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Design and Development of an Isolated Bidirectional Converter with High Transformation Ratio

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ABSTRACT: In this project, a bidirectional high frequency full bridge converter with high transformation ratio scheme is proposed. The main architecture of this project is dual active full bridge circuit. By using frequency modulation. Electric vehicle (EV) battery chargers often use LLC resonant converters. The energy can be transmitted between different voltage sides HV side and LV side. It shows the bidirectional conversion between the DC batteries 36Vdc and DC grid 400Vdc in order to overcome the drawbacks of traditional LLC resonant converters, the project presents a new method to enhance their efficiency in charging electric vehicles. The suggested method makes use of the overcurrent protection-originally-designed capacitor-clamped topology, this innovative approach optimizes the design of magnetics, leading to reduced size, increased power density, and cost savings. In reference with other related topics for dual active bridge converters the conventional transformation ratio is lower and equal to 8. The project with high transformation ratio can reach about 10 for practical high-low voltage bidirectional applications. The efficiency of the proposed design is validated though comprehensive simulations in MATLAB

KEYWORDS: Bidirectional full-bridge converter, phase-shift modulation, zero voltage switching, high transformation ratio, DAB

I.INTRODUCTION

Electric drive vehicles (EDVs) that are parked may contribute to vehicle-to-grid electricity by recharging their batteries. This may include grid-connected fuel cell vehicles, hybrids, or battery-electric cars. For V2G functionality, each vehicle must include: a power connection enabling electrical energy transfer to the grid, a control or communication system for coordination with grid operators, and onboard precision metering capabilities, Grid operators need to rely on a significant number of vehicles being parked and potentially plugged in throughout the day to effectively schedule power dispatch. The typical personal car parks for the majority of the day, spending just a small fraction of that time on the road. Ninety percent or more of people's cars are still parked, even during rush hour. Power from vehicle-to-grid (V2G) technologies is not financially viable when contrasted with large-scale power.

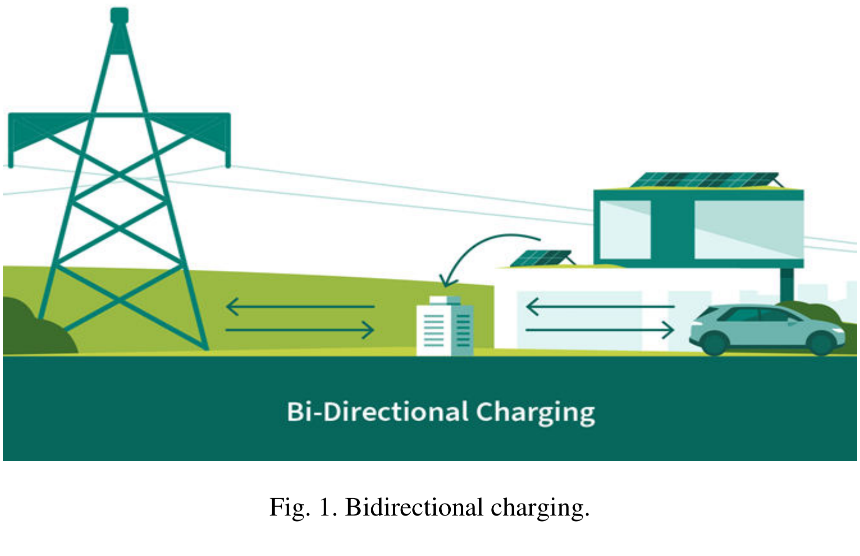

Fig. 1. Bidirectional charging.

