DEVELOPMENT OF DUO-CONTROL DC MOTOR
PICK AND PLACE ROBOT
WITH PIC16F877A MICROCONTROLLER

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MAY 2009

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

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Date	:	May 14, 2009

To my dearest father, W. Deraman Bin Che Mat, mother, Kamariah Bte Che Hassan and brother, Muhammad Aimran Bin W. Deraman for their encouragement and blessing. Special to my supervisors, Mr. Hyreil Anuar Bin Hj. Kasdirin for his fully support and caring from PSM 1 until PSM 2.

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Thank You.

ABSTRACT

In this paper, Development of Duo-Control DC Motor Pick and Place Robot with PIC16F877A Microcontroller project is being proposed. A robot will be build that would function as a tool to pick and place object. A small robot arm assembly simulating shoulder movement of a human arm to be built to pick and place object from point A to B. The arm has two of freedom so the hand is able to reach and pick object from any three dimensional point. Electric DC motors will be used as the actuator for the robot that are controlled by microcontroller with program and manually. The project encompasses all design areas required to make a hand able to move and pick an object, including hardware design, analysis, electronic controller circuit design and controller program. The controller circuit will use PIC16F877A microcontroller as 'the brain' of the robot.

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LIST OF ABBREVIATION

2D - 2 Dimension

DC - Direct Current

PIC - Peripheral Integrated Circuit

IC - Integrated Circuit

DOF - Degree of Freedom

CCW - Counterclockwise

CW - Clockwise

USB - Universal Serial Bus

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

1.1 PROJECT OVERVIEW

An industrial robot is officially defined by ISO as an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. The field of robotics may be more practically defined as the study, design and use of robot systems for manufacturing (a top-level definition relying on the prior definition of robot). Typical applications of robots include welding, painting, ironing, assembly, pick and place, packaging and palletizing, product inspection, and testing, all accomplished with high endurance, speed, and precision.

A pick and place robot is a robot manipulator, usually programmable, with similar functions to a human arm. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain. The business end of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand. The end effector can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application.

PIC microcontrollers are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming capability. The name PIC initially referred to "Programmable Interface Controller", but shortly thereafter was renamed "Programmable Intelligent Computer". Today they can be found in almost any complex electronic device - from portable music devices to washing machines to car. They are programmable, cheap, small, can handle abuse, require almost zero power, and there are so many varieties to suit every need. This is what makes them so useful for robotics - they are like tiny affordable computers that can be put right onto robot.

DC motors are extremely useful in robotics. The motors are small, have built in control circuitry, and are extremely powerful for their size. It also draws power proportional to the mechanical load. A lightly loaded DC motor, therefore, doesn't consume much energy.

This thesis explains about designing a pick and place robot that can pick certain size and form. A gripper is designed to grip the wanted object in the process. DC motors with gears are used as the actuators for the robot mainly because of their size, easy to control and implemented to the robot chassis. PIC microcontroller will control the DC motors by generating square wave pulse width to the motors through H-Bridge circuit. The pulse will depend on the program that burned into the microcontroller and manual override remote control included.

1.2 PROJECT OBJECTIVES

The objectives of this project are as follows:-

i. To design and build a prototype of pick and place robot that can pick up an object and move it from point A-to-B.
ii. To learn how to make program for microcontroller using certain software.
iii. To learn how to use microcontroller to control behavior of DC motors.
iv. To do analysis about the pick and place robot's performance, reliability and others.

1.3 SCOPE OF WORK

There are limitation tasks that is called scope of work. For this project, the scopes of work are:

i. Design a prototype of pick and place robot.
ii. Build controller circuit for the pick and place robot.
iii. Write a program that control the robot.

1.4 PROBLEM STATEMENT

A pick and place robot need to be design that contain a base, an arm, a gripper and a controller circuit. DC motors were choose as actuators for the robot. A controller circuit must be build to control each servo motors and the robot overall. That circuit must contain PIC microcontroller that would generate pulse to the DC motors through H-Bridge circuit.

1.5 METHODOLOGY

At the beginning, the project title and the functions must be understand. This is very important to make sure the objectives of this project can be achieved. Then, literature review need to be conducted to learn the basic knowledge and theory about this project. This can help in understanding and give early views before taking this project to next level.

