

Development of a Controller for the Contactless Electronic Auxiliary Brake System

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ABSTRACT

The auxiliary brake in a commercial vehicle is used to prevent the main brake from rupturing or not working by overheating. Contactless electronic brakes are developed as auxiliary brakes, and current-utilization increases the control accuracy. However, continuous charges and discharges of a battery due to the use of large amounts of current would shorten the battery life and could decrease the braking efficiency of a contactless brake.

This paper proposes a method to utilize the braking torque efficiently when an alternator creates a current by using diodes to distinguish the currents of a battery and an alternator and to extend the battery life by decreasing the number of charges and discharges of a battery. By implementing the controller and making the test bed, discharge of a battery has been prevented and stable operation of the electronic brake has been made.

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INTRODUCTION

When commercial vehicles like buses and trucks run downhill, mountain roads, rainy or snowy roads, service brakes are overheated by frequent braking and increment of braking time. Major accidents have occurred frequently due to brake ruptures and vapor lock/fade phenomenon. In order to solve the problems, auxiliary braking systems are used in Japan, Europe, and the United States. Auxiliary braking systems are classified by hydraulic brake system, exhausted brake system, and contactless electronic brake system[1,2,3,4,5].

This paper describes the controller development of a contactless electronic brake system. The principle of contactless electronic brake system is that when a conductor moves in a certain direction in the magnetic field, an eddy current occurs in the conductor and Lorentz' force is generated by combining the eddy current and the magnetic field[6,7,8,9,10].

A force is created in the opposite direction of the conductor's moving direction, and the braking force of a vehicle is generated. Figure 1 shows the Principle of a contactless electronic brake system.

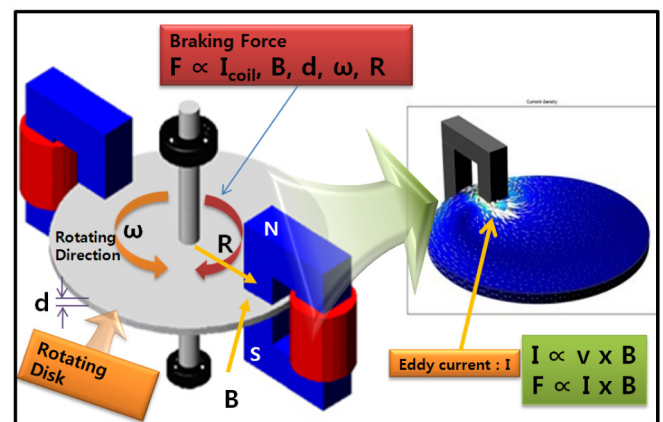


Figure 1. Principle of a contactless electronic brake system

This system has a very fast response time compared to the hydraulic auxiliary brake system, and accurate operation of the braking torque was possible by using current control.

Contactless brake in a commercial vehicle gets electric power from a battery and an alternator. The amount of

current is controlled by the controller. Figure 2 shows the electronics block diagram connected to a vehicle.

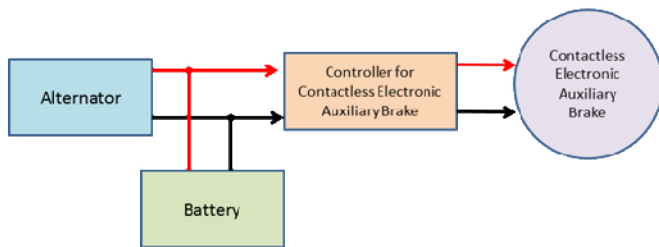


Figure 2. Block diagram of an electronic brake system

When the electronic brake is installed on a vehicle, the coil is connected to the transmission of a vehicle, and a drum is put on the driving axis to have a braking torque on the drum when an eddy current is created. Figure 3 is the diagram of a contactless electronic brake installed on a vehicle.

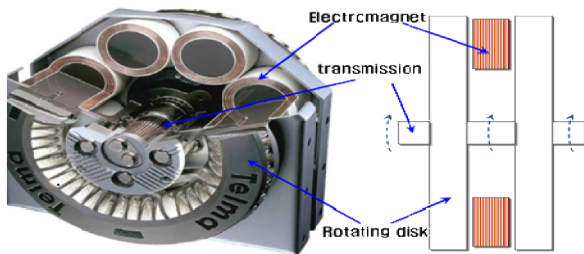


Figure 3. Contactless electric brake system installed on a vehicle

CONVENTIONAL CONTROLLERS FOR CONTACTLESS ELECTRONIC AUXILIARY BRAKES

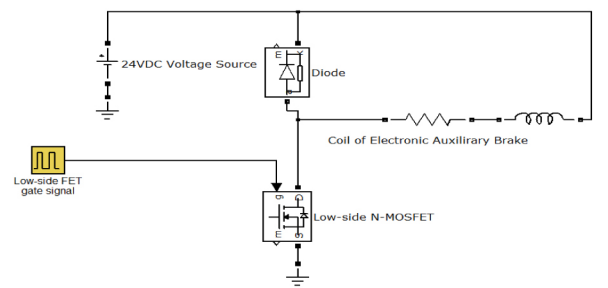
The contactless brake controller consists of two parts. One is the high power switching circuit part providing controlling current that gets power from the alternator. And the other one is a control circuit that performs the high speed switching control.

The power terminal of high-power switching circuit is connected to an alternator directly and it provides power to the contactless brake system by switching commands.

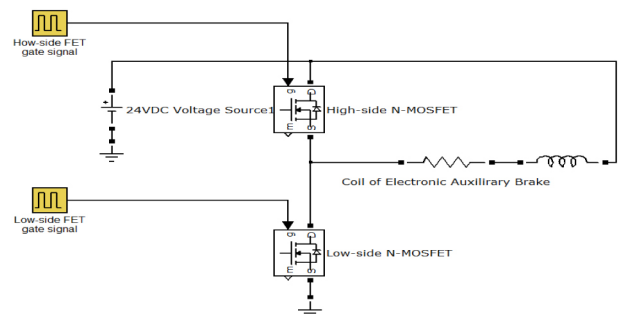
Hardware Configuration

The method of applying PWM(Pulse Width Modulation) Duty to the FET(Field-Effect Transistor) is used to control the current. To have a simple control of the coil's current, NMOSFET (N-channel Metal-Oxide Semiconductor FET) should be put on the bottom of a coil when the coil is connected to the voltage source, and the energy stored on the coil flows by using the free-wheeling diodes in figure 4-(a). However, when controlling a large amount of current, generation of heat in diodes should be reduced by utilizing the half-bridge structure to make the FET of HIGH side ON

and reduce the resistance in figure 4-(b). The figure 4 shows two structures of controlling coil current.



(a)



(b)

Figure 4. Contactless electronic brake system installed on a vehicle: (a) Diode-utilizing current controlling structure, (b) Half bridge current controlling structure

Since the characteristic of a contactless electronic brake keeps High side current on the Low side, two FETs should be connected on the Low side. Furthermore, since N-ch MOS FET is less expensive with better performance compared to P-ch MOS FET, it is desirable to use an N-ch FET on the High side. The figure 5-(a) shows the Half-bridge structure used on a controller. Verifying the current controlling wave by using the OR_CAD tool to inspect the operation of current controller is shown in the figure 5-(b).

Since a maximum of 90A should flow in the designed contactless electronic brake, coils are divided into two groups and control 45A each for considering thickness of the wire harness and stable operation of the brake. Therefore, FETs with 100A or more are usable. Turn-ON resistance of FET is internal parasitic resistance of FET when FET is turned. Equivalent circuit can be showed by figure 6.