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Design of Renewable energy source based inverter with 120^0, 150^0 and 180^0 mode of conduction with and without filter

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Abstract:

Energy is one of the main inputs for the expansion of any economy. In case of mounting countries, the energy sector presumes a great significance. Today the world depends upon such energy resources which are becoming limited and exclusive. The world faces a dichotomy with regards to the usage of the finite obtainable resources. As the demand for power increases with the increasing population, so is the use of fossil fuels for the generation of excess power.

In this Paper we present the renewable energy source based inverter simulation. Our Research work carried out in MATLAB and Give a different Result at various scenario.

Keywords: Fuel Cell systems, Fuel Processor

I. INTRODUCTION

Energy is one of the major inputs for the development of any economy. In case of developing countries, the energy sector assumes a great importance. Today the world depends upon such energy resources which are becoming scarce and expensive. The world faces a dichotomy with regards to the usage of the finite existing resources. As the demand for power increases with the increasing population, so is the use of fossil fuels for the generation of excess power. This leads to increase in the concentration of toxic and greenhouse gases in the environment, such as *SOX*, *NOX*, *CO*2 and *CO*. The effect of such impact can be seen in the form of global warming i.e. the rise in atmospheric temperature of the Earth. Such serious challenges or threats to the environment have made power industry realize the importance of alternate sources of energy's new field of interest in power generation, in order to resolve the problem of increasing energy demand, has emerged which concentrates on the non-conventional energy resources or the renewable energy resources. Different types of renewable and non-renewable sources of energy are as shown in Fig. 1.1.

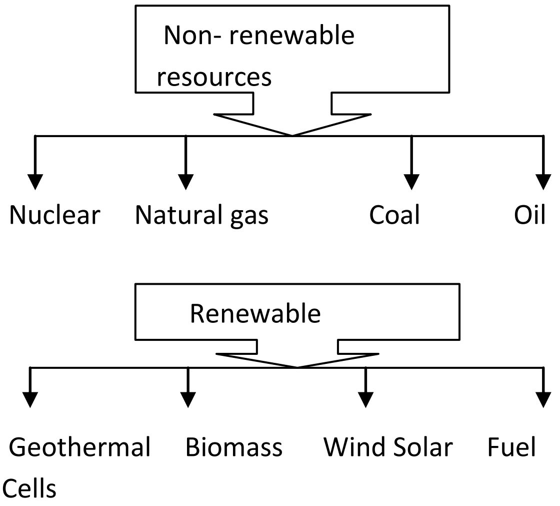


Fig. 1.1 Categorization of the Renewable and Non-Renewable Sources

Renewable energy is obtained from sources that are essentially inexhaustible. The most important feature of the renewable resources is that it can be harnessed without Introduction the release of harmful pollutants. As shown in the Fig. 1.1, the options mentioned under renewable category are of such nature. One such technology is fuel cell, which others the prospects of new, silent, modular, with few or no problem of emission and a fewer moving parts. Its modular nature suits to relatively small, distributed generation where it can offer high efficiencies than heat engines. Fuel cell systems under development for practical use are Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel Cell (SOFC), Phosphoric Acid Fuel Cell (PAFC) and Proton Exchange Membrane Fuel Cell (PEMFC). Phosphoric Acid fuel cell and Proton Exchange Membrane fuel cell are the closest of these systems to commercialization. The report discusses about the literature survey, simulation and dynamics of SOFC. SOFC is able to efficiently generate high power densities, thereby making the technology attractive for automotive and stationary applications. Specifically, the weight, volume, and ultimately cost are the primary factors of acceptance. SOFC technology differentiates itself from the other fuel cells technologies in that of solid phase polymer membrane are used as the cell separator/electrolyte. Because the cell separator is a polymer _lm, issues such as sealing, assembly, and handling are less complex than most other fuel cell systems. PEMFCs typically operate at low temperatures (60*o*¡ 80*o*C), allowing faster startup and immediate response to change in demand of power. Besides the detailed study of fuel cell modeling, study of power electronic converters is also made. It is always desirable to connect the load through a power electronic interface when powering source is fuel cell. Various topologies governing regulated power from fuel cell are described in literature. Since in the fuel cells with low power rating (typically in the range of 500W to few kW) we cannot obtain higher voltages, hence we require a proper power electronic interface to convert the low voltage levels of fuel cell to desirable voltage levels.

