Design, Contraction & Perform Test of Three Axis CNC Milling Machine

A Thesis
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Thanks to Mill Operator's Manual Next Generation Control 96-8210 Revision F
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Abstract

This project outlines the design and components of a 3 axis CNC Milling machine controlled by an Arduino UNO micro-controller. The system integrates a NEMA 17 stepper motor, Motor Driver Shield v3, A4988 Motor Driver, and a 775 DC motor (12V) for precise and controlled movement. Linear bearings (12mm), shaft rods, and 608zz bearings contribute to the smooth motion of the machine. The inclusion of an 8mm CNC screw nut and patch rod, along with a 5*8mm pulley, ensures accurate linear and rotational motion. Power is supplied through a 12V adapter with a female connector. This comprehensive setup allows for versatile CNC operations, showcasing a blend of precision and adaptability in the fabrication process.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 Introduction

In the realm of computer numerical control (CNC) machining, precision and versatility are paramount. This project introduces a 3 axis CNC Milling machine, a sophisticated tool designed for a diverse range of fabrication tasks. At its core, an Arduino UNO micro-controller orchestrates the functionalities, providing a scalable and programmable control platform. The incorporation of a NEMA 17 stepper motor, Motor Driver Shield v3, and A4988 Motor Driver ensures meticulous control over the machine's movements.

Complementing the precision-oriented components are the mechanical elements, including 12mm linear bearings, shaft rods, and 608zz bearings, which collectively contribute to the seamless and accurate motion of the CNC machine. The inclusion of an 8mm CNC screw nut and patch rod, along with a 528mm pulley, signifies a robust mechanism for managing linear and rotational actions. Powering this CNC system is a 775 DC motor operating at 12V, offering both strength and reliability. The 12V adapter, equipped with a female connector, serves as the lifeblood, supplying power to drive the motors and control the electronic components.

This introduction sets the stage for exploring the intricate design and capabilities of the 3 axis CNC Milling machine, showcasing a synergy of cutting-edge technology and mechanical prowess for precise and adaptable fabrication processes. Drilling is a cutting and removal of material process in which holes are made or enlarged with the help of a multi point sharp cutting tool. Other machining techniques that include drilling are, Reaming, trepanning, counter boring and boring. All of these techniques when paired with a linear feed gets to have the same movement. The two different types of drilling are short hole and deep hole drills.

The drilling process can be associated to turning in number of ways but the requirements for chip breakage and chip extraction are increasing. In drilling, this is important. The hole dimensions, as well as the size of the hole puts a limit to the amount of machining that needs to be done. The deeper the hole, the harder it is to maintain process control. Along with high quality, another important aspect to be considered is a high material removal rate. The main aim of our project is to study about this 3 axis CNC Milling machine holes in horizontal, vertical and upside down direction, providing us ease in drilling complicated parts. Connecting arms play a crucial role as with the help of them, we may be able to drill in any axis and any degree as per the requirement. Due to this setup, we can get more accuracy of drilling in the workpiece and eliminate the different needs of different drilling machines. Proper selection of material plays a very important role. The material chosen should be such that it is able to sustain the force and vibrations that are caused by the drilling operations.

The materials and components which we would be selecting for our project would resist any kind of vibrations and would make the setup rigid to make accurate drilling. The cost of handling and manufacturing cost is low in this machine compared to the old and traditional drilling machines. This 3 axis CNC Milling machine is not needed by skilled laborers as it is easy to handle and operate the drilling machine. Another highlight of this drilling machine is that it has its own swivel wheels which makes it portable and the wheels can provide the motion to the table. Due to occupying minimum space and being quite efficient it can prove to be quite helpful to the industries that use drilling operations. Drilled holes can be characterized by their sharp edge on the entrance