Next, basic design of the pick and place robot will be done to give early impression of the robot. Then, circuit of robot controller will be design and simulated to make sure it is functioning according to the design. The circuit will be modified if it is not suitable with hardware of did not same with what are expected. After that, the robot can start to be built according to the design. Changes of the design and of the robot will be made if necessary. Then, the prototype will be test about its functioning and performance. The pick and place robot will undergo modifying process if it did not functioning as expected. Analysis about the robot's function and performance will be conducted and will be reported in final report.

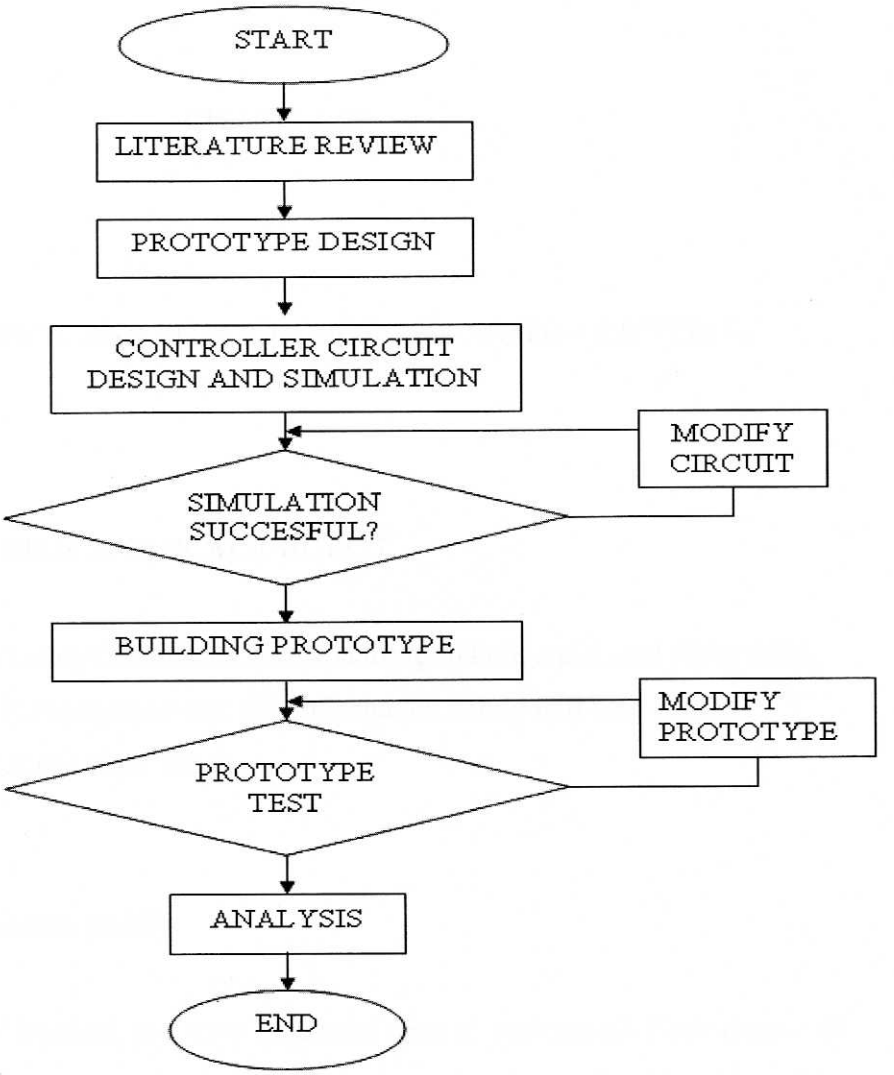

Figure 1.1: Flow Chart of Methodology

CHAPTER II

THEORY OF PICK AND PLACE ROBOT AND MOTOR CONTROL

2.1 THEORY OF PICK AND PLACE ROBOT

There are some theory that needed before starting to built a pick and place robot. Even though it is not compulsory, this information surely will help a lot in building any pick and place robot.