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The two halves of the ancillary service market's pricing structure make it possible to use this electrical energy for auxiliary services in a competitive manner. Budget for capacity Electricity cost. When a generator (like a battery powered car) offers supplementary services, it is paid for the energy it really delivers and the ability it has to react quickly (in milliseconds). By using electric vehicles (EVs) consumers can save money on fuel costs since electricity is cheaper than gasoline for equivalent travel distances. EVs with V2G (vehicle-to-grid) technology offer owners an additional revenue source by allowing them to sell excess power back to the grid. Utilities can also benefit from V2G by not only supplying electricity to EVs but also drawing power from them to provide ancillary services. Outside peak demand times, the power grid can produce and deliver a significant portion of the energy required to fuel national vehicle fleets at the marginal cost of fuel. V2G vehicles act as distributed generators, supplementing traditional power plants and providing valuable energy capacity during peak periods. V2G PHEVs (plug-in hybrid electric vehicles) contribute to reduced emissions and air pollution in the electricity sector by storing energy from intermittent renewable energy sources. V2G systems combine rarely integrated technologies. While unforeseen challenges may arise with large-scale implementation, there could also be serendipitous benefits and synergies. Effective communication and grid regulation systems are crucial for the proliferation of V2G technologies, enabling the management of power dispatch, recharging, and voltage regulation. The decentralized nature of V2G generation from individual vehicles may pose compatibility issues with existing systems designed around larger power units. V2G systems hold the promise of revolutionizing both energy and transportation sectors by fostering the adoption of electric vehicles, eliminating unnecessary investment in traditional power generation, and facilitating the integration of renewable energy sources. Naturally, such a trans-formative transition presents various challenges. Establishing a new charging infrastructure requires significant investment, not the elimination of existing networks. The long-term viability of V2G and sustainable energy production hinges on a fundamental choice to maintain the separation of the electric system and vehicle fleet, increasing the cost of renewable energy due to the need for dedicated storage capacity to accommodate intermittent production. To seamlessly integrate the vehicle and electric grid systems, leveraging the vast but currently unexploited storage potential of electric vehicles to support grid stability and de-carbonization**.**

II. LITRETURE SURVEY

Micro-grids rely heavily on energy storage systems to effectively integrate intermittent renewable energy sources.
EV batteries, often idle for 18 hours a day while parked, offer a unique opportunity to serve as storage devices within these micro-grids. Through the use of "vehicle-to-grid" (V2G) technology, electric vehicles may aid in micro-grid energy management by collecting and storing surplus power, which can then be released back into the grid as needed. While V2G implementation on the larger power grid faces challenges such as control complexities, large EV fleet requirements, and slow deployment, its integration into micro-grids presents a simpler and more manageable approach. Furthermore, the Society of Automotive Engineers has established three distinct charging levels for electric vehicles, further enhancing the possibilities for V2G integration within micro-grids. The electric scooter battery is set to 36 V for low voltage in this investigation, while the high voltage is 400 V from the DC grid. In order to prove that the suggested structure can work, the power level is set to 1 kW. The end goal is to establish a system where electric scooters and the DC grid can charge and discharge each other in both directions. In order to achieve high output, the LLC resonant converter must undergo a considerable frequency shift, which might lower its efficiency and cause it to operate outside of its ideal working range. Since the lowest conversion rate is associated with the greatest battery voltage, LLC-based EV charging systems often experience a decline in efficiency while operating at maximum power. This reduced efficiency necessitates enhanced cooling performance. Due to the substantial increase in flux linkage needed by the transformer as compared to the output voltage situation, the transformer design becomes somewhat large. any of the current designations

Reference	Input/output V (Vdc)	Transformation ratio	Power level of DAB
1	80/40-100	1.25-2	550W
2	140/70	2	4.5W
3	150/150	1	600W
4	300/100-200	1.5-3	500W
5	400/40	10	1KW

TABLE 1:COMPARISON OF DIFFERENT REFERENCE

A hybrid mode modulated DAB converter was presented (1), enabling the output voltage to be increased or decreased. The input voltage is 80 Vdc, while the output voltage can vary between 40 Vdc, 80 Vdc, and 100 Vdc. The

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transformation ratio ranges from 1.25 to 2.Reference [2] describes a DAB operating in a 1.5 kW micro-grid to energy storage system. The input voltage is set at 140 Vdc, and the output voltage is set at 70 Vdc. In this bidirectional power delivery scenario, the transformation is 2. Despite this advancement, the transformation ratio remains relatively low. Reference [3] introduced multiple input-series-output-series (ISOS) DAB modular converters designed for DC grid applications. Each module operates with an input voltage of 150 Vdc and an output voltage of 150 Vdc. The transformation is 1. Additionally, these modularized DABs offer series-resonant characteristics for soft-switching functionality. Reference [4] proposed a hybrid-bridge DAB converter employing hybrid modulation for a wide voltage range. In this study, the input voltage from the DC bus is 300 Vdc, while the output voltage varies between 100-200 Vdc for the energy storage system. The transformation ranges from 1.5 to 3.Table 1 provides a comparison of input/output voltages, transformation ratios, and power levels

