Chapter 7

Conclusion and Future Scope

This chapter presents the conclusion of the work carried out and spells out its future scope. An HEV is generally a complex and nonlinear system. It comprises of many components like, motor, generator, converter, controller, and an ICE. There is a huge scope of improvement in almost all these components.

The research work carried out in this thesis focuses on maximizing the fuel economy, enhancing the electric driving range, development of HESS and accurately estimating the SoC of battery for HEVs. The various EMS namely, Fuzzy logic, Elman neural network and ANFIS has been applied with some specific selected parameters and constraints. The exact SoC estimation of battery and HESS are of prime importance to increase the driving range of HEVs and have also been considered in the proposed work.

The proposed system has been tested and validated in real-time by means of FPGA based MicroLabBox (dSPACE) hardware controller. The results prove the adaptability of proposed EMS with different driving cycles.

7.1 Conclusion

The XEVs are seen as the future of road transport. These vehicles have the capacity to provide mobility without deteriorating the environmental status. A lot of work is going on in this field to improve the various aspects namely, driving range, fuel economy and the state of health of battery in these vehicles.

In this work battery SoC is estimated, sizing of HESS is carried out and various EMS have been explored to improve the performance of HEV. The major findings of the research are as below:

- The RC pairs have been added to the battery equivalent circuit to estimate the battery SoC accurately. The value of the parameters for RC pairs have been calculated mathematically. The obtained SoC is further corrected by using ANFIS tuned algorithms.
- The sizing scheme of hybrid energy storage system, composed of UC and battery, is carried out. The sizing scheme works on the threshold current set for UC.
- The HEV has been designed and simulated using fuzzy logic, Elman neural network and ANFIS tuned EMS. The net improvement in the fuel economy achieved by these strategies are 48.4 MPG, 60.17 MPG and 69 MPG, respectively.
- The input parameters namely, torque demand, battery SoC and regenerative braking have been considered for the formulation of the EMS.
- Various other constraints (mentioned in the equation 6.8) have also been considered due to which the on-board sources of the HEV are compelled to work in the efficient region.
- The proposed EMS allows engine and motor to maneuver in their efficient operating regions. The designed HEV and its control strategy follow the driver commands and regulations on vehicle performance and liquid fuel consumption.
- The proposed scheme results in better fuel economy, faster response and almost nil mismatch between desired and achieved vehicle speeds.
- MATLAB/Simulink is used to carry out simulations, and then, the whole system is validated in real time on hardware-in-the-loop testing platform. This work employs an FPGA-based MicroLabBox hardware controller to validate real-time behavior.

7.2 Further Work

The XEVs are going to be the transport of the future. Though its penetration in developing countries is not as expected but lot of research is going on in this area. Based on the various studies available in literature and the research presented in this thesis, the efforts can be put in future to carry out the following research work:

- Development of a highly efficient bidirectional multi-level converter to integrate the electric motor with the energy storage system.
- Exploration of various intelligent optimization techniques and their real-time validation to improve the performance of HEV.
- Development of hybrid energy storage system composed of PV, fuel cell, UC and battery for HEV applications.
- Experimental validation of the entire HEV.
- Implementation of battery management system.
- Exploration of Vehicle-to-grid (V2G) concept along with PHEVs.