Design And Implementation Of Seven Level Inverter With Solar Energy Genration System

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Abstract: In this paper, we use Photo voltaic cells to generate a dc voltage which acts a power source for the power generation. The gate pulses from the Photovoltaic cells are used to control the DC-DC Converter; the boosted and rectified DC Voltage is used as an Input to Seven Level (DC-AC Inverter). The seven level inverter which is an IGBT Bridge acts as AC-DC Converter thus providing sinusoidal AC voltage with some harmonics. In order to reduce the harmonics we keep a LC filter. Lastly the entire system should be connected to a grid system which in our case is the utility.

Keywords: DC-DC Converter, DC-AC Inverter, Photovoltaic system (PV system).

I. INTRODUCTION

The extensive use of fossil fuels has resulted in the global problem of greenhouse emissions. Moreover, as the supplies of fossil fuels are depleted in the future, they will become increasingly expensive. Thus, solar energy is becoming more important since it produces less pollution and the cost of fossil fuel energy is rising, while the cost of solar arrays is decreasing. In particular, small-capacity distributed power generation systems using solar energy may be widely used in residential applications in the near future.

The power conversion interface is important to grid connected solar power generation systems because it converts the dc power generated by a solar cell array into ac power and feeds this ac power into the utility grid. An inverter is necessary in the power conversion interface to convert the dc power to ac power. Since the output voltage of a solar cell array is low, a dc–dc power converter is used in a small-capacity solar power generation system to boost the output voltage, so it can match the dc bus voltage of the inverter. The power conversion efficiency of the power conversion interface is important to insure that there is no waste of the energy generated by the solar cell array.

Renewable energy sources are alternatives to our conventional energy sources such as fossil fuels e.g. oil, coal, gas that is not renewable. The conventional energy sources are limited and can be exhausted. Many renewable energy sources are existing such as solar, wind, biomass, hydro, geothermal and ocean power. Among PV has the advantage of clean and no pollution, and etc. So, PV systems are attracting attention in the world. The basic element of a PV system is the solar cell .A solar cell directly converts the energy of sunlight directly into electricity in the form of dc. A typical PV cell consists of a p-n junction formed in a semiconductor material similar to a diode.

Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, concentrated solar power, solar architecture and artificial photosynthesis.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

Active solar technologies encompass solar thermal energy, using solar collectors for heating, and solar power, converting sunlight into electricity either directly using photovoltaics (PV), or indirectly using concentrated solar power (CSP).

A photovoltaic system converts light into electrical direct current (DC) by taking advantage of the photoelectric effect.[33] Solar PV has turned into a multi-billion, fast-growing industry, continues to improve its cost-effectiveness, and has the most potential of any renewable technologies together with CSP.[34][35]Concentrated solar power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Commercial concentrated solar power plants were first developed in the 1980s. CSP-Stirling has by far the highest efficiency among all solar energy technologies.

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

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Grid interconnection of PV system requires [2-3] an efficient converter to converter the low voltage dc into ac. The conventional H-bridge inverter produces a square output, which contains infinite number of odd harmonics and dv/dt stress is also high. Normal PWM inverter can reduces the THD, but switching losses are high and also this inverter is restricted to low power applications. The importance of multilevel inverters [MLI] has been increased since last few decades[4], [5]. These new types of inverters are suitable for high voltage and high power application due to their ability to synthesize waveforms with better harmonic spectrum and with less THD. Generally MUs are classified into three types: they are

1. Diode Clamped MUs
2. Flying capacitor MUs
3. Cascaded H-bridge MUs.

Diode clamped MUs require large number of clamping diodes as the level increases. In flying capacitor MUs, Switching utilization and efficiency are poor and also it requires large number of capacitors as the level increases and cost is also high. Cascaded H-bridge MUs are mostly preferred [6] for high power applications as the regulation of the DC bus is simple. But it requires separate dc sources and also the complexity of the structure is increases as the level predominantly increase. In order to address the above concerns, this paper proposes a new type of multilevel inverter which requires less number of DC sources and switches compared to Cascaded H-bridge MUs. THD of the output voltage is also less when compared to the conventional MUs. By using this inverter we can efficiently integrate the PV into the existing conventional power grid.

