

High efficiency zero voltage switching PWM Push-Pull DC-DC converter for PV system

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ABSTRACT

For domestic photo-voltaic systems a PWM push pull DC-DC converter is used with zero voltage switching to obtain high efficiency. Thus the proposed system consist of PV cell, converter, inverter and MATLAB/ Simulink was used to build the dynamic model and simulate the system. Over the past decade due to large depletion of fossil fuels and green gas emission renewable energy has experienced drastic growth. Solar photo-voltaic(PV) are proven to be most promising among the other renewable energies. A zero voltage switching enables the voltage regulator to avoid the switching losses that are typically incurred during conventional PWM operation. Push pull converter have steadier input current, create less noise on the input line and more efficient in higher power applications.

Index Terms– Zero Voltage Switching (ZVS), Pulse Width Modulation (PWM), Photo-Voltaic (PV).

INTRODUCTION

Conventional energy sources based on oil, coal, and natural gas are proven to be highly effective drivers of economic progress. At the same time it may cause damage to the environment and to human health. The potential of renewable energy is enormous as they could meet many time the world's energy demand. Thus, this transition to renewable-based energy systems occurs increasingly due to the costs of solar and wind power systems have dropped substantially in the past 30 years, and are continuing to decline, while the price of oil and gas continue to drastically increase. Furthermore, the widespread dissemination and sustainable markets for renewable energy systems are already rapidly evolved they must also be supported by the economic and policy mechanisms. It is becoming clear that future growth in the energy sector is primarily in the new regime of renewable, and to some extent natural gas-based systems, and not in conventional oil and coal sources. The new power capacity of 57% to 2030 will be in the form of renewable technologies these as estimated based on the reports established by International Energy Agency. A PV panel is the summation of many individual solar cells which are made up of silicon (a common chemical element found in sand). The major advantages of this PV is no pollution, easy maintenance, and no noise for clean power generation systems. The main problem from this energy is the output voltage produced by PV can be increase or decrease depends on sunlight radiation. To solve this problem, push-pull converter is implemented to the system to maintain the output voltage at the desired value. Henceforth, the solar energy comprise almost 27% of the new power capacity added to 2030.

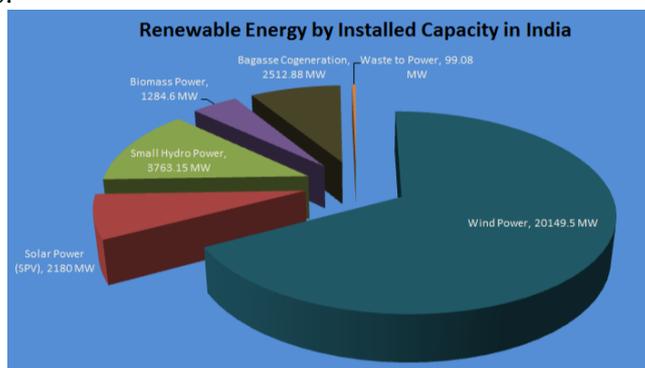


Figure.1.A pie chart & the overall percentage of the renewable energy sources

Pulse width modulation (PWM) are used in the circuit to control the switching frequency of semiconductors IGBT IN Push-Pull converter circuit. The partial shadows and mismatch of electrical parameters easily affects the performance of PV inverter system. Hence to avoid these effects we may install AC module technology and PV dc-building-module (PVDCBM) technologies. Many AC modules are connected in parallel to the grid hence here they are also called as MIC system offers “plug and play” and they are integrated with dc/ac converter with MPPT control. It is crucial to draw maximum power from PV modules due to the configuration of PV modules and corresponding power electronics design. Due to ambient environmental factors such as solar irradiance and temperature the high nonlinear voltage-current characteristics and the maximum power point (MPP) varies aggressively. For local load or utility grid ac voltage are generated from the centralized inverter. An uninterruptible power supply, active power filter and function of power conditioner are provided by energy storage which is used to overcome the intermittency of solar energy or grid instability. The MPP voltage range from 20 to 50V for a typical PV module. The low output voltage of PV modules could be boosted to a constant value of 200 or 400 V dc-link with MPPT operation using the high step-up dc/dc converter. The push-pull converter have necessary features like isolation boundary, short-circuit protection, over and under voltage

protection add considerable complexity to the basic converter topology. This LM5030 100V PWM Push-Pull Controller, replaces a wide range of converter designs and features, it is also a new highly integrated power management IC. This PWM push-pull converter provides a complete current-mode PWM control in a small 10 pin MSOP package. The switching frequency of a single resistor ranges between 100KHZ and 1MHZ. Other Features include a soft-start/enable input, error amp, feedback voltage reference, thermal protection, dual-mode over current protection and two 1.5A peak IGBT gate drivers. For solar inverter applications three level converters such as cascaded boost converters, switched capacitors converters, boost converters integrated with a coupled inductor, combination of coupled inductor and switched capacitors are proposed and analysed. The major issues of converters with low efficiency and voltage gain are the parasitic effect of devices and reverse recovery issue of diodes. The high step-up ratio and galvanic isolation between the PV primary switches and zero voltage switching (ZVS) for secondary switches, switching losses could be increased while a non-dissipated snubber is proposed to recycle the absorbed energy. To obtain high efficiency and achieve the ZVZCS of the devices at the same time the active clamping is most widely used.