1.2 Background Study

The development of CNC (Computer Numerical Control) machines has revolutionized manufacturing processes, providing unprecedented precision and automation. This background study delves into the key components and principles that underpin the design of a 3 axis CNC Milling machine, integrating electronic and mechanical elements for versatile fabrication applications. The Arduino UNO serves as the central processing unit, facilitating programmable control over the CNC machine. Its open-source nature and ease of programming make it a popular choice for diverse automation applications. Stepper motors, such as the NEMA 17, are widely employed in CNC systems due to their ability to move in precise increments. This motor type ensures accurate positioning, essential for intricate machining tasks. The Motor Driver Shield v3 and A4988 Motor Driver act as interfaces between the Arduino UNO and the stepper motor, translating control signals into precise motor movements. These components enable efficient and controlled motor operation. The 775 DC motor, operating at 12V, provides power for specific functionalities, such as spindle rotation. Its high torque and reliability make it suitable for various machining tasks. Mechanical components like linear bearings (12mm), shaft rods, and 608zz bearings contribute to the smooth and controlled motion of different parts in the CNC machine. These elements play a crucial role in reducing friction and ensuring precision. The combination of an 8mm CNC screw nut and patch rod, along with a 528mm pulley, forms the core of the motion transmission system. This setup enables controlled linear and rotational movements, essential for accurate machining. The power supply system, comprising a 12V adapter with a female connector, ensures a stable and reliable power source for driving the motors and other electronic components.

1.3 Objectives

The objectives of this project are:

- To study of an **3 Axis CNC Milling Machine.**
- To implement a system for easy to our daily life.
- To introduce with the advance technology of machining
- To Learn About Manufacturing with Efficiency & Productivity
- To take necessary notes from the project for future improvements.

1.4 Organization Of The Book

- **Chapter 1: Introduction.** This chapter is all about background study, air purifier, use or air purifier, Objectives and thesis book organization.

- **Chapter 2: CNC Basics.**

- **Chapter 3: CNC Programming.**

- **Chapter 4: Literature Review-** Here briefly describe about air purifier technology, filter availability, previous book review, Block diagram, Structural Diagram, Components List and Summary of this chapter.

- **Chapter 5: Hardware Analysis-** This chapter is discussed about our project hardware . Here we describe our hole instrument details.

- **Chapter 6: Methodology–** Here briefly discuss about project methodology, hardware parts, our system working mechanism, project final image, working principle and our system overview.

- **Chapter 7: Results and Discussion–** Here briefly discuss about project discussion, result analysis, advantages, disadvantages, application and our system overview.

- **Chapter 8: Conclusion** – This chapter is all about our thesis future recommendation and this project conclusion.

CHAPTER 2
BASIC CNC

2.1 CNC Milling Machine

CNC stands for Computer Numerical Control milling. This means that the milling machine is moved and monitored by numerical computer control rather than by hand. CNC milling tools perform a machining process similar to drilling and cutting parts with incredible precision, leaving no room for human error.

The Difference Between CNC And VMC

CNC is a computer numerical control machine i.e. any machine which can be numerically control by the use of computer. VMC is vertical Machining Center means in a machine whose spindle axis is vertical ex. milling machine and no. of several tools required to perform operation on a workspaces at a center.

2.2 Milling Operations (VMC)

In peripheral milling, also called plain milling, the axis of the tool is parallel to the surface being machined, and the operation is performed by cutting edges on the outside periphery of the cutter. In face milling, the axis of the cutter is perpendicular to the surface being milled, and machining is performed by cutting edges on both the end and outside periphery of the cutter

1) Facing
2) Drilling
3) Countering
4) Pocketing
5) Engraving
6) Profile Milling (3D)

2.3 Tow Types of CNC Milling Machine

1) Horizontal Milling Machine (HMC)
2) Vertical Milling Machine (VMC)

Types of Cutting or Tools for (VMC)

1) Face Mill Cutter
2) End Mill Cutter
3) Drill Bit Cutter
4) Ball Mill Cutter
5) Thread Mill Cutter
6) From Mill Cutter
7) T Slot Cutter
8) Side Mill Cutter
9) Dovetail Cutter
10) Fly Cutter
11) Hollow Mill Cutter

2.4 Safety

Objectives:

1. Recognize the importance of safety when working with CNC machines.
2. Become familiar with tool and work holding methods for CNC machining.
3. Learn how to calculate proper feeds and speeds for CNC machining.
4. Learn how to plan for CNC programming by using process planning documents.
5. Become familiar with coordinate systems and their use in CNC programming.
6. Learn terminology associated with the basics of CNC.
7. Learn the ABCs of CNC program format.

