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Implementation of a Phase Control Technique for Interleaved Flyback Inverter with Photovotaic AC Module system

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***Abstract*— A photovoltaic AC module system is considered for this project. In a conventional single flyback inverter for the photovoltaic AC module system, this inverter has drawbacks of a conduction losses of each switch, transformer copper and high ripple current of capacitor. To overcome these problems, two flyback converter modules with interleaved pulse-width modulation (PWM) are connected in parallel at the input and output sides reducing the ripple current on the input and output capacitors and decrease the current stress on the transformer windings. To implement a phase control technique to reduce voltage spikes and losses of the converter and also improve the high efficiency under all load condition. In order to verify these, theoretical analysis and simulation are performed. The Matlab/Simulink based simulations demonstrate the betterment of the proposed scheme.**

***Keywords*—AC Module system, control techniques, interleaved flyback inverter (ILFI), photovoltaic (PV), Voltage Spikes, Pulse Width Modulation (PWM).**

I. INTRODUCTION

Nowadays, an interest in photovoltaic (PV) energy has grown in response to increased concern about the environmental problems. However, the conventional PV systems have power loss due to mismatch between the PV modules and shadows by trees, buildings, and other obstacles that partially cover modules. To solve this problem, photovoltaic AC module systems that consist of a single PV module and a single-phase inverter are being studied. In photovoltaic AC module systems, a fly back inverter is an attractive solution as the single-phase grid connected inverter because of the advantages of fewer components, simplicity, and isolation between the PV modules and the grid line. Interleaved flyback inverters (ILFIs) for photovoltaic AC modules are generally designed for the maximum output power of a PV module. The efficiency of the inverter is the highest when the PV module generates the maximum power. However, the output power of a PV module is directly affected by solar irradiance and temperature. The efficiency of the inverter must be high, not only for the maximum output power, but also for other power levels according to the weather conditions.The proposed control method uses Phase control technique according to the output power of the inverter. In other words, only a converter of one phase of the ILFI is operated in the normal case, and the use of an active clamp circuit is determined by calculating the voltage spike imposed at both terminals of the main switch. Loss of a converter with two or more phases can be reduced through such a control method, and the loss of the active clamp circuit can also be reduced according to the voltage spike of the main switch. Using this technique, the efficiency of an ILFI can be improved by reducing the switching loss, switch conduction loss, diode conduction loss, and transformer loss.

II. INTERLEAVED FLYBACK CONVERTER

The interleaved pulse with modulation boost flyback converter has a high voltage conversion ratio because of its wide turn off period than the normal boost converters which have narrow turn off periods, which helps to get a higher output voltage and the interleaved operation reduces the input and output ripple currents and the size of the inductor and capacitor also reduced.

A. BLOCK DIAGRAM OF ILFI

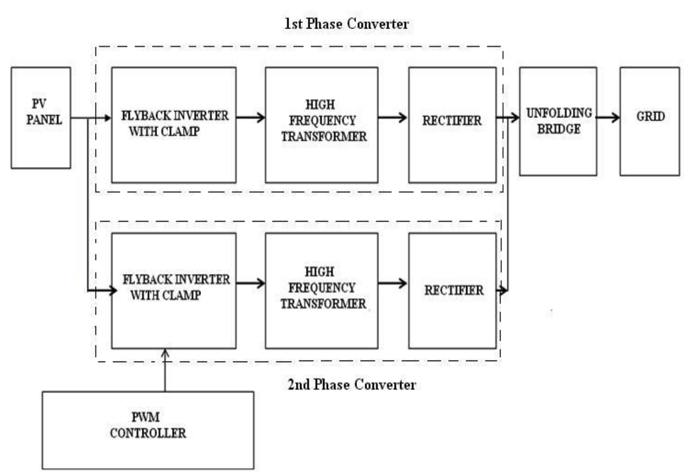

Fig 1.Block Diagram of ILFI for the PV ac module system

The DC to DC converter can increase or decrease the voltage of the PV system depending on the load requirements. The various DC to DC converters commonly used with PV array for impedance matching.

