MATLAB BASED MODELING AND SIMULINK PACKAGE FOR DC-DC BOOST CONVERTOR TO ENHANCE LEARNING PROCESS OF POWER ELECTRONICS.

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DEDICATION

To my beloved grandfather Mr. Haji Banaras Khan (Late), beloved parents, sisters, brothers, friends and lecturers, without your fully support, guidance and advice I might not had this kind of achievement. Thanks for all the supports.
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ABSTRACT

In this study, DC-DC boost converter Matlab Simulink Package has been developed and tested for the enhancement of learning process within academic course of power electronics. Respondent for this research were chosen randomly from Faculty of Electrical & Electronic Engineering, Tun Hussein Onn University of Malaysia. Aim of this study is to figure out and see the effectiveness of DC-DC boost convertors Simulink package for the enhancement of learning process of Power electronic course. A Pre-research statistical analysis based on the response of concerned students acquired through a relative questioner is employed to affirm the need of this simulation package. Analysis for this study has been verified by using Statistical Package for Social Science (SPSS) Version 20.0 software. Afterwards, a simulation package as required has been developed accordingly to test and illustrate the operation of DC-DC boost convertor using open-loop, Proportional integral derivative (PID) controller and Fuzzy logic controller topologies. Finally, a post-research questioner was also floated through same respondent population in order to evaluate and assess the effect and significance of the designed simulation package. It was observed through the statistical analysis of the afore mentioned post research questioner that, the use of simulation based package regarding the enhancement of learning proved to have a significant effect. Expect this study findings will be one of the catalysts in strengthening improve the instructional methods by using simulation software's in Power electronics and engineering courses.

ABSTRAK

Dalam kajian ini, DC-DC boost converter Matlab Simulink Package telah dibangunkan dan diuji untuk peningkatan proses pembelajaran dalam mata pelajaran kuasa elektronik. Responden bagi kajian ini telah dipilih secara rawak dari Fakulti Kejuruteraan Elektrik & Elektronik Kejuruteraan , Tun Hussein Onn Universiti Malaysia. Tujuan kajian ini adalah untuk mengetahui dan melihat keberkesanan DC-DC boost converter Matlab Simulink Package untuk menambahbaik proses pembelajaran mata pelajaran elektronik kuasa. Ujian sebelum (pre-research) untuk analisis statistik berdasarkan maklumbalas pelajar diperolehi melalui soal selidik untuk mengesahkan keperluan pakej simulasi ini. Di dalam kajian ini, penyelidik menggunakan perisian Statistical Package for Social Science (SPSS) versi 20.0. Selepas itu, pakej simulasi seperti yang dikehendaki telah dibangunkan dengan sewajarnya untuk menguji dan menggambarkan operasi DC -DC penukar rangsangan menggunakan open-loop, Proportional integral derivative (PID) controller dan Fuzzy logic controller topologies. Akhir sekali, ujian selepas (post-research) diapungkan melalui maklum balas responden untuk menilai dan menguji keberkesanan pakej simulasi yang direka. Melalui analisis statistik yang dilakukan dalam ujian selepas (post-research),, penggunaan pakej simulasi mengenai peningkatan pembelajaran terbukti mempunyai kesan yang ketara. Diharapkan dapatan kajian ini akan menjadi salah satu pemangkin dalam meningkatkan kaedah pengajaran dengan menggunakan perisian simulasi ini dalam mata pelajaran kuasa elektronik dan bidang kejuruteraan.

