Modified High Step up DC to DC Converter for Fuel Cell Power System

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***Abstract*- This paper inspects a novel PWM plan for two phase interleaved assistance converter with voltage multiplier for power module power framework by consolidating Exchanging Stage Shift (APS) control furthermore,customary interleaving PWM control.A grid connected fuel cell backed up by a super capacitor is consideredfor study. Fuel cell output voltage must be boosted before connecting to the grid. While using boost converter EMI interference andswitching losses will be high. Therefore, a high step up DC to DC converter is used for better performance. Reliability of system is improved by adding a super capacitor, which has higher lifespan compared to a battery. MATLAB is used for simulation. Finally, a satisfactory output results are presented.**

***Index Terms*- Boost Converter, Loss Breakdown, Fuel CellVoltage Multiplier**

I. INTRODUCTION

Energy unit is one of promisingdecisions because of its principal points of zero discharge,low voltage, higher energy, and beingeffortlessly modularized for compact force sources,electric vehicles, conveyed era frameworks, and so on[1].The matrix associated power framework in view ofenergy component is appeared in Fig. 1. For a regular10-kW proton trade layer power module, the yieldvoltage is from 65 to 107 V. In any case, the datavoltage of the three stage dc/air conditioning convertershould be around 700 V; the voltage increase of thedc/dc converter between energy unit and the dc/ac converter will be from 6 to 11 V. A highstride up dc/dc converter is required for the frameworkas appeared in Fig. 1. The dc/dc converter will producea high recurrence info current swell, which willdiminish the life time of the energy unit stack [2]–[4].Furthermore, the hydrogen vitality usage diminisheswith expanding the present swell of the energycomponent stack yield [5]. Along these lines, the dc/dcconverter for the framework as shown in Fig. 1 shouldhave high step-up ratio with minimum input currentripple.

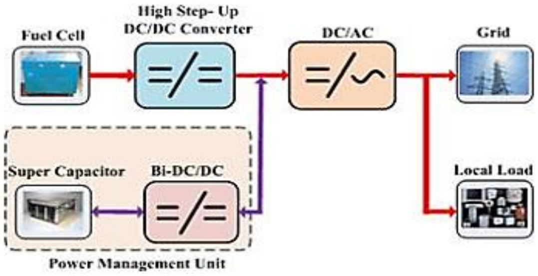


Fig.1.Grid-connected power system based onFuel cell

High step-up ratio can be achieved by combining classicalboost converter with switched inductors [6], coupled inductors [7]–[9], high-frequency transformer [10], or switched capacitor [11]–[14], [19]. They can obtain high step-up ratio withhigh efficiency, low-voltage stress, and low electromagnetic interference. In order to reduce output fuel cell stack output current ripple or the dc/dc converter input current ripple, either apassive filter [15] or active filter [5] can be used, however, thiswill increase the complexity of the system. In fact, interleavingthe dc/dc converter can reduce the input current ripple of thedc/dc converter [16]. An interleaved boost converter with voltage multiplier was proposed in [13], [14]. Its voltage gain wasincreased up to (M +1) times (M is the number of the voltagemultiplier) of the classical boost converter with the same dutycycle D and lower voltage stress. Besides, it has lower inputcurrent ripples and output voltage ripples in comparison to theclassical boost converter. The interleaving boost converter withvoltage multipliers is shown in Fig. 2.The converter shown in Fig. 2 can achieve low-voltage stressin the power devices, which increases the conversion efficiency.However, this is only true in heavy load when the voltage stressof the power devices might increase when it works in discontinuous conduction mode (DCM) [17], which occurs when fuel cellonly supplies a light local load as shown in Fig. 1.

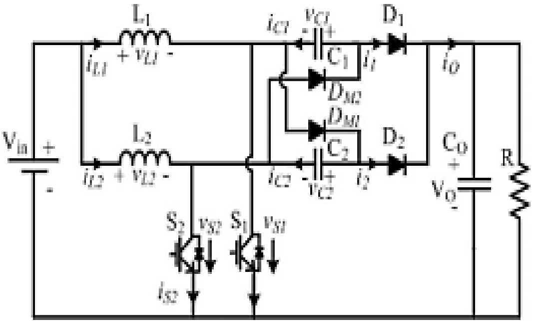


Fig. 2.Structure of two-phase interleaved boost converter with voltagemultiplier [13], [14].