II. RELATED WORK:

“An Approach to the dynamic modeling of fuel cell characteristics for distributed generation operation” describes an DC-DC converter and a 3-phase inverter. The LLC resonant converter boosts approach to the modeling of subsystems from the power systems point of view and main conclusions of modeling activity. This paper also suggests that fuel cell plants be designed to be capable of delivering ancillary services as well as power in order to facilitate their market entry with added value features This paper also reports on modeling of the different plant subsystems in order to understand how such a plant will operate in future[1] “Development of a Low Cost Fuel Cell Inverter System with DSP Control” describes the development of a low cost fuel cell inverter system in detail. The approach consists of a three-terminal push-pull dc–dc converter to boost the fuel cell voltage (48 V) to 200 VDC. A four switch [insulated gate bipolar transistor (IGBT)] inverter is employed to produce 120-V/240-V, 60-Hz ac outputs. High performance, easy manufacturability, lower component count, safety and cost are addressed. Protection and diagnostic features form an important part of the design. Another highlight of the proposed design is the control strategy, which allows the inverter to adapt to the requirements of the load as well as the power source (fuel cell). A unique aspect of the design is the use of the TMS320LF2407 DSP to control the inverter. Two sets of lead-acid batteries are provided on the high voltage dc bus to supply sudden load demands. Efficient and smooth control of the power drawn from the fuel cell and the high voltage battery is achieved by controlling the front end dc–dc converter in current mode. The paper details extensive experimental results of the proposed design on Department of Energy (DoE) National Energy Technology Laboratory (NETL) fuel cell[2]. “Power conditioning system for fuel cell with 2-stage DC-DC converter”This paper proposes a grid-tied power conditioning system for the fuel cell, which consists of an LLC resonant

the fuel cell voltage of 26-48V up to 400V, using the hard-switching boost converter and the high-frequency unregulated LLC resonant converter. The operation of proposed power conditioning system was verified through simulations with PSCAD/EMTDC software. The feasibility of hardware implementation was verified through experimental works with a laboratory prototype, which was built with 1.2kW PEM fuel-cell stack, 1kW high gain step-up converter, and 2kW PWM inverter. The proposed system can be utilized to commercialize a real interconnection system for the fuel-cell power generation [3]

III. FUEL CELL SYSTEM DESCRIPTION

In principle, a fuel cell operates like a battery. Unlike a battery, a fuel cell does not run down or require recharging. It will produce energy in the form of electricity and heat as long as fuel is supplied. A fuel cell consists of two electrodes sandwiched around an electrolyte. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat.

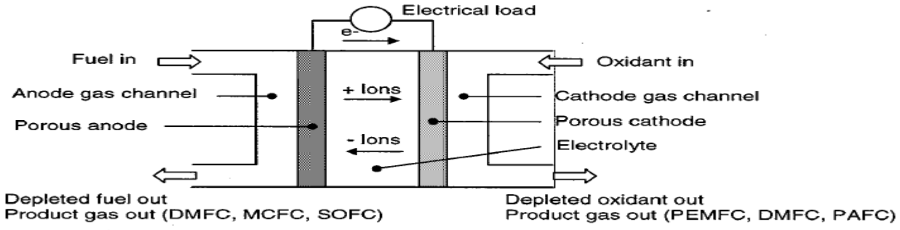


Fig. 1.2 Fuel Cell Principle

Hydrogen fuel is fed into the "anode" of the fuel cell. Oxygen (or air) enters the fuel cell through the cathode. Encouraged by a catalyst, the hydrogen atom splits into a proton and an electron, which take different paths to the cathode. The proton passes through the electrolyte. The electrons create a separate current that can be utilized before they return to the cathode, to be reunited with the hydrogen and oxygen in a molecule of water. A fuel cell system which includes a "fuel reformer" can utilize the hydrogen from any hydrocarbon fuel - from natural gas to methanol, and even gasoline. Since the fuel cell relies on chemistry and not combustion, emissions from this type of a system would still be much smaller than emissions from the cleanest fuel combustion processes.

Advantages of Fuel Cells

Fuel cells have a number of advantages over conventional power generating equipment:

- High efficiency
- Low chemical, acoustic, and thermal emissions
- Sitting flexibility
- Reliability
- Low maintenance
- Excellent part-load performance
- Modularity
- Fuel flexibility

IV. FUEL CELL SYSTEMS

4.1 System Configurations

The basic features of a fuel cell system are illustrated in Fig. 2.2. As this figure indicates, a fuel cell system is composed of six basic subsystems: the fuel cell stack discussed in the preceding section, the fuel processor, air management, water management, thermal management, and power conditioning subsystems. The design of each subsystem must be integrated with the characteristics of the fuel cell stack to provide a complete system. Optimal integration of these subsystems is key to the development of cost effective fuel cell systems

