NULL VOLTAGE TRANSITION SNUBBER CELL PWM-PFC BOOST CONVERTER

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ABSTRACT

For the PWM-PFC (Power Factor Corrected) Boost converter, a ZVT (Zero Voltage Transition) snubber cell is built in the proposed system. Apart from the traditional boost converter, the main and all auxiliary diodes in the proposed system work under soft switching. With ZVT, the key switch is perfectly turned ON, and with ZVS, it is perfectly turned off. The auxiliary switch is activated by ZCS and deactivated by ZVS, much like the main switch. During ZVT operation, the transformer passes the switching energy from the snubber inductance to the output, decreasing current strains on the inductance and switches. As a result, the main diode and main switch are not subjected to severe voltage or current strains. Also, for switching operations, this device has a suitable number of capacitors.

I. INTRODUCTION

Energy consumption has increased as a consequence of technical improvements and increased wealth, so it can be used more efficiently and economically. Increased nonlinear loads drain harmonic currents, leading grid-connected devices to malfunction and corrupt. As a consequence, the resource may be utilised effectively. In terms of high quality and dependability of energy utilisation, there are worldwide necessary criteria for power factor and harmonics. As a result, computer makers use a number of approaches known as Power Frequency Correction (PFC) circuits to achieve these criteria. Despite the fact that bulk passive filters and very complex and expensive active filters can be used to increase power factor, academic and industrial applications are increasingly focusing on high frequency AC-DC converter based PFC circuits. PFCs have been used to improve energy efficiency and quality in a variety of ways. Reactive power and harmonics are reduced to zero using PFC entities. The waveform of current drawn from the source approaches a sinusoidal wave as frequency rises in PFC circuits, reducing Total Harmonic Distortion (THD) of currents. Boost converters are widely used in power factor adjuster AC-DC Converters due to their simple structure, ease of operation, and high power density. Continuous Current Mode (CCM) is preferred in high power applications. In this case, the main diode's reverse recovery causes turn of loss on the diode and turning on loss on the main switch, EMI, and, as a result, a decline in performance.

II. PROBLEM DEFINITION

As rise in frequency in order to achieve a higher-quality PFC, the above-mentioned issues become more prevalent. Soft switching (SS) methods, rather than hard switching (HS), can be used to address these issues. Zero voltage switching (ZVS), zero current switching (ZCS), zero voltage transfer (ZVT), and zero current transition (ZCT) are the four forms of SS techniques (ZCT). When a MOSFET is used as a power transfer, the parasitic capacitor's discharge failure becomes substantial. Using an antiparallel diode to the main switch, an auxiliary switch, and an inductor, the basic ZVT technique recovers parasitic capacitor energy for active suppression. The main switch is perfectly turned on with ZVT, and the main diode is perfectly shut off with ZCS in this circuit. For ZVS main switch turn off and ZVS main diode turn on, a parallel capacitor can be connected to the main switch. On the other hand, the auxiliary switch shuts down rapidly and has a high current tension in the circuit. In addition, adding a capacitor to the key switch exacerbates the problem.
BLOCK DIAGRAM

CIRCUIT DIAGRAM

Fig 1

Vi - Rectified line voltage, Vo - Output voltage, TB – Main switch, DTB - Anti-parallel diode of the main switch, DB - Boost diode, LB - Boost inductor, Co - Out-put capacitor, Ro - Load resistor, TS - Aux-iliary switch, (D1, D2, D3, D4) - Snubber diodes, LS - snubber inductor, TR - Center tapped transformer, LM - magnetizing inductor, (CS1, CS2) - Snubber capacitors.

III. OPERATING STAGES

Over the course of one switching cycle, the proposed converter goes through nine stages. TB and TS are in the off state at t0. When the main diode DB is turned on, it conducts the input current Ii of the main inductor LB to the load.

STAGE 1: At time t=t0, the turn on signal VGSTS is applied to the gate of the auxiliary switch TS. The semiconductor devices TS, D1, and D3 are activated by ZCS. The snubber inductor LS controls the current increase rate via TS, D1 and D3. The DB current is zero at time t = t1. At t = t2, the primary diode DB is turned off with ZVS owing to CS1 and ZVS via LS, completing this step. As a result, auxiliary component current strains are greatly reduced.
STAGE 2: \( i_{TB}=0, i_{TS}=i_{LS2}+i_{LM2}, i_{DB}=0, i_{LS}=i_{LS2}, i_{LM}=i_{LM2}, v_{CS1}=V_{o}, v_{CS2}=0 \) are valid at \( t=t_2 \).

