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Three Phase VSI using SVPWM Technique for Grid Connected PV System

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Abstract:

Solar energy is one of the most promising Renewable Energy Sources (RES) that can be used to produce electric energy through Photovoltaic (PV) process. The Solar Photovoltaic (SPV) system which is directly supply power to the grid is becoming more popular. A power electronic converter which converts DC power from the Photo voltaic array to AC power at required voltage and frequency levels is known as Inverter. Generally different Pulse Width Modulation (PWM) methods have been implemented for grid connected 3-phase Voltage Source Inverter (VSI) system. This thesis defines few types of PWM techniques and mathematical model of LC filter circuit is given using state space analysis.

INTRODUCTION:

Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, Tides and Geothermal heat. Theseresources are renewable and can be naturally replenished. Therefore, for all practical purposes, these resources can be considered to be inexhaustible, unlike dwindling conventional fossil fuels. The global energy crunch has provided a renewed impetus to the growth and development of Clean and Renewable Energy sources. Clean Development Mechanisms (CDMs) are being adoptedby organizations all across the globe. Apart from the rapidly decreasing reserves of fossil fuels in the world, another major factor working against fossil fuels is the pollution associated with their combustion. Contrastingly, renewable energy sources are known to be much cleaner and produce energy without the harmful effects of pollution unlike their conventional counterparts.

PHOTOVOLTAIC TECHNOLOGY:

A PV array consists of a number of PV modules, mounted in the same plane and electrically connected to give the required electrical output for the application. The PV array can be of any size from a few hundred watts to hundreds of kilowatts, although the larger systems are often divided into several electrically independent sub arrays each feeding into their own power conditioning system.

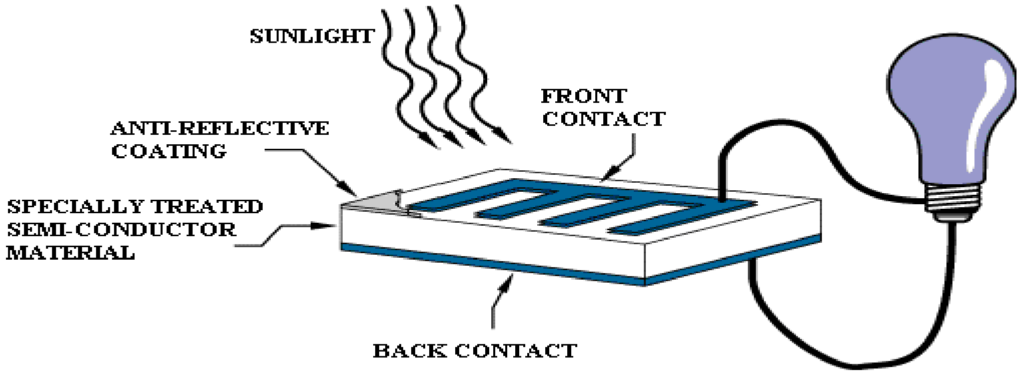
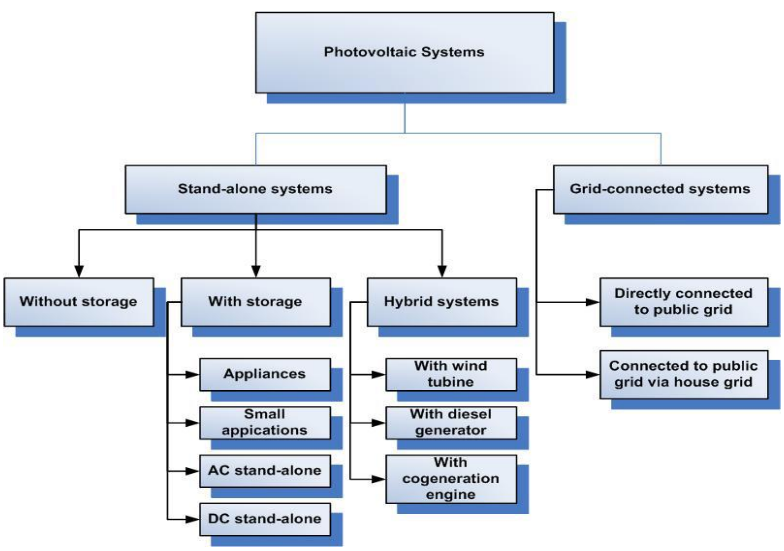


