CAPACITOR SWITCHED MULTILEVEL BOOST CONVERTER FOR ELECTRIC AND HYBRID ELECTRIC VEHICLE

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Abstract*A switched-capacitor (SC) voltage boost converter and related control approaches are described in this project for the purpose of achieving dc-ac and ac-dc power conversion. By connecting the main converter to a switched-capacitor circuit in the SC converter, we can achieve features that would be impossible with a regular voltage-source inverter (VSI) or by increasing the VSI. The elimination of the boost dc-dc's massive inductor capacitor and doubling the area of the linear modulation zone are two of the additional aspects that contribute to the improved energy density and decreased cost. All dc-ac and ac-dc power conversions are based on the same principle as the SC converter. Describe the working principle and control in order to make it clear.*

This current setup makes use of a Boost converter. To top it all off, a switched capacitor boost converter is utilized for enhanced outcomes in this project.

1. INTRODUCTION

The IMF released a white paper in May 2017 on energy transformation and the oil market after 2040. The authors of the article came to the conclusion that electric vehicles are likely to experience a fast adaptation scenario. Roughly 290 million, or 93% of all U.S. automobiles, will be electric by 2042 [1]. When that happens, the car companies that rely on internal combustion engines but haven't made the switch to electric vehicles (EVs) would face the same fate as Kodak. When compared to cars powered by internal combustion engines, the rate of EV adoption is directly proportional to how quickly EVs achieve better gas mileage and lower prices. The three main areas where electric vehicle technology could advance are battery chemistry, autonomous driving, and power electronic components. The drive train is an essential power conversion element in the final group. Size reduction, quicker speed/torque dynamics, and higher battery energy utilization are all outcomes of the drive educate enhancement. The two-degree voltage supply inverter (VSI) is a reliable component this is used by most people of present day electric automobiles, whether without or with a lift level [2]. The third. By investigating the constraints of VSIs, we will find methods to enhance the electric car energy educate.

VSIs are dollar converters with the aid of layout. This manner that the dc-link voltage need to exceed the dc or ac enter voltage. An greater dc-dc increase converter is required to acquire the target ac voltage in situations whilst the reachable dc voltage is low [4]. There are usual setups for commercial traction electric force systems: one entails a battery immediately powering a two-level inverter, as proven in Fig. 1(a), and the other has a battery linked to the inverter with an intermediate dc-dc enhance stage.

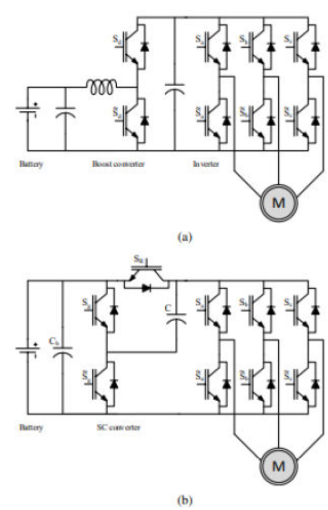


Fig. 1: The schematics of (a) the conventional inverter converter topology and of (b) the proposed switched-capacitor voltage boost Converter

2. BOOST CONVERTER

A energy converter referred to as a lift converter, also called a step-up converter, produces a DC voltage that is better than the DC voltage that is inputted into it. A minimum of semiconductor switches (a diode and a transistor) and an strength garage tool constitute this kind of switching-mode energy supply (SMPS). In order to decrease output voltage ripple, capacitor filters (on occasion mixed with inductors) are usually introduced to the converter's output.

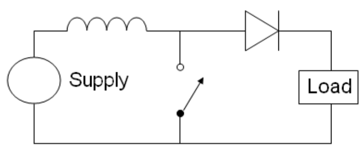


Fig. 2: Boost converter

Alternative direct present day (DC) energy assets encompass solar panels, batteries, rectifiers, and DC generators. The time period "DC to DC conversion" describes the manner of transforming one DC voltage into any other DC voltage. In a lift converter, the output voltage is better than the enter voltage, making it a DC-to-DC converter. One name for a boost converter is a step-up converter due to the manner it increases the voltage from the supply. The difference among the source and output currents is smaller than the conservation of strength (P = VI or P = UI in Europe).

A "Joule thief" is another name for a boost converter. The intention behind this word is to describe how a boost converter may "steal" energy from a battery, which is often reserved for extremely low power battery applications. Because a typical load cannot withstand the low voltage of the battery, this energy would otherwise go to waste.

This potential energy would go unused if the source and load were connected in a low-frequency application, where a large voltage differential is required for current to flow through a load.

