CONVERTER FOR EV APPLICATIONS WITH THE BLDC MOTOR CONTROLLING TECHNIQUES

Ms. K. Anusha[1], Dr.M.Saravanan[2]

[1]PG scholar in the Dept. of Electrical & Electronics Engineering, Holy Mary Institute of Technology & Science, Bogaram(V), Medchal District, Hyderabad, India.

[2]Assistant Professor in the Dept. of Electrical & Electronics Engineering, Holy Mary Institute of Technology & Science, Bogaram(V), Medchal District, Hyderabad, India.

***Abstract*— The BLDC motor in an electric vehicle might benefit from the bidirectional power flow, as suggested in this project, which uses the dual-source low-voltage powering mode. Hybrid electric cars are able to take advantage of a suggested converter. This kind of converter links a main battery (ES1), a secondary battery (ES2), and a variable voltage bus in hybrid electric cars. A suggested converter is capable of operating in both a step-up (i.e., Dual-source low-voltage powering mode) and a step-down (i.e., energy-regenerating high-voltage DC-link mode), enabling power to flow in both directions. It is also possible to use a model to simulate a transfer of power between any two low-voltage generators. Two methods of power transfer, circuit design, and operational modes are examined for a proposed Bidirectional DC/ DC Converter. We recommend the BLDC motor drive for this project because of its advantageous characteristics (including high torque, high efficiency, simple speed regulation, low noise, and extended service life).In a future, there will be the lot of potential for converting gas-powered cars into electric ones by swapping in the brushless dc motor.**

***Keywords*— BLDC motor, low-voltage, main battery, Dual-source low-voltage powering mode, energy-regenerating high-voltage DC-link mode.**

1. INTRODUCTION

Both the change in emphasis and a depletion of fuel supplies have contributed to developments in automotive technology. Research on a potential uses of cutting-edge technologies in automobiles continues. One efficient and potentially fruitful use is fuel-cell vehicle/hybrid electric vehicle (FCV/HEV) technology. Prior research (Ehsani et al., 1997) used vehicle dynamics to establish an optimum torque-speed pattern for an electric propulsion system. Various vehicle geometries, including those for hybrids, fuel cell vehicles, and more e-mobility; separate but equal power electronics treatment in today's vehicle power systems to handle massive vehicle loads (Emadi et al., 2005; 2006). Batteries, fuel cell stacks, and ultra capacitors, together with two energy management algorithms, can provide a necessary full-load power (Schaltz et al., 2009). Studies on hybrid and fully electric vehicles (HEVs) and on an effects of FC efficiency on control strategies are discussed in a literature (Thounthong et al., 2009; Chan et al., 2010). Battery-operated, unmanned, and FC-based automation were a focus of this study. Khaligh and Li (2010) looked at some of a hybrid ESSs that use several devices for storage. A correct current balance is achieved with a help of batteries, electric motors, and power electronic devices (Rajashekara, 2013).The group came up with the complex dc/dc converter with several characteristics that work together. For electric vehicles and DC micro grids, the dc/dc converter may increase an efficiency of voltage conversion (Lai et al., 2015). To use high voltage electricity from the micro grid, electric vehicle batteries need the bidirectional DC to DC converter (BDCC) (Lai, 2016). In many FCV setups, a primary battery is responsible for turning on a FC and powering a propel motor. As a vehicle gains speed, peak power is provided, mitigating a FC's effect. Maximum energy non-linearity's that might arise during acceleration and braking can be mitigated with a use of super-capacitors (SCs) and other high-density components (Moreno et al., 2006). Energy that is regenerated by SCs during braking might be stored until needed for propulsion. High-power-density SCs allow a FC stack and storage batteries to work more efficiently (Bauman & Kazerani, 2008). An innovative BDCC design for FCV/HEV power systems is created in this research by combining the synchronous buck-boost circuit (Jiang et al., 2013) with an interleaved voltage-double architecture (Jung et al., 2013). Low-voltage power from two sources and high-voltage dc-bus energy regeneration are a two major modes of operation (Wu et al., 2013).

The suggested converter has autonomous switching between two low-voltage sources operable in buck/boost mode. Provided the topology that just depicts the single notion, as opposed to (Farhangi and Toliyat, 2015) (Lin and Chao, 2013). Key characteristics of a suggested converter are as follows:

Allows a linking of several dc sources of varying voltages.

Through a use of an AC bus and the voltage regulator, two low-voltage sources may be connected.