Fig : photovoltaic systems

Classification of PV system:

The PV system classifications are these are two main general classifications as depicted in the figure are the stand-alone and the grid-connected systems. The main distinguishing fact tor between these two systems is that in stand-alone systems the solar energy output is matched with the load demand. To cater for different load patterns, storage elements are generally used and most systems currently use batteries for storage. If the PV system is used in conjunction with another power source like a wind or diesel generator then it falls under the class of hybrid systems. The balances of system (BOS) components are a major contribution to the life cycle costs of a photovoltaic system.



PV cell:

PVs generate electric power when illuminated by sunlight or artificial light. To illustrate the operation of a PV cell the p-n homo junction cell is used. PV cells contain

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a junction between two different materials across which there is a built in electric field. The absorption of photons of energy greater than the band gap energy of the semiconductor promotes electrons from the valence band to the conduction band, creating hole-electron pairs throughout the illuminated part of the semiconductor. These electron and hole pairs will flow in opposite directions across the junction thereby creating DC power.

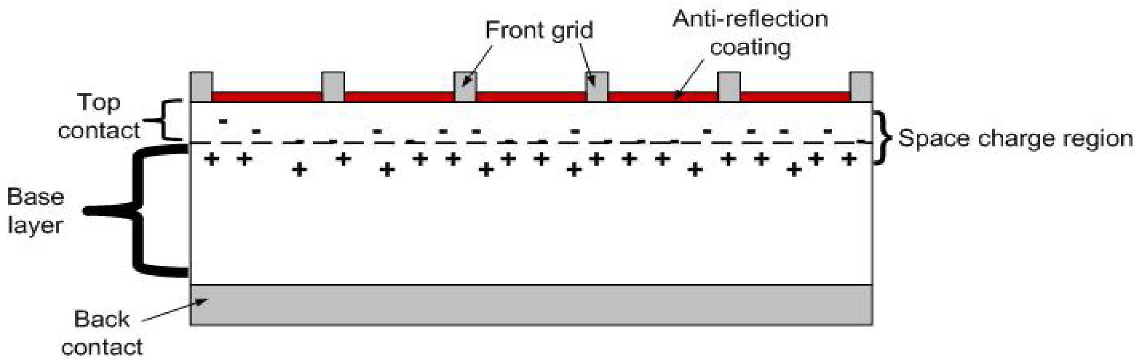

Figure: Structure of a PV cell

PV Module:

This PV module for the majority of applications multiple solar cells need to be connected in series or in parallel to produce enough voltage and power. Individual cells are usually connected into a series string of cells (typically 36 or 72) to achieve the desired output voltage. The complete assembly is usually referred to as a module and manufacturers basically sell modules to customers. The modules serves another function of protecting individual cells from water, dust etc. as the solar cells are placed into an encapsulation of single or double at glasses.Within a module the different cells are connected electrically in series or in parallel although most modules have a series connection connection of how 36 cells are connected in series. In a series connection the same current flows through all the cells and the voltage at the module terminals is the sum of the individual voltages of each cell. It is therefore, very critical for the cells to be well matched in the series string so that all cells operate at the maximum power points. When modules are connected in parallel the current will be the sum of the individual cell currents and the output voltage will equal that of a single cell.

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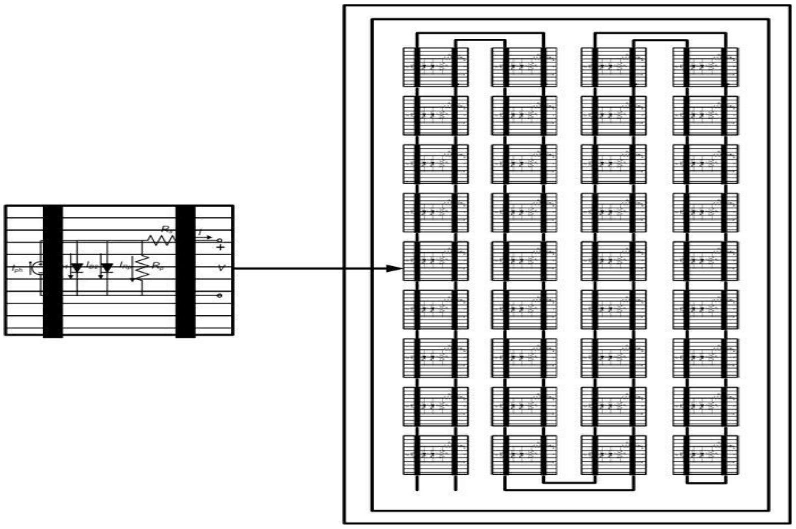

