ABSTRACT

In today's modern world, Automobile sector plays a major role in satisfying the basic needs. In India, automobiles mainly depend on fossil fuels which are being depleted day by day. Due to scarcity of oils, the prices of fuel will be increased in near future which is unbearable by a common man. Also due to the usage of fossil fuels, emission from automobile cannot be eliminated and it contributes significant amount in causing global warming. These issues forces the researchers towards energy efficient alternatives for transportation.

Fuel cell vehicle producing only water as it by product will serve as a major contributor in reducing greenhouse gas emission by automobile sector. Although it has very good prospects in terms of environmental concern and energy conservation, the complexity lies in the efficient design of cost effective fuel cell vehicle system. These problems should be resolved before fuel cell vehicle's mass commercialization. The cost of the vehicle lies in identifying suitable low cost catalyst similar to the performance of platinum material. The efficiency of fuel cell vehicle lies on the performance of the power drive train system. Due to poor response of fuel cell during start-up and abnormal load demands, power converters and the control strategy adopted plays a major role in improving the overall performance of the fuel cell vehicle. Although there are enormous new topologies developed for power converters, the analysis of the converters for vehicle dynamics is very few. Hence the motivation of the research undertaken is to design a near optimal fuel cell hybrid electric vehicle. The major focus is on the design of efficacy improved power conditioning unit which comprises of DC-DC converter and DC-AC converter.

Fuel cell generates energy at low voltage levels. Hence it becomes mandatory to boost the voltage as required by the load. Conventional boost converter provides infinite voltage gain theoretically. But due to the choice of parasitic elements, the output voltage is limited in practice. Different DC-DC topologies have been adopted for high voltage gain in high power application. KY converter is one of the emerging converter. The advantage of this converter is its fast load transient response. It reduces the current stress acting on the output capacitor and also reduces the output voltage ripple as it possess non pulsating output current. The voltage gain of the KY converter is been enhanced in the derived topology known as KY boost converter. For the same duty cycle, the obtained output voltage is tripled in KY boost converter when compared with the KY converter.

The operating modes of the converter is analysed and the mathematical modelling of KY boost converter is developed using state space analysis to analyse the stability and to determine the controlling parameters. The input to output voltage transfer function and control to output voltage transfer function are obtained which validate the stability of the system.

Besides the obtained output voltage is tripled in KY boost converter, the open loop system cannot meet the designed requirements when there are fluctuations with the output of the fuel cell and also the obtained voltage is less than the designed voltage. To overcome these drawbacks, closed loop control through Fuzzy Logic Controller (FLC), Particle Swarm Optimization (PSO) and Fruitfly Optimization Algorithm (FOA) are adapted. The closed loop control of the proposed converter using different control techniques are carried out in MATLAB/Simulink platform. The three control techniques are compared based on ripple value. FOA provides the better convergence and optimal voltage for the designed parameter when compared to FLC and PSO.

Fuel cell vehicle with AC drive requires DC-AC converter along with DC-DC converter. DC-AC converter is the part of the power conditioning unit used for fuel cell vehicle. An 11 level cascaded H bridge multilevel inverter is selected and a novel discrete sine area equalization PWM technique is used to obtain the switching angles. The switching angles for the proposed DSAE PWM technique is designed by using the basic electrical equations related to the alternating current. The detailed mathematical modelling on the area equalization technique is done to obtain the reduction on THD value.

Adaptive voltage reference control method is adapted to further reduce the THD value and to enhance the performance of the system. The proposed AVRC – PWM is straight associated with control input current and output voltage. The proposed converter enhances the performance of the vehicle by reducing the output voltage ripple and power losses thus increasing the efficiency of the system. Hardware prototype is developed for the proposed converter with selected optimization technique to validate the performance. A novel methodology is developed to produce switching angles for DC-AC converter which reduces the THD of the system, thus enhancing the overall system performance. Fuel cell vehicle is modelled in MATLAB/Simulink with the real time parameters and the results obtained validate the proposed methodology. Fuel cell and vehicle drive are modelled in MATLAB with the existing method and the proposed converter are analysed with the developed vehicle model incorporating the real time parameter values. The torque ripple is minimized using the proposed converter.