Increasing a static voltage gain while decreasing a load on a switch currents.

Over a last decade [37–45], several BLDC motor drive devices have been documented for the wide range of uses. There is not yet a straightforward BLDC motor model with a perfect trapezoidal back-EMF suitable for an EV application [33], despite the fact that previously mentioned research works contributed to the modeling of BLDC motors. In this work, we use Simulink to model an operation of the three-phase, star-connected BLDC motor generating perfect trapezoidal back-EMF waveforms. The following parts provide an overview of BLDC motor drives, the motor model, BLDC motor controllers, and simulation results.

2. BDCC PROPOSED ARCHITECTURE INCLUDING DUAL BATTERY STORAGE.

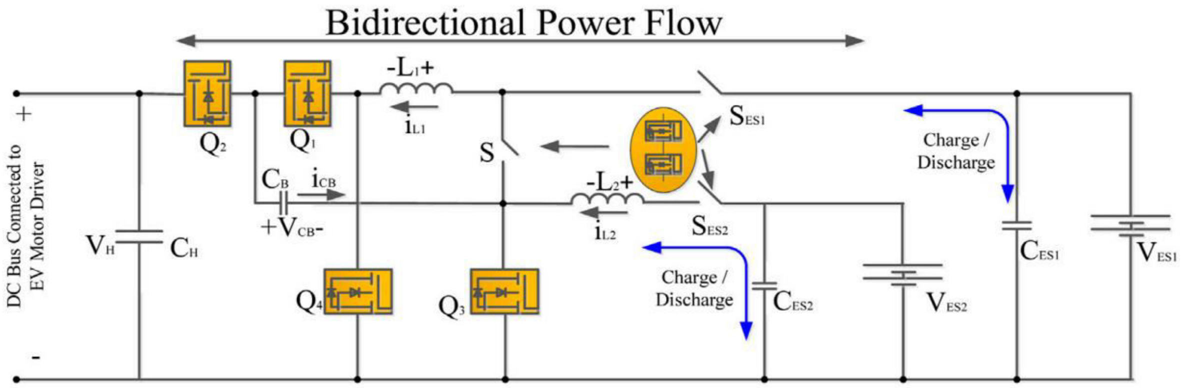

Figure1. Circuit Diagram of a DC-DC converter

3. SWITCHING STATES OF A PROPOSED CONVERTER

Modes of operation and topology

Figure 2 of a BDCC design (ES2) depicts a high dc bus voltage (VH, VES1, and VES2), a primary energy storage, and a supplementary energy storage. Two bidirectional power switches (S, SES1 and SES2) in a converter's design activate an ES1 and ES2 current circuits. A dynamic voltage gain between two low-voltage dual sources (VES1, VES2) and a higher-voltage bus (VH) is enhanced by the charge-pump capacitor (CB) with four active switches (Q1, Q2, Q3, Q4) and two-phase inductors (L1, L2). Including an additional CB alleviates switching voltage stress and eliminates a need for the high duty ratio. A relative levels of conductivity of a power devices used in each prototype implementation of a proposed converter's proof-of-concept experiment.

