IOSR Journal of Engineering (IOSRJEN) www.iosrjen.org
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Special Issue || Dec. 2019 || PP 29-34
International Conference on Management Practices, Innovations & Research 2019

High Voltage Gain with Neural Network Based Electric Vehicle

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ABSTRACT
Due to the more vigorous regulations on carbon gas emissions and fuel economy, Fuel Cell Electric Vehicles (FCEV) are becoming more popular in the automobile industry. This project presents a neural network based Maximum Power Point Tracking (MPPT) controller for 1.26 kW Proton Exchange Membrane Fuel Cell (PEMFC), supplying electric vehicle power train through a high voltage-gain DC-DC boost converter. The proposed neural network MPPT controller uses Radial Basis Function Network (RBFN) algorithm for tracking the Maximum Power Point (MPP) of the PEMFC. High switching frequency and high voltage gain DC-DC converters are essential for the propulsion of FCEV. In order to attain high voltage gain, a three-phase high voltage gain Interleaved Boost Converter (IBC) is also designed for FCEV system. The interleaving technique reduces the input current ripple and voltage stress on the power semiconductor devices. The performance analysis of the FCEV system with RBFN based MPPT controller is compared with the Fuzzy Logic Controller (FLC) in MATLAB/Simulink platform.
Index Terms: *Fuel cell electric vehicle, high voltage gain IBC, PEMFC, MPPT, RBFN.*

I. Introduction

Due To The Environmental Pollution And Finite Reserves Of Fossil Fuels, Automobile Industries Are Showing More Interest In Fuel Cell Electric Vehicles (FCEV). The Rapid Advancements In Power Electronics And Fuel Cell Technologies Have Empowered The Significant Development In Fcevs . Fuel Cells Have The Advantages Of Clean Power Generation, High Reliability, High Efficiency And Low Noise. Depending On The Type Of Electrolyte Substance Fuel Cells Are Categorized Into Different Types Such As Proton Exchange Membrane Fuel Cell (PEMFC), Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), Solid Oxide Fuel Cell (SOFC) And Molten Carbonate Fuel Cell (MCFC). Among All Of These, Pemfcs Are Dominating The Automobile Industry Due To Their Low Operating Temperature And The Quick Start-up.

1)FUEL CELLS

- Due To Environmental Pollution And Finite Reserves Of Fossil Fuels, Automobile Industries Are Showing More Interest In Fuel Cell Electric Vehicles (FCEV).
- Fuel Cells Have The Advantages Of Clean Power Generation, High Reliability, High Efficiency And Low Noise.
- PEMFCs Are Dominating The Automobile Industry Due To Their Low Operating Temperature And The Quick Start-up.

2)MPPT

- The MPPT Algorithms, P&O Is Simple, Popular And Easy To Implement. P&O And Incremental Conduction Methods Produces Oscillations At Steady State Which Will Reduce Efficiency Of Fuel Cell System.
- To Overcome This Problem, Fuzzy Logic Controller And Neural Network Algorithms Are Introduced To Track MPPT With Increased Efficiency And Accuracy.
- Radial Basis Function Network (RBFN) Base MPPT Controller Is Proposed To Track MPPT Of The PEMFC.

II. Literature Survey

1. ***Bhargavi ”High Voltage Gain Interleaved Boost Converter with Neural Network Based MPPT Controller for Fuel Cell Based Electric Vehicle Applications” International Journal of Technical Innovation in Modern Engineering & Science Volume 5, Special Issue 05, May-2019***

This Paper deal with Environmental Pollution And Finite Reserves Of Fossil Fuels, Automobile Industries Are Showing More Interest In Fuel Cell Electric Vehicles (FCEV). The Rapid Advancements In Power Electronics And Fuel Cell Technologies Have Empowered The Significant Development In Fcevs . Fuel Cells Have The Advantages Of Clean Power Generation, High Reliability, High Efficiency And Low Noise.

