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Bidirectional on-Board Charger for Electric Vehicles

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ABSTRACT: The advancement of Electric Vehicles (EVs) rapidly renewable energies within automotive human activities. Charging has a significant role in the functioning of an EV hence two types of charger exist, Off-Board Charger and On-Board Charger. Onboard Chargers (OBCs) are preferred in EVs for their ease of installation and lower cost. Limited space in the vehicle, as well as short time for charging, demand an OBC to be power-dense and highly efficient. In addition, the ability of EVs to return power to the grid has intensified interest in bidirectional power flow technologies in the automotive sector. Bidirectional OBCs are directed for Grid to Vehicle(G2V) and Vehicle to everything (V2X). Bidirectional On Board Chargers are the next generation of Onboard Chargers that are able to assist the Grid during peak demand on the system. This project concentrates on the topology that overcomes the limitations of existing Bidirectional OBCs. The main goal of this Project is threefold. To start, doing an overview about the current status of the electricity common carrier paradigm, one of the three pillars of the next smart grid allowing maximum power throughputs and near-instantaneous control of voltages and currents through every link in the power system chain. Second, to offer a means of interlinking the power systems and the power electronic communities, with their differing processors of how these devices behave when they are plugged into the power grid.

I. INTRODUCTION

EVs (Electric Vehicles) are super appealing in the car space because they rely on cleaner energy and can reach performance levels that surpass fossil-fueled vehicles. Many Subject: Deployment of Dual Use Items/Controlled Technologies by Users of Specific Countries, such as the US, Canada, China, India and certain EU countries already have govt incentive policies in place to promote EV development. For instance, the United Kingdom and Canada have released the Zero Emission Vehicle, which offers financial assistance for the sale of zero and ultra-low emission vehicles, upgrading the public EV charging network. EVs — Energy Efficiency Financial Sidies in China India also targets only EV will be achieved in 2030.

As the largest automotive European Union 10-year tax concession and price subsidy for EVs Hence, to cater to the growing demand of EVs it is crucial to develop chargers and beat the rush to nationalize global power infrastructure in the face of enormous future energy demand. The On-Board Charger (OBC) usually allows direct charging of the EV from the AC grid and has advantage in automotive industry, especially adapt to the AC grid to the off-board charging solutions that involves high cost and huge volume. Unidirectional OBCs are It is popular due to a very low battery degrade and a simple hardware requirement. However, EVs have been developed recently in order to function as a mobile energy source. Indeed, bidirectional OBCs can accomplish vehicle-to-grid (V2G) functionality by sending electrical energy back to the grid which may assist in times of peak power demand. Furthermore, bidirectional OBCs may enable EV owners to use their vehicles for other functions such as providing power from the vehicle-to-home (V2H) or vehicle-to-load (V2L) during a power outage or vehicle-to-vehicle (V2V) in an emergency. Despite many issues of Bidirectional OBCs application including, but not limited to, extra system costs and reliability burden, lesspower density and high weight, less-complicated smart grid architecture structure realization, so it is It is also tributary that bi direction OBCs will converge to be the one public charging solution in future OBCs for EVs have seen significant advancements in the past few years. Some excellent review You are never going to have the papers summarized OBCs. Topologies of ∞ T-around chains and topology ADTiso. charging solutions of Plug-in electric vechiles.

II. LITERATURE SURVEY

In a OBC two stage of conversion is necessary for efficient charging internally i.e. AC-DC and DC-DC. Mainly either Algorithm Development or Bidirectional On Board Charger, based method and Adaptive Topology. Published Articles October 12, 2023 The topological alteration of DC-DC Converter is necessary. (DAB Converter, CLLC Converter) --

Various Topologies. Fujiwara et al. (2022) on Industrial Electronics ,“An Innovative High-Efficiency DAB Converter for EV Charging” (IET Power Electronics, 2022) “DAB-Based Bidirectional OBC with Enhanced Efficiency” (IEEE Journal of Solid State Circuits, 2021). Dual Active

Bridge Converter for Electric Vehicle Charging (Journal of Power Electronics, 2020). DAB Converter Optimization for Bidirectional OBC (IEEE Transactions on Power Electronics, 2020).