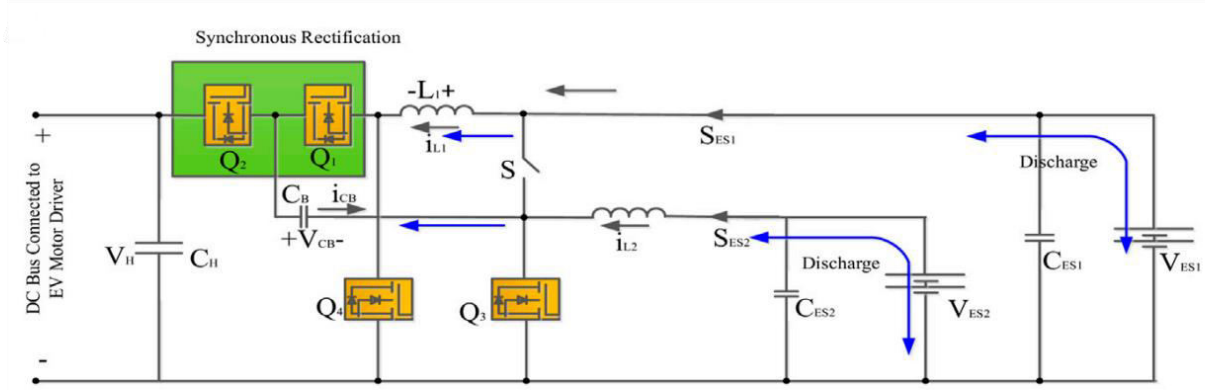

Figure2. Two bidirectional power switches of the Proposed Converter

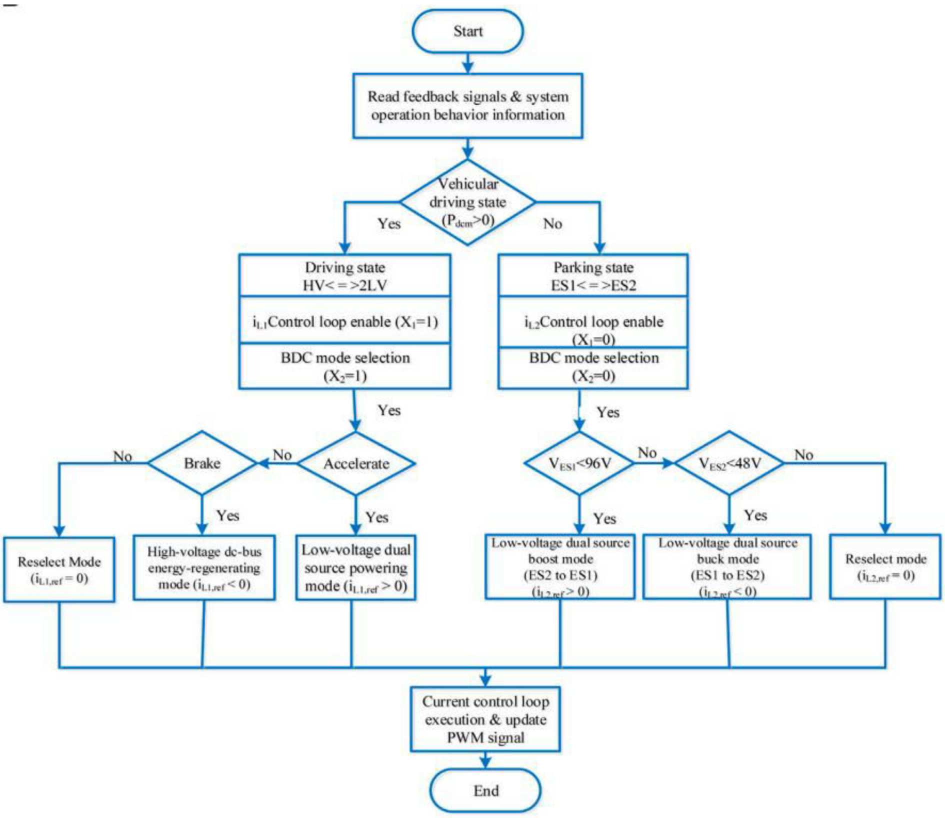

Figure3. High-voltage direct current bus with the power regeneration mode

In this setting, a motor drive is always connected to the power source and is always drawing power. It's possible that a battery's capacity for regeneration power will be exceeded. One viable alternative for storing this much energy is the rechargeable battery. Standard state pattern and circuit design of a BDCC in its energy-regenerative high-voltage DC-link mode. Active switches Q1, Q2 allows for modification of an inductive current in conjunction with an 1800 phase angle. To boost the effectiveness of a transformation. These four distinct levels are realizable, and they are given below; the remaining switches, Q3 and Q4, will function in SR mode, and a duty ratio of the steady waveforms is less than 50%.

4. ADJUSTING A CONVERTER

The converter control system's BDC controller, which includes the strategic management level for a vehicle. This is a real-time DSP flowchart that was used to test out a different BDCC implementation. Figure 10A depicts a use of the current reference (iL1, ref) to regulate flow from the lower potential source at two sides and the higher potential DC bus. Since iL2 is quite close to iL1, an average regulated inductor current in this BDCC architecture. In contrast, a reference at current iL2, ref is used to control the distribution of energy from generators and batteries. A PWM ON and OFF technique uses a triangle wave as one of the inputs, such as vtri1 and vtri2, to change a total duration determined by the specific choice.