B. CIRCUIT DIAGRAM OF ILFI

The proposed converter consists of decoupling capacitor, first and second phase converter, unfolding bridge circuit

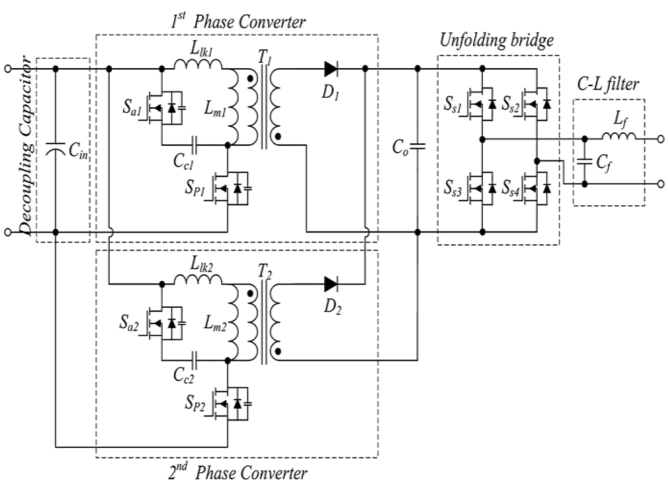

Fig 2.Circuit diagram of ILFI of the PV ac module system

and CL filter. In the Photovoltaic AC module system, maximum power point tracking (MPPT) is essential to make the PV module generate peak power, which depends on PV irradiance. For MPPT control, constant PV voltage and PV current are required. Thus, the decoupling capacitor is used to remove a 120-Hz harmonic frequency which distorts the constant PV voltage and PV current. In each phase, the fly back converters consisted of main switches, clamp circuits, transformers, and diodes. The clamp circuit is used to reduce the voltage spike across the main switch occurring in resonance between the output capacitor and the leakage inductance. And, the transformer is used to maintain the isolation between the PV module and grid line and boost the voltage. The unfolding bridge is employed for connection between AC power produced through the transformer and grid line.

C.OPERATIONAL ANALYSIS OF ILFI

Based on the steady-state operation, there are ten operational stages in a switching period. In the following analysis, only discontinuous conduction mode (DCM) is considered due to its simplicity of control. The corresponding equivalent circuits of the steady-state operation of the ILFI during one switching period. Two gate signals that are 180◦ out of phase are applied to the main switches $Sp1$ and $Sp2$. The gate signals of the active clamp switches $Sa1$ and $Sa2$ are applied for a very short time to reduce the conduction loss of the active clamp switches. During 0˚ to 180˚, switches S1 and S2 is turned ON which yields to the positive half cycle of the output AC voltage waveform. During this 180˚ to 360˚, switches S3 and S4 is turned ON which yields to the negative half cycle of the output AC voltage waveform. the ILFI activates a single-phase converter with the active clamp circuit using the phase control method because the output power of the PV module is smaller than half of the PV module maximum power and the voltage spike across the S_{p1} is larger than the S_{p1} voltage rating. Therefore, the second-phase converter loss can be eliminated. When the output power of the PV module is larger than half of PV module maximum power and the voltage spikes across main switch $S_{p1,}$ and S_{p2} is larger than the $S_{p1,}$ and S_{p2} voltage rating, the ILFI is fully activated as represented. Using this scheme, the proposed control method reduces the clamp circuit loss and phase converter loss.

III. CONTROL STRATEGIES

A.PHASE CONTROL TECHNIQUE

In the conventional ILFI both 1st phase converter and 2nd phase converters are operated under all load ranges. Due to these all the passive and active elements are always operate, so the ILFI system efficiency will be low. To overcome those problems the phase control technique will be introduced. Initially the 1st phase of the converter only operated. The load having any disturbance the output voltage and output power will be decreased. To compensate the load disturbance the 2nd phase of the converter is turned ON. Both 1st phase and 2nd phase converters the gate pulse is given by means of 180° phase shift. By using these phase control technique to maintain the efficiency of the ILFI system will be high.

