# PRISMATIC LIFTER ROBOT BY USING CPLD

**LAJA SUPIT**

**MAY 2007**

"I admit that I had read this report and in my opinion, this report had fulfilled all scope and quality for the Bachelor Degree of Electrical Engineering (Electronic Power & Drive)

Signature : .....

Supervisor : SHAHRUDIN BIN ZAKARIA

Date : 7 May 2007

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This Report is submitted in Partial Fulfillment of Requirements for the Bachelor Degree of Electrical Engineering (Electronic Power & Drive)

Fakulti Kejuruteraan Elektrik
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MAY 2007

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

Signature : .....

Student : LAJA SUPIT

Date : 7 May 2007

For my beloved father, supervisor and all my close friends

## ACKNOWLEDGEMENT

Alhamdulillah, thanks to the Almighty with his permission I have finally finished my Project Sarjan Muda II in a whole semester's time. This report is the outcome of my project and it has been submitted in time.

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## ABSTRACT

This report present about developing of Prismatic Lifter Robot. The objective of this project is to design a prismatic lifter robot by using CPLD. The robot has the capability to lift load in between 1 to 5 kg and will be able to move in a straight line. The whole robot process will be control by complex programmable logic digital chip. This CPLD chip is provided by Altera Coporation and has the abilities to control the robot process. The robot will use dc motor as it drive and also lifting process. The robot structure is made from aluminum bracket and aluminum bar. In the robot design, several mechanical advantages are used to make sure that the robot will be able to lift with suitable strength. This process depend on how the program are set. This project involves the interaction of sensors, DC motor and the CPLD chip.

# ABSTRAK

Laporan ini menerangkan tentang perlaksanaan "Prismatic Lifter Robot by using CPLD". Objective utamanya adalah untuk mereka bentuk robot pengangkat yang dapat bergerak dalam garis lurus dan mengangkat beban. Robot ini berkebolehan untuk mengangkat beban di antara 1 hingga 5 kg. Robot ini akan menggunakan motor DC bagi melakukan proses bergerak dan mengangkat beban. Keseluruhan pengoperasian robot ini akan dikawal oleh chip CPLD yang dikeluarkan oleh syarikat Altera Coporation. Keseluruhan struktur robot ini diperbuat daripada penyambung aluminium dan juga aluminium bar. Beberapa sistem '*mechanical advantage*' telah digunakan dalam merekabentuk robot ini. Ini adalah bagi membolehkan robot tersebut menggangkat beban degan kekuatan yg sesuai. Walaubagaimana pun semua itu bergantung kepada aturcara yg dibina bagi mengawal keseluruhan process pergerakkan robot tersebut. Secara keseluruhan, pembinaan robot ini melibatkan interaksi antara sensor, chip CPLD dan motor.

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CPLD - Complex Programable Logic Device

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# CHAPTER I

# INTRODUCTION

This chapter will discuss the objective and scope of the project. The purpose of this discussion is to explain the perspective and method that will be used in the implementation and observation section. It will also brief on the purpose in developing the robot.

## 1.1 PROJECT OBJECTIVES

The main objective of this project is to study the development of a prismatic lifter robot design using mechanical advantage that has capabilities to lift various loads with maximum load of 5kg. To get this main objective, there are some sub objectives that need to achieve as;

a) To study the development of system that will be able to lift various loads using mechanical advantage added to the design. By using the mechanical advantage the robot will reduce the obsolete power that used in the lifting process.
b) To study on how to design the robot that can stand weight more that 5kg.
c) To study the development of line sensor detector for the robot.
d) To study the development on how to control the robot process using ALTERA CPLD EPM7064SLC44-10 including the software implementation.

## 1.2 PROBLEM STATEMENT

Nowadays, there are many activities that require access in the prismatic direction. Lifting activities is one of the mean for accessing this matter. Whether indoors or outdoors, the operation environment will reflected in the lifter robot's design and the ability to withstand different condition such as maintenances work for tower, industrial solution and many more. The design of robot will determined by it's proposed of application. In this case, the robot is design to compete another robot in a contest call 'Robocon'.

In the contest, some of the opponent will send some trap robot, this prismatic lifter robot will used it capalilities to help the team robot to pass the trap robot.

## 1.3 SCOPE OF WORK

The scope of work for this project is divided into two parts, the hardware part and the software part. The hardware involves designing the mechanical parts and electrical parts of the prismatic lifter robot. The mechanical part involves the added mechanical advantage lifter changer, chassis, the drive system, and the electrical part involves in the controller, drive circuit and sensor interfaces.

The software involves designing and writing the program for the robot to move forward, lifting load and also changer process. Software also used to develop a combination digital circuit to do the process and the will be burn into the chip.

# CHAPTER II

# LITERATURE REVIEW

This chapter will discuss about the overall theories and concepts of the project. It will also brief on the previous work that has been done by other people that is similar to the prismatic lifter robot function. The purpose of this chapter is to explain the perspective and method used to implement the prismatic lifter robot. The full understanding of the theory is very important as a guideline to build and implement the robot.

