DIFFERENT MODES OF POWER INVERTERS WITH AND WITHOUT FILTER for RENEWABLE ENERGY SOURCE

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Abstract: Economic drivers, technologies and demand side management are keys in understanding the long-term trends of both energy and more specifically electricity consumption. Energy is one of the main inputs for the expansion of any economy. In case of mounting countries, the energy sector believes a great significance. Today the world depends upon such energy resources, which are becoming limited and exclusive. Fuel cells are considered to be one of the most promising sources of distributed energybecause of their high efficiency, low environmental impact and scalability. Unfortunately, multiple complications exist in fuel cell operation. Fuel cells cannot accept current in the reverse direction,do not perform well with ripple current, have a low output voltage that varies with age and current, Respond sluggishly to step changes in load and are limited in overload capabilities.

For thesereasons, power converters are often necessary to boost and regulate the voltage as a means toProvide a stiff applicable DC power source. Furthermore, the addition of an inverter allows forthe conversion of DC power to AC for an utility interface or for the application of an AC motor.

To help motivate the use of power conditioning for the fuel cell, a brief introduction of the different types, applications and typical electrical characteristics of fuel cells is presented. This is followed by an examination of the various topologies of DC–DC boost converters and inverters used for power conditioning of fuel cells. Several architectures to aggregate multiple fuel cells for high-voltage/high-power applications are also reviewed.

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, power converters, Renewable Energy

INTRODUCTION

Fuel cells are environmentally sound renewable energysources that are capable of operating at Efficiencies greater than traditional energy production methods. Moreover, thescalability of fuel cells has allowed for applications in almost every field, including distributed generation.

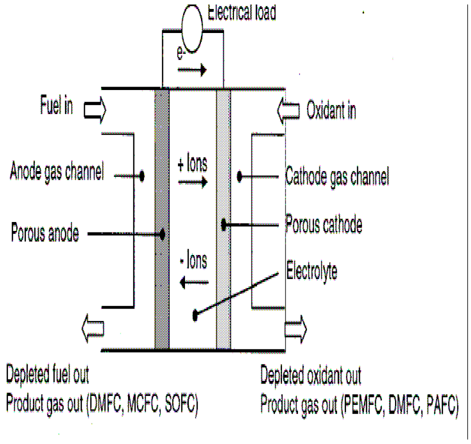
However, some inherent problems exist in the applicationof fuel cells. Low output voltage that varies with age andcurrent, reduced efficiency with output ripple current,slow response to a load step response, no overload capabilityand no acceptance of reverse current provide many Technical challenges that must be overcome by power conditioning systems. Energy crisis leading to energy demand across the globe force us to switch to other sources of energy.

Renewable Energysources are preferred more due to their less carbon emissionplaying major role in reducing global warming. Efficiency ofRenewable energy sources is comparatively less than theconventional fossil fuels, so improvements are made on either side for the purpose of power quality improvement andincrease the usage of Renewable Energy sources.

LITERATURE REVIEW

"An Approach to the dynamic modeling of fuel cell characteristics for distributed generation operation" describes an 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" 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 DC-DC converter and a 3-phase inverter. The LLC resonant converter boosts the fuel cell voltage of 26-48V up to 400V, using the hard-switching boost converterand 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 Fuel cell construction

In 1839, William Grove discovered that by combiningoxygen and hydrogen in a particular configuration, electricity could be generated. Although this discovery was made more than 160 years ago, the basic operating principle discovered still applies. Hydrogen is applied to the anodewhere a catalyst separates the hydrogen into electrons andpositive hydrogen ions. A membrane separating the anodeand cathode allows the positive hydrogen ions to permeatethrough while rejecting the electrons. This forces the electronsto take the provided electrical path, or circuit, to thecathode. Once the electrons reach the cathode, they recombinewith the oxygen and hydrogen ions to form water. Thefollowing basic reactions demonstrate the process:



Fuel Cell Principle

$$\text{Anode side:} \quad 2H_2 \rightarrow 4H^+ + 4e^-$$

$$\text{Cathode side:} \quad O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