2.1.1 Degrees of Freedom (DOF)

The degrees of freedom is a very important term to understand. Each degree of freedom is a joint on the arm, a place where it can bend or rotate or translate. The number of degrees of freedom can typically identified by the number of actuators on the pick and place robot. Each degree requires a motor, often an encoder, and exponentially complicated algorithms and cost. Three degrees of freedom are sufficient to bring the end of a pick and place robot to any point within its workspace, or work envelope, in three dimensions. Thus, in theory, a robot should never need more than three degrees of freedom. But the extra possible motions, provided by multiple joints, give a pick and place robot versatility that it could not have with just three degrees of freedom.

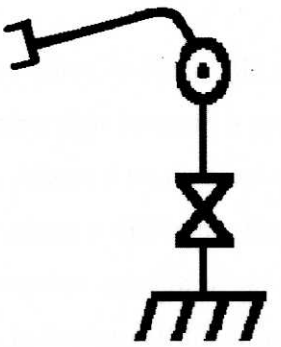

Figure 2.1: 2 Degree of Freedom

2.1.2 Robot Workspace

The robot workspace or sometimes known as reachable space is all places that the end effector or gripper can reach. The work space is dependent on the DOF angle or translation limitations, the arm link lengths, the angle at which something must be picked up at, etc. The work space is highly dependent on the robot configuration.

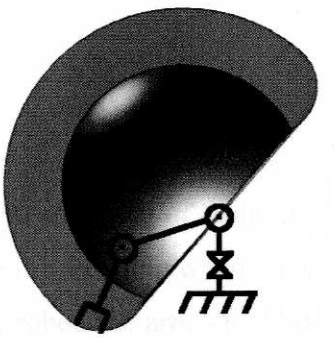

Figure 2.2: All locations that the end effector can reach

Rotating that by the base joint another 180 degrees to get 3D, we have this workspace image. Remember that because it uses servos, all joints are limited to a max of 180 degrees. This creates a workspace of a shelled semi-sphere. If the link length is changed, it can create a different size of workspaces, but this would be the general shape. Any location outside of this space is a location the arm can't reach. If there are objects in the way of the arm, the workspace can get even more complicated.

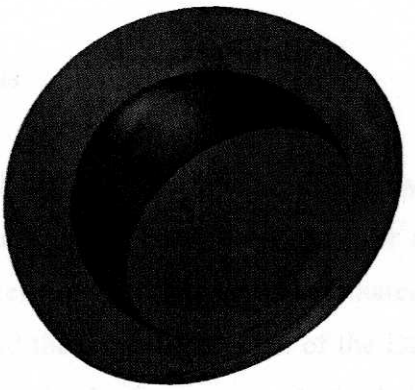

Figure 2.3: Workspace at 180 degrees in 3D

2.1.3 Arm Sagging

Arm sagging is a common affliction of badly designed robot arms. This is when an arm is too long and heavy, bending when outwardly stretched. When designing robot arm pick and place robot, the arm should be reinforced and lightweight and do a bending stress analysis. Keep the heaviest components, such as motors, as close to the pick and place robot base as possible. It might be a good idea for the middle arm joint to be chain or belt driven by a motor located at the base to keep the heavy motor on the base and off the arm.

2.1.4 End-Effector

A robotic end-effector is any object attached to the robot flange (wrist) that serves a function. This would include robotic grippers, robotic tool changers, robotic collision sensors, robotic rotary joint, robotic press tooling, compliance device, robotic paint gun, robotic arc welding gun, etc. Robot end effectors are also known as robotic peripherals, robotic accessories, robot tools or robotic tools, end of arm tooling (EOA), or end-of-arm devices.

2.1.5 Kinematical Analysis

The kinematical analysis gives the relationship between the rotation of the DC motors and the rotation of the base plate, shoulder and arm. This analysis also gives an empirical relationship between coordinates of any point in the three dimensional space and the angle of rotation of the DC motor. This helps the arm to reach a particular point in the space with the help of the servo motors. The empirical formulas also help in the development of the software for the control of the pick and place robot.

i. Forward Kinematics

Forward kinematics is the method for determining the orientation and position of the end effector, given the joint angles and link lengths of the pick and place robot. To calculate forward kinematics, all we need is trig and algebra.