Depending On The Type Of Electrolyte Substance Fuel Cells Are Categorized Into Different Types Such As Proton Exchange Membrane Fuel Cell (PEMFC), Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), Solid Oxide Fuel Cell (SOFC) And Molten Carbonate Fuel Cell (MCFC). Among All Of These, Pemfcs Are Dominating The Automobile Industry Due To Their Low Operating Temperature And The Quick Startup.

2. *El Manaa Barhoumi, Ikram Ben Belgacem "A Neural Network-Based Four Phases Interleaved Boost Converter for Fuel Cell System Applications"MDPI 6 December 2018*
This paper presents a simple strategy for controlling an interleaved boost converter that is used to reduce the current fluctuations in proton exchange membrane fuel cells, with high impact on the fuel cell lifetime. To keep the output voltage at the desired reference value under the strong fluctuations of the fuel flow rate, fuel supply pressure, and temperature, a neural network controller is developed and implemented using Matlab-Simulink (R2012b, Math Works limited, London, UK). The advantage of this controller resides in its simplicity, where limited number of tests is carried out using Matlab-Simulink to construct it. To investigate the robustness of the proposed converter and the neural network controller, strong variations of the fuel flow rate, fuel supply pressure, and temperature and air supply pressure are applied to both the fuel cell and the neural network controller of the converter.

3. *K. JYOTHEESWARA REDDY AND N. SUDHAKAR "Neural Network Based MPPT Controller for Fuel Cell Based Electric Vehicle" IEEE November 17, 2017*
This paper deals with that Due to the more vigorous regulations on carbon gas emissions and fuel economy, Fuel cell electric vehicles (FCEV) are becoming more popular in the automobile industry. This paper presents a neural network-based maximum power point tracking (MPPT) controller for 1.26-kW proton exchange membrane fuel cell (PEMFC), supplying electric vehicle powertrain through a high voltage-gain dc–dc boost converter. The proposed neural network MPPT controller uses a radial basis function network (RBFN) algorithm for tracking the maximum power point of the PEMFC. High switching-frequency and high voltage-gain dc–dc converters are essential for the propulsion of FCEV. In order to attain high voltage-gain, a three-phase high voltage-gain interleaved boost converter is also designed for FCEV system. The interleaving technique reduces the input current ripple and voltage stress on the power semiconductor devices. The performance analysis of the FCEV system with RBFN-based MPPT controller is compared with the fuzzy logic controller in MATLAB/Simulink platform.

4. *Moe Moe Lwin and Htin Lin "Neural Network Based High-Performance Double Boost DC-DC Converter in Using Renewable Energy System" International Journal of Science, Engineering and Technology Research (IJSETR) Volume 7, Issue 5, May 2018*
Difference types of DC-DC converter are used in various electronic devices and applications for so many years. But conventional converter cannot afford in high voltage and high current applications. Many researchers have been tried to full-fill the requirements. In this paper, dual stage double boost DC-DC converter is used for renewable energy system. To obtain a control method has the best performance under any condition is always demand.
Voltage mode control technique is applied to achieve the constant high output voltage with the help of advanced controller. The main objective of this paper is the study of Neural Network Controller (NNC) under the response of different parameters of proposed converter using Matlab/Simulink Software.