II. LITERATURE SURVEY

A. INTRODUCTION

This paper proposes a new solar power generation system, which is composed of a dc/dc power converter and a new seven-level inverter. The dc/dc power converter integrates a dc–dc boost converter and a transformer to convert the output voltage of the solar cell array into two independent voltage sources with multiple relationships. this new seven-level inverter is configured using a capacitor selection circuit and a full-bridge power converter, connected in cascade. the capacitor selection circuit converts the two output voltage sources of dc–dc power converter into a three-level dc voltage, and the full-bridge power converter further converts this three-level dc voltage into a seven-level ac voltage. in this way, the proposed solar power generation system generates a sinusoidal output current that is in phase with the utility voltage and is fed into the utility. the salient features of the proposed seven-level inverter are that only six power electronic switches are used, and only one power electronic switch is switched at high frequency at any time. a prototype is developed and tested to verify the performance of this proposed solar power generation system.

The extensive use of fossil fuels has resulted in the global problem of greenhouse emissions. Moreover, as the supplies of fossil fuels are depleted in the future, they will become increasingly expensive. Thus, solar energy is becoming more important since it produces less pollution and the cost of fossil fuel energy is rising, while the cost of solar arrays is decreasing. In particular, small-capacity distributed power generation systems using solar energy may be widely used in residential applications in the near future.

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Efficiency of the power conversion interface is important to insure that there is no waste of the energy generated by the solar cell array. The active devices and passive devices in the inverter produce a power loss. The power losses due to active devices include both conduction losses and switching losses. Conduction loss results from the use of active devices, while the switching loss is proportional to the voltage and the current changes for each switching and switching frequency. A filter inductor is used to process the switching harmonics of an inverter, so the power loss is proportional to the amount of switching harmonics

The literature review presented in this chapter starts with the structure of a 3-phase grid-connected PV system to give readers an idea about the functionality of a typical PV inverter. Since the PV inverter is interfaced to a utility grid, it is very important that the interconnection is in accordance with the utility codes and standards.

Photovoltaic systems require interfacing power converters between the PV arrays and the grid. These power converters are used for two major tasks. First, is to inject a sinusoidal current in to the grid. And second is to reduce the harmonics content in the grid injected voltage and current. Normally there are two power converters. The first one is a DC/DC power converter that is used to operate the PV arrays at the maximum power point. The other one is a DC/AC power converter to interconnect the photovoltaic system to the grid. As shown in fig.1

The classical single or three-phase two level VSIs is normally used for this power converter type. However, other topologies have been proposed is the multi level VSI. Multilevel converter topologies are a very interesting choice for realizing this objective.

Multilevel power converters present several advantages over a conventional two level converter such as:

- Reducing switching frequency

- Output voltage with very low distortion and
- Reduced dv/dt stress.

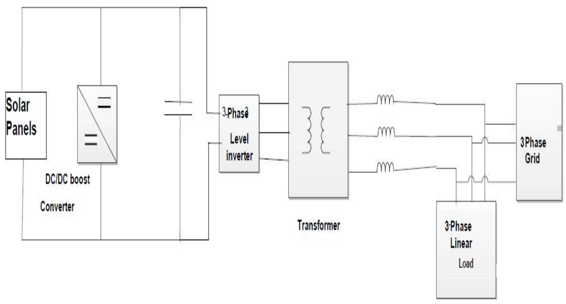

Fig.1: Grid connected solar panels with two stage inversion process

In order to obtain a galvanic connection between the grid and the PV generator many PV systems use a power transformer, avoiding that a leakage current may flow through the capacitance between PV generator and ground. Some systems use a transformer embedded in a high-frequency DC/DC converter. Others use a line frequency transformer at the output of the inverter as presented in the proposed model.

Related to these developments, this paper presents a new power converter structure for SPV systems. The proposed structure uses twin configured three-phase three levels NPC VSIs and a line transformer. This structure is specially developed to use with the central -string technology. A control system for the MLI is also proposed. This control system is based on a voltage oriented controller with a pulse width modulator (PWM). Several experimental results are presented in order to confirm the characteristics of the proposed system against the conventional two level inverters topology.

B. CONTROL STRATEGIES

Among multiple functions of grid connected systems, the current control plays one of the most important roles. The performance of the complete system largely depends on the quality of the applied current control strategy. It has to fulfill basic requirements, such as low harmonic distortion of the output current, high dynamic response, regulation of the dc-link voltage and, in a number of cases, provide bi-directional power flow. The desire to propose a current control strategy which combines most of these requirements has encouraged many researches in the last two decades [12] [14].

1. Controller of Proposed dc/dc converter

The DC to DC boost converters is shown in fig.2 is an important component to reach the desire voltage level in grid connected system so as to reduce the complexity and rating of the required PV modules. The voltage source provides the input DC voltage to the switch control, and to the magnetic field storage element.