Safety

As you begin to learn about CNC programming, it is important to become aware of and learn how to practice safe working habits. You should not operate any machine without first understanding the basic safety procedures necessary to protect yourself and others from injury and the equipment from damage. Most CNC machines are provided with a number of safety devices (door interlocks, etc.) that protect personnel and equipment from injury or damage. However, operators should not rely solely on these safety devices, but should operate the machine only after reading and fully understanding the safety precautions and basic operating practices outlined in the maintenance and operation manuals provided with the equipment. The following are some Do’s and Don’ts that should be practiced when working with CNC machines.

Safety Rules for NC and CNC Machines

Do’s:

• Wear safety glasses and safety shoes at all times.
• Know how to stop the machine under emergency conditions.
• Keep the surrounding area well lit, dry, and free from obstructions.
• Keep hands out of the path of moving parts during machining operations.
• Perform all setup procedures and loading or unloading of workpieces with the spindle stopped.
• Follow recommended safety policies and procedures when operating machinery, handling parts or tooling, and lifting.
• Make sure machine guards are in position during operation.
• Keep wrenches, tools, and parts away from the machine’s moving parts.
• Make sure fixtures and workpieces are securely clamped before starting the machine.
• Inspect cutting tools for wear or damage prior to use.

Don’ts:

• Never operate a machine until properly instructed in its use.
• Never wear neckties, long sleeves, wristwatches, rings, gloves, or loose long hair when operating any machine.
• Never attempt to remove metal chips with hands or fingers.

• Never direct compressed air at yourself or others.
• Never operate an NC/CNC machine without first consulting the specific operator manual for the machine.
• Never place hands near a revolving spindle.
• Electrical cabinet doors are to be opened only by qualified personnel for maintenance purposes.

2.5 Maintenance

A large investment has been made to purchase CNC equipment. It is very important to recognize the need for proper maintenance and a general upkeep of these machines. At the beginning of each opportunity to work on any turning or machining center, verify that all lubrication reservoirs are properly filled with the correct oils. The recommended oils are listed in the operation or maintenance manuals typically provided with the equipment. Sometimes there is a placard (plate) with a diagram of the machine and numbered locations for lubrication and the oil type is found on the machine. Most modern CNC machines have sensors that will not allow operation of the machine when the way or spindle oil levels are too low. Pneumatic (air) pressures need to be at a specified level and regulated properly. If the pressure is too low, some machine functions will not operate until the pressure is restored to normal. The standard air pressure setting is listed in pounds per square inch (PSI) and a pressure regulator is commonly located at the rear of the machine. Keeping machines maintained and in their optimum health is required to avoid costly failures and ensure maximum productivity. Check with your company and follow their Total Productive Maintenance (TPM) program. Refer to the operator or maintenance manuals for recommended maintenance activities.

2.6 CAD & CAM

Objectives:

1. Explain common CAD/CAM capabilities.
2. Describe the Mastercam X8 CAD/CAM Graphical User Interface.
3. Learn terminology specific to CAD/CAM.
4. Apply geometry creation techniques common to CAD/CAM.
5. Explain how to use the CAD/CAM software to create toolpath and CNC program code.
6. Complete a toolpath from a solid model for a lathe.
7. Complete a toolpath from a solid model for milling.

CNC & CAD/CAM

1. **Creating the component design in CAD software.** The first step in producing a CNC drilled component is creating a digital design of it in CAD software.
2. **Converting the design into machine instructions.** Once the component design is finalized, it needs to be converted into a language the CNC unit can understand. This step typically requires running the CAD design through CAM software to generate machine code.

3. **Loading the instructions to the CNC machine.** When loaded to the CNC machine, the machine code controls how the CNC machine and tooling will move and operate throughout the drilling process.
4. **Setting up the CNC machine.** Setting up the CNC machine generally involves installing the appropriate drill bit and securing the workpiece.
5. **Executing the drilling operation.** Once the machine code is loaded and the machine is set up, the operator can initiate the drilling operation.
6. **Evaluating the component.** After the drilling operation is finished, the operator evaluates the component for any errors or imperfections.

CAD/CAM

Computer-aided design and computer-aided manufacturing (CAD/CAM) utilize computers to design drawings of part feature boundaries in order to develop cutting toolpath and CNC machine code (a part program). By using CAM, specific cutting tool data are defined. Toolpaths are then created by selecting drawing geometry that identify feature shapes and how they are going to be machined. Drawing in CAD is simply constructing a drawing using lines, arcs, circles, and points and then positioning them relative to each other on the screen. One of the major benefits of CAD/CAM is the time saved. It is much more efficient than writing CNC code line-by-line.