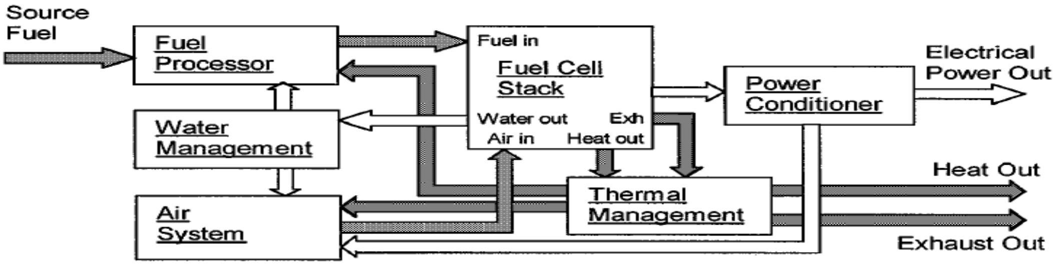


Fig.1.3 fuel cell system

4.2 Fuel Processor

Since most fuel cells use hydrogen as a fuel and most primary energy sources are hydrocarbons, a fuel processor is required to convert the source fuel to a hydrogen rich fuel stream. The complexity of the fuel processor depends on the type of fuel cell system and the composition of the source fuel. For low temperature fuel cells such as PEMFCs and PAFCs, the fuel processor is relatively complex and usually includes a desulfurizer, a steam reformer or partial oxidation reactor, shift converters, and a gas clean-up system to remove carbon monoxide from the anode gas stream. The development of a compact economical reformer to supply hydrogen rich fuel for low temperature fuel cells in building applications and automotive applications is a formidable challenge. In higher temperature fuel cells such as MCFCs and SOFCs, fuel processing for simple fuels such as methane may consist simply of de-sulfur zing and preheating the fuel stream before introducing it into the internally reforming anode compartment of the fuel cell stack. More complex fuels may require additional steps of clean-up and reforming before they can be used even by the high temperature cells. For all types of fuels, the higher operating temperatures associated with MCFC and SOFC systems provide better thermal integration of the fuel cell with the fuel processor.

4.3 Air Management

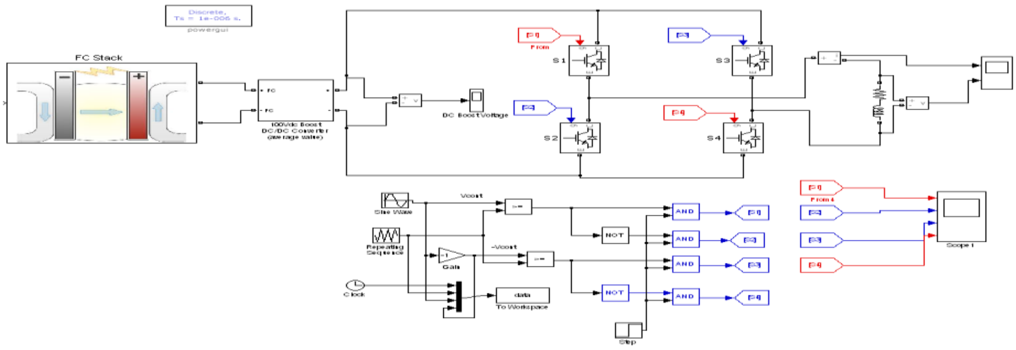
In addition to fuel, the fuel cell requires an oxidant, which is typically air. Air is provided to the fuel cell cathode at low pressure by a blower or at high pressure by an air compressor. The choice of whether to use low or high pressure air is a complicated one. Increasing the pressure of the air improves the kinetics of the electrochemical reactions and leads to higher power density and higher stack efficiency. Furthermore, in PEMFC stacks, increasing the air pressure reduces the capacity of the air for holding water and consequently reduces the humidification requirements. On the other hand, the power required to compress the air to a high pressure reduces the net available power from the fuel cell system. Some of this energy can be recovered by expanding the cathode exhaust through a turbine before exhausting it to the atmosphere. Nevertheless, the air compressor typically uses more power than any other auxiliary device in the system. Furthermore, while the fuel cell stack performance actually improves at low power, the performance of the air compressor is usually poor at very low loads. Currently, most fuel cell stack designs call for operating pressures in the range of 1–8 atm. To achieve high power densities and to improve water management, most automotive fuel cell systems based on PEMFC technology are operated at pressures of 2–3 atm.