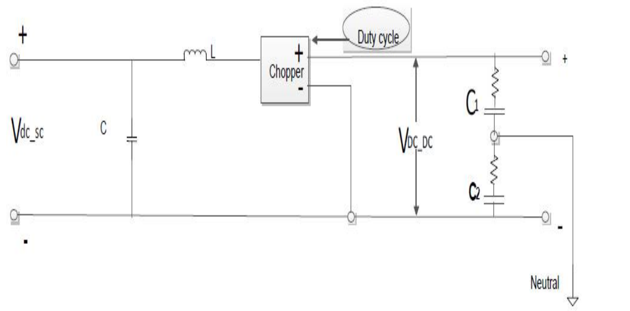

Fig.2: DC/DC boost converter with neutral point clamping

The control signal or duty cycle is given by open loop switch control that directs the action of the switching element, while the output rectifier and filter deliver an acceptable DC voltage at the output. The input of 200 volts represented by Vdc sc is given at the input terminal converter and in the control circuit the reference voltage which is required is given as input signal i.e. 400 volts is represented by symbol Vref as shown in fig.3. These two signals are compared in the PI controller and the controlled output is given to the signal generator. And required dc output voltage is given by equation (1).

$$V_{ref} = \sqrt{2V_{LL}/M} \qquad (1)$$

VLL = the line to line voltage of the AC-grid

M = modulating index

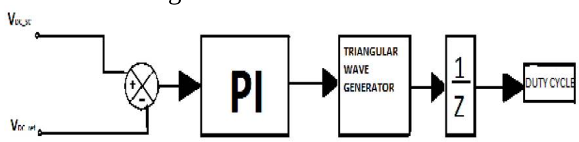

Fig.3: DC/DC converter controller

2. Controller design for dc/ac two levels inverter

The controller plays an important role in controlling and maintaining the proper functioning of the whole system by limiting the system parameter in specified ranges. Here in fig.4 the controller of grid connected two levels PV inverter is presented. As shown in the fig.4 we have to use the power feedback from grid to control the active and reactive power flow in the grid and to maintain the grid current sinusoidal and within specified limits. In controller the grid power is compared with the reference power and the resultant signal is then fed to the power controller which extracts the reference current signal in dq axes. Which again converted into three phase component and this reference current is compared with the gird current and the error signal fed to the hysteresis controller which directly generates the control signals or firing pulse for the inverter to maintain the gird current within specified limits.

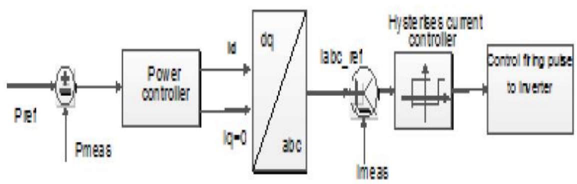

Fig 4: Controller design of two levels inverter

III. PROPOSED METHODOLOGY

A. INTRODUCTION

PROPOSED SYSTEM:

Proposed solar power generation system generates a sinusoidal output current that is in phase with the utility voltage. The seven-level inverter converts the dc power into high quality ac power and feeds it into the utility and regulates the voltages of capacitors.

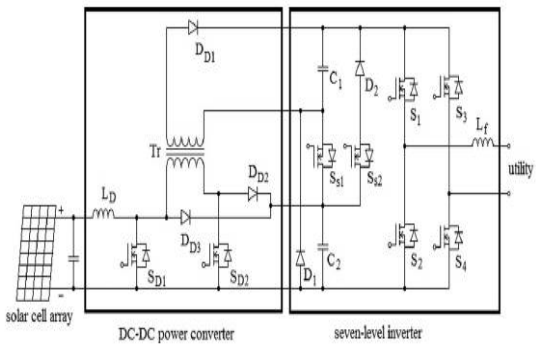

Fig 5: Proposed solar power generation system.

The proposed solar power generation system is composed of a solar cell array, a dc–dc power converter, and a new seven-level inverter. The solar cell array is connected to the dc–dc power converter, and the dc–dc power converter is a boost converter that incorporates a transformer with a turn ratio of 2:1. The dc–dc power converter converts the output power of the solar cell array into two independent voltage sources with multiple relationships, which are supplied to the seven-level inverter. This new seven-level inverter is composed of a capacitor selection circuit and a full-bridge power converter, connected in a cascade. The power electronic switches of capacitor selection circuit determine the discharge of the two capacitors while the two capacitors are being discharged individually or in series.

