IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 8, May 2023

Battery and Super Capacitor Fed BLDC Motor Drive for Electrical Vehicle Applications

Pramay Khandagale[1], Yash Satpute[2], Vivek Biradar[3], Sawpnil Jaybhay[4], Dr A. A. Kalage[5]
[1234]Student ,Department of Electrical Engineering
[5]Professor, Department of Electrical Engineering
Sinhgad Institute of Technology ,Maharashtra, India

Abstract: *This paper examines the feasibility and capability of a hybrid energy storage system (HESS), composed of battery and super-capacitor units, through simulation. Extensive use of internal combustion engine (ICE)- based vehicles has contributed to severe adverse impacts on the environment and accelerated depletion of fossil fuel reserves, leading to considerable rise in price of gas over the past two decades. These challenges, plus the low efficiency associated with the conventional drivetrains, have made the automotive industry seriously consider and move towards drivetrain electrification in vehicular systems. In electrified vehicles, the propulsion is fully or partially provided by electric motors, powered by onboard energy storage systems. In an attempt to make up for the limitations of the existing energy storage devices and contribute to vehicle electrification movement, The choice of HESS topology has been made based on simplicity of power and control circuits, cost and performance. The design takes into consideration the required power, the converter losses, limitations of energy storage devices, and quality of the current drawn from battery cells.*

Keywords*:* Super capacitor, Power Converter, Brushless DC Motor, battery

I. INTRODUCTION

EVs- have been a transportation mainstay because the work place and housing areas in most of these densely populated cities are within walking or cycling distance. This reliable yet overlooked form of transportation has evolved over the years from simple utility bicycles to powerful geared mountain bikes and now electric assisted bicycles. Environmental concerns in terms of emissions and depleting fuel reserves has revived the electric vehicle industry and research community. Electric assisted bicycles still retain the characteristics of a conventional bicycle with an added advantage of extra power, say when riding up a hill. This enables the elderly or not so physically fit people to still enjoy riding a bicycle up a slope. Batteries are the weak leak at the moment for any electrically propelled vehicle including the bicycle. The lack of a single reasonably priced energy storage device that can simultaneously provide high power density and high energy density has been the main stumbling block to the acceptance of electric propulsion as the main form of private and public transportation.

Presently the only viable solution to this problem is to combine a high energy storage device such as an electrochemical battery or fuel cell with a high power device such as an Electric Double Layer Capacitor (EDLC) or ultra capacitor or more often called a super capacitor. Usually, some form of power converter executing an energy management control technique is used to interface the battery bank and super capacitor array to the load bus. It is the aim of this research work to design a smart power converter with a heuristic based energy management technique which will optimize the power flow from the battery pack to the load. As the name implies, a super capacitor is a capacitor with capacitance greater than any other, usually in excess of up to 3400 Farad. Super capacitors do not have a traditional dielectric material like ceramic, polymer films or aluminum oxide to separate the electrodes instead a physical barrier made of activated carbon. A double electric field which is generated when charged, acts a dielectric. The surface area of the activated carbon is large thus allowing for the absorption of large amount of ions.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 8, May 2023

II. METHODOLOGY

The brushless DC (BLDC) motor can be envisioned as a brush DC motor turned inside out, where the permanent magnets are on the rotor, and the windings are on the stator. As a result, there are no brushes and commutators in this motor, and all of the disadvantages associated with the sparking of brush DC motors are eliminated.

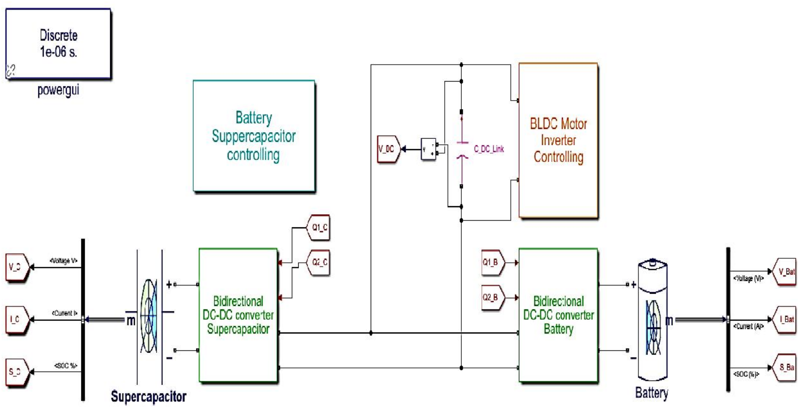
This motor is referred to as a "DC" motor because its coils are driven by a DC power source which is applied to the various stator coils in a predetermined sequential pattern. This process is known as commutation. However, "BLDC" is really a misnomer, since the motor is effectively an AC motor. The current in each coil alternates from positive to negative during each electrical cycle. The stator is typically a salient pole structure which is designed to produce a trapezoidal back-EMF wave shape which matches the applied commutated voltage waveform as closely as possible. However, this is very hard to do in practice, and the resulting back-EMF waveform often looks more sinusoidal than trapezoidal. For this reason, many of the control techniques used with a PMSM motor (such as Field Oriented Control) can equally be applied to a BLDC motor.

