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SWITCHED-CAPACITOR VOLTAGE BOOST CONVERTER FOR ELECTRIC AND HYBRID EV DRIVES

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Abstract - This article describes the variable voltage (SC) voltage to boost converter and its control using the - DC-AC and AC-DC converters. The SC converter uses the switching capacitor circuit to the power supply by adding main converter circuit, thus providing the special features of the that cannot be achieved with a normal power supply inverter (VSI) or VSI support. The bidirectional SC converter is a versatile power converter that is capable of performing both DC-AC and AC-DC power conversion. This type of converter is commonly used in electric and hybrid electric vehicles to convert high-voltage DC battery power into the required AC voltage for the electric motor, or vice versa. The video attached to this article shows the difference between the A value and the function change.

I. INTRODUCTION

The rapid adoption of EVs is how quickly EVs overtake combustion engine cars in mileage and cost. Potential developments in EV technology fall roughly into three types: autonomous driving, battery chemistry and power electronic units. Regarding the last is one of the critical power conversion units, the powertrain. Powertrain improvements result in reduced size, high speed/torque dynamics and better battery power-utilization.

The majority of electric vehicles (EVs) today rely on a two-level voltage source inverter (VSI) with or without a boost stage, primarily because of its proven reliability in powering EVs. However, to further improve the performance of EV powertrains. VSIs are money transmitters by nature. Therefore, the DC link voltage must be higher than the DC or AC input voltage. For applications where available DC voltage is limited,

In order to achieve the desired AC voltage, an additional DC-DC boost converter is typically needed. There are two configurations commonly used in commercial traction electric drive systems. The first configuration involves connecting the a two-level inverter directly to battery, while the second configuration involves connecting the battery to the inverter via an intermediate DC-DC boost stage, as illustrated in Figure 1(a). While the first configuration minimizes stress on the inverter side, it needs a costly battery with a large number of cells in series to achieve the necessary DC-link voltage. However, it's connection poses challenges of slow charge equalization speed. To address these challenges, combining the internet of things (IoT) generation with conventional battery control. Technology can meet the requirements of real-time tracking of battery information for shared electric bicycles and battery condominium organizations and fault diagnosis.

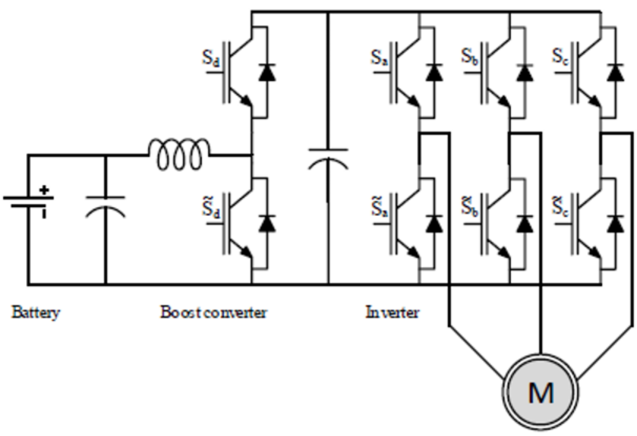

Fig. The conventional inverter converter topology

II. LITERATURE REVIEW

[1]. Y. song and b. wang 2014. HEV Evaluation and Control Strategy for Improving Power Electronics System Reliability," Y. Song and B. Wang 2014 Reliability Management EV

Decision and Control, because it can provide an objective standard for comparative analysis of different configurations and processes and can be used as effective tools to improve the overall design and management of electrical reliability Power systems research.

[2]. Y. Song and B. Wang 2013. Since electrical generators are widely used in many different industries, their reliability has been widely studied. This project conducts a qualitative analysis of electrical power system reliability assessment and improvement in three phases

.[3]. Fang Zheng Peng 2013. Impedance (or impedance source) power supply is used to power the converter (Z converter for short) and its control, dc-ac, ac-dc, ac-ac and dc-dc converters. The Z-source converter uses a unique impedance network (or circuit) for several main circuits from the converter to the main source, providing special features not found in normal voltage (or voltage-fed) and current sources. (Or current converter) uses a capacitor and an inductor.

