INTRODUCING A REVOLUTIONARY INVERTER UTILIZING SNUBBERLESS DC-DC CONVERTERS

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ABSTRACT: The inverter under consideration is a dc/dc converter without a snubber. The majority of dc-dc converters require snubber circuits to reduce voltage surges. When a traditional dc-dc converter is shut off, voltage overshoot occurs in all semiconductor components. An additional snubber circuit or voltage clamping is necessary to reduce voltage overshoot. The efficiency of the converter diminishes as the losses and number of components grow. This problem is overcome by using secondary modulation to run the converter with soft-switching capabilities. As a result, no additional snubber is required. This architecture employs Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS). The converter controls activate at ZVS and deactivate at ZCS. It is recommended to use a voltage converter with a high step-up voltage conversion ratio. The dc-dc converter's output is then connected to a thorough bridge inverter. The inverter's output alternating current is connected to the grid or supply. These inverters with snubberless dc/dc converters are typically employed in fuel cell automobiles, energy storage systems, and home photovoltaic (PV) applications. Simulink Model (Matlab Software) tools were used to model the designed system.

Key Words: Snubberless dc-dc converter, Soft Switching, Zero Voltage Switching, Zero Current Switching, Secondary modulation Technique

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1. INTRODUCTION

In 2006, Lizhi Zhu released a two-way soft-commutating isolated boost full-bridge ZVS-Pulse Width Modulation (PWM) dc-dc converter for high-power applications. They suggested a soft-commutating and control mechanism for an isolated boost full bridge converter that interacts in two ways with the well-known soft-switching full bridge dc/dc buck converter. During commutation, special commutation logic guarantees that the current in the current-fed inductor and the leakage inductance of the transformer are the same. This reduces the power rating of a voltage clamping snubber greatly, allowing you to use a passive clamped one. To minimize mismatch, the approach and control plan make use of the voltage-fed full bridge inverter's resonant tank and freewheeling circuit. It resonantly sets the transformer leakage inductance current. All voltage-fed inverter switches can be set to zero voltage when in boost mode. Soft-commutating is demonstrated by running a 3-kW bidirectional isolated full bridge dc/dc converter in boost mode for fuel cell electric vehicles. Alexander Isurin et al. investigated a soft switching passive snubber circuit with energy recovery in a report published in 2008. This passive circuit feeds energy back into the source. The "load line" returns at least 70% to 80% of the energy from the power switch to the source.

This snubber circuit allows for full leg power conversion. Wu et al. [3] described an isolated bidirectional full-bridge dc-dc converter with a fly-back snubber in 2010. They suggested a converter with a high conversion ratio, high output power, and a quiet start-up. When the leaky inductance of the current-fed inductor and the isolation transformer differs in current, the flyback snubber can prevent voltage spikes. It can also cut current in half by using current-fed active switches. Because current does not flow through the full-bridge switches, under high stress, their current stresses can be decreased, making the system more reliable. To slow starting, the flyback snubber can be adjusted.

Soft-switching bidirectional isolated full bridge converter with active and passive snubber was invented by Tsai-Fu Wu, Jeng-Gung Yang, and Chia-Ling Kuo. This design provides a bidirectional isolated soft-switching full-bridge converter for battery charging and discharging from 42V to 54V.

A soft-switching current-fed half-bridge front-end isolated DC-DC converter inverter was recommended for AC modules. For PV applications, a novel low-cost converter design with good efficiency, integration, galvanic isolation, source flexibility, and dependability is advocated. Converters regulate secondary voltage to clamp device voltage without using snubbers or active clamp circuits. This structure assists people in understanding the benefits of soft-switching and how to obtain it.

Rong-Jong Wai and colleagues create a high-efficiency two-way converter for a variety of voltage sources. To reduce switching losses, this study offers transformer-based circuit designs and soft switching technologies such as zero voltage switching (ZVS) and zero current switching (ZCS). Adding more than four switches to transformer-based topologies, however, raises production costs and reduces conversion efficiency. This research is looking for a coupled-inductor bidirectional converter technology that uses three power switches to control current in both directions. Because of its fast step-up and step-down speeds, a low-voltage battery module can be used on a high-voltage DC bus. Power from a wide range of voltage sources is converted efficiently via voltage clamping, synchronous rectification, and soft switching.

