ABSTRACT

In recent days energy crisis has become a vital problem so renewable energy generation is required. However it is susceptible to natural factors which results in power instability both in generation and distribution. To solve this issue, an energy storage device say batteries is utilized in renewable energy generation system. To interface the batteries with the generation systems obviously it requires a bidirectional DC-DC converter. It must be stated that these converters play a major role in transferring the power between low voltage and high voltage buses in Hybrid Electric Vehicle drive systems.

So far different types of bidirectional DC-DC converters have been proposed and they are majorly classified into isolated and non-isolated. The main objective of this research work is to highlight the utility of the non isolated type due to its transformer less operation, compactness and less cost. The bidirectional DC-DC converter can perform both step up and step down (boost and buck) operation, and during boost operation and buck operation there will be current stress on the conducting switches and voltage stress on the non conducting switches. Also it exhibits winding losses due to the presence of parasitic inductance and capacitance. To overcome these problems, an efficient switched coupled inductor based non-isolated soft switched Bidirectional DC-DC converter with soft switching and voltage gain improvement has been designed and analyzed in this research work.

The proposed enhanced cascaded multi level non isolated topology is operated with steep conversion ratio, soft switching, continuous inductor current and fixed switching frequency. In this proposed converter topology, the voltage conversion ratio was increased by switched coupled inductor. Cascading is one of the techniques used to operate the DC-DC converter with low switching stress and without voltage spikes across the switch during turn off. This technique was implemented in proposed topology to improve voltage gain of the non-isolated bidirectional DC-DC converter.
The performance of proposed converter with resistive load was simulated and compared with existing bidirectional DC-DC converter. Comparison showed that the proposed converter has reduced loss, improved voltage gain and efficiency. The prototype model of non isolated converter was constructed and tested using PIC microcontroller and validated with simulation results.

The performance of the proposed converter was enhanced by implementing closed loop control using various controllers such as PID controller, Fuzzy Logic controller, ANN controller, ANFIS controller, which were utilized to regulate the output voltage whenever input voltage variation occurs. The ANFIS controller minimizes the error voltage and loss thereby improving the efficiency. It has less rise time, quick settling time, less steady state error and dynamic error is also less compared to other controllers. The experimental validation of proposed topology was done using ATMEL microcontroller with PID, Fuzzy Logic, ANN and ANFIS controllers.

The optimization controllers such as BBO, GWO and hybrid GWOGA controller were implemented. From the results, it was found that the proposed hybrid GWOGA controller provided good regulation and dynamic response compared to other controllers. The proposed GWOGA has less rise time, fast settling time, less steady state & dynamic errors and improved efficiency compared to ANFIS controller.

The special application of 2 level non-isolated soft switched bidirectional DC-DC converter with motor load used in Hybrid Electric Vehicle (HEV) was also carried out. The open and closed loop operation of 2 level proposed converter with motor load was simulated. The closed loop speed control was implemented by using PID, Fuzzy Logic, ANN and ANFIS controller. The ANFIS controller gave improved speed regulation than other controllers.

The stability of the proposed bidirectional DC-DC converter was analyzed in time and frequency domains. Open and closed loop stability analysis was done by using Pole Zero mapping, Routh array, Root locus and...
bode plot methods. From the results, it was found that the proposed converter is stable under both modes.

Thermal analysis was also carried out to investigate the reliability of the switching devices. The increase in temperature results in increased thermal resistance of the switching device hence power loss increases and reduces the life of switch. In order to overcome this, design of heat sink was carried out.

All these studies of the proposed converter were evaluated using simulation in MATLAB/Simulink platform and it was also validated experimentally. From both the simulation and experimental results, it was concluded that the proposed bi-directional converter has improved voltage gain, less switching loss and higher efficiency compared to existing bi-directional converters. Hence, it can also be implemented for interfacing low voltage and high voltage buses in HEV applications.