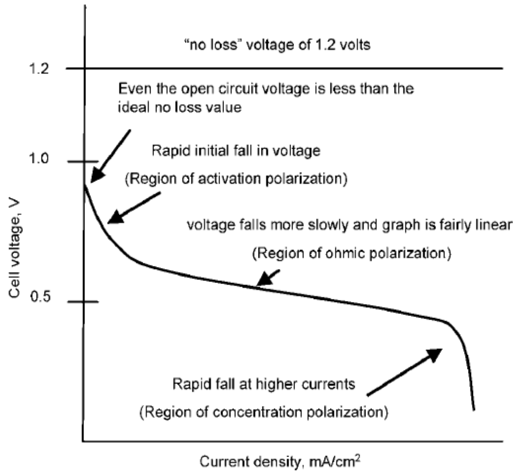
$$\text{Net reaction:} \quad 2H_2 + O_2 \rightarrow 2H_2O$$

Typical electrical characteristics of fuel CellsThe operation of a fuel cell is similar to that of a battery inthat a fuel cell employs two electrodes (anode and cathode) and produces DC voltage. One key advantage that fuel cellshave over battery technology is the seemingly unlimitedamount of power that can be produced as long as fuel is supplied. Unfortunately, as the amount of current is increased, the voltage drop is increased. For this reason, fuel cells are often modeled as ideal DC voltage sources with a seriesresistor. The major factors that contribute to this voltagedrop are: activation loss, ohmic loss and concentration loss. At low current densities, the dominant loss is a result ofactivation loss. Activation loss is the sluggish response ofthe electrochemical reaction of hydrogen and oxygen as result of electrode kinetics.

Ohmic losses originate from the flow of electrons throughthe electrolyte and electrodes. Ideally the electrolyte shouldonly permit the transport of ions through the cell, but a small
Amount of the fuel is able to diffuse through the membrane. Unlike activation losses, which are nonlinear, ohmic losses are essentially linear and are directly proportional to thecurrent density.

Type	Electrolyte	Operating temperature, °C	Fuel	Applications
AFC	KOH	50–200	pure H_2	transportation, portable pow
PAFC	phosphoric acid	~220	pure H_2	stationary power
PEMFC	solid polymer	50–100	pure H_2	stationary power, transportatio portable power
MCFC	lithium and potassium carbonate	~650	H_2, CO, CH_4, other hydrocarbons	stationary power
SOFC	solid oxide electrolyte	500–1000	H_2, CO, CH_4, other hydrocarbons	stationary power, portable po

Type of electrolyte, operating temperature and fuel for different fuel cells

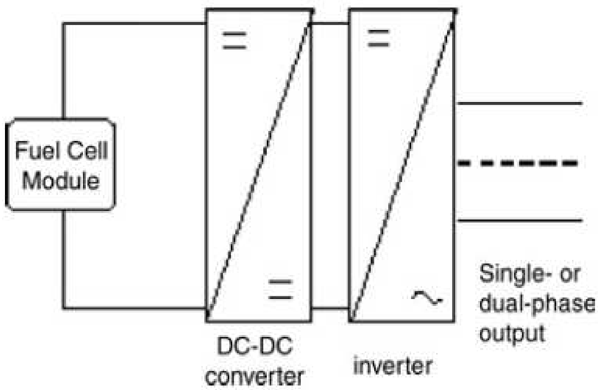


Cell voltage for a low-temperature air pressure fuel cell

Power electronics interface requirements

Currently, no standard output voltage rating for fuel cells hasbeen established. Most of the present fuel cell stack modulesproduce an output voltage in the range 24–150 VDC.However, the large number of applications in which fuelcells can be implemented necessitates that a power electronicsinterface be present. This interface should:
† control the fuel cell voltage
† convert the fuel cell output to the appropriate type andmagnitude
† deliver a high power factor (grid applications)
† provide little to no harmonics
† operate efficiently under all conditions and
† add little to the cost of the overall system.

The power electronics interface for fuel cells often utilize DC–DC boost converters and inverters to boost the fuel cellvoltage and convert the DC voltage to AC .The expectations from the boost converter, in addition toboosting the fuel cell voltage, are regulation of the inverterinput voltage and electrical isolation of the low- and highvoltagecircuits. The inverter need only convert the DC toAC with reasonable harmonic elimination and can eitherbe single, dual, or three phase depending on the application. Single- and dual-phase inverters are used for residentialapplications, whereas three-phase inverters areimplemented in industrial applications and in centralized power generation.Another topology that is possible, but rarely capitalized,The following sections discuss the specific fuel cellrestrictions and possible methods for power converters to
cope with these requirements.



Fuel cell power electronics interface block diagram for residential applications

No regeneration/reverse currentFuel cells, in general, cannot accept current. Therefore toobstruct current flow to the fuel cell, a diode DFC can beinserted in series with the fuel cell module .