III. EXISTING SOLUTION

SERIES-SERIES DAB —A Dual Active Bridge (DAB) is an isolated DC (Direct Current) to DC (Direct Current) converter that includes two active bridges, one at the input, and one at the output with a high frequency transformer in between. This type of construction is very common to the systems which deal with efficient power supply conversion with galvanic isolation such as in battery chargers, renewable energy systems, and electric vehicles (EVs). When talking about series – series Dual Active Bridge (SSDAB) it is a modification where two active bridges are stacked in series. This is done in order to achieve higher voltage conversion ratios which are needed for specific applications, like high voltage direct current networks.

Active Bridges (H-Bridge) are the key components of a Dual Active Bridge (DAB) system. Input Active Bridge (Bridge 1) – this bridge is the one which connects to the input DC power source. Output Active Bridge (Bridge 2) – this bridge is connected to the load or to next section of the system. Each of these bridges contain set of semiconductor switches

which are usually MOSFETs or IGBTs

Series-Series Dual Active Bridge (SS-DAB): In the series-series topology of the DAB, both primary and secondary converter sides are designed in series with the high-frequency transformer. Larger voltage conversion ratios are possible and hence it becomes more appropriate where high voltage has to be dealt with. The series-series configuration is especially effective in high-voltage systems since it allows the system to maintain higher voltage differences between input and output. Renewable Energy Systems: In solar power or wind power systems, where a DC-DC converter is required to regulate the output to a useful voltage or control power flow Energy Storage Systems: The DAB can efficiently control power flow between storage systems and the grid, enabling applications such as grid stabilization

IV. PROPOSED SOLUTION

THREE LEVEL AC TO DC CONVERTER

The Three Level AC to DC Converter functions as an electronics converter which changes AC power to DC following a threelevel voltage structure. This device applies to high-voltage applications because it enhances efficiency and decreases harmonic distortion and decreases passive components (especially filters) when compared to traditional two-level converters. Each phase in the system uses three distinct voltage levels in three-level converters according to their name. Two distinct models exist within the range of three-level AC to DC converters. When used as Neutral-Point Clamped Converter the Three-Level Diode Clamped Converter remains another name for the same system. Three-Level Flying Capacitor Converter Three-Level Cascaded H-Bridge Converter The subsequent analysis investigates each system one by one.

1. The Three-Level Diode Clamped Converter also known as Neutral-Point Clamped Converter operates with three voltage levels used for each phase in the system. The threelevel converter presents itself as one of the most widely implemented configurations. Such converters regulate output voltage levels through diodes in connection with a neutral point. Working Principle: The converter accepts a standard AC voltage supplied by a three-phase AC power source. A three-level output is produced through the sequential distribution of diodes and capacitors within the converter. V_{dc} represents the peak rectified voltage as the output DC voltage yet the three voltage levels exist at 0V

and $+V_{dc}/2$ and $-V_{dc}/2$. These levels emerge from the converter thanks to the diodes which control the current path. The system forms the neutral point at a center point in the capacitor or transformer to divide the output DC voltage into two separate levels. Key Features: Semiconductor switches experience decreased voltage strain thanks to the converter which hence produces better efficiency compared to conventional two-level converters.

Advantages: A reduction in switching losses occurs because lower voltage stress on switches creates more efficient systems.

Three output voltage levels and the converter design operating mechanism produce fewer harmonics to enhance the overall quality of DC output power. The machine produces reduced lower harmonics allowing the elimination of additional filtering needs. Disadvantages: The control circuit becomes more complex in three-level converters because they require advanced control systems to both maintain neutral point balance and control device switching operations. System instability will happen if capacitors remain unbalanced for proper operation.

2. Three-Level Flying Capacitor Converter Without relying on diodes for clamping the converter implements capacitors to generate three voltage levels in its design.

Working Principle: Three different output voltages emerge from the converter system through its implementation of flying capacitors. The phase-specific capacitors operate by cycling between three voltage conditions which include zero and positive and negative half V_{dc} . Each pair of flying capacitors becomes charged and discharged through the switching devices to enable voltage level switching for the output. Key Features: A proper functioning of this converter depends on capacitor balancing since it uses capacitors to produce voltage levels. The control sequence operational plan enables the flying capacitors to properly receive and transmit power which generates selected voltage outputs. Advantages: Modification of the Circuit Requires No Diodes: Such conversion eliminates the need for diodes which simplifies design work and minimizes parts utilization. The operation of this arrangement generates similar low harmonic output compared to the diode-clamped converter. Disadvantages:

The process necessitating the balancing of flying capacitors remains challenging primarily when the system encounters output load variations.

