Design and Analysis of Renewable Energy Based Interleaved Flyback Inverter

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Abstract
Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic (PV) power generation has become one of the main ways to use solar energy. And the renewable energy source based distributed generation (DG) system are normally interfaced to the grid through power electronic converters or inverters. An interleaved flyback inverter based photovoltaic system with an improved control strategy with MATLAB Simulink is used result is discussed in this paper.

Keywords: Photo Voltaic (PV), Pulse-Width Modulation (PWM), Distributed Generation DG, Interleaved Flyback Inverter (ILFI)

INTRODUCTION
Generally Photovoltaic (PV) energy has plays the major role in the renewable energy. The PV technique also grown faster even though the initial cost is high but the solar energy is available at free of cost by naturally and its efficiency also high. To obtain the sufficient power the PV system use the PV modules are connected in series or parallel. By means of mismatch between the modules, shadows from trees or tree branches, buildings and other things partially cover the PV module so the conventional PV system having power losses. To overcome this problem photovoltaic AC module is considered, For the photovoltaic AC module flyback inverter is the best for the grid connection because it having advantages of less components, simple in construction and provide the isolation between the PV modules and grid line.
Interleaved flyback inverter (ILFI) is basically design for to get the maximum power from the PV module. Normally the conventional flyback inverter having the voltage spike across the main switch. For reducing the voltage spike across the main switch the active clamp circuit is used. The clamp circuit is also used to reduce the switching loss because the main switch is operate with soft switching. By using of the interleaved technique in the inverter the conduction loss of each switch can me minimized, reliability, system life is improved, the ripple current is reduced by the capacitor.

II. SYSTEM STRUCTURE AND ANALYSIS
A. BLOCK DIAGRAM

![Block diagram for ILFI](image)

Fig 1. Block diagram for ILFI
Interleaved flyback inverter for photovoltaic AC module consists of the PV module as input, decoupling capacitor, 1\textsuperscript{st} phase converter, 2\textsuperscript{nd} phase converter, unfolding bridge and C-L filter. For the Photovoltaic AC system, Maximum Power Point Tracking (MPPT) is essential to get the peak power from the PV module.

Decoupling capacitor is used to remove the harmonic frequency which distorts the constant PV voltage and current. Both the flyback converters consist of main switches, active clamp circuit, Transformer and Diode.

The active clamp circuit is used to reduce the voltage spike across the main switch which is occurring in resonance between output capacitor and leakage inductance.

Transformer is used to maintaining the isolation between PV module and grid line and also boost the voltage. Unfolding bridge is used for connection between transformer and grid line.

**C. MODES OF OPERATION**

The ILFI having ten operational modes in the switching period, Based on its steady state operation. Due to simplicity of control here considered only discontinuous conduction mode (DCM). It having ten modes of operations, Two PWM signals with 180\(^\circ\) phase is given by means of this each switch is controlled in interleaved method. Mode [1]- Mode [5] operated first. Similarly after 180\(^\circ\) phase shift, Mode [6]- Mode [10] is operated. The following modes are shows the steady state operation of ILFI.
III. ACTIVE CLAMP CONTROL TECHNIQUE

A. Without Active clamp circuit:

When the main switch $S_{p1}$ is turned off, the voltage across $S_{p1}$ is sum of the input voltage, feedback voltage and voltage spike which is cause by means of resonance between the leakage inductance $L_{lk1}$ and output capacitance $C_{oss}$ of the $S_{p1}$. When the voltage spike of $S_{p1}$ increased over the rating then the $S_{p1}$ has to fail. For reducing this voltage spike of the main switch $S_{p1}$ the active clamp circuit is used.

B. With Active clamp circuit:

When using the active clamp circuit the leakage energy will be absorbed by the clamp capacitor $C_{c1}$. Hence the voltage spike across the main switch $S_{p1}$ can be reduced. So
during the grid period the ILFI operates stable due to the small voltage across the main switch $S_{p1}$ than its rating.

**IV. MAXIMUM POWER POINT TRACKING**

MPPT charge controller is a maximum power point tracker which is an electronic DC to DC converter which takes the DC input from the solar panels, changes it to high frequency AC and converts it back to a different DC current to match with the batteries.

**A. DIFFERENT MPPT ALGORITHM**

The different types of algorithms which are used for finding MPPT of the solar panel are

- **Conventional Algorithms**
  - Perturb & Observe
  - Incremental conductance
  - Constant voltage method
  - Constant current method

**B. PRINCIPLE OF P&O**

If the operating current or, in other words, the current drawn from the PV array is perturbed in a given direction and if the power drawn from the PV array increases, the operating point becomes closer to the MPP and, thus, the operating current should be further perturbed in the same direction.

If the current is perturbed and this results in a decrease in the power drawn from the PV array, this means that the point of operation is moving away from the MPP and therefore, the perturbation of the operating current should be reversed.

Fig 4.shows the flow chart of the perturb and observe MPPT algorithm.
Fig 4. Flow chart of the P&O technique

Table I: Design parameter of ILFI

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Frequency ( f_{\text{grid}} )</td>
<td>50</td>
<td>Hz</td>
</tr>
<tr>
<td>Input Capacitance ( C_{\text{in}} )</td>
<td>11</td>
<td>mF</td>
</tr>
<tr>
<td>DC link Capacitance ( C_{\text{o}} )</td>
<td>136</td>
<td>nF</td>
</tr>
<tr>
<td>Leakage Inductance ( L_{\text{lk1}},L_{\text{lk2}} )</td>
<td>0.21</td>
<td>µH</td>
</tr>
<tr>
<td>Transformer Turns Ratio</td>
<td>1:6</td>
<td>-</td>
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<tr>
<td>Magnetizing Inductance ( L_{\text{m1}},L_{\text{m2}} )</td>
<td>8.28</td>
<td>µH</td>
</tr>
<tr>
<td>Filter Capacitance ( C_{\text{f}} )</td>
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<td>µF</td>
</tr>
<tr>
<td>Filter Inductance ( L_{\text{f}} )</td>
<td>3</td>
<td>mH</td>
</tr>
</tbody>
</table>
V. ILFI SIMULINK MODEL

**Fig 5.** Simulation diagram for ILFI

**Fig 6.** Simulation diagram for MPPT block
VI. SIMULATION RESULTS

The simulation results are produced with MATLAB 2009b. The result shows the waveforms for voltage and current across PV panel. Also, the gate pulses of each switch, voltage across the main switch and active clamp switch, DC input voltage for the inverter, inverter output voltage without filter and grid voltage, grid current.

**Fig 7.** Voltage and current across PV panel

**Fig 8.** Gate pulses of each switch
**Fig 9.** Voltage across switch Sa1, Sp1

**Fig 10.** Voltage across switch Sa2, Sp2

**Fig 11.** DC input voltage for the inverter
**CONCLUSION**

The flyback inverter has become an unavoidable 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 ILFI being practice in renewable energy system. A flyback inverter based energy efficient PV system has been developed. The system consist of transformer, diode rectifier, unfolding bridge, filter, etc. The working of the system with mode diagram has been presented. The crux of the system, active clamp control technique helps in energy efficient operation through the power loss. The ILFI based PV system is modeled in the MATLAB simulink and the results are verified. In this the Perturb & Observe algorithm is used in the PV to get the maximum power. The proposed flyback inverter system characteristics are analysed with the help of waveforms.
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