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# Performance Analysis of Multilevel Inverters in Fuel Cell Applications

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***Abstract: As the world's energy use continues to grow, the development of clean distributed generation becomes increasingly important. Fuel cells are an environmentally friendly renewable energy source that can be used in a wide range of applications and are ideal for distributed power applications.A Fuel Cell is a device that electrochemically converts fuel into electricity. The fuel cell uses an electrochemical process which converts the fuel directly into electricity with little energy loss in the form of heat. The static (V-I) characteristics of fuel cells show more than a 30% difference in the output voltage between no-load to full-load conditions. This inevitable decrease, which is caused by internal losses, reduces the utilization factor of the fuel cells at low loads. Additionally, the converters fed by these fuel cells have to be derated to accommodate higher input voltages at low currents. When one of these fuel cells is connected to an inverter, they will not be able to produce ac grid level voltages. A dc-dc boost converter is generally required to boost the voltage level for the inverter. This boost converter, in addition to boosting the fuel cell voltage, also regulates the inverter input voltage and isolates the low and high voltage circuits. In this paper Analysis of cascaded bridge multilevel inverter have with & without pwm techniques have been done & results are also compared based on the harmonics available.***

Keywords: fuel cell, PWM , Harmonics, converter and inverter

## 1. INTRODUCTION

An increase in worldwide energy consumption and, economic and environmental concerns has increased interest and demand for alternative energy conversion technologies. Renewable energy sources would be the most viable alternative energy resource for growing energy demand in response to depletion of fossil fuels and global warming effect caused by excessive combustion of fossil fuels. With such perspective Fuel Cells are viable, environmental sound, sustainable energy sources for power generation. These sources have great potential for several modern applications including distributed energy generation to provide as a clean energy resource. since they generate low amplitude and load dependent varying dc voltage and are associated with other inherent obstacles like low efficiency, sluggish response to sudden change in load current, poor cell utilization; power conditioners are necessary to be incorporated in the system to boost and regulate the input low dc voltage and to convert the dc voltage into desired ac signal for distributed applications . Additionally power conditioners also improve, performance, power quality of the system, and utilization of renewable energy source modules. Designing renewable power conversion systems normally depends on the requirement, cost, and reliability demands of a particular application. Obviously, a better renewable power conversion system comes with complex designs and thus costly systems. Much different architecture has been proposed for renewable power conversion systems. In this study, static and dynamic modeling of equivalent electrical model of proton exchange membrane (PEM) fuel cell is performed to demonstrate their electrical characteristics and associated power loss factors and adopted fuel cell based power conditioning circuits include, a wide input range dc-dc converter developed in which is compatible with slow transient response of fuel cell. Ural et al. proposed a PEM fuel cell system has been modelled and simulated for ohmic, inductive and capacitive loads. Polymer electrolyte membrane (PEM) fuel cells used hydrogen as a fuel . These fuels can either be directly fed into the fuel cell, or sent to a reformer to extract pure hydrogen, which is then directly fed to the fuel cell. Graphics of output voltage and current of the system have been acquired for different load situations using Matlab- Simulink and z.peng et a. proposed a new zero-voltage-switching (ZVS) bidirectional dc–dc converter for fuel cell application. The results of proposed method is compared with traditional full and half bridge bidirectional dc–dc converters and it has been observed that the new topology has the advantages of simple circuit topology with no total device rating (TDR) penalty, soft-switching implementation without additional devices, high efficiency and simple control. The new converter promising for medium and high power applications especially for auxiliary power supply in fuel cell vehicles and power generation where the high power density, low cost, lightweight and high reliability power converters are required and Jain et al. studied one of the most promising devices for standalone/grid connected distributed generations due to its cleanliness, modularity and higher potential capability. The barriers in the widespread use of fuel cells are their slow response for sudden load changes and higher installation cost. PEM fuel cell with DC/DC boost converter is carried out for compact design of PCU. The necessity for the requirement of boost converter compared with cascaded two stack fuel cell model is also addressed. Moreover the performance of the simple DC/DC boost converter as power modulator. PEM fuel cell model is analyzed for varying loads in order to control power flow for enhanced performance .The PEM fuel cell technology is the best candidate for residential and commercial applications due to low operating temperature, quick start up and high power density tial and stationary power needs but unsuitable for abrupt load changes due to slow response of underlying electrochemical and thermodynamic processes. The DC-DC Converter is an integral part of fuel cell power conditioning unit, The design of DC/DC converter and their controller plays an important role to control power regulation particularly for a common DC bus.