IV. THE ROLE OF SIMULATION

Simulation has become a very powerful tool on the industry application as well as in academics, nowadays. It is now essential for an electrical engineer to understand the concept of simulation and learn its use in various applications. Simulation is one of the best ways to study the system or circuit behavior without damaging it .The tools for doing the simulation in various fields are available in the market for engineering professionals. Many industries are spending a considerable amount of time and money in doing simulation before manufacturing their product. The libraries contain models of typical power equipment such as transformers, lines, machines, and power electronics. These models are proven ones coming from textbooks, and their validity is based on the experience of the Power Systems Testing and Simulation Laboratory of Hydro-Québec, a large North American utility located in Canada, and also on the experience of Evolve de Technologies superior and Universities Laval. The capabilities of SimPower Systems for modeling a typical electrical system are illustrated in demonstration files. And for users who want to refresh their knowledge of power system theory, there are also self-learning case studies. The SimPower Systems main library, power lib, organizes its blocks into libraries according to their behavior. The powerlib library window displays the block library icons and names. Double-click a library icon to open the library and access the blocks. The main SimPower Systems powerlib library window also contains the Powergui block that opens a graphical user interface for the steady-state analysis of electrical circuits.

A. SIMULATION PARAMETER FOR ILFI MODEL

The below table 1 shows the simulation parameter for Main block of ILFI model. The simulation models are done by using of this parameter only.

PARAMETER	VALUE
Grid Frequency f_{grid}	50 Hz
Input Capacitance C_{in}	5000 μF
DC link Capacitance C_o	90 μF
Leakage Inductance L_{lk1},L_{lk2}	1.5 μH
Transformer Turns Ratio	1:6
Magnetizing Inductance L_{m1},L_{m2}	260 μH
Filter Capacitance C_f	90 μF
Filter Inductance L_f	0.06H

Table 1.Simulation Parameter for ILFI Model

V. ILFI SIMULATION MODEL WITH DIFFERENT CONTROL STRATEGIES

A. MAIN ILFI MODEL WITH SAG DISTURBANCE

The output power of a PV module is always changing according to weather conditions such as solar irradiance and atmospheric temperature. Thus, the efficiency of a PV power conditioner (ILFI) has to be high, not only for the maximum irradiance, but also for other irradiance values according to weather conditions. However, all active and passive elements of an ILFI for a con- ventional PV ac module operate over all load range regardless of the PV output power. For this reason, in a low output power of a PV module, high efficiency cannot be obtained owing to the losses of the active and passive elements.

In this case, only the 1st phase of the converter only operated. At the load side sag disturbance will be created by means of connecting resistance with one switch.

