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SINGLE PHASE INVERTER WITH HF TRANSFORMER FOR PV APPLICATION

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ABSTRACT

Scope of this paper relates current fed interleaved phase modulated single phase unfolding inverter for renewable solar energy application. The solar panels are configured to retrieve and utilize solar energy to be an input for the DC-DC converter. Electronic switch mode DC-DC converter is proposed to convert one DC voltage level to another by storing the input energy temporarily and then releasing that energy to the output, a variable voltage .The control signals required for DC-DC converter is generated from PIC micro controller. High Frequency transformers are used and insulated with DC-DC converters to transfers electrical power from a power source to a load. Low pass filter plays a vital role to reduce ripples and gives the reasonable voltage to the output resistive inductive load. Unfolding inverters are amended to produce constant single phase sine voltage for resistive load. Various modulation strategies have been discussed for the dual active bridge DC-DC converter. Simulation studies have been carried out using MATLAB to verify the theoretical results.

Keywords: DC-DC Converter,HF Transformer, Unfolding Inverter, Phasemodulation.

I. INTRODUCTION

Resource for conservative energy decreases bit by bit with each passing day, stirring up worries among many. Economic and concerns over fossil fuels encourage the development of photovoltaic (PV) energy systems. As a kind of clean and renewable resource, PV energy has gained significant attention rapidly since the last decade, due to the high energy cost and adverse environmental impacts of conventional fossil fuels. Photovoltaic technology refers to the technology that converts solar energy directly into electricity, through the use of solar cells.

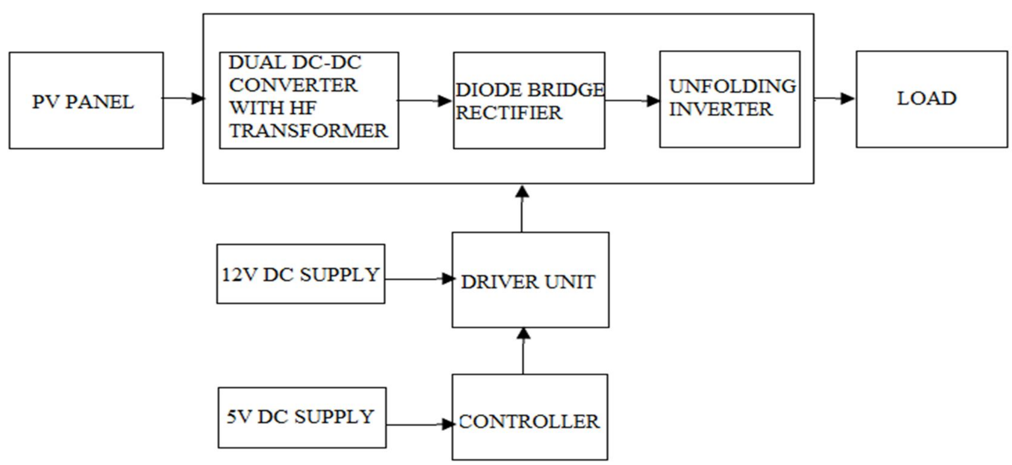

Fig.1. Proposed block diagram of Interleaved Current- Fed Phase-Modulated Single-Phase Unfolding Inverter.

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A solar cell constitutes the basic unit of a PV generator which, in turn, is the main component of a solar generator. A photovoltaic generator, also known as a photovoltaic array, is the total system consisting of all PV modules connected in series or parallel with each other .Solar energy, along with other renewable energy resources, does not deplete in source, is reliable, and environment-friendly. Especially, solar power is arguably the cleanest, most reliable form of renewable energy available, and it can be used in several forms to help power your home or business. Solar-powered photovoltaic (PV) panels convert the sun's rays into electricity by exciting electrons in silicon cells using the photons of light from the sun. This source is used to drive the load with the help of the DC-DC converter .It consists of eight switches which are controlled by eight different duty ratios. This duty ratio controls the power flow from the input to load .HF transformer is used to isolate the power to the load and also uncontrolled rectifier is used with low pass filter in order to reduce the HF component in the rectified output voltage. Single phase AC voltage is obtained by unfolding inverter switching at line frequency. This will make the allowance of only line frequency to drive the load.

II. TOPOLOGY DESCRIPTION

The proposed block diagram ofcurrent fed interleaved phase-modulated single phase unfolding inverter is shown in Fig.1. Two indistinguishable active clamped current-fed DC-DC converter cells are connected in parallel to the input DC source. These two converters are modulated with a phase shift such that the phase difference between these two converters is a sine function of line frequency. Secondary of the HF transformers are connected in series followed by a diode bridge rectifier. A low-pass filter is used to filter HF components of signals to achieve rectified sinusoidal voltage across filter capacitor $C_o$at twice the line frequency. Single-phase AC voltage is obtained by simply unfolding the rectified sine wave using the H-bridge inverter switched at line frequency,i.e.,unfolding.

