DESIGN OF CASCADED H6 INVERTER WITH LEAKAGE CURRENT ELIMINATION FOR TRANSFORMER LESS PHOTOVOLTAIC SYSTEM

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ABSTRACT

There has been an increasing interest in transformer less inverter for grid-tied photovoltaic (PV) system because of the benefits of lower cost, smaller volume as well as higher efficiency compared with the ones with transformer. However, one of the technical challenges of this inverter is the safety issue of leakage current which needs to be addressed carefully. In addition, according to the international regulations, transformer less inverter should be capable of handling a certain amount of reactive power. In this study, a new H6-type transformer less inverter for grid-tied PV system is proposed that can eliminate the threat of leakage current. The proposed topology has also the capability to inject reactive power into the utility grid. Three-level output voltage employing unipolar sinusoidal pulse width modulation can be achieved with the proposed topology. The proposed topology structure and detail operation principle with reactive power control are investigated. The relationship among the existing topologies and their reactive power control capability are also discussed. The proposed topology is simulated in MATLAB/Simulink software to initially verify the accuracy of theoretical explanations. The experimental results validate the theoretical analysis and simulation results.

Keywords : *Converter, Inverter, Photovoltaic System.*

1.INTRODUCTION

Electric energy is widely used and it is indispensible source of useful work almost in every field of life. The increasing demand for the electric energy and declining energy resources such as fossil fuels have forced mankind to place significant emphasis on renewable energy sources, which emerged as the interconnection of different clean sources to yield higher reliability, reduced greenhouse gas emissions and increased power quality. Among the renewable energy systems, wind energy systems experienced major growth within the last two decades. However these sources may be geographically far away from the settlements and installations where the energy is needed. Moreover, flicker problems may arise at the point of common coupling (PCC) due to the unpredictable nature of the wind .Besides, the instantaneous real and reactive power of the source and the grid should be matched to continue nominal voltage and frequency of the grid, which is a hard task to achieve in the case of wind energy due to the difficulties in estimating the wind speed nearly instantaneously. In the second most popular renewable energy source, the solar energy source, these drawbacks are rather eliminated. The generation location of solar power may be very close to the place where the power is consumed, without circulating the current along a long distance through the power system. The variation in the illumination of sunlight with respect to time is considerably lower than the variation in wind speed; therefore flicker problems are rather reduced in solar systems.

In the photovoltaic (PV) solar technology, system installations have been experiencing exponential growth over the last couple of years. The government incentives provided all around the world and decreasing photovoltaic (PV) module and other installation prices (such as inverters, labor, shipping etc.)are the key factors behind this growth photovoltaic energy systems can be grouped as large-scale PV systems (solar farms involving MW ratings), medium scale (in tens of kW ratings) put on the roofs of industrial buildings etc., and finally the residential PV systems typically placed on the roofs of the residential places (several kW or less). However if the load is not a critical one such that the electric power is not always required, battery back-up is not necessary which is the case for PV energy fed water pumping systems. In grid-connected systems with battery back-up, the batteries are charged either from the PV source or from the utility grid. If the batteries are full, excessive power is delivered to the utility grid. In case of an electric power cut-off, the system operates as an uninterruptible power supply (UPS) by feeding the local loads from the batteries with the disconnection from the utility grid. In the case of grid-connected systems (where the grid-connected systems without battery back-up are intended hereby), battery charging and discharging losses are nonexistent which increases the system efficiency and cost, sacrificing the UPS operation. Although the choice among these PV systems is application dependent, grid-connected systems are the most favorable in terms of commerciality, due to their lower cost and size, and less maintenance. As a result of these, more than 78% of global market in 2008 was reported to be grid-connected application.