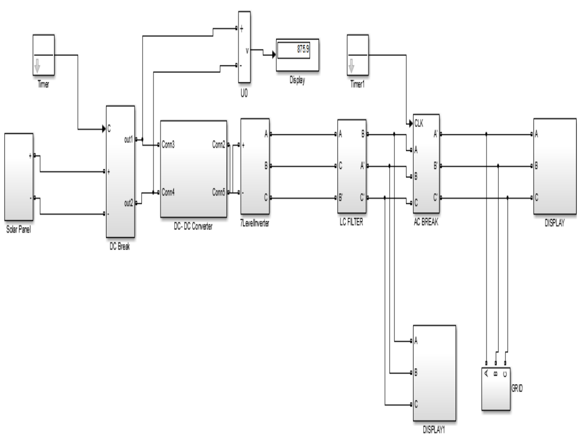

Fig 6: Simulink block diagram of solar power generation system with inverter

IV. SIMULATION RESULTS

Simulation was done on MATLAB R2013a, the results was shown that the solar inverter with reduced harmonics.

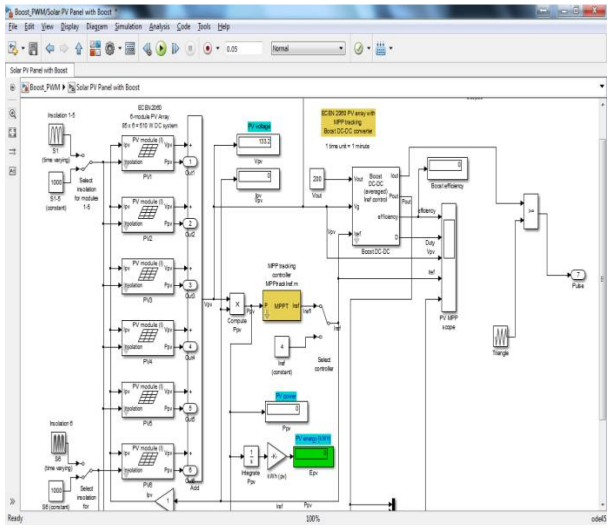

Fig 7:Matlab/Simulink diagram of proposed nine level inverter.

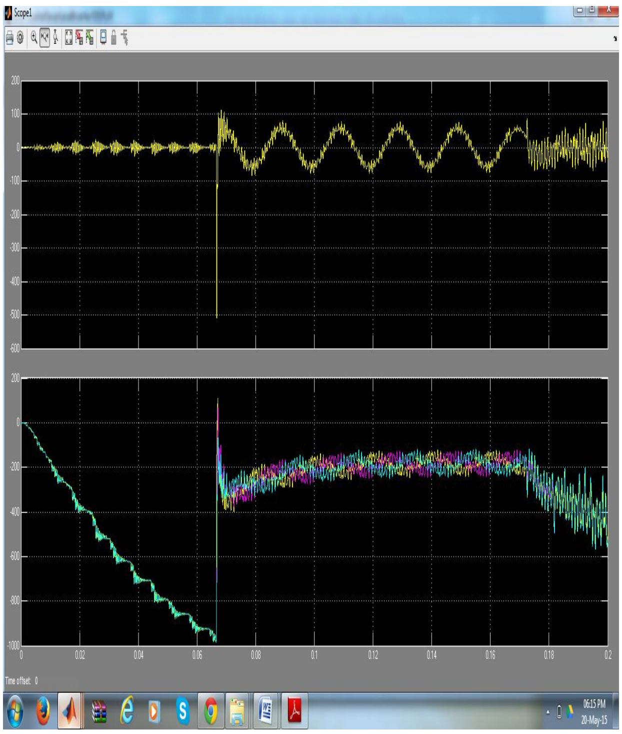

Fig 8: Inverting outputs

V. CONCLUSION

This project proposes a solar power generation system to convert the dc energy generated by a solar cell array into ac energy that is fed into the utility. The proposed solar power generation system is composed of a dc–dc power converter and a seven level inverter. The seven-level inverter contains only six power electronic switches, which simplifies the circuit configuration. Furthermore, only one power electronic switch is switched at high frequency at any time to generate the seven-level output voltage. This reduces the switching power loss and improves the power efficiency. The voltages of the two dc capacitors in the proposed seven-level inverter are balanced automatically, so the control circuit is simplified. Experimental results show that the proposed solar power generation system generates a seven-level output voltage and outputs a sinusoidal current that is in phase with the utility voltage, yielding a power factor of unity. In addition, the proposed solar power generation system can effectively trace the maximum power of solar cell array.

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