Another misconception about the BLDC motor is related to how it is driven. Unlike an open-loop stepper application where the rotor position is determined by which stator coil is driven, in a BLDC motor, which stator coil is driven is determined by the rotor position. The stator flux vector position must be synchronized to the rotor flux vector position (not the other way around) in order to obtain smooth operation of the motor. In order to accomplish this, knowledge of the rotor position is required in order to determine which stator coils to energize. Several techniques exist to do this, but the most popular technique is to monitor the rotor position using hall-effect sensors. Unfortunately, these sensors and their associated connectors and harnesses result in increased system cost, and reduced reliability.

In an effort to mitigate these issues, several techniques have been developed to eliminate these sensors, resulting in sensorless operation. Most of these techniques are based upon extracting position information from the back-EMF waveforms of the stator windings while the motor is spinning. However, techniques based on back-EMF sensing fall apart when the motor is spinning slowly or at a standstill, since the back-EMF waveforms are faint or non-existent. As a result, new techniques are constantly being developed which obtain rotor position information from other signals at low or zero speed.

BLDC motors reign supreme in efficiency ratings, where values in the mid-nineties percent range are routinely obtained. Current research into new amorphous core materials is pushing this number even higher. Ninety six percent efficiency in the 100W range has been reported. They also compete for the title of fastest motor in the world, with speeds on some motors achieving several hundred thousand RPM (400K RPM reported in one application).

The most common BLDC motor topology utilizes a stator structure consisting of three phases. As a result, a standard 6-transistor inverter is the most commonly used power stage, as shown in the diagram. Depending on the operational requirements (sensored vs. sensorless, commutated vs. sinusoidal, PWM vs. SVM, etc.) there are many different ways to drive the transistors to achieve the desired goal, which are too numerous to cover here. This places a significant requirement on the flexibility of the PWM generator, which is typically located in the microcontroller. The good news is that all of these requirements are easily achieved in TI's motor control processors.



BATTERY & SUPER CAPACITOR FED BLDC MOTOR

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 8, May 2023

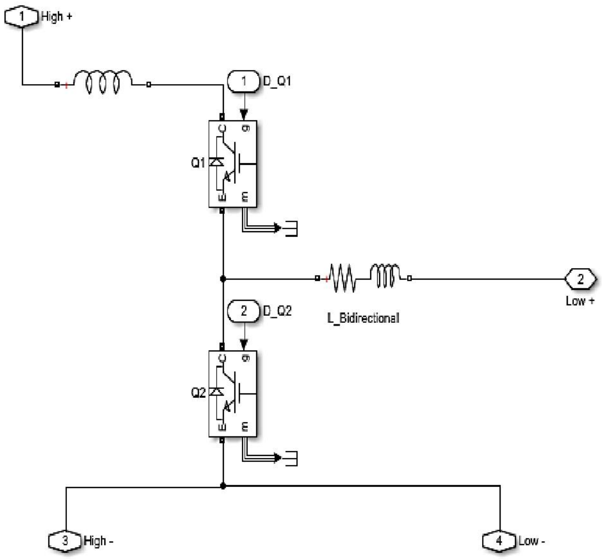
III. SYSTEM CONFIGURATION

The proposed circuit is, as shown in Fig. 1, uses a battery and super capacitor to fed the electric vehicle in that BLDC motor is used for propulsion. The SC and battery is connected across the dc link through two bi directional converters. Here the three phase BLDC motor is used as electric vehicle and controlled through a three phase two level voltage source converter.

IV. SUB-SYSTEM

Design of bi direction converter

A buck converter (step-down converter) is a DC-to-DC power converter which steps down voltage (while stepping up current) from its input (supply) to its output (load). And the boost converter is used to step up the voltage.



Control strategy for bi directional converter

The bi directional converters are used to control the battery and super capacitor voltage. BLDC motor connected at DC link through a bi directional DC-DC converter is controlled in constant current/constant voltage (CC/CV). Until the terminal voltage of the EV battery reaches the voltage corresponding to the full charge condition, the EV charges in CC mode. However, after reaching near to the desired terminal voltage in nearly full charge condition, the charging of the EVs is shifted in CV mode. Here, the CC/CV mode of charging is controlled using two PI controllers as shown in Fig. 3.