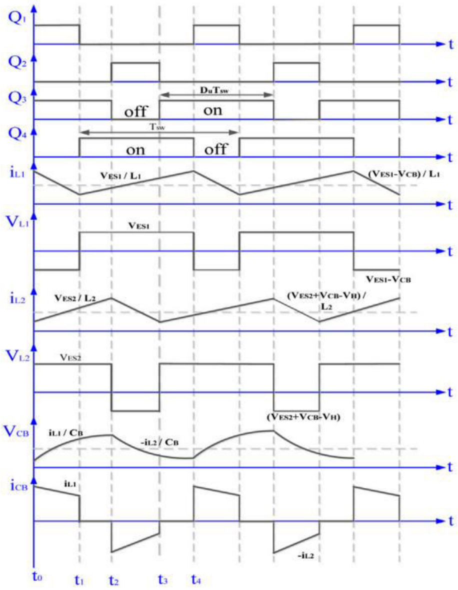

Figure4. Designed DSP flowchart of a proposed BDCC’s multiple operating modes

Non-sinusoidal (more trapezoidal) back-EMF waveform BRUSHLESS DC (BLDC) machines are mature technology well suited to an expanding electrification sector [1, 2]. Existing uses of BLDC machines typically use quasi-rectangular currents, either sensor less [4]-[6] or censored [7]-[10] approach, as opposed to sinusoidal currents used by permanent magnet (PM) machines. One of the most prevalent approaches is the sensor-free one based on rotor position inferred from the detection of back-EMF zero crossing [11]-[12], also known as a zero-crossing point (ZCP). High resolution resolvers and encoders are often utilized in censored techniques to determine the location of a rotor [13, 14]. Hall Effect sensors, often known as "Hall sensors," are an inexpensive alternative to sensorless methods and a reliable backup in high-volume production. Three Hall sensors are typically installed on the fixed portion of the BLDC motor, electrically offset by 120 degrees and aligned parallel to a rotor's PMs. The unbalanced functioning of a motor drive [15] is the result of an unequal installation or erroneous reading owing to hardware/signal processing difficulties, and it lowers the performance of a BLDC motor. To improve the dependability of a drive system, many methods for filtering Hall sensor signals have been developed in recent research [16–20]. In [16], the method is presented for correcting commutation errors caused by misaligned Hall sensors. A basic component of a dais current is extracted from filtered three-phase currents before an abs/dq transformation and then utilized as an input to the proportional-integral (PI) controller, which indirectly compensates for a phase delay error. Misaligned Hall sensor signals may be corrected with the use of the new position error compensation and sophisticated angle control approach introduced in [17]. Hall sensor misalignment is addressed in [18] by using an average filtering approach to rectify signals, while [19] suggests the mixed commutation scheme. Voltage source inverters (VSIs) are often utilized in BLDC motor drives, and their three-level and four-level phase voltage waveforms [21], [22] are a consequence of conventional six-step 120o and 180o commutation schemes. Voltage space vectors in a six-step approach are uniformly spaced and over-modulated by 60 degrees. In [23], the authors examine the BLDC motor's torque and efficiency with an excitation angle range of 120o to 160o. When comparing the efficiency of various square-wave excitation angles, they found that, even in the basic BLDC motor driving system, an excitation angle of 150 degrees with an over-modulated phase voltage utilizing the pulse amplitude modulation (PAM) control provided the best results. In [24], the sensorless drive with the phase voltage modulation control and an enlarged excitation angle (higher than 120o and less than 180o) is presented. Using the logic function, authors of [25]-[26] convert data provided by a line-to-line back-EMF voltage into square pulses that are then included in the torque-speed control algorithm.