3. Three-Level Cascaded H-Bridge Converter

The output creation of three voltage levels happens through a series connection of multiple H-bridge converters. The Hbridges offer output voltages at three levels of zero as well as positive or negative through their functionality.

Working Principle: The output of three-level operation emerges when H-bridge converters connect in an array to function as a

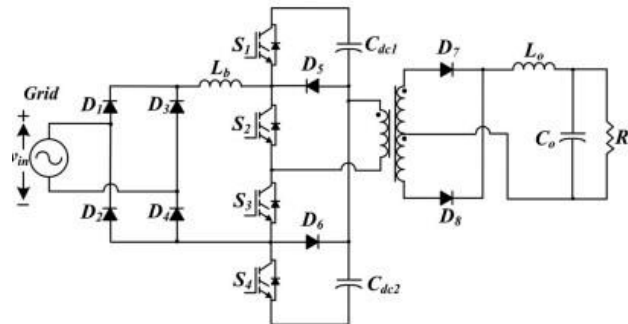
multiple-stage system. Every stage of the converter uses multiple H-bridge units for its operation. Each H-bridge switch operates by producing either the positive $+V_{dc}$ rating or zero $0V$ or the negative $-V_{dc}$ voltage level. Each H-bridge inverter obtains its output control through modulation methods (including Pulse Width Modulation and PWM) so it can produce a suitable voltage shape for the load. Key Features: This converter exhibits flexible configuration because adding more H-bridge units enables the creation of higher voltage levels starting from five-level to seven-level and beyond.

The modular design feature makes this configuration compact and enables simple expansion for increased voltage capacity handling. The combination of multiple voltage stages produces an output voltage which shapes near a pure sine waveform thus reducing harmonic distortion for better power quality.

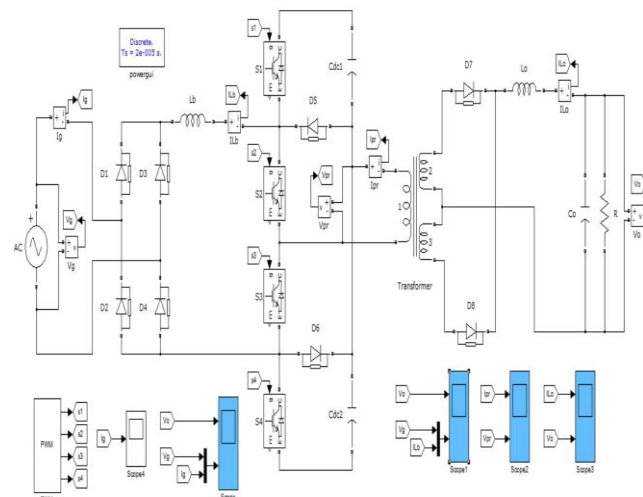
Advantages: The cascaded H-bridge topology provides easy scalability through increased power applications which can be achieved by connecting additional H-bridge modules. The output voltage quality improves because this converter type generates waveforms that closely match sinusoidal forms thus requiring minimal filter systems. Disadvantages: The control of numerous H-bridge inverters becomes complicated since managers must handle power distribution alongside modulation between separate units. Higher system expenses and more intricate circuit design often result from needing multiple H-bridges because of the increased number of power electronics devices used in the system. Applications of ThreeLevel AC to DC Converters: The converter suits high-power AC to DC conversion requirements in motor drives and industrial power supplies because of its three-level configuration.

V. OPERATING PRINCIPLE

The converter design merges operational features of boost PFC circuits and three-level isolated dc–dc converters into one single system. a diode bridge together with an inductor are inserted into the three-level isolated dc–dc converter topology. The charging process of the inductor takes place during simultaneous S2 and S3 activation. The primary transformer winding receives $V_{dc}/2$, $-V_{dc}/2$, then zero voltage when S1 to S4 are used for switching.