For power factor pre-regulation, zero voltage transition PWM three-level boost converters were recommended. Active soft switching circuits necessitate the addition of one more switch, which is advantageous. This design allows the major switches to turn on and off with zero voltage, lowering the reverse recovery loss of the boost diode. During switch-on, ZCS on the auxiliary switch displays how effectively the converter functions.

R. wrote this book. Gopinath et al. investigate an isolated dc-to-dc converter and a zero-voltage switching active-clamping PWM current-fed half-bridge converter. By capturing the voltage spike across switches when power is switched off, an active-clamp supports devices with soft switching. A functional clamp so loses 1% of its power. It raises switch rms current by increasing current stresses between the parts and adding flowing current. There are two more active switches, two snubber capacitors, and a huge HF capacitor required. The converter becomes increasingly complex and contains more pieces. Voltage across switches is held constant in the absence of an active clamp or dormant snubber circuits. It reduces the size and cost of the machine. The primary devices' ZCS, zero-current turn-on, and natural cycling of the secondary and body diodes of the primary devices all improve converter efficiency. Many switching transition costs are cut.

In 2010, Wei Chen, Ping Rong, and Zhengyu Lu proposed the lowest switching loss snubberless bidirectional dc-dc converter [9]. A new CLLC-type resonant tank for a two-way dc-dc converter (BDC) is proposed. In the BDC, ZVS and ZCS are used for input inverting choppers and output rectifier switches. If all major switches are metal-oxide-semiconductor field-effect transistors, this converter has the lowest switching loss. The suggested converter is soft switched and does not require snubbers. It goes over operational concepts and design considerations. A one-way ZVS+ZCS dc-dc converter is proposed for matching frequency modulation and pulse-width modulation converters. Akshay K. Rathore et al. published a paper in 2013 describing a fuel cell vehicle snubberless bidirectional naturally clamped ZCS/ZVS current-fed half-bridge dc/dc converter [10]. This paper discusses a fuel cell vehicle (FCV) snubberless naturally clamped bidirectional current-fed half-bridge isolated dc/dc converter. Primary and secondary active semiconductor devices with zero-current switching (ZCS) and zero-voltage switching (ZVS) are used in the proposed converter. It could power fuel cell cars, convert alternating current to direct current at fuel cell inverters, and store energy. When the switch is turned off with ZCS, a proposed secondary modulation clamps the voltage across the primary-side devices and eliminates voltage spikes, so no additional circuit is required. This saves money. Unlike other current-fed converters, primary-side current-fed devices limit voltage at a mirrored output voltage rather than duty cycle. By choosing devices with low voltage ratings and ON-state resistance, this decreases conduction losses and enhances efficiency.

Pan Xuewei and colleagues have created a full-bridge isolated interleaved soft-switching bidirectional current-fed device for FCVs. Despite considerable changes in output power, this ZCS current-fed full-bridge dc/dc converter keeps semiconductor devices' ZCS off and ZVS on. Important devices have also had less turn-on loss. Keeping all devices soft-switched reduces switching loss and allows the converter to operate at a higher frequency, allowing the system to be smaller and more power-dense. With zero-current commutation, this modulation approach automatically clamps the voltage across primary-side devices. In current-fed systems, this eliminates the need for active clamps or passive snubbers to absorb the device turn-off voltage surge. The interleaved topology improves power handling. It is possible to achieve better thermal distribution, lower input current ripple, fewer passive elements, and lower voltage and current.