III PROPOSED SCHEME AND OPERATIONS

This paper proposes and implements a bidirectional full bridge frequency-modulated converter with a high voltage ratio, as depicted in Figure(2). The paper establishes the forward charging mode (G2V mode→Vgrid transfers energy to Vbat) to power the battery of the electric scooter. The reverse discharging mode (V2G mode→Vbat supplies energy to Vgrid) enables the battery to supply energy to the DC grid in the opposite direction.The proposed circuit is a modified version of the conventional one-way phase-shift converter, where the output-side rectifier diodes are substituted with power switches. The dual active bridge (DAB) serves as the foundational architecture of the system, enabling bidirectional energy conversion.

A. Transformation ratio

Once the converter specifications were finalized, the transformer's turns ratio was meticulously calculated. To enhance efficiency and minimize circulating power, the DC grid port voltage and the storage port voltage, acting as design parameters, were carefully selected. The resulting transformer design is represented by Equation (1). This equation incorporates the chosen voltage levels to establish the optimal turns ratio, ensuring efficient power transfer between the grid and the storage system. By minimizing circulating power, the transformer operates with reduced energy losses, ultimately improving the overall efficiency of the converter system. This meticulous design process guarantees a well balanced transformer capable of handling the demanding requirements of the energy conversion application.

$$N = V_{grid}/V_{bat} = 400/40 = 10 \quad (1)$$

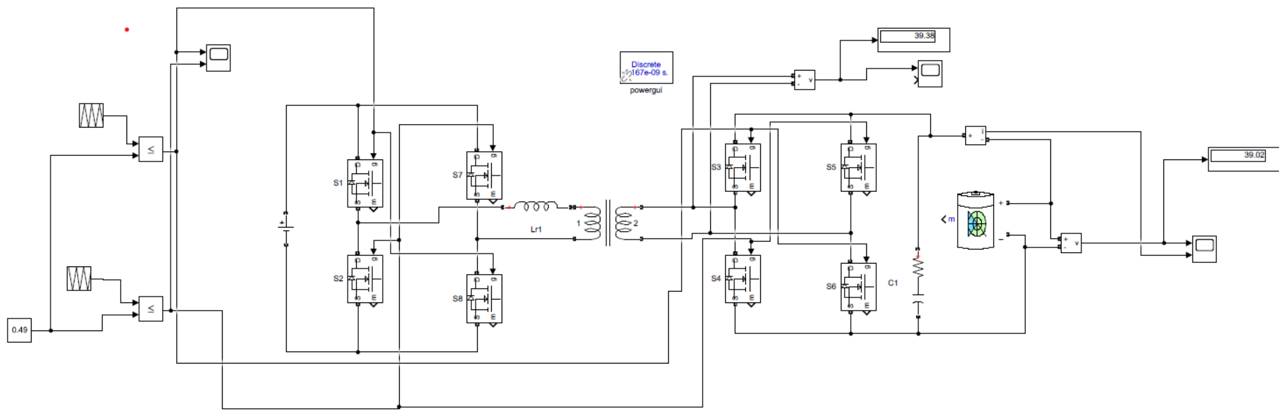

Fig. 2. Proposed architecture

IV. RESULT AND DISCUSSION

To reduce the switching losses, frequency switching is selected instead of phase shift modulated switching smooth switching can be performed. Here the fig(3) shows the input given for soft switching and the Fig (4),(5) shows the voltage and current that has been generated at output end for charging battery of 48Vdc of a electric vehicle.The same simulatioon test were done or a battery of 36Vdc at the generated voltage measurment isl shown in fig (6)