## 2.1 THE ROBOT

A lot of robot's definition can be found. It is not easy to bear the exact and perfect meaning of robot. The difference of these definitions can be seen from many aspects and angles. Some defined robot from aspect that the robot can be re-programmed and some defined robot by its manipulation, behaviors, intelligence and etc.

According to history, robot has been invented in 1921 and introduced by a Czech dramatis, Karel Capek in "Rossum's Universal Robot" drama. While the pronunciation and the word robotic was introduced by Isaac Asimov in robot science fiction story in 1940. The Webstar's New World Dictionary has defined robotic as science and technology of robot development that include design, production, application and other function. In Europe, robotic defined as "robotilogi science" while robotilogi was defined as "method of how the robot can be manipulated to do work".

Most of us assume robot as a part of technology but robotic actually comprehend all field of technology such as mechanical, electrical, electronics, computer software and various type of sophisticated technologies.

### 2.1.1 Prismatic Lifter Robot

Basically, robot can classify into two categories, fixed robot and mobile robot. The prismatic lifter robot is a combination of fixed robot and mobile robot where the robot will be fixed robot when it doing lifting process but a mobile robot when searching the load that it has to lift. Fixed robot is a robot that placed in one static place and its work limited by area. Mobile robot can move from one place to another place. The combination of these two types of robot can make the robot more perfect and more effective in doing a job. These type of robot commonly used in dangerous task such as in searching process and also where need a lifting process. Industrial and agricultural field can also use the prismatic lifter robot as their harvest machine. At home, mobile robot probably manipulates as security and do the daily houses work.

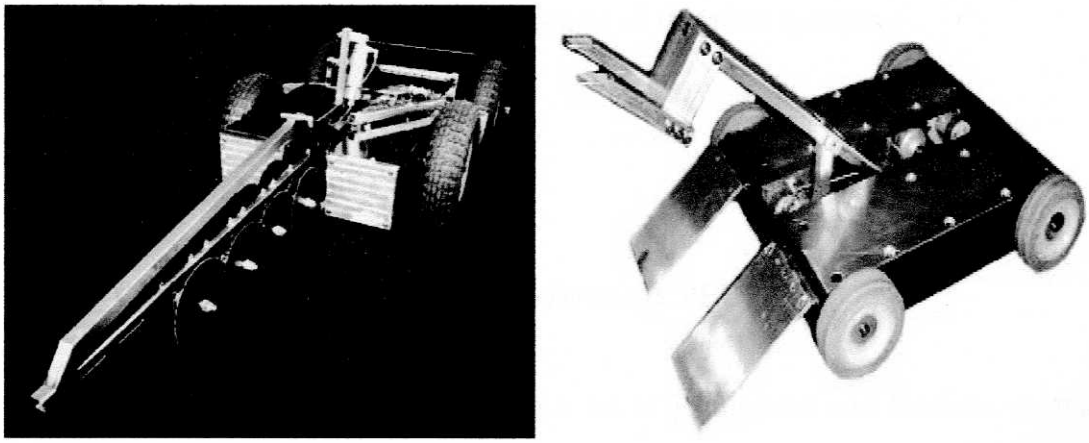

Figure 2.1: Types of lifter robot

The robot in the black background is design and inspire of a Caterpillar loader. Simple, lots of steel and a few interesting challenges. The name is chosen from among the legendary men of war. The general idea is to be low, strong and irresistible. The robot is quit similar to the spec to the one that wanted to build accept

on the lifting process it only has one process where it try to lift the load as hard as it can. The second robot is a robot that with a white background is a 6kg feather weight class robot built for the NERC. This robot has four wheel drive, supplied by 4 Barber-Coleman gear head motors. It will run at 18 volts. Its lifting arm is powered by a 24 volt/33 rpm surplus wheel chair motor. It is capable of dead lifting a 9 kg cast iron weight. This type of lifter robot commonly design only to lift what ever load that show in front of the robot. But that is not the kind of lifter robot that wanted to be constructed. The robot that was tries to develop for this robot project where the robot can save the robot power during lifting process. The idea is to use mechanical advantage in the robot lifting process design. This will make the robot intelligent on doing the lifting process.

The prismatic lifter robot will basically made up of five main systems. The controller which is the brains of the robot makes all the decision in moving the robot and makes the robot lifting process. The lifting system which is the arm of the robot that allows the robot to do lifting process. The drive system which is the legs of the robot moves the robot anywhere it wants to go. The sensors systems represent the eyes of the robot help the robot to detect the line. Lastly, the power supply which is the heart of the robot that will pumps power to all the other systems.

## 2.2 THE CONTROLLER

### 2.2.1 Complex Programmable Logic Device (CPLD).

In the digital design, we will deal with a lot of logic gates and Boolean algebra. These basic foundations of combinational circuit, as well as the sequential logic circuits will form the fundamental building blocks of many digital integrated circuits (ICs). For robot that using digital design, of course it will use a lot of combination circuit and also sequential circuit to make the robot working.

