**Modeling and Simulation of H6 Topology using Single Phase Transformerless Grid Connected Photovoltaic System**

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**ABSTRACT**

This paper proposes a new technology of solar energy system, which is gaining immense fashion ability due to the increase of significance to exploration on indispensable sources of energy over reduction of the conventional reactionary energies each around the world. The systems which are being developed excerpt energy from the sun in the most effective manner and utilize them for the available loads without affecting their performance. In this paper, the design and control issues associated with the development of a1.8 kW prototype single- phase grid- connected photovoltaic system of multilevel protruded inverter are bandied. For the system current regulator, a ramp time zero average current error control system algorithm combined with an optimized cyclic switching conception sequence is suggested. Simulation results of Grid tie inverter have been considered to demonstrate the felicity of the total control system. The Simulation results parade bettered performance analysis due to harmonics and the studied system is modeled and dissembled in the MATLAB/ Simulink.

**Keywords−** Grid tied inverter, MPPT, H6 topology, Photo Voltaic System.

# INTRODUCTION

PV inverter has became a trend due to unattainable centralised maximum power point tracking( MPPT) incongruous issue during partial shading situations( 1- 4). Module integrated motor system is thus introduced to overcome the issue (5). With each panel upgraded with its own MPP Tracker (MPPT), the resolution is made best. Therefore the system achieves advanced effectiveness. Similar systems are called as AC Modules integrated motor ( MIC) or inverters. Various inverter topologies are introduced for PV operations. Transformer-less bones came up for its small size, but they are problematic with the panel’s parasitic capacitor (6). Also a DC- link capacitor is required in between the inverter and the motor. Impotent to gauge its affair voltage by several times advanced also makes the topologies unfit to serve in countries with high grid voltage. To overthrow the voltage boosting issue, slinging insulated motor is introduced to the inverter(7). It also connects to a low frequency unfolding inverter to flip the opposition to produce affair in the sinusoidal wave form.This way the DC- link capacitor is reduced to only the one the panel. Also, away from the MPPT, the only control task is on the DC- DC motor to shape its affair as asked. Flyback motor has its dynamic analogous to that of buck boost motor, and it utilises a motor to deliver a huge voltage step- up rate and galvanic insulation. Because of the existence of a non-minimum phase (NMP) zero (8) and system dynamic issue (9) in CCM, the topology is designed to operate in DCM. Therefore fusion of operation is suggested for similar systems (10, 11). Using a simple analog regulator (8, 12) The control problem for CCM has been overcome for the current regulator. Another system is built for testing the affair from grid side sludge rather (9), making it possible to control the system using digital regulator. Indeed the system is designed to operate under CCM operation, it also works best in DCM during grid voltage opposition shifting period (12). These designs by design it enhances the topology’s efficiency .As a matter of Fact it also shows deformations in the affair current (8, 9, 12). This paper puts forward a topology for interleaved flyback inverter participating two common switches and grid- side sludge with other transformers from different panels. For this to be in action , primary current control scheme is demanded (8).

In single stage grid connected inverters, a motor can be used to enhance the input voltage. The advanced input voltage will also be required than the maximum grid voltage. But this demand isn't fair for Photo voltaic operations since the characteristics of solar panel changes all the time. As the capacitance also has an impact on Maximum power point tracking (MPPT) effectiveness, the maximum capacitance leads to advanced MPPT effectiveness. Recently, a boost- buck motor connected inverter is proposed.

**II. SINGLE STAGE GRID CONNECTED INVERTER**

Figure 1 shows a single- stage regulator solar inverter system. It consists of a solar- array source, bulk input array sludge, capacitor CBULK, line- sludge, DC/ DC motor, 50/ 60Hz switching ground, affair sludge and a system regulator design. The system regulator can be perished into six introductory control sub-systems videlicet( 1) maximum power point shadowing( MPPT),( 2) solar- system array voltage regulation,( 3) motor affair normal-current regulation,( 4) DC/ AC switching ground inverter,( 5) compensated current supplying reference creator and( 6) mileage over-voltage protection.