CAD/CAM is now the conventional method of creating mechanical drawings and computer numerical control (CNC) programs for machine tools. CAD is the standard throughout the world for generating engineering drawings. The personal computer is a powerful tool used by manufacturing and many other divisions within an organization. Engineers seldom use the drafting board to design their projects; they now use computers extensively. Designers can create the drawings needed and share them electronically with the manufacturing department. Drawings are exported/saved to a common fi le format, such as the Initial Graphics Exchange Specification (IGES), Standard for the Exchange of Product model data (STEP), Stereo Lithographic (STL), and Drawing Exchange Format (DXF) to name a few. There continue to be huge advancements in the design field and solid models are prevalent over two-dimensional drawings.

Many CAM systems import solid model fi les directly for toolpath creation (dragand-drop functionality), allowing the manufacturing engineer/CNC programmer to create the toolpath and assign cutting tool information relative to the desired results. CAD is limited in nature to the generation of engineering drawings, whereas CAD/CAM combines both design and manufacturing capabilities.

When using CAD/CAM, the drawing may be created from scratch or imported from a CAD program using one of the fi le formats mentioned earlier. It is not necessary to have the drawing dimensioned for this operation, but the full scale of the part is required. The CAD/CAM operator assigns the tools and their order of usage while creating the toolpath. There are many CAD/CAM programs on the market today. The most popular ones are easy to use; they have excellent service and support as well as a strong background of reliability. To make good use of this computing power, it is important to fully understand the machining processes. Just as CNC doesn’t change the actual machining, the same is true of CAD/CAM for programming.

Remember: the overall objective of CAD/CAM is to generate a toolpath for a CNC machine in the form of a CNC program. It is imperative to have a full understanding of the rectangular and polar coordinate systems. It is also necessary to have a complete understanding of cutting tool selection, speeds, and feeds. Nearly all CAD/CAM programs will automatically develop speed and feeds data based on the tool and work material selection saved in a database, however, adjustments are commonly made. This database of information can and should be updated to match the requirements for your shop for the best results.

When constructing the part geometry, consider the type of machining operation. For instance, if the desired result is to drill a hole using a standard drill, construction of only the point that represents the holes center location in the coordinate system is necessary.

In this chapter, Mastercam X8 is featured as the CAD/CAM software used for the programming examples. This chapter is intended only as an introduction to CAD/CAM. To cover the full extent of its capabilities would require an entire text, if not volumes. Many other CAD/CAM programs available today use similar techniques to accomplish the same result.

Associativity

The concept of associativity is inherent to most modern CAD/CAM programs. The information input to the program regarding the toolpath, tool, material, and parameters specific to each are linked to the geometry. This means that if any of the parameters for the parts mentioned above are changed, the other related data can be regenerated to take these changes into account without recreating the entire operation.

CAD/CAM is the tool of choice for creating CNC programs. The power it has now will only be magnified in the future. The basic concepts that are demonstrated here are merely a taste of the capabilities CAD/CAM has to offer.

Personal Computers

A personal computer or Apple Mac has important minimum requirements to run this type of software. Normally, a large screen or even two is desirable for ease of viewing the geometry created. CAD/CAM programs require a lot of hard disk space so a large hard drive is also recommended. Because CAD/CAM is used to create complex drawings and perform graphic simulations, the computer has the following basic needs:

• The memory the computer uses to access fi les while working on them is called RAM (Random Access Memory). A large amount of RAM is highly recommended (individual software manufacturers have recommended minimums).

• The computer's processing speed is listed in MHZ (Megahertz). Again, the higher the number, the better.

• The computer's graphics card and monitor controls the screen resolution. A powerful graphics card is strongly advised. Remember to consult the specific minimum requirements for the CAD/CAM program you choose.

2.7 Glossary

Absolute Dimension
All numerical values (dimensional measurements) are derived from a fixed origin or datum in the coordinate system.

Absolute Programming
Programming co-ordinates from a fixed datum.

Address
Commonly referred to as letter address because, in programming, each program word is preceded by a letter in order to identify what function is to be executed. Examples of letter address are: S for spindle speed designation, T for tool identification, M for miscellaneous functions, and G for preparatory functions.