## 2. .FUEL CELL WITH POWER ELECTRONIC INTERFACE

For economical reasons, the fuel cell stack produces a nominal voltage of 0.48 V;
Therefore the input voltage must be boosted with a dc-dc converter before it can be
inverted. Also required is some type of energy storage to supplement the fuel cell during start-up and load transients. The basic structure of the system is shown with the block diagram in Figure.1

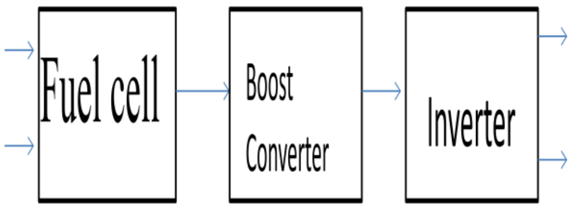


*Fig. 1 Block diagram*

## 3. SIMULATION DESIGN

The single phase and multilevel inverter with pwm and without pwm techniques and results are also compared based on less harmonics compensation and the various models used for simulating and validating its performance are given under

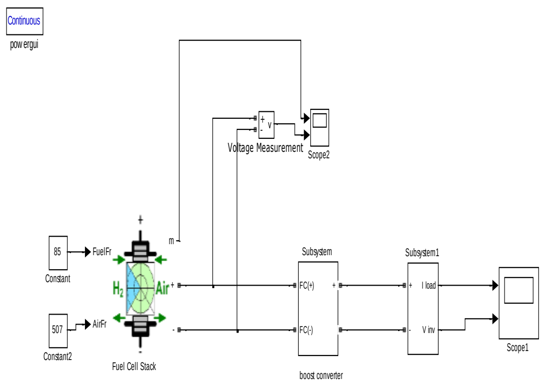


*fig 2:Simulink model of Single Phase inverter with PWM*

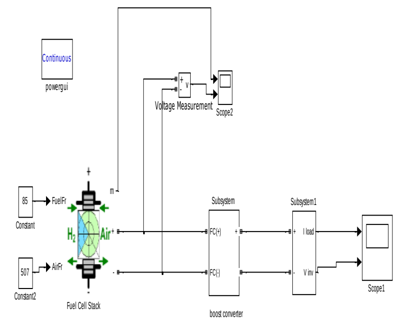

*fig .3:Simulink model of multilevel inverter*

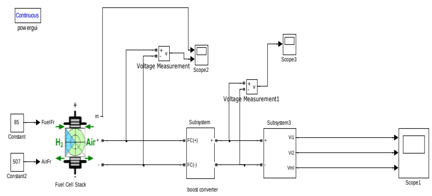

*fig .4:Simulink model of multilevel inverter with PWM*

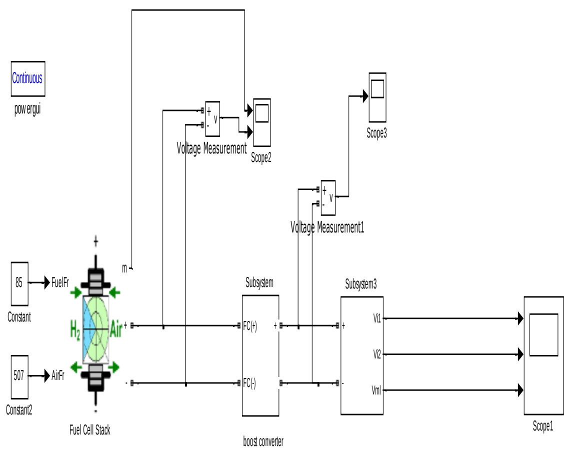


*fig .5:Simulink model of single phase inverter without PWM*

## 4. SIMULATION RESULTS

The single phase and multilevel inverter analysis in the previous sections were investigated through Matlab®/ Simulink© *V-2012a* and the results obtained are shown below for an electric network voltage and current responses without pwm Fig.9 , Fig.10 & Fig.11, Fig.12 and with pwm in Fig.6, Fig. 7 & Fig.8, Fig.9

