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Solar Based High Gain Interleaved Boost Converter Fed to BLDC Motor

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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 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. This hybrid GWOT-FLC controller stabilizes the source power under various operating temperature conditions of the fuel stack. However, the fuel stack supplies very little output voltage which is improved by introducing the Single Switch Universal Supply Voltage Boost Converter (SSUSVBC) in the second objective. 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.

KEYWORDS: BLDC motor, Solar PV, Interleaved converter, Efficiency, Power factor correction.

I. INTRODUCTION

The modern, advancing smartphone space seems to have an energy need that is directly proportionate to population. To fulfil this requirement, a lot of fuels are required, but since they are depleting and having negative impacts on the environment via climate change, ozone depletion, and other factors, we must use renewable resources to a greater extent to match requirement and be environmentally friendly. Although there are several renewable energy solutions, solar is among the most often used. Due to its simple maintenance requirements, capacity for productivity, and lack of pollution, PV technology is currently on the rise. These systems operate on the straightforward premise of turning sunlight into electricity using the solar cells' internal photovoltaic effect. A photovoltaic cell consists of a fabricated semiconductor layer PN junction⁴. The effectiveness of the PV is influenced by various factors. One of these is geography, or the places they are positioned, the shadowing effect, and the climate there. Other effects are brought on by various PV technical units and the PV array's inclined angle⁵. PV cell output voltages are absolutely insufficient for high-powered applications like solar powered electric vehicles. Difficult switching converters rarely meet the requirement because of their inadequate effectiveness; as a result, soft switching converters were employed as an alternative because of their excellent performance and low degree of loss.

Therefore, the voltage can be increased to the required level by using a step-up DC converter. However, employing a standard step-up or boost converter to achieve large voltage output for high-powered applications makes it challenging to preserve greater performance. Furthermore, solar powered EV requires a converter with a high-power rating to meet the preferred voltage characteristic because it includes maximum voltage and current ranges. So, the idea of interleaved boost converter (ILBC) is applied. ILBC could be the sole option to accomplish design goals in light of the rising frequency of energy-saving standards. Using a power converter will make it possible to link the solar farm to the grid network (mainly boost converter).