The implementation of this topology ensures that all switches function in both stages thus enabling a single-stage converter without requiring any additional auxiliary switches. The switching arrangement for conventional threelevel isolated dc/dc converter appears . The fixed duty ratios of S2 and S3 approach 50% in this conventional scheme to keep control simple and prevent short-circuits through dclink capacitors that occur when upper or lower three switches turn ON at the same time. The combined signal of these two pulses does not affect the circuit operation when the shortcircuit state remains absent. The primary transformer experiences zero voltage conditions which function equally to the benchmark scheme. The new switching technique appears . The boost inductor connected to the diode bridge at the nodes allows users to apply input voltage through the enhancement of S2 and S3 gate signals. The converter uses the switching mechanism presented . The duty ratios for switches S2 –S3 need to exceed 0.5 to generate signal intersection. The Inductor current will decrease linearly under $V_{in} - V_{dc}$. Then, $V_{dc}/2$ is put on the primary side of the transformer. Current in the leakage inductance flows to Cdc2 and output current flows from D8 to D7. By the end of this time interval, energy in the input inductor is fully transferred to the de-link capacitors and output diode commutation is completed. One of these operations depending on the de bus voltage and input current for these reasons is earlier than the other one. The energy stored in L_b is transferred to the de-link at $t = 15$. At $t = 16$, D8 to D7 current commutation is completed. Mode 5 [$t_5 < t < t_6$]: Cdc2 transfers to the load and $V_{dc}/2$ is applied to the primary side of the transformer. The output inductor voltage is given by $V_{Lo} = V_{dc}/2N - V_o$. The input current during DCM mode is zero. Mode 6 [$16 < t < 17$]: At $t = 16$, S4 is turned OFF and S3 only is ON.



This will enable leakage current to freewheel through D6 and the voltage across the primary side is zero. The output current is reduced linearly with $-V_o$. Mode 7 [$t_7 < 1 < 18$): At $t = 17$, S2 is turned ON. The input energy is stored in the inductor. This is as in Mode 3 but in this case the primary side current is negative. Converter Features The suggested converter offers these benefits over current two-stage PFC converters:

1) Fewer Switches/Diodes: This converter has an influence on high PF operation by just changing how it switches using the same number of switches as a three-level isolated dc/dc converter. It adds a diode-bridge and a boost inductor to the dc/dc stage. It doesn't introduce extra switches/diodes or switching actions compared to other SSTL designs. But, due to its three-level structure, it has more parts than SSFB designs 2) Adaptable DC-Link Voltage: This single-stage converter based on a three-level converter cuts the voltages across switches in half compared to full-bridge or two-stage designs. We'll talk about the loss mechanism and this give-and-take in Section III. 3) High Power Factor: Building on the last point, you can keep a higher PF with a higher dc-link voltage when the input current isn't continuous. If the converter runs at a steady duty ratio, the peak current follows a sine wave pattern. This happens because $v_{in}(t)$ is put across the input inductor terminals and the input voltage is a sine wave. So, the average current value in a switching period also has a sine wave shape. But when the switch turns OFF, a steady de bus voltage goes to the inductor terminals. This means the turn-off current averaged over the switching period doesn't follow the sine wave pattern. With a higher dc-link voltage, the downward slope of the current is steeper. This makes the current averaged over the switching period closer to a sine wave pattern. The math below explains how this works.

