MITIGATION OF HARMONICS IN SINGLE PHASE GRID CONNECTED FUEL CELL SYSTEM BASED ON BOOST INVERTER AND DIODE CLAMPED INVERTER

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ABSTRACT:

Renewable energy sources such as fuel cell operates at higher efficiency than other energy production methods.These are the electrochemical devices that convert chemical energy directly into electrical energy and the fuel power systems are interfaced with utility grid connected systems through a suitable set of inverters.Here we are comparing two inverter topologies-boost inverter and multilevel diode clamped inverter.Boost inverter topologies result in the production of low output voltage compared to the multilevel diode clamped inverter.It is used for small power applications. The multilevel diode clamped inverter topologies are suitable for high power applications because of their ability to synthesize waveforms with better harmonic spectrum. Reduction in the counts of power electronic devices results in decreasing the complexity and over all system cost for the inverter. The multilevel diode clamped inverter is used for large power applications such as high power distribution networks,power conditioning systems and variable speed drive systems because of the production of higher number of voltage levels at the output.In addition the proposed system also incorporates the energy storage backup unit to support the slow dynamics of FC. The hardware and simulink based model is developed and the simulation results for the proposed model is applied to the load by using MATLAB.

KEYWORDS:Fuel cell,Diode clamped inverter,boost inverter,batterybackup unit

1.INTRODUCTION:

Now a days,the recent trends of power generation is by using the fuel cell as it is renewable and does not contribute to pollution or global climatic change.There has been a growing interest in multilevel inverter topologies as it finds a great demand in the area of power electronics for high voltage applications and are becoming popular for various industrial drives applications.A multilevel inverter is a power electronic system that converts the dc input voltage into ac voltage.The multilevel voltage source inverters has unique structure and allows them to reach high voltage and power levels without the use of transformers.In previous papers the power generation from the fuel cell is done with the help of boost inverter.Boost inverter (DC-AC) is a device that uses the same principle as the ordinary inverter but it produces the output voltage higher than the input voltage.This device is used in the applications of distributed energy systems,with the renewable energy sources. A two stage FC power conditioning system is considered to produce ac power.It requires a separate DC source.But the disadvantage is that it is used only for small power applications and it is relatively costly,bulky and inefficient due to its cascaded power conversion levels.To reduce these drawbacks we are using diode clamped inverter.In diode clamped inverter more steps are added to the waveform,therefore the harmonic distortion of the output wave decreases by approaching zero as the number of levels increases.It has the ability to regulate the dc voltage so that only one dc source is

required.The advantages of multilevel diode clamped inverters over the two stage inverters are higher voltage capability,lower switching losses,higher amplitude and reduction of input and output harmonic content.The multilevel diode clamped inverter system is very promising in AC drives when both the high power and reduced harmonic contents are required.It plays a major role in enhancing the quality of high power distribution networks,power conditioning systems and variable speed drive systems because of the production of higher number of voltage levels at the output.Thus it provides a efficient way of generating power with the renewable energy sources such as fuel cell with less harmonic distortion and higher output for various power electronic applications.In this project,modeling and simulation study of fuel cell system using diode clamped inverter is investigated.In future different placements of fuel unit can be studied and analysed.

2.LITERATURE SURVEY:

Several studies have explored the concepts and constructional features of the various components used in this system.

In the paper "HIGH EFFICIENT SINGLE STAGE SINGLE PHASE BOOST INVERTER WITH MINIMISED HARMONIC DISTORTION" it tells about the usage of drive to the autonomous loads and home appliances without any filter.Here,the total harmonic distortion of the boost inverter is reduced to zero if filter design is more accurate.

From the paper "A SINGLE-PHASE GRID-CONNECTED FUEL CELL SYSTEM BASED ON A BOOST-INVERTER" incorporates battery-based energy storage and a dc–dc bidirectional converter to support the slow dynamics of the FC.The low frequency current ripple is supplied by the battery minimizes the effects of ripple being drawn directly from the fuel cell itself and also provides a fast signal conditioning for single phase systems.

In the paper titled "A NOVEL THREE PHASE MULTILEVEL DIODE CLAMPED INVERTER TOPOLOGY WITH REDUCED DEVICE COUNT" describes about the concept of space vector modulation technique with new multilevel diode clamped inverterand to make the control schemes simpler and easily implementable.

From the paper "CASCADING OF DIODE CLAMPED MULTILEVEL INVERTER BOOSTERS FOR HIGH VOLTAGE APPLICATIONS" describes about the production of output voltages at various levels and also tells about these inverters are very promising in ac drives with reduced harmonic content,high power production and better power factor.