In this case,higher voltage power devices need to be used, and therefore itscost and power loss will be increased.This paper explores a novel PWM plan for two phaseinterleaved support converter with voltage multiplier forEnergy component Power Framework by joining APS andconventional interleaving PWM control. The APS controlis utilized to diminish the voltage weight on switches inlight load while the customary interleaving control isutilized to keep better execution in substantial burden. Thelimit condition for swapping between APS and customaryinterleaving PWM control is determined. In view of theabove examination, a full power reach controlconsolidating APS and customary interleaving control isproposed. Misfortune breakdown examination is likewisegiven to investigate the proficiency of the converter. Atlong last, it is checked by test results.

II. METHODOLOGY OF SYSTEM

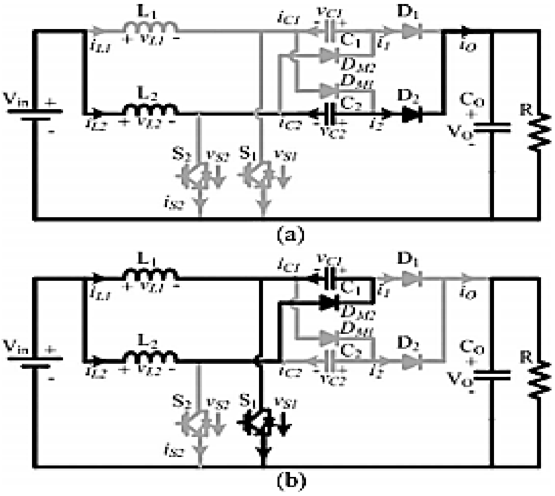
Considering the utilization of ideal components, capacitor C_1 and C_2 with big enough value, and duty cycle less than 0.5, the operation could be divided into 6 stages at boundary condition as shown in Fig.2 And main theoretical waveforms at boundary condition.

1) First Stage (t0, t1): At the moment of t0, the switch S_1 and S_2 are in off-state, the energy stored in the inductor L_2 in previous stage is transferred to the output capacitor C_O through C_2 and D_2, and the other diodes are in off-state as shown in Fig.3(a). The voltage stress on both switch S_1 and S_2 is V_o-V_{c2}.

2) Second Stage(t1,t2): At the moment of t_1, the switch S_1 is turned on, the inductor L_1 starts to store energy from zero, the diode D_2 will be turned off as the energy in the inductor L_2 and the capacitor C_2 is notenough to be transferred to the output capacitor C_O at the beginning of the stage as shown in Fig. 3. The capacitor C_2 in the First Stage and the capacitor C_1 in previous switching cycle are both in discharging state, thus their voltage sum is less than Vo, the energy stored in the inductor L_2 will be transferred to the capacitor C_1 through the diode DM2 at first. Considering the period of the First Stage and the energy stored in the inductor L_2, if there is still enough energy in C_2 and L_2 at the beginning of this stage or the energy in C_1 is charged to be enough after t1, there will be a stage that the diode is still in conduction state as shown in Fig.3; otherwise the voltage in C_1 and C_2 will decrease to be less than half of the output voltage, increasing the voltage stress on switch S_1 and S_2. However, this violates the boundary condition. Above all, the energy of C_1 for charging is equal to the one for discharging at boundary condition. And the diode D_2 is in off state during the stage.

3) Third Stage(t2,t3): At the moment of t2, the current in the inductor L_2 just falls to zero, all the diodes are in off state and the inductor L_1 is in charging state. In the end of this stage, the current in the inductor L_1 comes to the peak value IL1P is where Vin is the input voltage, L is the inductance of L_1 and L_2,D_m is the duty cycle at boundary condition, and TS is the switching period.

4）Fourth Stage (t3,t4): At the moment of t3, switch S_1 sand S_2 and all the diodes are in off state, the energy in the inductor L_1 will be transferred to the output capacitor C_O through the capacitor C_1 and the diode D_1. The voltage stress on switch S_1 and S_2 is V_o-V_{c1}. In the end of thisstage, the current in the inductor L_1 decreases where V_O is the output voltage and V_{C1} is the voltage of the capacitor.