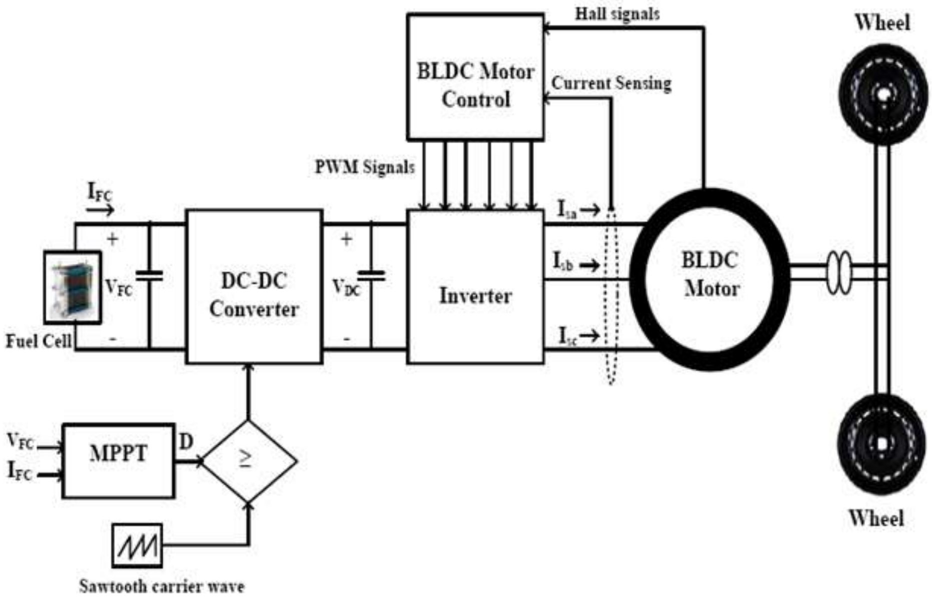
PROBLEM DEFINATION
1)EXISTING CONFIGURATION

Boost converter is extensively used as aFront-end power conditioner for the fuel cell. For low power applications, the conventional boost converter is used as a power electronic interface whereas for high power applications boost converter might not be compatible because of its low current handling capability and thermal management issues. To overcome these problems different high voltage gain DC-DC converters are designed in the literature. Isolated converters with coupled inductors or high frequency transformers are proposed to achieve high voltage gain. The high voltage gain is achieved by adjusting the transformer turns ratio. However, these isolated converters are more expensive compared to non-isolated DC-DC converters. So, this project proposes a high voltage gain three-phase non-isolated interleaved boost converter (IBC) for fuel cell applications to attain low switching stress and high voltage gain.

Interleaving technique increases the reliability of the fuel cell and provides high power capability. The output voltage of the proposed converter is given to the electric motor through an inverter for propulsion of the vehicle. The electric motor plays an important role in FCEVs. An adequate motor considerably reduces the cost and size of the fuel cell. In past, the majority of automakers are used DC motors for electric vehicle applications.

Adversely, DC motors have high maintenance cost and low efficiency due to the brushes and rotating devices. At present, permanent magnet BLDC motor is mostly using in FCEV applications due to simple control, high reliability and high ruggedness.

- The power train Architecture of FCEV Is Shown in Fig. 1, A Stack of PEMFC Produces an Unregulated Low Dc Output Voltage.
- Boost or step-Up DC-DC Converter Is Required to Boost and Regulate the PEMFC Output Voltage.



A quadratic boost converter composed of two boost converters is proposed to attain high voltage gain. But, using of two boost converters may reduce the overall efficiency of the system. A cascaded 2-phase interleaved DC-DC boost converter is proposed. However, this topology suffers from poor reliability and less efficiency. In a boost converter with voltage multiplier cell is proposed to achieve high voltage gain, but the voltage gain of single multiplier cell is not much enough to drive the power train of FCEV.

- **DISADVANTAGES OF EXISTING CONFIRGURATION**

 Poor Reliability
 Less Efficiency.
 Expensive
 For Low Power Applications, The Conventional Boost Converter Is Used As A Power Electronic Interface Whereas For High Power Applications Boost Converter Might Not Be Compatible Because Of Its Low Current Handling Capability And Thermal Management Issues.
 To Overcome These Problems Different High Voltage Gain Dc-Dc Converters Are Designed In The Literature.

Fig.1. Conventional configuration of fuel cell fed BLDC motor driven electric vehicle.

2) PROPOSED CONFIGURATION

This project proposes a high voltage gain three-phase non-isolated interleaved boost converter (IBC) for fuel cell applications to attain low switching stress and high voltage gain. Interleaving technique increases the reliability of the fuel cell and provides high power capability

Fig.2. Shows the proposed BLDC motor driven FCEV system with three-phase high voltage gain IBC. It consists of a 1.26 Kw PEMFC, three-phase high voltage gain IBC, voltage source inverter (VSI) and a BLDC motor.