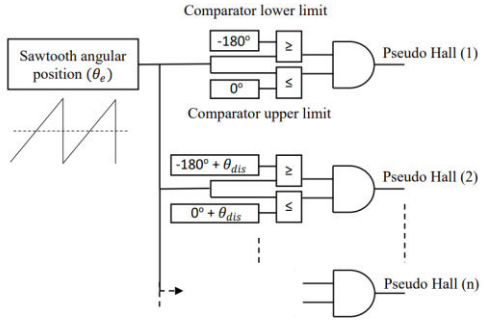

Figure5. PWM Switching's of the Motor Inverter

5. VSI commutation strategies.

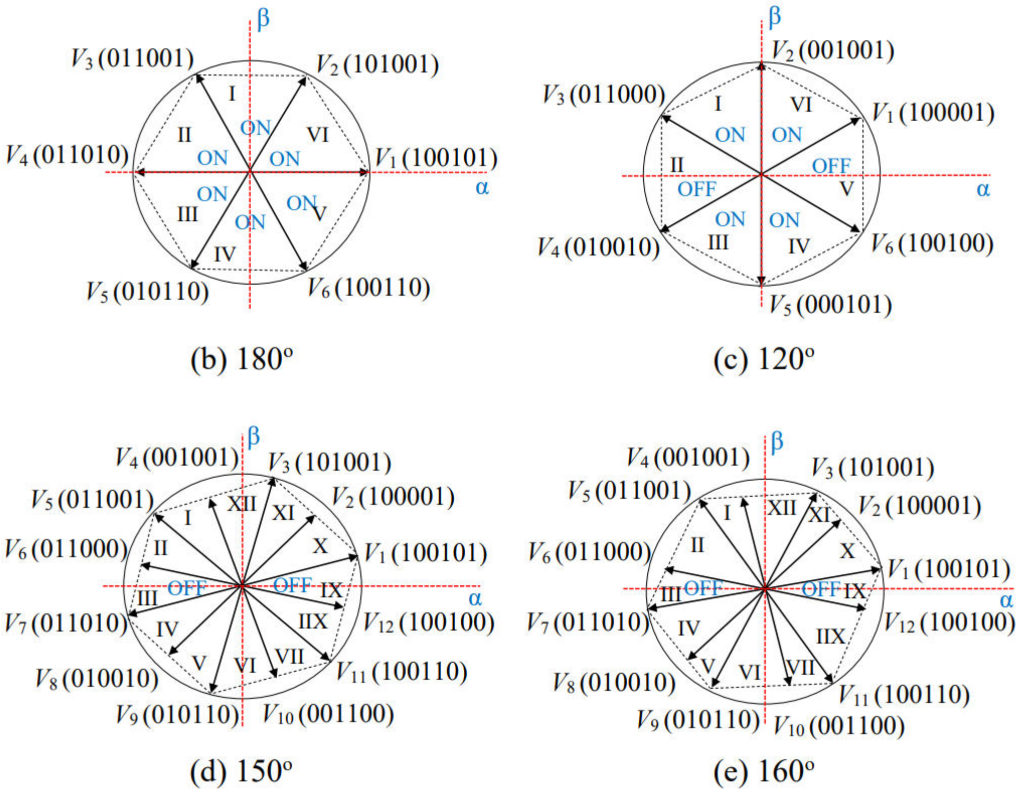

Figure6. pseudo-Hall signals, the 3-phase VSI calculated an optimal phase voltage for a standard six-step 180o and 120o commutation techniques.

Using suggested pseudo-Hall signals, the 3-phase VSI calculated an optimal phase voltage for a standard six-step 180o and 120o commutation techniques in an over-modulation zone. A 180o and 120o techniques in a - plane are vector representations of voltage space. Six voltage space vectors (V1-V6) are distributed throughout six different sectors (I, II, III, IV, V, and VI) in both approaches. Whereas in the latter strategy, a VSI switching logic for switches S1-S6 is shown next to each voltage vector, the former strategy does not. Comparison of a 120° and 180° switching benchmarks. When compared to a 120o technique, a 180o strategy produces greater peak and RMS phase voltage. However, a ZCC period for an 180o is ideally 0 as observed from a phase voltage waveform and reported in Table I. One Hall signal for both speed and location calculation has been discussed before. Maximum torque in BLDC motors is maintained by controlling a phase current such that it is in phase with a back-EMF. As the result, a d-axis current (id) is set to zero using the PI controller to provide an advanced angle (adv) [16]. To generate a necessary amount of pseudo Hall sensor signals, a PI output is multiplied by a position sawtooth angle (old). Sawtooth peaks, both positive and negative, are kept within a range (-180o to +180o) by using the new angle (new) correction method.