VI. SIMULATION RESULT

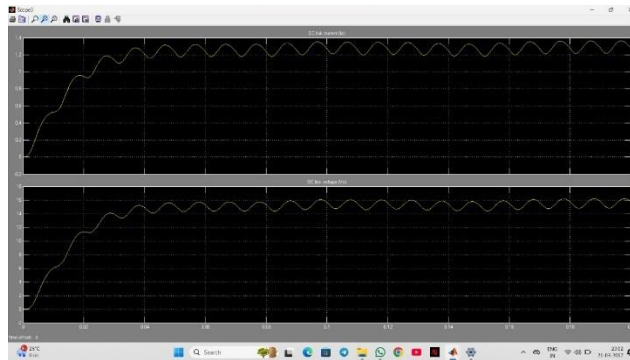


Fig .1(a) Current and voltage waveforms of existing solution

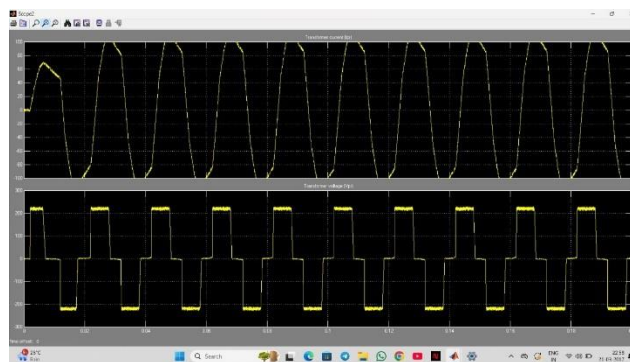


Fig .1(b) Transformer voltage and current waveforms of existing solution

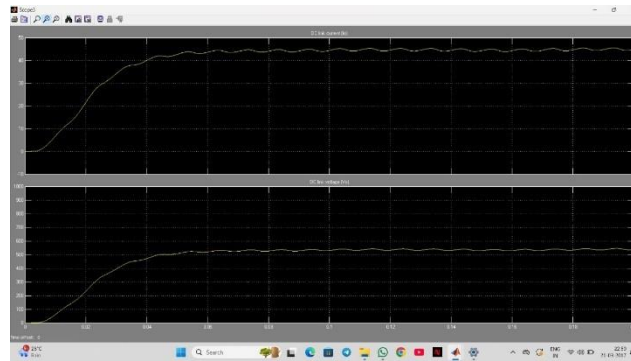


Fig .2(a) Current and voltage waveforms of proposed solution

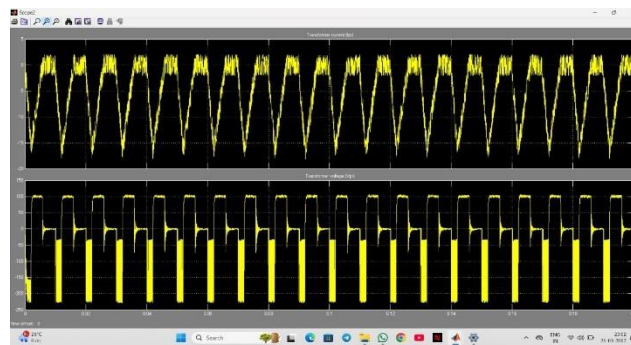


Fig .2(b) Transformer voltage and current waveforms of proposed solution

VII. CONCLUSION

Comparing fig 1(a),1(b) with fig 2(a),2(b). fig 1(a),1(b) are the waveforms of existing solution and fig 2(a),2(b) are the wave forms of present proposed solution. we concluded that after comparing the wave forms reliability and efficiency of bidirectional on board charger for EVs is increased and harmonics of bidirectional on board charger for EVs reduced .so that efficiency of bidirectional on board charger is increased. This paper began by introducing a DAB-based energy storage converter configuration. The DAB-based converter topology allows the use of parallel and series LVbridges. The dc port contains two LV-bridges to allow for some flexibility in operation and application based on the orientation of the switches. Thus, the DAB-based converter with the inclusion of a switch for specific capabilities doubles the voltage utilization, allowing for batteries (48-V, 120-V, etc.) and many more applications. The research progressed to an investigation of the converter with respect to the harmonics of the switching key waveforms, and eventually a comparison of two different transformer designs, yet still intended for use in the DAB configuration. The peculiarity of the high-current magnetics transformer with copper foil was compared to a design based on a new general construction method design for a transformer which reduced the capacitive transformer coupling between primary, and secondary by about fivefold and organized the windings layer and the three layer shield design. The proposed wire-wound shielded transformer in the two parallel LV-bridges and series HVbridge demonstrated improved characteristics with respect to common mode currents and electromagnetic compatibility, extending performance for the DAB topology. Stray capacitance was reduced through the organization and arrangement of the heatsinks and the three-layer shielding transformer layout, leading to reduced losses through reduced leakage currents and increased range of soft-switching opportunity, and compensation range of the bridge converter. The analysis also addressed comparisons between hard and soft-switching operation at reduced power to find hardswitching was the worst-case scenario in operation, this condition was the most relevant case of reduced performance fluctuations of the DAB energy storage converter. Finally, the DAB-based converter topology provided an interesting solution to energy storage and DAB converter technology for the application of increased gain, and power capabilities.

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