is busy, in contract with the fall quantity of the button, the stand in need of braking strength can be obtained during the operation of EV. Depending on EV conditions, such as speed (velocity) and status of the battery, secondary controllers like neural network and lookup slab are normally utilize to conclude the standards of the braking energy and involuntary braking force for the front wheels. Furthermore, in modern technology braking energy system, such as electronic braking energy system and corner brake energy, the braking force is inequitably deal among dissimilar wheels of EV to decrease the hazard of skid, rotating, and the unsteadiness. The helpful dynamics of such system cannot be simply handling by the mentioned controller.

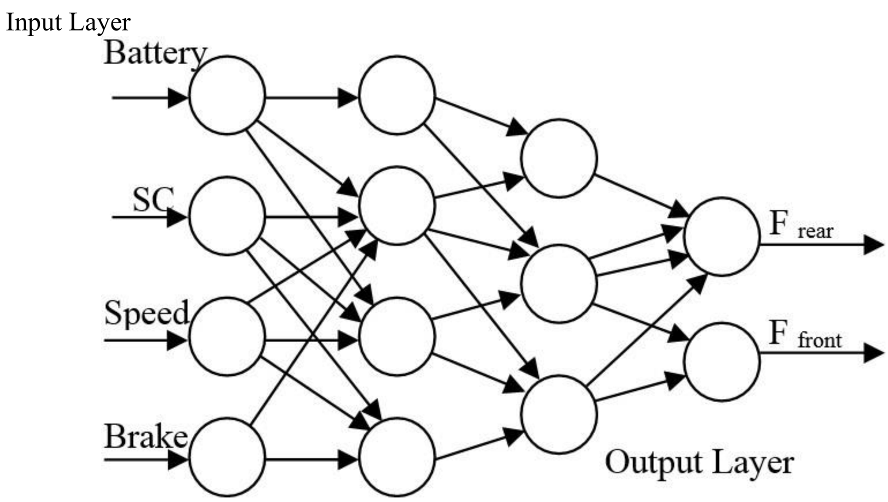

Fig.3. ANN Controller for proposed EV

Sigmoid function is chosen as the beginning function for the neurons in the output layer is,

$$f(x) = 1/1 + e - x \ldots\ldots\ldots (1)$$

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Similarly, linear transmit function is applied for the neurons in the output layer of the ANN. The organization of planned multilayer close to network is shown in figure 4. The connections among the brake strength, the rear braking energy and the front braking energy could be considered uncomplicatedly by perfect allotment task using ANN. To generate the preparation dataset, a variety of simulations are approved absent in MATLAB/SIMULINK by apply diverse standards of state of charge for the battery and MOSFETs semiconductor module. EV rate and brake power is recognized by preparation drive cycle. The selection of the drive cycle is significant for simulation of enough braking scenario. The braking scenario arises at unique EV speed and diverse brake strength. The EV is decelerated or blocked in specific reserve and instance resolute by the drive cycle; most regeneration energy is achieved; and charge state of battery and MOSFETs module remain with the safe limitations. The back extends procedure with Levenberg–Marquardt process is come to teach the ANN. A clear condition to assess the performance of ANNs is the normalize root mean square error (NRMSE), which is the fault between predictable outcome and accurate outcome and can be written as follows:

$$NRMSE = \sqrt{\sum n\, H(n) - H'(n)\,/\,\sum n\, H'(n)} \quad \ldots\ldots (2)$$

Where, H (n) and H' (n) are the predictable and objective principles of the output, correspondingly, and n is the number of statistics points. The flow chart of EV is shown in figure 4,