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LIST OF SYMBOLS AND ABBREVIATIONS

μe- Degree of membership function of error

Δe- Degree of membership function of delta of error

u- Degree of membership function of voltage output

∨ - Maximum operator

O - Output of COG

∧ - Minimum operator

B - Bisector of Area

C - Capacitor

CCM - Continuous Conduction Mode

che - Change of Error

COG - Centroid of Gravity

D - Duty Cycle

DC - Direct Current

DCM - Discontinuous Conduction Mode

e - Error

FLC - Fuzzy Logic Controller

Fs - Frequency Switching

FKEE – Faculty of electrical and electronics engineering.

gaussmf - Gaussian Membership Function

KD - Derivative gain

KI - Integral gain

KP - Proportional gain

L - Inductor

MF - Membership Function

MOM - Mean of Maximum

MOSFET - Metal–Oxide–Semiconductor Field-Effect Transistor

NB - Negative Big

NS - Negative Small

PB - Positive Big

PID - Proportional Integral Derivative

PS - Positive Small

PWM - Pulse Width Modulation

R - Resistor

S – Switch

UTHM- University Tun Hussein onn Malaysia

VC -Voltage (Calculation)

Vo -Output Voltage

s -Kth - switching cycle Input Voltage

Vref- Reference output

ZE – Zero

UTHM-Universiti Tun Hussein Onn Malaysia

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CHAPTER I

INTRODUCTION

1.1 Introduction

Power electronics is, by nature, a multi-disciplinary subject, and for any instructor a challenging course to teach. It is especially demanding course because of variety of topics, such as circuit analysis, signals and systems analysis, and control theory. It is a combination of hands-on experience and solid knowledge of theory provides an active learning environment that leads to successful learning and understanding process.

The use of simulation has always been a powerful tool for technology in all its various fields of application. Power Electronics course is essential for electrical and electronics engineers and it is included in the undergraduate and Postgraduate syllabus. An effective power electronics laboratory is expected to combine theoretical and experimental aspects of the topics by using state-of-the-art software/hardware tools. Sometime during experiment students face many problems in understanding of the procedure of experiment. For them simulation based demonstration of experiment is very useful especially in power electronic and some relevant courses.

DC to DC boost converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily. Such electronic devices often contain several sub-circuits, each with its own voltage level requirement different from that supplied by the battery or an external supply (sometimes higher or lower than the supply voltage) and boost converter (step-up converter) is a DC-DC power converter with an output voltage greater than its input voltage. They provide smooth acceleration control, high efficiency, and fast dynamic response. DC converter can be used in regenerative braking of DC motor to return energy back into the supply, and this feature results in energy saving for transportation system with frequent stop; and also are used, in DC voltage regulation (Rashid, 2004).In many ways, a DC-DC converter is the DC equivalent of a transformer. There are four main types of converter usually called the buck, boost, buck-boost and Boost converters. The main feature of a fuzzy controller is that it can convert the linguistic control rules based on expert knowledge into automatic control strategy. So it can be applied to control systems with unknown or un modeled dynamics. (Ozdemir, 1997)

Mostly, the DC-DC converter consists of the power semiconductor devices which are operated as electronic switches and classified as switched-mode DC-DC converters. Operation of the switching devices causes the inherently nonlinear characteristic of the DC-DC converters. Due to this unwanted nonlinear characteristics, the converters requires a controller with a high degree of dynamic response. Pulse Width Modulation (PWM) is the most frequently consider method among the various switching control method (J. Alvarez-Ramirez, Jan. 2001). In DC-DC voltage regulators, it is important to supply a constant output voltage, regardless of disturbances on the input voltage.

Currently, the control systems for many power electronic appliances have been increasing widely. Crucial with these demands, many researchers or designers have been struggling to find the most economic and reliable controller to meet these demands. The idea to have a control system in dc-dc converter is to ensure desired voltage output can be produced efficiently as compared to open loop system.

The focus of this research is the development of DC-DC boost convertor Matlab simulink package by using fuzzy logic controller for enhancing the learning process of power electronic course. In this project, Matlab simulink package is used as a platform for students to understand the function of DC-DC boost convertor. After the development of Boost convertor Matlab Simulink will be test on UTHM, Faculty of electrical and electronics engineering students and then evaluate and analyze the effectiveness of this Matlab simulink package with the help of design Post-research questioner which will discuss in chapter 4 of this study.