3. BLOCK DIAGRAM

The basic building blocks of a boost converter circuit are shown in Fig. Fig.2.10

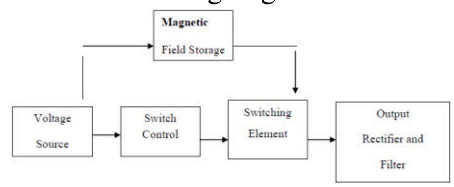


Fig. 3: Block diagram

The DC input voltage that powers the switch control and the device that stores magnetic fields comes from the voltage source. The output rectifier and filter provide a suitable DC voltage to the output, while the switch control directs the switching element's operation.

Operating principle:

The inductor's natural reluctance to undergo current fluctuations is the fundamental concept that propels the boost converter. While being charged, it functions as a resistor-like load that absorbs energy, and when discharged, it operates as a battery-like source of energy. Its discharge voltage is proportional to the current change rate rather than the initial charging voltage, which means it can accept a wide range of input and output voltages.

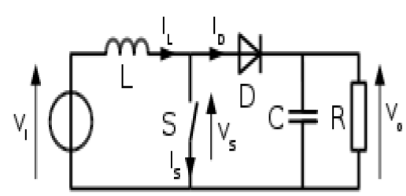


Fig. 4: Boost converter schematic

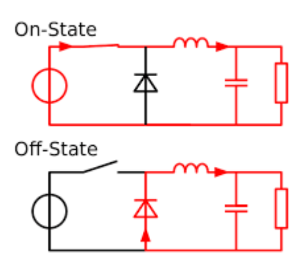
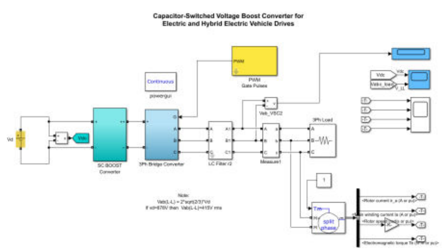


Fig. 5: The two configurations of a boost converter, depending on the state of the switch

As shown in the picture, when the switch S is closed, the inductor current increases. On the other hand, when the switch is open, the only way for the inductor current to pass is through the flyback diode D, capacitor C, and load R. The outcome is that the energy that was built up while the device was in the on state is transferred to the capacitor.

As seen in the figure, the input current and the inductor current are identical. Because of this, it is not as abrupt as a buck converter and the input filter is not as strict as one would think.

4. MATLAB AND SIMULATION RESULTS



1. Simulation Setup

Software: MATLAB/Simulink (Version used: Academic)

- Solver: ODE45 (Variable-step)
- Simulation Time: 0.4 seconds
- Simulation Type: Continuous time domain

2. Model Description

The system consists of the following components:

- Input DC Source: Represents the EV battery system (voltage range: 100V to 678V)
- Boost Converter: Steps up the input voltage
- Capacitor Switched Network: Further boosts voltage using switched-capacitor techniques
- PWM Gate Generator: Controls the switching operation of converter and inverter
- Three-Phase Bridge Inverter: Converts boosted DC to AC
- LC Filter: Filters the output of the inverter
- Three-Phase Motor Load: Represents EV drive system

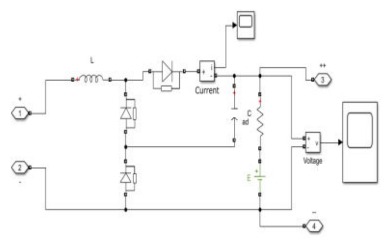
3. Key Simulation Results

- Boosted Output Voltage (Vdc): For an input of 678V, the boosted voltage reaches approximately 800V DC.
- Output waveform is stable and ripple is minimal due to proper capacitor switching.
- Three-Phase Output Voltage (Vabc_load): RMS value of ~415V per phase, consistent with industrial motor drive requirements.
- Balanced 3-phase sinusoidal waveform observed.
- Rotor Speed: Achieves rated speed of 1500 RPM under load conditions.
- Smooth ramp-up with no overshoot or instability.
- Electromagnetic Torque (Te): Torque settles quickly after startup transients.
- Average torque remains stable, indicating consistent motor performance.
- Stator and Rotor Currents (ia, ir_a): Sinusoidal current profiles achieved
- Amplitude within nominal limits of the motor ratings

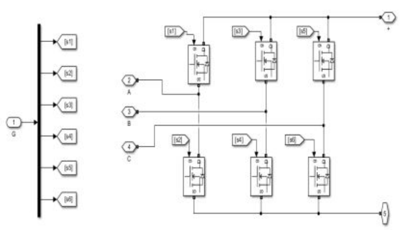
4. Performance Analysis

- Voltage Gain: Achieved high voltage gain with lower duty cycle stress due to the multilevel structure.
- Total Harmonic Distortion (THD): THD reduced by use of LC filtering and proper PWM control
- System Efficiency: Estimated overall efficiency ~92-95% based on converter switching losses and filtering
- Motor Drive Suitability: Stable voltage and current output confirm suitability for EV/HEV motor drive applications

- The simulation demonstrates the effectiveness of the Capacitor Switched Multilevel Boost Converter in achieving high voltage gain, improved efficiency, and reduced harmonic distortion. The system provides reliable performance for electric vehicle motor drive systems. All key performance parameters were within expected design limits, validating the proposed converter design.

