# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# DEVELOPMENT OF LOW COST 3-AXIS DESKTOP ROUTER AND PLOTTER MACHINE FOR EDUCATIONAL PURPOSE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Industrial Electronic) with Honours.

by

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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Tajuk: DEVELOPMENT OF LOW COST 3-AXIS DESKTOP ROUTER AND PLOTTER MACHINE FOR EDUCATIONAL PURPOSE

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Date:

**APPROVAL**

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirement for the degree of Bachelor of Electronic Engineering Technology (Industrial Electronic) with Honours. The member of the supervisory is as follow:

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# ABSTRAK

Pemesinan CNC adalah proses pembuatan di mana perisian komputer diprogramkan bagi menentukan pergerakan alat dan jentera kilang. Proses ini boleh digunakan untuk mengawal rangkaian jentera kompleks untuk kilang. Dengan mesin CNC, tugas pemotongan tiga dimensi boleh dicapai dalam satu set arahan. Tujuan projek ini adalah untuk menyelesaikan masalah pada mesin yang paling biasa digunakan oleh kilang pembuatan. Biasanya, mesin CNC adalah besar dan mahal. Mesin CNC besar tidak dapat menghasilkan produk bersaiz kecil dengan betul. Saiz dan kos mesin CNC juga menjadi masalah bagi institusi pendidikan untuk memperoleh mesin ini untuk tujuan pendidikan kepada belanjawan mereka dan ruang yang terhad. Ini menimbulkan masalah untuk mengajar pelajar tentang mesin CNC. Antara kaedah yang digunakan untuk mencapai matlamat tersebut adalah untuk mendapatkan maklumat daripada kajian yang telah dilakukan pada projek yang serupa dengan kajian ini dan juga dari sumber internet. Kriteria utama yang diperoleh selepas menjalankan kajian tajuk projek ini ialah kos pembinaan termasuk komponen yang berkenaan, bahasa pertengahan antara mesin dan manusia dan sistem yang digunakan dalam projek. Sebagai kesimpulan, projek kecil ini memerlukan sistem yang canggih dengan kos yang lebih rendah. Dengan kata lain, mesin cnc perlu dilengkapi dengan penambahbaikan mengikut teknologi hari ini untuk mendapatkan hasil yang diinginkan dan juga memudahkan kerja serta mengurangkan masa pembuatan supaya kuantiti hasil produk meningkat.

## ABSTRACT

CNC machining is a manufacturing process in which pre-programmed computer software dictates the movement of factory tools and machinery. The process can be used to control a range of complex machinery, from grinders and lathes to mills and routers. With CNC machining, three-dimensional cutting tasks can be accomplished in a single set of prompts. The purpose of this project is to solve the problem on the machines that most commonly used by manufacturing factories. Normally, CNC machines are large and expensive. Large CNC machines are unable to produce small-sized products properly. The size and cost of CNC machines are also a problem for educational institutions to acquire these machines for educational purposes to their budget and limited space. This is pose a problem to teach students about CNC machines. Among the methods used to achieve that goal is to obtain information from the studies that have been done on projects similar to this study and also from internet sources. The key criteria that were obtained after conducting a review of this project title were the construction costs including the applicable components, the intermediate language between machine and human and the system applied in the project. In conclusion, this small-sized project requires a sophisticated system with less cost. In other words, a cnc machine should be equipped with improvements in accordance with today's technology to get the desired results and also facilitate the work as well as reducing manufacturing time so that the quantity of product revenue increase.

## DEDICATION

This report is dedicated to my parents, siblings, supervisor and friends for their support and every single person that help me without tired for making this project success.

## ACKNOWLEDGEMENTS

First of all, I am deeply thankful to God Almighty for giving me these chances to gain more knowledge and understanding. I would like to thank my parents that always give me support during the process of making this project. I also want to say a big thank you to my supervisor Madam Izadora binti Mustaffa that always give me advises and accepting me. To my friends and colleagues thank you all for your support.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

| | | |
|---|---|---|
| CNC | | Computer Numerical Control |
| IT | | Information Technology |
| ADC | - | Analog Digital Converter |
| GUI | - | Graphical User Interface |
| NCC | - | Canonical Code |
| PCB | - | Printed Circuit Board |
| DSP | - | Digital Signal Processor |
| 3D | - | 3 Dimension |
| CAD | - | Computer Aided Design |
| PLC | - | ProgrammableLogic Controller |
| LCD | - | Liquid Crystal Display |
| EIA | - | Electronic Industries Association |
| NC | - | Numerical Control |
| CAM | - | Computer Aided Manufacturing |
| LED | - | Light Emitting Diode |
| UGS | - | Universal Gcode Sender |

# CHAPTER 1
# INTRODUCTION

## 1.1 Introduction

This chapter contains the background of the CNC router and plotter machine, the problem statement which have led to the development of this project, the objectives which are the aims to be achieved and the scope of work involved in achieving the objectives. Chapter 1 also consists the thesis outline.

