

Development of Electric Control System for Dual Power Driving Vehicles

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ABSTRACT

In recent years, the international oil price still rising and greenhouse effect the global warming, it causes to inflict heavy losses the economic development with people life and wealth of many country. Since 1997, a hybrid electric car was put into batch production in Japan by Toyota Prius. The kind of hybrid electric vehicle (HEV) utilization with a gasoline engine and an electric motor has the characteristics of low pollution and zero emission. In the environment protection and energy crisis, the HEV will have the opportunity to become the main car of automobile in the future.

The central purpose of this study is developed the driver and controller of electric control system for dual power driving vehicle including brushless direct current (BLDC) motor driver, lithium iron phosphate (LiFePO₄) battery charging system, generator driver and major controller management system. In the electric control system, using high performance Texas Instruments TMS320LF2407 digital signal process (DSP) connects various controllers.

This study applies the electric control system for a parallel hybrid system and controls vehicle 's operation with energy management strategy under variation load condition. According to the construction of the experiment platform, the components have been allocated and real tests have verified the dual power function of the electric control system and control strategy.

Keywords : Hybrid electric vehicle (HEV)、 Brushless direct current (BLDC)、 Lithium iron phosphate (LiFePO₄)、 Digital signal process (DSP)

Table of Contents

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	LiFePO ₄ 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

REFERENCES

- [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] Rwei-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.