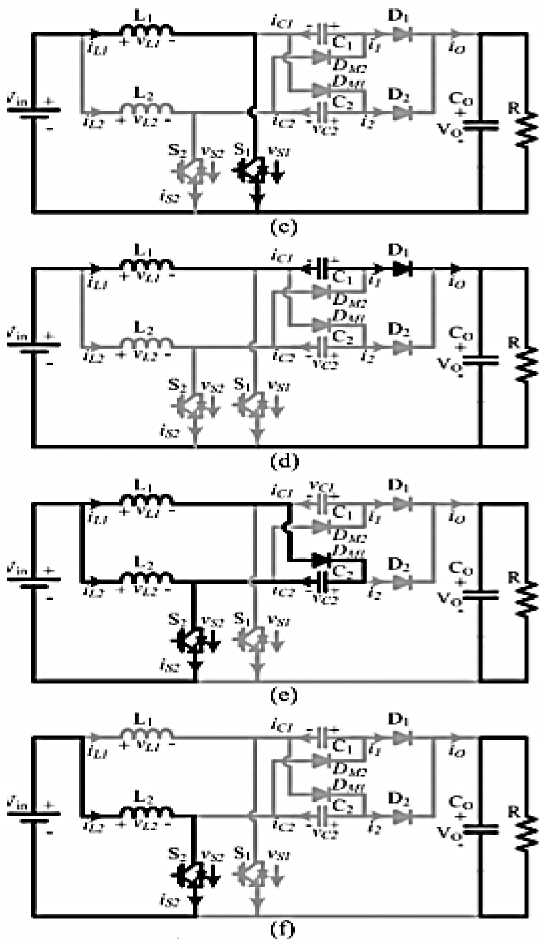


Fig. 3.Stages at boundary condition. (a) First stage (t0, t1), (b) second stage(t1, t2), (c) third stage (t2, t3), (d) fourth stage (t3, t4), (e) fifth stage (t4, t5),(f) sixth stage (t5, t6)

5) Fifth Stage(t4,t5): At the moment of t4, the switch S_2 is turned on and the inductor L_2 starts to store energy. The amount of the energy in the inductor L_1 determines whether the capacitor C_2 is in charging state, which is similar to the Second Stage. In the end of this stage, the current in the inductor L_1 decreases to be zero from I_{L1M} .

6) Sixth Stage(t5, t6): At the moment of t5, the current in the inductor L_1 decreases to be zero. All the diodes are in off state and the inductor L_2 is in charging state until the stage comes to the end at the moment t6, at which a new switching period begins with the next First Stage. From the above analysis, the energy in the inductor L_1 for charging C_2 is equal to the energy for discharging C_1 while the energy in the inductor L_2 for charging C_1 is equal to the energy for discharging C_2 at boundary condition. Once the energy for charging is greater than the energy for discharging, the converter will operate above the boundary condition, and the stage as shown in Fig.3 which also happens when duty-cycle is greater than 0.5 will appear; otherwise, the voltage sum of capacitor C_1 and C_2 will be less than Vo. As the voltage stress on switch S_1 and S_2 is V_O-V_{C1} and V_O-V_{C2} respectively, their voltage stress will be increased larger than $V_o/2$.

III. RESULTS AND DISCUSSION

In order to verify the previous analysis, a simulation model is built. The circuit parameters are as follows, Vin=100V, VO=700V, C1=C2=40μF, CO= 500μF,L1=L2=480μH, TS=100μs.The voltage stress on power switches in all power range of the load. The voltage stress almost keeps half of the output voltage. Therefore, the control scheme proposed in this paper could achieve low voltage stress in all power range of the load.