The three phase IBC operates as an interface between PEMFC and VSI. RBFN based MPPT algorithm is designed to extract the maximum power from the fuel cell. Three-phase IBC supplies power to the BLDC motor through VSI. The switches of the VSI are controlled by using electronic commutation of BLDC motor. The motor shaft is connected to vehicle wheels for the propulsion.

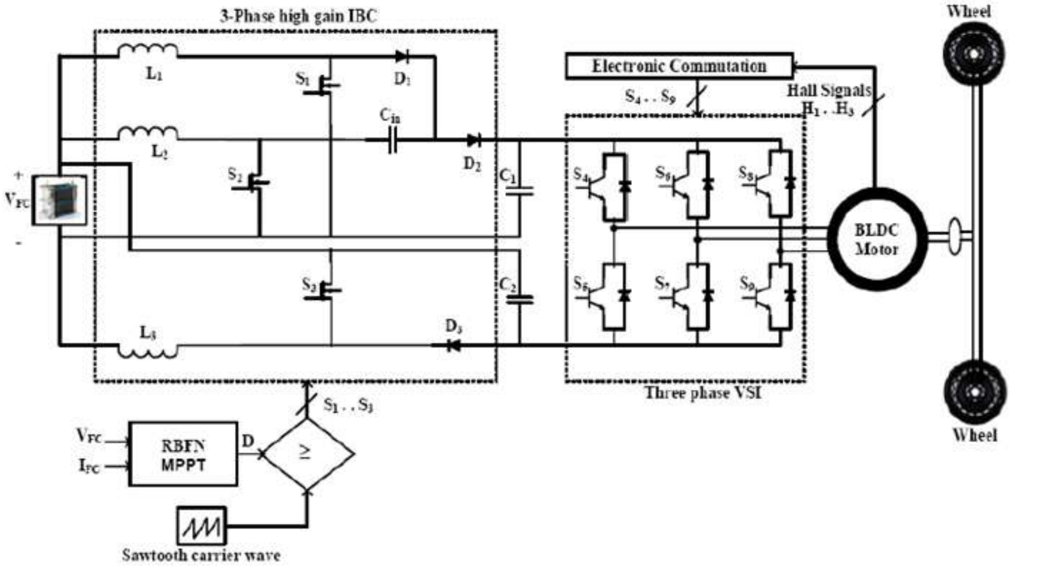
- **ADVANTAGES OF PROPOSED CONFIGURATION**

1. Clean power generation,

2. High reliability,
3. High efficiency
4. Low noise
5. High voltage gain

- **APPLICATIONS**

Fig.2. the proposed BLDC motor driven FCEV system with three-phase high voltage gain IBC



1. Fuel cell applications
2. Solar power applications

- **EXTENSIONS**

This project has two extensions

1. PI Controller is used in this controlling we replaced that conventional controller with modern controller like FUZZY because of drawbacks of conventional PI controller.
2. PI Controller is used in this controlling we replaced that conventional controller with modern controller like ANFIS because of drawbacks of conventional PI controller.

III. Simulation And Result Analysis

The performance of the proposed BLDC motor driven FCEV system is analyzed by using the MATLAB/Simulink platform.