4.4 Water Management

Water is required for a variety of purposes in the fuel cell system. The fuel reforming process requires water to react with the hydrocarbon fuel in the steam reforming reaction. In PEMFC systems, the reactant gases must be humidified in order to avoid drying out the fuel cell membrane. Water is available from the fuel cell reaction, but it must be removed from the exhaust gas, stored, and pumped to a pressure suitable for the various operations. In automotive applications, it is critical that the system operate in such a way that water condensed from the exhaust stream is sufficient for reforming and reactant humidification. Otherwise, the vehicle must periodically be recharged with water as well as fuel

IV. Experimental Setup:

5.1 MATLAB Simulink model of single phase inverter system and results:



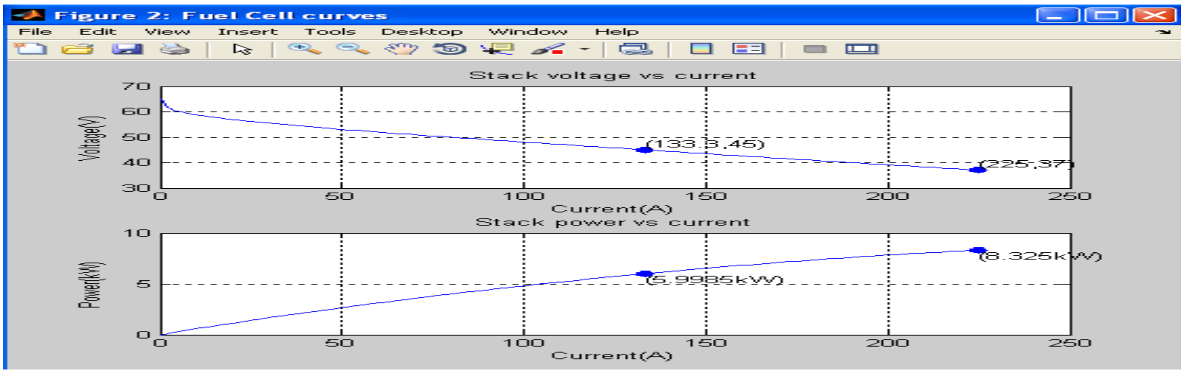


Fig.1.3 Power, Current and Voltage waveform for fuel cell system

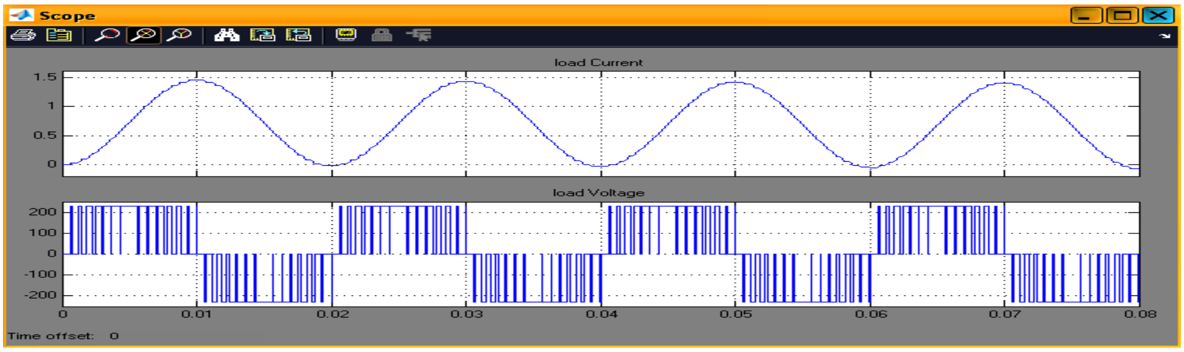
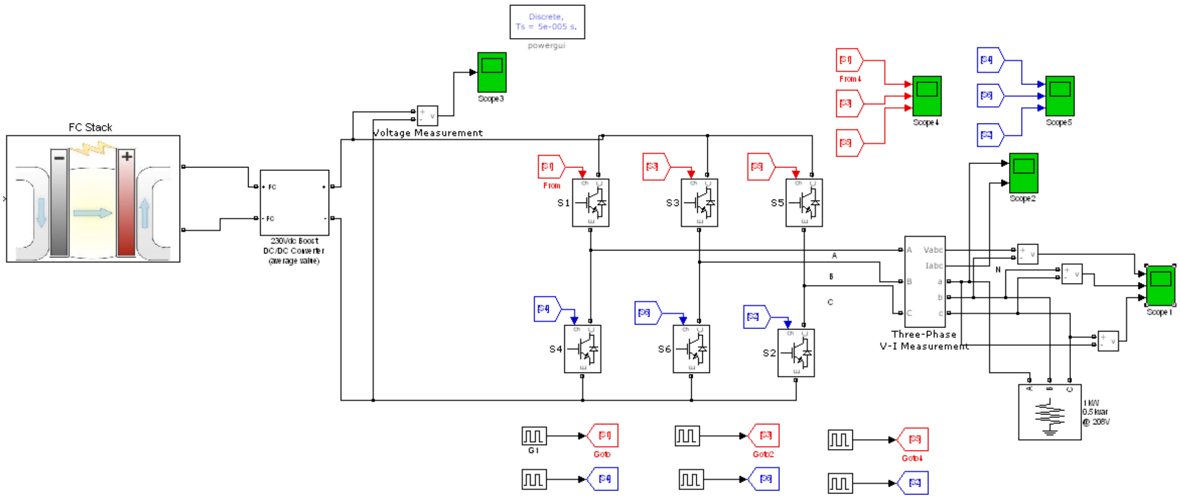


