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Efficiency Improvement of PV system by using coupled-inductor single-stage boost inverter (CLSSBI) and NSPWM method

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Abstarct:

In comparison to photovoltaic (PV) power systems with transformers, the transformer-less systems are more affordable, smaller in size, and more efficient. The safety issue of the leakage current brought on by common mode voltages, conducting in the loop with parasitic capacitors between the solar panel and the ground, is one of the technological difficulties. . An impedance network with a coupled inductor at the front-end of the inverter bridge is introduced by the proposed coupled inductor single-stage boost inverter (CL-SSBI). While LCD might be seen as a snubber, the construction is straightforward.

Introduction:

The converter steps up the bus voltage by storing and transferring energy within the special impedance network using shoot-through zero vectors. It is also possible to optimise the boost gain by adjusting the connected inductor's turns ratio inside the impedance network.[1] As a result, the ac output voltage may be adjusted throughout a large range and increased. The drawback of inverters of this sort is that larger boost gain would be necessary, which would need more power loss and lesser efficiency. The equivalent switching frequency as seen from the impedance network can be six times the switching frequency of the inverter bridge, which will significantly reduce the power density and cost of the inverter. Shoot-through zero vectors are vectors that are evenly distributed among the three phase legs during a switching period. This letter outlines a CLSSBI-based technique for reducing the leakage current of a transformer-free grid-connected PV system. To stop the leakage current loop when in the active vectors and open-zero vectors, a diode is placed to the front of the topology. Additionally, the leakage current induced in the transient stages of switching from and to open-zero vectors is reduced by using the near-state PWM (NSPWM) approach with one-leg shoot-through zero vectors. Additionally, because NSPWM's modulation index remains in the high modulation region, the leakage current may be efficiently controlled without reducing the maximum magnitude of the output reference voltage.[2]

EXISTING SYSTEM:

The drawback of inverters of this sort is that larger boost gain would be necessary, which would need more power loss and lesser efficiency. Due to the low switching frequency of a typical system, shoot-through zero vectors are often distributed equally throughout the three phase legs during a switching period.[3]

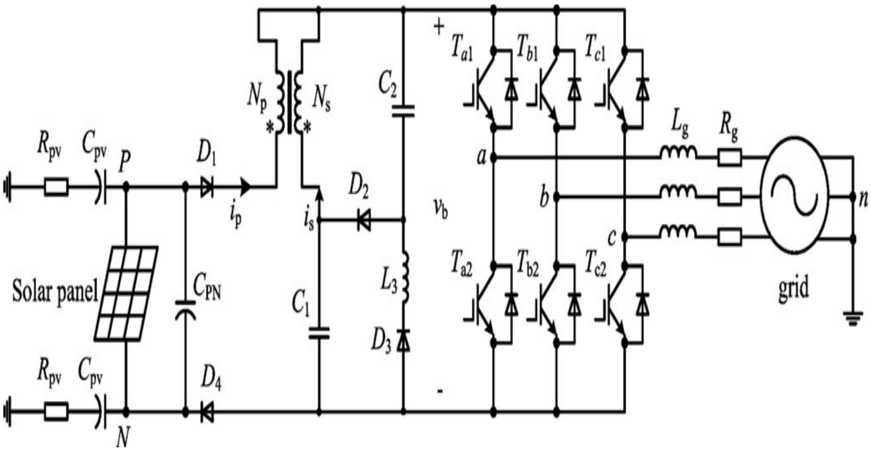


Fig. 1. 1 Transformer less grid-connected PV system based on CL-SSBI.

Depending on the kind of supply source and the associated topology of the power circuit, the dc to ac converters, also known as inverters, are divided into two categories: voltage source inverters (VSIs) and current source inverters (CSIs). Three-phase VSIs handle medium to high power applications, whereas single-phase VSIs handle low to midrange power applications. These topologies' primary goal is to offer a three-phase voltage source with controllable voltage amplitude, phase, and frequency.[4] In order to produce controllable frequency and ac voltage magnitudes using various pulse width modulation (PWM) strategies, three-phase dc/ac voltage source inverters are widely used in motor drives, active filters, and unified power flow controllers in power systems and uninterrupted power supplies.[5-6] An impedance network with a coupled inductor at the front-end of the inverter bridge is introduced by the proposed coupled inductor single-stage boost inverter (CL-SSBI). While LCD might be seen as a snubber, the construction is straightforward. The converter steps up the bus voltage by storing and transferring energy within the special impedance network using shoot-through zero vectors. It is also possible to optimise the boost gain by adjusting the connected inductor's turns ratio inside the impedance network. As a result, the ac output voltage may be adjusted throughout a large range and increased. The drawback of inverters of this sort is that larger boost gain would be necessary, which would need more power loss and lesser efficiency. The equivalent switching frequency as seen from the impedance network can be six times the

