An Economic Fuel Cell with Triple Winded Coupled Inductor withFuzzy Controller for Fuel Cell Applications

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***Abstract*—in this paper, a high step up converter is designed for applications of power supply in fuel cell. The proposed high step up converter is designed with three windings coupled inductor. This three windings coupled inductor achieves flexibility in adjusting the voltage transformation proportion and stress voltage in each diode. This high step up converter increases the fuel cells voltage to required level. Technology passive subject without loss recycles energy leakage to enhance proficiency and alleviates large surges to limit the tensile stress. The energy generated is used to traction, D C grid units and battery. The speed and torque of the traction motor is analyzed. Engine performance is improved in traction drives by using fuzzy logic controller. The speed and torque of traction drive is compared with the proposed fuzzy logic controller to improve the functioning of the traction unit converter. Also the proposed converter is analyzed for different load conditions.**

***IndexTerms*—Stride, coupled inductor, Traction, Fuzzy logic.**

I. INTRODUCTION

Renewable energy sources have gained great interest due to the rising amount of the fossil fuels and the new systems of CO2 discharges. Therefore, renewable energy sources like fuel chambers, solar drive, wind drive and extensively used. The rapid development of telecommunications and wireless industry resulted in a need for reliable energy storage and uninterruptible power supply in remote areas and areas served by electric utilities networks. The backup power sources in these applications are batteries and diesel generators. These commercial technologies have existed for a significant period of time, but end users had experienced several drawbacks such as frequent maintenance, parts and reliability problems, noise, etc. Therefore, a need exists for alternative energy solutions. The electrical vitality storage be present among most presentations, such as telecommunications devices, stand-by structures, hybrid automobiles and fresh electric hybrid automobiles. Electrochemical capacitors are also termed as supercapacitor, ultra-capacitor or double layer capacitors. The first high power supercapacitor have been developed in Pinnacle Study Institute (PSI) for US military uses for example laser weapons and missile supervision systems. In the 19th century supercapacitor are widely used in hybrid electrical vehicles promoted through the Division of Energy (DOE). The technology remains increasing our dynamism needs, and also showing new ways to generate energy effectively with less impact on the environment. So fuel cells have been most promising options for additional future sources of supply.
Fuel cells are considered an excellent source of energy to replace conventional diesel or gasoline.It can provide clean energy for users without CO2 emissions. This is due to the stable operation, and high-efficiency and sustainable supply of fuel, has been used as an alternative source for the future efficiently. Features such as small size and high conversion efficiency and make the possibility of value. Therefore, fuel cells are suitable sources of food for energy sources applications. Fuel cells have the ability to create reliable power with lower levels of unwanted emissions, noise and high overall efficiency of the systems generating more traditional energy around applications and projected ranging from spacecraft to private cars, large stationary power generating systems for small electronic devices. Fuel cells are produced increasingly play a critical role in meeting the growing global demand for clean and reliable energy. Fuel cell energy sources are used in many applications as in portable applications, and applications of transportation and stationary power applications.

II. FUEL CELLS

A fuel cell is an electrochemical device that converts chemical energy of a fuel directly into electrical energy. No intermediate fuel conversions required in thermal and mechanical energy. It consists of two electrodes namely anode and cathode and an electrolyte. They operate as a battery, except the reagents are not stored, but continuously supplied to the cell.

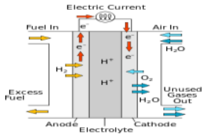

Figure 2.1: Flows and reactions in a single fuel cell.

Figure above shows the flows and reactions of a single fuel cell. The fuel (hydrogen-rich) and oxidant (typically air) are supplied to the fuel cell separately. Flows fuel and oxidant are separated by an electrode-electrolyte system. The fuel is fed to the anode (negative electrode) and an oxidant is fed to the positive electrode cathode). Electrochemical oxidation and reduction occurs at the electrodes to produce electric current. The primary product of reaction of fuel cells is water.