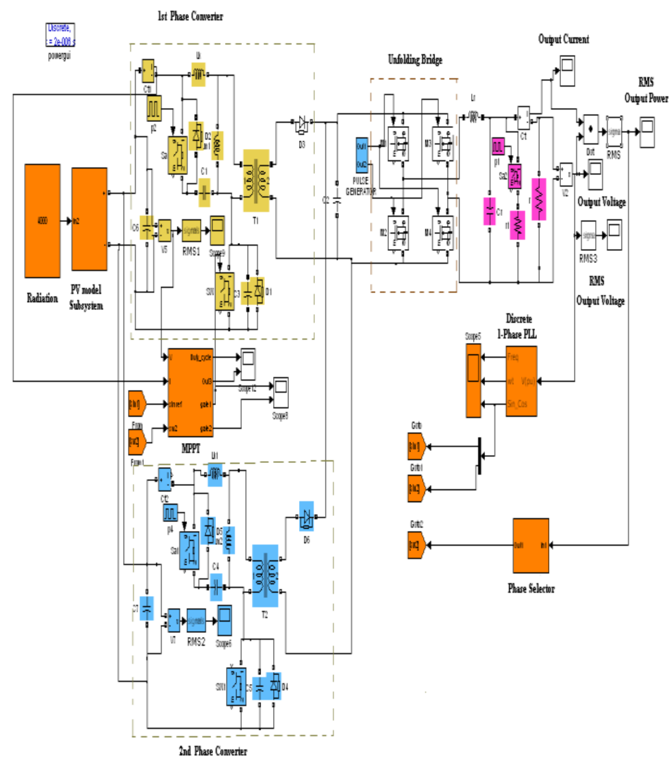

Fig 7.Main ILFI model

The disturbance will be connected by means of the switch at the time of 0.3 sec. The performance of the normal case is shown in above the model.

Figure 8 shows the simulation waveforms of the input voltage for main ILFI model with sag disturbance

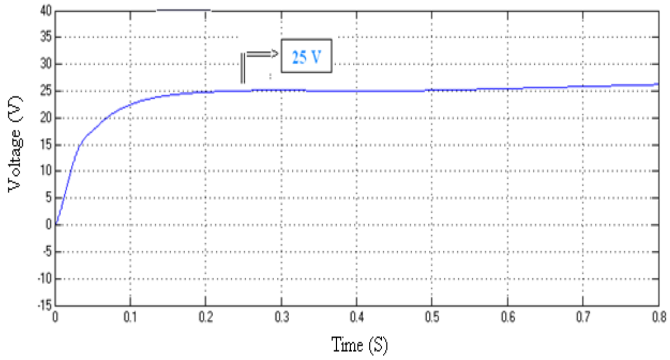

Fig 8.Input Voltage

It has draw with voltage and time period. The Input Voltage has 25V during the time period 0.2s to 0.8s.

Figure 9 shows the simulation waveforms of the inverter output voltage for main ILFI model with sag disturbance.

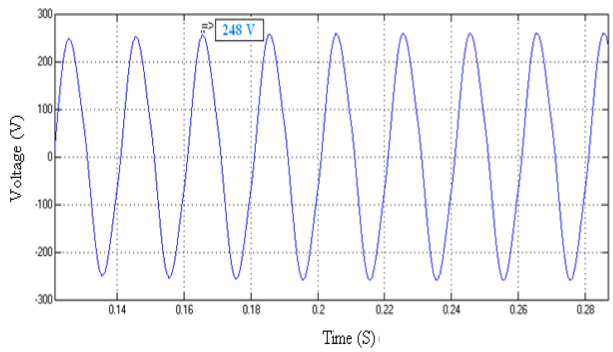

Fig 9.Inverter output Voltage

It has draw with voltage and time period. The output Voltage of the inverter has 248V.

Figure 10 shows the simulation waveforms of the inverter output current for main ILFI model with sag disturbance.

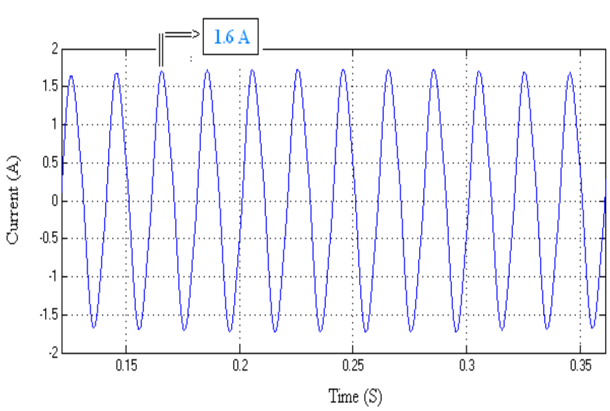

Fig 10.Inverter output current

It has draw with current and time period. The output current of the inverter has 1.6A.

