UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF AN ELECTRIC VEHICLE DASHBOARD MONITORING SYSTEM USING MICROCONTROLLER

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Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Engineering Universiti Putra Malaysia

January 2000

I Dedicate This Work
to
My Parents and My Wife

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in partial fulfilment of the requirements for the degree of Master of Science.

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A microcontroller is a complete microcomputer on a chip that integrates a CPU with memory and various peripherals such as analog-to-digital converters (A/D), serial communication units etc. Microcontrollers are designed to be embedded within event-driven control applications and generally have all necessary peripherals integrated onto the same piece of silicon. An Intelligent Energy Management System (IEMS) is a microcontroller based system which is used in an electric vehicle to monitor and control the various parts of the vehicle such as the motor and motor drives, the current and voltage of the battery packs, dashboard, pedals and other subsystems. This aids the driver to achieve optimal driving conditions from the vehicle.

In tropical countries the temperature is very high especially during the day. As a result, when the vehicles are parked in an open space the temperature in the vehicle rises and this could lead to many problems. The objective of this project was to develop an Automatic Fan Controlling System (AFCS), which may be used to control the temperature of the electrical vehicle cabin to counter any potential

problems. This new proposed system is one of the many systems that may be made available to the user via the IEMS. This project also looked into the development of the battery pack voltage level monitoring system for electric vehicles.

The MC68HC11 evaluation board (EVB) NMIX-0020, which uses a Motorola F68HC11 microcontroller for its CPU, is used to monitor and control both of the systems mentioned above. The development work carried out for the automatic fan controlling system and the battery pack voltage level monitoring system include the design, construct and testing of the system.

The automatic fan controlling system consists of a temperature sensor (AD590), a current-to-voltage converter, digital relay and a microcontroller. The battery pack voltage level monitoring system comprises of a voltage divider, a digital display and a microcontroller.

Simulation and experimental results are also included and discussed in detail. Based on these results, the systems mentioned above have been successfully developed. The systems can be extended for high temperature controlling and high voltage monitoring by changing some parameters in both systems.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian dari keperluan untuk ijazah Master Sains.

PEMBANGUNAN SEBUAH SISTEM PENGAWASAN PANEL KAWAL KENDERAAN ELEKTRIK MENGGUNAKAN PENGAWAL-MIKRO

Oleh

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Pengawal-mikro adalah komputer-mikro lengkap di dalam sebuah chip di mana unit pemprosesan pusat (CPU) beserta dengan ingatan digabungkan dengan berbagai peralatan seperti pengubah analog-kepada-digital, unit komunikasi siri dan lain-lain. Pengawal-mikro direka untuk dimuatkan ke dalam aplikasi pemacu-keadaan terkawal (event-driven), dan selalunya mempungai alat-alat yang di integrasikan bersama di dalam unit silikon yang sama. Sistem pengurusan tenaga pintar [Intelligent Energy Management System (IEMS)] adalah sistem berasaskan pengawal-mikro yang digunakan di dalam kenderaan elektrik bagi mengawasi dan mengawal berbagai bahagian kenderaan seperti motor dan pemacu motor, arus dan voltan untuk pak bateri, papan kawal, pengayuh dan juga lain-lain sub-sistem. Sistem ini akan dapat membantu pengendalian kenderaan dalam keadaan yang optimum.

Bagi negara tropikal, cuaca biasanya adalah panas terutamanya pada waktu siang. Jika kenderaan diletakkan ditempat lapang, suhu di dalam kenderaan akan naik pada tahap yang tinggi. Ini boleh membawa kepada berbagai masalah. Objektif projek ini adalah untuk membina sistem pengawalan kipas otomatik [Automatic Fan

Controlling System (AFCS)] yang boleh digunakan untuk mengawal suhu ruang kenderaan elektrik bagi mengelakkan masalah yang disebabkan oleh suhu yang tinggi. Sistem baru yang dicadangkan ini adalah di antara sistem yang boleh dibekalkan kepada pengguna-pengguna melalui teknologi IEMS. Projek ini juga akan melibatkan pembangunan satu sistem pengawasan tahap voltan pak bateri bagi kenderaan elektrik.

Papan penilaian MC68HC11 NMIX-0020 (EVB) yang menggunakan pengawal-mikro Motorola F68HC11 sebagai unit pemprosesan pusat (central processing unit) digunakan untuk mengawasi dan mengawal kedua-dua sistem yang dicadangkan di atas. Kerja-kerja pembangunan yang telah dijalankan termasuklah rekabentuk, pembinaan dan ujian ke atas sistem-sistem tersebut.

Sistem pengawalan kipas otomatik terdiri dari pengesan suhu (AD590), penukar arus kepada voltan, penyampai digital dan pengawal mikro. Sistem pengawasan tahap voltan pak bateri terdiri dari pembahagi voltan, layar digital dan pengawal mikro.

Hasil-hasil keputusan simulasi dan ujikaji juga disertakan dan dibincangkan secara mendalam. Berdasarkan dari keputusan tersebut, sistem-sistem yang disebutkan di atas telah berjaya dibangunkan. Sistem ini boleh diubahsuai dan digunakan untuk mengawal suhu tinggi dan memantau voltan tinggi dengan mengubah parameter yang berkaitan dengan kedua-dua sistem tersebut.