To analyze the dynamic response of the FCEV system, sudden changes in the temperature of the fuel cell is considered as,

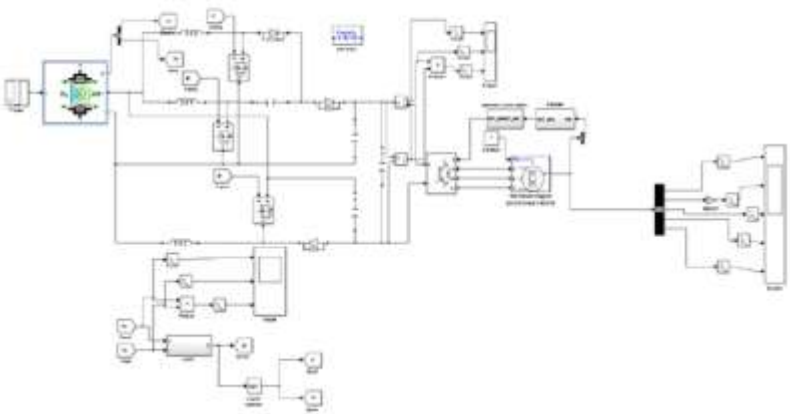


Fig.3. Simulation Architecture of proposed system of project

$T = 320°K$ for a period of 0 to 0.3sec,
$T = 310°K$ for a period of 0.3 sec to 0.6 sec and $T = 330°K$ for a period of 0.6sec to 0.9 sec.
Fuel cell generates a power of 1080W for 0 to 0.3 sec, 970W for 0.3sec to 0.6 sec and 1220W for 0.6sec to 0.9sec. The DC link current, voltage and power by using the FLC base MPPT technique. It generates a power of 1000W, 830W and 1150W for the temperatures of $320°K$, $310°K$ and $330°K$ respectively. The DC link output current,

voltage and power using proposed RBFN based MPPT controller are shown in the Fig. 4.
The proposed controller gives 1050W for the temperature of $320°K$, 900W for $310°K$ and 1200W for the temperature of $330°K$.

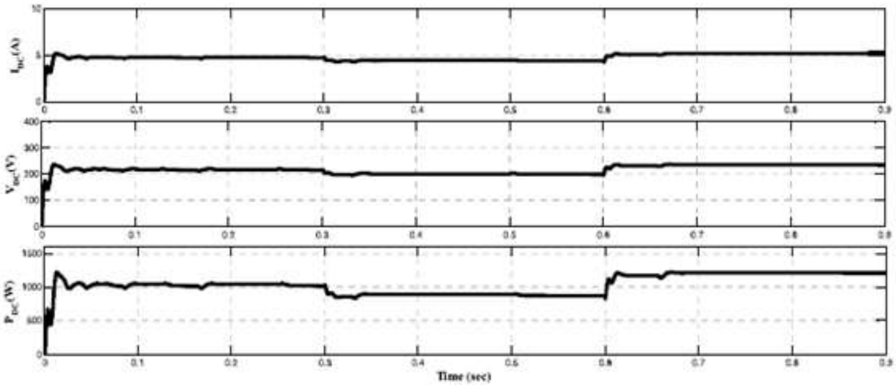


Fig. 4.DC link output current, voltage and power at different temperatures using RBFN.

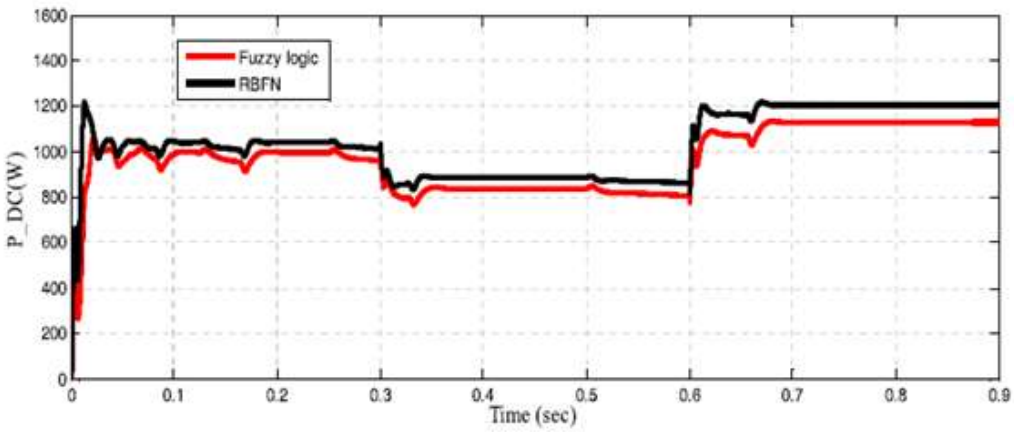


Fig. 5. Comparison of DC link power with both RBFN and Fuzzy based MPPT controllers.