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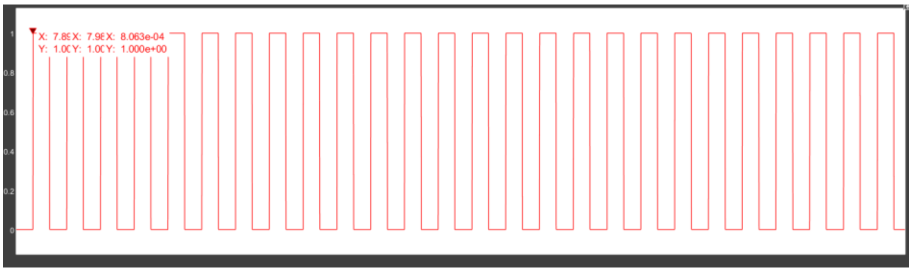

Fig. 3 Input Frequency

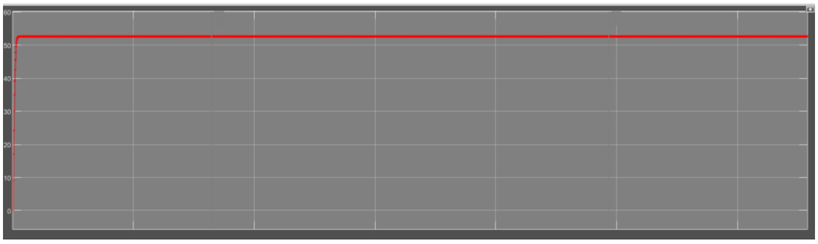

Fig. 4. voltage measured in output for 48v battery charging

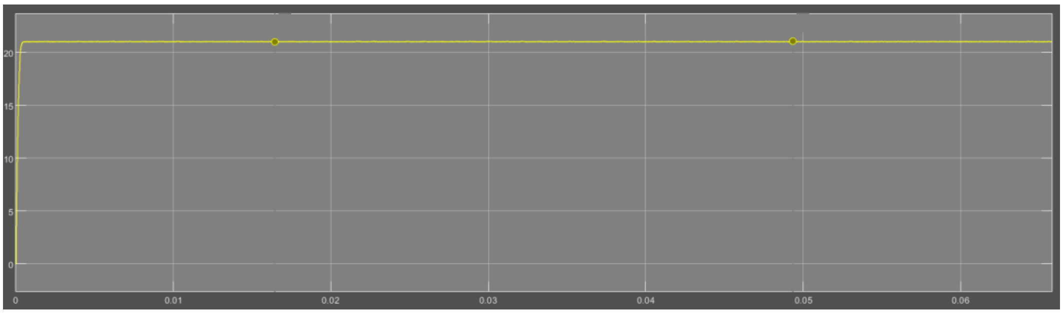

Fig. 5. Current measured in the output for 48v battery charging

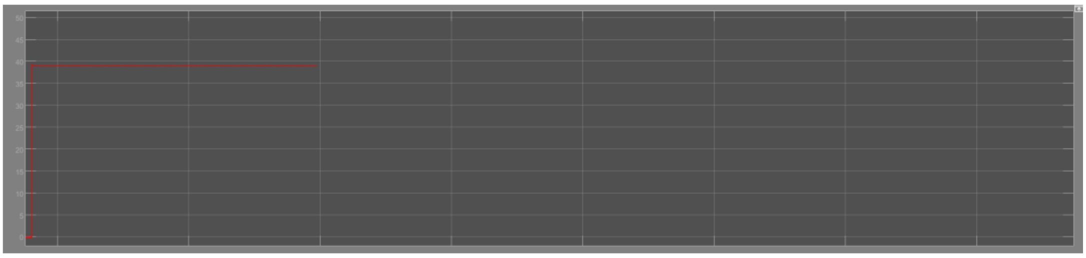

Fig. 6. voltage measured in output for 36v battery charging

V. CONCLUSION

A high-transformation-ratio bidirectional complete-bridge section-shift converter is detailed in this paper. This design ensures synchronized voltage switching by replacing output rectifier diodes with power switches, which improves the efficiency of traditional segment-shift converters. Applications with a high-to-low voltage ratio are ideal for the suggested approach. The Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) modes have been confirmed by experimental findings. A MATLAB simulation of the bidirectional converter has been constructed, with 400vdc grid and ev battery of 36v and 48v and they are charging. In real-world charging/discharging scenarios, factors such as charging station capacity, Determinants of bidirectional power converter stability include the prevalence of electric vehicles and the amount of time spent charging. To tackle these issues, future research will concentrate on creating solutions for quick voltage control with high-speed