Axis
The axis is the primary identifier of the cutting tool direction of movement in relationship to the machine type and orientation. The three linear axes for a machining center are X, Y, and Z; they are perpendicular to each other. The rotary axes are; A, B, and C.

Block
A single line of CNC code consisting of program words that identify the activities the machine is to execute. Generally, each block is preceded by a block or sequence number (N) and is followed by an "End of Block" (EOB) character, represented by the semicolon (;).

Block number
A number identifying the position of a block of NC data, e.g. N006 G41 H24.

Block Skip
Block Skip is sometimes called Block Delete or Optional Block Skip. When the Block Delete or Optional Block Skip button or switch is on, the controller skips execution of the program blocks that are preceded with "/"and that end with the end of block (;) character. If the button or switch is off, the machine will execute the programmed blocks and disregards the "/" symbol.

Canned Cycle
A single statement called from the CNC control to expedite a sequence of tool movements (such as a peck drilling cycle) that is repeated at specific co-ordinates until cancelled.

CAM (Computer-Aided Manufacture)
The use of a computer to generate toolpath cutting data and hence CNC part programs.

Circular Interpolation

A programming feature that enables programming of two axes simultaneously to create arcs and circles. Information generally needed includes the location of the arc center, the arc radius, the starting and ending points of the arc, and the direction of cutting motion.

CNC (Computer Numerical Control)

A microcomputer-controlled NC (numerical control) machine that controls the movements and operating functions of a tool by coded numerical data; has the facilities for storing programs, editing and in some cases displaying 3D toolpath graphics.

Conversational Format/Programming

A system that checks the validity of the program entered into the CNC controller and informs the operator/programmer if the next statement can be entered or if a mistake must be corrected.

Coordinates

Numerical values that define the positional location of points from a predetermined zero point or origin from within the Cartesian Coordinate System.

Dimensional data which defines a location; it can be either absolute or relative.

Cutter Path

The path taken by a cutter to generate a component of the desired shape.

Cutter Radius Compensation

On receipt of a G code, the cutter is moved to the left or right of the programmed co-ordinates by the length of the cutter radius or the tool nose radius.

Cutting Speed

The surface speed of the component relative to the cutting edge of the tool.

Datum

A reference point from which all co-ordinates are measured; it can be set in the machine parameter settings (the machine table datum) or it can be movable (the component datum).

or A datum is an exact point, axis, or plane. A datum is the origin from which the dimensional location and/or the characteristics of features of a part are established.

Dwell

Dwell is determined by the preparatory function G04 and by using the letter address P or X, which corresponds to the time duration of dwell (also U for lathes). When used, dwell causes a pause in the machining operation for the length of time indicated in seconds (X or U), milliseconds (P), or revolutions (depending on parameter setting).

DXF
Format for allowing CAD drawings to be exchanged to and from CAD systems or CAM systems.

End of Block Character
A special character represented by the semicolon (;) that identifies the end of a program block. Known by the acronym EOB or E-O-B.

End of program
A miscellaneous function (M30) is placed in the last line of a program to indicate the end of the part program. At this command, the spindle, coolant, and feed are stopped and the program is returned to its start.

Feedrate Override
Feedrate Override allows control of the traverse feedrate by adjustment of a rotary dial. This function allows the control of the cutting feedrates defined by the F-word in the program by increasing or decreasing the percentage of the value entered in the program. It can also be used to control feedrates during jog mode function.

Feedrate Or Feed
The travel of the tool per revolution of the workpiece in turning; the linear velocity (per minute) of the table or spindle in milling

G-Codes
Preparatory functions (G-Codes) are programmed with an address G, typically followed by two digits, to establish the mode of operation in which the tool moves.

Gnomon
A gnomon is a graphical representation of three perpendicular axes connected at the origin; it allows the programmer the ability to manipulate model transformations dynamically.

Hardware
Physical equipment; for a CAM system this could be a computer, plotter, printer, punched tape reader.

Incremental Dimension
An incremental dimension is a position within the coordinate system in which each numerical value is taken from the previous point.

Incremental Programming
Programming co-ordinates relative to the last position, that is, the present tool position is 0.