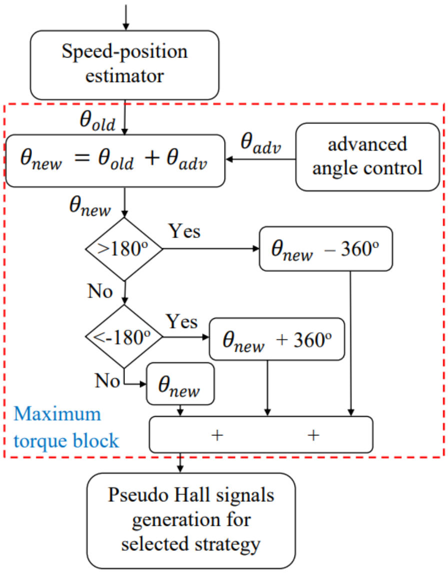

Figure7. Pseudo Hall signal Generation

- After being run through upper and lower limit comparators, a new adjustment angle is computed by adding an advanced angle (adv) and a sawtooth angle (old).
- A result of a comparison is used to add or remove 360 degrees, keeping a saw tooth waveform within the 2 range from peak to peak. Next, the positive edge shift equal to a displacement angle (dis) is used to create 180o pseudo Hall pulses.
- Using the saw tooth position signal and some basic logic gates (a comparator and an AND gate), a desired displacement angle may be chosen. This is done using a VSI commutation approach.
- Take note that an algorithm is the control system component for ensuring that a BLDC motor always operates at its full torque, albeit similar methods have been employed before [16].

6. SIMULATION RESULTS

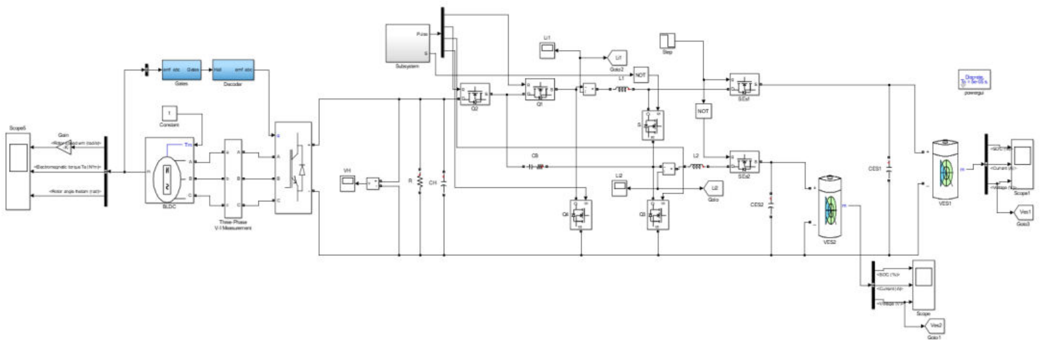

Figure7. Simulation model of the Proposed System

Case 1: Switch On condition

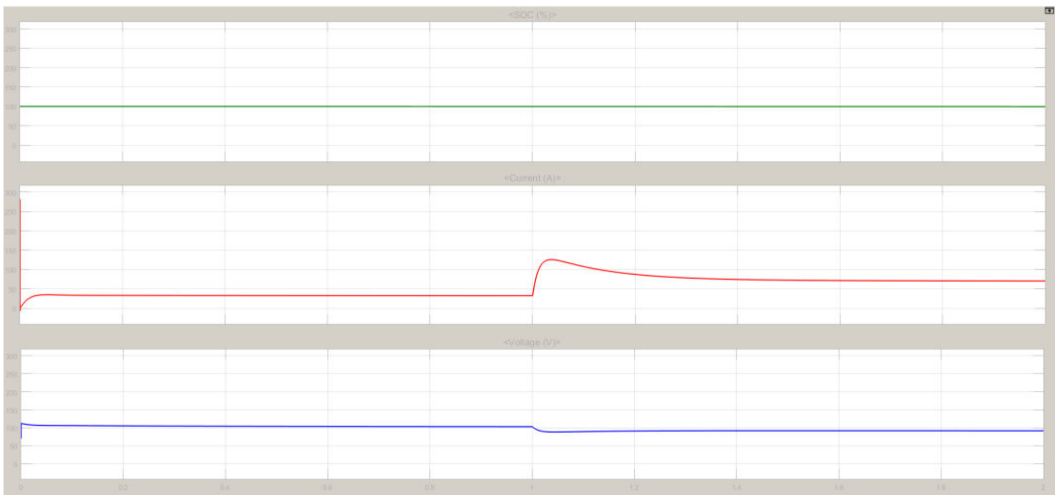

Figure8. If SOC, voltage, and current measurements taken from BES1 at time t=1, S indicate that BES2 is in an on state, then BES2 is on.