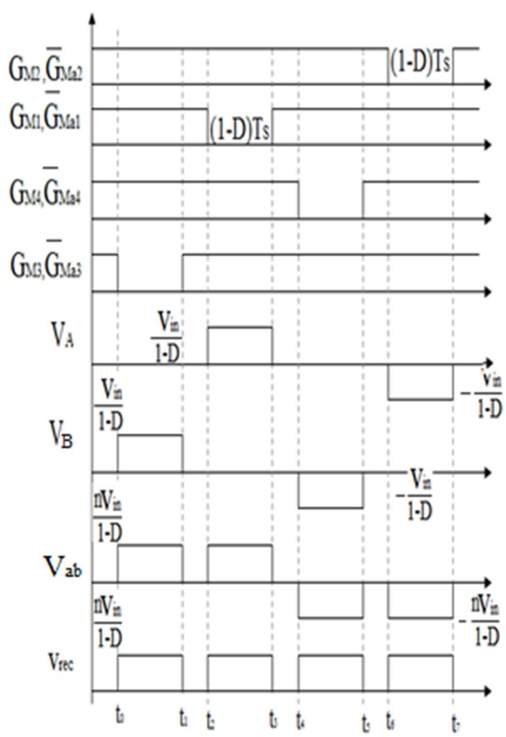

Fig.2.1 Gating signals for M1,M2,M3 and M4 and voltages V_A, V_B, V_{ab}, and V_{rec}.

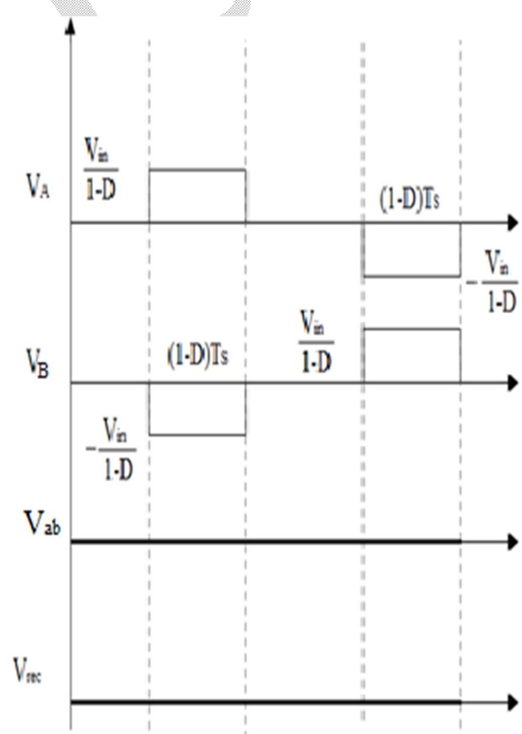

Fig.2.2 Waveforms of the DC-DC converter for ωt = 0, π, and 2π.

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Fig.2.1 shows the gating signals for M_1,M_2,M_3,M_4 and voltages V_A,V_B,V_{ab}&$V_{rec}$and the fig.2.2 shows the waveforms of the converter with three different phase angle(0, π and 2π).

The following aspects are followed for understanding the steady-state operation and analysis of the converter.

1) Inductors L_1−L_4 are large enough to maintain constant current through them over a HF switching cycle.

2) Clamp capacitors C_1 and C_2 are large enough to maintain constant voltage across them over a HF cycle.

3) All the components and devices are ideal.

4) Series inductors L_{s1} and L_{s2} represent the leakage inductance of the corresponding transformers, which are neglected during the analysis.

5) Components of both the converter cells are indistinguishable.

III.STEADY STATE OPERATION

The two main switches M_1 and M_2 are activated with gating signals phase shifted by 180◦ with a delay. The delay varies with duty ratio D. The duty cycle of the main switches (M_1- M_4) is always preserved greater than 50%. The auxiliary switches (Ma_1-Ma_4) are controlled by gating signals complementary to the corresponding gating signals of the main switch. Hence, the duty cycle ratio of the auxiliary switches is $(1 - D)$ and less than 50%. Fixed frequency duty cycle modulation is used for control. Voltages across the primary and secondary of the transformer, i.e., V_A, V_B, and V_{ab}, are shown in fig.2.2.