Fig.1.4.Load Current and Load Voltage waveform for single phase fuel cell system

5.2 MATLAB Simulink model of three phases with inverter 120^0 mode of conduction without filter and results:



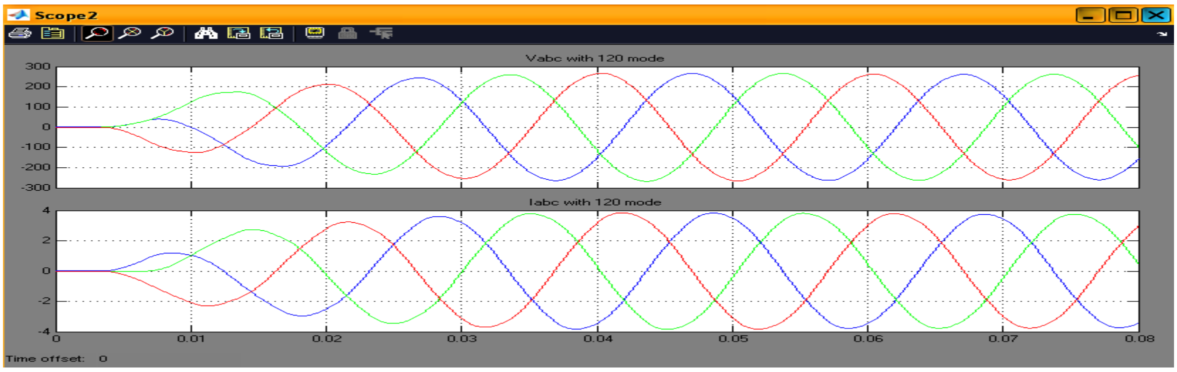


Fig.1.5.Three phase Load Current and Load Voltage waveform for inverter 120^0 mode of conduction with filter

5.3 MATLAB Simulink model of three phase with inverter 150^0 mode of conduction without filter and results

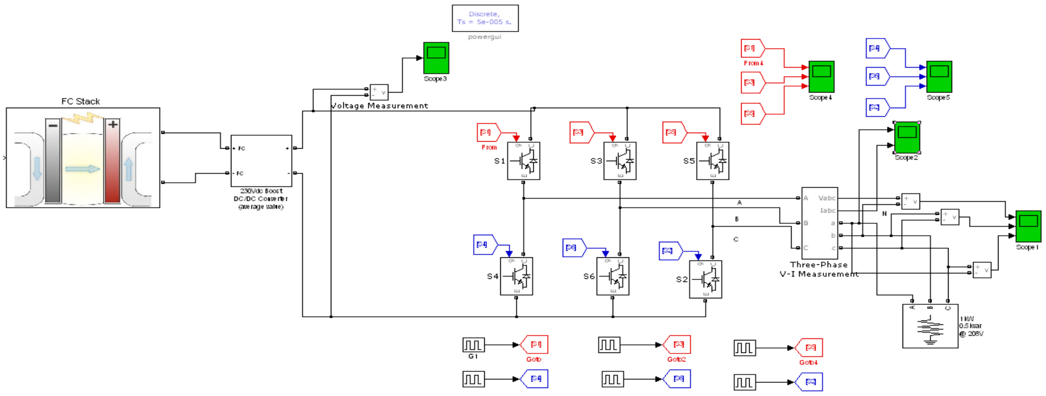
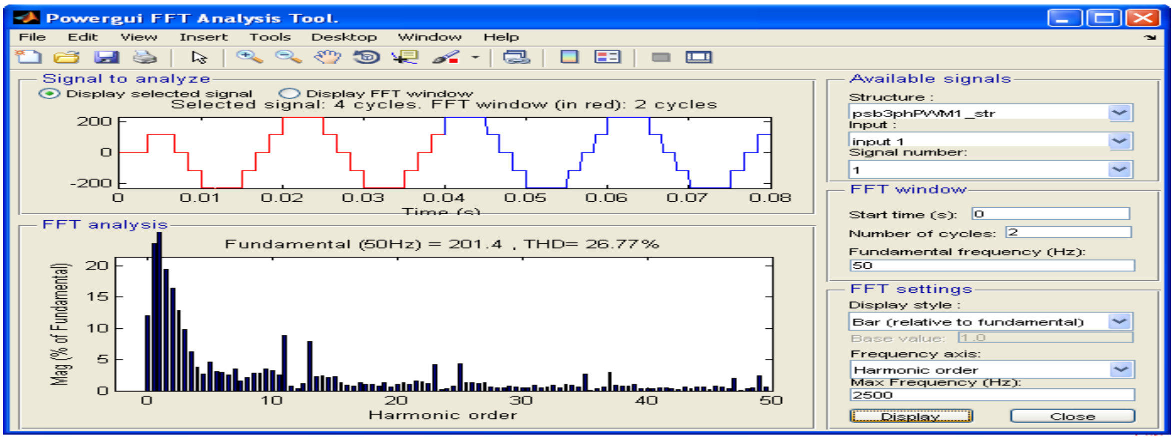