Pan Xuewei et al. published soft-switching snubberless naturally clamped current-fed full-bridge front-end converters in 2014. It is proposed to use a novel naturally clamped zero-current commutated soft-switching bidirectional current-fed full-bridge isolated dc/dc converter. This secondary-modulation technique uses zero-current commutation to clamp the voltage across primary-side devices, eliminating the need for active-clamp circuits or passive snubbers. When main and secondary devices convert to zero current and voltage, respectively, low switching losses result. Load-independent voltage holding and soft switching are included in. Even when the input voltage and output power fluctuate, the duty cycle has no effect on the primary-side device voltage. Because the voltage is clamped at a low mirrored output voltage, low voltage semiconductor devices can be employed. Because of its benefits, the converter is essential for fuel cell cars, fuel cell inverters, and energy storage.

Udupi R. Prasanna and Akshay K. Rathore developed a soft-switching snubberless current-fed half-bridge front-end converter for photovoltaic inverters in 2013. This denotes the introduction of a new solar-focused snubberless current-fed half-bridge front-end isolated dc/dc converter-based inverter. It can be utilized on-grid with or without a utility interface. Secondary modulation is used by the converter to clamp device voltage without the usage of a snubber or active-clamp. Primary devices can switch to zero-current or natural commutation, while secondary devices can switch to zero-voltage.

Battery chargers, electric autos, cell phones, laptop computers, and other devices need DC/DC converters. The converter should be able to safely transition from no-load to full load as a battery charger after fully charging. The primary disadvantage of the typical full bridge DC/DC converter design is that it cannot guarantee ZVS for a wide range of load fluctuations. Transformer leakage inductance causes output diodes to spike. A current-fed full-bridge snubberless DC to DC converter topology eliminates voltage stress and allows for smooth switching.

2. PROPOSED SYSTEM

The dc/dc snubberless converter was inexpensive, efficient, and had a high step-up conversion ratio. Due to its high voltage gain and simple circuit construction, the boost converter was previously the best option. Electricity is limited by hard switching. This raises switching losses and inefficiencies in the system. Power can be increased by using parallel power devices. As a result, this method cannot reduce input and exit current ripples. Interleaved construction can increase power, minimize current ripple, reduce the size of passive components, improve transient reactivity, and allow for heat distribution. Power devices, on the other hand, hard switch, making them less efficient.

The goal of this program is to make switching all semiconductor devices easier. A novel secondary modulation technique can clamp voltage without the need of snubbers. Switching losses are considerably reduced with zero-current and zero-voltage switching. Soft switching is pre-installed, load-independent, and steady even when input voltage and power fluctuate. It is suitable for usage in PV. High-frequency transformers and boost converters increase the voltage at the output. Furthermore, the boost converter separates the input and output stages. Unlike the usual boost converter, which has a high duty cycle and switch voltage stress, the recommended converter is inexpensive, has a high step-up conversion ratio, and performs smoothly.

Operation of the proposed system

The steady-state operation and analysis of the proposed high step-up dc-dc converter are discussed here. To simplify the proposed system, the following assumptions are made:

The large boost inductor L keeps the current steady.

Every component is excellent.

Transformer leaking inductances are contained in series inductors Llk1 and Llk2. Llk_T is the sum of Llk1 and Llk2.

The magnetizing inductance of a transformer is high.

The stable-state working waveforms show that the primary switches S1 and S2 are activated and deactivated using 180° out-of-phase gating signals. Best to keep duty cycle above 50%. The waveforms in fig.3 simplify the proposed system.

MODE 1 (to < t < t1)

The first mode. The secondary side switch's anti-parallel body diode D3 and main side switch S2 conduct. The system's HF transformer powers the load. The main device S1 blocks the reflected output voltage VDC/n, while the secondary device S4 doesn't conduct electricity. Currents across the sections are: iS1 = 0, iS2 = Iin, iLlk1 = 0, iLlk2 = Iin, and iD3 = Iin/n. The voltage across switch S1 is VDC/n. VS4 = VDC across switch S4.