METHODS AND OPERATION OF PUSH PULL CONVERTER

The steady-state operation and analysis of proposed PWM push-pull converter have been explained. These analysis could be simplified by, the following assumptions: 1) The constant current is maintained through the boost inductor L ; 2) The components used here are ideal; 3) The total value of L_{lk1} and L_{lk2} is L_{lkT} these are the series inductors and also mentioned as leakage inductances of the transformer; 4) The magnetizing inductance produces in the transformer is drastically large. The equivalent circuits are used to explain the different intervals produced in one half cycle due to the Steady-state operation of the converter. Hence, to complete the full cycle the intervals gets repeated in the second half cycle with repeated intervals.

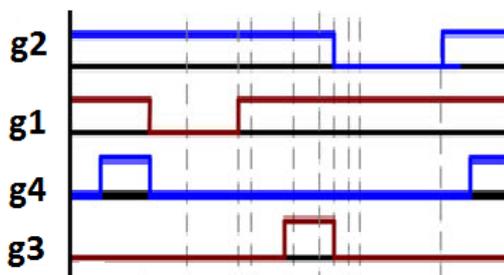


Figure.2. Gate signals for the required switches in the circuit

MODE 1: ($t_0 < t < t_1$): During this mode, anti-parallel body diode D_3 of secondary side switch and primary side switch S_2 are in the conduction mode. The HF transformer is used to transfer the power. The non-conducting secondary device S_4 is blocking output voltage V_{DC} and the non-conducting primary device S_1 is blocking reflected output voltage V_{DC}/n . The values of current through the switches varies. At $t = t_1$, primary switch S_1 gets turned-ON. The corresponding snubber capacitor C_1 discharges in a very short period of time. Finally at this interval, gets completely discharged and S_1 is fully conducting.

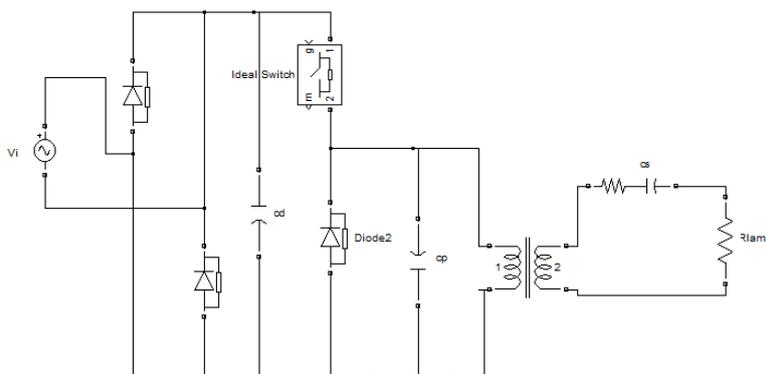


Figure.3. Equivalent circuit for the mode-1 & steady state analysis

MODE 2: ($t_1 < t < t_2$): Here all two primary switches are conducting. In this interval the reflected voltage appears across this series inductors L_{lk1} and L_{lk2} . Here the current get diverted/transferred through the switch S_2 to S_1 . To reduce linearly in the former conducting device S_2 . The turn-on loss could be reduced while the switch S_1 conducts with zero voltage. also results. In various components the current can be given by $L_{lk1} + L_{lk2} = L_{lkT}$.