Fig.1.6 MATLAB Simulink model of three phases with 150^0 mode of conduction without filter



● Display selected signal ○ Display FFT window

Selected signal: 4 cycles. FFT window (in red): 2 cycles

Fundamental (50Hz) = 201.4 , THD= 26.77%

Structure : psb3phPWM1_str

Input : input 1

Signal number: 1

Start time (s): 0

Number of cycles: 2

Fundamental frequency (Hz): 50

Display style : Bar (relative to fundamental)

Base value: 1.0

Frequency axis: Harmonic order

Max Frequency (Hz): 2500

Fig.1.7 THD spectrums for Voltage waveform for inverter 150^0 mode of conduction without filter

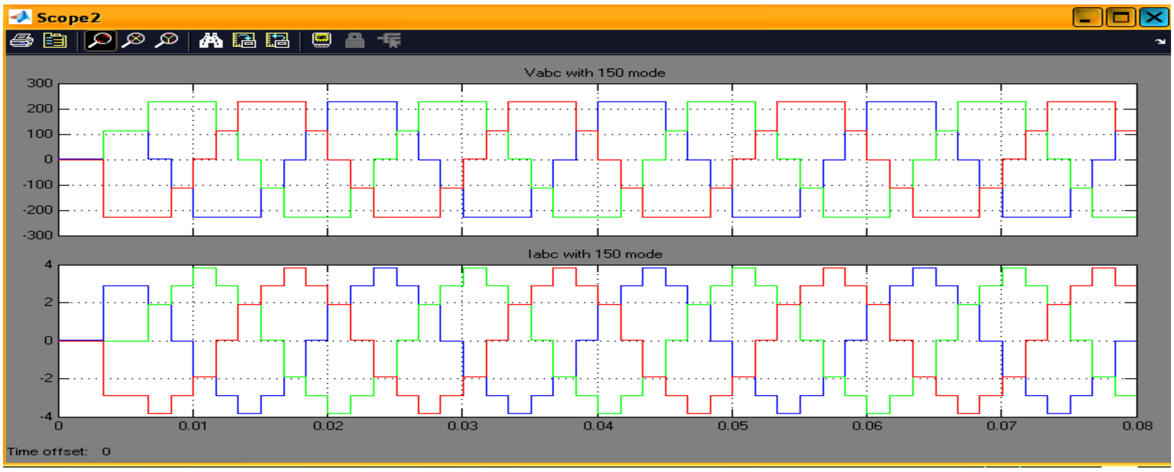


Fig.1.8.Three phase Load Current and Load Voltage waveform for inverter 150^0 mode of conduction without filter

5.4 MATLAB Simulink model of three phase with inverter 180^0 mode of conduction without filter and results

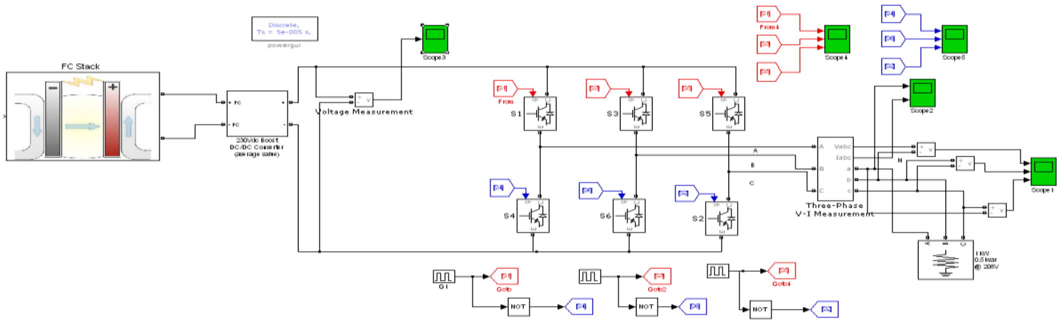


Fig.1.9. MATLAB Simulink model of three phases with 180^0 mode of conduction without filter