In the paper titled "ANALYSIS AND CONTROL OF BOOST INVERTER FOR FUELCELL APPLICATIONS" deals about the usage of boost inverter at various applications and also a dual loop control method is applied to ensure pure sinusoidal output voltage with fast dynamic response and low input current ripple.

In the paper "FUEL CELL ENERGY SOURCE BASED MULTILEVEL INVERTER"describes about the analysis of the performance of a fuel cell energy source based multilevel inverter topology and also gives the information multilevel inverter circuit analysis and selection of proper references based on formulation switching patterns.

From the paper "A NEW DIODE CLAMPING MULTILEVEL INVERTER"says about the new diode clamping inverter,which gets rid of the need for series association of clamping diodes in the conventional diode clamping multilevel inverter.It utilizes the same number of switches and diodes as the conventional one for synthesizing an inverter for a given level.

3.BLOCK DIAGRAM

BOOST INVERTER

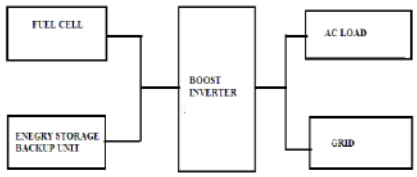


fig 3.1

DIODE CLAMPED INVERTER

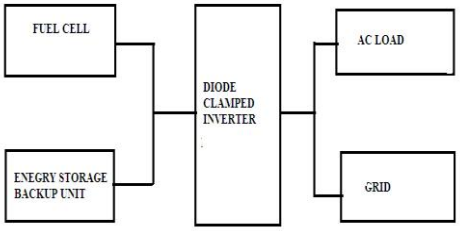


Fig 3.2

The block diagram consists of

- Fuel cell
- Energy storage backup unit
- Boost inverter
- Diode clamped inverter
- Load
- Grid

In proposed paper the power generation from the fuel cell is done with the help of boost inverter and multilevel diode clamped inverter(three level) and their performance levels are compared.The produced power from the fuel cell is given to the boost inverter (DC-AC) and backup energy storage unit. Boost inverter is same as the ordinary inverter but it produces the output voltage higher than the input voltage. It requires a separate DC source.The output produced from the boost inverter is then given to the grid and load.similarly instead of boost inverter,the diode clamped inverter is employed in which more steps are added to the output waveform,so that the harmonic distortion of the output wave decreases by approaching zero as the number of levels increases.It has the ability to regulate the dc voltage so that only one dc source is required. It plays a major role in enhancing the quality.