Figure: Structure of a PV module with 36 cells connected in series

Array:

An array is a structure that consists of a number of PV modules, mounted on the same plane with electrical connections to provide enough electrical power for a given application. Arrays range in power capacity from a few hundred watts to hundreds of kilowatts. The connection of modules in an array is similar to the connection of cells in a single module. To increase the voltage, modules are connected in series and to increase the current they are connected in parallel. Matching is again very important for the overall performance of the array. The structure of an array.which has 4 parallel connections of 4 module strings connected in series.

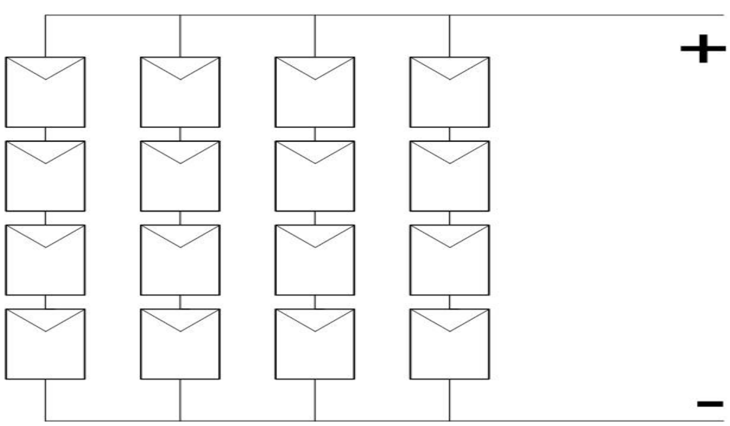

Figure: Structure of a PV array

SOLAR CELL:

The photovoltaic effect was first reported by Edmund Becquerel in 1839 when he observed that the action of light on a silver coated platinum electrode immersed in electrolyte produced an electric current. Forty years later the first solid state photovoltaic devices were constructed by workers investigating the recently discovered photoconductivity of selenium.
In 1876 William Adams and Richard Day found that a photocurrent could be produced in a sample of selenium when contacted by two heated platinum contacts. The photovoltaic action of the selenium differed from its photoconductive action in that a current was produced spontaneously by the action of light.

ELECTRICAL CONNECTION OF THE CELLS:

The electrical output of a single cell is dependent on the design of the device and the
Semi-conductor material(s) chosen, but is usually insufficient for most applications. In order to provide the appropriate quantity of electrical power, a number of cells must be electrically connected. There are two basic connection methods: series connection, in which the top contact of each cell is connected to the back contact of the next cell in the sequence, and parallel connection, in which all the top contacts are connected together, as are all the bottom contacts. In both cases, this results in just two electrical connection points for the group of cells.

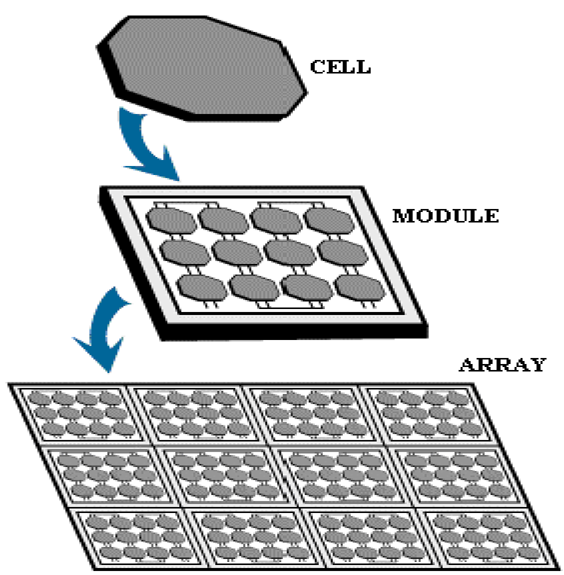

Fig: model of PV cell

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SYSTEM DESIGN:

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.