Alternative converter is connected in input parallel and output series formation. Switches are modulated in similar fashion with the same value of duty ratio D as the first converter, except the phase shift between the two converters. Gate signals between switches M_1 and M_3 are phase shifted by time δ, which is given by

$$= \frac{}{2} + \propto . \sin(\quad)$$

Where T_S is the time period of the HF cycle of the converter, ω represents the frequency of the anticipated output sine wave in radian/sec. Magnitude of the output voltage is a function of α, which will be discussed in the latter part of this section. Similarly, switch pairsM_2−M_4,M_{a1}−M_{a3}, andM_{a2}−M_{a4} have the same duty ratio and phase shifted by time δ. Whenever one of the main switch is turned off, then corresponding auxiliary switch is turned on. This results in the clamping capacitor voltage to appear across the primary of the transformer. Voltage across the clamping capacitors, i.e., V_{C1} and V_{C2}, are assumed to be constant and are given by

$$= \quad = \frac{}{1 -} \; .$$

When switch M1 is turned off, voltage across the primary of the transformer, i.e., V_A, is given by

$$= \quad + \quad = \frac{1}{1 -} \; .$$

Similarly, when switch M2 is turned off, voltage across the primary of the transformer, i.e., V_A, is given by

$$= - \quad - \quad = -\frac{1}{1 -} \; .$$

From the voltage across the transformer primary of the second converter, i.e., V_B can be derived likewise. From the primary voltage, the voltage across the secondary of the transformer is calculated as a multiple of turn's ratio n, which is the same for both the converter cells. The secondary of the transformers is connected in series and is rectified using a full-bridge diode rectifier. V_{rec} shows the voltage waveform at the rectifier output. The rectifier is followed by a low-pass filter, which absorbs HF switching components, correspondingly resulting in average voltage V_{CO} across capacitor C_o.Single-phase sinusoidal voltage is obtained by switching S_1 to S_4using square-wave control at line frequency. During one cycle of the rectified voltage, switches S_1 and S_4 are turned on. $S_2$and $S_3$are turned on for the next cycle.

IV. SIMULATION RESULT

Simulink circuit of Unfolding inverter with solar energy system is shown infig.4.1.

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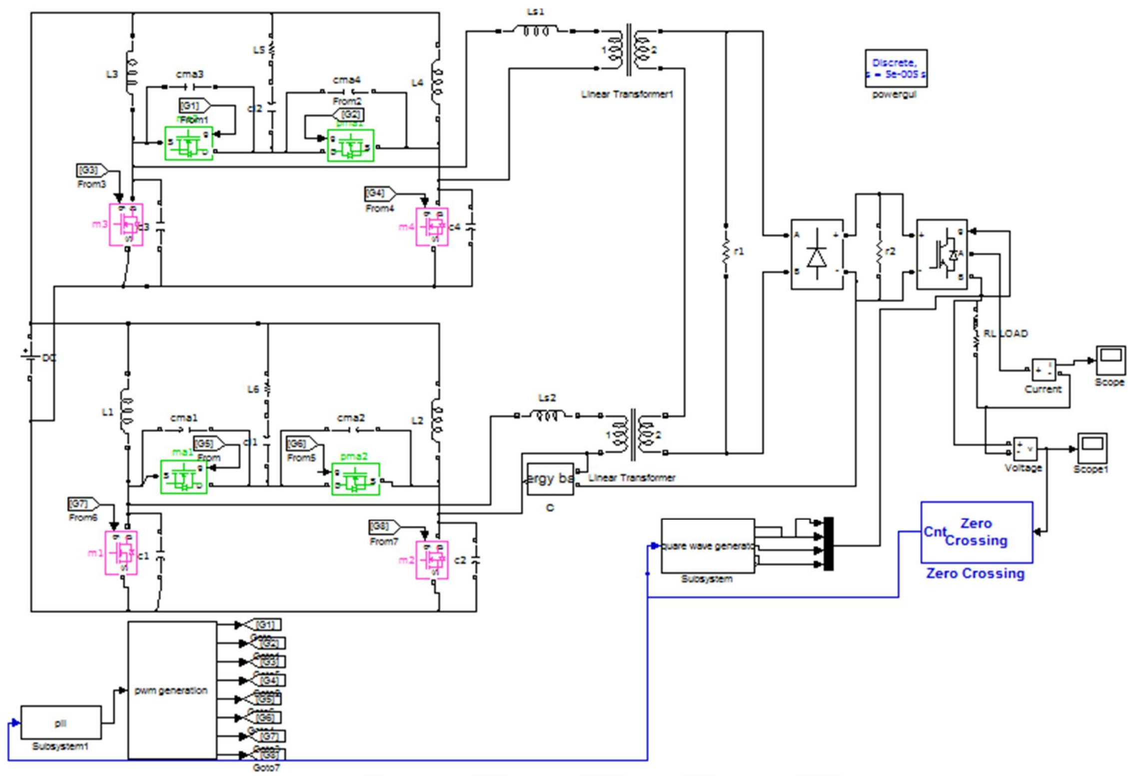

Fig.4.1 Simulink circuit of unfolding inverter with solar energy system.