2.PROPOSED SYSTEM

A new H6-type topology that can overcome the drawback regarding reactive power controlling capability. A shows the circuit structure of the proposed H6-type PV inverter topology, compared with the topologies presented in a result, some differences are automatically created in the freewheeling path and control signals. An excellent DM and CM characteristics would be possible with the proposed topology by employing unipolar sliding mode shows the gate drive signal for the proposed circuit structure. It can be seen that when a phase shift is occurred

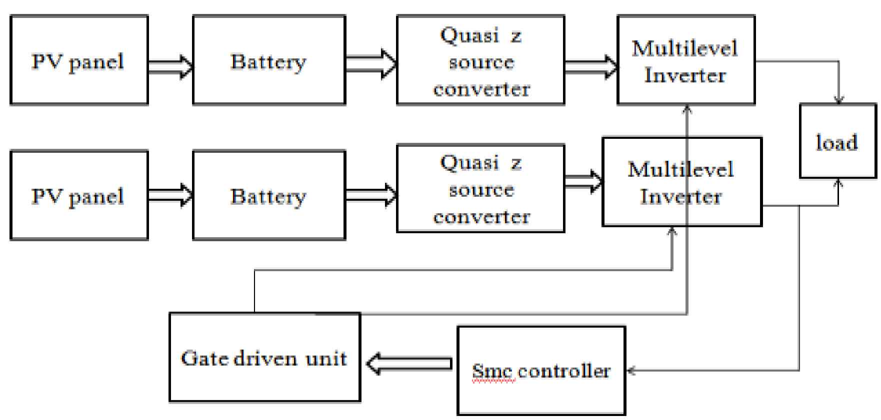

Fig -1 Block diagram of proposed system

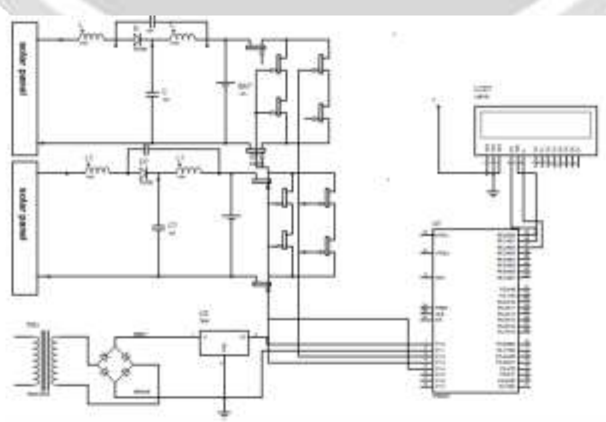

Fig -2 circuit diagram of proposed system

3. REACTIVE POWER CONTROL CAPABILITY ANALYSIS

Recently, almost every international regulation imposes that a definite amount of reactive power should be handled by the Grid-tied PV inverter. This is because of the problem of grid Voltage stability. According to the standard VDE-AR-N 4105, Grid-tied PV inverter of power rating below 3.68 kVA, should Attain PF from 0.95 leading to 0.95 lagging. When the Inverter injects or absorbs reactive power, a phase shift is occurred Between the voltage and current as shown in . The shifted Degree can be calculated as follows

$$\mathbf{U = COS^{-1}\ PF} \qquad \ldots\ldots (1)$$

Where θ is the shifted phase and PF is the commanded power factor. The grid voltage and current have opposite Polarity in the negative power region. Consequently, the PWM Strategy should be changed to draw power in this region. In the case of topologies presented in the anti-parallel diodes of MOSFETs will be activated if a phase shift is occurred between the voltage and current. Accordingly, the dependability of the system will be reduced because of the MOSFETs anti-parallel diode reverse recovery issues. Therefore the lack of reactive power handling capability constitutes a huge drawback of these topologies

The capacitive leakage current described in Section 2 is a reactive current (without loss). However, if a fault such as a defective insulation causes a live line to come into contact with grounded person additional current flows to ground. This unwanted current causes losses and is referred to as residual current. The total of both currents (leakage current and residual scurrent) is the differential current

In order to provide personal safety, in addition to the protection class of the PV array, transformer less inverters must be disconnected from the utility grid immediately upon occurrence of a residual current of 30 mA (DIN VDE 0126-1-1). For this purpose, during feed-in operation, the differential current (leakage current + residual current) is measured using an all-pole sensitive residual-current monitoring unit (RCMU). However, this can only measure the differential current (leakage current + residual current). It is only possible to factor out the residual current to a limited extent, and this becomes more difficult with increasing leakage current. From approximately 50 mA upwards, random fluctuations in the leakage current become so great that they can be interpreted as sudden surges of residual current of over 30 mA. In such cases, the inverter disconnects automatically from the utility grid as a preventative measure.