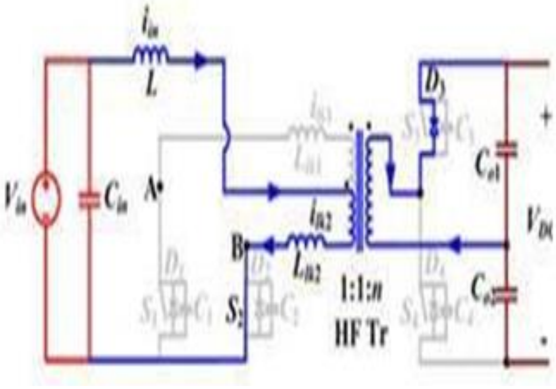

Fig -1: Mode 1

MODE 2 (t1 < t < t2)

S1, the main switch, is on at t1. Soon after, capacitor C1 leaks electricity. S1 entirely conducts and C1 totally releases after this time.

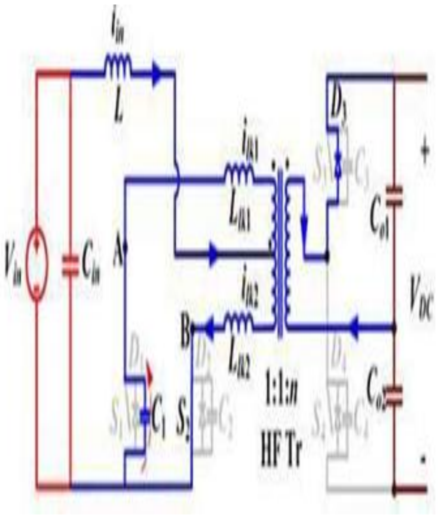

Fig -2: Mode 2

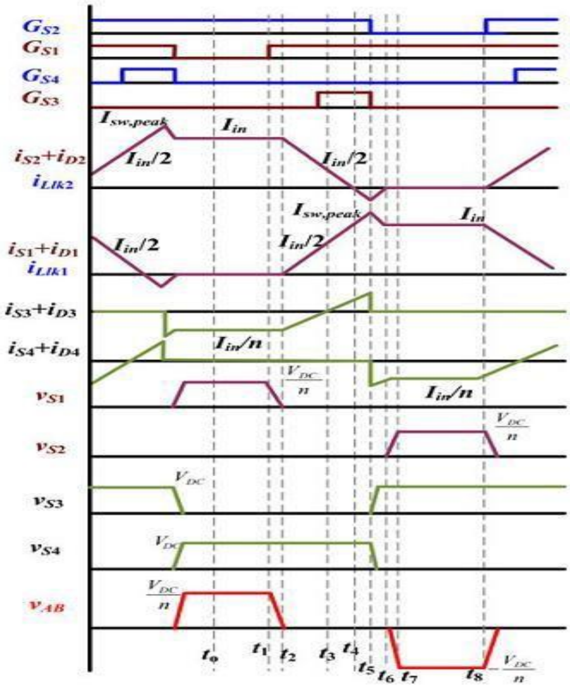

Fig -3: Waveforms of the proposed system

MODE 3 (t2 < t < t3)

This option opens both major switches (S1 and S2). Reflected output voltage across series inductors Llk1 and Llk2 shifts current from switch S2 to S1. The previously conducting gadget S2's current drops straight down. Thus, switch S1 conducts without current, reducing turn-on losses. Body diode D3 conducts before this time-out. To activate ZVS, turn on S3. After that, D3 will switch statuses. All major devices' current reaches Iin/2. The total numbers are iLlk1 = iLlk2 =Iin/2, iS1 = iS2 =Iin/2, and iD3 = 0.

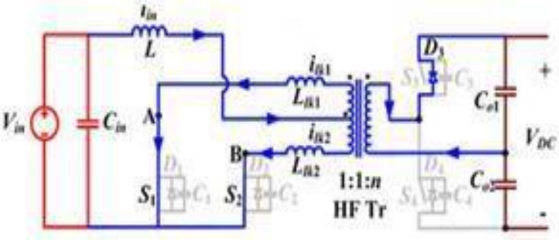

Fig -4: Mode 3

MODE 4 (t3 < t < t4)

Mode 4 has the secondary side switch S3 on and no voltage change. All switching device currents rise or fall with interval 3. After this period, Zero Current Commutation (ZCS) adjusts the main side switch S2 on its own. ZCS occurs when iS2 goes to zero. Another device, S1, takes up the input current. iLlk1 = iS1 = Iin, iLlk2 = iS2 = 0, and iS3 = Iin/n are the final figures.