switching frequency of the inverter bridge, which will significantly reduce the power density and cost of the inverter. Shoot-through zero vectors are vectors that are evenly distributed among the three phase legs during a switching period. This letter outlines a CLSSBI-based technique for reducing the leakage current of a transformer-free grid-connected PV system. To stop the leakage current loop when in the active vectors and open-zero vectors, a diode is placed to the front of the topology. Additionally, the leakage current induced in the transient stages of switching from and to open-zero vectors is reduced by using the near-state PWM (NSPWM) approach with one-leg shoot-through zero vectors. And because the size of CMVs is lowered, the leakage current brought on by other transitions may also be decreased. Because NSPWM's modulation index remains in the high modulation portion, the leakage current may be efficiently controlled without reducing the maximum magnitude of the output reference voltage.[7]
Sunlight is converted into power via a photovoltaic system. The photovoltaic cell is the fundamental component of a solar system. Panels or modules can be created by grouping cells. Large solar arrays may be created by grouping many panels. A solar panel (with many cells linked in series and/or parallel) or a collection of panels are typically referred to as an array.

PROBLEM STATEMENT

The drawback of inverters of this sort is that larger boost gain would be necessary, which would need more power loss and lesser efficiency. Because the switching frequency in a typical system is modest, shoot-through zero vectors are frequently distributed equally throughout the three phase legs during a switching period. To minimise leakage current across the conduction route during the transition from and into open-zero vectors, the proposed system uses the near state pulse width modulation (NSPWM) approach with one-leg shoot-through zero vectors. The magnitude of common-mode voltages can be lowered while simultaneously reducing the leakage current brought on by other transitions.

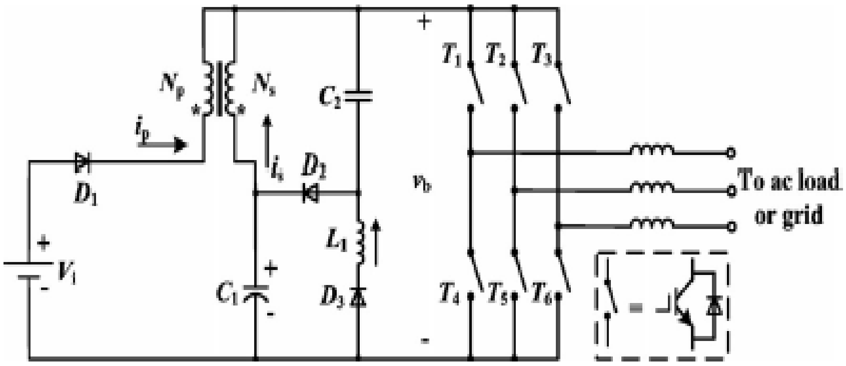
Objectives:

The "Modified Coupled Inductor Single Stage Boost Inverter Based Grid-Connected Photovoltaic (PV) System" is being suggested with the following goals:

I Decreasing the magnitude of reference common mode voltages without lowering the leakage current induced by common mode voltages in grid-connected photovoltaic (PV) systems.

ii) Increase the boost gain to regulate a wide variety of output voltages while reducing power loss and boosting system effectiveness.

PROPOSED SINGLE-STAGE BOOST INVERTER



Topology of single stage boost inverter with coupled inductor

The overall layout of the suggested one stage boost inverter is shown in Fig.5.1. It connects the three-phase inverter bridge with the power supply using an original impedance network. The impedance network, which does not need any switching hardware, might result in increased dependability, greater efficiency, and cheaper costs. The use of a linked inductor with a low leakage inductance helps the inverter's operating range to be increased. A battery, diode rectifier, fuel cell, or PV cell are examples of possible dc sources. This study focuses on one application of the single-stage boost inverter, a single-stage boost inverter for wind power production, to detail the features and working principle.

Because variable speed wind turbines are proven to provide more effective power tracking than fixed speed wind turbines, they are frequently used in wind power generating systems. Eight switching states are possible in conventional VSI, of which two are zero states and six are active states. Turning on either the top three devices or the bottom three devices will cause two zero states, which result in load terminals being shorted through. Switches from various phase legs may be activated to represent six active states when the input dc voltage is applied across the load. The traditional VSI forbids shoot-through zero state because it would cause device failure events to occur. The inverter's special boost feature is provided by the shoot-through zero state in conjunction with the impedance network in front of the three-phase bridge. It should be observed that the allocation of shoot-through zero states into open-zero states does not alter the duration of all open-zero state time intervals. The active states are therefore unaltered. The shoot-through zero state generates the same zero voltage as the open zero state to the load terminal, hence it has no effect on the pulse width modulation (PWM) regulation of the inverter.

OPERATION PRINCIPLE, BOOST FEATURE ANALYSIS, AND CONTROL STRATEGY

Equivalent circuits for the single-stage boost inverter in each of the three switching states are shown in Fig. 5.2.

Condition 1: As seen in Fig. 5.2, the converter is in the shoot-through zero state throughout this time (a). Bus voltage vb was shorted to ground, and diode D2 is biassed in the other direction. Primary current increases linearly when input dc voltage is delivered across the connected inductor's primary winding. C1 is charged by the secondary winding's inductive voltage. Assuming the capacitor voltage is constant, L1 simultaneously discharges C2 with a linearly increasing current.

Condition 2: The converter is in one of the two conventional open-zero states throughout this time, as shown in Fig. 5.2. (b). Through diode D2, linked inductor L1 and its secondary winding charge capacitors C1 and C2, respectively. The current of inductor L1 falls from its highest value to zero in this state.

Condition 3: Diode D3 is reverse biassed when the circuit is in one of the six active states, as shown in Fig. 5.2(c). The bus voltage is raised as a result of the energy released from the linked inductor and C1 into the load.

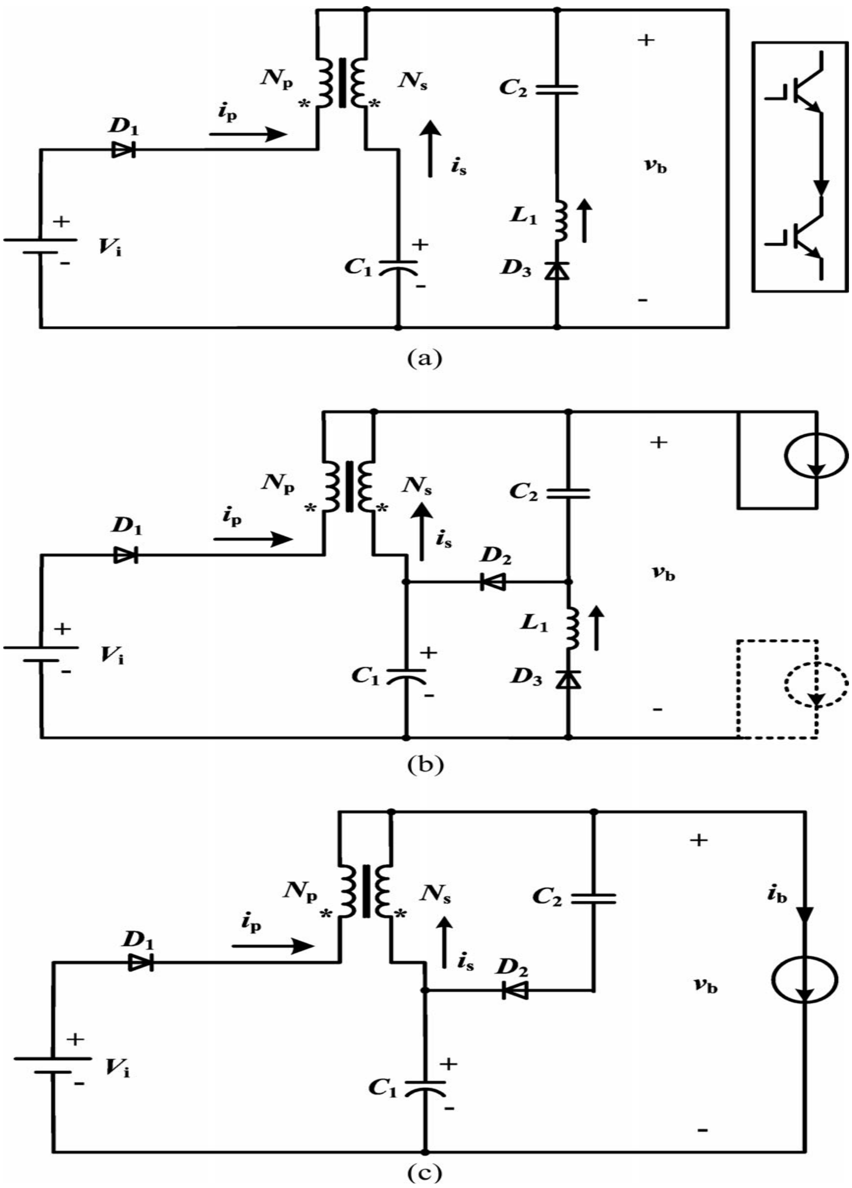


Fig. 5.2 Equivalent circuit under three switching states. (a) Shoot-through zero state. (b) Open-zero state. (c) Active state

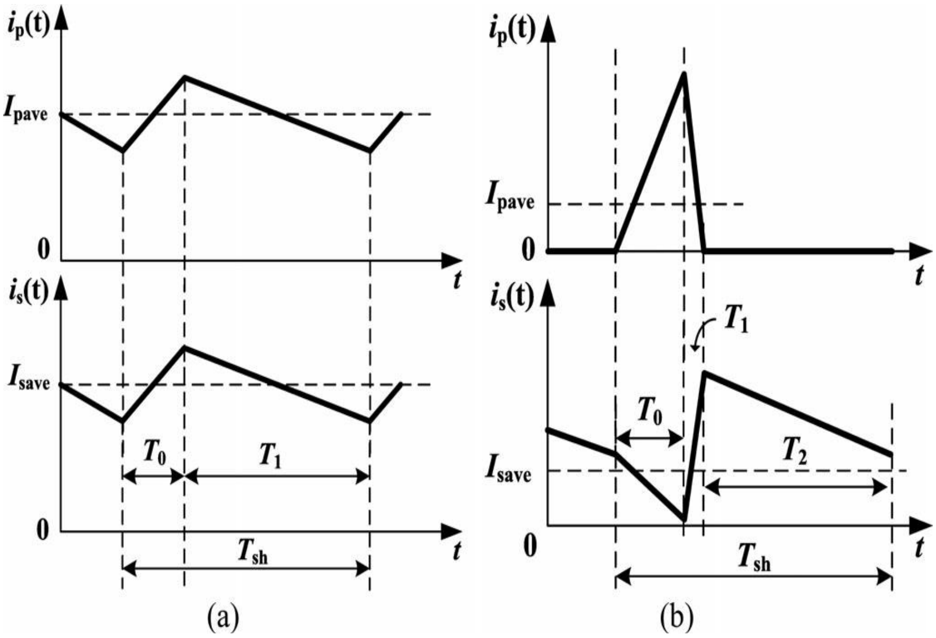


Fig. 5.3. Coupled inductor current waveforms under two operation modes. (a)Inductor *Lp* works in CCM. (b) Inductor *Lp* works in DCM.

By controlling the shoot through zero state as well as the linked inductor's turn ratio and coupling coefficient, two boost modes may be produced. Under these two modes, the single-stage boost inverter's operating principle is examined. The linked inductor's inductance should be built with a big enough value to guarantee continuous current-mode operation while using the converter for voltage drop compensation or other tasks requiring less boost gain. The primary winding's Lp inductance should be as low as possible to keep the circuit operating in discontinuous current mode when a bigger boost gain is necessary. In two different operation modes, Fig. 6 depicts the coupled inductor current waveform for one shoot-through time Tsh. Be aware that the switching period Ts of the inverter bridge is not comparable to the shoot-through period Tsh, which is the equivalent switching period as seen from the impedance network. Depending on the modulation technique employed, Tsh may be two to six times that of Ts, which minimises the linked inductor's size and weight requirements.

CL-SSBI BASED GRID CONNECTED PV SYSTEM WITHOUT USING NSPWM TECHNIQUE

The system taken into account for the simulation is a solar panel that supplies dc power to a linked inductor to increase power gain since a three phase inverter has to convert dc electricity to three phase power and needs boosted gain. DC electricity is converted into three phase power using a single stage boost inverter. This is transformed and supplied to the grid system. Six IGBTs are employed in a single stage boost inverter to perform the switching function, and a pulse generator is used to deliver the firing pulse to the IGBT. The Simulink/MATLAB environment is used to run the simulation.

The connection of a parasitic capacitor between a solar panel and the grid system is what generates the leakage current. To measure the amount of leakage current flowing between the grid system and solar panel, current measuring block and scope are linked. To determine the value of power loss and efficiency in the total system, a simultaneous Power Loss and Efficiency display block is also included. The three phase grid system is linked to scopes for the purpose of displaying the voltage and current output waveforms. The simulation models for this theory are depicted in Fig. 7.1 as being at odds with the control strategies. The SIMULINK block set's mathematical building blocks are used to assemble the model.

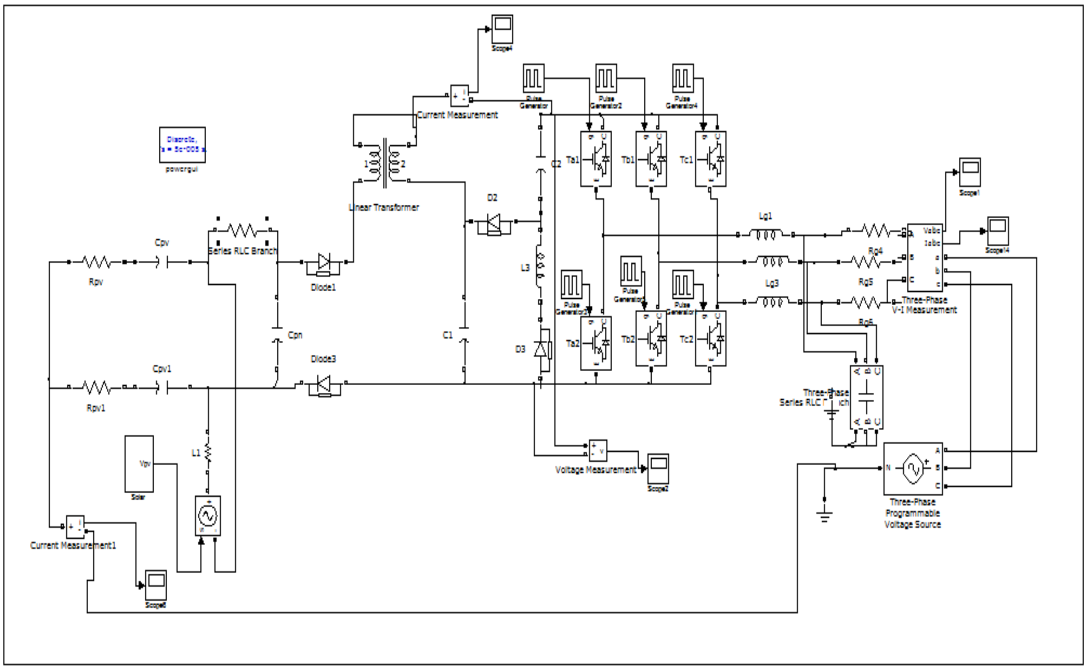


Fig 7.1 Simulation block diagram of coupled-inductor single-stage boost inverter based grid-connected PV system without using NSPWM technique.

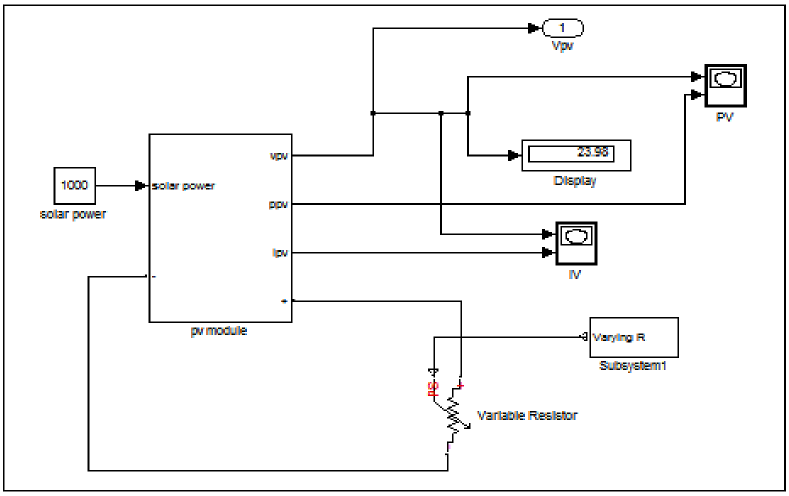


Fig 7.2 Simulation block diagram of Solar panel

Conclusion

a grid-connected photovoltaic system without a transformer that uses a linked inductor, single-stage boost inverter. Along with Diode D1, Diode D4 is placed to the topology's front to prevent leakage current loops during active and open-zero vectors. The NSPWM approach with one-leg shoot-through zero vectors, when open-zero vectors are eliminated, also reduces the leakage current induced in the transient states of switching from and to shoot-through zero vectors. The magnitude decrease of the common mode voltages can also be employed to further lower the leakage current brought on by other transitions. The common mode voltages and the resulting leakage currents of CL-SSBI and NSPWM are contrasted. The simulation results show that the leakage current's amplitude and RMS value can fall well below the threshold level, indicating that the leakage current has been effectively reduced. The simulation results also show that the boost gain can be improved to regulate a wide range of output voltages without increasing power loss, increasing the system efficiency.

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