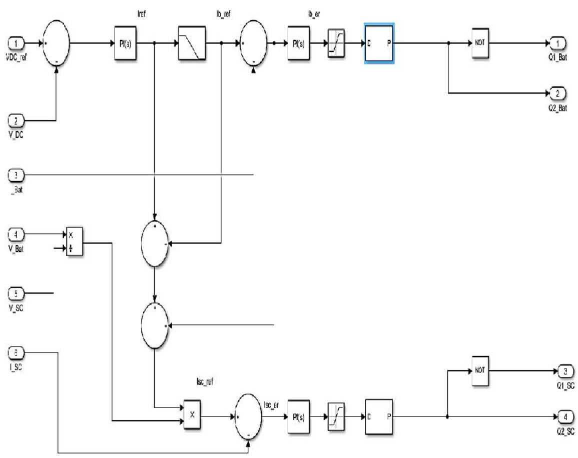


Fig. Battery & Super Capacitor Controlling Unit

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 8, May 2023

Here the DC link voltage is compared with reference voltage and the error in voltage is provided to PI controller. After that the generated reference current is compared with battery current and the error is provided to PI controller. The generated reference voltage is provided to PWM generator to provide gate pulses for bi directional converter at battery.

And to give pulses to bidirectional converter at SC the battery voltage is divided with SC voltage and then multiplied with generated reference current.

Control of VSC

In order to control the speed of electric vehicle that is BLDC motor, the speed is controlled through voltage source converter. By controlling dc link voltage the VSC is controlled.