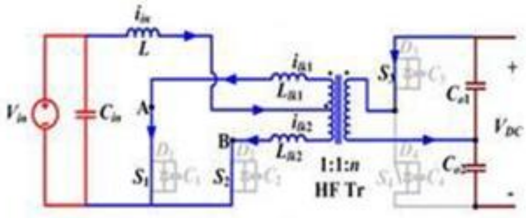

Fig -5: Mode 4

MODE 5 (t4 < t < t5)

The leaky inductance current iLlk1 rises even further with the same slope, and the anti-parallel body diode D2 conducts. To turn off the ZCS, the extended zero voltage appears over the commutated switch S2. Now turn off backup device S3. Switch S1 has the most current after 5 periods.

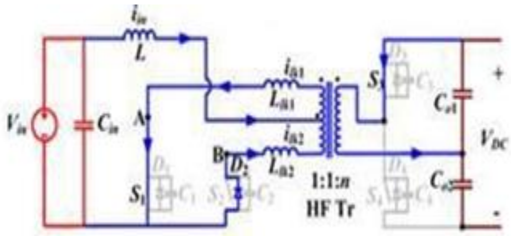

Fig -6: Mode 5

MODE 6 (t5 < t < t6)

Mode 6 disables secondary side switch S3. Switch S4's anti-parallel body diode D4 takes up the current immediately. Voltage across the transformer's primary switches polarity. Current through switch S1 and body diodes D2 decreases. The circuit automatically commutates when D2 current goes to zero after this time. S1 carries current to Iin.

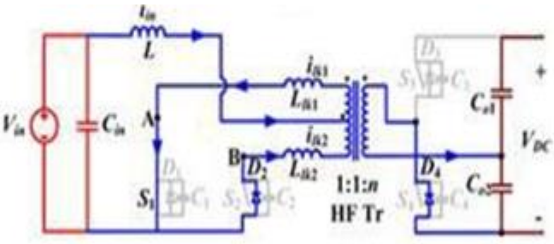

Fig -7: Mode 6

MODE 7 (t6 < t < t7)

In this mode, capacitor C2 charges quickly and stays charged to VDC/n. Switch S2 allows forwarding block.

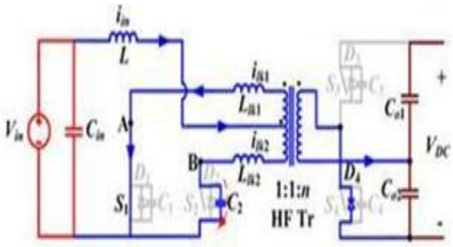

Fig -8: Mode 7

MODE 8 (t7 < t < t8)

S1 and transformer currents remain constant at Iin. Iin/n flows through secondary switch D4's anti-parallel body diode. Final numbers: iLlk1 = iS1 = Iin, iLlk2 = iS2 = 0, and iD4 = Iin/n. The voltage across switch S2? VDC/n = VS2. Current has flowed from switch S2 to S1, changing the transformer current direction.

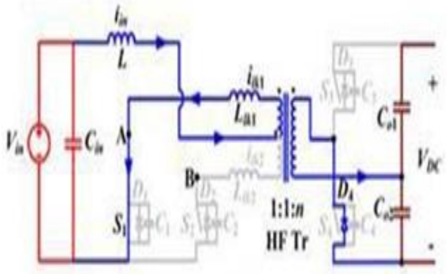

Fig -9: Mode 8

3. SIMULATION RESULTS

The proposed system's simulink model is here. It can make pulses, convert dc to dc, and operate a full-bridge inverter.