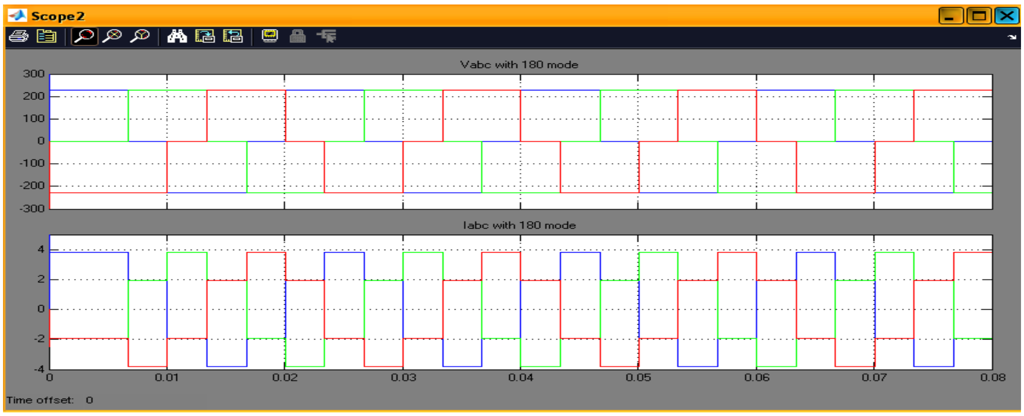


Fig.2.0.Three phase Load Current and Load Voltage waveform for inverter 180^0 mode of conduction without filter

5.5 MATLAB Simulink model of three phase with inverter SPWM without filter and results

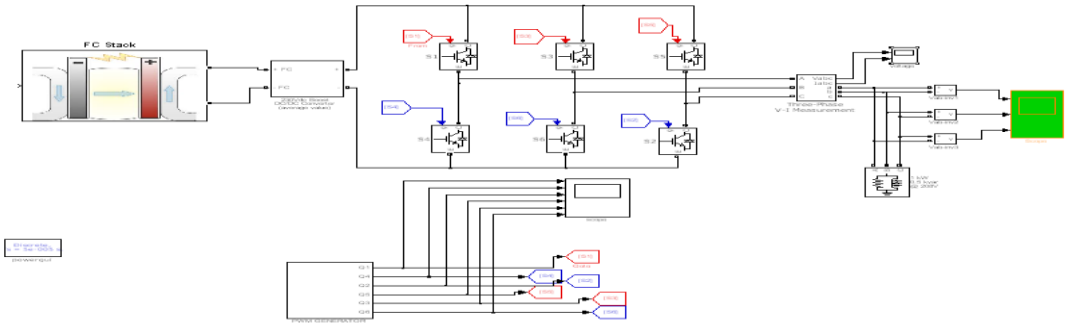


Fig.2.1 MATLAB Simulink model of three phases with SPWM without filter

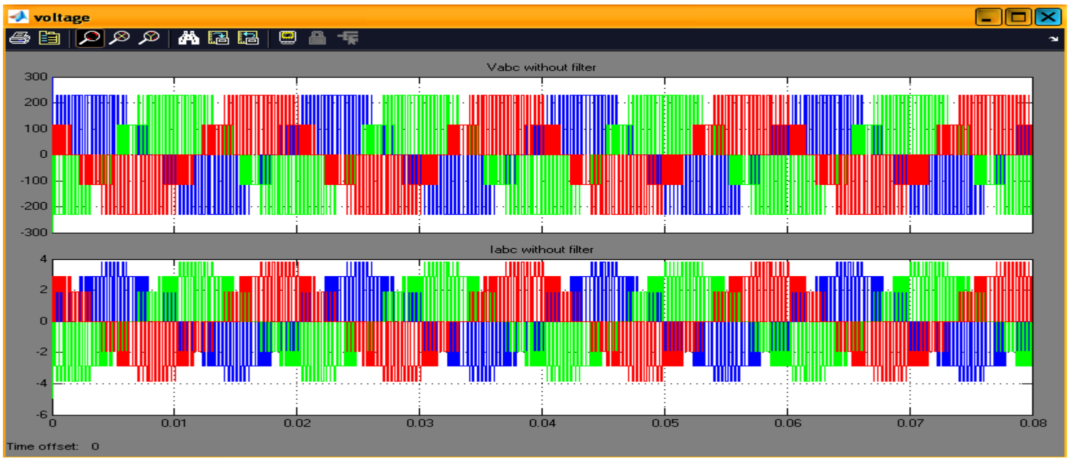


Fig.2.2.Three phase Load Current and Load Voltage waveform for SPWM without filter