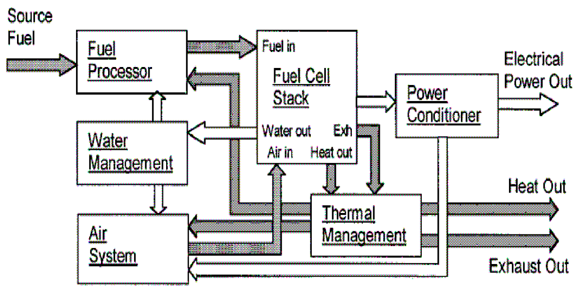
Advantages of Fuel Cells

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

Fuel cell systems

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, thermalmanagement, 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



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.

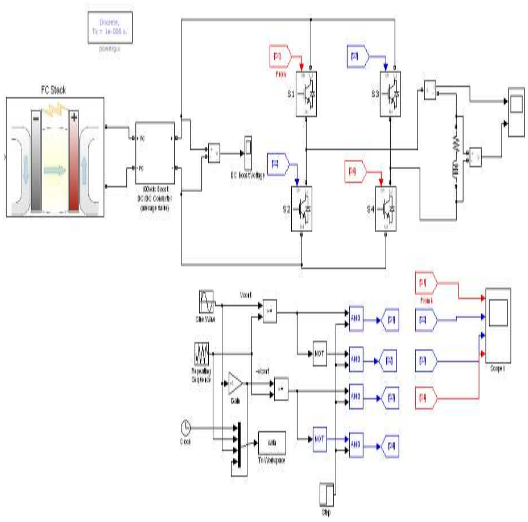
Air Management

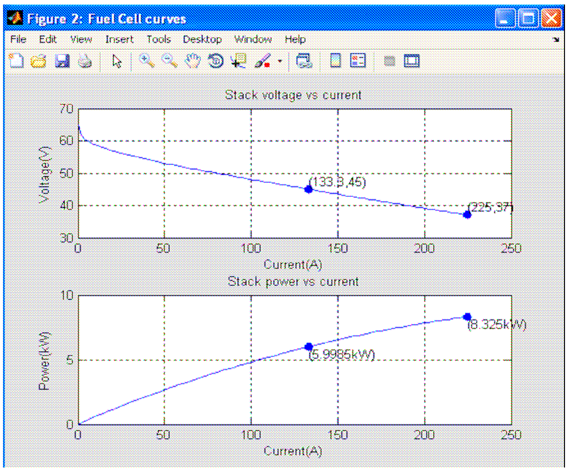
In addition to fuel, the fuel cell requires an oxidant, which is typically air. Air is provided to the fuel cell cathode at low pressure by a blower or at high pressure by an air compressor. The choice of whether to use low or high pressure air is a complicated one. Increasing the pressure of the air 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 powerdensities and to improve water management, most automotive fuel cell systems based on PEMFC technology are operated at pressures of 2–3 atm.

Water Management

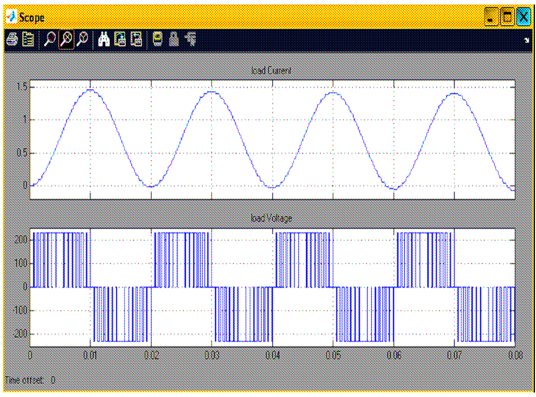
Water is required for a variety of purposes in the fuel cell system. The fuel reforming process requires water to react with the hydrocarbon fuel in the steam reforming reaction. In PEMFC systems, the reactant gases must be humidified in order to avoid drying out the fuel cell membrane. Water is available 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

MATLAB SIMULINK MODEL OF SINGLE PHASE INVERTER SYSTEM AND RESULTS:



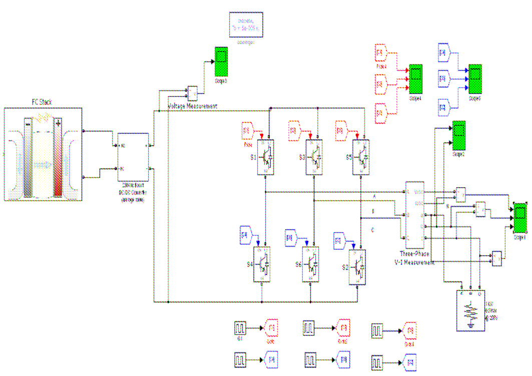


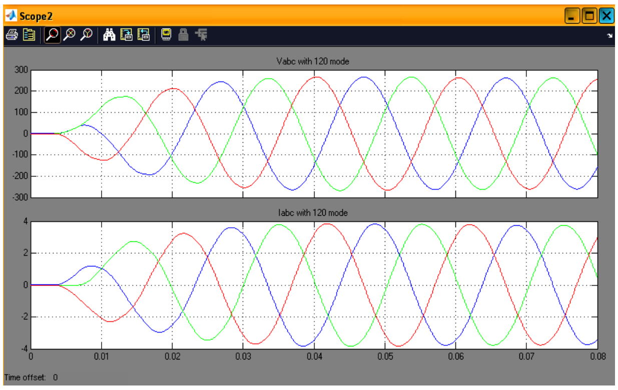
Power, Current and Voltage waveform for fuel cell system



Load Current and Load Voltage waveform for single phase fuel cell system

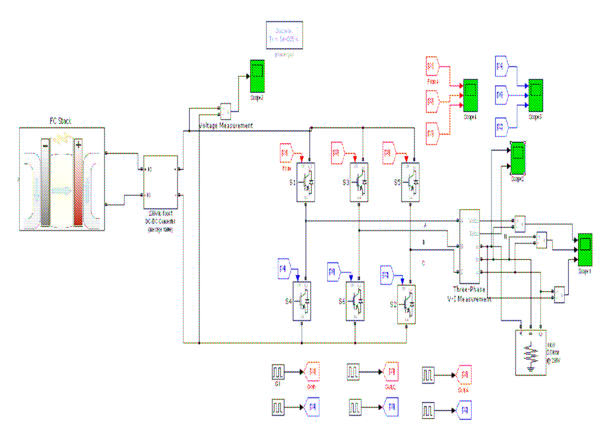
MATLAB Simulink model of three phases with inverter 120degree mode of conduction without filter and results:

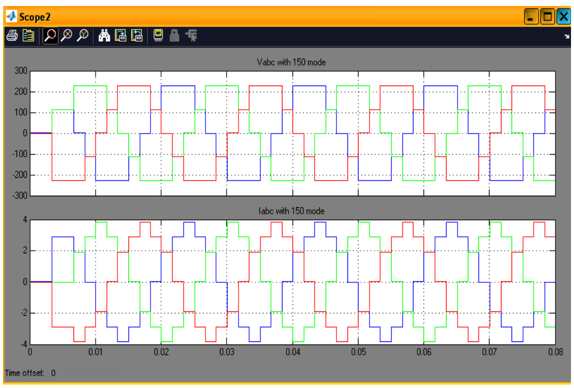




Three phase Load Current and Load Voltage waveform for inverter 120degree mode of conduction with filter

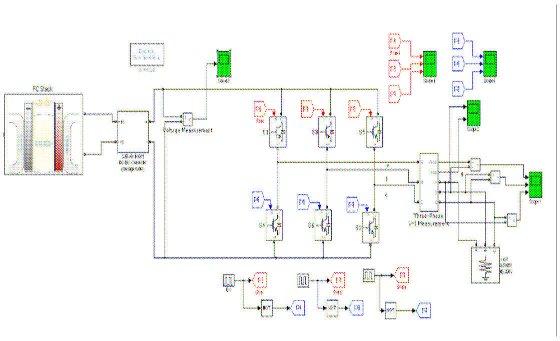
MATLAB Simulink model of three phase with inverter 150degree mode of conduction without filter and results



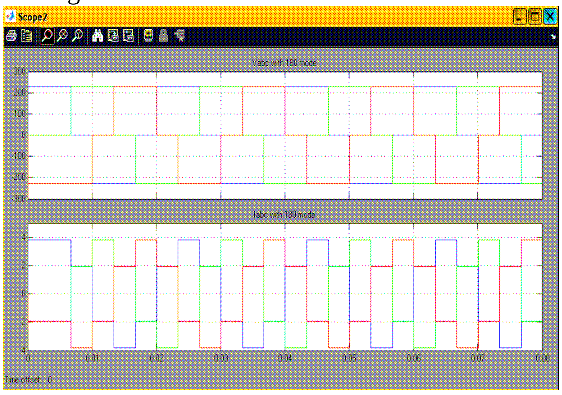


Three phase Load Current and Load Voltage waveform for inverter 150degree mode of conduction without filter