Figure 11 shows the simulation waveforms of the RMS output voltage for main ILFI model with sag disturbance

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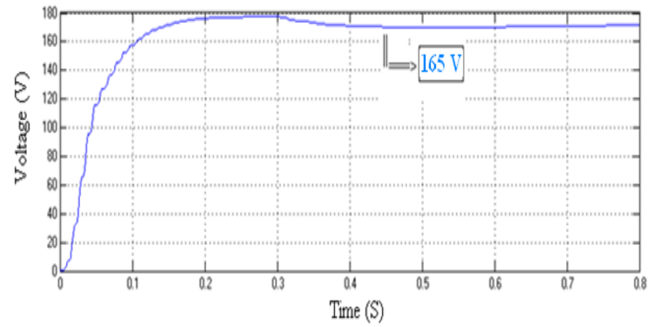

Fig 11.RMS output voltage

It has draw with voltage and time period. The Voltage has 165V during the time period 0.2s to 0.8s.

Figure 12 shows the simulation waveforms of the RMS output power for main ILFI model with sag disturbance. It has draw with voltage and time period. The output power of the inverter has 228w during the time period 0.3s to 0.8s.

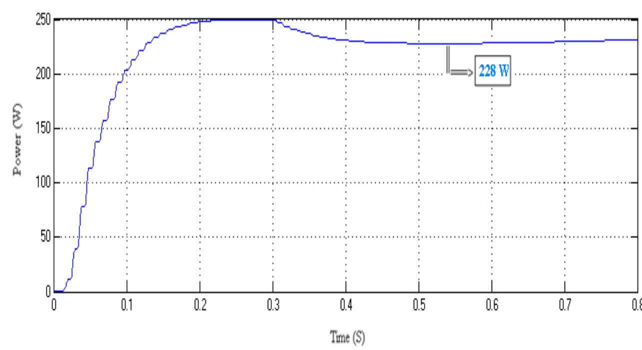

Fig 12.RMS output power

B. MAIN ILFI MODEL WITH PHASE CONTROL TECHNIQUE

The above ILFI Model with sag disturbance, both the phase converters are working having the disturbance so the RMS output voltage and the output power decreased

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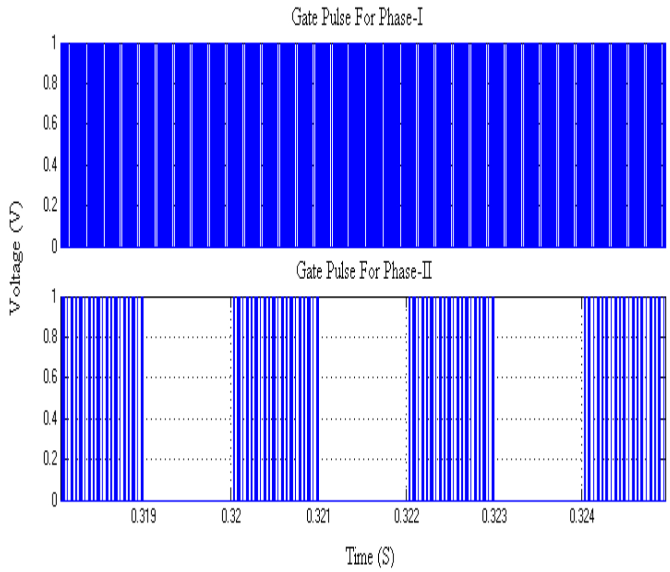

Fig 13.Gate Pulse Phase I and II

For compensating the disturbance will go for the phase control technique. Whenever the sag is occur the 2nd phase converter should be turned ON and compensate the disturbance. The gate pulse for the both converter will given by 180° phase shift. The performance of Phase control technique shown below.