The reactions are as follows

Anode (-) $2H_2(g) \rightarrow 4H^+(aq) + 4e^-$ $E^0 = 0.00V$ OXIDATION

Cathode (+) $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(I)$ $E^0 = +1.23V$ REDUCTION

Overall reaction $2H_2(g) + O_2(g) \rightarrow 2H_2O(I)$ $E^0 = +1.23V$

III. TYPES OF FUEL CELLS.

There are 6 different types of fuel cells. In general, the electrolyte and the operating temperature distinguishes the different fuel cells. Fuel cells are listed below in order of increasing operating temperature:

- fuel cell proton exchange membrane (PEMFC) --- 1750F (800C)
- phosphoric acid fuel cell (PAFC) --- 4000F (2000C)
- fuel cell molten carbonate (MCFC) --- 12500F (6500C)
- fuel cell solid oxide (SOFC) --- 18000F (10000C)

IV **SYSTEM COMPONENTS**

4.1 DC-DC CONVERTER

The high DC converter is step-DC as shown in Fig. devices low voltage power used to reduce conduction losses. Switching losses are minimized and the EMI noise is reduced due to dt / dv low voltage. However, the power devices operating under condition of hard switching and reverse recovery solution output diode is serious. The voltage gain is still not suitable for a high step-up conversion. Coupled inductor serve as a transformer to extend the voltage gain in non-isolated DC-DC converters. The coupled inductor has three windings. The two windings acts as a filter inductor. The third winding functions as a voltage source in the field of power series. The voltage gain can be expanded by appropriate design of the coupled inductor. Leakage power coupled inductor can be absorbed and call forward voltage in the MOSFET can be suppressed by clamp diodes and capacitor clamp. By combining the switched capacitor coupled inductor with improved power density and efficiency of the circuit.

This converter has the following performances:

a) The voltage gain spans the coupled inductor and the switched capacitor.

b) Leakage is recycled energy and voltage spikes in the MOSFET are absorbed by the clamp circuit without passive loss.

c) The effort to switch voltage is low to reduce conduction losses.

d) The problem of reverse recovery of the diode output is relieved by the leakage inductance of coupled inductor.

PART	**SPECIFICATIONS**
Input DC voltage	89.5518 V
Output DC voltage	405 V
Switching frequency	50 kHz
Current mode PWM controller	UC3845
Coupled inductor turns ratio	1:1:1.5
Magnetizing inductor	170Mh
Main power MOSFET Diodes	IXFN 130N30 300V, 130A, 22MΩ D1 DSEP 30-06A 600V, 30A D2/D3/D4 MBR20200CT 200V,20A
Capacitors	C_b 220µF/200V C_1 220µF/200V C_2/C_3 470µF/450V

Table 4.1 Components of the proposed converter.

4.2. PARAMETERS PROPOSED CONVERTER COMPONENTS

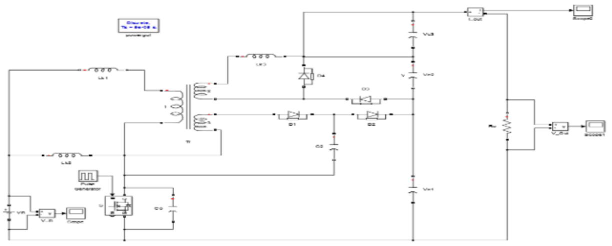

Figure 4.1: High boost converter coupled inductor and switched capacitor.

4.3 PULSE WIDTH MODULATION

Pulse width modulation is a modulation technique used to encode a message in a pulsed signal. Although this modulation technique is used to encode information for transmission, its main function is to provide control power supplied to electrical devices mainly inertial loads such as motors. PWM is also one of the two main algorithm used in photovoltaic solar battery charges , the other being tracking the maximum power point .

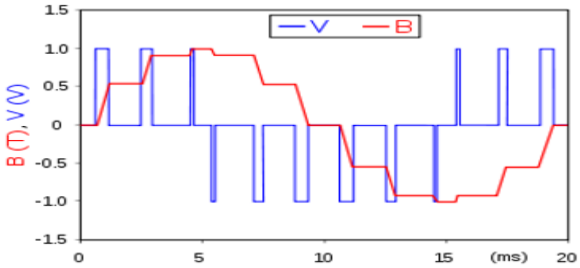

Figure 4.2: PWM in a romanticized inductor.