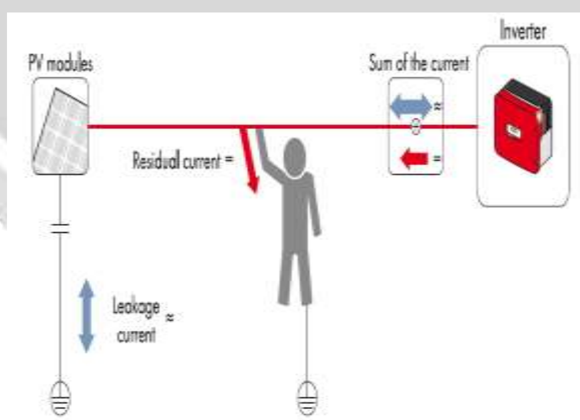

Fig-3 Diagram of leakage current affects residual current

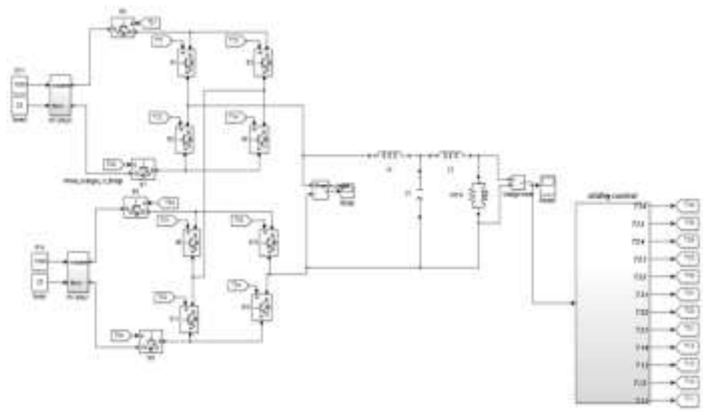

Fig 4 Simulation diagram of proposed system

4.SIMULATION AND RESULTS

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

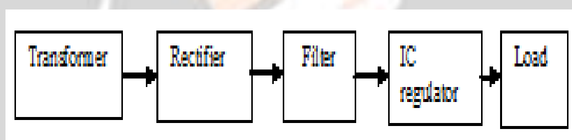

Fig -5: Block diagram of hardware

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantages of using precision rectifier are it will give peak voltage output as DC; rest of the circuits will give only RMS output. When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4. The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow. The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. this path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3.One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. Waveforms (3) and (4) can be observed across D2 and D4. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5). Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit. This may be shown by assigning values to some of the components shown in views A and B. assume that the same transformer is used in both circuits. The peak voltage developed between points X and y is 1000 volts in both circuits. In the conventional full-wave circuit shown—in view A, the peak voltage from the center tap to either X or Y is 500 volts. Since only one diode can conduct at any instant, the maximum voltage that can be rectified at any instant is 500 volts.

5.APPLICATIONS

Most of the world's lead–acid batteries are (SLI) batteries, with an estimated 320 million units shipped in 1999. In 1992 about 3 million tons of leads were used in the manufacture of batteries. Wet cell stand-by (stationary) batteries designed for deep discharge are commonly used in large backup power supplies for telephone and computer centers, grid energy storage, and off-grid household electric power systems. Lead–acid batteries are used in emergency lighting and to power sump pumps in case of power failure. Large lead–acid batteries are also used to power the electric motors in diesel-electric (conventional) submarines when submerged, and are used as emergency power on nuclear submarines as well. Lead–acid batteries were used to supply the filament (heater) voltage, with 2 V common in early vacuum tube (valve) radio receivers.

6. CONCLUSION

A H6 inverter for transformerless inverter has been proposed for a limitation of square current. A Quasi Z source is used for doubling the panel voltage. The leakage current is minimized by maintaining common mode voltage as constant thereby leakage current is automatically reduced. Hence harmonic current reduced so efficiency increased. A H6 inverter for transformer less inverter has been designed and its performance is simulated in MATLAB/simulink environment for achieving an improved power quality over a wide range of speed control. Finally, the performance of the proposed drive has been verified experimentally on a developed hardware prototype. A satisfactory performance of the proposed drive has been achieved and it is a recommended solution for low power application.

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