Jog
Activating the JOG feed mode allows the selection of manual feeds along a single X, Y, or Z axis (rotary axes may be jogged as well). With the mode activated, use the Axis/ Direction buttons and the Speed/Multiply buttons to move the desired axis at the chosen feed rate (in/min or mm/min) and amount.

Linear Interpolation
This function allows programming of one, two, or three axes simultaneously; it enables movement either along a straight-line path or at an angle in plane or space.

Machining Cycle
A series of moves with one or more cutting tools to produce a machined part.

Machine Home
A reference position located within the machine tool working envelope determined by the manufacturer, in order to establish a measurement system for the machine.

Macro
A separate program for executing a series of machining moves that may be called up within the main program; a macro may be at the end of the main program or stored as a separate program within the machine control.

Manual Data Input (MDI)
The MDI mode enables the automatic control of the machine, using information entered in the form of blocks through the control panel without interfering with the basic program.
or Manual data input of information into the CNC machine control

Miscellaneous Function (M-Codes)
Miscellaneous functions are used to command various auxiliary operations such as activating coolant flow (M08) or starting clockwise spindle rotation (M03). The code consists of the letter M, typically followed by two digits. The M-Code is normally the last entry in a block.

Modal Commands
Modal commands remain in effect until they are replaced by another command from the same group. The F-Word is modal as are many G-Codes.

Mouse
An input device for a computer; it defines the position of the cursor on the screen.

Origin
A starting point for the coordinate system used to machine parts; a fixed point on a blueprint from which dimensions are taken.

Parameter
A value, usually in bit form, that remains constant in the CNC controller until changed.

Part Program
Specific and complete set of data and instructions to program a CNC machine tool to machine a part/component.

Peck Drilling
In this technique the drill enters the work to the peck depth specified and then returns to a point at a specified distance above the work: this is repeated until the drill reaches the final depth of the hole (that is, the second peck distance is added on to the first peck distance, and so on); peck drilling enables the swarf to leave the hole.

Pocket
A term used in milling to describe a feature inside a profile that has a base, other than slots, blind holes etc.

Post-Processor
A complete program that converts the computer output data of a CAM system (the tool cutter path) into the CNC code for a particular machine tool.

Single Block
The execution of a single block of information in the program is initiated by activating a switch or button on the control panel. While in this mode, each time the cycle start button is pressed, only one block of information will be executed.
or When in this mode (for example, when proving a program) the CNC machine executes one program block at a time; to begin the next block the operator has to press the start button.

Tool Insert
A carbide tip of various geometrical shapes, held in the tool holder.

Tool Length Compensation (TLC)
Automatic compensation for the length difference between the tool to be used and datum tool; if the datum tool is the longer compensation is negative, and if it is shorter compensation is positive.

Tool Length Offset (TLO)
Tool Length Offsets, or TLO, are called in the milling program by the H word. The measured values representing the difference between the spindle face gage line and the tools tip are input into corresponding offset registers and are needed for proper positioning of the tool along the Z-axis.

Workpiece Zero
A starting point, workpiece zero is the point from which dimensions on the workpiece are established.
Sometimes referred to as part zero.

X-Axis
The axis of motion that is always horizontal and parallel to the machine tool table. For a vertical milling machine, this axis moves left or right.

Y-Axis
The axis of motion that is perpendicular to both X- and Z-axes in relation to the machine tool table. For a vertical milling machine, this axis moves forward and backward.

Z-Axis
The machine tool axis of motion that is always parallel to the primary spindle. For a vertical milling machine, this axis moves up and down.

2.8 Cutting Parameters

The Cutting Fluid or Coolant
The metal cutting process is one that creates friction between the cutting tool and the workpiece. A cutting fluid or coolant is necessary to lubricate and remove heat and chips from the tool and workpiece during cutting. Water alone is not sufficient because it only cools and does not lubricate; it will also cause rust to develop on the machine ways and table. Also, because of the heat produced, water vaporizes and thus compromises the cooling effect. A mixture of lard-based soluble oil and water creates a good coolant for most light metal-cutting operations. Harder materials, like stainless steel and high alloy composition steels require the use of a cutting-oil for the optimum results. Advancements have been made with synthetic coolants as well. Finally, the flow of coolant should be as strong as possible and be directed at the cutting edge to accomplish its purpose. Some machine tools are equipped thru-spindle/tool and high pressure coolant that really aid in cutting zone cooling and removal of chips. Programmers and machine operators should research available resources like the Machinery's Handbook and coolant manufacturer data, for information about the proper selection and use of cutting fluids for specific types of materials. The manufacturer data will include the coolant mixing ratio requirements and PH-level checking parameters.

