



**DEVELOPMENT OF VIRTUAL COMPONENT TECHNOLOGY-  
BASED CNC SYSTEM FOR ISO 6983 DATA INTERFACE  
MODEL**



**BACHELOR OF MANUFACTURING ENGINEERING  
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**Faculty of Mechanical and Manufacturing Engineering  
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SYSTEM FOR ISO 6983 DATA INTERFACE MODEL**



**Hamdan Syakirin Bin Md Amir**

**Bachelor of Manufacturing Engineering Technology (Bmmw)  
with Honours**

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**DEVELOPMENT OF VIRTUAL COMPONENT TECHNOLOGY-BASED CNC  
SYSTEM FOR ISO 6983 DATA INTERFACE MODEL**

**HAMDAN SYAKIRIN BIN MD AMIR**

**A thesis submitted  
in fulfillment of the requirements for the degree of  
Bachelor of Manufacturing Engineering Technology (Bmmw) with Honours**



**Faculty of Mechanical and Manufacturing Engineering Technology**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2022**

## DECLARATION

I declare that this Choose an item. entitled “ Development of Visual Component Technology Based CNC System for ISO 6983 Data Interface Model” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature

:



Name

:

HAMDAN SYAKIRIN BIN MD AMIR

Date


:

18 JANUARY 2022



## APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology with Honours Engineering Technology (BMMW) with Honours.

Signature : 

Supervisor Name : TS. DR. KAMRAN LATIF

Date : 28-01-2022



## DEDICATION

This research paper is wholeheartedly dedicated to my dearest parents Norizah Binti Othman and Md Amir Bin Ahmad, who have extremely been willing to support me mentally and physically and have been my source of strength and inspiration for me to accomplish my report. Thank you for always being by my side. Next, to all my family members and friends, thank you for helping me, encouraging me and also supporting me to complete the research. Lack of support and help from them, I might not be able to accomplish my thesis on time. Lastly, my sincere appreciation to my supervisor and panels for guiding, helping as well as giving me the knowledge to complete this thesis throughout the project.



## ABSTRACT

This paper reports development of a visual component technology-based CNC machine system for the ISO 6983 data interface model. This can do three-axis simultaneous interpolation. Today's fast-paced CNC machines are governed by the ISO 6983 data interface model, which was already deemed a poor script, and diverse CNC programs are generally viewed as owing to reliance on manufacturer requirements. Most of the existing systems are high cost and black box in nature. This is most likely because of these robots' remarkable capability. The goal of this project is to create a low-cost, portable machine using the characteristics of a conventional PC interface as well as an ATMEGA 328 microprocessor CNC system in an Arduino. This device also has an offline G-Code parser that is read via a USB and instead interpreted just on the microcontroller. The primary goal of this study is to create a three-axis soft CNC motion control system for a three-axis milling machine that incorporates virtual components to carry out ISO 6983. An interpreter is a software model that interprets input code according to the mechanical properties of a CNC machine. The method that is used in this project is LabView software where it can interpret the G-Code and run the machine to create the design. The result has been shown that the G-Code running smoothly and no error while machine doing the process. This project can improve the quality of the machine, the need to reduce human errors, reduce wastage and maintain high quality and precision are some intrinsic properties driving the potential volume for CNC milling machine.

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## ABSTRAK

Kertas ini membentangkan perubahan sistem mesin CNC berasaskan teknologi visual untuk model antara muka data ISO 6983. Ia boleh dilakukan interpolasi tiga paksi serentak. Mesin pantas CNC hari ini dikawal oleh model yang mengawal data ISO 6983, yang sudah dianggap skrip yang lama, dan pelbagai program CNC umumnya dilihat sebagai bergantung kepada keperluan pengeluar. Kebanyakan sistem yang sedia ada adalah kos yang tinggi dan kotak hitam dalam alam semula jadi. Ini kemungkinan besar kerana kemampuan luar biasa robot ini. Matlamat projek ini adalah untuk mewujudkan mesin CNC kos rendah dan mudah alih menggunakan ciri-ciri antara muka PC konvensional serta sistem CNC mikroprosesor ATMEGA 328 di Arduino. Peranti ini juga mempunyai penghuraian G-Kod luar talian yang dibaca melalui USB dan sebaliknya ditafsirkan hanya pada microcontroller. Matlamat utama kajian ini adalah untuk mewujudkan tiga paksi sistem kawalan pergerakan CNC sistem untuk tiga paksi mesin pengilang yang menggabungkan komponen visual untuk menjalankan ISO 6983. Penterjemahan model perisian adalah yang mentafsirkan kod input mengikut sifat-sifat mekanikal mesin CNC. Hasilnya telah menunjukkan bahawa G-Code berjalan lancar dan tiada ralat semasa mesin melakukan proses. Projek ini boleh meningkatkan kualiti mesin, keperluan untuk mengurangkan kesilapan manusia, mengurangkan pembaziran dan mengekalkan kualiti dan ketepatan yang tinggi serta beberapa sifat intrinsik yang mendorong potensi volum untuk mesin pengilangan CNC.



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## LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
ISO	-	International Standards Organization
CNC	-	Computer Numerical Control
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
NC	-	Numerical Control





## CHAPTER 1

### INTRODUCTION

#### 1.0 Background

The Computer Numerical Control (CNC) machines are based on a method that employs minicomputers to create, interpret, and implement progressive control. These machines, which were first created in the 1970s, use computers to replace Numerical Control (NC) (Correa, Toro and Ferreira, 2018). The CNC computer's most important component is the controller, which is made up of two parts which are software and hardware. The interpreter is the controller's software component that converts the International Standards Organization (ISO) data interface model instructions to hardware instructions (Latif, Yusof, Latif, *et al.*, 2017)

Today's fast paced CNC machines are governed by the ISO 6983 data interface model, which was already deemed a poor script, and diverse CNC programs are generally viewed as owing to reliance on manufacturer requirements. Overall, the world's accelerated industrialization necessitates greater CNC versatility. In other, worldwide during the past CNC aims to make it more adaptable, open, interoperable, and informative (Iliyas Ahmad *et al.*, 2020). One of the most significant problems of vendor specification dependence was seen in modern commercial CNC systems are encountered in the race to develop next generation CNCs. The majority of new systems are costly and have a back-end nature. According to (Aktan *et al.*, 2016), CNC controllers are included in the majority of today's devices for CNC machine tools that are supplied as a black box by control suppliers, making it problematic for machine tool builders to rapidly create and execute new ideas or customized control functions.

Most of the CNC devices are configured using the ISO 6983 G and M code languages. The ISO 6983 data interface model is commonly used in numerical control apparatus manufacturing processes. CNC machines use the ISO 6983 data interface format,

commonly referred to as G-code. As a consequence of these additions, component programmed cause problems with machine interchangeability. Following proposed instructions render more machine-specific G-code, but they are not included in ISO 6983. Since their development, these machine tools have progressed in a wide range of applications, including milling, spinning, grinding, tube welding, and cutting robots, using simple to cutting-edge CNC techniques (Magdum *et al.*, 2018).

CNC computers also have a wide range of capabilities, such as multi-axis control and using many processes production. CNC system has exhibited cost-effective mass, bunch, as well as several more solitary manufacturing scenarios. Fast production speed, product uniformity, lower component deprivation, reduced replacement parts costs, less operator interference, and ease of convoluted form machining are a few of the major factors that contribute to CNC technology's economic viability (Latif and Yusof, 2016).

Each vendor has its own set of specifications, compatibility between component programmed is due to the manufacturing shop floor programming must adhere to the ISO 6983 G&M code for, various development data, such as machining design elements, machining mechanism, and machining military hardware, cutting equipment, machining experience (Manu *et al.*, 2018). Besides, function information, can be left out of the component software or even lost. Adaptable manufacturing has grown in popularity in the 1970s and 1980s as part of the transition to more modern systems, to permit batch processing in small quantities of a diverse variety of components. Because of their ability to be reprogrammed to produce various components, CNC machines have become a vital manufacturing resource in order to achieve modular manufacturing (Manu *et al.*, 2018).

According to the IEEE concept (Covert, 2020), a framework that requires features that allow accurately deployed applications to run on a range of platforms from several vendors, interoperate through other methods, applications, and demonstrate consistency in style of user interaction (Gao *et al.*, 2010). In other words, Open Architecture Control is a concept that arose from the need for versatility in a computer-assisted environment. There is a variety of hardware implementation and networking, together with advanced NC programming technologies in the latest generation growth of the CNC system (Majda and Powalka, 2017).

A new-found approach of ISO data model analysis has been implemented, which is based on the Laboratory Virtual Instrument Engineering Workbench (LabVIEW)

framework (Yusof and Latif, 2016). Although CNC motion control methods based on LabVIEW software had been implemented in previous approaches (Sang and Xu, 2017), none had used the LabVIEW software framework for ISO data model interpretation. According to (Yusof and Latif, 2016) several areas must be focused on for the implementation of these types of systems. Therefore, the CNC controller element of software, also referred to as a translator for ISO 6983 data interface model will be discussed in this study. The experiment has been done successfully and each design takes around 18 to 25 minutes to finish the cutting process. These three different designs of different tool path strategies to check the machine execution.

### 1.1 Problem Statement

The CNC machinery has been proven to be cost-effective in mass, batch, and several other single item manufacturing scenarios. The majority of significant contributors to the commercial viability of CNC technology are fast production speeds, product uniformity, decreased feature denial, less expensive equipment, a smaller amount of machinist intervention, and ease of machining convoluted forms (Lin, 2018). The limitation of CNC Milling was the sizing axis coordination and size of tool bit. This model cannot meet the demands of today's manufacturing environment. The majority of the existing systems are high cost and black-box in nature.

Workers might still press the wrong buttons, create incorrect orientations, and misplace pieces on a jig. Operator mistake might contribute to machine accuracy issues. (Latif, Yusof, Nassehi, *et al.*, 2017). As a consequence, developing and implementing custom control functions for machine tool builders is extremely challenging (Sang and Xu, 2017). As a result, this system is complete in terms of both hardware and software such as the Human Machine Interface (HMI) platform, input/output functionality, networking, data interface model, and so on. Unsurprisingly, every producer of machine tools uses patented hardware and software. Consequently, this form of proprietary controller model prevents the customer from independently installing and interfacing indigenously new designed or commercially purchased functional modules to improve the machine's functionality. In addition, milling machines are far more expensive than manual devices. The first expenditure for these robots is thought to be prohibitively expensive. They also require high

maintenance costs and can be expensive to repair. CNC machinery does not eliminate the need for expensive tools. They also necessitate significant maintenance expenditures and might be costly to fix. The use of CNC technology sometimes doesn't eradicate the necessity for costly tools.

To address these concerns, open-architecture control technologies strive to create independent controllers of the manufacturer's skill, accepting the customer to purchase hardware and software from a variety of vendors and easily build the equipment they have purchased.

## **1.2 Research Objective**

This research aimed to develop of virtual component technology-based CNC system for ISO 6983 data interface model. Three objectives were set up to attain the goals of this research. The objectives were:

- To develop a three-axis soft CNC motion control system for a three-axis milling machine incorporating virtual components to execute ISO 6983.
- To integrate a development system using a three-axis CNC milling machine to implement the production method.
- To test system experiments to be used validate the production framework.

## **1.3 Scope of Research**

The Scope of this research are as follows:

- Only influences the motion of a three-axis milling unit.
- Only a Windows-based problem has been exacerbated.
- Just operate with the GRBL controller, which appears to be able the hardware using G-Code.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.0 Introduction

Through this part, the investigator discusses and focuses on related hypotheses of the development of an ISO 6983 data interface model-based CNC system based on virtual component technology. Many scientific initiatives that can be linked to this initiative were mentioned in the literature review. The knowledge acquisition of an ISO 6983 data interface model-based CNC system and more evidence correlated is depicted from the available journals, conference papers, thesis, book and other sources. The highlights concerning this research are processed in the subtopics of this chapter.

#### 2.1 Insight of CNC Machine

CNC is the computerization of system tools that are managed via computer programmes to produce a certain product shape. Computer-aided design (CAD) and computer-aided manufacturing (CAM) programmes are employed in advanced CNC applications to build product designs. The programmes generate a computer file, which is then processed by a post processor to retrieve the instructions required to run a specific machine and inserted through CNC machines for output (Aktan *et al.*, 2016).

Most of the CNC devices are configured using the ISO 6983 G and M code languages. The ISO 6983 data interface standard is commonly used in numerical control apparatus manufacturing processes. CNC machines use the ISO 6983 data interface format, also referred to as G-code. Since their development, these machine tools have progressed in a wide range of applications, including milling, spinning, grinding, tube welding, and cutting robots. During this project, CNC Milling Machine has been chosen.

## **2.2 Elements of CNC System**

The main parts of the CNC machine are Input Devices, Machine Control Unit (MCU), Machine Tool, Driving System, Feedback System and display unit.

### **i. Input Devices**

The input devices are employed in the input of the component programme in the CNC machine. Three input devices are commonly used such as a punch tape reader, magnetic tape reader and computer via RS-232-C communication.

### **ii. Machine Control Unit (MCU)**

The CNC machine's main component is the Machine Control Unit (MCU). The CNC machine's control is handled entirely by the MCU. Among the MCU's functions are:

- It decodes the encoded data that is supplied into it.
- It interprets the ciphered command.
- It employs statistical approaches such as linear, circular, and helical to create axis motion commands.
- It sends axis motion commands towards the amplifier circuits, which then drives the axis systems.
- It retrieves position and speed feedback signals for each driving axis.

### **iii. Machine Tool**

A CNC machine tool will always be equipped with a sliding table as well as a spindle for controlling direction and velocity. The X and Y axes of the machine table are controlled, while the Z axis of the spindle is handled.

### **iv. Driving System**

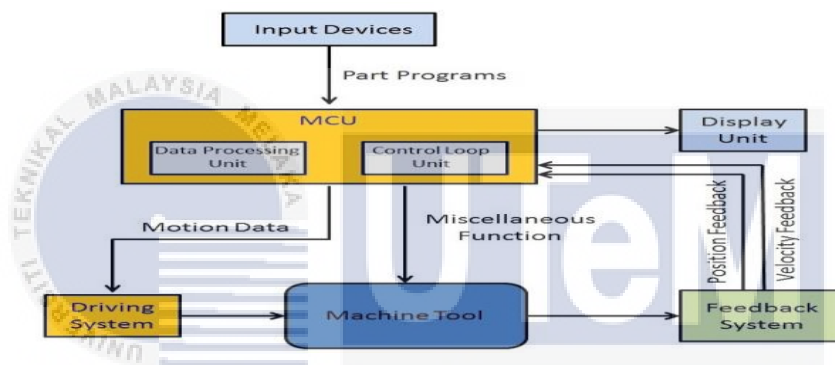
A CNC machine's driving system is made up of circuit elements, drive motors, and ball lead screws. The MCU sends signals toward the amplifier circuits indicating the position and velocity for every axis. The commands are then amplified in order to activate the drive motors. The ball lead screw is then rotated by the actuating drive motors to align the machine table.

## v. Feedback System

Transducers that function as detectors make up the feedback system. It is often mentioned as a measurement method. It is equipped with position and speed sensors that constantly monitor the direction and velocity of the cutting tool at all times. The signs in those sensors are received by the MCU, and the difference seen between reference and information signals is used to produce command indicators for rectifying speed and location faults.

## vi. Demonstration Unit

The CNC machine's programming, instructions, and other important data are shown on a panel.



**Figure 1 shows the Flow Process of CNC Machine**

[Source: (The Complete CNC Guide', 2020)]

Figure 1 depicts the block diagram of a CNC machine. That the very first objective is to develop and input the G and M code part programme through the CNC machine's Machine Control Unit. All data processing occurs in the MCU, and it creates all motion commands and transmits them to the drive system based on the programme that has been developed. The drive system eventually operates while the MCU transmits motion orders. The drive system regulates the motion and velocity among its mechanical system. The referral program measures the machine tool's location and speed and delivers an input command toward the MCU. The response shows a displayed in the following information in the MCU, and whether there are mistakes, the MCU fixes problems and directs fresh signals toward the machine tool so that the successful implementation may take place. The output device serves also as the machine's eye, allowing it to view all instructions, programmes, and some other essential functions.



## 2.3 Type of CNC Machine

CNC machines are categorized as follows:

### i. CNC Laser Cutting Machine



**Figure 2 shows CNC Laser Cutting Machine**

A laser that uses for this machine technology to vaporize materials, resulting in a cut edge. Laser cutting is accomplished by concentrating the output of a strong laser, very frequently using optics. A movement control unit is used by a commercial laser for cutting materials to match a CNC or G-code of the shape to either be cut it on substance. The CNC is used to guide the substance or laser beam produced. Because there is no cutting edge that could be polluted either by a substance or contaminate the material, the benefits of laser cutting involve simpler operation handling and less infection of the product.

### ii. CNC Lathe Machine



**Figure 3 shows CNC Lathe Machine**



CNC Lathe Machine is widely used as a lathe due to its quick and precise operation. Computer programmes are used to operate the lathe machine. Once the programme is loaded into the computer, it begins to operate at a high speed and accuracy. Even if a pre-planned, programmed machine is available, once the code for the various activities is set, it can begin operating without the need to change the code again. After the initial setup, a semi-skilled employee may simply operate this. Those sorts of lathes, including capstan and turret, are also utilised in large scale production, although no programmed feed mechanism is available. Dimensional tolerances are extremely tight on the components produced by these lathes.

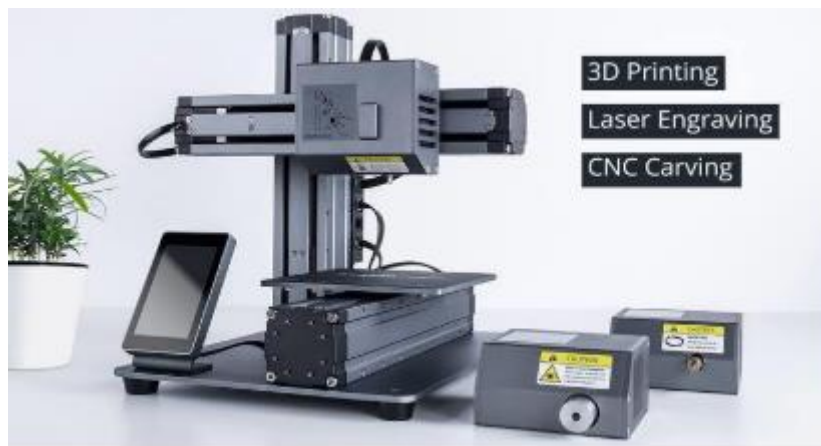
### iii. CNC Milling Machine



**Figure 4 shows CNC Milling Machine**

A CNC Milling Machine is a machine that utilises a spinning cylindrical cutter to move along several axes and produce slots, holes, and features in the material in order to transform it into a vehicle or mechanical part. Many other machines have three to five axes, which allows for significantly more accuracy and intricacy. Today CNC milling machines are made as both vertically and horizontally machining centres. Plastics, ceramics, and composite materials, in addition to metals, can be used to create components. Automatic tool changers, tool carousels and magazines, coolant systems, and enclosures are among the technical elements that keep machines working properly without human intervention.

#### iv. 3D Printers



**Figure 5 shows 3D Printers**

3D Printer as illustrated in Figure 5 is a CNC machine that involves the creation of objects with a wide range of shapes, sizes, hardness and colours, including materials such as plastics, composites or biomaterial. The 3D printing machine is used to print structures. The CAD and CAM procedures are used to create the idea and design, which will be subsequently rendered by a 3D printer. In order to create a 3D object from a standpoint, the 3D printer uses a combination of state-of-the-art software, powder-like materials and precision tools.

#### v. CNC Plasma Cutting Machine



**Figure 6 shows CNC Plasma Cutter**

Plasma cutting as illustrated in Figure 6 is a procedure that uses an accelerated stream of hot plasma to cut through electrically conducting materials. Even though additional conductive metals exist can be cut, typical materials cut using a plasma torch includes steel,

stainless steel, aluminium and brass and copper. In manufacturing shops, automotive repair and restoration, industrial construction and operations for the rescue and scrapping of plasma are often used. Due to the extremely high speed and accuracy, cuts and low cost, plasma cutting is widespread, ranging from large CNC industrial applications up to smaller hobby stores.

## **2.4 Advantages of CNC machines**

- It has the best precision and accuracy from any manual machine.
- It is capable of running 24 hours a day.
- It produces parts with the same level of precision. The produced pieces are identical.
- It does not necessitate the use of a highly qualified technician. In addition, a sub technician can work more correctly and efficiently.
- Modification and enhancements may be made simply by technicians, reducing the wait time.
- It is capable of producing complicated designs with great precision in the shortest amount of time.
- The designer can mimic the manufacturers' of his/her idea using contemporary design tools. As a result, there is no need to create a concept or design, saving both resources and time.
- A CNC requires fewer employees to run, which reduces labour expenses.

## **2.5 Disadvantage of CNC Machines**

Despite its numerous benefits, the CNC machine has certain drawbacks, which include:

- When compared to a mechanically operated machine, the costs of a CNC machine is quite expensive.
- CNC machine components are costly.
- CNC has a high maintenance cost.
- It does not do away with the necessity for expensive tools.

## 2.6 Application

CNC machines are used in nearly every industrial industry. The need for CNC use has grown in tandem with the competitive environment and expectations. Lathes, mills, shapers, welding machines, and other machine tools are included with the CNC. The automobile industry, material removal industries, metal fabrication industries, electrical discharge machining industries, and wood industries are among the industries that use CNC equipment.

In the 1970s and 1980s, flexible production was dominant in the progress towards more modern systems, allowing low batch production for a variety of components. CNC machines, because of their flexibility to be reprogrammed to manufacture diverse components, have become an important industrial source in understanding flexible manufacturing. As a result, multi-axis and multi-process workstation CNC machines were created to facilitate the high-speed manufacture of precision parts such as complicated aircraft components. Since development, CNC machines are operated by International Standards Organization (ISO) 6983 standard formally known as G-M codes. This ISO standard is based on digitised tool path representation in relation to tool size and machine command status.

Today's common CNC machine user interface is still ISO 6983-based, and there are several CAM options to help NC producers. As a result of these expansions, every sort of equipment and controller necessitate a unique post-processor. The majority of today's CNC machine tool systems are outfitted with a CNC controller given as a "black box" by controller suppliers, making it challenging for manufacturers of machine tools to swiftly create and implement bespoke control functionalities (Yusof and Latif, 2016).

The CNC machine is controlled by a computer and runs CAD and CAM applications. CAD software could be used to raise the creator's production efficiency, increase design and quality, increase collaboration into documentary evidence, and analyze data for production, whereas CAM has two codes, G-code and M-code, on which these programmes are recorded and fed this into the system to perform various functions.

From the design to the manufacturing stage, A CNC machine employs three types of applications which are, CAD, CAM and CNC controller software. Firstly, create a vector file (DXF) using Computer-Aided Design (CAD) software. Then, convert the vector file to G-Code using Computer-Aided Manufacturing (CAM) software. After that, To run the

machine as intended, utilise CNC software to process the G-Code. Below is the software to start the operation:

- a. CAD
- b. CAM
- c. Machine control and operation

### 2.6.1 Computer-Aided Design (CAD)

Computer-Aided Design (CAD) is a software platform that allows you to sketch the geometric pieces you want to make in each measurement then transfer the two-dimensional models into three-dimensional shapes as needed. That one similarly aids in the development of geometric components regarding acceleration, stress distribution, and the sketching of force and moment curves that impact the engineering component to be built. The file is then saved in a suitable format for interpreting CAM software, the most well-known of which is:

- Autodesk Inventor
- SolidWorks
- CATIA

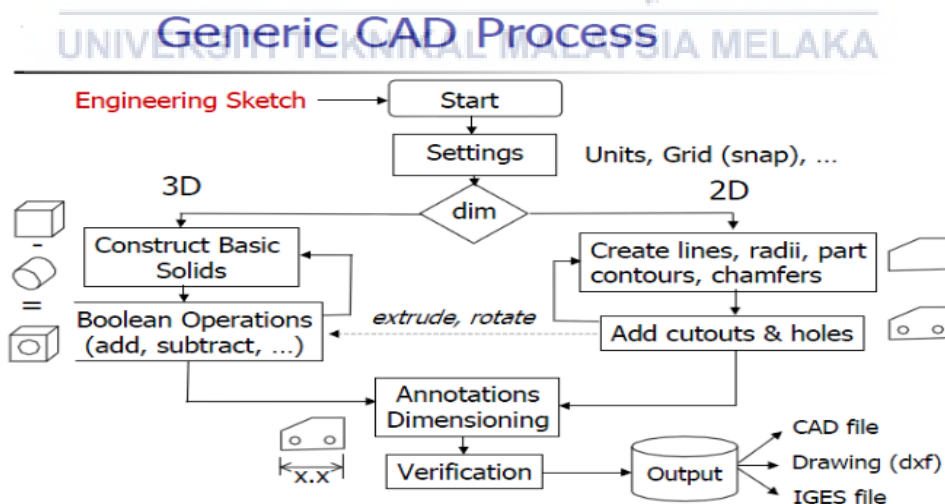


Figure 7 shows CAD Process

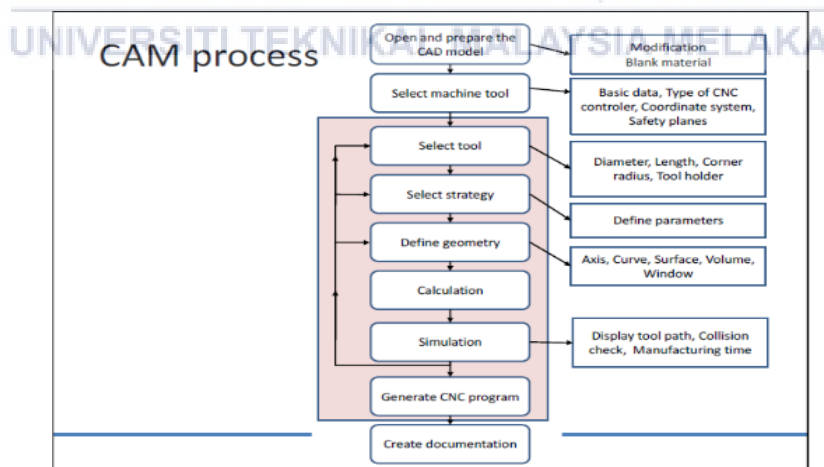
[Source: (DesignTech Systems Pvt., 2019)]

Figure 7 shows the CAD process flow. The sketch is beginning from start and adjust settings. Select the 2D symbol if the user needs to sketch two dimensions. If the user requires three dimensions, choose the 3D icon and utilise the software's option to convert the design from two to three dimensions. After completing the design, it is necessary to export the design to programming languages for the CAM to read the design (Autodesk Inc, 2014).

## 2.6.2 Computer-Aided Manufacturing (CAM)

Computer-Aided Manufacturing (CAM) is a software that transforms an engineering design created on CAD software to G-code therefore the CNC computer can recite the model. This G-code remains transmitted towards the CNC machine right away from the programme via a network cable or indirectly via Flash memory and then used to decide the CNC machine's parameters at the start of the manufacturing stage. The most well-known of these systems are as follows:

- Surfcam
- PowerMill
- Hsm
- Solidcam



**Figure 8 shows CAM Process**

[Source (MAI *et al.*, 2021), CNC]

Figure 8 shows the CAM machine workflow. When using a CAD/CAM system, the operator may perform all programming mostly on a computer, analyse the results on the

screen to confirm the established, and then download the proven programme to the CNC machine. Later it will be adept to identify the necessary manufacturing procedures, and the CAM method will incorporate them into a CNC programme. The programmer will obtain visual feedback at each stage of the programme via a graphic CAM system. Another significant feature of the visual CAM system is the ability to simulate tool paths. It's a computer animation that shows how often the programme will run more on a CNC machine. If anything isn't working properly, improvements may be created by the programme is executed. This is known as 'proving the software.' When the programme is transmitted to the CNC, it is ready for activation within the CNC control itself. The application can be saved on the computer's hard drive, a floppy disc, or a USB memory stick when it is transferred back to the computer. In different CAM systems, the order of the definitions can vary, however, the definition in terms of mentioned information remains required during some cases meant for sufficient employment. The milling technology is the most significant application of CAM systems, therefore the milling technology will be focused on these studies.

## **2.7 3-Axis of CNC Milling Design**

The stepper motor was chosen, and a machine aluminium plate was utilised to construct the prototype's frame. The machine tool's "backbone" is its construction. It combines all machine components into a single system. Because it is typically used at faster speeds, A small device option gives much more rigidity than standard machinery on a huge scale. This building uses less material and so costs less to create. The guide rods are chosen to give correct motion for the machine while also being robust sufficient to sustain the machine weight table with all of the appropriate tools attached to it. It only has to support the weight of a tiny carriage and cutting tool, the Z-axis guiding system is generally smaller than the other two axes. Other hardware that is selected adapter, sliding bearing, nut holder, screw rod, power wire, spindle motor, power supply and support system which is window

10.



## 2.8 Type of G-Code in CNC Machine

The most frequently used computer numerical control (CNC) programming language is G-code, commonly known as RS-274. It has numerous variations and is mostly used in computer-aided manufacturing to operate automated machine tools. A machine controller receives G-code directives, which instructs the motors on where to go, which direction to choose and how rapidly to go. The two commonly prevalent possibilities are that Within a machine tool, such as a lathe or mill, a cutting tool is moved according to these instructions through a toolpath, cutting away material to retain just the completed product and/or an incomplete workpiece in any of up to nine axes from around three dimensions relative to a toolpath, and either or both can respond correctly to each other. Noncutting techniques such as shaping or burnishing tools, photo plotting, additive processes such as 3D printing, and measurement equipment are all covered under the same idea.

G-codes are any words in a CNC programme that start with the letter G. They are also known as preparation codes. In general, it is a code that instructs the precision machining on what sort of action to take, such as:

- Quick movement, for example, moves the tool as fast as feasible between cuts.
- Accurate feed in a straight line or an arc.
- A sequence of controlled feed motions that results in a hole being bored, a component getting cut in routed to a specified dimension, or a profile being inserted towards the edge of a workpiece.
- Configure tool data including offset.
- Change the coordinate systems.

From this G-code in milling machines, various letter addresses are utilized. For this project, variable G is chosen where G instructions are frequently used to inform the control of the desired kind of motion for example rapid positioning, linear feed, circular feed, fixed cycle or what offset value to use.



## 2.9 ISO 6983 Data Interface Model

This part of ISO 6983 characterizes details and gives ideas to an information design for computer numerical control frameworks that utilization the situating, line movement, and shaping control frameworks. This section of ISO 6983 helps in the coordination of device project as well as reduce the number of programme manuscripts needed, make programming approaches more consistent, and promote input interchangeability programmes between numerically controlled devices of the same kind by type, operation, feature, scale, and accuracy. Simple numerically operated devices are designed must be coded in an easy-to-understand style that is routinely extensible for other complicated machines. This section of ISO 6983 is not meant to be utilized in the advanced instances of numerically operated flame cutting machines and drafting machines used solely even in manufacturing business (International Organization for Standardization, 2009).

It's hardly unexpected that the CNC Data interface is a source of consternation in many facilities. One factor has been the variety of names used to specify CNC data ports. To mention a few, data port, serial port, communications interface, Behind-the-Tape-Reader Interface (BTRI), Direct Numerical Control (DNC) interface, and parallel port are some of the more prevalent terminologies. These phrases are frequently used in conjunction with ambiguous definitions and are included in equipment specifications. Because the aforementioned assertions are ambiguous, the CNC provider can obey not including specifying what capabilities will be given. Perhaps, an RS-232 interface may feature a complex protocol that allows for input validation and communication plan or might not have those features at all.

Those were three functions to utilise when designing a serial data interface: the link, the information protocol, and the capabilities to be offered. Here is the most fundamental component of the specification. It is the method via which data will be sent. Serial interface connectors include RS-232, RS-422, and RS-423. This level should also include the speed or baud rate. Realize that, while every single one of the aforementioned requirements offers a range of frequencies, the gap whereby the information must be conveyed is a significant barrier to feasible speeds. Furthermore, when using an error-checking protocol, speed is frequently lost.

This layer's functionality is frequently overlooked in user requirements. The user should specify what capabilities the programmer expects the interface to have at this level.

Downloading part programmes, tool data, probe data, machine type, handle cycle start/stop across the data line, defined machine error sign, and specialised CNC error sign are a few examples.

The preceding explanation was meant to cover those most important aspects of serial data interfaces in CNCs. It is important to note that every capability required at the CNC data interface will be programmed into a computer as well system if meaningful communications are to take place. The user must coordinate the organizations as a result into both ends of the data line while the appropriate interface tools are available whenever the time comes to utilize them.

The same factor combined this interpreter function. The data file control scheme allows access to upload ISO 6983 code through the system. Once uploading, the read function reads the whole strings of the input code and passes it to the line index function, which selects the process's beginning point. As default, this method returns zero, indicating that the procedure will begin with the initial line of data code. The data collection mechanism differs due to the varied file format of each data interface model. When compared to ISO 14649, ISO 6983 provides less information. However, the operation of its output data module is the same as described in the ISO 14649 translation module.

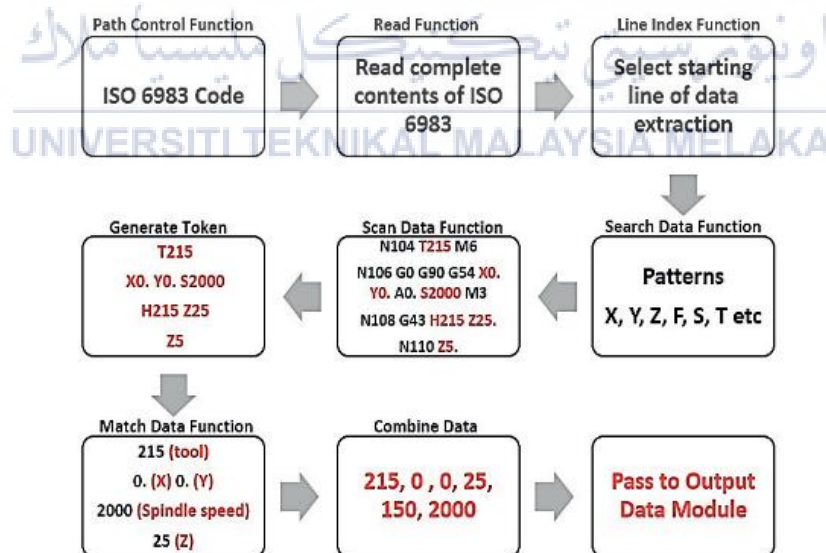


Figure 9 show Data Extraction Module ISO 6983

[Source: (Yusof and Latif, 2015)]

### 2.9.1 Module Software Platform

The created software platform is made up of three modules which are input, data extraction, and output. The input data module offers a route for file accessing, while the data collection module uses lexical and syntactic analysis to obtain data such as location, feed rate, spindle speed, tool, and so on. The final output signal device's role is to organise collected features based on the current machine's interior structure and interpret or create output in terms of user-defined.txt or.xml file types, as illustrated in Figure 10.

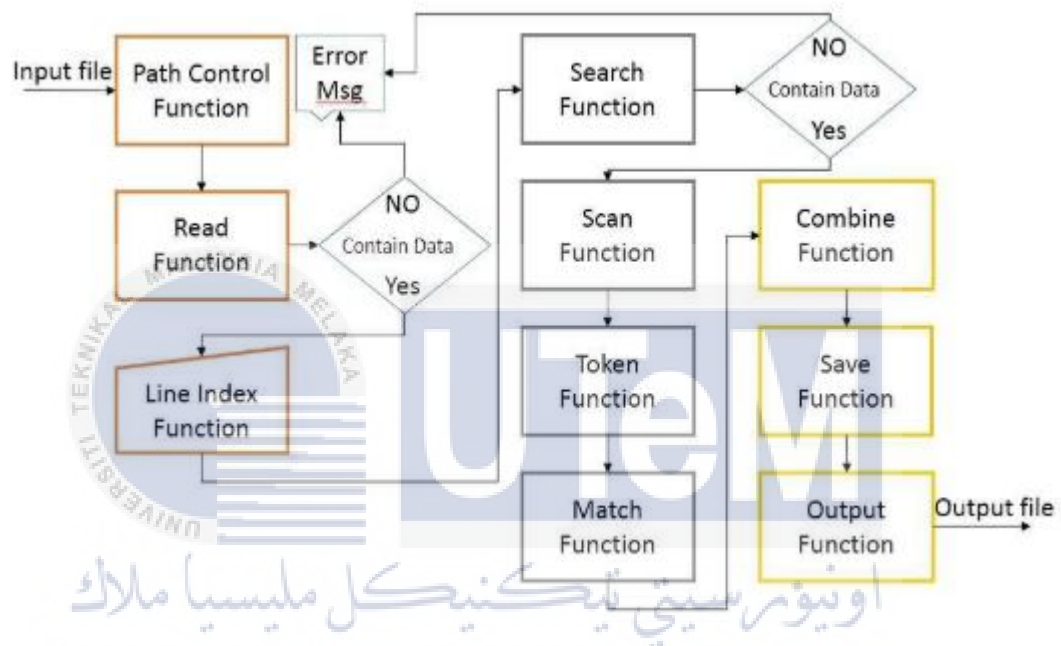


Figure 10 depicts the ISO 6983 translator's internal structure

[Source: (Yusof and Latif, 2014)]

### 2.9.2 Input Data Modules

The method constructs the location control mechanism for document uploading while also enabling the read info function, where it analyzes the whole contents of the input file. One such module also includes a line indexed mechanism that instructs the translator on where to begin reading the input file. Input path control, read input data, and line indexing are the three function blocks that make up this module.

It is the first step of the created product's functionality, which begins with the development of a route feedback signal obtain input raw data. The following phase of the receive file mechanism is performed after obtaining the system software path. This method

analyzes the whole of the input source. Therefore at end of the process, a line indexing function is created. This function's purpose is to instruct the translator on where to begin analyzing the code. When this operation is enabled, the interpreters can generate code from whatever line within the input file.

### **2.9.3 Data Extraction Modules**

This method looks in the input file for entity numbers. Then, every one of the detected item numbers is sent to the matches data function, which retrieves the complete data of the sought item numbers from the input data. The matching data is then passed towards the extracts data function, which mines the data according to its kinds, like entity names, values, and integers. Following that, the token function is called, where it converts all of the data extracted in string tokens then passes them to the data source function, which saves all of the information in its memory. The function of data combining would be performed at the end with this information extraction module, whereby merges every one of the collected tokens data into a single code and passes it to the tool path system component. This function produces tool routes based on the result of the combined data method. The created function uses extensive data interface model position, depths, feed rate, rotational speed, tool diameter, limit length measured, limitation plus minus such variables to produce tool paths during drilling, facing, and pocketing procedures. The data extraction module's functionality is shown in Figure 9.

This interpreting system's data collection module is made up of searching, visualizing, token, matching, and merging data structures. This module's functionality begins also with the search data function, where it looks for similarities within the supplied ISO 6983 code. Inside the input language, this function looks for F, S, T, X, Y, Z, and C patterns. Following the search, the check information function begins, which analyzes the contents of the discovered patterns within the input code and passes the values to the create token function, which splits the string into tokens. The tokens are then passed toward the match data function, where it mines all of the information extracted in accordance with their results, for example, for position patterns it mines the X, Y, and Z pattern values, and for T it mines the tool number. The merge input function is called at the end of that kind of function. This method combines all of the extracted data from the data extraction unit into a

singular piece of code that is then passed to the output signal module. Figure 9 depicts the capabilities of the ISO 6983 interpreter module.

#### 2.9.4 OUTPUT DATA MODULES

This module sends the output of its data collection modules toward the CNC machine controller's relevant components. The output data module is important in delivering data towards the machines controller system application together in a user-defined format file (.txt or.xml), for example, x-axis values to the x-axis servo/stepper motor and tool values towards the tool changers. The modules may also produce data files in.txt and.xml formats with a user-defined filesystem. Its produced output files could be utilised in any sort of PC-based open source CNC machine system. The output data module is seen in Figure 11.

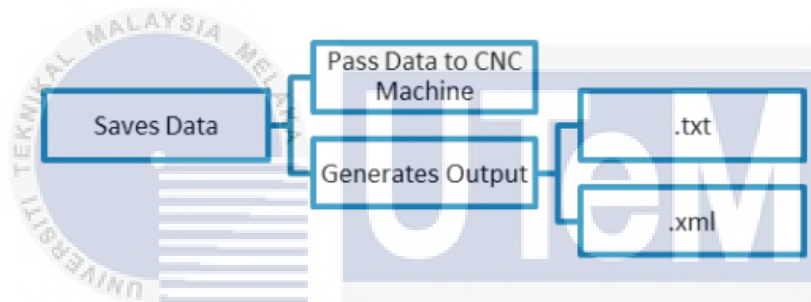
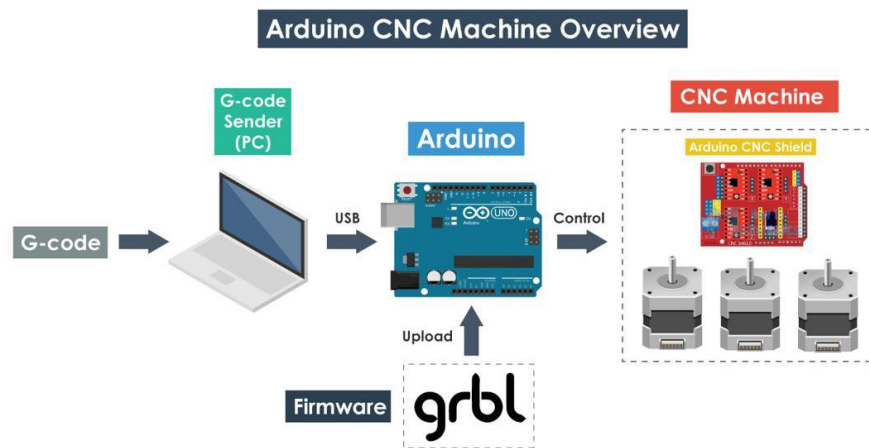


Figure 11 shows Output Data Modules

#### 2.10 CNC Controller Software

Numerous aspects must be prepared in order for the project's path to be as smooth as possible. A better idea by looking at the diagram below:



**Figure 12 shows Arduino CNC Machine Overview**

The graphic shows where the GRBL fit into the big scope of a CNC machine's operation. First, G-code must be done by the user then send to Arduino. It is firmware that must be installed or uploaded to the Arduino in order for it to operate the CNC machine's stepper motors. To put it another way, the GRBL firmware's job is to transform G-code into motor functions.

## 2.11 GRBL Software for Arduino

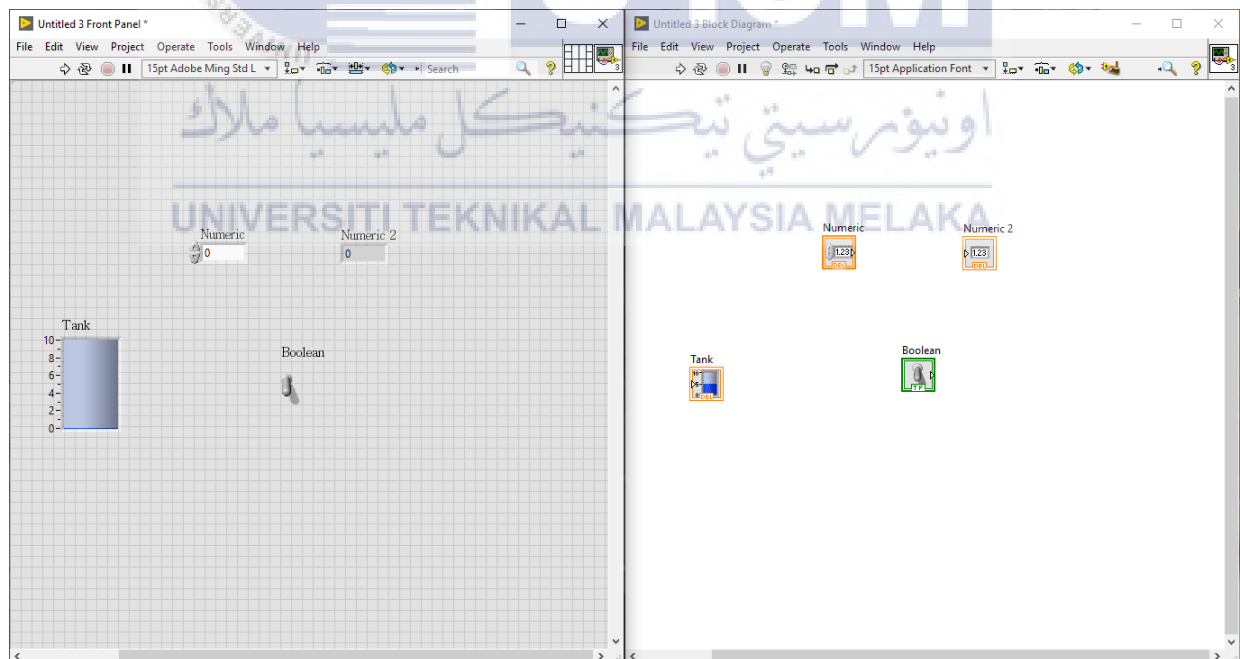
GRBL is free open-source software that was created as motion control for an Arduino microcontroller board, allowing an Arduino to be used to operate CNC machines. The GRBL software is operated on ATmega328-based microcontrollers, which are available on the majority of Arduino boards, and the GRBL Controller is software programmed to send G-code to CNC machines, such as 3D milling machines.

During this task, as the control unit, the Arduino Uno is used. The Arduino Uno is a microcontroller board that utilizes the ATmega328 microprocessor. G-code interpreter code written in C is flashed into the microcontroller board. The control board is in charge of generating the control signal for the equivalent control system from the mainframe toward the stepper motors, where regulate the tool path's movement instantly. As a stepper motor driver, an easy driver is employed. It takes the microcontroller's steps data and converts it into current electrical impulses that drive the motor.

## 2.12 Insight of LabVIEW

LabVIEW capabilities include interchangeable code libraries, support for constructing OUIs, the dataflow paradigm, and automated memory management. Software is divided into two parts by LabVIEW: a block schematic as well as a user interface which, during LabVIEW, is called the front panel. Without writing code, a computer operator in LabVIEW can sort, position, and configure any of the observable objects on the front screen. Furthermore, no code is required to link the input and output standards shown on the front panel to the consequent variables concerning a program's block diagram (Yang and Gao, 2010).

This system is separated into numerous function components based on the project and is written in the LabVIEW language. The LabVIEW technology is used to construct the component modules, with the master control module acting as a server and the other component modules acting as clients. A standard interface is used to communicate amongst all component modules. The master module identifies and loads modules when the system is operational. The use of this overall structure benefits CNC software openness and stability.



**Figure 13 shows the LabVIEW screen**

This LabVIEW is used as a visual component for this project. There are several functions on this software. The front panel is a VI's interactive user interface, so named since



this resembles the front panel of a physical instrument, as depicted in Figure 13. Knobs, pushbuttons, graphs, and a variety of additional controls that are user inputs and indications that are programme outputs can be found on the front panel. The user may enter data with a mouse and keyboard and then watch the output of his or her programme on the screen.

Figure 13 shows the block diagram, which is the source code for the VI written in LabVIEW's graphical programming language. The actual executable programme is represented by the block diagram. Lower-level VIs, built-in functions, constants, and programme execution control structures constitute the elements of a block diagram. To specify the flow of data between items, the user can draw wires to connect them. Front panel items have matching terminals on the block diagram, allowing data to flow from the user to the programme and back to the user.

The benefits of adopting LabView include graphical user interfaces in which design experts utilize the drag-and-drop user interface library to interactive customize the hundreds of developed consumer objects on the control's palette. Furthermore, because a single computer equipped with LabVIEW may be used for a wide range of applications and functions, it is a cost-effective and investment-protecting tool. Integrated instruments libraries may be built at below the price of a single typical, commercial instrument.

## 2.13 Hardware Specification

### 2.13.1 A4988 Motor Driver

The A4988 is a full Micro stepping Motor Driver with an integrated translator for simple operation. The maximum output capacity of the driver is 35 V and 2 A. It is capable of running bipolar stepper motors in full-, half-, quarter-, eighth-, and sixteenth-step modes. Because this motor driver contains low-ESR ceramic capacitors on board, it is susceptible to voltage spikes, hence it is recommended that a 47 $\mu$ f capacitor be used across the motor power supply ports. The wires from the stepper motor are linked to the driver module's output pins (1A, 1B, 2A, and 2B). It is often used to control stepper motors in the NEMA series, such as the NEMA17, NEMA23, and NEMA34.

<b>Minimum operating voltage</b>	<b>8 V</b>
<b>Maximum operating voltage</b>	<b>35 V</b>
<b>Continuous current per phase</b>	<b>1 A</b>



<b>Maximum current per phase</b>	<b>2 A</b>
<b>Minimum logic voltage</b>	<b>3 V</b>
<b>Maximum logic voltage</b>	<b>5.5 V</b>
<b>Microstep resolution</b>	<b>full, 1/2, 1/4, 1/8 and 1/16</b>
<b>Reverse voltage protection?</b>	<b>No</b>
<b>Dimensions</b>	<b>15.5 × 20.5 mm (0.6" × 0.8")</b>

**Table 1 shows A4988 Motor Driver Specification**

### **2.13.2 Spindle Motor**

The heart of any mill is the CNC spindle. It is made up of a revolving assembly with a taper into which tool holders may be inserted. The CNC spindle is rotated by a CNC spindle motor with a transmission of some type. The transmission fits the highest power rpm range of the CNC spindle motor to the spindle RPMs that are optimal for the material being cut's specific speeds and feeds. There are three varieties of spindles. Cartridge spindles are simply the rotating part without the motor or transmission. There are also numerous types of self-contained spindles. Spindles that are self-contained combine the rotating assembly with the motor. Finally, there are manufactured spindles, which have items like spindle bearings attached to a cast iron casing.

<b>Rated voltage</b>	<b>12V</b>
<b>No-Load Speed</b>	<b>18000±10% RPM/MIN</b>
<b>No-Load Current</b>	<b>0.85A</b>
<b>Diameter</b>	<b>28mm</b>
<b>Length excluding shaft</b>	<b>32mm</b>
<b>Shaft length</b>	<b>9mm</b>
<b>Weight</b>	<b>50g</b>

**Table 2 shows the 12V DC Motor Specification**

### 2.13.3 NEMA 17 Motor

The NEMA 17 is a hybrid stepping motor with a step angle of  $1.8^{\circ}$  (200 steps per revolution). Each phase consumes 1.2 A at 4 V, resulting in a holding torque of 3.2 kg-cm. Stepper motors with NEMA 17 ratings are commonly found in printers, CNC machines, and laser cutters. NEMA17 Stepper Motors are widely used in CNC machines, hard drives, and linear actuators. The motor is wired with six lead wires and has a rated voltage of 12 volts. It may be run at a lower voltage, but the torque will suffer as a result. These motors have a step angle of 1.8 degrees, which means that it has 200 steps for each revolution and that each step covers a 1.8-degree angle, resulting in a high level of control. These motors operate on 12V and so have a high torque capacity.

<b>Rated Voltage</b>	<b>12V DC</b>
<b>Current</b>	<b>1.2A at 4V</b>
<b>Step Angle</b>	<b>1.8 deg</b>
<b>No. of Phases</b>	<b>4</b>
<b>Motor Length</b>	<b>1.54 inches</b>
<b>Operating Temperature</b>	<b>-10 to 40 °C</b>
<b>Unipolar Holding Torque</b>	<b>22.2 oz-in</b>

**Table 3 shows NEMA 17 Motor Specification**

### 2.13.4 Board Arduino Control Shield

Arduino Shields are add-on boards that can be plugged on top of an Arduino board and provide additional capabilities and functionalities to an Arduino Board. They have the same pin position as an Arduino Board and are usually designed to implement a specific function. While it is easy to play around with Arduino by placing components on a breadboard, it is not a preferable option to design a final product with breadboards. With the help of Arduino Shields, Sensor Boards and other expansion boards, you can significantly reduce the complexity of wiring the circuit and at the same time reduce the build time and construction process.

## CHAPTER 3

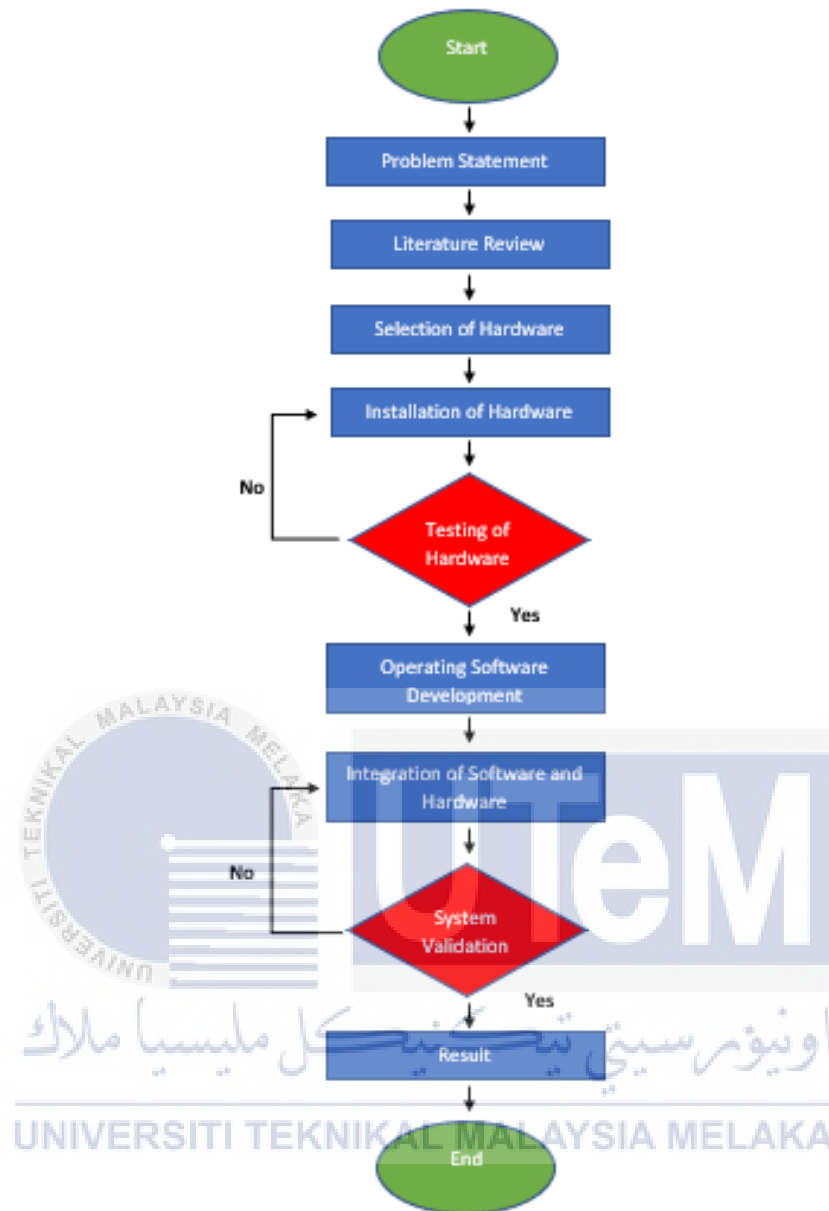
### METHODOLOGY

#### 3.0 Introduction

This section represents the system used for this project. The Development of Visual Component Technology Based CNC Machine System for ISO 6983 Data Interface Model is proposed for CNC motion control system for a three-axis milling machine. The development steps in this study are described accordingly. LabVIEW technology software is used in this project. Besides, The CNC machine is designed for precision stepper motors to work in tandem with lead screws to move the axis smooth manner on linear bearings, resulting in more exact output.

#### 3.1 Flow Chart

The initial part of the project is mainly focused on the three chapters of introduction, review of literature, and methodology. At this stage, the issue definition, objectives, scope, and project-related information have been gathered from various sources. This is a sequence diagram that will be used to represent the flow of processes in this entire project. The flow chart will outline the methods required to assure the end output in order to meet the project's aim.



**Figure 14 shows the Flow Chart of Methodology Process**

The development steps in this study are depicted in Figure 14. The project starts with an initial inquiry and background study on existing research to fill the research gap, establish the aims, importance of the study, and addition to the body of knowledge. The scope of the study is to focus on the CNC motion control system for a three-axis milling machine that incorporates virtual components in order to complete ISO 6983 for this project. The knowledge acquisition on the CNC system for ISO 6983 Data Model Interface and other relevant information is gathered from published journals, conference papers, theses, books, and white papers.

The initial step towards making this selection is to comprehend the goal framework as well as the environment in which the system will operate. At this stage, system configuration requirements are created, and the decision to obtain the system is made by a selection hardware such as adapter, sliding bearing, nut holder, screw rod, power wire, spindle motor, power supply and support system is window 10.

Installation of hardware for this project consists of part program, where the motorised scheme is built in a rather way that the three-dimensional motion is accomplished through the use of linear bearings and guide rods. Stepper motors are installed on their respective axis and operate as the basis of motion in response to the control motion supplied by the microelectronics circuit. With the use of a coupling bush, each stepper motor is attached to a screw rod that bears a nut. The screw rod and nut arrangement are in charge of transforming the stepper motor's rotating motion to linear motion. The linear bearing and guide rod assembly attached to each axis, can carry loads and permit linear movement along each axis, carrying out the linear motion of each axis smoothly. Controlling the rotation of the stepper motor directly results in regulated motion in each axis. Each axis's speed of motion may also be governed directly by controlling the speed of the stepper motor with the necessary command indicators. As a result, the tool path of the spindle attached towards the end effector is regulated in each axis enabling smooth carving or cutting of the workpiece. Linear rods are rigid, robust steel shafts that sustain linear movement by carrying weight without altering the motion. The linear bearing carries the weight away and decreases friction glides over linear rods. Element program, system input device, machine control unit, drive system, machine tool and feedback system are the process of installation.

The hardware is tested by giving the code and receiving the response. Testing is required to guarantee that every component of a system is functioning properly and that the system is working perfectly in compliance with local regulations. In this project, testing is thoroughly organized to guarantees that all parts of a system are examined. Among the testing procedures that might be used are including:

- Generate the power supply.
- Make microcontroller board.
- Get stepper motor driver board.
- Input the G code on the software.

In this project, the Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is used as an operating software for test, measurement, and control applications that demand quick access to hardware and data insights.

The hardware and software are integrated in order to effectively manipulate data and produce useful output. In this project, the CNC milling machine is used as a hardware and the G code is used as a language. Power supply, microcontroller board and stepper motor driver board hardware are chosen to generate the project. The item designate machined is developed with computer-aided design (CAD) software, the result of which is one of several drawings suitable forms, the most preferred format being .stl. This design is then input into computer-aided manufacturing (CAM) software, the result of which is machine-readable code used to drive the machine numerically. Because G code implementation is machine dependant, it is required to evaluate several options for a G code translator that is free software for the Arduino in order to achieve the right movements for the machine axes via the stepper motor driver. GRBL, an open-source G-code interpreter or milling controller for the Arduino development board, was utilised in this project.

System of Validation is a collection of operations that formerly ensure that any component, such as a system component, a document, a service, a task, a system requirement, and so on is in accordance with its purpose and functions. The goal of validation for this project is to ensure that any activity output was in accordance with the activity's inputs.

### **3.2 Hardware Configuration**

The first step in making this decision is to understand both the objective concept and the environment whereby the system will function. At this point, system configuration parameters are determined, and the choice to purchase the system is influenced by hardware choosing. Configuration settings on hardware devices can influence the overall functioning and performance of the system.

The CNC machine receives instructions from the Arduino. On the CNC shield, we have attached the stepper motor driver A4988. This stepper motor driver A4988's output is sent to the appropriate stepper motor. The board travels front and back because of the X axis stepper motor. The spindle rotates left and right owing to the Y axis stepper motor, while

the tool moves up and down due to the Z axis servo motor. The Z axis servo motor provides the depth to the spindle.

### 3.3 Hardware Flow System and Specification

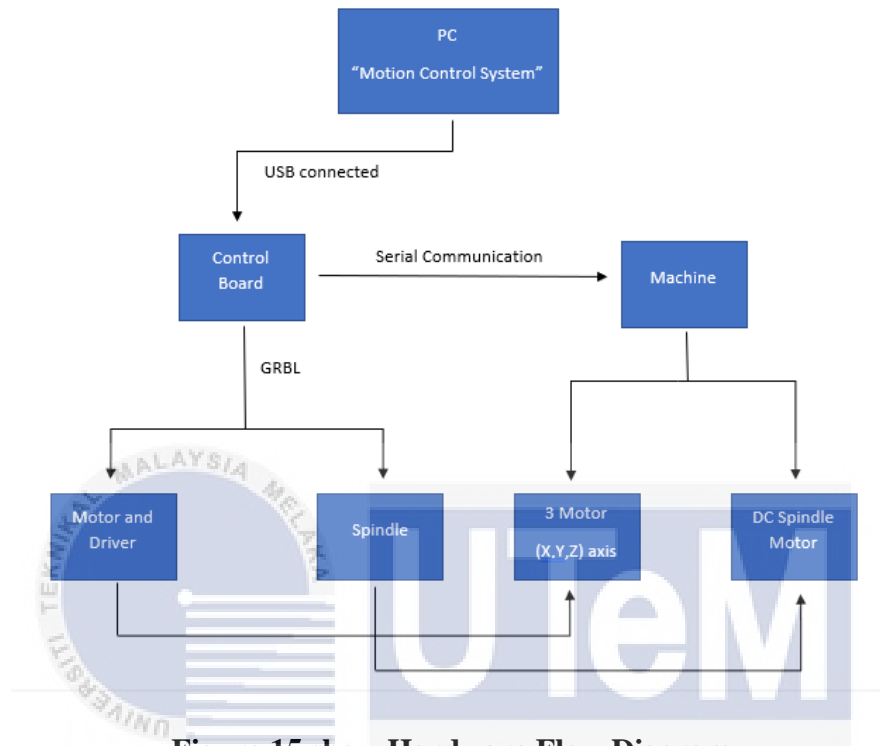


Figure 15 show Hardware Flow Diagram

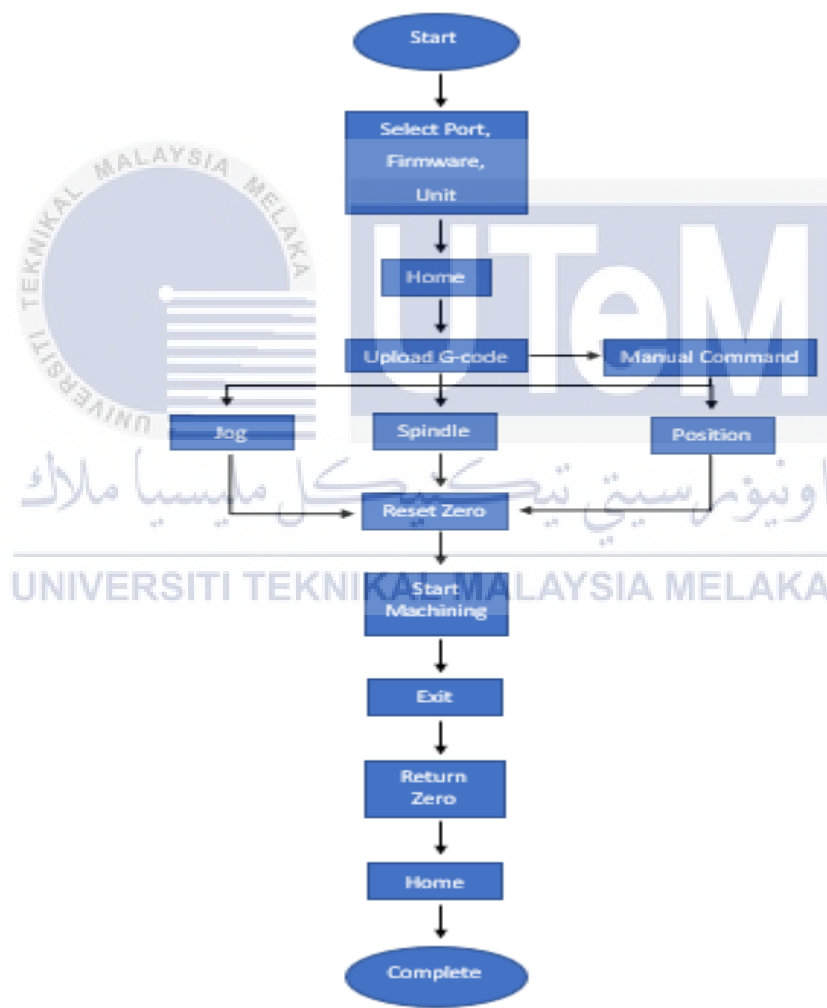
The Arduino Uno microcontroller core platform serves as the foundation for this project. Connecting to computers, drivers, and stepper motors is also straightforward. The Arduino IDE software will be used to dump the programme, after which it will be transmitted to the Arduino compiler. The drive circuit was created to power the mechanical equipment and communicate with the computer through software. This study will look into a CNC machine's ability to produce its components. A Mini CNC Milling Machine is a small machine that a computer controls the machine's axes through motors.

The stepper motors are powered and controlled by a driver. These stepper motors are connected to servo motor lines on the X, Y, and Z axes. G-code is a computer numerical control (CNC) programming language that is used in computer-aided design and manufacturing (CAD/CAM) (CNC). The g-code on the computer tells the CNC machine how far and fast it should move. The G-code is connected to the Arduino microcontroller, which serialises the code to a USB converter. Additionally, this code is

delivered to three motors using simple drivers, who translate the code and move the three motors as ordered.

### 3.6 Software Configuration

Networking, axis control, simulator, alarm, monitoring, and report output are among the program's sub-components. Virtual component technology is used to generate the entire software. The connectivity component is in charge of establishing a USB connection between the computer and the microcontroller.



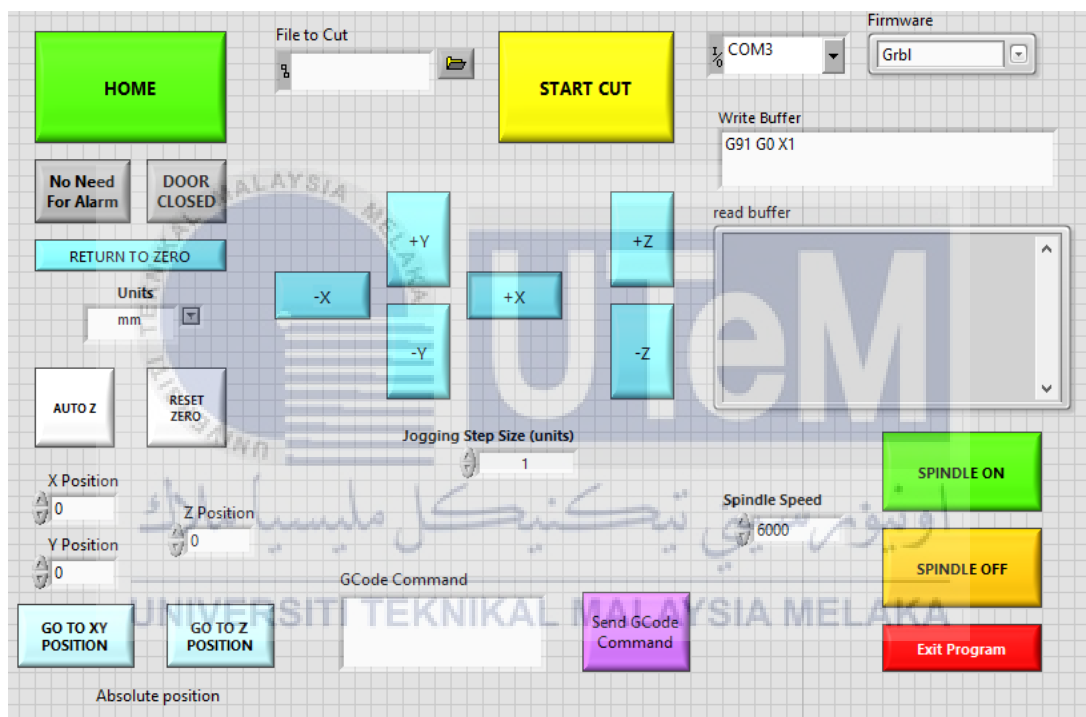
**Figure 16 shows the System Working Mechanism**

This hardware can interface with a variety of firmware, including grbl, Mach 3, and marlin, to name a few. It is made up of port, firmware, and unit modules that allow users



to choose between a connected USB port, microcontroller firmware, and operational units.

Jog, spindle position, start machining, home, and reset to zero. The jog module is in charge of manually driving the machine axis motors with a set of federate and step size values. The location module directs the machine's movement to exact coordinates. The spindle module allows you to manually control the machine's spindle. The entire G code component programme may be run via the start machining module. The machine is returned to its original place via the home module. The reset zero module resets the machine's zero position, whereas the return to zero module restores it.



**Figure 17 shows Operating System GUI**

As illustrated in Figure 2, the operating system's graphical user interface (GUI) is separated into two tabs: main and simulator. On the left side of the main tab, you'll find the upload file, G code display and editor, manual command control, and command indication. The exit, start machining, reset zero, return to zero, and preview file control buttons are located on the right side of the screen. In the centre, will find connectivity, jog, position, and spindle control buttons.

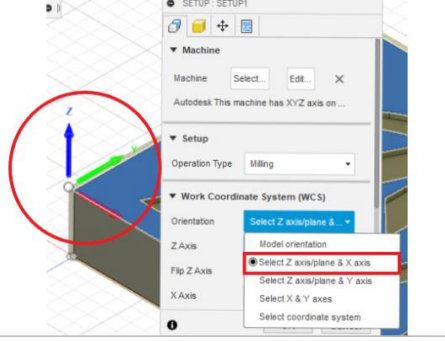
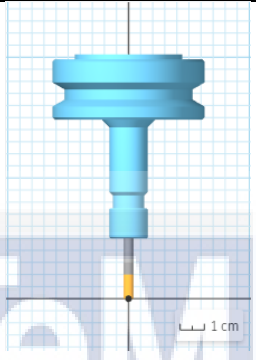
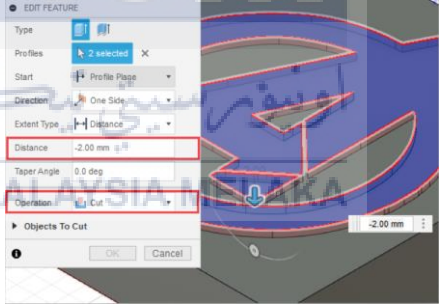
### **3.7 Integration of Software and Hardware**

This module's first function is the tool path generator, which takes the combined code of the abstraction module as input and creates tool routes based on the values of the combined code. The facing, drilling, and pocketing tool path generator sub-functional blocks are part of the tool path generator function. The activation of a sub-function is identified by the process names included in the abstraction module's combined code. Following the development of the tool path, the module sends the data to the output function, which transfers the data to the relevant hardware components of the CNC machine controller. The output function is critical in correctly transferring data to the machine controller hardware elements for example, axis values go to the relevant X, Y, and Z axis servo/stepper motors, tool values go to the tool changer, and so on. At the same time, using the physical file generator function, this module may produce physical output files with user-defined structures in.txt and.xml formats. The produced files are suitable for usage in any PC-based open architecture CNC machine system.

### **3.8 Experimental Setup**

In this study, various experiments have been performed for a developed interpreter. In this section are discussed system generated ISO 6983 file and generated output in user text. This experiment is to run the program while cutting the workpiece on a selected design by using CAD/CAM system developed interpreter and Mini CNC Milling Machine.

The design process started with this experiment, were designed by using CAD/CAM software. Before generating ISO 6983 code, need to design CAM machine features that are given to the design. After the generation of ISO 6983 code, the next step is to upload code in a developed interpreter. Following the production of ISO 6983 code, the following step should be to enter the code into the constructed interpreters. Before beginning the interpreting procedure, the output file was configured according to the specifications of the produced interpreter's setup tab. After finished configuring everything, run the code, and save the result file in.txt form. The interpreted code is then passed to the machine, where operations are carried out.

<p>Orientation</p>	 <p>Orientate the tool to the machine component or feature at any angle that differs from a 3-axis orientation.</p>
<p>Tool Diameter</p>	 <p>Sizing of tool selection</p>
<p>Cutting Depth</p>	 <p>Depth of tool goes to cut</p>

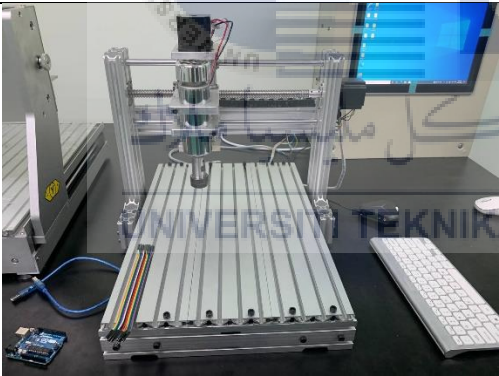

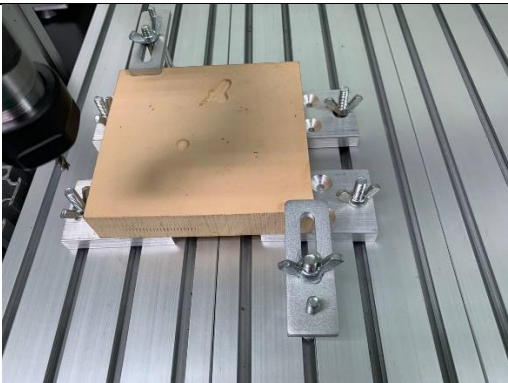

**Table 4 shows list of parameters to run the machine**

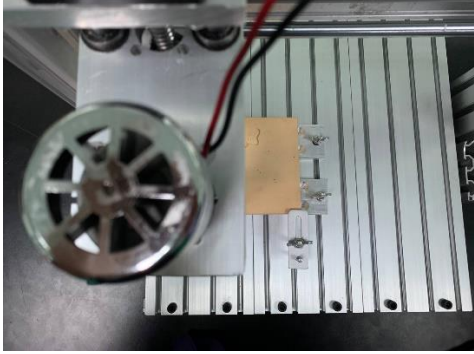
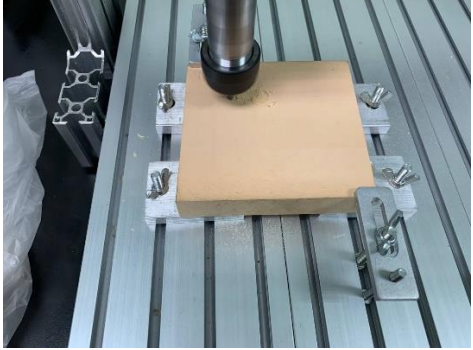


**Figure 18 shows Wooden Block**

This wooden block size is 100 mm in length, 100 mm in width and 20 mm height. This workpiece will be cut by the selected design.

### 3.9 Step On Doing the Experiment

	
<p>1. Insert the file into the software.</p>	<p>2. Select the workpiece.</p>
	

3. Clamp the workpiece and make sure it is not easy to move.	4. Test run the machine.
	
5. Set zero on the X-axis, Y-axis and Z-axis.	6. Start the experiment.

### 3.10 Summary

The proposed of this project was to develop a three-axis soft CNC motion control system for a three-axis milling machine incorporating virtual component to execute ISO. This project only influences the motion of a three-axis milling unit and just operate with the GRBL controller, which appears to be able the hardware using G-Code. The project design focused on a small CNC which is a small CNC milling machine. This paper presents a concept for the application of a new method of programming using the LabView standard. The comparative analysis of existing and programming methods and the basic structure of the operating system Graphic User Interface (GUI) format are shown. In comparison to a standard CNC system, the experimental system achieves a balance between computing capabilities and network communication burden, as well as the quality of service (QoS) in the network and quality of performance (QoP) in control. These experiments have confirmed that it is possible to realise scenarios for programming CNC machine tools based on G-code programs.

## CHAPTER 4

### RESULT AND DISCUSSION

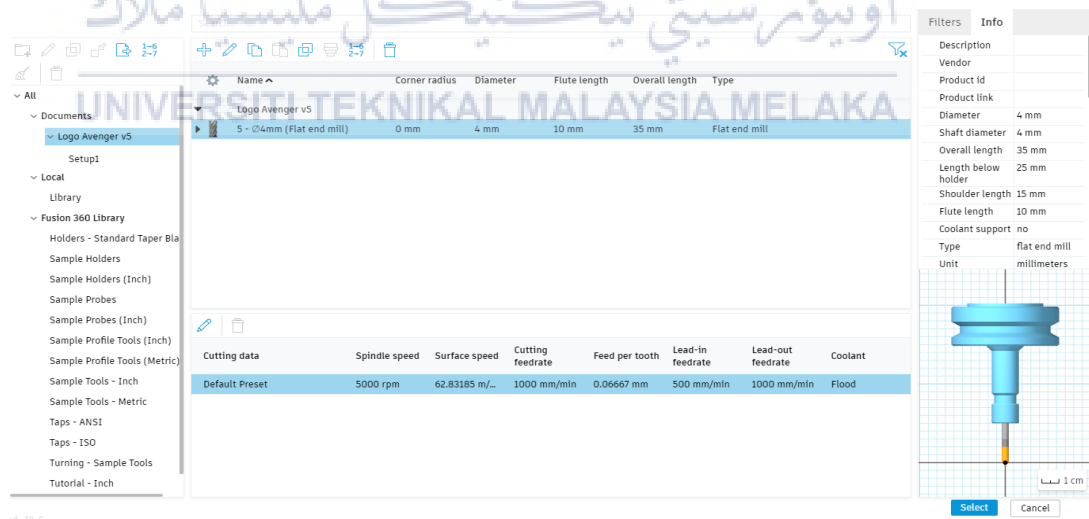
#### 4.0 Introduction

This chapter explained the results and the experiment of the CNC system. The flow chart diagram was done to identify and record the results obtained. Furthermore, this chapter highlighted the details of the flow chart diagram from the hardware to the software parts and the experiment results obtained. The result shows that the CNC machine carries out the milling process on the G-code that is sent into the CNC machine. Hence, the summary described the whole findings for this chapter.

#### 4.1 Results

##### 4.1.1 Parameter 1

The first design is using a 4 mm diameter. The first design has been successfully done and the process is run by a Mini CNC Milling machine. Before the CNC process is run, the process of generating the G-code has been made.



**Figure 19 shows the tools setting for First Design**

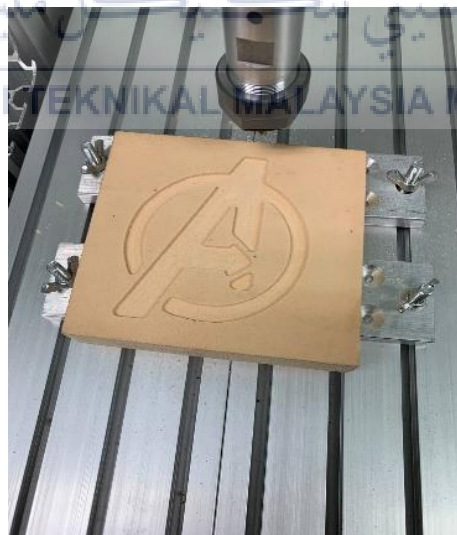
From figure 19, it shows that selected tool for this design. When using this tool, it already set for spindle speed, cutting feedrate and so on.



Group	Parameter	Edit All	2D Pocket2 [2D Pocket]	2D Contour1 [2D Contour]
Passes	Origin	Setup WCS origin	Setup WCS origin	Setup WCS origin
Passes	Pocket Selections	< not editable >	Selection	
Passes	Select Same Plane Faces	< not editable >		No
Passes	Side	< not editable >		Start outside
Passes	Stock Point	Selection	Selection	Selection
Passes	Stock Selections	Selection	Selection	Selection
Passes	Surface Point	Selection	Selection	Selection
Passes	Tool Orientation	Setup WCS orientation	Setup WCS orientation	Setup WCS orientation
Passes	Tool Orientation Origin	Selection	Selection	Selection
Passes	Tool Orientation X Axis	Selection	Selection	Selection
Passes	Tool Orientation Y Axis	Selection	Selection	Selection
Passes	Tool Orientation Z Axis	Selection	Selection	Selection
Passes	Use Stock Contours [G]	< same, expressions differ >	No	No
Passes	Clockwise Spindle Rotation [R]	Yes	Yes	Yes
Passes	Tool Body Length [R]	25 mm	25 mm	25 mm
Passes	Tool Corner Radius [R]	0 mm	0 mm	0 mm
Passes	Tool Diameter [R]	4 mm	4 mm	4 mm
Passes	Tool Shaft Diameter [R]	4 mm	4 mm	4 mm
Passes	Tool Shoulder Length [R]	15 mm	15 mm	15 mm
Passes	Tool Taper Angle [R]	0 deg	0 deg	0 deg
Passes	Tool Thread Profile Angle [R]	0 deg	0 deg	0 deg
Passes	Tool Tip Angle [R]	0 deg	0 deg	0 deg

**Figure 20 shows list parameter for First Design**

According to figure 20, this are the list for parameter 1 where the tool orientation was started. Selection which means that the origin position for x-axis, y-axis, and z-axis at the stock.



**Figure 21 shows result for First Design**

```

(Coding Design 1)
(Machine)
( vendor: Autodesk)
( model: Generic 3-axis)
( description: This machine has XYZ axis on the Head)
(T5 D=4 CR=0 - ZMIN=-4 - flat end mill)
G90 G94
G17
G21

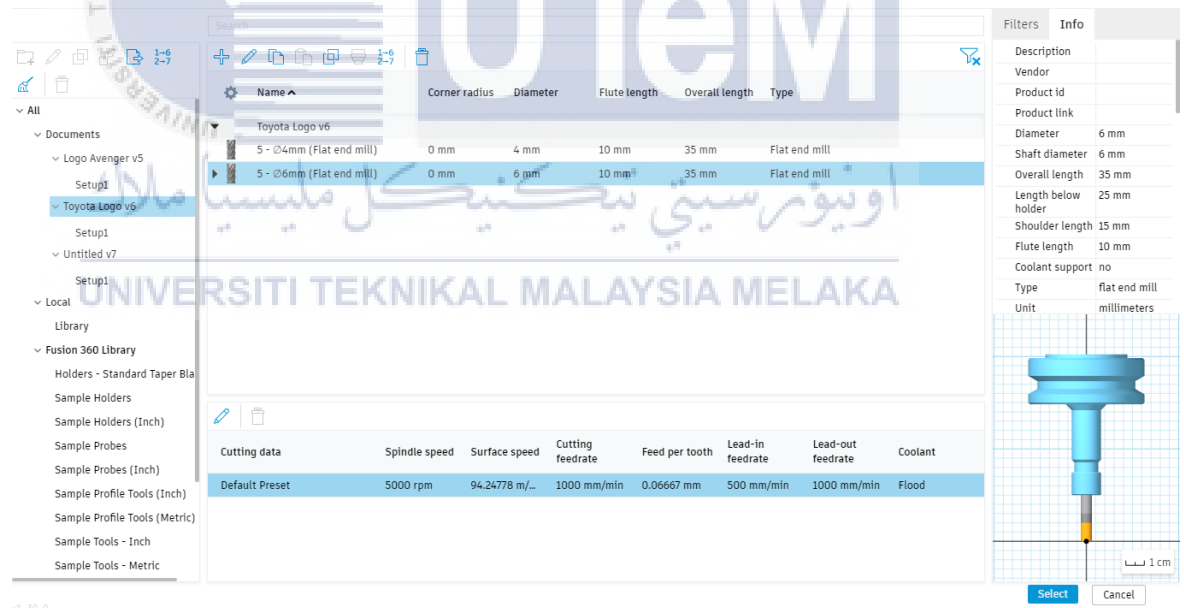
```

**Figure 22 shows coding tool parameters for First Design**

This are the coding where D represent for diameter 4 mm and Z minimum is cutting depth for tool to go in z-axis only.

#### 4.1.2 Parameter 2

The second design was using a 6 mm diameter tool with a flate end mill. From the design, this tool diameter is relevant to use because the cutting depth is not too big. It is just a medium size for this machine and can cut in a short time.



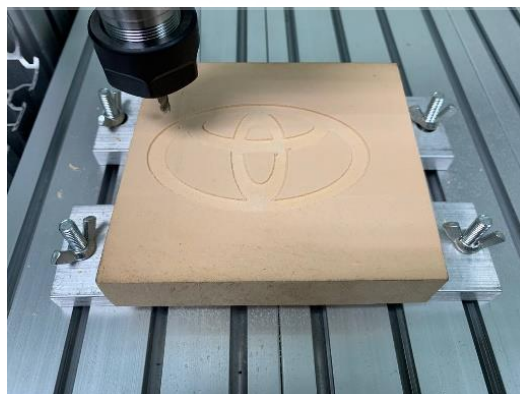
**Figure 23 shows tool setting for Second Design**



Group	Parameter	2D Adaptive 1 [2D Adaptive Clearing]
Passes	Origin	Setup WCS origin
Passes	Pocket Selections	Selection
Passes	Stock Point	Selection
Passes	Stock Selections	Selection
Passes	Surface Point	Selection
Passes	Tool Orientation	Setup WCS orientation
Passes	Tool Orientation Origin	Selection
Passes	Tool Orientation X Axis	Selection
Passes	Tool Orientation Y Axis	Selection
Passes	Tool Orientation Z Axis	Selection
Passes	Use Stock Contours [G]	No
Passes	Clockwise Spindle Rotation [R]	Yes
Passes	Tool Body Length [R]	25 mm
Passes	Tool Corner Radius [R]	0 mm
Passes	Tool Diameter [R]	4 mm
Passes	Tool Shaft Diameter [R]	4 mm
Passes	Tool Shoulder Length [R]	15 mm
Passes	Tool Taper Angle [R]	0 deg
Passes	Tool Thread Profile Angle [R]	0 deg
Passes	Tool Tip Angle [R]	0 deg
Passes	Tool Tip Diameter [R]	4 mm
Passes	Tool Tip Length [R]	0 mm

**Figure 24 shows list parameter for Second Design**

Adaptive clearing are seemly for this process. World Coordinate System (WCS) define the location of all object and standard views.



**Figure 25 shows Second Design That Have Been Selected**

```

(Coding Design 2)
(Machine)
( vendor: Autodesk)
( model: Generic 3-axis)
( description: This machine has XYZ axis on the Head)
(T5 D=6 CR=0 - ZMIN=-2 - flat end mill)
G90 G94
G17
G21

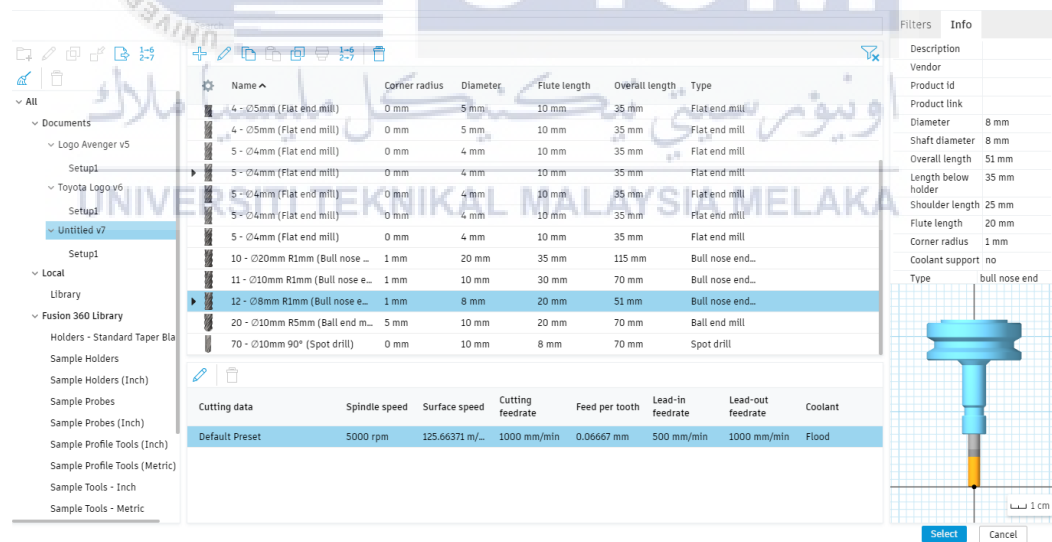
```

**Figure 26 shows the coding tool parameter for Second Design**

D represent for tool diameter is 6 mm and Z min is minimum for tool movement for Z-axis. The tool diameter changes for second design. Besides, the minimum for Z-axis change to 2 mm.

#### 4.1.3 Parameter 3

The third design was a mechanical part where use an 8 mm diameter tool. This design has a 10 mm diameter where it needs to fix with tool diameter to cut all the way through.



**Figure 27 shows tool setting for Third Design**

Group	Parameter	Edit All	2D Contour2 [2D Contour]	2D Pocket2 [2D Pocket]
Passes	Origin	Setup WCS origin	Setup WCS origin	Setup WCS origin
Passes	Pocket Selections	<not editable>		Selection
Passes	Select Same Plane Faces	<not editable>	No	
Passes	Side	<not editable>	Start outside	
Passes	Stock Point	Selection	Selection	Selection
Passes	Stock Selections	Selection	Selection	Selection
Passes	Surface Point	Selection	Selection	Selection
Passes	Tool Orientation	Setup WCS orientation	Setup WCS orientation	Setup WCS orientation
Passes	Tool Orientation Origin	Selection	Selection	Selection
Passes	Tool Orientation X Axis	Selection	Selection	Selection
Passes	Tool Orientation Y Axis	Selection	Selection	Selection
Passes	Tool Orientation Z Axis	Selection	Selection	Selection
Passes	Use Stock Contours [G]	<same, expressions differ>	No	No
Passes	Clockwise Spindle Rotation [R]	Yes	Yes	Yes
Passes	Tool Body Length [R]	25 mm	25 mm	25 mm
Passes	Tool Corner Radius [R]	0 mm	0 mm	0 mm
Passes	Tool Diameter [R]	4 mm	4 mm	4 mm
Passes	Tool Shaft Diameter [R]	4 mm	4 mm	4 mm
Passes	Tool Shoulder Length [R]	15 mm	15 mm	15 mm
Passes	Tool Taper Angle [R]	0 deg	0 deg	0 deg
Passes	Tool Thread Profile Angle [R]	0 deg	0 deg	0 deg
Passes	Tool Tip Angle [R]	0 deg	0 deg	0 deg
All			OK	Cancel

Figure 28 shows list parameter for Third Design



Figure 29 shows Third Design That Have Been Selected

```
(Coding Design 3)
(Machine)
( vendor: Autodesk)
( model: Generic 3-axis)
( description: This machine has YXZ axis on the Head)
(T5 D=8 CR=0 - ZMIN=-5 - flat end mill)
G90 G94
G17
G21
```

**Figure 30 shows the coding tool parameter for Third Design**

Flat end mill is the tool type. D=8 which mean diameter tool is 8 mm and Z min represent for minimum movement for tool on Z-axis.

## 4.2 Summary

In summary, each design was successfully run by the CNC and there has no error on the G-code. Therefore, the project solely affects the motion of a three-axis milling unit and uses the GRBL controller, where it seems to be capable of controlling the hardware through G-Code. The system's design was centred on a mini-CNC milling machine. These designs are comparable with the tool parameter of the CNC system and sufficient for a conventional 3-axis milling processing. This program may enhance users' lives easier by extracting entire data from high-level code and displaying it in an easy-to-understand manner on the GUI. It divides the extracted data of setup, workpiece, coordinates, locations, depth, tool, tolerance, and so on into different sections to help the user comprehend the content of the input file and gives choices for quick data adjustment as needed.

## CHAPTER 5

### CONCLUSION AND RECOMMENDATION

This chapter inspects the conclusion for the whole project of the Mini CNC system for ISO 6983 Data Interface Model and recommendation for future work and research. The experiment and results of the project have culminated, and the recommendation is being analysed for more efficient work and functions for the upcoming Mini CNC system.

#### 5.0 Conclusion

Networks and open architecture CNC systems are becoming popular. To be highly efficient and compatible, the CNC system's communication platform must be very effective and adaptable. Adoption of real-time Ethernet technology and the development of network interaction mode are two methods for boosting efficiency and interoperability. The main objective of this project had been accomplished when the system was successfully integrated development system using a three-axis CNC milling machine to implement the production method. Furthermore, in this work, a software system for CNC controllers was developed, this module is capable of translating ISO 6983 data interface model code according to the machine internal structure.

This programme simplifies users lives by extracting entire data from low-level and high-level code and displaying it in an easy-to-understand format on a graphical user interface. It separates all of the collected data from the setup, workpiece, coordinates, locations, depth, tool, and tolerance into different sections to help the user comprehend the content of the input file, and it also allows for quick data update as needed. The expected results in the previous chapter also were managed to be the actual results where the G-code can be generated and run the software.

Furthermore, the expected result showed the inputs and the outputs of the proposed CNC that applied in software platform which applied to monitor and control the machine. Thus, this showed that this project can improve the quality of the machine, the need to reduce

human errors, reduce wastage and maintain high quality and precision are some intrinsic properties driving the potential volume for CNC milling machines.

## 5.1 Recommendation

In future of this project, will be implemented on 3D Printing and Laser Cutting. In addition, the software will be modified to enable new capabilities, such as automated and precise tool path creation, response, monitoring, and safety checks GUI improvement.



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## APPENDIX



# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA

TAJUK: **DEVELOPMENT OF VIRTUAL COMPONENT TECHNOLOGY-BASED CNC SYSTEM FOR ISO 6983 DATA INTERFACE MODEL**

SESI PENGAJIAN: **2020/21 Semester 1**

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WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Project Briefing																													
Find Problem Statement									M I D													M I D							
Literature Review																													
Methodology																								S E M					
Project Proposal written									S E M																				
Submit Project Proposal																							B R E A K						
Start doing LabView Software																													
Testing of Hardware																													
Operating Software Development																													
Report draft																													
Final Report and Submission																													
Presentation																													

### Parameter Coding Design 1

```

(Coding Design 1)
(Machine)
( vendor: Autodesk)
( model: Generic 3-axis)
( description: This machine has XYZ axis on the Head)
(T5 D=4 CR=0 - ZMIN=-4 - flat end mill)
G90 G94
G17
G21

```

### Parameter Coding Design 2

```

(Coding Design 2)
(Machine)
( vendor: Autodesk)
( model: Generic 3-axis)
( description: This machine has XYZ axis on the Head)
(T5 D=6 CR=0 - ZMIN=-2 - flat end mill)
G90 G94
G17
G21

```

### Parameter Coding Design 3

```

(Coding Design 3)
(Machine)
( vendor: Autodesk)
( model: Generic 3-axis)
( description: This machine has YXZ axis on the Head)
(T5 D=8 CR=0 - ZMIN=-5 - flat end mill)
G90 G94
G17
G21

```

## Turnitin

All chapter

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