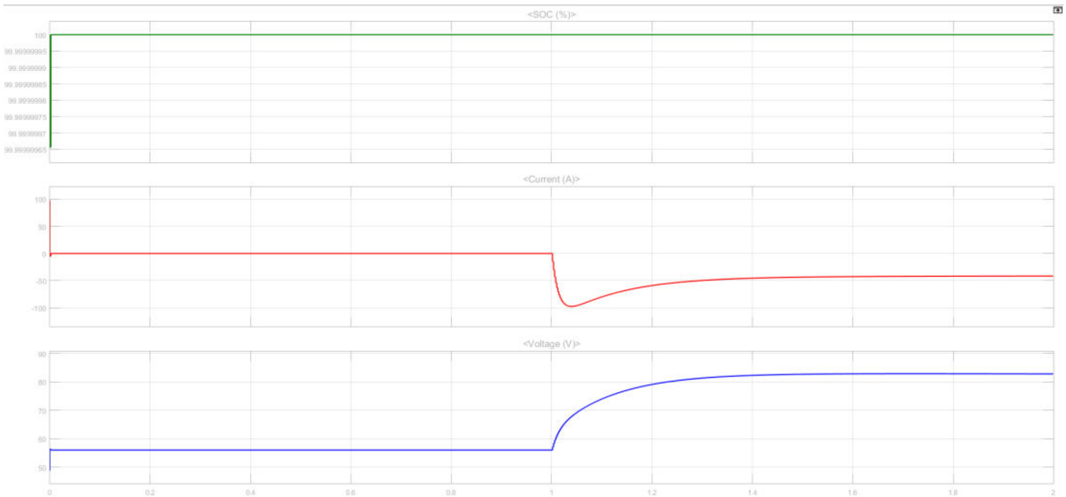

Figure 9. If at time t=1, S a BES2 SOC, voltage, and current are all on, then a BES1 is off.

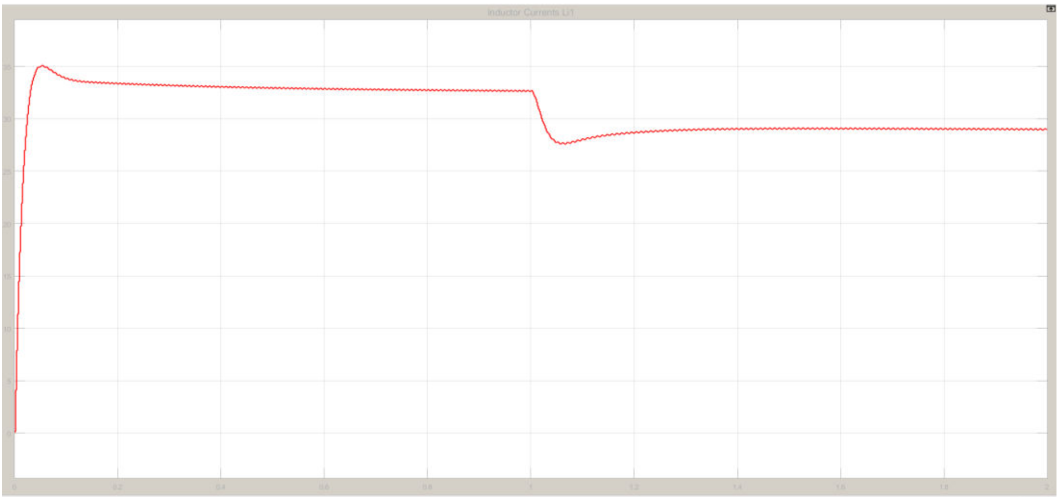

Figure10. Inductor currents of a BES1

Figure11. When a BES2 is on, an inductor currents will be negative.