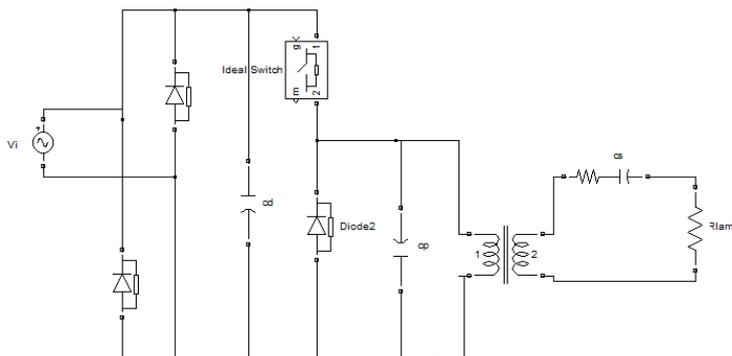


Figure.4.Equivalent circuit for mode-2& steady state analysis

MODE 3: ($t4 < t < t5$): During this interval, the body diode D2 starts conducting and it may cause extended zero voltage across commutated switch S2 to turn-off ZCS and further leakage inductance current $iLk1$ increases further with the same slope. The secondary device S3 gets turned-OFF during this interval. The switch S1 reaches its peak value due to the current in this interval. To limit heavy current through transformer and switch and KVA ratings this interval should be very short. During the end of this interval, diode D2 gets commutated naturally and current through it reduces to zero. Current through S1 reaches I_{in} and the last values $iLk1 = iS1 = I_{in}$, $iLk2 = iD2 = 0$, and $iD4 = I_{in} / n$.

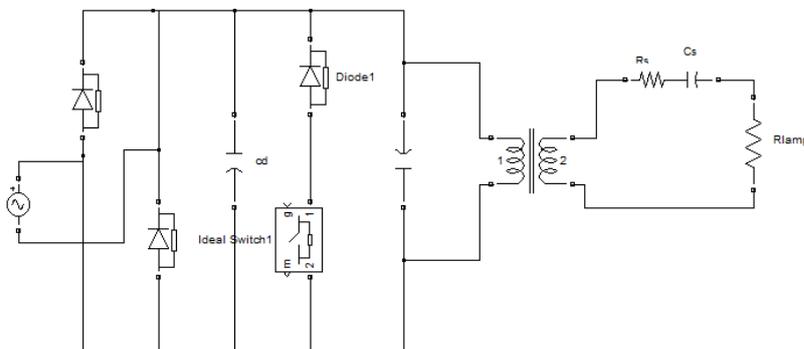


Figure.5.Equivalent circuit for mode-3 & steady state analysis

MODE 4: ($t3 < t < t4$): During this interval the snubber capacitor C2 charges to V_{DC}/n in within a short period of time. Hence Switch S2 operates in forward blocking mode in this interval. The current is kept constant while flowing through S1 and transformer at input current I_{in} . The current in the anti-parallel body diode of the secondary switch D4 is at I_{in} / n . The values obtained are: $iLk1 = iS1 = I_{in}$, $iLk2 = iS2 = 0$, and $iD4 = I_{in} / n$. Voltage across the switch $S2 V_{S2} = V_{DC}/n$. The transformer current has reversed its polarity and the current get transferred from switch S2 to S1 during the half cycle.

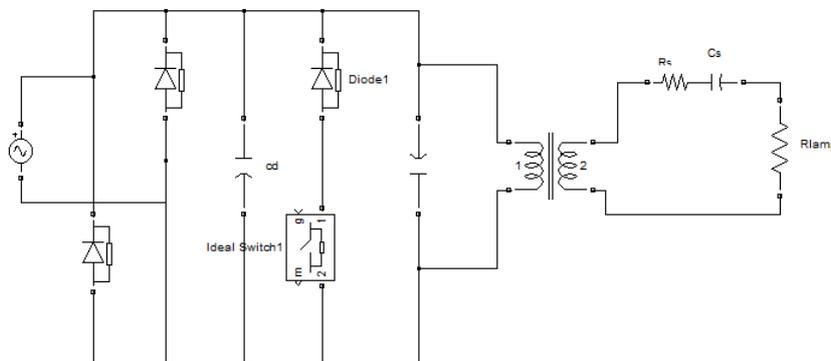


Figure.6.Equivalent circuit for mode-4 & steady state analysis

RESULTS AND DISCUSSION

The experimental proto type discussed above with the major components parameters of the experimental prototype. Hence, here the converter designed are rated at 250W are simulated using MATLAB to verify the analysis, design, and performance of the converter.