MATLAB Simulink model of three phase with inverter 180degree mode of conduction without filter and results

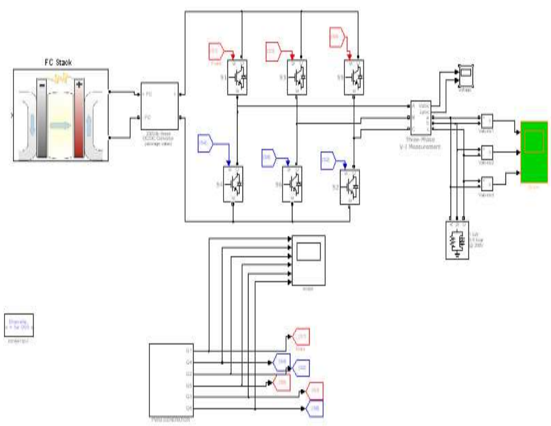


MATLAB Simulink model of three phases with 180degree mode of conduction without filter

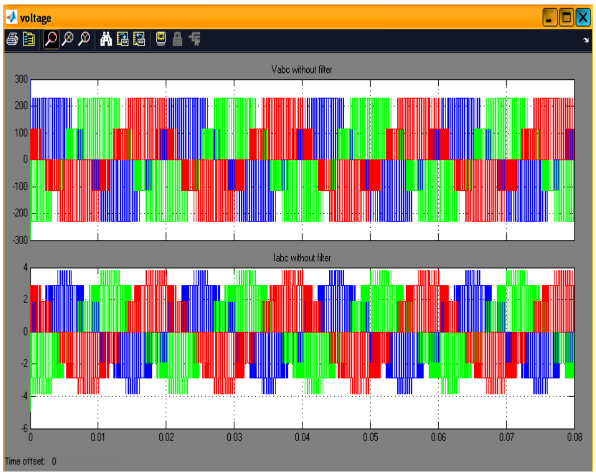


Three phase Load Current and Load Voltage waveform for inverter 180degree mode of conduction without filter

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

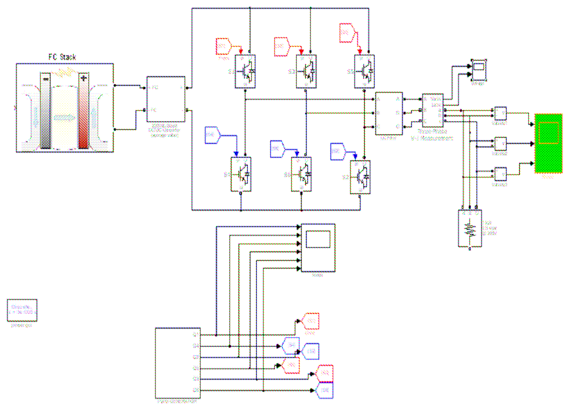


MATLAB Simulink model of three phases with SPWM without filter

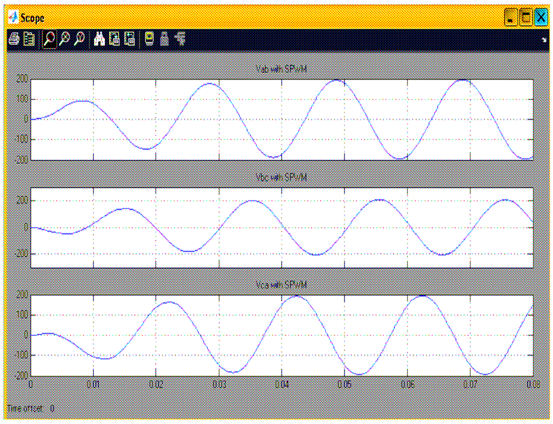


Three phase Load Current and Load Voltage waveform for SPWM without filter

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



MATLAB Simulink model of three phases SPWM with filter



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

CONCLUSION

As one of the most prominent sources of distributed energyin the future, fuel cells are under consideration for almostevery application including both residential and industrialpower generation. Yet, a power electronics interface mustbe incorporated between the fuel cell and output toprovide flexibility due to the inherent restrictions fuelcells produce, such as low voltage, large voltage variation,

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. 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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