HEXAPOD ROBOT MOTOR CONTROLLER USING FPGA

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Computer Engineering) With Honors

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FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

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Tajuk Projek : Hexapod Robot Motor Controller Using FPGA

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For my lovely mum and dad, thanks for sacrifice towards my success.

For my supervisor, Pn. Nur Alisa Bt. Ali, thanks for all your supports

To my friends who's helped me lots, I'll appreciate very much

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ABSTRACT

The project is Hexapod robot motor controller using FPGA. This project will be use a single chip system (FPGA) to control all the motors in movement of the Hexapod. FPGA is use to replace conventional microcontroller which have limited PWM signal. The movement for the Hexapod will use servo motor. Servo motor can give a natural and precise movement. With FPGA, single chip is enough to control all the servo motors. Hexapod robot is a six-legged robot with each leg consists of three servos motor that act as actuators for the movement. The main focus of this project is how the servomechanism can be generated by using FPGA based system. The algorithm movement of the Hexapod robot is closely configured and design with three main aspect. The aspects are stability, speed and synchronization of eighteen servos motor. Lastly, the project will be discussing how can FPGA based system can replace the conventional PIC microcontroller for servo motor.

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ABSTRAK

Projek ini adalah berkaitan “Hexapod robot motor controller” menggunakan FPGA yang bertindak sebagai pengawal. Projek ini akan menggunakan sistem cip tunggal (FPGA) untuk mengawal semua motor dalam pergerakan Hexapod. FPGA digunakan untuk menggantikan mikropengawal konvensional yang mempunyai keupaayan menjana isyarat PWM yang terhad. Pergerakan untuk Hexapod akan menggunakan motor servo. Motor servo boleh memberi pergerakan semula jadi dan tepat. Melalui penggunaan FPGA, cip tunggal adalah mencukupi untuk mengawal semua servo motor. Robot Hexapod merupakan robot berkaki enam dengan setiap kaki terdiri daripada tiga servo motor yang bertindak sebagai penggerak bagi pergerakan itu. Fokus utama projek ini adalah bagaimana mekanisma-servo boleh dijana dengan menggunakan sistem yang berasaskan FPGA. Algoritma pergerakan robot Hexapod dapat dikonfigurasikan dan direkabentuk dengan tiga aspek utama yang akan menjadi tumpuan utama. Aspek-aspek tersebut adalah seperti kestabilan, kelajuan dan penyegeraman lapan belas servos motor. Akhir sekali, projek ini akan membincangkan bagaimana sistem berasaskan FPGA boleh menggantikan mikropengawal PIC konvensional untuk mengawal motor servo.

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LIST OF ABBREVIATIONS

DOF	-	Degree of Freedom
DC	-	Direct Current
PWM	-	Pulse Width Modulation
CCW	-	Counter Clock Wise
CW	-	Clock Wise
FPGA	-	Field Programmable Gate Array
HDL	-	Hardware Description Language
LED	-	Light Emitting Diode
RTL	-	Register Transfer Level

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CHAPTER 1

INTRODUCTION

1.1 Overview

This project is about designing, implement and utilizing FPGA based servo motor control for the movement of Hexapod. This project will be focusing on the servomechanism of the Hexapod robot. This robot could move through uneven terrain with speed, stability and synchronization of the robot movement are prioritized. Together with capability to move uneven terrain, the robot has the flexibility to move into isolated places with ease. XILINX Spartan-II XC2S50 chip is used as brain or main controller to control the servos motors. The controller will manipulate the 6-legs of the robot. Servos are used because of the accuracy in determining the angle of the legs to provide stability for the movement.

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Each leg is actuated by three (3) servos which makes 18 servos in total. Hexapod means that the robot will be have 6 legs (Hex). An array of algorithm will be program to make the Hexapod move.

1.2 Objective

Objective of the project are to design algorithm of movement, implement and the design of FPGA based servo motor control for the movement of Hexapod.

1.3 Problem Statement

A robot walks on six legs can be describe as Hexapod robot. Each leg consists of 3 servos which make 18 servos in total. Most of servo control are using PIC based controller. The use of PIC is no longer relevant as there are too many servos to control and to make the hexapod movement more precisely. Therefore, we need to control and achieve multiple servo control synchronization. Using FPGA base controller, we can get a precise movement of control for all servo motor. Others micro-controller like PIC have limited number of servo motor control. Therefore need more than one IC need to be utilized all the servo control for the whole operation. Furthermore, micro-controller like PIC needs larger board size and magnifying the use of discreet IC.

1.4 Project Scope

In this project, the system for the controller of the Hexapod movement is developed using FPGA architecture. The language for the FPGA programming is using Verilog programming. The controller will control eighteen servo motor in total.

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1.5 Brief Explanation of Methodology

The methodology of this project is made to determine the objective of the project and ensure it will not derail from project‟s scope. Beginning of the project, literature review and background study is made. This is to ensure what, why and how the FPGA based system is different from conventional PIC microcontroller system. Furthermore, this will lead to problem solving method for problem statement that occurs for PIC based Hexapod robot motor controller.