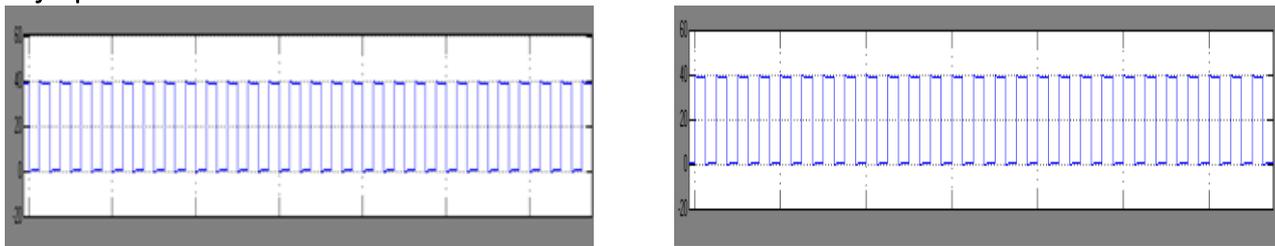


Figure.7.(a),(b): Input voltages across the switches S1 & S2

The MPP of the input sources are sensitive to current ripples then the ripple magnitude is considerable low. Thus here the Ripple cancelation results in very lower output ripple magnitude. Here, the capacitors are fed with a required amount of input voltages. Reduction in harmonics in output voltage (THD of less than 1%) Due to LC filter is adequate to supply residential loads the reduction in harmonics in output voltage (THD of less than 1%) occurs. Loss distribution estimation of proposed push-pull converter could be easily determined by the table mentioned above by the increase in input voltage, switching losses and the copper loss reduces a lot. Due to ZCS of primary switches and ZVS of secondary switches switching losses are reduced drastically.

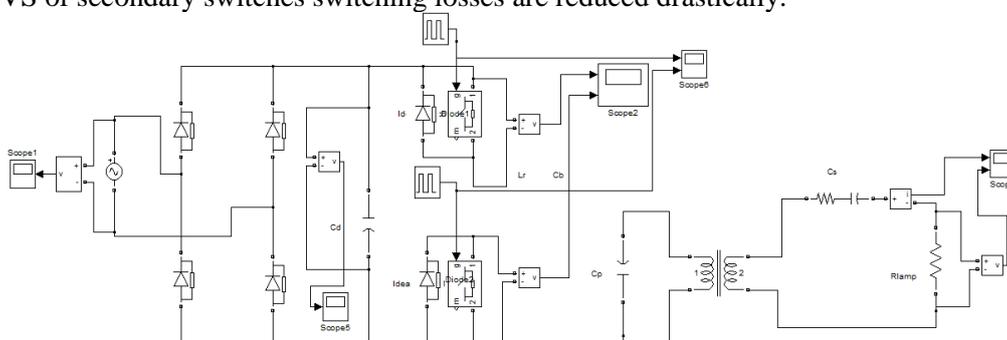


Figure.8.Simulated and the output waveforms are being discussed below

In addition, soft switching is inherent, independent of the load and is maintained with variation in source voltage.

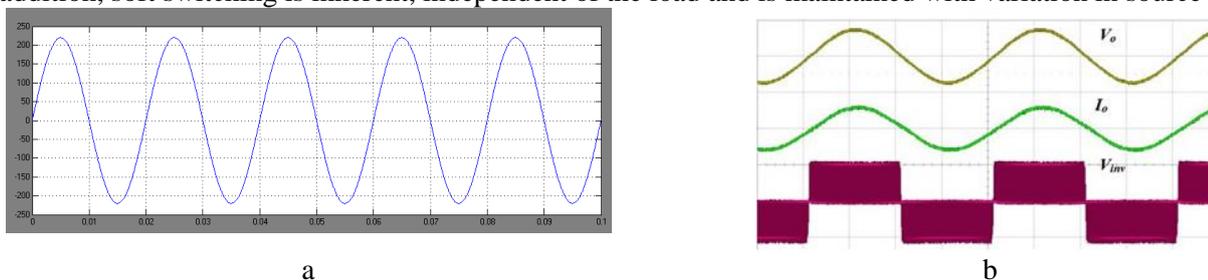


Figure.9.Experimental Input & Output Waveforms for the above discussed Simulation

Soft switching permits high switching frequency operation leading to design compact, low cost, light weight system and high efficiency over wide range of load and input voltage. Therefore, the experimental peak efficiency of the proposed Push-pull dc/dc converter is obtained in a range of 92.7% to 94.8%. Due to the low value of the current the efficiency of the inverter is nearly 97%. The overall efficiency of the inverter system is about 87% to 91.9%.

INPUT VOLTAGE(V)	CONVENTIONAL EFFICIENCY(%)	PROPOSED EFFICIENCY(%)
100	46	93
120	54	89.8
150	56	91
175	66	92

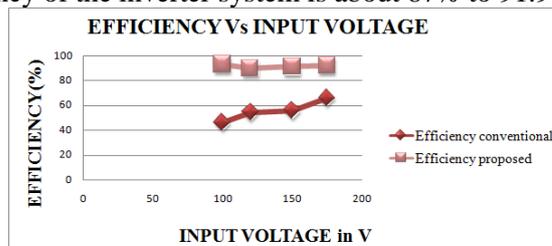


Figure.10.Overview tabulation & Overall efficiency difference between Conventional & proposed systems

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