[4]. W. Qian, H. Cha, F.Z. Peng, and L.M. Tolbert. Instead of traditional DC-DC converters, it connects the battery to the inverter DC bus in plug-in hybrid electric vehicles (HEV) traction drives. The boost converter used in commercial HEVs has encountered obstacles in increasing the power rating and achieving good efficiency while reducing the size of the converter.

[5]. Zonggen, YiMatthewShirk 2018. This study presents an optimal charging decision framework for connected and automated electric vehicles under a personal use scenario. The aim of this framework is to provide charging strategies, i.e., charging station selection and the amount of charged energy, taking into account the limitations of personal daily routes and existing charging infrastructure.

[6]. Jim Francfort1 Brion Bennett1 Richard "Barney" Carlson1 Thomas Garretson2 2018, With gas stations seemingly on every block, one would logically expect that refuelling or recharging PEVs would require a similarly ubiquitous network of public charging stations. However, charging stations can be installed where filling stations cannot (i.e., in homes, workplaces and destinations where PEVs spend long periods of time parked).

[7]. Michael Evzelman, M. Muneeb Ur Rehman, Kelly Hathaway 2019, Electric vehicles, including plug-in hybrids battery for propulsion and a low-voltage (LV) DC bus for auxiliary loads. This paper presents an architecture that uses modular DC and DC bypass converters to perform active balancing of battery cells and to power auxiliary loads, thereby eliminating the need for a separate high-step-down DC-DC converter.

[8] Jorge Estima 2021, One of the most important research topics of powertrain topologies applied to electric/hybrid vehicles is the analysis of powertrain component efficiency, including global drive efficiency. In this paper, two basic traction electric propulsion systems for electric/hybrid vehicles are presented and evaluated, with a special focus on efficiency analysis.

[9] Zong-Zhen Yang 2020, In this paper, an active equalizer based on a bidirectional buck-boost-converter is developed. Energy between adjacent cells can be transferred bi-directionally by manipulating the balancing current to solve the imbalance problem in the battery module. It should be noted that the conduction time of the main switch in a conventional buck-boost equalizer is fixed. Thus, the balancing current will decrease as the voltage difference of adjacent cells decreases, resulting in an extended balance period.

III. EXISTING WORK

VSIs are money transmitters by nature. Therefore, the DC link voltage must be higher than the DC or AC input voltage. For applications where available DC voltage is limited, two configurations are commonly used for commercial traction electric propulsion: A battery directly feeding a two-level converter and a battery connected to a DC/DC intermediate stage inverter The power rating of the DC-DC converter should match the power of the battery, resulting in a proportionally large choke. The inductor is a costly and heavy component

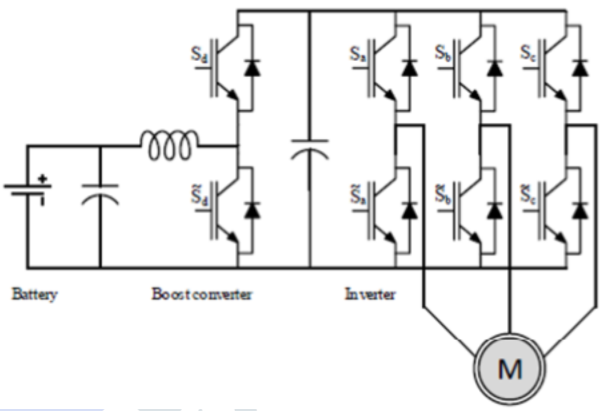

Fig. The conventional inverter converter topology

IV. PROPOSED WORK

Accurately predicting the reliability of hybrid electric vehicles (HEVs) is essential in planning, designing, managing, and controlling vehicle operations. This helps to objectively evaluate different configurations and topologies and can improve the design and control of the entire system. To achieve this, the paper proposes a MATLAB-based simulation model that can quantitatively evaluate the reliability of HEV electric powertrains. The simulation model takes into account variable driving scenarios, idle mode, electrical stress, and thermal stress, thereby achieving a more reliable and accurate prediction of system reliability. The paper details the methodology used and presents the results of the reliability evaluation for the HEV series. Using the reliability analysis results, two control strategies are proposed to increase the mean time to failure of HEV power units. These strategies include variable DC link voltage control and a hybrid discontinuous pulse width modulation scheme. Implementing these new control schemes reduces energy losses and thermal stress on the power converters, ultimately improving system reliability. The numerical simulation results confirm the advantages of the two proposed control strategies in terms of performance losses and reliability to overcome the above limitations of traditional drivetrains, this project presents a switched capacitor (SC) voltage converter and its control methods.