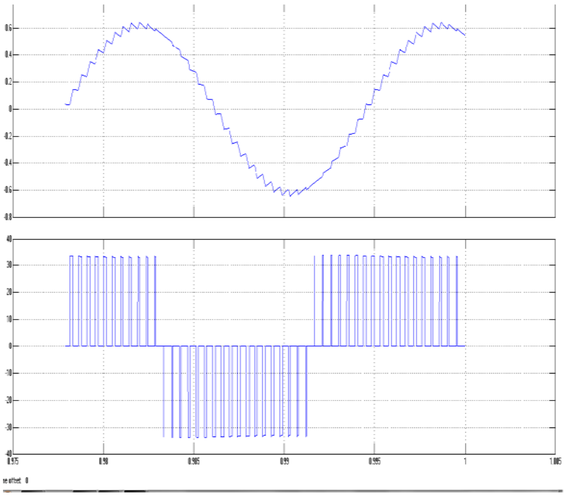

*Fig .6:Waveform Obtained of single phase inverter with PWM*

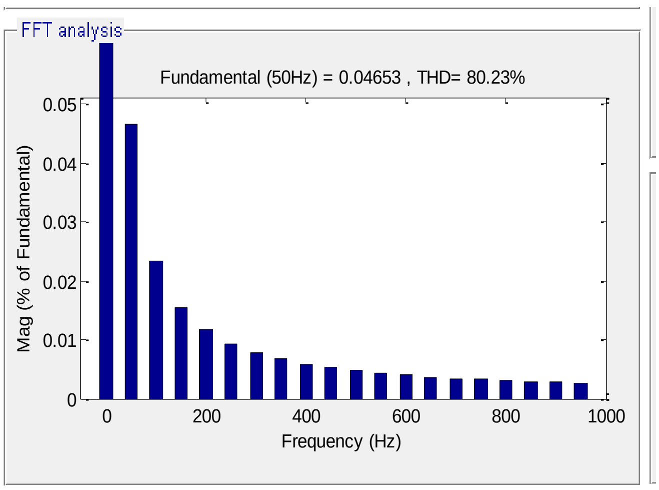


*Fig. 7: FFT Analysis of Single Phase inverter with PWM (THD % =80.23%)*

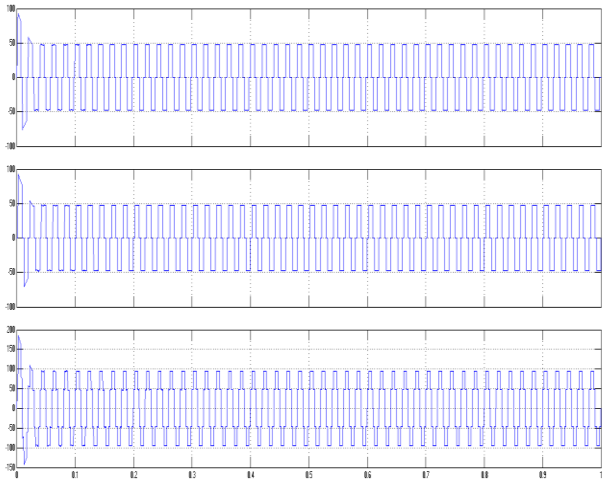

*Fig .6:Waveform Obtained of multilevel inverter with PWM*

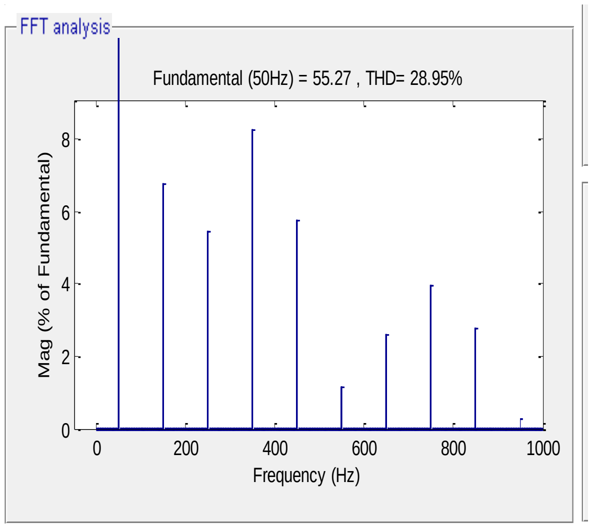


*Fig .8: FFT Analysis of multilevel inverter with PWM (THD%=28.95%)*

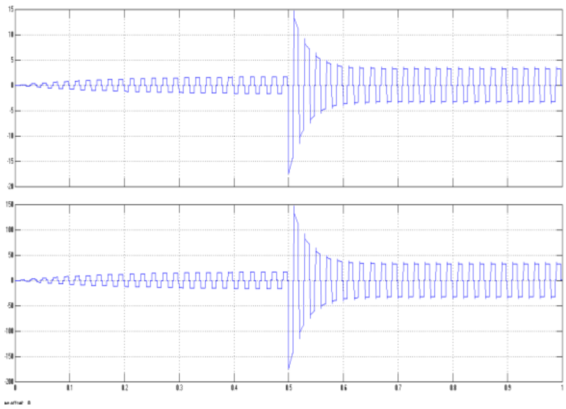

*Fig .9Waveform Obtained of multilevel inverter without PWM*

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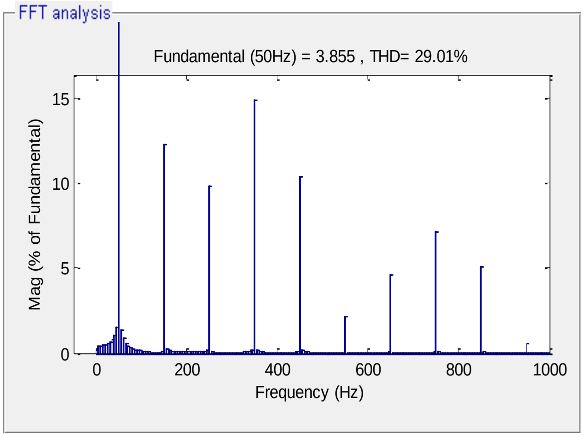


*Fig .10:. FFT Analysis of multilevel inverter without PWM (THD%=29.01%)*

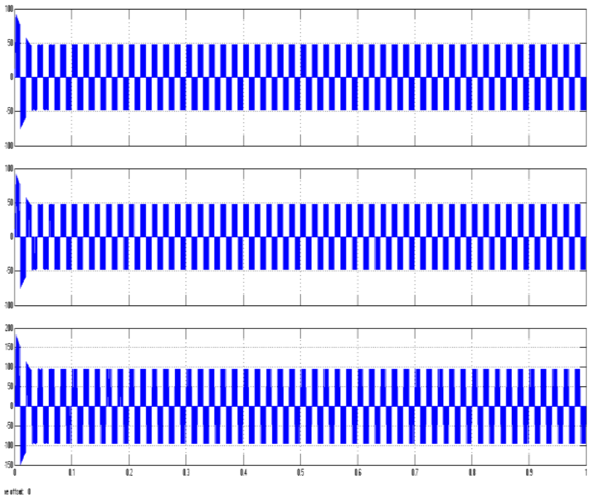

*Fig .11:Waveform Obtained of single phase inverter without PWM*

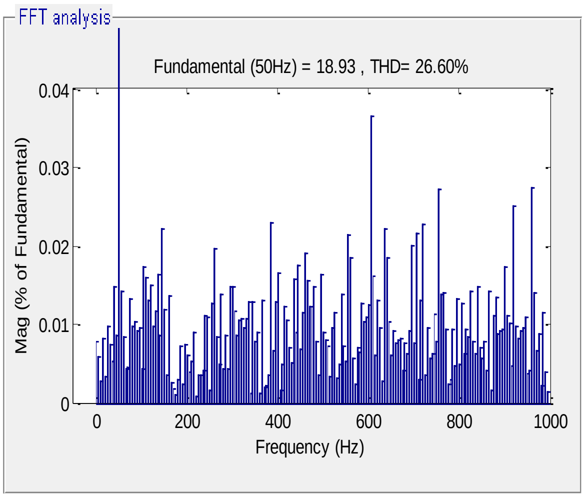


*Fig .12: FFT Analysis of single phase inverter without PWM (THD%=26.60%)*

**COMPARE BETWEEN SINGLE PHASE INVERTER AND MULTILEVEL INVERTER THD LEVEL RESULT**

| | Single phase inverter | | Multilevel Inverter | |
|---|---|---|---|---|
| particular | With PWM | With out PWM | With PWM | With out PWM |
| 3th harmonics | 33.38% | 0.48% | 0.04% | 0.00 |
| 5th harmonics | 20.08% | 0.58% | 0.04% | 0.04% |
| 7th harmonics | 14.40% | 0.82% | 0.08% | 0.00% |
| THD | 80.23% | 29.01% | 26.60% | 28.95% |

## 5. CONCLUSION

The Concept Of Modularity In Power Electronic Circuits Was The Main Focus In This Dissertation is to analyse the performance of various types of inverters i.e. single phase two level and multilevel inverter with and without PWM techniques based on available harmonics and Total harmonic distortion. The detailed results obtained through simulation can be concluded as given below:

*Two level inverter with and without PWM technique obtained THDS are (80.23%) and (29.01%) respectively.

*Multilevel inverter with and without PWM technique obtained THDS are (26.60%) and (28.95%) respectively

## 6. ACKNOWLEDGEMENT

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