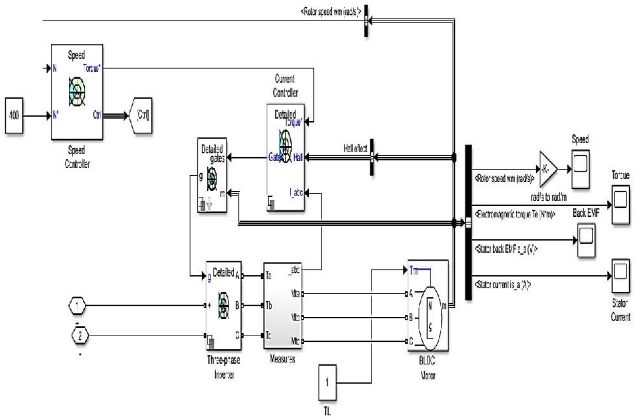


Fig. BLDC Motor & Inverter Controlling Unit

V. SIMULATION RESULTS

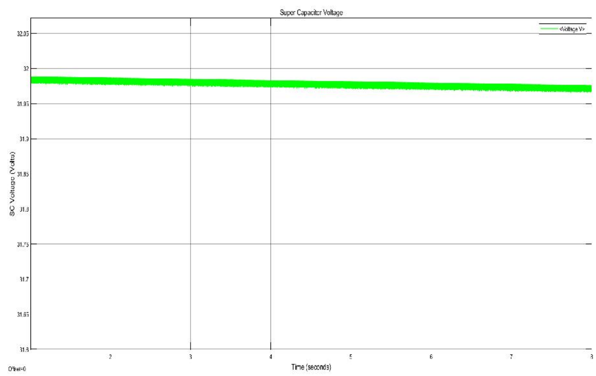


Fig. Super capacitor current characteristics

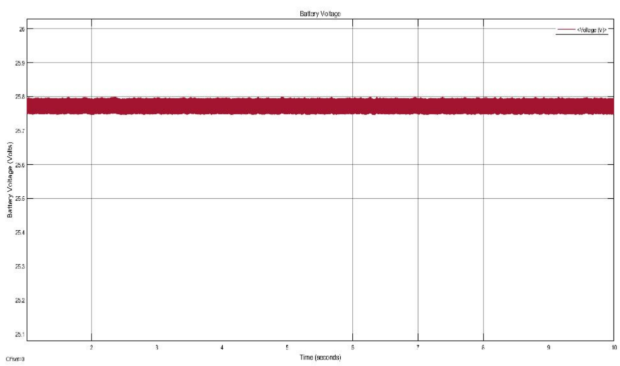


Fig. Battery voltage characteristics

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 8, May 2023

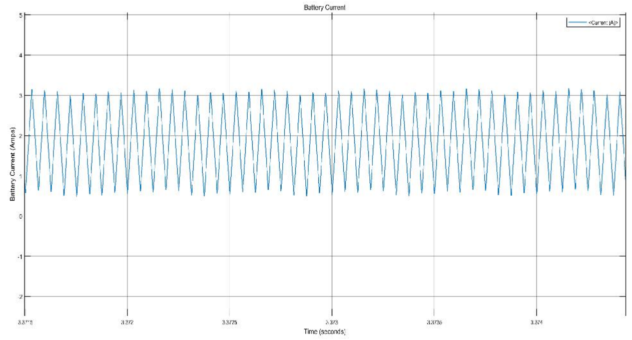


Fig. Battery Current characteristics

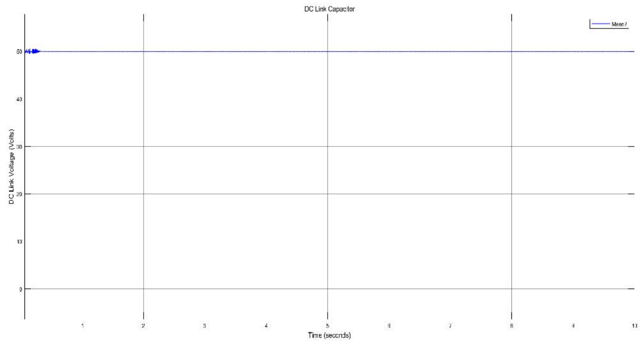


Fig. DC Link Voltage characteristics

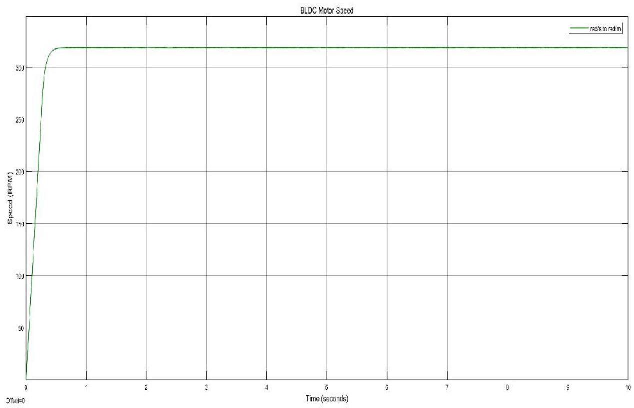


Fig. BLDC motor speed characteristics

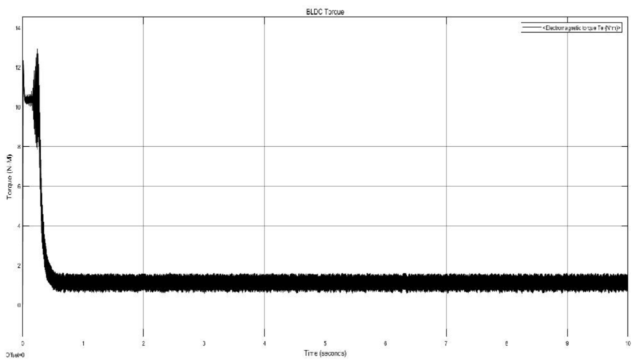


Fig. BLDC motor torque characteristics

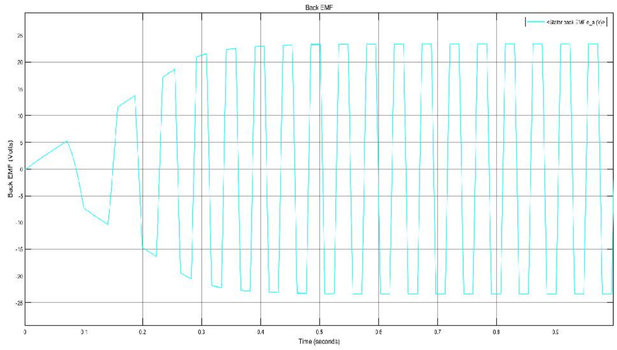


Fig. BLDC motor back EMF characteristics

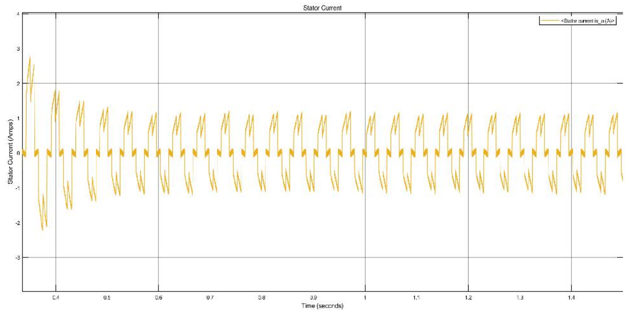


Fig. BLDC motor stator current characteristics

VI. APPLICATIONS

Transport

High power brushless motors are found in electric vehicles and hybrid vehicles. These motors are essentially AC synchronous motors with permanent magnet rotors.