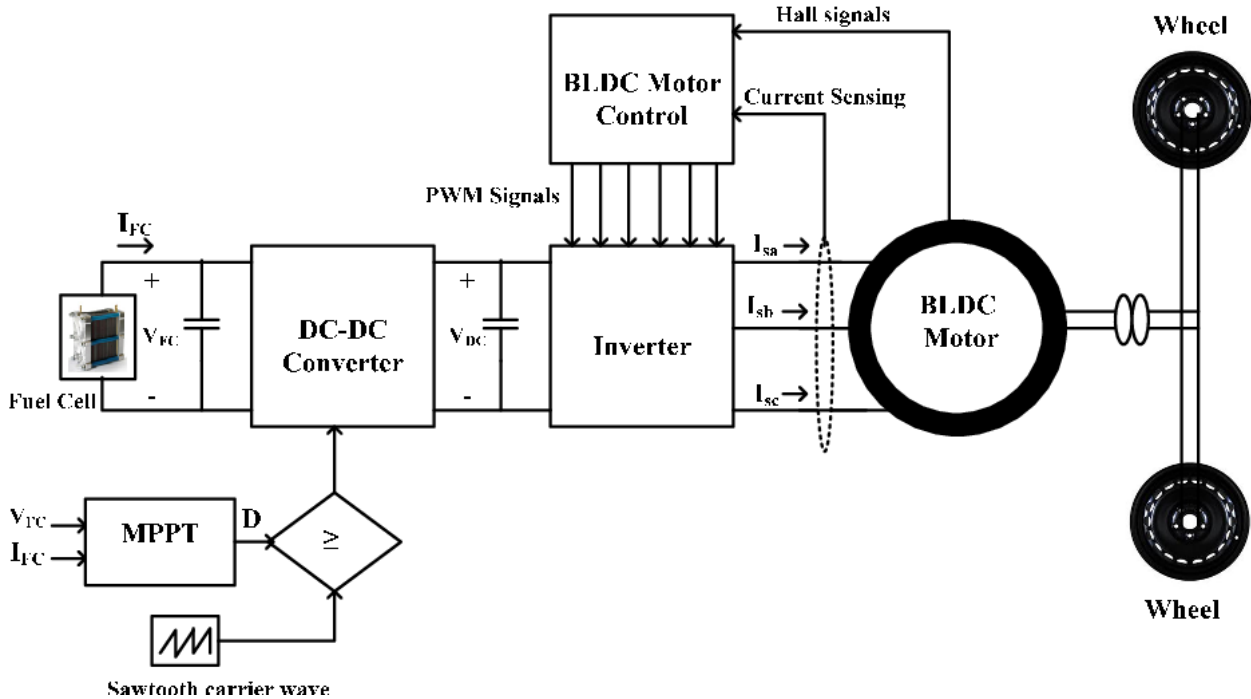


Fig 1: High Voltage Gain Interleaved Boost converter

Consequently, a direct DC link is established with the PV system. The performance of PV arrays is unaffected, and its main benefits are simplified circuit and cheaper converter expenses. Due to the minimal amount of technology modification required, this architecture may be retrofitted to the present solar based power generation methods. With the existing MPPT methods, identification of global peak is difficult with fixed step size. AI techniques have been introduced to overcome the problems associated with fixed step size MPPT technique. Fuzzy logic based variable step size in incremental conductance gave better performance but not in the settling time. The ANN based MPPT gave better solutions to the conventional MPPT but still conversion efficiency and tracking efficiency are poor.

The suggested technique makes use of NN to determine the best scaling factor for the present irradiance level by feeding it the observed voltage and current values of two successive perturbation locations. In-depth simulations are not necessary using the adjustable scaling parameter approach to obtain the optimal scaling factor. Additionally, it can eliminate the challenging calculations necessary when using state estimate techniques for calculation of the irradiation levels. The suggested approach comprises the benefits like easy to use, easy to calculate, and performing at its best under rapidly changing solar irradiance conditions. The suggested approach is contrasted with WCO-PO MPPT to validate the efficiency of the suggested MPPT method. The outcomes of this study show that the robustness and constancy of the suggested method are superior for MPP tracking time. Paper's organization-second section-methodology; third section-simulation results and discussion; fourth section-conclusion.

II. LITERATURE REVIEW

From the literature review, the past isolated power converter circuits needed more implementation cost and needed more reliability. Also, these converter topologies require high installation space. So, transformerless power converter circuits are developed in for battery charging systems with the help of solid oxide cells. The basic buck converter circuit is utilized in the PV/fuel stack microgrid system for balancing the power in the all-distribution loads. These converters required only one capacitor, plus one switch for balancing the supply voltage. Similarly, a simple boost converter circuit is applied in a telecommunication network for solar battery charging, plus discharging. The general boost converter circuit required less manufacturing cost, was easy to handle, and needed very low space for installation. However, these types of power converter circuits give less efficiency for high switching frequency applications, the authors worked out the hybrid electric vehicle technology to reduce the dependency on fuel engines. The combustion engine is interlinked with the electric drive network for regulating the power of the vehicle at various working temperature conditions of the fuel engine. The hybrid EV network's overall efficiency depends on the electric vehicle powertrain.

In EVs, the permanent magnet machine is utilized along with the battery for running the EV at constant speed., the solid oxide fuel stack network is merged with the quasi-source DC-DC converter topology and it is applied to the four-wheeler electric vehicle system to improve the efficiency of the system. In SOFS, the electricity supply process happens by utilizing the ceramic electrolyte. Here, the negative oxygen ions flow from the cathode layer to the anode layer via a ceramic electrolyte. The analysis and the specifications of various categories of fuel stacks are explained. In the SOFS, there is a high level of chemical decomposition happening at high operating temperature conditions of the fuel stack. As a result, the performance efficiency of the overall system is improved. Also, it consists of high fuel flexibility, less carbon dioxide emissions, and a relatively very low cost of implementation when compared to the phosphoric acid fuel cell. The interleaved single-phase power electronic circuit topology is applied for the high voltage rating battery-based fuel stack system for running the battery in a dual power flow direction at peak load conditions. The lithium-ion battery state of charge and the state of discharge parameters are supplied to the incremental resistance MPPT block for optimizing the discharge state of the battery. In this MPPT methodology, the variation of fuel stack voltage and current variables is utilized for finding the duty ratio of the bidirectional power converter. Here, the incremental resistive value is positive when the controller reaches the required MPP place. Otherwise, it may go to the left side of the MPP position of the fuel stack V-I curve.