4.3 VOLTAGE SOURCE CONVERTER

The main requirement in a power transmission system is the control flow of active and reactive power to maintain the stability of system voltage. This can be obtained with the help of electronic converter and its ability to convert AC power to DC or vice versa. Converters voltage source with the strategy specifies the vector control can be performed independent control of the active / reactive power at both ends. This ability makes it suitable for VSC connection weak AC networks, i.e. without local voltage sources. Reverse power, the DC voltage polarity remains the same for the VSC based transmission system and energy transfer depends only on the direction of the DC current.

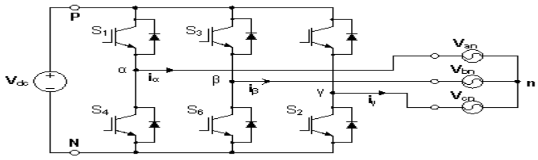

Figure 4.3: converter voltage source.

4.4 FUZZY CONTROLLER:

A fuzzy control system is a control system based on fuzzy logic --- a mathematical system that analyzes analog input values in terms of logical variables taking continuous values between 0 and 1, in contrast to classical logic or digital , which operates in discrete values of 1 or 0 (true or false, respectively).

Fuzzy logic is widely used in machine control. The term "fuzzy" means that the logic used can deal with concepts that cannot be expressed as the "true" or "false" but as "partially true". Although alternative, approaches such as genetic algorithms and neural networks can perform as well as fuzzy logic in many cases.

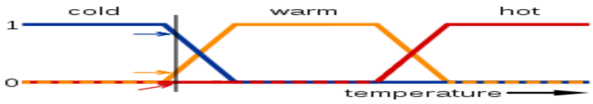

Figure 4.4: Temperature fuzzy logic.

The meanings of the cold, warm and hot expressions are represented by functions mapping a temperature scale. A point on the temperature scale has three “truth values " --- one for each of the three functions. The vertical lines in the image represents a particular Anemometric the three arrows that temperature. From the red arrow pointing to zero, this temperature can be interpreted as “hot ". The orange arrow can be described as “a little hot" and the blue arrow “a little cold ".

The single feedback controller with a microcontroller chip is as shown below:

A fuzzy set defined for the variable input error “e", and the resulting change in error, "delta” and "exit", as follows

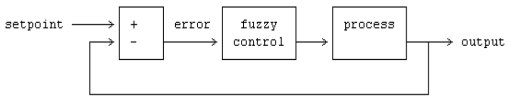

Figure 4.5: Block diagram of the fuzzy controller.

4.5 FUEL CELL STACK

The number of fuel cells are arranged in parallel depending on the rated power of the system. There are stacks of fuel cells are commercially available in the market as consumer requirement. So we can able to include the source of fuel cells depending on our consumption. In 2013, the Department of Energy estimates that 80-kW system costs automotive fuel cell of US $ 67 per kilowatt, assuming that the production volume of 100,000 cars a year. Many companies are working on techniques to reduce the cost in a variety of ways, including reducing the amount of platinum needed in each individual cell. In the fuel cell the membrane must be hydrated, requiring water to be evaporated at the same rate that occurs. If the water evaporates too quickly, the membrane dries, resistance across it increases, and crack, creating a gas "short circuit" where hydrogen and oxygen combine directly, generating heat that will damage the battery made out of fuel. The constant temperature should be maintained throughout the cell in order to avoid destruction of the cell through thermal load.

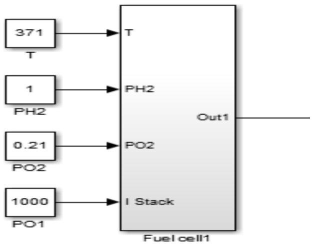

Figure 4.6: Parameters FC stack

V SYSTEM PROPOSED

5.1 Modeling and simulation of high lift converter

The model consists of fuel cell power. The voltage obtained from the fuel cell is driven elevator with the aid of high voltage converter necessary. The converter output is sent to D C grid, the battery and the voltage source converter. In voltage source converter of the DC source it becomes AC source and is supplied to the system configuration consumers. The shown in Fig. 5.1 Engine speed on the load side decreases as time product and also reduces the torque electromagnetic due to load increase or decrease the tension. So this will have an effect on engine operation.