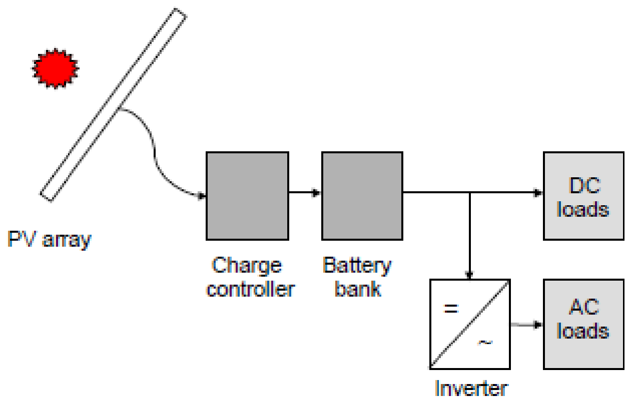

Fig :Schematic diagram of a stand-alone photovoltaic system.

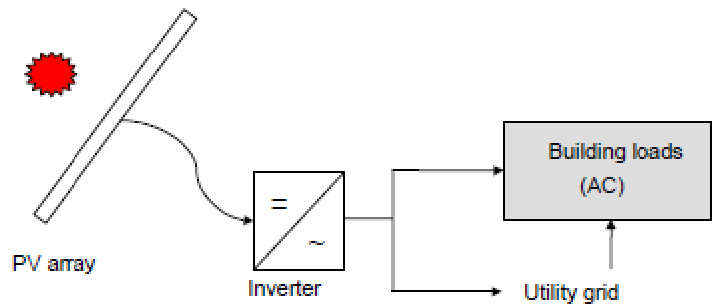

Fig :Schematic diagram of grid-connected photovoltaic system.

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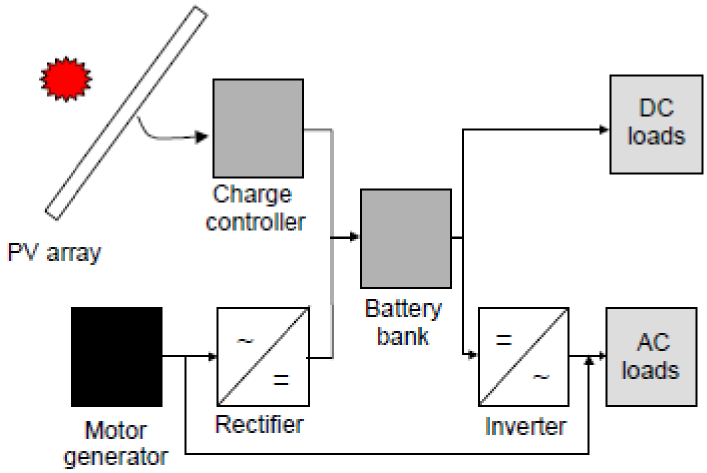

Fig :Schematic diagram of hybrid system incorporating a photovoltaic array and a motor generator

PV modeling:

A PV array consists of several photovoltaic cells in series and parallel connections. Series connections are responsible for increasing the voltage of the module whereas the parallel connection is responsible for increasing the current in the array. Typically a solar cell can be modeled by a currentsource and an inverted diode connected in parallel to it. It has its own series and parallel resistance. Series resistance is due to hindrance in the path of flow of electrons from n to p junction and parallel resistance is due to the leakage current.