1.2 Problem Statement

Power electronics is one of the essential course in engineering (electrical and electronics), and the main focus of this course on diploma and degree level on DC-DC boost convertors. DC-DC boost convertors are widely used in industrial applications according to the requirement of project. Firstly, most of the power electronics final year degree students of Electrical engineering they are facing problems during working on hardware without testing on simulation based software, that's why they waste a lot of their money and time and sometimes they may damage expensive laboratory equipment's of university and Polytechnics because they are working on hardware without any precaution and proper handling.

Secondly most of the students have different learning styles like auditory, visual and hands-on. Sometimes student they cannot understand on first attempt and sometimes because of improper material used in class might be the reason why students can't perform well in exams. Students also might feel annoyed with the material used which will lead them to lose concentration and attention in the class. Many students they prefer visual and hands-on learning style rather than auditory or teacher center. For these type of students simulation based software's are very useful and especially in electrical and electronics engineering students with the help of this simulation based software they can

repeat and redo their required experiment before working on hardware even the last year students of faculty of Faculty of Electrical and Electronic, UTHM are facing same problem in their experimental work which is analyzed from Pre-Research Questioner data of this research for the justification of this problem statement.

For enhancing the learning process of power electronics course, experimental work before working on hardware its better and effective to implement DC-DC convertor on Matlab simulink for sufficient learning outcome and also save costly electrical equipment. Developing the fuzzy controller is cheaper than developing a model based or other controllers for the same purpose. Proportional-Integral- Differential (PID) controllers have been usually applied to the converters because of their simplicity. However, the main drawback of PID controller is unable to adapt and approach the best performance when applied to nonlinear system. It will suffer from dynamic response, produces overshoot, longer rise time and settling time which in turn will influence the output voltage regulation of the Boost converter.

The implementation of practical Fuzzy Logic controller that will deal to the issue must be investigated. The Fuzzy control is a practical alternative for a variety of challenging control applications because Fuzzy logic control is nonlinear and adaptive in nature that gives it a robust performance under parameter variation and load disturbances. Fuzzy controllers are more robust than PID controllers because they can cover wider range of operating conditions than PID, and can also operate with noise and disturbance of different natures. Fuzzy logic is suited to low-cost implementations and systems of fuzzy can be easily upgraded by adding new rules to improve performance or add new features.

1.3 Objective

The objectives of this project are,

i. To develop a DC- DC Boost convertor Matlab Simulink package to enhance learning process of power electronics course.

ii. To investigates the voltage output for DC-DC Boost converter between open loop, PID controller and fuzzy logic controller through Matlab simulink package.

iii. To compare the output of close loop and open loop DC-DC boost convertor.

iv. To identify the ramifications of Boost convertor Matlab Simulink software package.

v. To analyze the Learning outcomes from Boost convertor Matlab Simulink software package.

vi. To analyze the response from Boost convertor Matlab Simulink software package.

vii. To identify the benefits of Boost convertor Matlab Simulink software package.

1.4 Hypothesis

H_0 : There is no significant change in the mean value of learning process of DC DC boost convertors by using Matlab simulink package.

1.5 Importance of Study

i. To provide experience and the importance of simulation based power electronic course for final year degree student of electrical engineering.

ii. Students will directly involve in this study and they are final year degree students from Faculty of Electrical and Electronic Engineering (FKEE), UTHM.

iii. After the successful completion of this study, it might help various aspects. It can be used in Electrical Engineering Faculty (FKEE) and other Faculties for enhancing student's simulation based engineering skills.

1.6 Study Scope

The scopes of this project is to simulate the proposed method of voltage tracking of DC-DC boost converter using Fuzzy controller with Matlab Simulink software for the enhancement of learning process of power electronic students. Analyses of the converter will be done for continuous current mode (CCM) only. The analysis only covered the output voltage based on reading on overshoot ratio, rise time, peak time and settling time. In this project, Matlab simulink package is used as a platform in designing the fuzzy logic controller. This Matlab simulink package is develop to study the dynamic behavior of DC-DC boost converters and performance of proposed controller for the enhancement of learning process of Power electronics students.

1.6.1 Simulation Scopes Of Matlab Simulink

Simulation consists of:

a) Modeling DC to DC converter.
b) Modeling fuzzy logic controller.

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