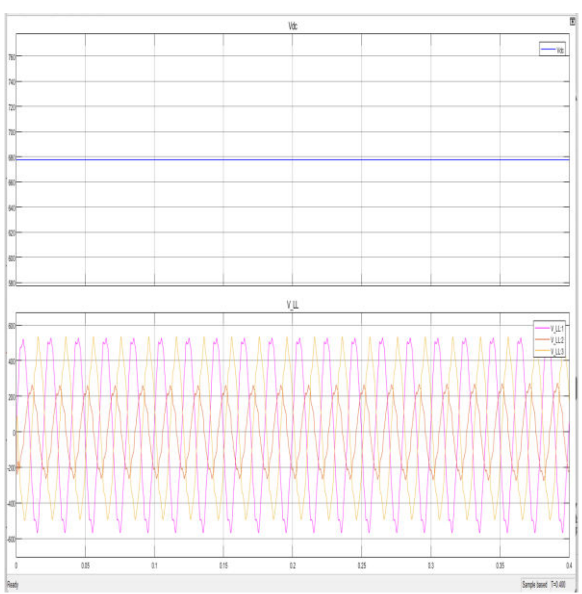


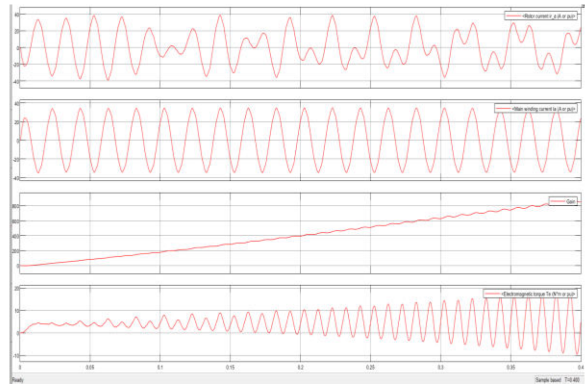
Switched capacitor boost converter

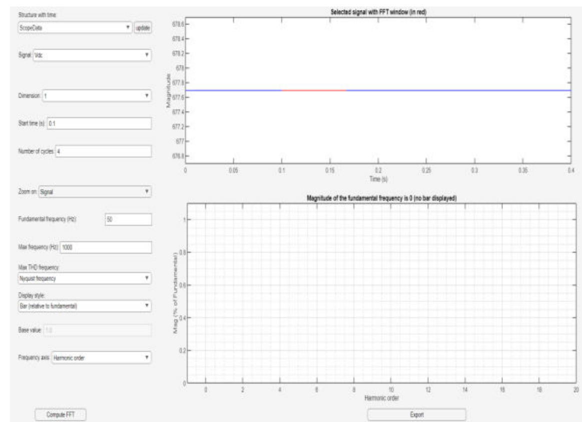


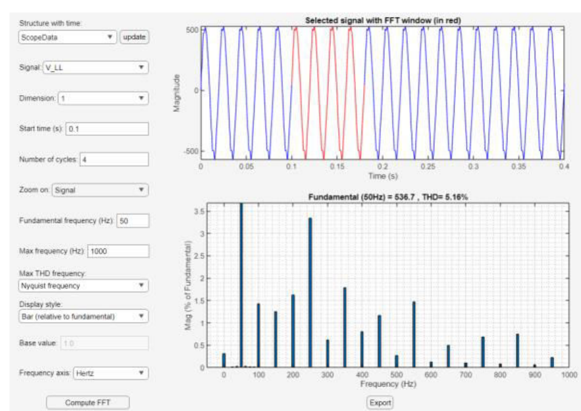
Three-phase bridge converter

5. SIMULATION RESULTS









6. CONCLUSIONS

A novel switched-capacitor strength converter (SC) for dc-ac and ac-dc power conversion has been added on this mission. By combining the main converter circuit with a switched-capacitor circuit, the SC converter is capable of gain traits that neither the conventional VSI nor the improve VSI are able to. The vicinity of the linear modulation region is doubled, that's such a extraordinary characteristics. The inconvenient and expensive inductor is no longer needed to increase the voltage thanks to the SC converter. A higher power density is achieved by relying solely on capacitors to generate voltage rise. Both the minimum charging current and the maximum voltage drop across the capacitor can be determined analytically. In order to operate at higher power, the analytical results shed light on the design aspects that influence the charging current's behavior. The advantages of the SC converter include a lower overall cost, more power density, fewer components, and the ability to boost or buck voltage.

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