- The research proposes the utilization of an inverter combined with a switched capacitor circuit to create a unified circuit.

- A switching capacitor circuit is employed to generate a multi-level DC voltage.
- Consequently, the suggested switched capacitor circuit differs from the conventional circuit by eliminating the need for a reverse blocking diode or a large filter capacitor on the load side.
- The regulation of output current and voltage is achieved through unified control of both the inverter and the switched capacitor.

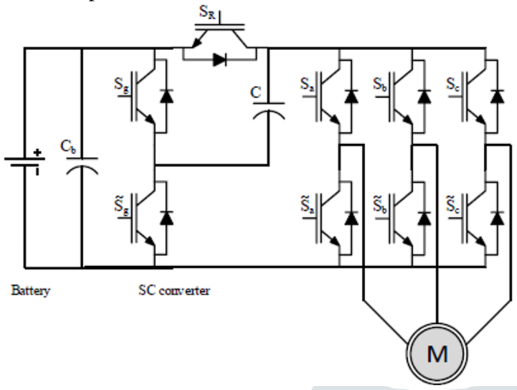

Fig. The Proposed switched-capacitor voltage boost convertor

V. METHODOLOGY

The proposed system will be implemented in the following module:

Determine the input and output voltage range and maximum load current for the SCVBC. Select appropriate MOSFETs and capacitors based on input and output voltage range and switching frequency. In this design, Si2302 MOSFETs and 10uF capacitors are selected.

Design the SCVBC topology and calculate the duty cycle and voltage gain. The SCVBC topology consists of two capacitor stages and a switch between them. The duty cycle and voltage gain are calculated using the following equations:

Duty cycle)

Voltage gain = (C1 + C2) / C1

Simulate SCVBC using circuit simulation software such as LT Spice. Verify the voltage gain, efficiency and ripple of the SCVBC output voltage.

Evaluate SCVBC performance at various load currents and analyze efficiency and voltage gain. Plot the efficiency and voltage gain upstream of the load to determine the performance characteristics of the SCVBC

Here is the schematic diagram for the proposed SCVBC:

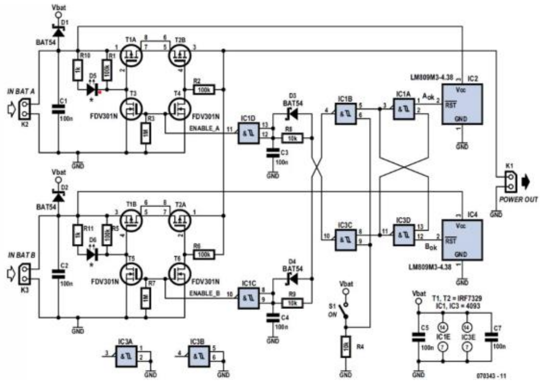

Fig. Schematic diagram of SCVBC

In the schematic diagram, the input voltage is connected to the first capacitor stage, which consists of capacitors C1 and C2. A MOSFET switch is connected between two capacitor stages. The output voltage is obtained from the second capacitor stage, which consists of capacitors C3 and C4. SCVBC is controlled by a PWM signal generated by a controller circuit. The switching frequency is set to 1MHz.

The above methodology and schematic diagram can be used as a guideline for designing and simulating a Switched Capacitor Voltage Boost Converter for a specific input and output voltage range and load current.

