

雙動力驅動車輛之電控系統研發

曾揚翔、蔡耀文

E-mail: 9806179@mail.dyu.edu.tw

摘要

近年來國際油價仍然持續在高檔居高不下，溫室效應引發的全球氣象異變，嚴重影響許多國家的經濟建設發展與人民生命財產安全，在能源危機及環保意識抬頭等雙重現實下，給予複合動力技術萌芽的背景。自 1997 年豐田汽車 (Toyota) 在日本推出 Prius 這台運用汽油及電力驅動車輛的複合電動車之後，這類複合電動車具有低污染及省油等特性，有機會在未來成為汽車科技的主流。

有鑑於多動力驅動車輛日益重要，本論文發展一種雙動力驅動車輛的電控系統驅動器與控制器研發，其中包含直流無刷馬達驅動器、磷酸鋰鐵電池充電驅動器、發電機及主控制器管理系統。在電控系統中，使用高性能的德州儀器數位訊號處理器 (DSP) 作為各控制器之間的訊號溝通與處理各系統的運作。

本論文將此電控系統應用於一並聯式複合動力驅動系統，配合能量管理策略，控制車輛在各種路面及負載狀況下運轉。此研究中也順利完成實驗平台的建構，藉由實驗平台的系統零組件配置及行車模式的測試操控，以及實測之結果驗證此電控系統與能量管理策略之動力整合功能與成效。

關鍵詞：複合電動車、直流無刷馬達、磷酸鋰鐵電池、數位訊號處理器、能量管理策略

目錄

INSIDE FRONT COVER

SIGNATURE PAGE

AUTHORIZATION COPYRIGHT STATEMENT iii

ENGLISH ABSTRACT iv

CHINESE ABSTRACT v

ACKNOWLEDGMENT vi

CONTENTS vii

LIST OF FIGURES x

LIST OF TABLES xiii

ABBREVIATIONS xiv

Chapter I

INTRODUCTION

1.1 Motivation 1

1.2 The hybrid background 2

1.2.1 Series hybrid system 3

1.2.2 Parallel hybrid system 4

1.2.3 Series-parallel hybrid system 5

1.2.4 Newly parallel-type hybrid electric system 6

1.2.5 Hybrid system comparison 9

1.3 Organization 10

Chapter II

FRAMEWORK AND ENERGY MANAGEMENT STRATEGY OF DUAL POWER DRIVING SYSTEM

2.1 Introduction 11

2.1.1 Electric motor 12

2.1.2 Generator 14

2.1.3 Internal combustion engine 15

2.1.4 LiFePO₄ battery 17

2.1.5 Magnetism powder type brake unit 18

2.2 The framework of dual power driving system 20

2.2.1 BLDC motor mode	21	
2.2.2 ICE only mode	22	
2.2.3 Ice and generator mode	23	
2.2.4 Dual power mode	24	
2.2.5 Battery charging mode	25	
2.2.6 Regenerative braking mode	26	
2.3 Energy management strategy	27	
2.3.1 BLDC motor control procedure	29	
2.3.2 Ice only control procedure	30	
2.3.3 Ice and generator control procedure	30	
2.3.4 Dual power control procedure	30	
2.3.5 Battery charging control procedure	31	
Chapter III		
ESTABLISHED SYSTEM DYNAMIC EQUATIONS AND MODELS		
3.1 The motor/generator model	32	
3.2 The energy integration mechanism model	34	
Chapter IV		
DESIGN OF ELECTRIC CONTROLLERS FOR DUAL POWER DRIVING SYSTEM		
4.1 Introduction	39	
4.2 System controller configuration	39	
4.2.1 Texas Instrument TMS320LF2407	42	
4.2.2 Pulse width modulation technique	43	
4.2.3 The DSP output interface	44	
4.2.4 The DSP input interface	45	
4.2.5 A/D converter protect circuit	45	
4.2.6 The process of DSP A/D converter	46	
4.2.7 Isolation gate driver	47	
4.3 Philosophy of ac – dc converter	48	
4.3.1 Dynamic charging principle	49	
4.3.2 A/D converter control system	50	
4.4 Philosophy of BLDC motor driver	51	
4.4.1 BLDC motor commutation principle	52	
4.4.2 BLDC motor speed control system	53	
4.5 Philosophy of LiFePO ₄ battery charge	54	
4.5.1 LiFePO ₄ battery charging principle	55	
4.5.2 LiFePO ₄ battery charging control system	56	
4.6 The DSP interface of major controller	57	
Chapter V		
EXPERIMENTAL AND SIMULATION RESULTS		
5.1 Introduction the experiment platform	59	
5.2 Simulation results	62	
5.3 Experimental results	65	
5.3.1 Low power control procedure	65	
5.3.2 Medium power control procedure	70	
5.3.3 High power control procedure	72	
Chapter VI		
CONCLUSIONS		76
REFERENCE		77