4.CIRCUIT DIAGRAM

4.1 BOOST INVERTER

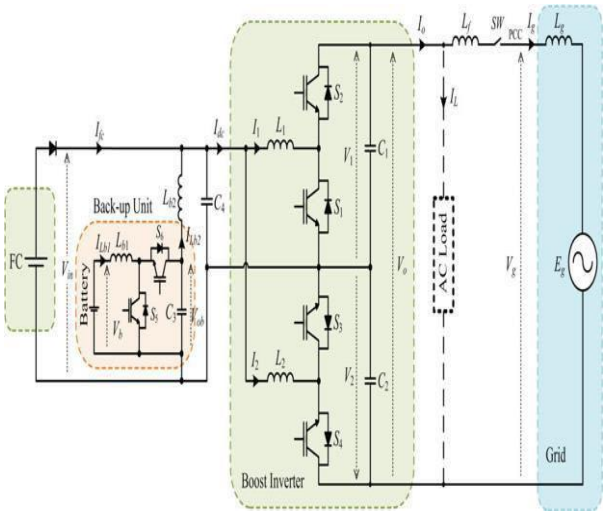


Fig 4.1.1

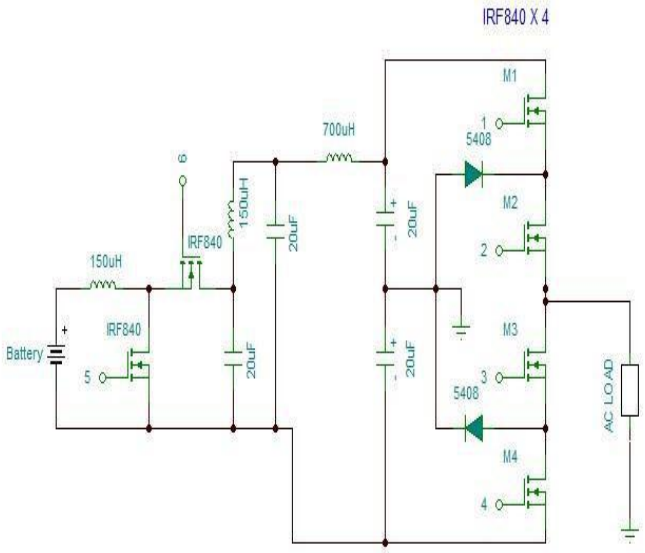


Fig 4.1.2

4.2DIODE CLAMPED INVERTER

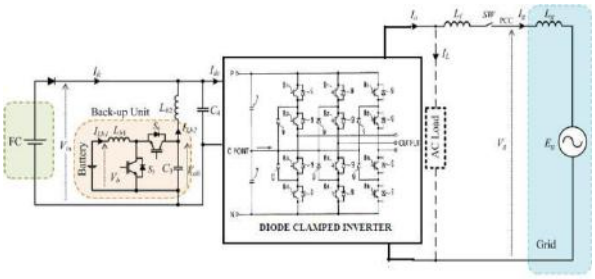


Fig 4.2.1

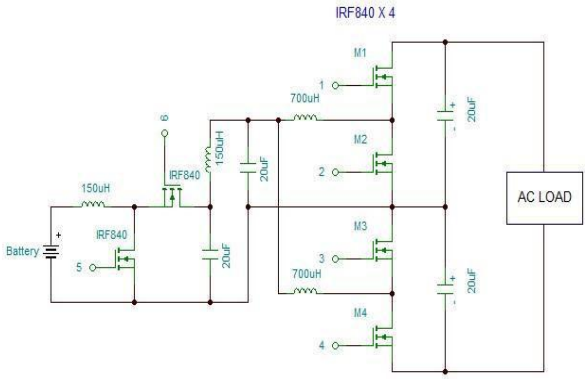
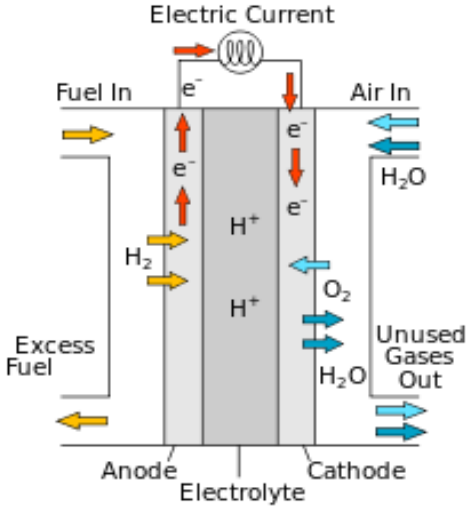


Fig 4.2.2

5.CIRCUIT DESCRIPTION

5.1FUEL CELL

Fuel cell ia a device that produces electricity through a chemical reaction between a source fuel and oxidant.The source fuel could be almost anything that can be oxidized,includinghydrogen,methane,propane, methanol,diesel fuel or gasoline.The only by products are water and small amount of nitrous oxide if air is used as the oxidizer.Fuel cells are to used to power just about anything conceivable,from cars to mobile phones to space vehicles.Due to their high efficiency fuel cells are very clean,with their only byproducts being electricity,excess heat and water.Fuel cells operates much like a battery,except they don't require electrical recharging.A battery stores all of its chemicals inside and converts the chemicals into electricity.Once those chemicals runout,the battery dies.A fuel cell,on the otherhand,receives the chemicals it from the outside;therefore,it won't run out.It can generate power almost indefinitely,as long as they have fuel to use.



The basic reaction is

$H_2 \rightarrow 2H^+ + 2e^-$ (at anode-an oxidation reaction)

$2H^+ + ½\ O_2 + 2e^- \rightarrow H_2O$ (at cathode-reduction reaction)

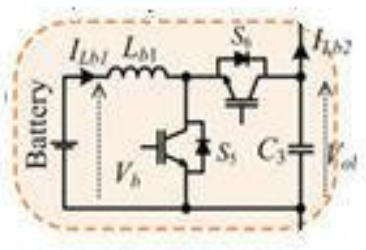
The final reaction is

$H + ½\ O_2 \rightarrow H_2O$ (the redox reaction)

5.2 BACK UP ENERGY STORAGE UNIT

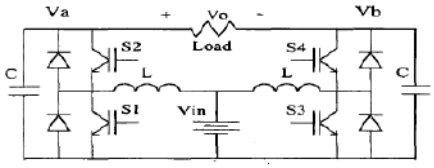
The functions of the backup energy storage unit are divided into two parts. First, the backup unit is designed to support the slow dynamics of the FC. Second, in order to protect the FC system, the backup unit provides low-frequency ac current that is required from the boost inverter operation. The backup unit comprises of a current-mode controlled bidirectional converter and a battery as the energy storage unit. when the load is disconnected suddenly, the surplus power from the FC could be recovered and stored into the battery to increase the overall

efficiency of the energy system. The backup unit controller is designed to control the output current of the backup unit .