The modified slider methodology is utilized in the hybrid diesel engine, battery, and fuel stack system for identifying the peak power point of the fuel stack, plus enhancing the dynamic response of the overall network. In this power production network, the interleaved multiphase power converter is utilized for equal power distribution to all local loads. In this slider controller, the fuel stack oxygen ions, resistive load voltage, and hydrogen decomposition constants are utilized as the state input variables, and the output variable is the switching signal to the fuel stack-fed rectifier circuit. All the rectifiers generate fluctuated currents and voltages which are given to the Kalman filter block for mitigating the losses of the hybrid PV/fuel stack network. The merits of this slider MPPT method are very easy, plus good static response. Also, it helps to optimize the fuel stack system power conduction losses. However, this slider controller may not give efficient converter output power. The demerits of this slider controller are overcome by using Artificial Neural Networks (ANNs).

The ANN controller is developed from the human brain's behavior and the human brain consists of multiple nodes that are interlinked with each other. All the nodes are exchanging their information to identify the required objective. In the PEMFS/battery-fed bidirectional power conversion circuit duty signal is monitored with the help of a neural network-based MPPT controller. The merits of these neural networks are very low implementation cost, more useful for all nonlinear issues, ease of use for highly complex problems, and the capability to alter any unknown conditions. However, these neural networks need high convergence time, plus more complexity in the ANN structure.

III. METHODS

As we know nonrenewable power system utilization is reducing drastically in electric vehicle systems because of its demerits such as large space for installation, plus high-power generation cost. So, renewable power systems are playing the predominant role in the present electric vehicle systems for optimizing environmental pollution and reducing grid dependence. From the literature study, there are different types of renewable power systems available in the society. However, most of the renewable power supply networks give discontinuous power supply. So, in this work, the fuel stack technology is referred for continuous power supply to the automotive systems. The researchers studied the phosphoric acid fuel stack-based microgrid network for giving energy to local consumers. In this microgrid, the PV/wind/fuel stacks are involved in storing the energy in batteries, and the stored energy is utilized for emergency applications. In PAFSM, the phosphoric liquid is utilized as an electrolyte, and it is highly tolerant to carbon monoxide and carbon dioxide. In addition, it is pollution-free and eco-friendly. The PAFSM is very less sensitive to CO₂ and it has the capability of regeneration of heat along with electricity. Finally, the phosphoric acid fuel network consists of very low volatility. In this fuel stack, the anode accelerates the hydrogen oxidation reaction rate in phosphoric acid. In this fuel stack, the anode must and should be stable for high operating temperature conditions of the phosphoric acid. Sometimes, hydrogen starvation happens in the PAFSM and then the anode gets affected by reverse polarization. However, this fuel stack is inherently much less powerful when compared to the other fuel cells.

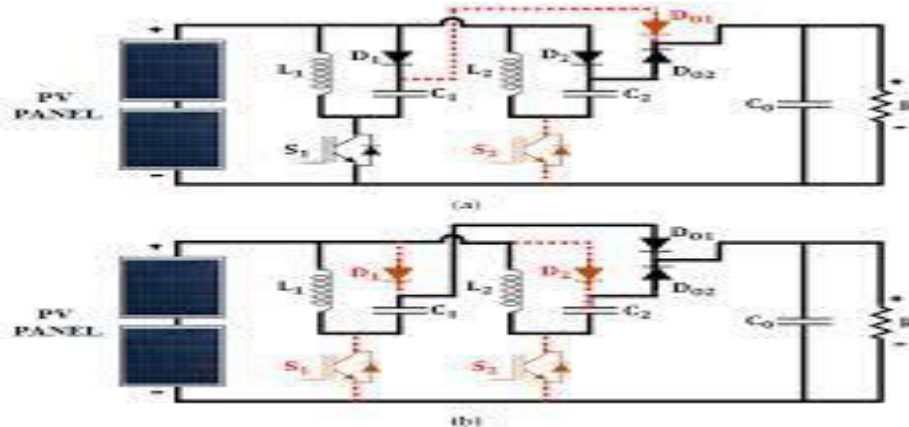


Fig 2: PV Array BLDC Motor

The demerits of the phosphoric acid fuel stack are limited by using the solid oxide fuel cell. In the SOFSM, the natural gas flows through the steam reforming process for generating electricity. Here, the methane and oxygen chemical recombination generates carbon monoxide, carbon dioxide, water, and hydrogen. The merits of solid oxide cells are high-functioning efficiency, long-term stability, fuel flexibility, less emission, relatively low cost, and low environmental pollution. The biggest disadvantage of SOFSM is taking more time to start functioning. However, the demerits of SOFSM are limited by using the polymer membrane fuel stack. In this PEMFSM, the proton ions are transferred from the anode chamber to the cathode chamber via a polymer electrolyte. Here, the membrane structure is in the form of a thin plastic film and it is permeable with the proton when the membrane is saturated with water. However, it may not conduct with the electrons.