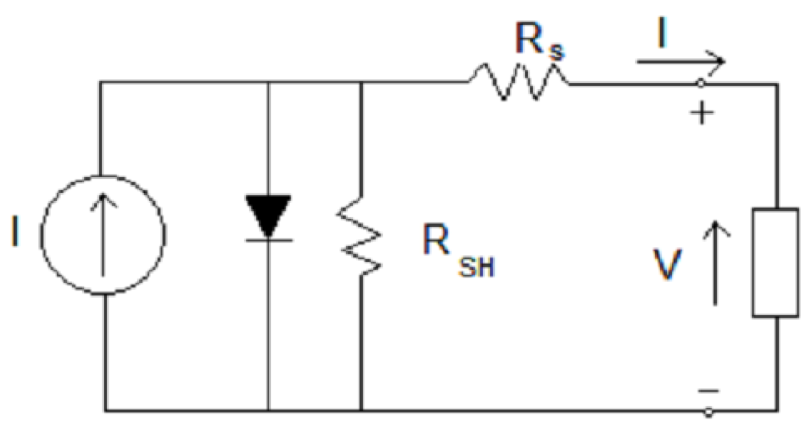

Figure: Single diode model of a PV cell

MATLAB/SIMULINK RESULTS:

Case i: Matlab/Simulink diagram for Proposed Grid connected PV system

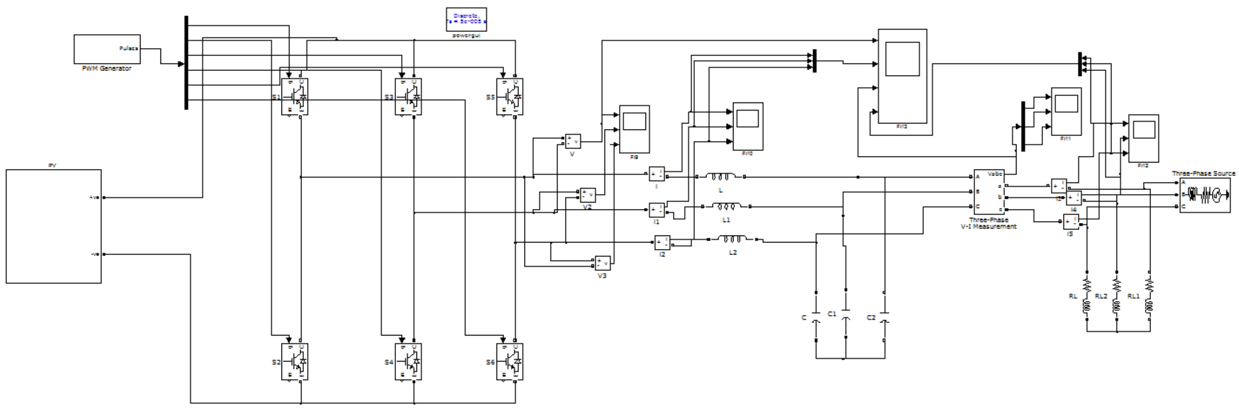

Figure : MATLAB/Simulink Circuit diagram of aGrid Connected SPV system