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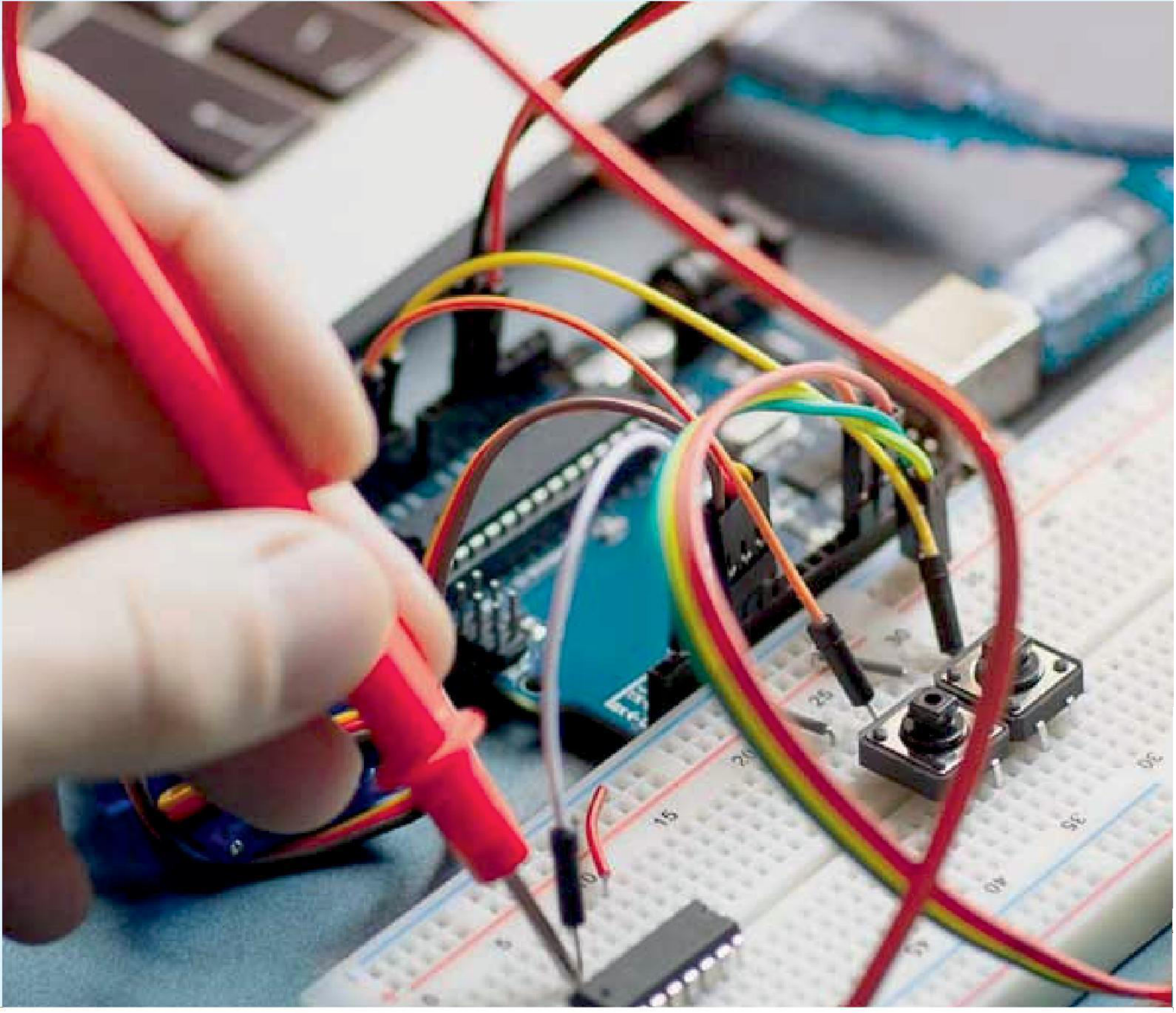

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