After that, the FPGA architecture is study and familiarize. Study on block diagram of the FPGA and the LP-2900 experiment kit which hold the FPGA chip and input/output module on it are made and documented. Basically the controller for this project is place on LP-2900 Spartan II board. On that board have input/output module. The expected use of input are the switches where it control the movement of the Hexapod, while the output will be connected to the eighteen servos motor at each six-leg of the Hexapod. Then, basic PWM signal for control motor movement will be design and developed.

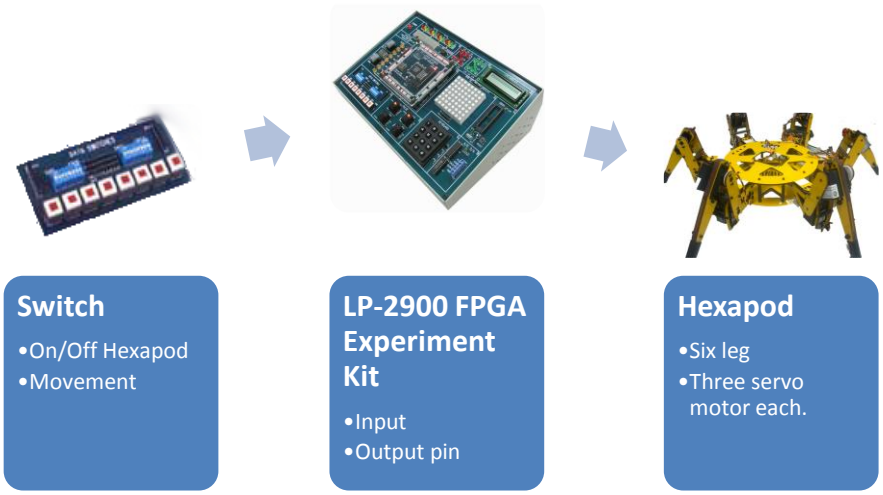

Figure 1: Basic block diagram of project

Next step for project methodology is the most crucial for Hexapod development. The algorithm for each leg to move is carefully design and constructed. Movements were insect-inspired where three crucial aspects are look into. Stability, speed and synchronization of all servos motor are coming into place. This is to ensure the

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fluidity of the Hexapod movement to move at all terrain and all direction. The servomechanisms that make the Hexapod move are actually generated by the FPGA and this make the FPGA is ideal for Hexapod motor controller.

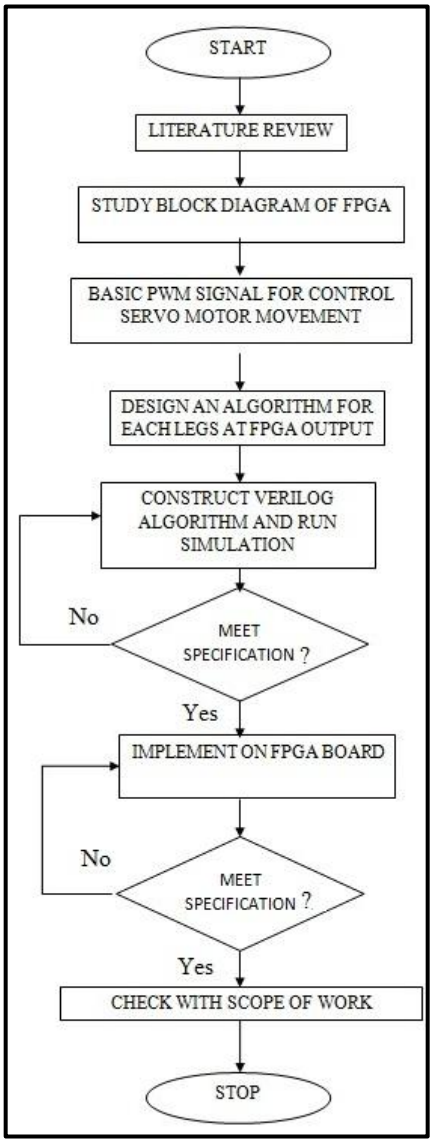

Figure 2: Flow-chart of project methodology

After the algorithm of the Hexapod movement is designed, the next step is to implement it on simulation using Xilinx ISE and ModelSim PE software. The language used is Verilog programming language. By using software, the result can be determined via simulation. This is to ensure not to waste time to troubleshooting during

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implementation on the FPGA board itself. If the implementation is succeeded, the end result must be check to see whether it is still within the scope of the project and if it does the project can be classify as successfully delivered.

1.6 Report Structure

This report consists of three chapters which are Introduction, Literature Review, and Methodology.

In Chapter 1 is Introduction, discussed about project background, project objectives, problem statement, scope of work, short brief of project methodology and overview the remaining chapters.

In Chapter 2 is Literature Review, reviews some references from previous project, journals, articles, books and datasheet. All the materials was useful to success this project.

In Chapter 3 is Methodology, where flow process of project had been discussed this project is divided into two parts software development and hardware design. The details process for the both part will be presented in this chapter 3.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, about the Hexapod robot, the leg coordination FPGA based controller, degree of freedom and the servomechanism theory is discussed. The background study or literature review come from various resources such as:

1. Senior‟s past project thesis
2. Books
3. Journals

But in some cases, resources like online article, video and images also contribute to the better understanding and concrete theory for this project.

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