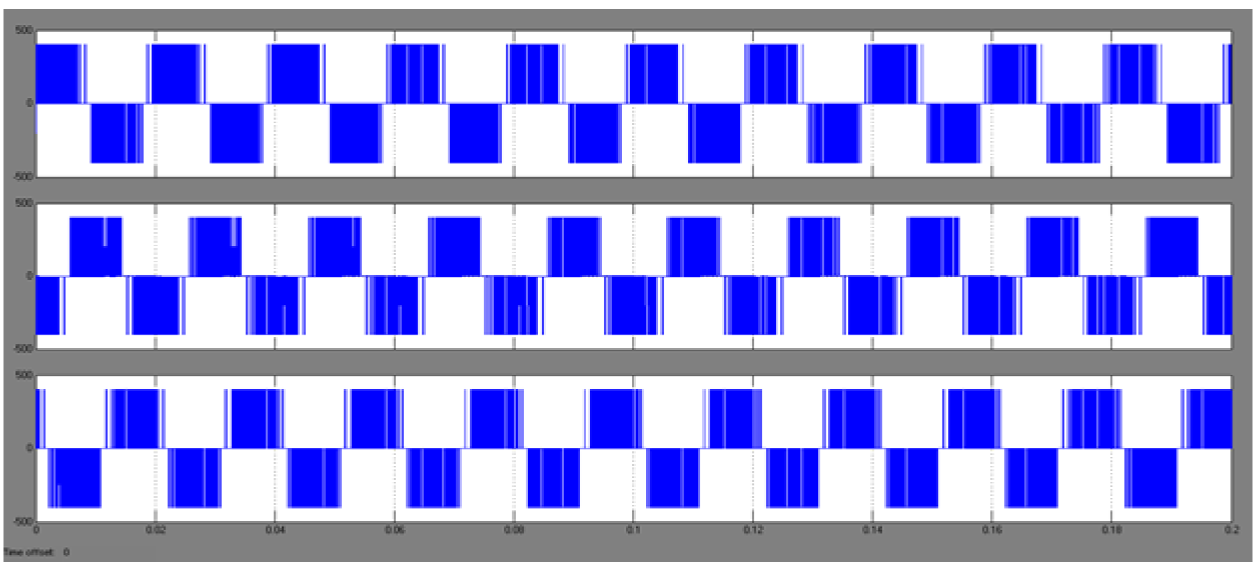

Figure : Inverter Output line to line Voltages ($ViAB$,$ViBC$,$ViCA$)

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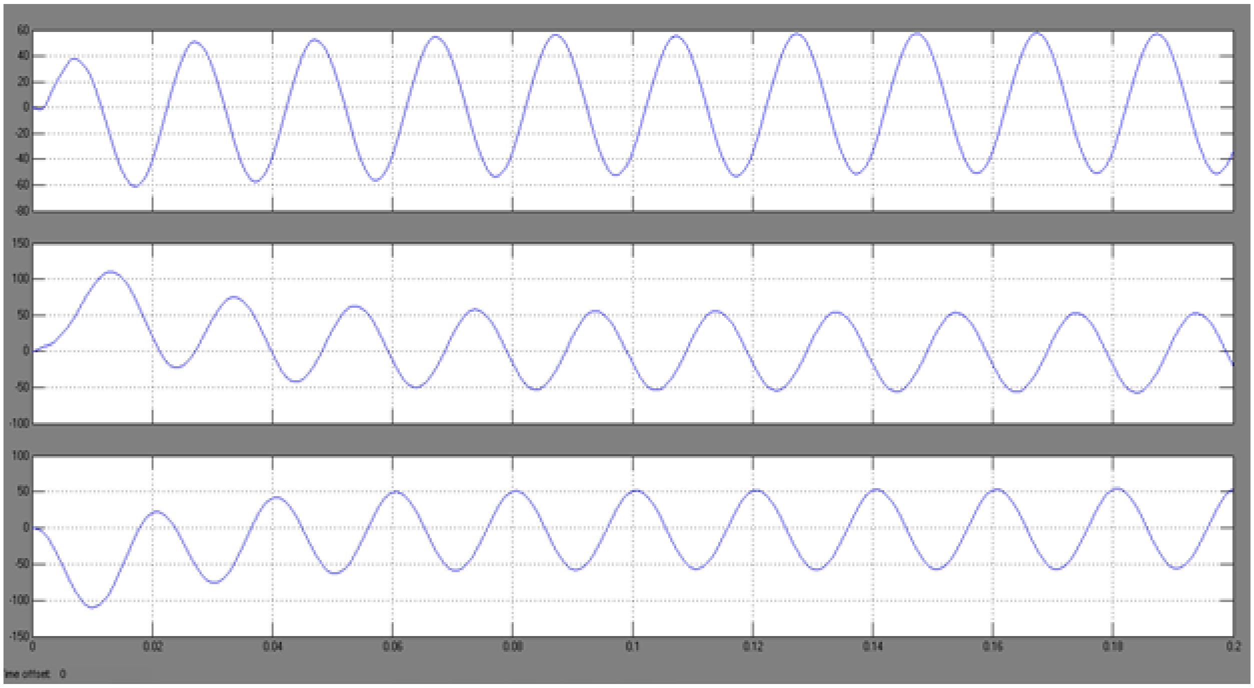

Figure :Inverter Output Currents (iiA,iiB,iiC)