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**Figure 1. Maximum Power Tracking Solar Inverter (Single stage)**



Figure 2 .Phase-Shift DC/DC Converter and Full-Bridge Unfolding Circuit

A full- bridge unfolding circuit with the inverter for converting the rectified sinusoid current into sinusoidal current, switched in 50/ 60Hz frequency is considered.

**III BUCK-BOOST BASED ON PV INVERTER**

A dc- dc motor with boost- buck type of circuit is considered as the prime stage with regulated output inductor current. A full- bridge motor unfolding circuit with 50 or 60 Hz line frequency is supplied to the dc- ac stage, which will be unfolding clamp remedied sinusoid current which has been regulated by the dc- ac stage into a pure sinusoidal current, as shown in Figure 5. Its first stage can be absolutely effective due to buck or boost mode if the low conduction voltage drop switching power MOSFET is considered and ultra-fast rear recovery diode.

In this interpretation, IGBT is turned on and off at ease with gating control.

In addition to the before mentioned, trust ability can be greatly enhanced because of the presence of a single high operating frequency power processing stage in this complete PCS. Figure 3 shows the illustration of Buck- boost grounded PV inverter.



Figure 3. Buck-boost inverter (PV Based)

**IV BOUNDARY MODE ANALYSIS**

During the buck mode, due to low input current of filter’s inductor, input current is considered, . In boost mode, the output current can be the output circuit filters and inductor current, whose ripple is also much mitigated. Circuit operates perpetually in continuous current mode (CCM) for input current (buck mode) and output current( boost mode). In addition, discontinuous current mode (DCM) or boundary mode can occur only in output current( buck mode) and input current (boost mode). Based on the input current ripple for boost mode and output current ripple for buck mode, boundary condition can be obtained and are shown in figures 4 and 5

  **Figure 4 Boundary power condition (Input current Figure 5 Boundary power condition (output**

 with various input voltage) current with various input voltage)

**V LEAKAGE CURRENT ANALYSIS**

It is inferred that the range of capacitance is between 100 – 400 pF between a single PV module and the point of contact. Its value relies on rainfall conditions, and in the worst case as stormy periods, the capacitance can be maximum as 80 nF KW. Leakage current in the grid tied inverter is shown in Figure. 6.



Figure 6 Leakage current in grid tied inverter system

To maintain the safety and follow the safety protocol , the leakage current should be of minimum value as possible for transformer less inverter. For the proposed topology, the negative outstation of solar modules is fixed as the set point, and the middle points on the bridge legs are fixed as phase and neutral for the affair outstations. Since grid voltage is varied with 60 Hz, small line frequency leakage current is in the proposed inverter. For a 2.5 kW system, the 200 nF capacitance is considered between the PV modules and the ground CPV.

**VI THE BOOST –BUCK MODE PV INVERTER CONTROL**

Inductor current will be treated as normal buck motor’s affair inductor current during buck mode. Still, it is hard to control inductor current in boost mode. Therefore, there is a need to design a compensator for boost mode an should be a applied into buck mode. In practice, if the boost mode is steady and well controlled, buck mode will be stable and well controlled. It clearly shows that the RHP zero and double pole make 2700 phase detention, which makes it intricate to be compensated. therefore, the compensated crossover frequency should be implemented first before double- pole’s frequency of the boost mode and assured that the peak Q value is lower than 0 dB. In order to have a compensator that's good for every operation point, the compensator design is system grounded on the worst conditions, which is defined as a condition with loftiest Qpk and the foremost phase drop. Here, when input voltage is the smallest defined value 200 V and output voltage is the peak voltage of the grid 340V then poor condition happens

For getting smooth waveform in transition between boost to buck modes, the saw tooth (offset) carrier right on the top of the buck mode PWM modulator can be applied to boost mode and it is shown in Figure 7.

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Figure 7. Block diagram of the buck boost single phase voltage source inverter

With lower bandwidth control , the maximum power point tracking power can be implemented as an outer loop, considering the magnitude of the output current reference for smooth transition between buck and boost modes respectively..

**VII SIMULATION MODEL AND RESULTS**

1. **SIMULATION OF GRID AND PLL**

The PLL is an integral part of the inverter operation.Here DC/ AC conversion is handled consequently with the AC line. All state operation and inversion- related control operations are accompanied to the line. The ripple cancellation control algorithm is the single operation that is not connected to the line though it could be done. The PLL operation is slightly else than that of other PLLs.. Simulation model of proposed System and Interleaved Flyback Inductor Simulation System are shown in figure 8.