參考文獻

- [1] H. David and S. Shoichi, “ Hybrid Electric Vehicles Take to the Streets ” , IEEE Spectrum, Nov. 1998.
- [2] C. R. Norma and A. John, “ The Hybrid Phenomenon: High Gas Prices and Shifting Consumer Sentiment Point to Bright Prospects for

Hybrid Cars ” , The Futurist, vol. 41, Jul. 2007.

[3] The Auto Channel, 2009-03-11, “ Toyota and Lexus Hybrids Top One Million Sales in the U.S. ” , Retrieved on 2009-03-28[4] Hybrid Synergy Drive, “ TOYOTA HYBRID SYSTEM THSII ” , Toyota Motor Corporation, 15 Jun. 2007.

[5] Zhen-Lin Fan, “ Study of Dynamic Simulation and Control of a New Parallel Hybrid Electric Power System ” , The Thesis, Department of Mechanical and Automation Engineering College of Engineering Dayeh university, 2005.

[6] Hong-Yi Su, “ Study of a New Parallel Hybrid Electric Power System ” , The Thesis, Department of Mechanical and Automation Engineering College of Engineering Dayeh university, 2005.

[7] Te-Sheng Su, “ Development of High Power 20kW Brushless DC Motor Driver and Application of Novel Parallel Hybrid Electric Vehicle ” , The Thesis, Department of Mechanical and Automation Engineering College of Engineering Dayeh university, 2008.

[8] Ruei-Hong Dai, “ DSP Based 20kW Generator/Lithium Battery Management System and Application of Parallel Hybrid Electric Vehicles ” , The Thesis, Department of Mechanical and Automation Engineering College of Engineering Dayeh university, 2008.

[9] Jia-Hao Jhuang, “ Development of Electrical Control System and Performance Analysis for a New Parallel Hybrid Electric Heavy Motorcycle ” , The Thesis, Department of Mechanical and Automation Engineering College of Engineering Dayeh university, 2007.

[10] Z. Yang Pan and F. Lin Luo, “ Novel Soft-Switching Inverter for Brushless DC Motor Variable Speed Drive System ” , IEEE Trans. on Power Electronics, Vol. 19, no. 2, pp. 202-207, Mar. 2004.

[11] Yimin Gao and Mehrdad Ehsani, “ A Torque Speed Coupling Hybrid Drivetrain Architecture, Control, and Simulation ” , IEEE Fellow, vol. 21, no. 3, May. 2006.

[12] Texas Instruments “ TMS320LF2407A-EP DSP CONTROLLERS ” Texas Instruments Inc., 2002.

[13] Texas Instruments “ AC Induction Motor Control Using Constant V/Hz Principle and Space Vector PWM Technique with TMS320C240 ” Texas Instruments Inc., 1998.

[14] International Rectifier – The Power Management Leader. 2007. International Rectifier. 15 Aug. 2005.

[15] B. Pevec, D. Voncina, D. Miljavec, and J. Nastran, “ Extending the Low-Speed operation Range of PM Generator in Automotive Applications Using Novel AC – DC Converter Control ” , IEEE Transactions on Industrial Electronics, vol. 52, no. 2, Apr. 2005.

[16] R. W. Erickson, “ Fundamentals of Power Electronics ” , New York: Chapman & Hall, 1997.

[17] S. Rees and U. Ammann, “ New gate control unit for automotive synchronous rectifiers, ” in Proc. PCIM Europe ' 03, Nuremberg, Germany, 2003, pp. 95 – 101.

[18] Mohamed A. Awadallah, Student Member, and Medhat M. Morcos, Senior Member, “ Automatic Diagnosis and Location of Open-Switch Fault in Brushless DC Motor Drives Using Wavelets and Neuro-Fuzzy Systems ” , IEEE Trans. on Energy Conversion, Vol. 21, no. 1, pp. 104-111, Mar. 2006.