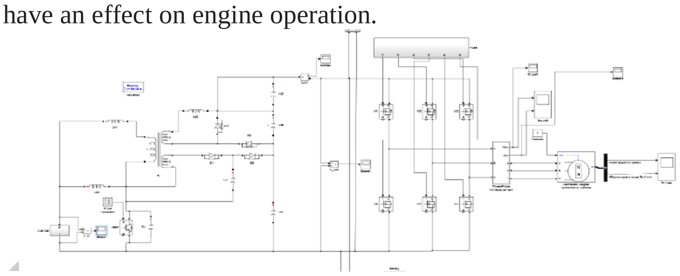

Figure 5.1: High up converter.

5.2 Modeling and simulation of high lift converter with fuzzy logic controller

Configuration with high up converter proposed fuzzy logic controller is shown in Figure 5.2. The system is composed of the fuzzy controller. Speed synchronous permanent magnet motor is compared with the reference speed given in the fuzzy logic controller and the required speed is maintained on the basis of the error value. Fuzzy logic is useful for improving the voltage and current of the inverter.

The input variables in a fuzzy control system are generally assigned by sets of membership functions known as fuzzy sets. The process of converting a crisp input value to a fuzzy value is called fuzzification

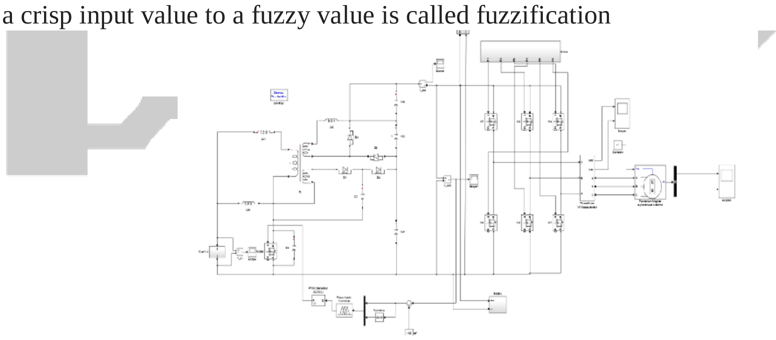

Figure 5.2: High boost converter with fuzzy logic controller

VI RESULTS OF THE SIMULATION

6.1 ANALYSIS SYSTEM WITHOUT FUZZY LOGIC CONTROLLER

The simulation results of high lift converter when connected to an AC source is as follows. Rpm speed is analyzed as shown in Fig.6.1

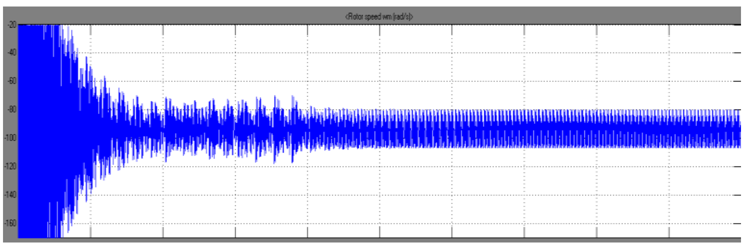

Figure 6.1 Rotor speed motor without fuzzy logic controller.

6.2 ANALYSIS SYSTEM WITH FUZZY LOGIC CONTROLLER

The simulation results of high lift converter when connected to an AC source shown below. The engine speed is constant when the system is connected to fuzzy controller. The speed in rpm is as shown in Figure 6.2

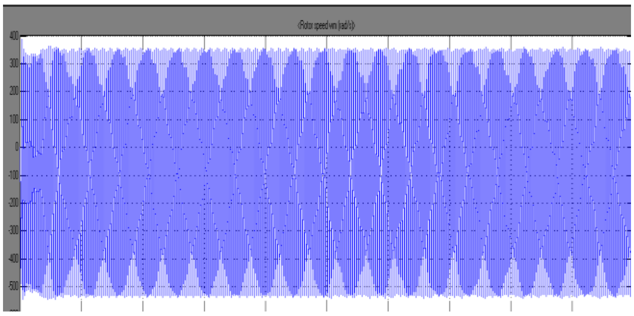

Figure 6.2: Rotor speed engine with fuzzy logic controller.