VI. CONVERSION METHOD

DC-DC Converter Introduction System A DC-DC motor is a device that accepts a DC input voltage and produces a DC voltage. generally, the produced matter is in a different stress position than the input. In addition, DC to DC transformers is used for noise isolation, power machine regulation, etc. This is a summary of some popular DC motor topologies. Buck Converter STEP-DOWN Motor In this circuit, turning on the transistor will apply a voltage Vin to one end of the choke. This voltage will tend to increase the inductor current. When the transistor is off, the current will continue to flow through the inductor, but now it flows through the diode. Initially we assume that the current through the inductor will not reach zero, therefore the voltage on Vx will now only be the voltage on the conducting diode for the full turn-off period. The average voltage at Vx will depend on the normal on-time of the transistor, which is the inductor current is continuous,

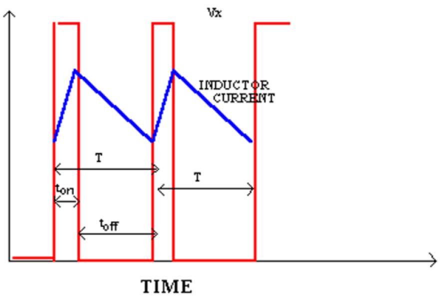

Fig. Buck converter

Transition Between continuous and Discontinuous:

When the current in the inductor L remains always positive then either the transistor T1 or the diode D1 must be conducting. For continuous conduction the voltage Vx is either Vin or 0. If the inductor current ever goes to zero then the output voltage will not be forced to either of these conditions. At this transition point the current just reaches zero.

$$I_L(peak) = (Vin - Vout)\cdot\frac{t_{ON}}{L}$$

The average current which must match the output current satisfies

$$I_L(average\ at\ transition) = \frac{I_L(peak)}{2} = (Vin - Vout)\frac{dT}{2L} = Iout(transition)$$

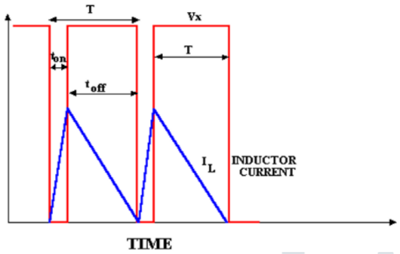

Fig. Buck converter at Boundary

VII.SWITCHED CAPACITOR CONTROLLER

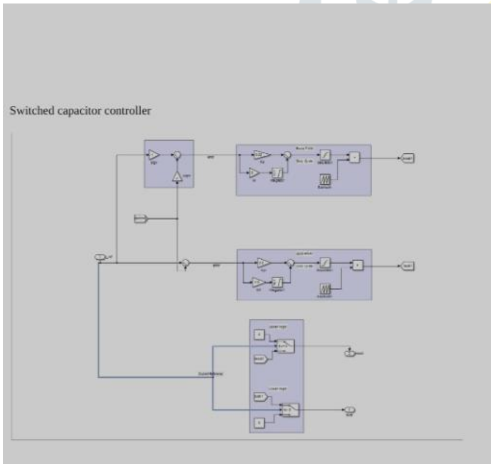

Fig Switch Capacitor

VIII.SIMULATION RESULT

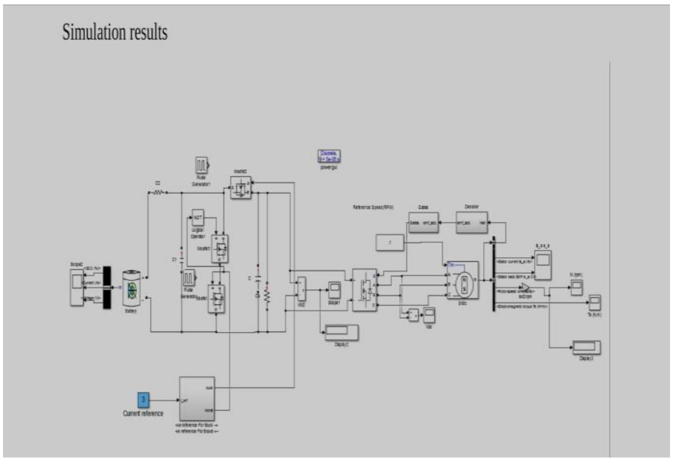

Fig. simulation result

XI.OUTPUT.