**Figure 8. Simulation model of proposed System**

1024 slices are generated in a line cycle , or 512 slices per half- sine with no change in the number of slices. No restriction for varying the distance between each slice. The sine reference information is always the same that is a huge advantage. Figure 9 and 10 represents Average flyback input currents and Current error.



Figure 9 Flyback input currents (Average)



Figure 10 Current error representation

The load which shares between the local load and grid to control circle constantly monitors the error between the input currents of the transformers which helps in reducing the error. It also firmly adjusts the duty rate of every transformer by the inclusion/deduction of a correction factor value based on the error sign.

The presence of combined feed- forward and feedback system improves the system performance of the control system to an high range whenever there is a major measurable disturbance. In an ideal situation with zero measurement of disturbance, gain of the feed-forward compensator will completely eradicate the measured disturbance signal at best than the compensator operating alone. The important role of the feed-forward compensator in the solar inverter system is to provide the steady state duty rate D( t), to the sharing system, thereby allowing the compensated value to the error system. The cargo resistance is added in Rf, coming bone for a sludge inductor and DCR is in series to the cargo resistance in the AC-original circuit. By looking at the the open- circle forebode plot, it can be noted and viewed that periphery of both gain and and phase of the system are low in. value which makes the system innately to has a poor relative stability. Also, it is vividly observed that the ripples of switching frequency attenuation requires improvement and that the system gain at the needed system operating frequency (100/120 Hz) is definitely low. Grid current, current reference and voltage are shown in figures 11 and 12.



Figure 11. Current and current reference (Grid)



Figure 12. Grid voltage



 Figure 12 Output for Ripple control



 Figure 14 output current (DC/AC controlled )

Thus, the MPPT circle and the current control circle appears as a balanced gain system with zero or minimum phase error. The current circle in the circuit modulates the motor current into a remedied signal as a sine surge affair. Ripple control result and DC/ AC controlled affair current are shown in figures 13 and 14. The MOSFET full- ground needs to unfolds this remedied current and commute an interspersing current to be delivered to the grid. Gain feed forward compensator is used to improve the current circle bandwidth efficiently. The steady- state duty cycle can be clearly computed with the PV panel voltage and grid voltage. Steady- state modulation is being supplied through the feed-forward compensator, the current control circle takes into account dynamic variations and modulates the controlled current consequently.

**VIII.CONCLUSION**

A novel control approach has been successfully implemented for a solar-grounded inverter, aimed at efficiently harnessing available power while maintaining a near unity power factor. The new approach exhibits superior signal-to-noise ratio for feedback signals, ensuring reliable and robust Maximum Power Point Tracking (MPPT), while also tightly regulating the sinusoidal waveform of AC current supplied to the grid with a harmonious power factor. By employing a simplified feed-forward compensation mechanism and integrating a single stage of DC/DC power conversion, the proposed inverter system surpasses conventional designs in terms of complexity. Notably, this discussion introduces a high-performance grid connected solar PV inverter with a single-stage boost-buck topology, leveraging its unique operating mode to propose an appropriate control system for seamless mode transitions. Building on this analogous concept, three additional inverters with both step-up and step-down capabilities are presented, accompanied by three advanced control strategies. Multiple topologies can be explored based on the operating mode concept, with the option to integrate a boost stage when the inverter operates on the buck mode principle. Consequently, the new inverter eliminates the input voltage limitations, rendering it unnecessary for the input voltage to exceed the peak voltage of the grid's alternating current. This widens the input voltage range, reduces switching losses, and significantly improves the overall system efficiency. Achieving high effectiveness is made possible by implementing an innovative interleaved active-clamp flyback topology with Zero Voltage Switching (ZVS) technology. Effectiveness of ripple control and the resulting DC/AC controlled output current are shown in the simulated results. Utilizing a MOSFET full-bridge configuration, the rectified current is then converted into alternating current for the transmission to the grid. To enhance the current loop's bandwidth, a gain feed-forward compensator can be employed.

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