Chapter 8. Conclusions

8.1. Conclusions

Electromagnetic brakes are important supplementary retardation equipment in addition to the regular friction brakes. They have been used in heavy vehicles such as coaches, buses, or trucks under conditions such as reducing speed on motorways and trunk roads, and braking for prolonged periods during downslope operations. New types of electromagnetic brakes have been under development for lighter vehicles as well. Regular friction brakes have an outstanding and vital load absorbing capability if kept cool. Electromagnetic brakes help friction brakes to retain this capability under all conditions by absorbing energy at a separate location based on a totally different working principle.

In this study, we proposed a modified static mathematical model for the electromagnetic brakes. A sliding mode controller is designed and simulated for a nominal vehicle model under different road surface conditions. Microcontroller implementation of electromagnetic anti-lock braking system is evaluated.

The performance of the modified mathematical model for electromagnetic brake is better than the other three models available in the literature in a least-square sense. There is only one “global” model which can be used at both low speed and high speed regions. Unfortunately, this model does not agree with the experimental results in the high speed region. Based
on the phenomena summarized from observation in the high speed region, we modified the old “global” model by taking the “reluctance effect” into account. After this modification, we can model the speed-torque relationship more accurately.

A sliding mode controller is designed to implement the wheel slip control system. A nominal vehicle system model is used in a Matlab/s-function simulation for testing the controller performance in different road surface scenarios. According to the simulation results, the controller performance is satisfactory. The wheel slip is kept in the appropriate range and brake torque is controlled to adapt to the new road surface quickly whenever the road surface changes.

The wheel slip control system can be implemented by using high speed, highly integrated digital microcontrollers such as Motorola the 68HC11 series. The on-chip input/output hardware like 8-bit analog inputs, the high speed input capture function, and serial communications allow interfacing with sensors and actuators. The instruction set and architecture of the Motorola 68HC11 fulfill the requirement of the wheel slip control design. The new generations of 16-bit microcontroller should have better real time performance and I/O capability than the Motorola 68HC11.

It can be concluded from this study that the electromagnetic brake is an effective supplementary retardation device. The application and control of electromagnetic brakes should be integrated with the design of vehicles and their friction braking systems so that an ideal match of the complementary benefits of both systems might be obtained to increase safety to a maximum while reducing vehicle operating costs to a minimum.

8.2. Future works
Further research could be performed to evaluate the parameters for static model analytically, and implementing and integrating regular friction brakes and electromagnetic brakes in an anti-lock braking system. All these should be conducted with the close cooperation of the manufacturer of electromagnetic brake system.