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LIST OF SYMBOLS AND ABBREVIATIONS

AFCS	Automatic Fan Control System
ADCTL	Control-Status Register
AS11	Assembler Program
ADC	Analog-to-Digital Converter
ABS	Antilock Braking System
BUFFALO	Bit User Fast Friendly Aid to Logical Operation
CPU	Central Processing Unit
DDR	Data Direction Registers.
EMS	Energy Management System
EV	Electric Vehicle
EVB	Evaluation Board
EROM	Erasable Read-Only Memory
ECU	Electronic Control Unit
HCMOS	High-Density Complementary Metal-oxide Semiconductor
IEMS	Intelligent Energy Management System
Io	Output Current of the Temperature Transducer
ICEV	Internal Combustion Engine Vehicle
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCU	Microcontroller Unit

RAM	Random-Access Memory
ROM	Read-Only Memory
Rf	Feedback Resistor
R	Current Limiting Resistor
S19	Assembling File
SCC	Signal Conditioning Circuit
SCI	Serial Communications Interface
SPI	Serial Peripheral Interface
Vo	Output Voltage of the Converter
V1	DC Voltage
Vc	Capacitor Voltage
Vm	Peak Rectifier Voltage

CHAPTER I

INTRODUCTION

A microcontroller performs various functions in automobiles and it can be found in the heart of almost any Electronic Control Unit (ECU) in use today. At least one microcontroller within the ECU is used to control the antilock braking system (ABS), engine performance, navigation, temperature, and vehicle dynamics. Understanding the various features and offerings of microcontrollers that are available in the market today is important when making a selection for an application (Derato, 1994).

The electric vehicle is one automobile, which uses microcontrollers to monitor and control all its subsystems. Variables like temperature, speed, current, and voltage which are basic to the vehicles operation are measured with transducers that convert operating condition measurements to analog signals. These signals are then digitized and relayed to the microcontroller. It evaluates the subsystem signals and accordingly sends out control signals.

Temperature Control in Passenger Cabins

The microcontroller in electric vehicles is an intelligent system, which can monitor various operations at a high speed obtaining optimum results, and can also perform multifunction simultaneously. The controlling of temperature in passenger cabins is a new area that can be added to the microcontroller's previous uses. This temperature control will protect the windscreen from damage and prevent deformation of plastic-based instrumentation in the vehicle, in addition to prevent poor ventilation when the vehicle is parked in open space during the day

Temperature control can also be used in Gasoline Vehicles, but its primary use will be for electric vehicles, the vehicle of the next millenium. Most advanced electric vehicles use microcontrollers and advantages include eliminating emissions from the car thus protecting the environment, eradicating oil stains that run off and pollute watersheds, removing the necessity of having tune-ups, no more requiring messy oil changes, or need for coolants (Suggs, 1994).

Battery Pack Voltage Level Monitoring System

The battery is the heart of the electric vehicle and the monitoring of the battery pack voltage level in the dashboard is the key to the operation of the vehicle. The driver can monitor the status of the battery voltage level by observing the voltage indicator in the dashboard and thus knows when it is time to charge the battery again.

Objective of the Project

Objective of this project is to design, construct and test the microcontroller-based temperature control and battery pack voltage level monitoring systems in electric vehicles.

Temperature control system is used as mentioned before to protect the windscreen from damage and prevent deformation of plastic-based instrumentation used in the vehicle, in addition to preventing poor ventilation when the vehicle is parked in open space during the day. The monitoring of the battery pack voltage level in the dashboard is essential to prevent the battery from being totally discharged.

The temperature controller and the battery voltage monitor consist of both hardware and software. The hardware of the temperature controller includes analog interfacing (temperature sensor and signal conditioning circuit) and digital interfacing. The hardware of the battery voltage monitor includes the analog interfacing (voltage divider) and output display using LEDs.

With respect to software, Assembly language is used for controlling temperature and monitoring battery voltage.

Layout of the Thesis

The thesis is divided into five chapters. Chapter I outlines the introduction and the objectives of the project. The second chapter summarizes the literature review. Whilst Chapter III presents the methodology. The results and discussions are presented in Chapter IV. Finally, Chapter V, general conclusions of the research work are drawn and recommendations on areas for future study are also made.

CHAPTER II

LITERATURE REVIEW

History of Electric Vehicles

Early electric vehicles may have appeared as early as 1830. Historians generally credit J.K. Starley, an English inventor, and Fred M. Kimball of Boston, Massachusetts, for building the first practical electric car in 1888. In 1896, the Woods Motor Vehicle Company of Chicago became the first American manufacturer.

By 1904, about one-third of all the cars in the cities of New York, Chicago, and Boston were electrically powered. By 1912, there were 20,000 electric cars and 10,000 electric trucks and buses in the United States. A handful of manufacturers, notably Baker and Detroit Electric, lingered into the 1930s. A few devotees continued to drive electric cars well into the 1940s. A handful of small manufacturers reappeared first in the 1960s in response to environmental concerns and then again in the 1970s, in the aftermath of the oil shortages that had been faced. More recently, in 1996, General Motors Corporation announced the first modern, mass-produced car designed specifically as an electric car.