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Single Phase Seven Level Grid Connected Inverter for PV System

C. Pratheep Kumar Reddy[1], Mrs. K.Anitha Reddy[2], Mrs S. Bharathi [3] and Dr. S. Arumugam [4]

1 Final Year B.Tech, Department of Electrical and Electronics Engineering, Malla Reddy Engineering College (A), India.

2,3 Assistant Professor, Department of Electrical and Electronics Engineering, Malla Reddy Engineering College (A). India.

4 Professor, Department of Electrical and Electronics Engineering, Malla Reddy Engineering College (A). India.

E-Mail: anithamrec1@gmail.com

Abstract— ***A single-phase grid-connected inverter is usually used for residential or low-power applications of power ranges that are less than 10 kW. Types of single-phase grid-connected inverters have been investigated. A common topology of this inverter is full-bridge three-level. The three-level inverter can satisfy specifications through its very high switching, but it could also unfortunately increase switching losses, acoustic noise, and level of interference to other equipment. Improving its output waveform reduces its harmonic content and, hence, also the size of the filter used and the level of electromagnetic interference (EMI) generated by the inverter's switching operation. Multilevel inverters are promising; they have nearly sinusoidal output-voltage waveforms, output current with better harmonic profile, less stressing of electronic components owing to decreased voltages, switching losses that are lower than those of conventional two-level inverters, a smaller filter size, and lower EMI, all of which make them cheaper, lighter, and more compact. Various topologies for multilevel inverters have been proposed over the years. Common ones are diode-clamped, flying capacitor or multi cell, cascaded H-bridge, and modified H-bridge multilevel. This paper recounts the development of a novel modified H-bridge single-phase multilevel inverter that has two diode embedded bidirectional switches and a novel pulse width modulated (PWM) technique.***

***Keywords*— Electromagnetic Interference, Pulse Width Modulated (PWM) Technique.**

I. INTRODUCTION

The ever-increasing energy consumption, fossil fuels' soaring costs and exhaustible nature, and worsening global environment have created a booming interest in renewable energy generation systems, one of which is photovoltaic. Such a system generates electricity by converting the Sun's energy directly into electricity. Photovoltaic-generated energy can be delivered to power system networks through grid-connected inverters. A single-phase grid-connected inverter is usually used for residential or low-power applications of power ranges that are less than 10 kW. Types of single-phase grid-connected inverters have been investigated. A common topology of this inverter is full-bridge three-level. The three-level inverter can satisfy specifications through its very high switching, but it could also unfortunately increase switching losses, acoustic noise, and level of interference to other equipment. Improving its output waveform reduces its harmonic content and, hence, also the size of the filter used and the level of electromagnetic interference (EMI) generated by the inverter's switching operation. Multilevel inverters are promising; they have nearly sinusoidal output-voltage waveforms, output current with better harmonic profile, less stressing of electronic components owing to decreased voltages, switching losses that are lower than those of conventional two-level inverters, a smaller filter size, and lower EMI, all of which make them cheaper, lighter, and more compact. Various topologies for multilevel inverters have been proposed over the years. Common ones are diode-clamped, flying capacitor or multi cell, cascaded H-bridge, and modified H-bridge multilevel. This paper recounts the development of a novel modified H-bridge single-phase multilevel inverter that has two diode embedded bidirectional switches and a novel pulse width modulated (PWM) technique. The topology was applied to a grid-connected photovoltaic system with considerations for a maximum-power-point tracker (MPPT) and a current-control algorithm.

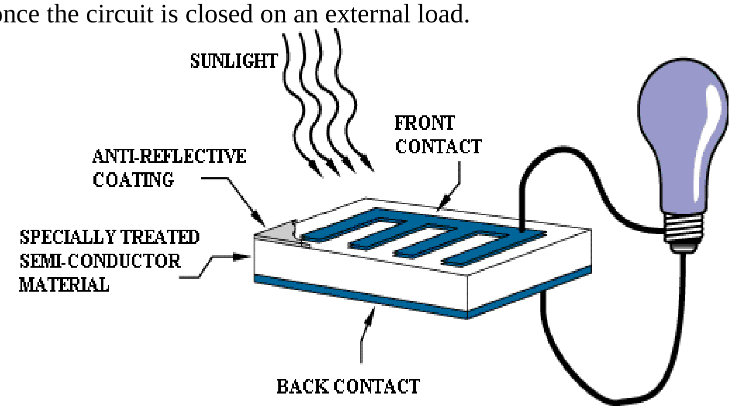
II. PHOTOVOLTAIC TECHNOLOGY

Photovoltaic' is the field of technology and research related to the devices which directly convert sunlight into electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic effect involves the creation of voltage in a material upon exposure to electromagnetic radiation. The photovoltaic effect was first noted by a French physicist, Edmund Becquerel, in 1839, who found that certain materials would produce small amounts of electric current when exposed to light. In 1905, Albert Einstein described the nature of light and the photoelectric effect on which photovoltaic technology is based, for which he later won a Nobel prize in physics. The first photovoltaic module was built by Bell Laboratories in 1954. It was billed as a solar battery and was mostly just a curiosity as it was too expensive to gain widespread use. In the 1960s, the space industry began to make the first serious use of the technology to provide power aboard spacecraft. Through the space programs, the technology advanced, its reliability was established, and the cost began to decline. During the energy crisis in the 1970s, photovoltaic technology gained recognition as a source of power for non-space applications.