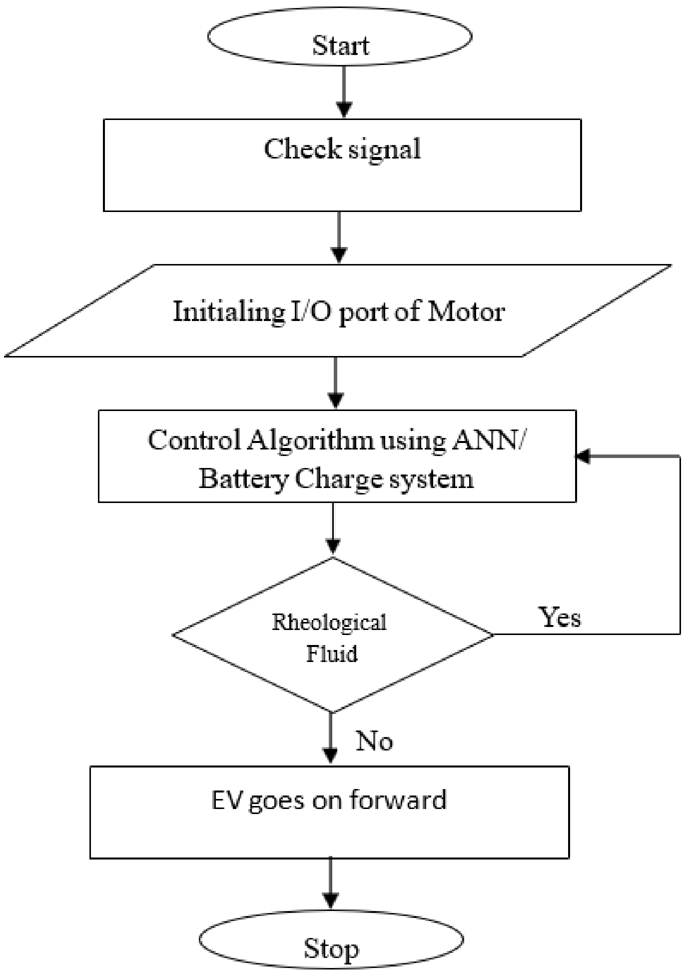

Fig 4: Flowchart of EV

3 The Regenerative Braking Circuit

The regeneration braking circuit consists of a battery set and the capacitor bank which gives the power to the controller circuit of the EV. The battery type is Lead-Acid battery and made-up with voltage of 12 volts and the ability of current rating is 7.5 Ah. A Capacitor bank circuit of EV is placed with the motor drive circuit which uses to supplies the power. The Buck- Boost convertor is stepdown converter and step-up converter. The deceleration of EV than the Buck operation takes place during when EV brakes. The Boost operation performed during the acceleration of EV i.e. when EV moves to a fast rate from a lower rate. Here, this is acquired by push the consecutive velocity switch given in the circuit. Buck-Boost convertors both of them can generate a limit of output voltages, ranging from much higher than the input voltage, low to almost zero.

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The circuit of regenerative braking circuit is shown below in figure 5.