Under the input current \( I_i \), a resonance begins between \( CS1, LM, \) and \( LS \) in this interval. The voltage on \( CS1 \) falls to zero at the end of this interval, and the body diode \( DTB \) of the main switch \( TB \) is turned on with ZVS via \( CS1 \). During this interval, switching energies, including \( CS1 \), are transferred to both the \( LS \) and \( LM \) inductors and output via the \( LS \). It should be noted that the parasitic capacitors of the main diode are included in the capacitor \( CS1 \).

![Fig 3](image)

STAGE 3: \( i_{TB}=0, i_{TS}=i_{LS3}+i_{LM3}, i_{DB}=0, i_{LS}=i_{LS3}, i_{LM}=i_{LM3}, v_{CS1}=0, CS2=0 \) are valid at \( t=t_3 \). The antiparallel diode \( DTB \) of the primary switch \( TB \) is switched on. The turn on signal \( VGSTB \) is applied to the \( TB \) gate during this time, which is the zero-voltage transition interval. The voltage applied to the \( LM \) inductor and transformer is zero at this time, and the voltage produced by the \( LS \) inductor is the same as the voltage applied to the \( LM \) inductor and transformer. At \( t=t_4 \), the auxiliary switch \( TS \)'s gate signal is deleted, resulting in \( TS \) being perfectly switched off with ZVS and \( TB \) being perfectly switched on with ZVT, and the stage being finished. The \( LS \)'s energy is transmitted to the output, reducing current strains in the auxiliary components.

![Fig 4](image)

STAGE 4: \( i_{TB}=0, i_{TS}=i_{LS4}+i_{LM4}, i_{DB}=0, i_{LS}=i_{LS4}, i_{LM}=i_{LM4}, v_{CS1}=0, v_{CS2}=0 \) are valid at \( t=t_4 \). After the auxiliary switch \( TS \)'s gate signal is removed, \( i_{TB}=I_i-I_{LS4} \) and \( i_{TS}=0 \), and this stage begins. During this interval, a resonance occurs between the \( LS, LM \) inductors, and the \( CS2 \) capacitor under constant input current \( I_i \), as shown in the equivalent circuit's paths. At \( t=t_5 \), the inductor current \( i_{LS} \) goes to null, the \( D3 \) diode is turned off, completing this stage. At this point, \( CS2 \)'s auxiliary switch the voltage is applied, and switch \( TS \) is thus turned off under ZVS via \( CS2 \). In addition, under ZCS, the \( D3 \) diode is switched off via \( LS \). \( LS \) energy is also being transferred to output and contributing to the decrease of current tensions.
**STAGE 5:** \(iT_B=I_i, iT_S=0, iDB=0, iLS=0, iLM=ILM_5, vCS_1=0, vCS_2=VCS_{25}\) are valid at \(t=t_5\). This stage begins when the D3 diode is turned off and \(iD_2=ILM_5\). A resonance occurs between LM and CS2 during this interval. At \(t=t_6\), the CS2 voltage reaches VO, and the D4 diode with ZCS turns on, bringing this stage to a close.

**STAGE 6:** At \(t=t_6\), the following values are valid: \(iT_B=I_i, iT_S=0, iDB=0, iLS=0, iLM=ILM_6, vCS_1=0, vCS_2=Vo\). This stage begins when the D2 and D4 diodes are both turned on at the same time, and the values \(iT_B=I_i-ILM_6\) and \(iD_2=iD_4=ILM_6\) are valid. The current of LM declines to zero at \(t=t_7\), while the current of TB increases to \(I_i\) in a simultaneous and linear manner, completing this stage.

**STAGE 7:** The main toggle switch During this stage, TB continues to conduct input current \(I_i\), and the snubber circuit is turned off. The duty cycle determines the duration of this stage, which is the normal on-state duration of a traditional PWM converter.
STAGE 8: The switch signal of gate SB is removed at t=t_8 to start this stage. During this interval, input current I_i charges and discharges the CS1 and CS2 capacitors synchronously and linearly. The voltage of CS1 hits V_0 at t=t_9, while the voltage of CS2 falls to zero, leading the main diode DB to turn on and the stage to finish.

