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作品名稱

運用系統晶片實現智慧型真空剎車輔助系統
Implementing An Intelligent Auxiliary Vacuum Brake System with System-on-Chip

隊伍名稱

剎~很~大 Die Hard

隊長

林智郁 建國科技大學電機工程系暨研究所

隊員

林祐豪・李師帆 建國科技大學電機工程系暨研究所

作品摘要

傳統煞車系統由真空輔助及高壓油路所組成，駕駛輕踩煞車踏板，推動真空倍力器內之煞車油推桿，壓迫油路總幫將煞車油經金屬油管導入，然後將煞車油分配至各輪煞車卡鉗，對煞車碟盤施壓，產生車輛煞車制動效果。可是當車輛重載、下坡、冷氣負荷或其他因素造成倍力器真空度不足時，車輛煞車的制動力也會降低；若於上述情況下，自動啟用真空輔助幫浦，保持煞車倍力器良好的真空度(-300 mm-Hg至-450mm-Hg)，則車輛之煞車系統可完全發揮作用。

對於目前業界使用的真空輔助煞車系統中，有一種常見問題，因為此系統是使用機械式的繼電器與壓力開關進行開與閉，基於物理現象的慣性，可能造成動作時間過長或過短，使得倍力器真空度不足影響煞車制動力或真空過度造成倍力器的機械結構損毀。且經實際測量後發現，啟動時電流高達120安培，會減短蓄電池壽命、繼電器故障或造成汽車電器迴路的損毀。由於此產品會進行量產所以對於成本的需求特別嚴苛，基於此條件所以選用系統晶片取代，因為系統晶片具有尺寸小巧，功能強大，抗雜訊強，成本低，開發時程短，軟硬體都具有修改彈性等等優點。

本作品運用系統晶片技術，將真空煞車補助系統所有感測、訊號放大處理、顯示器、控制器等硬體電路，整合建入在系統晶片中，簡化此真空煞車補助系統的體積與硬體電路，此作品有三大功能特點：

1. 將卡爾曼濾波器與磁滯控制器以軟體型式，內建於系統晶片中，用以對抗車輛嚴重的電路雜訊干擾。卡爾曼濾波器為最佳化的濾波器，真空煞車倍力器中之壓力，經壓力感測器檢出放大後，可由卡爾曼濾波器估算出最可能之壓力值，在車輛吵雜的環境下，去除白雜訊(white noise)，正確判斷壓力值，同時選用抗雜訊的磁滯控制器驅動真空幫浦，可避免誤動作的發生。
2. 運用系統晶片以PWM控制Power MOSFET，取代電磁繼電器控制真空幫浦，並增添電流感測器監控幫浦馬達電流，避免過大之啟動電流，降低馬達工作電流，可達成延長電池壽命，節省電能同時使壓力控制更精確，避免真空過度而損傷煞車倍力器。
3. 運用系統晶片設計自動偵錯診斷系統，當系統主要元件，如壓力感測器、真空幫浦、電流感測器、MOSFET(或電磁繼電器)等重要元件，出現錯誤及故障時，能及時警示告知，提高系統運作上的安全性。

指導教授

董佳璋　建國科技大學電機工程系暨研究所

- 1986年獲得逢甲大學電機工程學士(B.S.E.E)，分別於1992年及1995年獲得美國 杜蘭大學(Tulane University)，電機工程碩士(M.S.E.E)與杜蘭大學(Tulane University) 電機工程博士(Ph.D.E.E)。
- 現職為建國科技大學電機工程系副教授，曾擔任美商汎利工程顧問公司，工程師(1990~1997)，南榮技術學院電機工程系，系主任 (1996~1998)、美國德州休士頓大學訪問學者(June ~ Sep., 2007)。
- 研究領域：最佳化控制、超音波測距系統、電子電路設計、數位訊號處理、模糊與類神經控制、灰色系統理論應用、可程式系統晶片。

Abstract

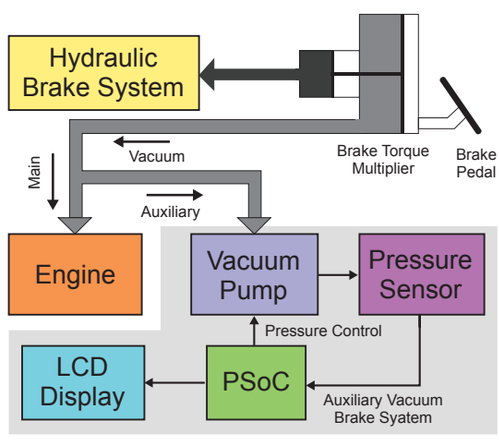
The purpose of this project focuses on designing an intelligent, compact, reliable, and robust auxiliary vacuum brake system (VBS) with Kalman filter and self-diagnosis scheme. All of the circuit elements in the designed system are integrated into one programmable system-on-chip (PSoC) with entire computational algorithms implemented by software. In this system, four main goals are achieved:

(a) Kalman filter can get rid of noises and big disturbances. Experiment proves that along with hysteresis, vacuum pressure regulation can be assured, there is no switching back and forth during control change as expected. Noise immunity has been assured. As a consequence, relay contactor could be also prolonged as well as the VBS liability.

(b) PWM control provides two advantages over relay control: (1) Low starting current and operating current. The starting current has been diminished from 107.8 Amp to 76.4 Amp for pressure originating from 0 mm-Hg to -450 mm-Hg. Also, the starting current has been cut from 90.1 Amp to 69.6 Amp during normal operation. The operating current has been confined to 43.7 Amp for both cases. Battery life can be extended as well. (2) Low overshoot. The overshoot is obviously reduced from -492.3 mm-Hg to -461.5 mm-Hg.

(c) Intelligent self-diagnosis scheme can identify different types of errors caused by different elements such as: (1) pressure sensor open, short, or unbalance. (2) compressor open or short. (3) current sensor failure. (4) relay or MOSFET open or short.

(d) A prototype has been designed and made with one PSoC chip. All of the signal conditioning circuits, algorithms, and self-diagnosis scheme are integrated and implemented inside the system-on-chip IC.



Structure of Auxiliary Vacuum Brake System (VBS): The purpose of this project focuses on designing an intelligent auxiliary vacuum brake system (VBS) with Kalman filter and self-diagnosis scheme. This system is so compact that most of the circuit elements are integrated into single programmable system-on-chip (PSoC) with entire computational algorithms implemented by software. This VBS system gives some benefits including providing reliable and robust brake function when the engine is not operating or the engine is under heavy loads.