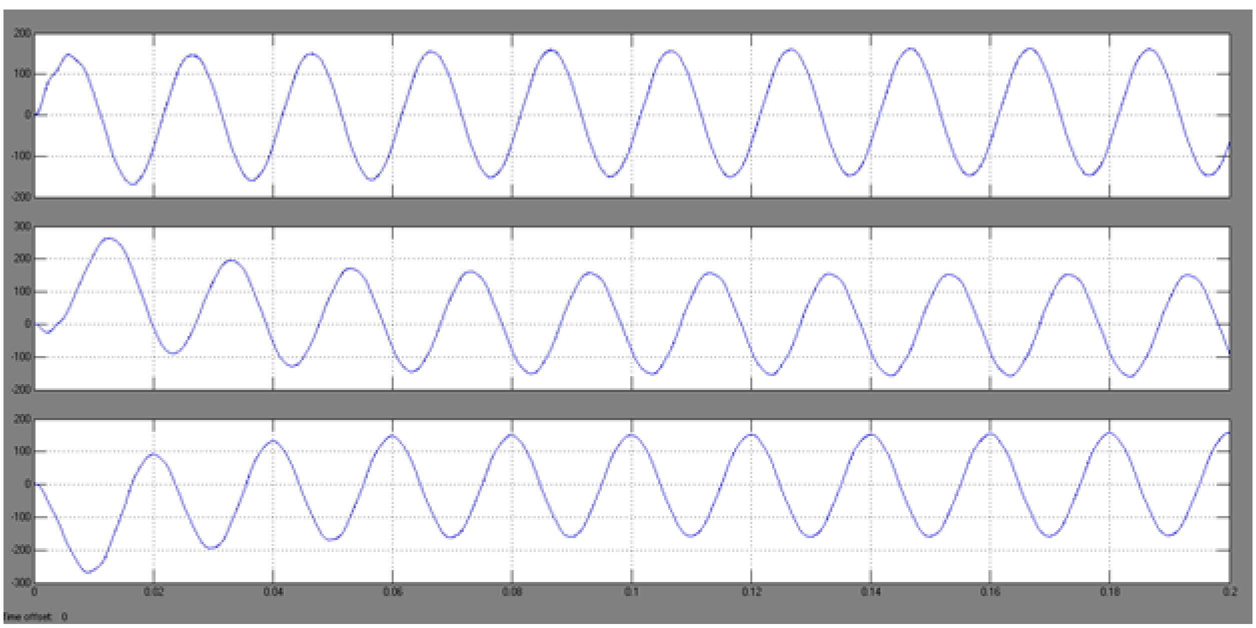

Figure : Load line to line voltages ($VLAB$, $VLBC$, $VLCA$)

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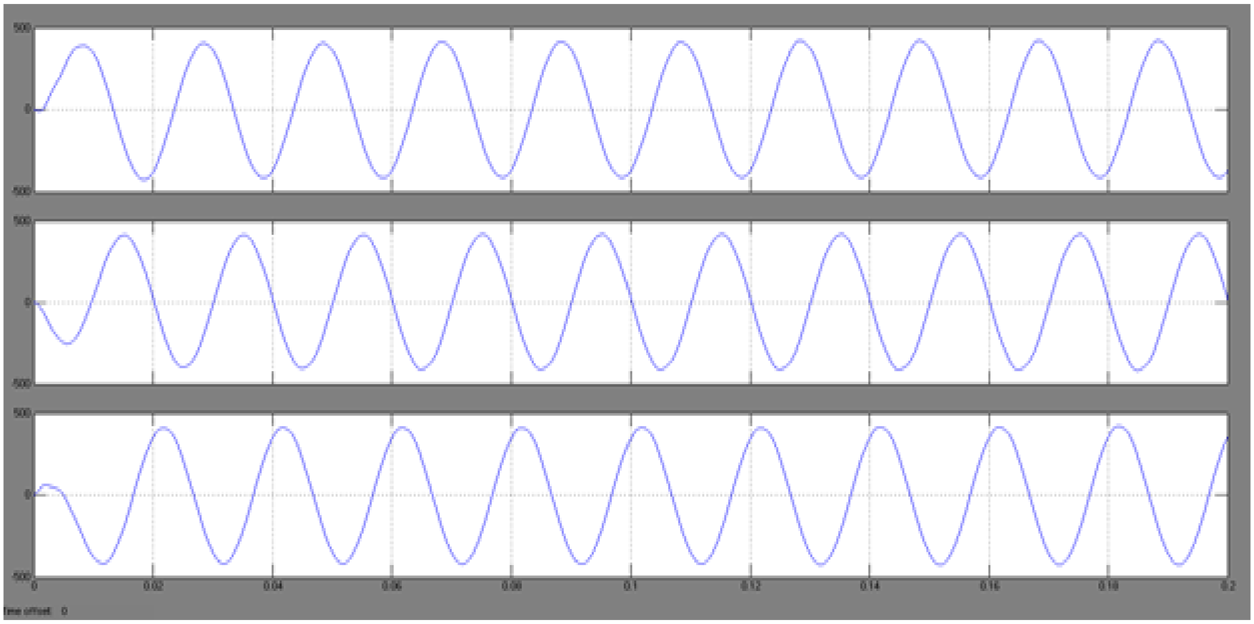