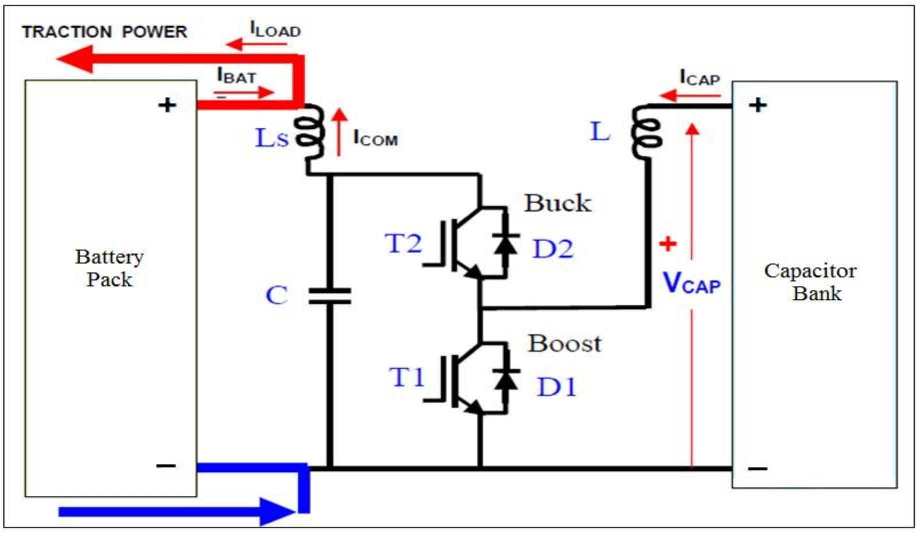

Fig. 5. Regeneration Braking Circuit of EV

4 Simulation of Regenerative Braking System

Simulation of regenerative braking system circuit for EV is develop in Simulink/MATLAB-12 which is shown below in figure 6. The variables of every system mechanism are located as describe as per the objectives. In the simulation of EV, graph is shown on computer screen in Simulink scope for battery electrical energy, capacitor bank voltage, battery existing and PWM indication known to constrain insulated gate bipolar transistor. The output results are display for three sets of PWM signal which is specified to the EV controller circuit. EV capacitor bank electrical energy goes on mounting through the buck operation. EV battery voltage is 12-volt spot through unimportant fluctuations. The existing as of battery elevation is strained towards the capacitor bank alone through the run instance of the pulsation set to the MOSFET module circuit is or else nil.