5.6 MATLAB Simulink model of three phase with inverter SPWM with filter and results

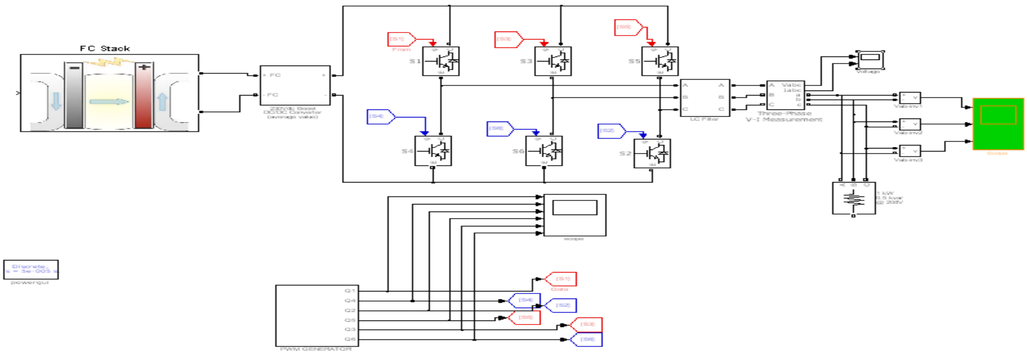


Fig.2.3 . MATLAB Simulink model of three phases SPWM with filter

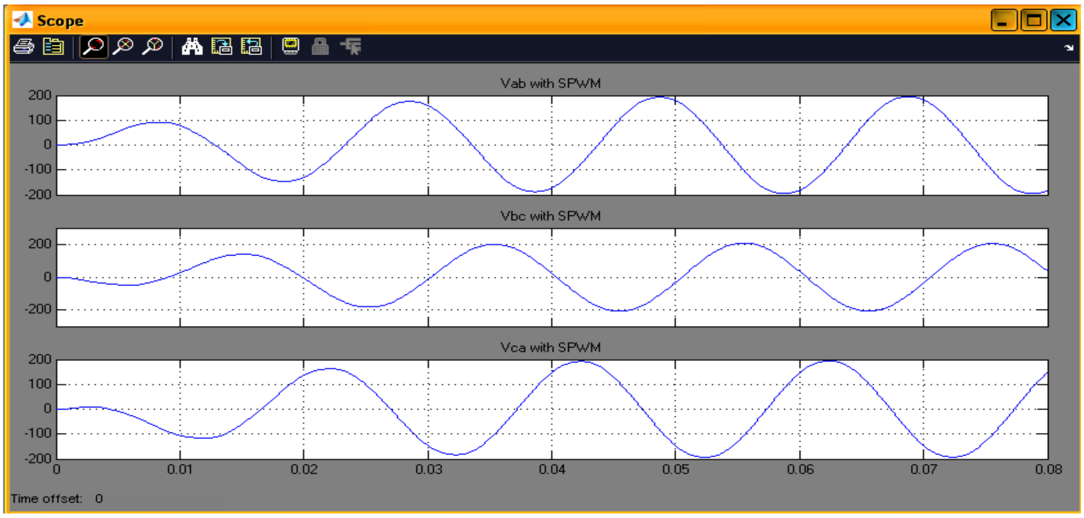


Fig.2.4.Vab, Vbc and Vca line to line Voltage waveform for SPWM with filter

VI. CONCLUSION:

1. Those Fuel Cells are preferred which have high voltage ratings and low current profile. This is because at higher current the losses within the fuel cell will be more and hence the efficiency of the system, for which it is known, will deteriorate. But the main drawback of higher voltage fuel cells is that voltage level can be increased only by adding series stacks. This adds to the system cost.

2. In low power rating fuel cells, low voltage is an issue. Boost converter provides solutions to raise the voltage level of the FC stack. Besides this bi-directional DC to DC converters are also used for boosting and isolation. This increases the bulkiness of the whole application. For AC applications the inverter discussed in the above theory is a good candidate for single phase inverter, three phase inverter with 120,150 and 180 degree mode of conduction with and without filter and analysis THD of these conditions.

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