The solar cell is the elementary building block of the photovoltaic technology. Solar cellsare made of semiconductor materials, such as silicon. One of the properties of semiconductors that makes them most useful is that their conductivity may easily be modified by introducing impurities into their crystal lattice. For instance, in the fabrication of a photovoltaic solar cell, silicon, which has four valence electrons, is treated to increase its conductivity. On one side of the cell, the impurities, which are phosphorus atoms with five valence electrons (n-donor), donate weakly bound valence electrons to the silicon material, creating excess negative charge carriers.

On the other side, atoms of boron with three valence electrons (p-donor) create a greater affinity than silicon to attract electrons. Because the p-type silicon is in intimate contact with the n-type silicon a p-n junction is established and a diffusion of electrons occurs from the region of high electron concentration (the n-type side) into the region of low electron concentration (p-type side). When the electrons diffuse across the p-n junction, they recombine with holes on the p-type side.

However, the diffusion of carriers does not occur indefinitely, because the imbalance of charge immediately on either sides of the junction originates an electric field. This electric field forms a diode that promotes current to flow in only one direction. Ohmic metal-semiconductor contacts are made to both the n-type and p-type sides of the solar cell, and the electrodes are ready to be connected to an external load. When photons of light fall on the cell, they transfer their energy to the charge carriers. The electric field across the junction separates photo-generated positive charge carriers (holes) from their negative counterpart(electrons). In this way an electrical current is extracted once the circuit is closed on an external load.



A. Mounting Structure

The main purpose of the mounting structure is to hold the modules in the required position without undue stress. The structure may also provide a route for the electrical wiring and may be free standing or part of another structure (e.g. a building). At its simplest, the mounting structure is a metal framework, securely fixed into the ground .It must be capable of withstanding appropriate environmental stresses, such as wind loading, for the location. As well as the mechanical issues, the mounting has an influence on the operating temperature of the system, depending on how easily heat can be dissipated by the module.

B. Tilt Angle And Orientation

The orientation of the module with respect to the direction of the Sun determines the intensity of the sunlight falling on the module surface. Two main parameters are defined to describe this. The first is the tilt angle, which is the angle between the plane of the module and the horizontal. The second parameter is the azimuth angle, which is the angle between the plane of the module and due south (or sometimes due north depending on the definition used). Correction of the direct normal irradiance to that on any surface can be determined using the cosine of the angle between the normal to the Sun and the module plane.

However, although this condition will give the maximum output over the year, there can be considerable variation in output with season. This is particularly true in high-latitude locations where the day length varies significantly between summer and winter. Therefore, if a constant or reasonably constant load is to be met or, particularly, if the winter load is higher than the summer load, then the best tilt angle may be higher in order to boost winter output. Prevailing weather conditions can influence the optimization of the array orientation if they affect the sunlight levels available at certain times of the day. Alternatively, the load to be met may also vary during the day and the array can be designed to match the output with this variable demand by varying the azimuth angle. Notwithstanding the ability to tailor the output profile by altering the tilt and azimuth angles, the overall array performance does not vary substantially for small differences in array orientation. Figure shows the percentage variation in annual insulation levels for the location of London as tilt angle is varied between 0 and 90degrees and azimuth angle is varied between –45o (south east) and +45o (south west).

The maximum insulation level is obtained for a south-facing surface at a tilt angle ofabout 35 degrees, as would be expected for a latitude of about 51oN. However, the isolation level varies by less than 10% with changing azimuth angle at this tilt angle. A similarly low variation is observed for south facing surfaces for a variation of +/- 30degrees from the optimum tilt angle.