## 1.2 Project Background

As the manufacturing trade is gradually becoming machine-controlled with the industry moving from craft production to mass customization, many paradigm shifts have become necessary from the use of machines to exchange hand-made elements, through the use of production lines to increase the amount of merchandise created, culminating in the increased use computer technology.

The most challenging thing nowadays is to fit into rapid technology development changes and to ensure that the technology used is a coefficient for the latest technology. One of the most difficult issues that need to be resolved is how long it takes between designs to manufacturing. Computer Numerically Controlled (CNC) machines is one of the solution to the problem. The CNC machine can be easily produce a product ranging from a simple to a complex specification through a computer program. The CNC machine is usually programmed by determining the movement of the different axes in orderto produce

a product. CNC machines are usually expensive even the ones used for educational purposes. The purpose of this project is to develop a dekstop size CNC machines which utilizes Arduino and stepper motor which is low-cost.

## 1.3 Problem Statement

CNC is a computer-based automated control of machining tools for drills, boring tools, laths and 3D printers. It automatically changes a blank piece of material into product by following programmed instructions and without a manual operator. Normally, CNC machines are large and expensive. Large CNC machines are unable to produce small-sized products properly. In addition, due to its costs, a CNC machine is too costly for small businesses. The size and cost of CNC machines are also a problem for educational institutions to acquire these machines for educational purposes to their budget and limited space. This is pose a problem to teach students about CNC machines. It is a loss if students are not exposed to CNC machine since it is widely used in industries. Hence, the aim of this project is to develop a 3-axis desktop CNC machine which is reasonably priced for the purpose of machining of small products and education.

## 1.4 Objective

The main objectives of this project are:

i. To design low-cost CNC machines that can be used for small product production.
ii. To develop 3-axis router and plotter CNC machine desktop size with CNC system to operate it.
iii. To implement the developed system to produce desired product.

## 1.5 Scope

This project consists of designing and fabricating 3 axis low cost CNC machine with a maximum size of 400x 480x 350 mm. A suitable control algorithm is written to control the position and speed of the CNC machine. The algorithm written in inkscape software generates the G-code to control the machine to move along the X, Y and Z axis at a suitable speed. The machine is able to move a tool to produce a product according to the design programmed in the software.

## 1.6 Thesis Outline

The thesis of the 3 axis desktop router machine consists of a combination of five chapters: Introduction, Review of Literature, Methodology, Result and Discussion, Conclusion and Future Recommendation.

Chapter 1: Introduction
Introduction of the project is explained in briefly. In the problem statement the motive for this project is described. This section also describes the objectives and scope of the project.

Chapter 2: Literature Review
This chapter discusses the other project involving 3 axis desktop router machine based on different method. The methods, hardware and software of each system are explained and compared. Conclusion of which methods for the proposed system is given.

Chapter 3: Methodology
This chapter discusses the entire methodology used in developing this project. It also describes about the designed program in this project and how it is applied.

Chapter 4: Result and Discussion

Result of the program including simulation and measurement are presented in this chapter. The project's performance is demonstrates by the results and reports on the assessment of 3 axis router machine.

Chapter 5: Conclusion and Reference

This chapter concludes the developed project and state future recommendation to improve the developed system.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Introduction

The purpose of this chapter is to provide a basic overview of the low cost 3-axis desktop router machine and CNC system. This project is basically about to innovate a factory CNC machine into a desktop size of CNC machine that can be used extensively by all parties. The problem with the CNC machine in today market is there are expensive and to big, due to this problem most of the universities don't have enough CNC machine for the student use. This project is proposed to solve this problem. Most of the CNC and router machine articles or journals have been analyzed. There are two journal that has similarity with the this project that is "Prototype CNC Machine Design" by (Rocha, Souza and Tostes, 2010) and "Low Cost Production CNC System' by (Khanna *et al.*, 2013). The method and hardware type used in the research is the core element to be analyzed. Furthermore, the system under analysis and comparison was made to search for the strength and weakness of each research. Therefore, the best method and solution can be chosen to complete the low cost 3-axis desktop router machine and CNC system.

## 2.2 Computer numerical control (CNC)

CNC machining is a manufacturing process in which pre-programmed computer software dictates the movement of factory tools and machinery. The process can be used to control a range of complex machinery, from grinders and lathes to mills and routers. With CNC machining, three-dimensional cutting tasks can be accomplished in a single set of prompts. This means a computer converts the design produced by software like Inkscape into numbers. The numbers can be considered to be the coordinates of a graph

and they control the movement of the cutter. In this way the computer controls the cutting and shaping of the material. Since computers are used to control machines, it means that all major operations of production can be automated to increase speed and quality of manufacturing. The computer-numerical control offers a few types of financial and production advantages over the conventional method. In manual lathing, for example, there must be a skilled technician for every machine, while with CNC machining, one skilled person can operate several machines.

## 2.3 Overview of previous projects

### 2.3.1 Prototype CNC Machine Design

Paulo et-al 2010, developed prototype of CNC machine to allow future researches on the process performances, educational purposes and the demonstration of parts used in the CNC machine. Their machine basically consists of three parts, the mechanical parts of a CNC machine, the software and electronic circuit. It consists of stepper motor as the mechanical drive in the mechanical part, steel threaded rod as rotational to translational mechanic converter. The software used was LabVIEW IDE and the main controller a PIC18F2550. The main program for feeding into microcontroller was G and M codes which could be comprehended by machine. After that, a signal conditioning circuit was connected to the controller to give the correct current value within a microcontroller. The signal conditioning circuit was necessary because the ADC intent to reduce quantization error can amplify and drive the signal full voltage. It will therefore create a machine with the right component and the right current supply for the entire system.(Rocha, Souza and Tostes, 2010)

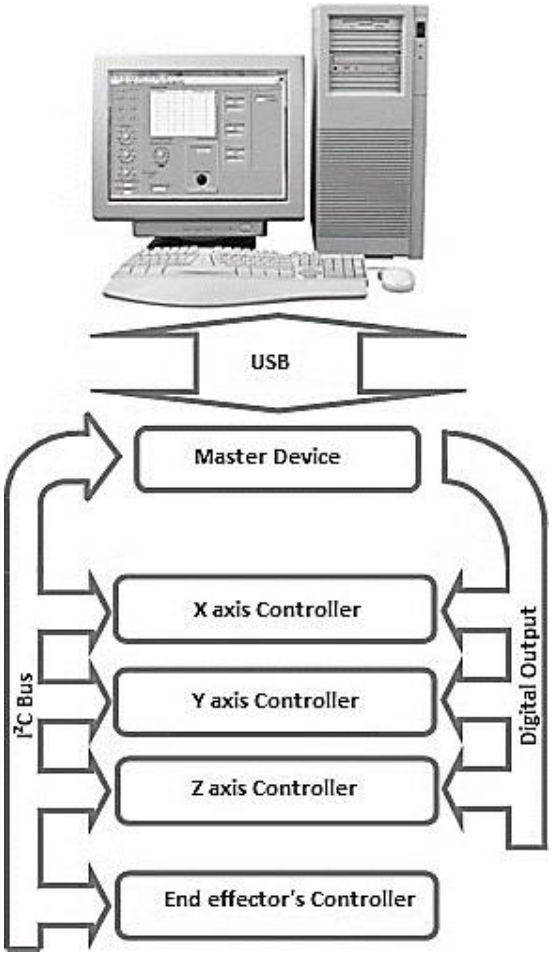


**Figure 2.1 Dataflow between the machines (Paulo et-al 2010)**

### 2.3.2 Low Cost Production CNC System

This low cost CNC system is capable of interpolating six axis operations. The system exploits the advantages of Arduino. The system also represents an offline G-code parser. Basically, there are two parts for the complete system which are graphical user interface (GUI) parser and the microcontroller system. The graphical user interface (GUI) parser converts the input file (G-code) into less complicated file that contain the canonical functions known as canonical code