Input voltage and Input current of DC-DC converter is nearly 30V and 9A as shown in fig.4.2 and fig.4.3respectively. Stepped up HF transformer output voltage is nearly 100V as shown in fig.4.4. The rectified output voltage of proposed system is shown in fig.4.5.The inverter output voltage of the proposed system is nearly 100V and is shown in fig.4.6.

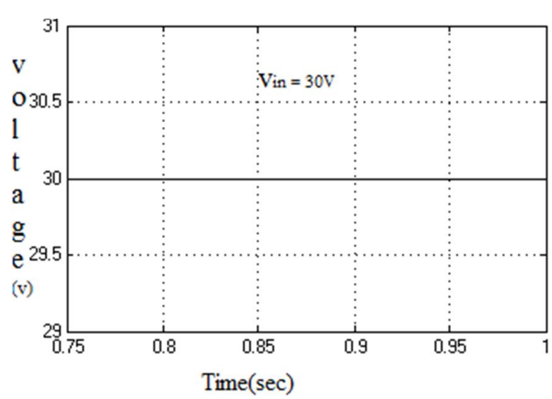

Fig.4.2 Input Voltage of DC-DC Converter.

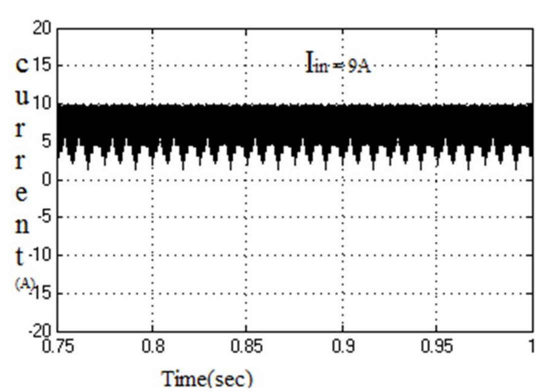

Fig.4.3 Input Current of DC-DC Converter

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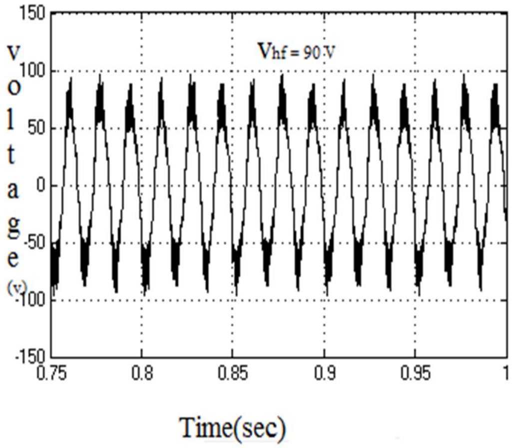

Fig.4.4 HF Transformer Output

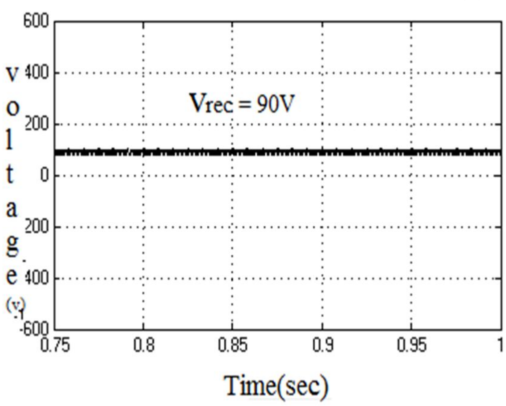

Fig.4.5Rectifier Output voltage of Proposed System

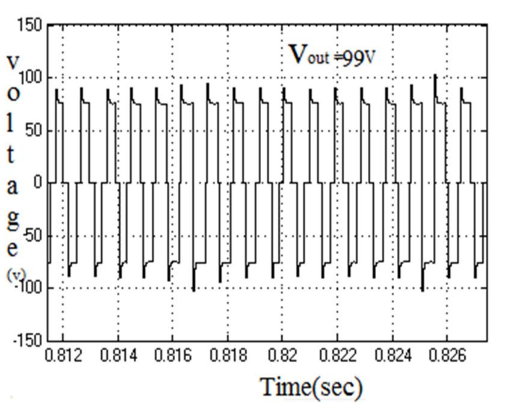

Fig.4.6Output Voltage of the Proposed System

V. CONCLUSIONS

Dual DC-DC converter with unfolding inverter has been intended for renewable energy application. Phase modulation of two half-bridge current-fed converters has been proposed to generate rectified sinusoidal voltage at the DC link. The design of DC-AC inversion stage to an unfolding circuit operating at the line frequency reduces the switching losses. The future scope is to use active-clamping circuits for decoupling, and to reduce the size of the input electrolytic capacitor or it can be eliminated there by the efficiency can be further improved.

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