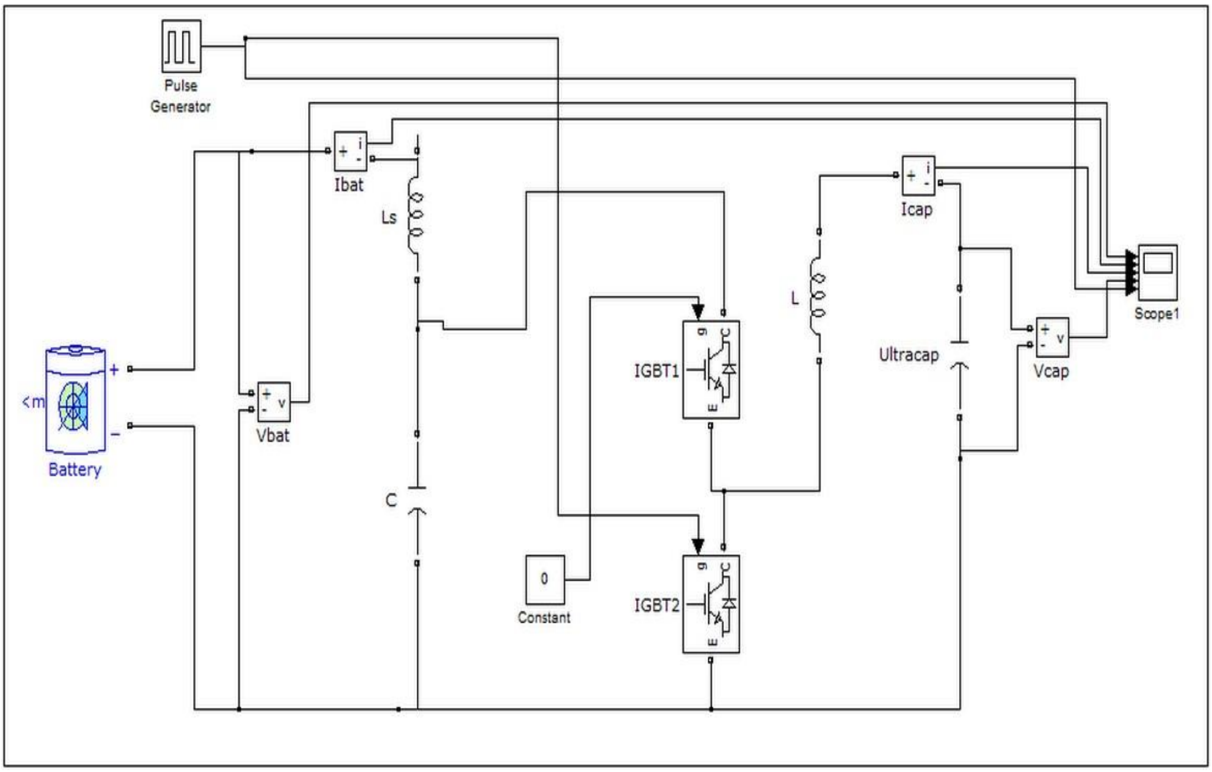

Fig.6. Simulink Module of Regenerative Braking System

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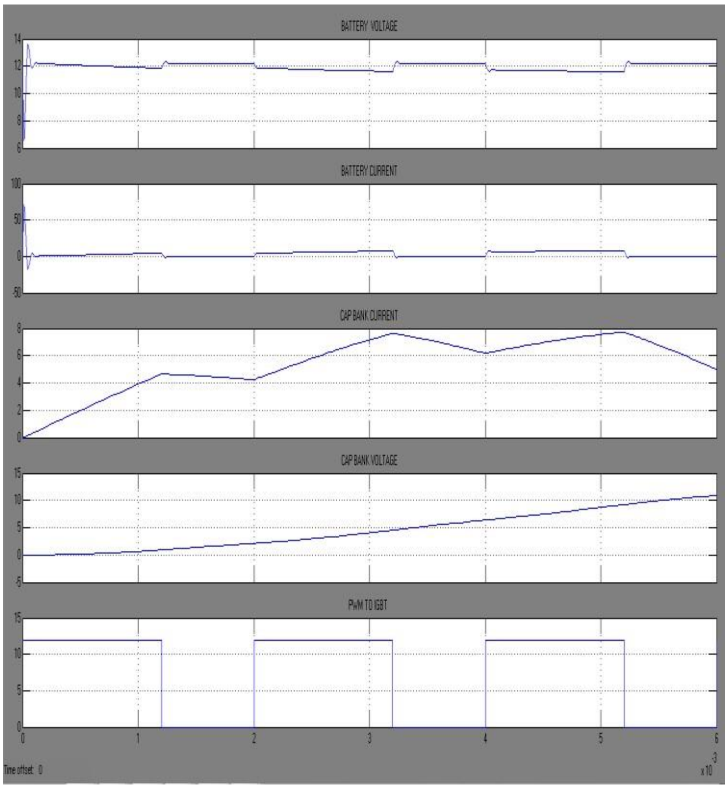

Fig.7. Simulation Results of Buck Operation

The inductor L starts storing power when the specified battery banks and MOSFET modules are fully charged or avoid transient behaviour of regenerative braking. The results of buck and boost are shown in figure 7 and 8.

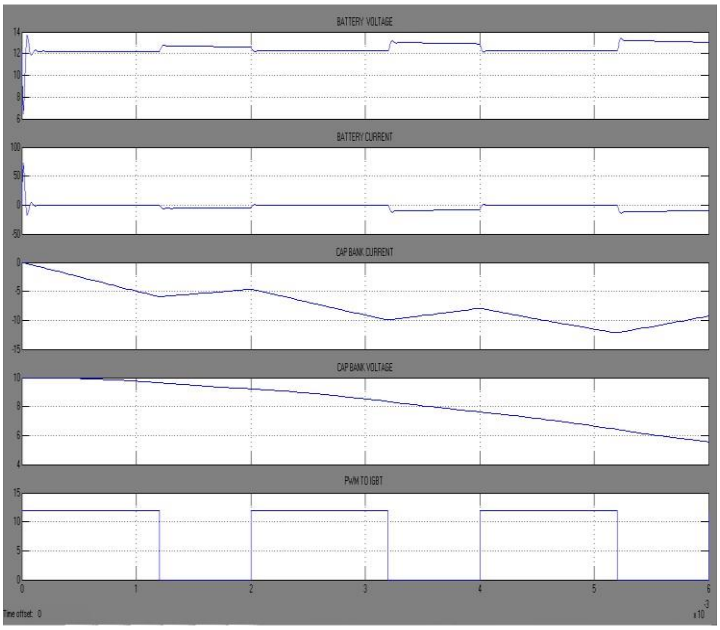

Fig.8. Results of Boost Operation in Simulink

This charge in the capacitor bank and MOSFET module as it is awaiting the next boost process set and at that moment of the charge is transfer to the battery.

5 Conclusion:

The Regenerative braking system provide the power reverse to the battery which would have been waste in the form of heat. The RBS is useful to generate electric power for the EV increase the battery life and mileage of the system. The magneto rheological fluid is mainly used in its braking system to increase the efficiency of brake timing and its control during run time. The capacitor bank also charges and discharge rapid so that the power limit can be express and capable with no much thrashing. This makes a battery longer life as well as allows EV to run extra on a solitary battery charge i.e. the mileage of EV increase significantly. Regeneration system with fluid all along with braking mechanism make EV powerful and well-organized as well as safer and easier to make use of and prove to be a imperative part in the suitable implementation of EV.