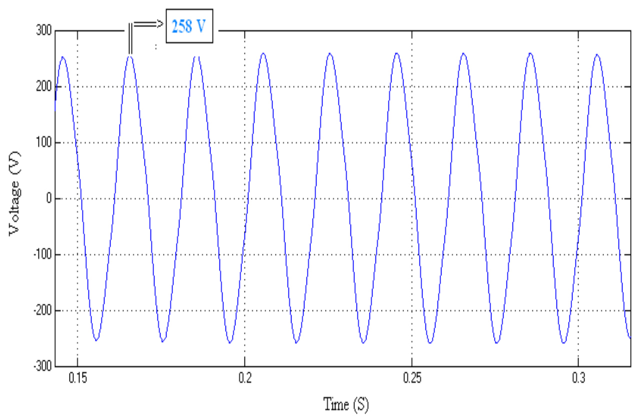

Fig 14.Inverter output Voltage

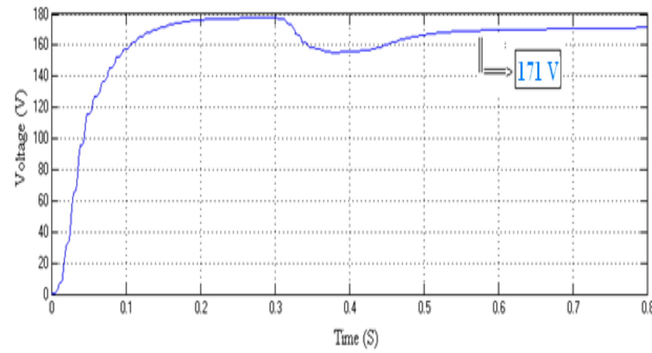

Fig 15.Inverter RMS output Voltage

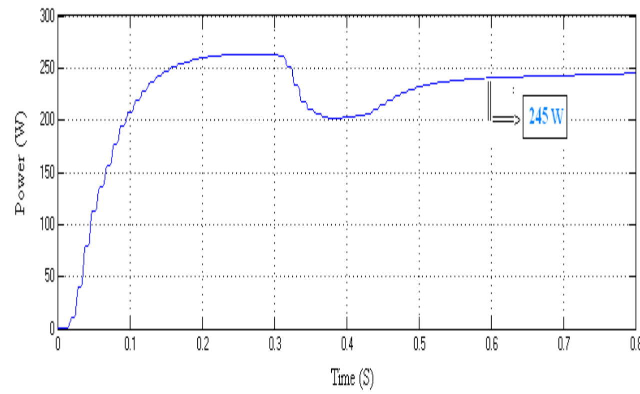

Fig 16.Inverter RMS output power

E. COMPARISION OF RESULTS

Table 2.Comparision of results

PARAMETER	NORMAL CASE WITH DISTURBANCE	METHODS USED FOR COMPENSATION
		PHASE CONTROL
Input Voltage (V)	25V	25V
Output Voltage (V)	248V	258V
RMS Output Voltage (V)	165V	171V
Sag (V)	165V	155V
Compensation Voltage (V)	-	171V
Compensation Time (S)	-	0.76S
RMS Output Power (P)	228W	245W
Sag (P)	228W	200W
Compensation Power (P)	-	245W
Compensation Time (S)	-	0.79S
Output Current (A)	1.6A	1.72A

Table 2 shows that the comparison of results of Phase control technique and sag disturbance. From the comparison table it shows that the Phase control is the best for compensating the sag disturbance.

VI. CONCLUSION

The interleaved flyback inverter has become an important component because it having the advantages of fewer components, simplicity in construction, Isolation between the PV modules and the grid line. By using the interleaved technique in the flyback inverter the conduction loss of each switch can be reduced. The crux of the system Phase control technique reducing the voltage spikes and losses of the converter and also improve the high efficiency under all load ranges. The ILFI based Photovaltaic AC module system is modeled in the MATLAB simulink and the results are verified. The proposed flyback inverter system characteristics are analysed with the help of waveforms.

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