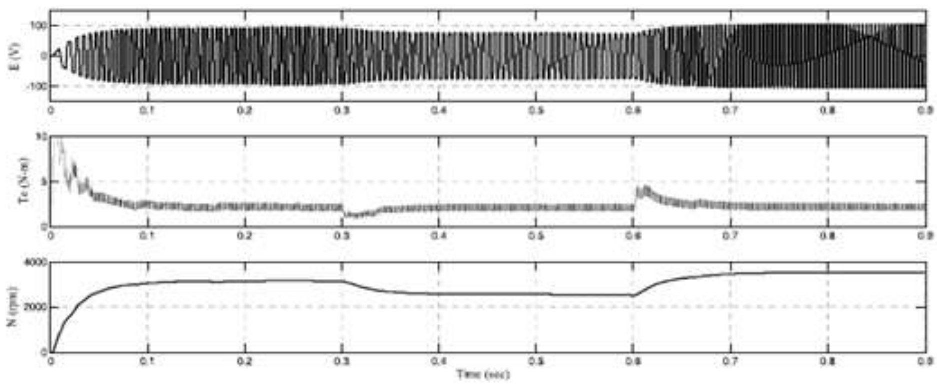


Fig. 6. BLDC motor parameters.

In Fig. 5, the Performance of the RBFN based MPPT controller for fuel cell is compared with fuzzy logic based MPPT controller.
From Fig. 5, it is observed that proposed controller generates the high DC link power than the FLC. The comparative analysis of FLC and RBFN controllers are listed in Table.
The starting and steady-state characteristics of the BLDC motor at different temperatures of the fuel cell are as shown,

TABLE 1. Comparison of DC link power with both RBFN and Fuzzy based MPPT controllers.

Parameter	1.26 kW PEMFC with fuzzy based MPPT			1.26 kW PEMFC with RBFN based MPPT		
Period (sec)	0 to 0.3	0.3 to 0.6	0.6 to 0.9	0 to 0.3	0.3 to 0.6	0.6 to 0.9
Fuel cell temperature (°K)	320	310	330	320	310	330
DC link current (A)	4.71	4.3	5.1	4.8	4.4	5.21
DC link voltage (V)	212	193	225	220	205	230
DC link power (W)	1000	830	1150	1050	900	1200

In the Fig.6. The motor parameters such as stator current (Isa), back EMF (E), electromagnetic torque (Te) and load torque (TL) are presented at dynamic temperature conditions of the fuel cell. The BLDC motor has a speed of 3300 rpm for 0 to 0.3sec, 2400 rpm for 0.3sec to 0.6sec and 3700 rpm for 0.6sec to o.9sec. The torque of the BLDC motor remains constant for varying speed conditions.

IV. Conclusion

In this project a Three-Phase High Voltage Gain DC-DC Converter Is Proposed For FCEV Applications. The Proposed Converter Has Reduced The Fuel Cell Input Current Ripples And The Voltage Stress On The Power Semiconductor Switches. The RBFN Based MPPT Technique Is Designed For 1.26 Kw PEMFC For Extracting The Maximum Power From The Fuel Cell At Different Temperatures. The Proposed MPPT Technique Is Compared With The FLC MPPT Controller. The Simulation Results Reveal That The RBFN Based MPPT Controller Has Tracked The Maximum Power Point Faster When Compared To The Fuzzy Logic Controller. Also, Different Performance Characteristics Of The BLDC Motor Such As Electromagnetic Torque, Speed And Back EMF Are Analyzed At Different Temperatures Of The Fuel Cell System.

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