6.3 WITHOUT ELECTROMAGNETIC TORQUE FUZZY LOGIC CONTROLLER

The results of the simulation system without fuzzy controller shown below. The electromagnetic torque decreases as time progresses. The waveform shown in pair figure 6.3

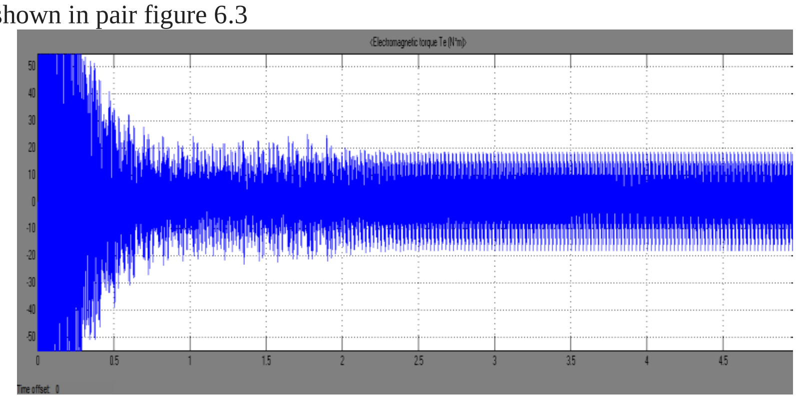

Figure 6.3: electromagnetic torque of the engine without fuzzy logic controller.

6.4 ELECTROMAGNETIC TORQUE WITH FUZZY LOGIC CONTROLLER

The simulation results of the system with the fuzzy controller shown below. The electromagnetic torque remains constant throughout the simulation when fuzzy logic controller is used. The waveform shown in pair figure 6.4

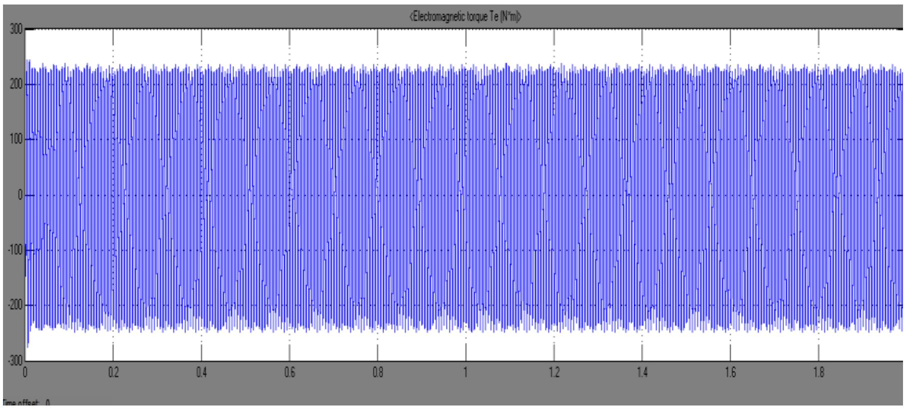

Figure 6.4: electromagnetic torque motor with fuzzy logic controller

6.5 COMPARISION OF RESULTS OBTAINED

Time (seconds)	Rotor speed Without fuzzy logic Controller (Rpm)	Rotor speed with fuzzy logic controller (Rpm)	Electromagnetic torque without fuzzy logic controller (N-M)	Electromagnetic torque with fuzzy logic controller (N-M)
0.5	-50	330	40	220
1	-70	350	25	230

Table 6.1: Comparison of rotor speed and electromagnetic torque without and with fuzzy logic controller in the load side.

The rotor speed and electromagnetic torque without and with fuzzy logic controller are compared in the table 6.1. From the above results, the speed and electromagnetic torque is increased.

VII CONCLUSIONS

Fuzzy controller with the source of fuel cells is effective in increasing the speed and electromagnetic torque on the load side. Fuel cell also is helpful in reducing emissions of carbon dioxide. The high up converter proposed with fuzzy logic controller improves engine operating parameters as the load connected.

The speed remains constant with the reference speed specified in fuzzy logic controller. The error signal based on the reference speed is generated. The conclusion is that the fuzzy controller is effective to control the speed and torque to reduce operating limitations.

VIII FUTURE SCOPE

In this project high boost converter is designed with three coupled inductor breath. The output of this converter is used to run the motor and the control method of fuzzy logic to the control mechanism is applied. With this, the speed and motor torque is analyzed. This work can be done with adaptive control techniques such as fuzzy logic controller or proportional controller resistive and comparison can be made. Also a high boost converter can be designed with switched capacitor and other devices in order to reduce the cost of converter with increasing voltage levels.

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