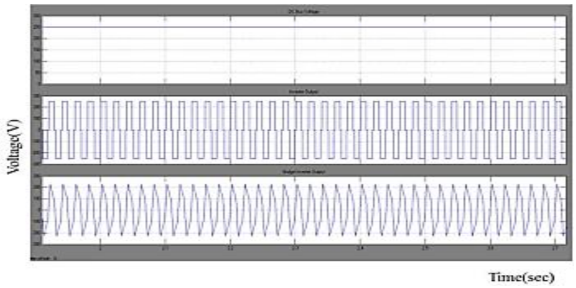


Fig. 4. Output Waveform of Inverter

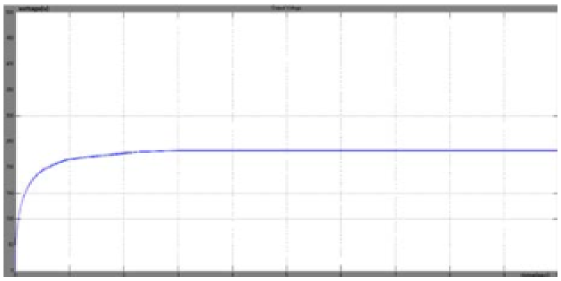


Fig. 5. Output Waveform Bidirectional Converter

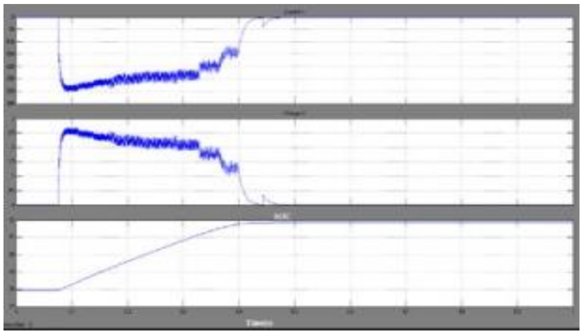


Fig. 6. Super capacitor Output Waveform

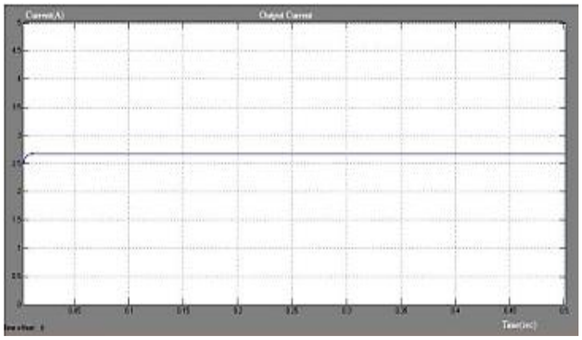


Fig.7. Output Current Waveform

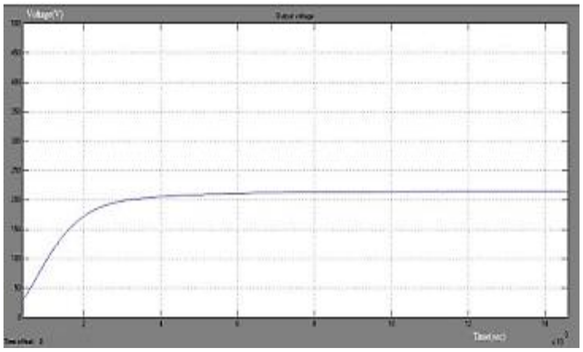


Fig. 8. Output Voltage Waveform

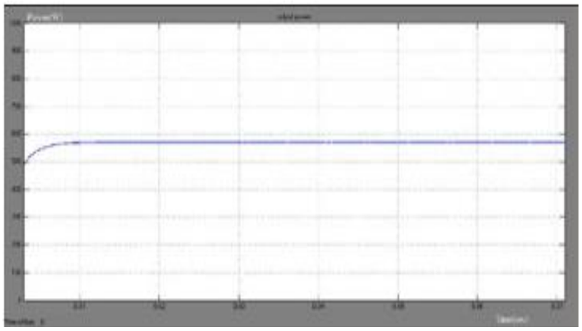


Fig. 9. Output Power Waveform

IV. CONCLUSION

The limit condition is conditional after stage investigationin this paper. A high voltage DC to DC converter is used to boost fuel cell voltage before connecting to a grid. By using this EMI interference, stress caused on the devices and switching losses are diminished to a reasonable limit. The proposed system output are validated to prove better performance and enhanced efficiency.

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