In the past, such digital ICs were fixed in their logic functions it was not possible to change designs without changing the chips in a circuit. Programmable logic offers the digital circuit designer the possibility of changing design function

even after it has been built. A programmable logic device (CPLD) can be programmed, erased, and reprogrammed many times, allowing easier prototyping and design modification. The number of IC packages required to implement a design with one or more CPLD is often reduced, compared to a design fabricated using standard fixed-function ICs.

CPLDs can be programmed from a personal computer (PC) or workstation running special software. This software is often associated with a set of programs that allow us to design circuits for various CPLD. MAX_PLUS II, owned by Altera Corporation, is such a software package. MAX_PLUS II allows us to enter CPLD designs, either as schematics or in several hardware description languages (specialized computer languages for modeling and synthesizing digital hardware). A design can contain components that are in themselves complete digital circuits. MAX_PLUS II converts the design information into a binary form that can be transferred into a CPLD via a special interface connected to the parallel port of a PC.

The controller will works as the brain of robot that will do all the logic for the robot. It will interpret the output of sensor and control the drive system. All these tasks will be complete by programming the controller. In this project, EPM7064SLC44-10 CPLD will be use.

### 2.2.2 EPM7064SLC44-10

Programmable logic device that produce by Altera Company have various type of family such as MAXII, MAX3000 and MAX7000 family. In this robot project, EPM7064SLC44-10 chip has been selected by the supervisor as the controller for the robot.

The EPM7064SLC44-10 chip comes in a socket-mounted 44-pin PLCC package and with a capacity of maximum 1,250 gates, 64 LC (Logic Cells). The chip is a high performance device and it based on EEPROM elements, and it can operate stand-alone. The chip used In-system-programming (ISP) interface and It can be program device with program object file (.pof) using the printer port download cable.

It supports Windows98/Me/2000/XP system. The chip is operating in 5V and has 31 user I/O pins.

The chip feature:

1. High-performance, EEPROM-based programmable logic devices (PLDs) based on second-generation MAX® architecture.
2. 5.0-V in-system programmability (ISP) through the built-in IEEE Std. 1149.1 Joint Test Action Group (JTAG) interface available in MAX 7000S devices ISP circuitry compatible with IEEE Std. 1532.
3. Includes 5.0-V MAX 7000 devices and 5.0-V ISP-based MAX 7000S devices.
4. Built-in JTAG boundary-scan test (BST) circuitry in MAX 7000S devices with 128 or more macrocells.
5. Complete EPLD family with logic densities ranging from 600 to 5,000 usable gates.
6. 5-ns pin-to-pin logic delays with up to 175.4-MHz counter frequencies (including interconnect).
7. PCI-compliant devices available.

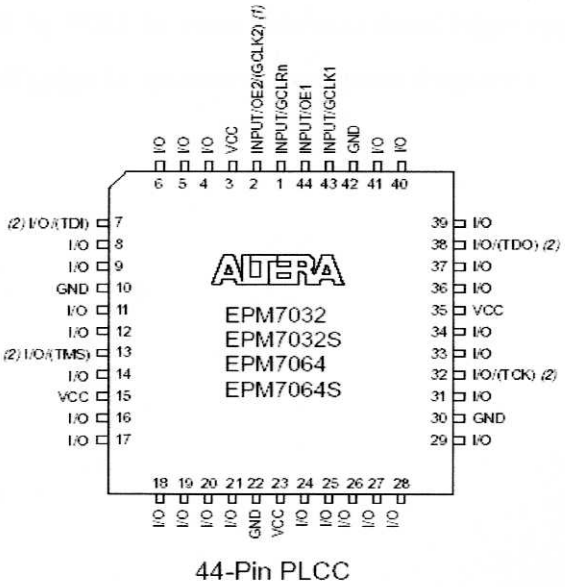


Figure 2.2: EPM7064SLC44-10 Block Diagram

Table 2.1: EPM7064SLC44-10 Device features

| Feature | EPM7032S | EPM7064S |
|---|---|---|
| Usable gates | 600 | 1,250 |
| Macrocells | 32 | 64 |
| Logic array blocks | 2 | 4 |
| Maximum User I/O pins | 36 | 68 |
| $t_{PD}$(ns) | 5 | 5 |
| $T_{SU}$ns) | 2.9 | 2.9 |
| $T_{FSU}$(ns) | 2.5 | 2.5 |
| $T_{COI}$(ns) | 3.2 | 3.2 |
| $F_{CNT}$(MHz) | 175.4 | 175.4 |

### 2.2.2.1 Power Supply

EPM7064SLC44 MAX7000S device needs +5V power supply to be function. MAX 7000 devices offer a power-saving mode that supports low-power operation across user-defined signal paths or the entire device. This feature allows total power dissipation to be reduced by 50% or more, because most logic applications require only a small fraction of all gates to operate at maximum frequency.