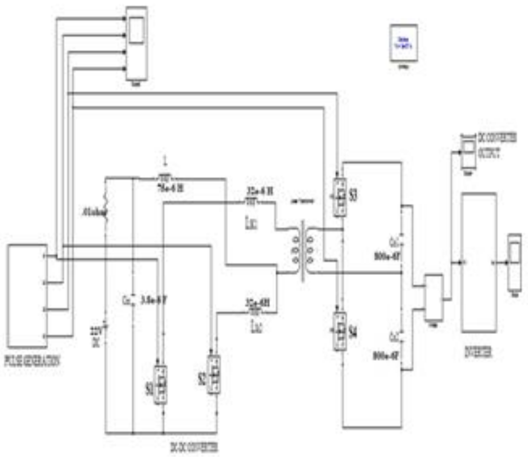

Fig -10: Simulink Model of Suggested System

PWM generates waves for switches S1, S2, S3, and S4. PWM signals are created by comparing a triangle carrier wave to the duty cycle ratio and delaying each switch. The carrier wave changes at 10 kHz.

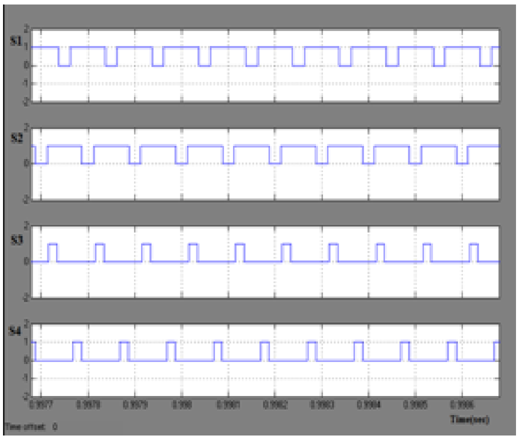

Fig -11: DC-DC converter switching pulses

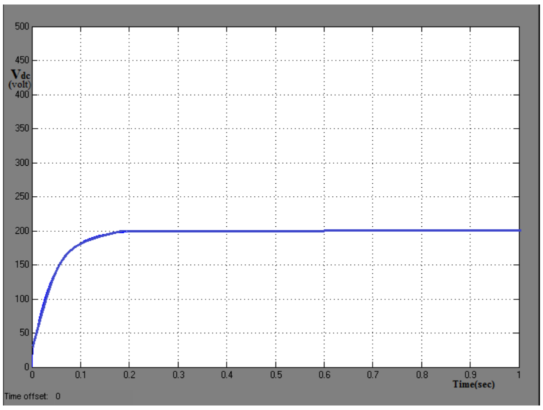

Fig -12: Snubberless DC-DC converter output for 12V input.

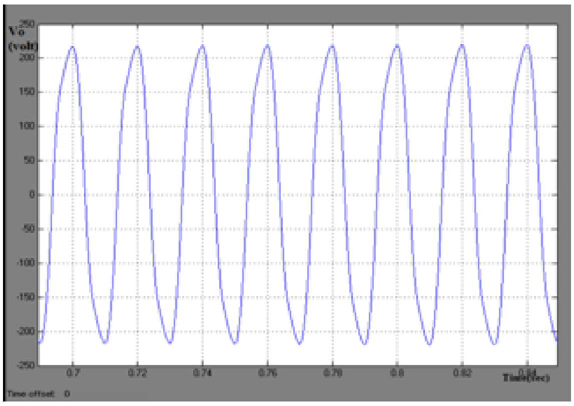

Fig -13: Full bridge 12V output

4. CONCLUSION

This snubberless dc/dc converter inverter allows soft switching. Most dc-dc converter inverters have snubber circuits. However, flowing current and high ON-state resistance devices will generate losses, reducing efficiency. More parts increase machine size and expense. Thus, the proposed system uses secondary modulation. Secondary modulation allows soft switching characteristics like Zero Current and Zero Voltage Switching and eliminates the need for snubber circuits in dc-dc converters, making it unique and snubberless.The converter offered can convert one type of direct current to another and generate 200V from 12V. Then, the complete bridge inverter connects to the dc-dc converter output. Inverters generate AC power for the grid or load. Lower switching and conduction losses, high step-up conversion ratio, and good performance are this system's main advantages.

These snubberless dc/dc converter-based inverters are typically utilized in fuel cell automobiles, energy storage, and home PV systems. The designed system was modeled using Simulink (Matlab).

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