Figure : Load Phase Currents (iLA,iLB,iLC)

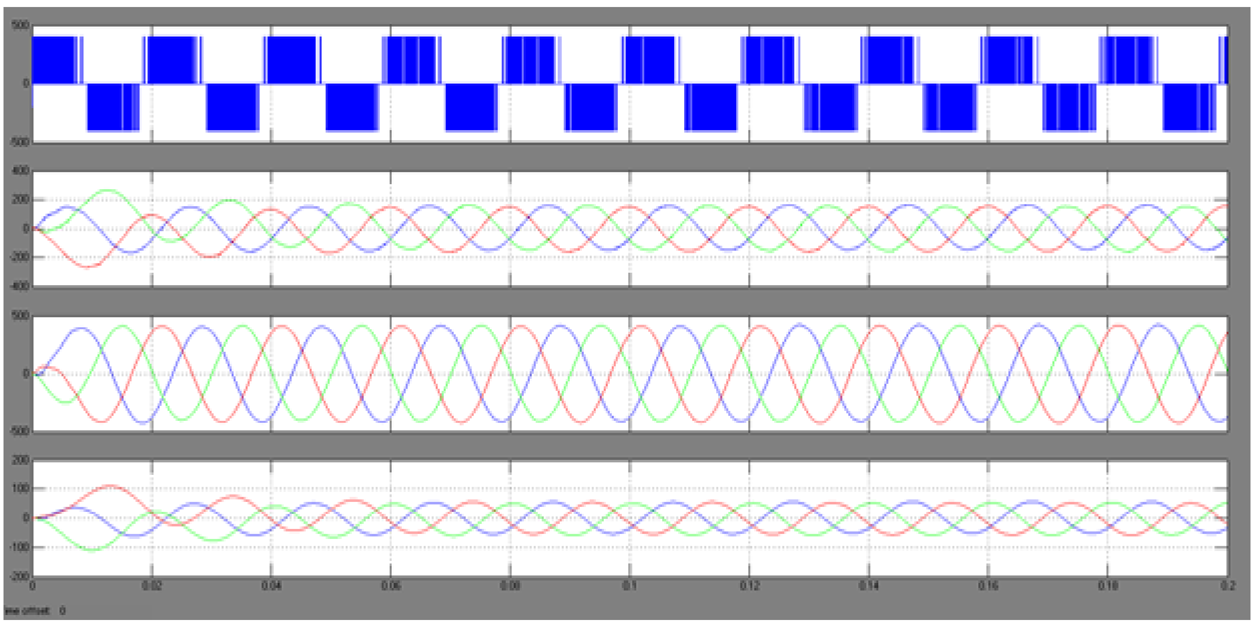

Figure : Inverter output line voltage, Inverter output current, Load line voltage, Load phase currents

CONCLUSION:

Increasing demand on energy efficiency and power quality issues, grid connected solar PV systems is taking a good place. In this paper SPWM and SVPWM techniques have been discussed for 3-phase grid connected VSI. The LC filter circuit is used in the proposed system. This filter circuit is mathematically modeled by using state space analysis and complete state space equation is obtained. The SPWM technique is implemented and simulated on 3 phases VSI using state space model of the LC filter circuit for grid connected solar PV system. Various simulation results are analyzed and presented on the inverter and load side of the proposed system in order to demonstrate the satisfactory performance of sine-PWM technique for grid connected solar PV system.

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