References

1. Awad. F and Shamroukh.R , " EV Detection by Intelligent Machine Urban Search and Rescue Using Image Processing and Neural Networks" International Journal of Intelligent Science , pp.4 39-53, 2014.
2. Dennis, Jacob D., et al. (2013), "Rheological characterization of monomethylhydrazine gels", Journal of Propulsion and Power 29.2,313-320.
3. Gold.J and Koren.K, "Hybrid vehicle with Obstacle Avoidance with Ultrasonic Sensors". IEEE Journal of Robotics and Automation, vol. RA-4, No.2, pp. 213-218, 2018.
4. Hook.A, and Koren. K, "The vector field histogram-fast obstacle avoidance for EV, IEEE Trans. on Robotics and Automation, pp.501-518, 2011.
5. Harrol. J and Latombe .J.C, "Hybrid Machine motion planning: a distributed representation Approach", International Journal of Robotics Research, vol.10 no.6, pp. 628-649, 2018.
6. H. M. Luan C. Korman and N. Willenbacher, (1996) Rheometry on magnetorheological (MR) fluids, Rheol. Acta., 35, 417.
7. KatiyarA., Singh A. N., Shukla P., and Nandi T., (2012), "Rheological behaviour of magnetic nanofluids containing spherical nanoparticles of Fe–Ni" Powder technology224,86-89.
8. Mongin.A.K , Chatterji.B.N, Ray A.K . "Design of a real-time tracking system for fast-moving objects with Solar EV" IETE J. Res 43, pp.359-369, 2017.
9. Nick.D and Forsyth.A, "Finding and tracking people from the autonous electric machine", in Proceeding of Computer Vision and Pattern Recognition (CVPR), Madison Wisconnin , June 2019.
10. Nian, X. Peng, F. and Zhang, H. "Regenerative braking system of EV driven by brushless DC motor," IEEE Trans. Ind. Electron., vol. 61, no. 10, pp. 5798–5808, Jan. 2014.
11. Prassler, E. Bank, D. Kluge, B. and Hagek, H. "Key technologies in robot assistants: Motion co-ordination between a human and a mobile robot," proc. 30thint .sym. Robotics, 2001, pp. 410-415, Mar. 2001.
12. Schulz, W. Burgard, D. and Fox, "People tracking with mobile robots using Sample-based joint probilistic data association filters", International Journal of Robotics Research pp.99-116, Sept. 2003.
13. Urzelai, J. and Ezkerra, J, M. "Fuzzy controller for wallfollowing with a non- holonomous mobile robot" FUZZY-IEEE / IFES, BARCELONA, July, 1997.
14. Yadav, A. Chaturvedi, D, K. "Design and development of safe intelligent moving machine". International Journal of Electrical Machines & Drives(IJEMD). vol.2, pp 16-21, Feb. 2016.
15. Yadav, A. Chaturvedi, D, K. "Mathematical Model for Ground EV Using Matlab-Simulink". International Journal of Automatic Control System (IJACS). Vol. 2, pp 26-34, April 2016. 16. Yadav, A. Yadav, N. Chaturvedi, D, K. "An Intelligent EV (IEV)Using LabVIEW". IEEE 2nd International Conference on Communication, Control and Intelligent Systems (CCIS) vol.2, ISSN 978-5090 Nov. 2016.
17. Yang, Y, P. Liu, L. Wang, T, J. Kuo, K, C.and Hsu, P, E."An electric gearshift with ultracapacitors for the power train of an EV with a directly driven wheel motor," IEEE Trans. Veh. Technol., vol. 56, no. 5, pp. 2421–2431, Sep. 2007.
18. Zhou, H. and Sakane,S. "Sensor planning for mobile EV localization based of probalistic inference using bayesian network," proc. of the 4th IEEE International Symposium on Assembly and Task Planning, pp. 7-12, May 2001.