The sum of CS1 and CS2 ensures that the main switch is switched off and the main diode is activated with ZVS at this moment.

STAGE 9: During this stage, the primary diode DB conducts input current continuously. The snubber circuit has been disabled. This time gap represents between the typical converter (PWM) to off position, and the duration of this stage is proportional to the duty cycle. This stage is finished at t=t_{10}=t_0, when the control signal of TS is applied to its gate, and a new switching period begins.

IV. HARDWARE DESCRIPTION

TRANSFORMER: A transformer is a permanent component that converts electric power from one circuit to electric power from another circuit at the same frequency. By increasing or lowering current, it can alter the voltage in the circuit. The mutual induction concept is used. The electronic circuits in our project are powered by a step-down transformer. Here, we convert 230v ac to 110v ac and 230v ac to 12v ac.

FULL BRIDGE RECTIFIER: Using a technique known as Rectification of the complete waveform, a dc level derived from a sinusoidal input can be enhanced by 100%. To achieve complete wave rectification in our project, we employ a bridge rectifier. From t = 0 to T/2, the basic bridge setup shows two diodes (say, D2 and D3).
conducting and the other two diodes (D1 and D4) in the off state. The conducting diodes for the negative cycle of the input are D1 and D4. As a result, the polarity of the load can be switched. The 1N4007 is used because it can tolerate up to 1000 volts.

**FILTER:** To get a dc voltage of 0 Hz, you'll need a low pass filter. As a result, a capacitive filter circuit is utilised, with a capacitor connected to the rectifier output and a direct current flowing through it. In essence, the filtered waveform is a dc voltage with small ripples.

**MOSFET:** The switch in the inverter unit is a MOSFET, which is a voltage-controlled mechanism. They're power semiconductors with quick switching capabilities and a simple drive need. To the designer, this MOSFET delivers the optimum mix of rapid switching, low resistance, and cost-effectiveness. This kit is ideal for commercial and industrial applications that require more power.

**DRIVER CIRCUIT:** It is used to supply 9 to 20 volts to the inverter's MOSFET switches. The voltage from the microcontroller, which is 5 volts, is amplified by the driver. It also has an optocoupler for isolation. As a result, MOSFET damage is avoided eventually fed to the load.

**PIC 16F877A MICROCONTROLLER:** A multilevel inverter uses a PIC 16F877A to create switching pulses. so that vectors at the inverter poles do not produce any common mode voltage. The use of common mode voltage is no longer necessary. It's also utilised to remove capacitor voltage that isn't balanced. The driving circuit supplies power to the microcontroller and elevates 9V as trigger signal. We incorporate an isolator in the form of an optocoupler in the same driver circuit to safeguard the microcontroller from harm caused by direct 230V supply. We incorporate an isolator in the form of an optocoupler in the same driver circuit to safeguard the microcontroller from harm caused by direct 230V supply.

**OPTOCOUPLEER:** Optoisolators are another name for optocouplers. An optoisolator consists of an optical emitter, such as an LED, neon bulb, or incandescent bulb, and an optical receiver element, such as a resistor that changes resistance as light intensity varies, or a transistor or other device that conducts differently when exposed to light. This type of device is used to separate the control voltage from the controlled circuit.

### V. HARDWARE PROTOTYPE

![Prototype image]

### VI. CONCLUSION

To produce a dc voltage of 0 Hz, we'll need to use a low pass filter. As a consequence, a capacitive filter circuit with a capacitor linked to the rectifier output and a dc acquired through it is employed. The filtered waveform is
nothing more than a low-noise dc voltage, which is then provided to the load. The auxiliary switch is activated by ZVS and deactivated by ZCS. Both of the diodes are in SS mode During ZVT operation, the switching energies are transmitted to the output via a transformer, reducing current strains on the auxiliary components. This transformer also ensures ZVS has sufficient capacitors to turn off the main and auxiliary switches. The voltage and current stress on the primary switch and primary diode components are not significant. There is no extra voltage limitation on the auxiliary switching voltage. In addition, the recommended converter may work with either a voltage or a current as an input. The new converter features a basic design, is easy to use, and is reasonably priced.

REFERENCES: