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Transformer less Hybrid Bridge Inverter for Photovoltaic Grid Connected Systems

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Abstract:
The transformer-less inverters is trending in the grid-connected single-phase photovoltaic (PV) systems, for their high efficiency with low cost. The interface between the PV power source and the grid is formed using the DC/AC inverters. The common-mode ground leakage current surfaces are considered in between the solar panels and ground for parasitic capacitor. These inverters sustain in low input voltage similar to full-bridge inverter and eliminate common-mode leakage current. The essential requirement in proposed system is the reduction of leakage current to reduce the cost and increase the efficiency. An advanced hybrid- bridge transformer-less inverter is obtained by combining the half-bridge and ground point voltage level shifting modules. This reduces leakage current and the bus voltage required when compared to the basic half-bridge or neutral point clamping inverters.

Keywords : PV systems, hybrid transformer-less inverter, grid connected systems

I. INTRODUCTION

PV connected to line transformer in grid provides galvanic isolation in between the PV systems and the grid[1]-[4]. This enables protection and avoids unwanted leakage between the solar panel array system and ground. Additionally, it significantly reduces unwanted leakage in between the neutral and the solar panel array system. There is no direct current (DC) flows to the grid. However due to its low operating frequency (50 c/s), the transformer size large, heavy and expensive [5]-[7].

The inverter can be of the isolated type or non-isolated type depending on resistance in the grid and PV panels[8]-[9]. The transformer generally provides this galvanic isolation, which distinguishes transformer-based inverters from their transformer-less counterparts. On the DC side, the galvanic isolation can likely be in the form of a DC-DC transformer operating at high frequency or as a heavy AC transformer on the grid side[10]-[12]. Because of these factors, it becomes desirable to eliminate the transformer in the PV system. This will result in improving the efficiency and reducing the cost and size, but the ground current problem due to ground current capacitance will appear. To avoid the leakage currents, it is essential to use an inverter topology that can avoid common mode voltage and have higher efficiency. The technology allows the use of inverters without line transformer and without any effect on the system characteristics with respect to personal safety and grid integration[13]-[14]. The disadvantages are: Galvanic isolation in between the inverter and grid is needed, Heavy and costly transformer are used, Transformer must be designed with specified frequency, Required high safety issues, Increased weight, size and volume of the PV systems.

II. PROPOSED SYSTEM

The major issues in addressing the energy problems are the renewable energy sources. The PV systems will be dominant because of their availability and reliability. The capacitive ground current is the common problem that arises because of connection in solar PV panels. Although transformer reduces this problem, the major disadvantage of connecting transformer in solar array systems is its larger size and difficulty in installing the complete PV system. The cost of PV system is higher and leads to poor efficiency as the power losses are higher losses. The transformer-less inverter configuration provides better efficiency, smaller size and low weight problems.

The leakage current depends on topology of inverter used and but also on the choice of control strategy. A simplified transformer-less PV grid-connected system, which consists of PV panels, DC-link capacitors, power stage, filter stage and the AC grid. The parasitic capacitors in case of PV

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system depend on the leakage current through them into the grid, which is accentuated without galvanic isolation.

The existing topologies are summarized and divided into two groups to explore the leakage current. Besides, a hybrid-bridge single-phase topology is derived for the PV transformer-less applications because of the DC–AC decoupled circuit configuration. The introduced topology can have high efficiency and high reliability with the simple circuit configuration.

The main aim is to design a model for single phase transformer-less PV inverter systems with respect to the unwanted current, with the topology of a half bridge (leg) module and a Neutral Point Clamping bridge (leg) module. The need to develop a photovoltaic grid connected inverter system is essential for the mitigation of energy and environmental issues.

The advantages of the system are: Low power consumption Higher energy efficiency nearing 90% High power handling capability, Temperature variation and ageing do not cause drifting or degradation in linearity, Easier

implementation and control, removing the transformer results in reduced system losses and hence increased efficiency, Improvement in power factor lesser loads due to absence of inductive factor, Reduction in cost of the solar powered system due to elimination of transformer. The functional diagram of the proposed system is shown in Fig.1

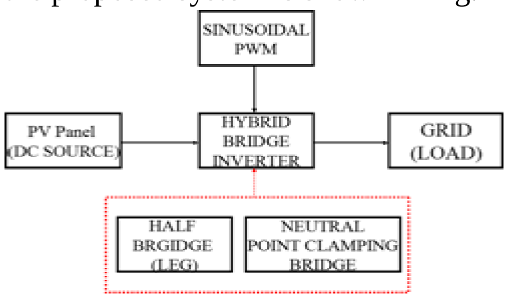

Fig.1.Functional Block diagram of proposed system

The block details are:

- Photo Voltaic (Solar Energy) based DC source is used as the input for the hybrid bridge inverter.
- Hybrid bridge inverter is a combination of half bridge and ground point clamping bridge.
- Sinusoidal PWM switching pulses are given to the hybrid bridge inverter to drive the switches on it.
- Output of the inverter is connected to grid with a LC filter on inverter side to generate sinusoidal outputs.

Transformer-less inverter are compact, light in weight and relatively inexpensive. Transformer-less inverters use electronic switches for regulation but mechanical switches produces heat and the humidity generally produced is reduced. Transformer-less inverter utilize power point trackers in two directions in which installations are connected as PV Systems. In case of transformer-less inverters, PV panels are installed in the north and west directions on the same rooftop. They generate maximum output at peak hours with best possible way. In case of traditional inverters, there is one working power point. At this point performance at lower frequencies gives less DC output for the whole system.

Inverter efficiency is obtained from the measurement of convergence of energy which considers DC to AC conversion is achieved for longer durations. It is necessary to calculate the performance under peak and off-peak conditions. Calculation of efficiency of the inverter operation is done at rated capacity.

The benefits of transformer-less inverter are: light weight, higher efficiency, ratings to accommodate dual MPPT inputs, possibility for isolated or non-isolated inverters. Introducing a boost converter between the solar system and the inverter reduces the losses by eliminating the transformer. This way, the efficiency of the whole PV system can be increased. The main disadvantage of transformer-less systems is the DC currents surfacing of injected AC current by the inverter. When transformer core is saturated, overheat may lead to failure.

III. GROUND LEAKAGE CURRENT AND HYBRID BRIDGE TOPOLOGY

Stand-alone PV systems operate independent of the electric utility grid. PV systems which are connected to grid are designed to operate in parallel combination with the utility grid. In earlier times, stand-alone PV systems were most commonly used. However, significant price reductions of PV modules and improvements in power conversion technology have increased the use PV systems with grid connection. PV power system with grid connection consists of PV panel along with power conversion unit.

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The inverter can achieve the MPPT of the solar panels and also facilitate injection of sinusoidal currents into the grid. Inverters used for grid are selected based on the resistance between the solar panel and the load because there are inverters with and without galvanic isolation in the grid connection. Galvanic isolation is done either by using a transformer operating at high frequency in the grid side or by connecting dc side of inverter a low frequency transformer. Removal of the transformer used for isolation purpose increases the efficiency. The size and cost of power system depends on the isolation transformer used in the system. The use of parasitic capacitance may lead to leakage current. The leakage current produces degradation in panels, safety problems, system losses, reduction in quality of current in the grid and induces electromagnetic interference. Generally half bridge or full bridge inverters are used to reduce leakage current using sinusoidal pulse width modulation. Bridges do not have common mode voltage. But half bridge inverter is used for high input voltage. This requires series connection of PV modules or a boost dc/dc converter with very high voltage gain to be used in the initial power processing stage. The advantage full bridge inverter is it requires less input voltage as compared to half bridge connection. This induces low system efficiency, high current ripple and large filter inductor. In case of PV panels, the junction is enclosed with metallic frame which is grounded. A stray capacitance is caused in between the metallic frame and the ground. The stray capacitance depends on the area of the solar panel. The main leakage current is due to the capacitance between the ground and solar panel when the common mode voltage is produced by the inverter. Generally leakage current should be restricted to a safe value.

IV. PROPOSED HYBRID BRIDGE INVERTER

Based on the leakage-current-suppression principle, a hybrid- bridge topology is presented in Fig. 2. to solve the current due to leakagein the non-isolated PV grid-connected system. The topology consists of a half bridge (leg) module and a NPC bridge(leg) module. Two symmetrical inductors (L1 and L2) are employed as the output filters to balance the common-mode voltage, which restrains the leakage current. An input DC-link capacitor is used to minimize the bus voltage fluctuation. Owing to the similar operational mode as the FB inverter, the required input DC voltage of the hybrid-bridge topology is as low as that in the FB inverter, which makes it suitable for the low voltage applications. The circuit diagram is shown in Fig. 2.

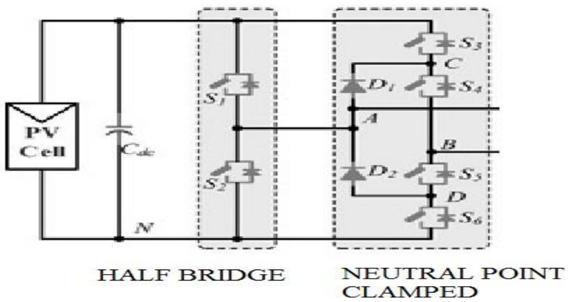

Fig. 2. Hybrid-bridge topology

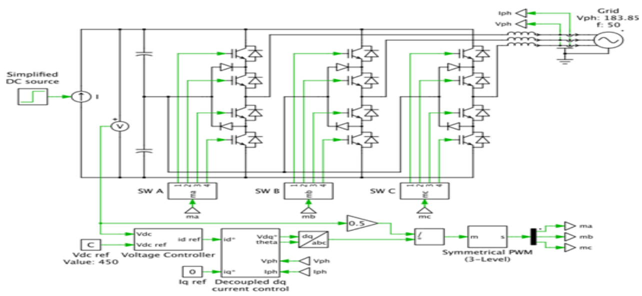

FIG.3 CIRCUIT DIAGRAM OF PROPOSED SYSTEM

To make the hybrid-bridge topology suitable for the PV grid-connected systems, a SPWM topology is used and the dead time is nullified. ug is the modulation signal, which keeps the same phase with the grid voltage vgrid to attain the unity power factor. And uc is the triangular carrier wave, which determines the switching frequency. The gate signals of S1–S6 are given out by comparing ug and uc.

In the positive half cycle of ug, if ug is larger than uc, S1 and S6 are turned on, and the two switches commutate at the switching frequency simultaneously. Meantime, S5 keeps in on state, S2–S4 are always turned off. Then in the negative half cycle of ug, S1, S5 and S6 are turned off, S2 and S3 commutate at a high frequency simultaneously and the gate signals are produced by comparing ug and uc, if ug is smaller than uc, S2 and S3 are turned on. Meantime, S4 keeps conducting. Therefore there are four main operational stages when the improved SPWM is applied to the hybrid-bridge inverter. The circuit diagram of the proposed system is shown in Fig. 3.

V. CONCLUSION

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The combination of split capacitor in the input and filter inductor components can reduce the leakage current to the satisfactory levels. The values of the dual components need to be made equal to avoid imbalance which may lead to a higher leakage current. Considering the above conditions the measured results for leakage current were minimal as compared to output current. The dc ac isolation is made possible using freewheeling bridge but has its effect on power efficiency. The frequency modulation from the control signals and specific combinations of filter elements can provide optimum operation.

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