IV. RESULT ANALYSIS

The genetic optimization methodology is used in to identify the functioning point of the solar and fuel stack system. This algorithm does not require any derivate information. The merits of this algorithm are more exploration of search space, good flexibility, more adaptability, good parallel processing information, and global optimization. However, this algorithm has many disadvantages which are more computational complexity, high difficulty in tuning parameters, more dependence on randomness, risk of premature convergence, and limited understanding of results. So, the genetic algorithm is combined with the proportional and integral block to improve the steady-state response of the system and maintain the transient stability of the overall system. The genetic controller is combined with the artificial neural network for tracking the MPP of the hybrid wind/PV/FS power generation system with high efficiency. Here, initially, the neural network collects the signals from the fuel stack and solar networks which are sunlight intensity, fuel stack power, solar power, and functioning temperature of all the sources for moving the functioning point of the overall system from the initial stage to the required MPP location. Once, the functioning point of the hybrid network stabilizes with the actual MPP point, then the hill climb starts working to generate the highly accurate nonlinear power characteristics of the system.

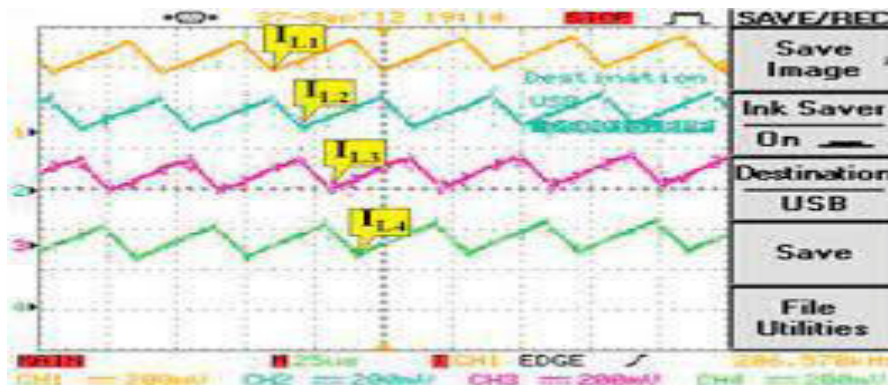


Fig 3: High Voltage Gain Interleaved DC Boost converter result analysis

Conventional neural networks take more time to achieve the optimal nonlinear solution of the fuel stack network because it takes more convergence time, high training data are needed when the neural network involves multiple layers in the structure, and it is less suitable for continuous changes of the environmental conditions of the fuel stack network. So, the artificial neural network limitations are overcome by using the fuzzy logic controller. Fuzzy logic is one type of approach which is used to process the variable towards the true value. Most of the fuzzy controllers are used for solving highly complex nonlinear problems. The features of fuzzy systems are easy to implement, highly robust, more flexible, good interpretability, and easy to understand. However, the fuzzy logic MPPT controller may not be accurate in the MPP position. In addition, it cannot recognize the neural network and machine learning patterns. Also, it required a highly knowledgeable person to implement the fuzzy logic controller, was very difficult in tuning, less accurate in MPP tracking, and had high computational complexity.

V. CONCLUSION

The overall GWAFC interfaced polymer membrane fuel stack system is developed by using the MATLAB software. Here, the polymer membrane fuel cell is selected because of its attractive features such as fast response, easy handling, ability to work in low as well as high-temperature conditions, more energy density, and simple construction. However, the fuel stack source voltage is very low which is not suitable for electric vehicle application. So, the new power DC-DC single switch converter is developed to enhance the system voltage to meet the required peak load demand. The advantages of this converter are a good voltage conversion ratio, fewer power components required for implementation, easy handling, wide output voltage operation, and suitable for all renewable energy system applications. Here, the duty signal of the converter is obtained by using the grey wolf optimization-based fuzzy logic power point tracking controller. In this MPPT controller, the fuzzy membership functions are selected by applying the grey wolf controller. The merits of this proposed MPPT controller are high flexibility, good dynamic response, easy handling, high robustness, and more reliability.

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