The Segway Scooter and Vectrix Maxi-Scooter use brushless motors.

A number of electric bicycles use brushless motors that are sometimes built into the wheel hub itself, with the stator fixed solidly to the axle and the magnets attached to and rotating with the wheel.

Motion control systems

Brushless motors are commonly used as pump, fan and spindle drives in adjustable or variable speed applications. They can develop high torque with good speed response. In addition, they can be easily automated for remote control. Due to their construction, they have good thermal characteristics and high energy efficiency. To obtain a variable speed response, brushless motors operate in an electromechanical system that includes an electronic motor controller and a rotor position feedback sensor.

Positioning and actuation systems

Brushless motors are used in industrial positioning and actuation applications.[12] For assembly robots, stepper or servo motors are used to position a part for assembly or a tool for a manufacturing process, such as welding or painting. Brushless motors can also be used to drive linear actuators

VII. CONCLUSION

This research work has successfully implemented a battery/super capacitor hybrid power source for an electric assisted bicycle using state of the art hub motor technology. A power converter was designed and implemented based on the energy requirements of the system. Based on the implemented system experimental results show an improvement in the up-hill acceleration of the bicycle as a direct result of the power converter being responsive enough to harvest the extra current from the high power complementary super capacitor module avoiding deep discharges from the battery. This

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 8, May 2023

enhanced battery life. The maximum speed remained unchanged. The main battery pack was shielded from high discharge currents which would eventually enhance its life cycle.

REFERENCES

[1] Alan. A Parker , Electric Power-Assisted Bicycles Reduce Oil Dependence and Enhance the Mobility of the Elderly electric power assisted bicycle. Presented at 29th Australian Transport Research Forum.
[2] Don Tuite ,“Get the Lowdown on Ultracapacitors”, Technology report electronic design online , November 2007. URL: http://electronicdesign.com/Articles/ArticleID/17465/17 465.html.
[3] Adrian Schneuwly, Bobby Maher, Juergen Auer. “Ultracapacitors, the New Thinking in the Automotive World”. Maxwell Technologies Inc.
[4] Pay, S.; Baghzouz, Y.; , "Effectiveness of batterysupercapacitor combination in electric vehicles," Power Tech Conference Proceedings, 2003 IEEE Bologna , vol.3, no., pp. 6 pp. Vol.3, 23-26 June 2003
[5] Dixon, J.W.; Ortuzar, M.E.; "Ultracapacitors + DCDC converters in regenerative braking system," Aerospace and Electronic Systems Magazine, IEEE , vol.17, no.8, pp. 16- 21, Aug 2002.
[6] S. M. Lukic, J. Cao, R. C. Bansal, F. Rodriguez, and A. Emadi, “Energy Storage Systems for Automotive Applications,” IEEE transacions on industrial electronics, vol. 55, no. 6, pp. 2258–2267, 2008.
[7] J. Bauman, M. Kazerani, “A Comparative Study of Fuel-Cell – Battery , Fuel-Cell – Battery –Ultracapacitor Vehicles,” IEEE transactions on vehicular technology, vol. 57, no. 2, pp. 760–769, 2008
[8] B. Singh, A. Verma, A. Chandra and K. Al-Haddad, “Implementation of Solar PV-Battery and Diesel Generator Based Electric Vehicle Charging Station,” in IEEE Int. Conf. Power Electronics, Drives and Energy Systems (PEDES), Chennai, India, 2018, pp. 1-6.
[9] N. Saxena, B. Singh and A. L. Vyas, “Integration of solar photovoltaic with battery to single-phase grid,” IET Generation, Transmission & Distribution, vol. 11, no. 8, pp. 2003-2012, 1 6 2017.
[10] H. Razmi and H. Doagou-Mojarrad, “Comparative assessment of two different modes multi-objective optimal power management of microgrid: grid-connected and stand-alone,” IET Renewable Power Generation, vol. 13, no. 6, pp. 802-815, 2019.
[11] O. Erdinc, N. G. Paterakis, T. D. P. Mendes, A. G. Bakirtzis and J. P. S. Catalão, “Smart Household Operation Considering Bi-Directional EV and ESS Utilization by Real-Time Pricing-Based DR,” IEEE Trans. Smart Grid, vol. 6, no. 3, pp. 1281-1291, May 2015.