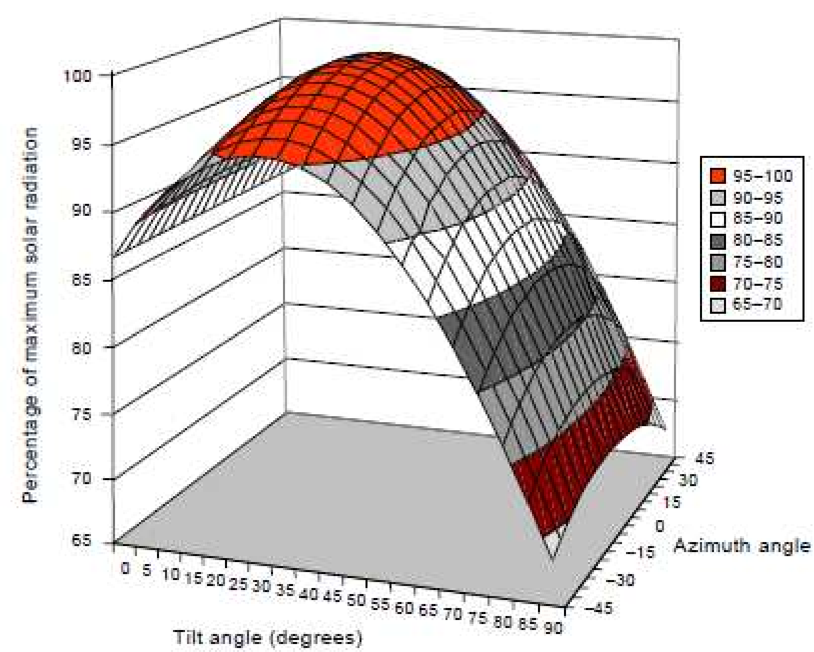


Fig. 2.1 Percentage variation of annual sunlight levels as a function of tilt angle and azimuth angle.

The calculations were carried out for the location of London using Metronome Version 3.0.The final aspect to consider when deciding on array orientation is the incorporation in the support structure. For building-integrated applications, the system orientation is also dictated by the nature of the roof or façade in which it is to being corporated. It may be necessary to trade off the additional output from the optimum orientation against any additional costs that might be incurred to accomplish this. The aesthetic issues must also be considered.

III. System Design

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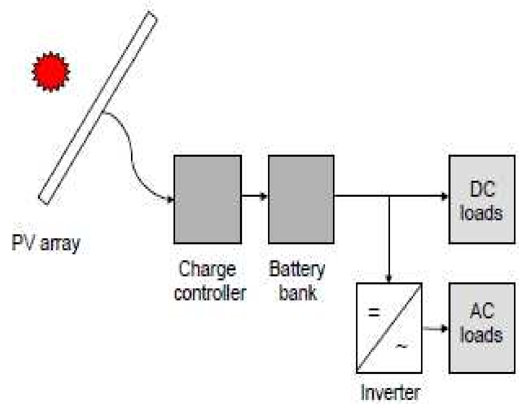
There are two main system configurations – stand-alone and grid-connected. As its name implies, the stand-alone PV system operates independently of any other power supply and it usually supplies electricity to a dedicated load or loads. It may include a storage facility (e.g. battery bank) to allow electricity to be provided during the night or at times of poor sunlight levels. Stand-alone systems are also often referred to as autonomous systems since their operation is independent of other power sources. By contrast, the grid-connected PV system operates in parallel with the conventional electricity distribution system. It can be used to feed electricity into the grid distribution system or to power loads which can also be fed from the grid.

It is also possible to add one or more alternative power supplies (e.g. diesel generator, wind turbine) to the system to meet some of the load requirements. These systems are then known as 'hybrid' systems. Hybrid systems can be used in both stand-alone and grid-connected applications but are more common in the former because, provided the power supplies have been chosen to be complementary, they allow reduction of the storage requirement without increased loss of load probability. Figures below illustrate the schematic diagrams of the three main system types.



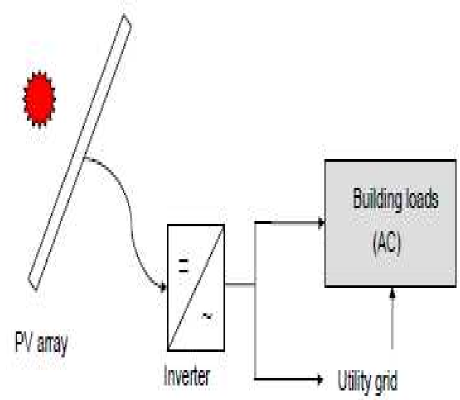


Fig. 3.1 Schematic diagram of a stand-alone photovoltaic system. Fig. 3.2 Schematic diagram of grid-connected photovoltaic system.

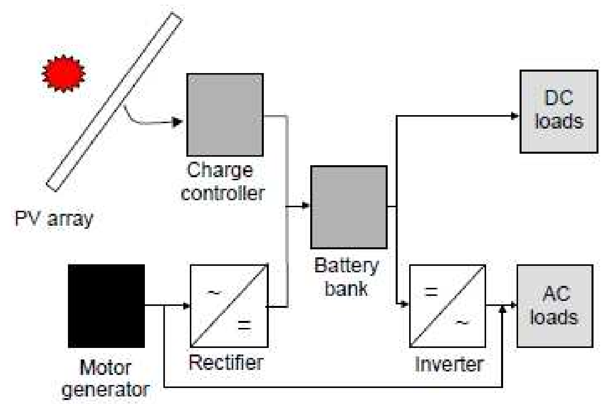


Fig. 3.3 Schematic diagram of hybrid system incorporating a photovoltaic array and a motor generator

IV. CONCLUSION

Multilevel inverters offer improved output waveforms and lower THD. This paper has presented a novel PWM switching scheme for the proposed multilevel inverter. It utilizes three reference signals and a triangular carrier signal to generate PWM switching signals. The behavior of the proposed multilevel inverter was analyzed in detail. By controlling the modulation index, the desired number of levels of the inverter's output voltage can be achieved.

The less THD in the seven-level inverter compared with that in the five- and three-level inverters is an attractive solution for grid-connected PV inverters.

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