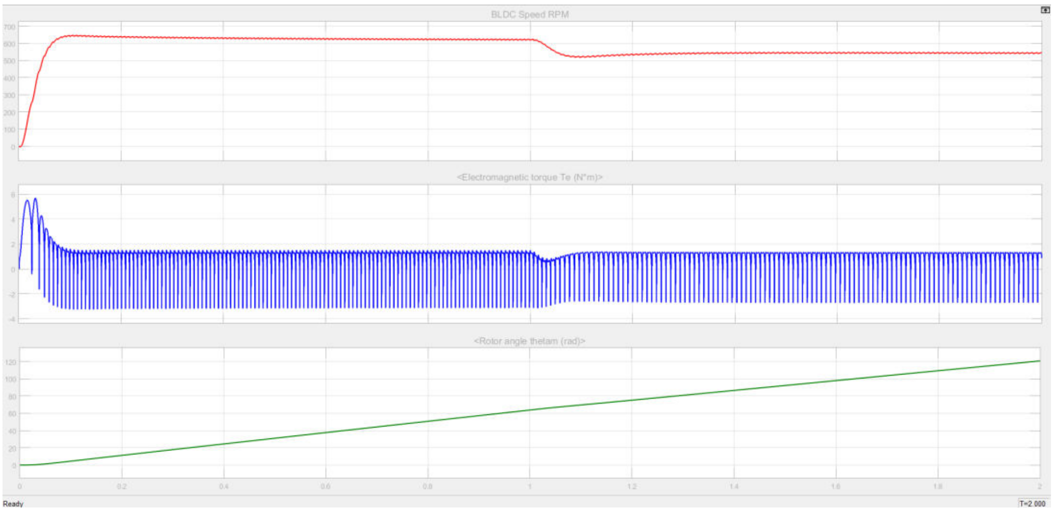

Figure12. BLDC motor RPM, Torque, and Angular Disturbance while an S-Off Switch Is Engaged. (BES1 is turned off at t=1 seconds)

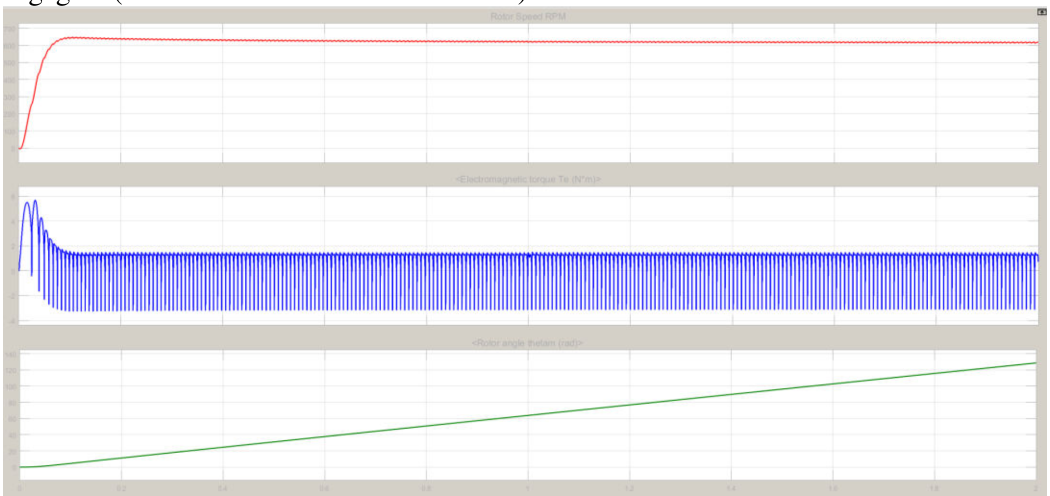

Figure13. BLDC motor Speed, Torque, and an angle in an S On state. (BES1 is on at time t=1 sec)

CONCLUSION

The suggested BDCC controller was developed with the use of digital signal processor (DSP) flow chart representations, and it has the revolutionary converter control for a strategic management level of vehicles. In order to deal with the circuit design, operating principles, analysis, and static voltage gains of a suggested BDC, a number of different power transmission techniques were used. When an in-wheel motors' control techniques are optimized, an electric vehicle's total performance rises. This section presents a simulation model of an ideal back-EMF three-phase star-connected BLDC motor. A suggested DC-DC controller has been tested in simulation, and under load circumstances, a BLDC motor model performs as expected. A given simulation model is straightforward and relies on a BLDC motor's Hall sensor. A suggested model is beneficial in the design of BLDC motor drives for EV applications because of its simplicity and the mentioned requirements.

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AUTHOR DETAILS :

Ms. K. Anusha received a B. Tech in Electrical and Electronics Engineering from Mina Institute of Engineering and Technology for women's (MINA), Miryalaguda, Nalgonda dist. And studying M.Tech in electrical power systems at holy Mary Institute of Technology and science, Bogaram, Medchal Dist, Hyderabad, India in the Dept. Electrical and Electronics Engineering.

Dr.M.Saravanan received a B.E. in Electrical and Electronics Engineering from Sri Sairam Engineering College, West Thambaram in 2004 and M.Tech.in Power Electronics & Drives College of Engineering, Guindy in 2010 and a Ph.D. degree in Electrical Engineering from Anna University, Chennai in 2018. He is currently A Professor of Dept. of Electrical and Electronics Engineering at Holy Mary Institute of Technology and Science, Hyderabad.