ABSTRACT

DC-DC converters are used in various industrial, commercial and domestic applications like DC drives, welding power supplies, discharge lamp ballast, etc. Due to the advancements in manufacturing technology of power semiconductor devices, the converters continue to become smaller in size and more efficient. Power electronic based converters play a significant role in automotive applications like temperature control unit, power steering unit, headlamps, etc. Due to increased comfort level demand from the customers, the number of electrical loads in an automobile has increased. Consequently, the power rating of converters used in automotive application also has increased in the past decade.

The power converters used in automobiles will be subjected to temperature and space constraints. Therefore, compact and efficient converters which perform well even under extreme temperature and environmental conditions are required. The choice of DC-DC converter topology is dictated by the output to input voltage conversion ratio and power handling capability.

When the voltage conversion ratio lies in the range of 0.5 to 5 within a few hundred watts of output power, simple buck and boost converter topologies can be used. However, when the voltage conversion ratio is either
too small (around 0.1 to 0.25) or too high (between 5 to 10), the general practice is to use a high frequency transformer with suitable turns ratio to obtain the required voltage gain and provide electrical isolation between the input and output. This increases the size and weight of the converter.

In this thesis, non-isolated resonant DC-DC converter is proposed for a wiper motor application. Since higher efficiency is one of the main requirements for automotive applications, resonant converter (RC)s are preferred over hard switched converters. RC provides soft switching of power devices and the required voltage gain without using a transformer. As a result, they are compact and more efficient when compared to hard switched converters. In this thesis, after carefully considering many available hard and soft switched topologies, a group of one inductor-two capacitors (LCC) resonant topologies are chosen. For each topology, mathematical expressions for voltage gain have been derived using fundamental harmonic approximation (FHA) technique. The derived expressions have been validated using the simulation results. Based on the voltage gain and load voltage regulation requirements of a wiper motor application, one topology is proposed.

To obtain a compact resonant converter, the energy stored (E) and kVA/kW ratio of the resonant tank network are the index parameters. Further, the voltage and current stress experienced by the resonant tank elements must be known to verify the practicality of the design. Therefore, expressions for voltage and current stress are derived theoretically and validated using simulation results. The value of the resonant inductor (L) that optimises E and
kVA/kW is found out graphically. The resonant capacitors (C) are designed from the optimal inductor value and resonant frequency. The proposed converter with the optimally designed elements is simulated to verify the suitability for the wiper motor application.

As the converter will be subjected to temperature variations, the behaviour of the proposed converter when temperature varies needs to be studied as well. In order to study this behaviour, the temperature sensitive parameters of the converter are identified and carefully adjusted to reflect the variation in temperature. The converter is simulated again with a new simulation model that is suitably modified to accommodate the temperature variations. Based on the simulation results, it is observed that the converter performs satisfactorily even when temperature varies.

The proposed DC-DC converter under open loop control is practically implemented by suitably constructing individual blocks namely inverter, resonant tank and high frequency rectifier. The supply to the converter is obtained from a 12V battery. A simple full bridge inverter converts the input DC voltage to output AC voltage. The LCC resonant tank that was optimally designed provides the desired soft switching characteristics, voltage gain and load voltage regulation. Based on the experimental results obtained, the proposed converter is a better alternative to existing solution in terms of increased efficiency, reduction in size, weight and cost.