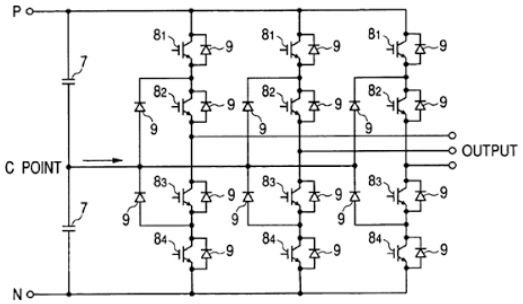
5.3 BOOST INVERTER

The boost inverter concept evolves from the boost DC-DC converters and inverters. Boost inverter is a device that uses the same principle as the ordinary inverter,but with the output of the voltage is higher compared to the input one.this device is usually used in the application of distributed energy systems,especially with the renewable energy sources.Boost inverter consists of boost dc-dc converters that have to be controlled in a variable-operation point condition. Due to the exact 180 degree phase shift the resultant voltage across the load is twice of the AC voltage amplitude as the DC voltage eliminates each other.



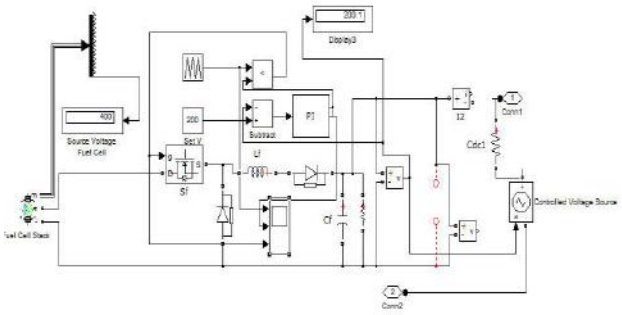
5.4DIODE CLAMP INVERTER

- The first practical multilevel topology is the neutral-point-clamped (NPC) PWM topology.Voltages across the switches are only half of the dc-link voltage. As the name suggests, and unlike Cascaded H-Bridge Inverters, they need clamping devices.
- Diodes are used as clamping devices.
- Three phase diode clamped multilevel inverters have three legs with a common DC bus.
- This DC voltage is subdivided into switches via capacitors.
- For n-levels, n-1 switch pairs are required.
- One of the switches from each pair should be turned on.
- If one switch is turned on, the other one from the pair should be necessarily off.
- For n-levels, n-1 capacitors are required for clamping DC voltage.
- Switching devices (e.g. transistors) need to block only the supplied DC voltage; however the clamping diodes have a whole different story.
- Each diode has to block the voltage equal to number of switches above it times the supplied DC voltage

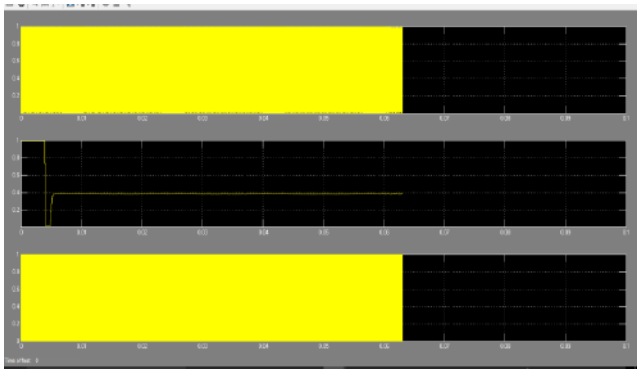


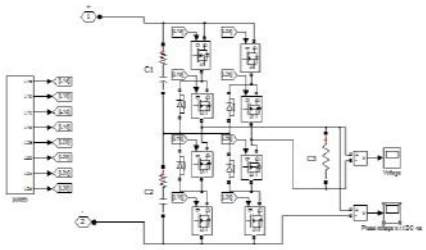
7.SIMULATION AND RESULTS:

FUEL CELL



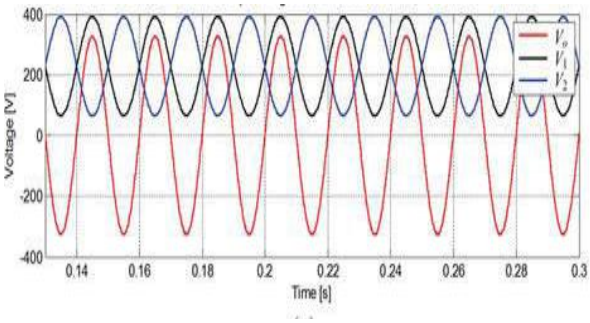
DIODE CLAMPED INVERTER

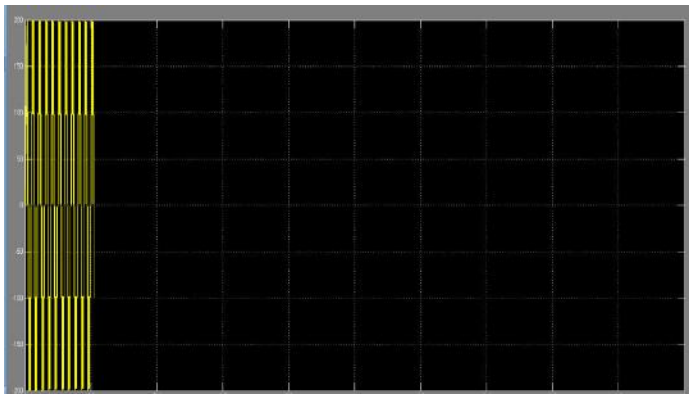




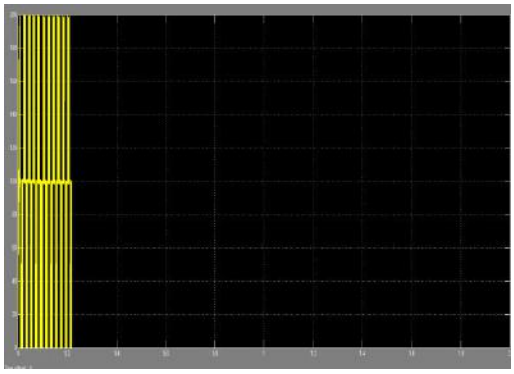
OUTPUT VOLTAGE OF BOOST INVENTER

OUTPUT VOLTAGE OF DIODE CLAMPED INVERTER





Line voltage output



FUEL CELL OUTPUT

Phase voltages

8.CONCLUSION

From this we understood that multilevel inverters are most promising technology in the power industry. The multilevel voltage source inverters has unique structure and allows them to reach high voltage and power levels without the use of transformers Harmonic content is less and high efficiency output is obtained.THD value of diode clamped inverter is less when compared to boost inverter.

9.REFERENCE

1. "Analysis and control of boost inverter for fuel cell applications"Himadry Shekar Das,Chee wei Tan,IEEE transactions,VOL.3,NO.12,DECEMBER2016.
2. "A Single-Phase Grid-Connected Fuel Cell System based on a Boost-Inverter" Minsoo Jang,Mihai Ciobotaru and Vassilios G. Agelidis,IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 28, NO. 1, JANUARY 2013.
3. "Boost Inverter based single phase grid connected fuel cell system"B.Mahesh Kumar,S.M.Zafarullah,International Journal Of Engineering Science and Computing,Volume 6,Issue No.11,November 2016.
4. "A grid connected fuel cell based on boost inverter system",B.Haritha, P.dhanamajaya,IJIREEICE,Vol .2,Issue 8,August 2014.
5. "Fuel Cell energy source based Multilevel inverter",Kishwar Jhan Ali,Rajesh Sahu,International Journal of Scientific and Research Publications,Volume 3,Issue12,December 2013.
6. "Fuelcell fed Dc-Ac multilevel converter for various applications" ,M.Nagaraju,VanaparyhiNareshKumar,IJATIR,Vol.8,Issue.18,Oct2016.
7. "Fuel cell based grid connected boost inverter system",N.venkateswarlu,P.Ankineedu Prasad,International Journal of Electrical and Electronics Engineering,vol.8,No.1,2015.
8. "Grid connected Multilevel inverter for renewable energy applications"R.Mahalakshmi,K.C. Sindhu Thampathy,vol.2212,ELSEVIER ,2015