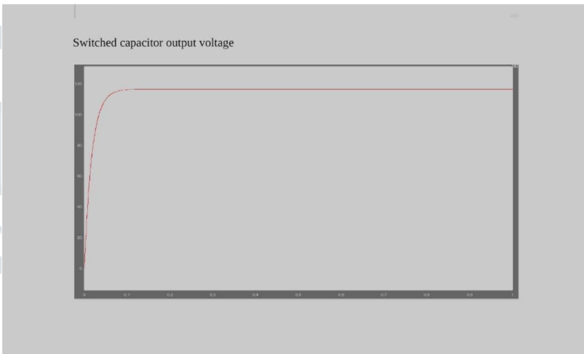

Fig. Switched Capacitor output voltage

Fig. BLDC motor speed

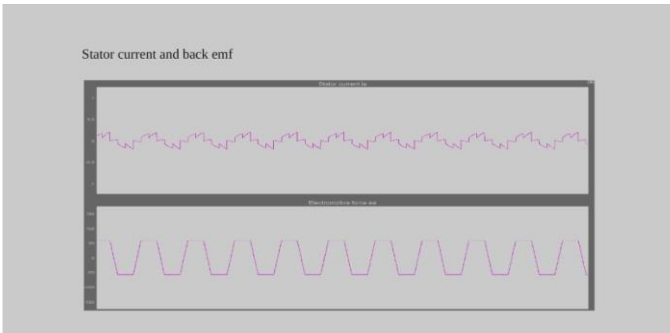

Fig. Stator current and back emf

X. CONCLUSION

The primary aim of this research paper is to introduce a switched capacitor (SC) power converter designed for DC/AC and AC power conversion purposes. The SC converter incorporates a switched capacitor circuit that collaborates with the main converter circuit to supply power to the source. This unique configuration offers a range of features that are not achievable with traditional voltage inverters (VSI) or boost VSI. A major advantage of the SC converter is that it eliminates the need for an expensive and bulky voltage boost coil, relying only on capacitors to achieve a voltage boost, thus enabling a higher power density. The study provides analytical derivations for maximum capacitor voltage drop and minimum charging current, and provides insight into the design elements that influence charging current behaviour. A carrier-based modulation technique is proposed, which utilizes the exact switching sequence of the SVPWM method with minimal computational effort. The efficacy of the designed converter's principle of operation and modulation techniques is validated through simulation and experimental results. The SC converter can increase power density, reduce cost, minimize component count, and step up or down voltage. This research paper proposes a control method for a low-cost maximum power point tracking (MPPT) GC microinverter for photovoltaic applications. The paper presents a macro-model for testing the proposed system and improving the simulation time. The macro model facilitates the development and comparison of different MPPT algorithms. The AM and the circuit used for the converter simulations are verified by experimental results. The proposed macro model accelerates the tuning of the voltage loop and the design of the input filters used to track the maximum power point.

XI. REFERENCES.

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[2] Y. Song and B. Wang present a comprehensive review on the reliability of power electronic systems in their paper titled "An Overview of Power Electronic System Reliability," published in IEEE Transactions on Power Electronics, Volume 28, Issue 1, pages 591-604.

[3] In the IEEE Transactions on Industry Applications, Volume 39, Issue 2, pages 504-510, Fang Zheng Peng explores the concept of a Z-source inverter, discussing its functionality and applications.

[4] The article titled "55kW Variable 3X DCDC Converter for Plug-in Hybrid Electric Vehicles," authored by W. Qian, H. Cha, F. Z. Peng, and L. M. Tolbert, is published in IEEE Transactions on Power Electronics, Volume 27, Issue 4, pages 1668-1678. The authors present a variable 3X DCDC converter designed for plug-in hybrid electric vehicles (PHEVs).

[5] M. Shen and F. Z. Peng discuss converter systems for hybrid electric vehicles (HEVs) in their paper presented at the International Conference on Electric Machines and Systems, with the proceedings published on pages 8-11.

[6] In the article titled "Efficiency Analysis of Drive Train Topologies Applied to Electric/Hybrid Vehicles," published in IEEE Transactions on Vehicular Technology, Volume 61, Issue 3, pages 1021-1031, J. O. Estima and A. J. Marques Cardoso analyse the efficiency of various drivetrain topologies in the context of electric and hybrid vehicles.

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[10] H. Chen, H. Kim, R. Erickson, and D. Maksim present an electrified automotive powertrain architecture utilizing composite DCDC converters in their paper titled "Electrified Automotive Powertrain Architecture Using Composite DCDC Converters," published in IEEE Transactions on Power Electronics, Volume 32, Issue 1, page 98.