The Workpiece and the Work Holding Method
The material to be machined has a definite effect on decisions about what tools will be used, the type of coolant necessary, and the selection of proper speeds and feeds for the metal-cutting operation. The shape or geometry of the workpiece affects the metal-cutting operation and determines the type of work holding method that will be used. This clamping method is important for CNC work because of the high performance expected. It must hold the

workpiece securely, be rigid, and minimize the possibility of any fl ex or movement of the part.

The Cutting Speed

Cutting speed is the rate at which the circumference of the tool moves past the workpiece in surface feet (sf/min) or meters per minute (m/min) to obtain satisfactory metal removal.
The cutting speed factor is most closely related to the tool life. Many years of research have been dedicated to this aspect of metal-cutting operations. The workpiece and the cutting tool material determine the recommended cutting speed. The Machinery's Handbook is an excellent source for information pertaining to determining proper cutting speed. If incorrect cutting speeds, spindle speeds, or feedrates are used, the results will be poor tool life, poor surface finishes, and even the possibility of damage to the tool and/or part.

The Spindle Speed

When referring to a milling or a turning operation, the spindle speed of the cutting tool or chuck must be accurately calculated relating to the conditions present. This speed is measured in revolutions per minute, r/min (formerly known as RPM), and is dependent upon the type and condition of material being machined. This factor, coupled with a depth of cut, gives the information necessary to fi nd the horsepower required to perform a given operation. In order to create a highly productive machining operation, all these factors should be given careful consideration. Refer to the formulas below needed to calculate r/min.

Feedrate

Feedrate is defined as the distance the tool travels along a given axis in a set amount of time, generally measured in inches per minute in/min (formerly known as IPM) for milling or inches per revolution in/rev (formerly known as IPR) for turning. This factor is dependent upon the selected tool type, the calculated spindle speed, and the depth of cut. Refer to the Machinery's Handbook and cutting tool manufacturer data for the chip load recommendations and review the formula below that is necessary to calculate this aspect of the metal-cutting operation.

The Depth of Cut

The depth of cut is determined by the amount of material to be removed from the workpiece, cutting tool flute length or insert size, and the power available from the machine spindle. Always use the largest depth of cut possible to ensure the least effect on the tool life. Cutting speed, spindle speed, feedrate, and depth of cut are all important factors in the metal-cutting process. When properly calculated, the optimum metal-cutting conditions will result. Refer to the Machinery's Handbook, tool and insert ordering catalogs, and online applications from the tool and insert manufacturers for more information on recommended depths of cut for particular tooling.

Points of Reference

When using CNC machines, any tool location is controlled within the coordinate system. The accuracy of this positional information is established by specific zero points (reference points). The first is Machine Zero, a fixed point established by the manufacturer that is the basis for all coordinate system measurements. On a typical lathe, this is usually the spindle centerline in the X-axis and the face of the spindle nose for the Z-axis. For a milling machine, this position is often at the furthest end of travel in all three axes in the positive direction. Occasionally, this X-axis position is at the center of the table travel.

This Machine Zero Point establishes the coordinate system for operation of the machine and is commonly called Machine Home (Home position). Upon startup of the machine, all axes need to be moved to this position to establish the coordinate system origin (commonly called homing the machine or Zero Return). The Machine Zero Point identifies to the machine controller where the origin for each axis is located. Some machines today are equipped with absolute encoders so that homing is no longer necessary at machine startup.

The operator's manual supplied with the machine should be consulted to identify where this location is and how to properly home the machine.

The second zero point can be located anywhere within the machine work envelope and is called Workpiece Zero; it is used as the basis for programmed coordinate values used to produce the workpiece. It is established within the part program by a special code and the coordinates are taken from the distance from the Machine Zero point. The code number in the program identifies the location of offset values to the machine control where the exact coordinate distance of the X, Y, and Z axes of Workpiece Zero is in relationship to the Machine Zero. All dimensional data on the part will be established by accurately setting the Workpiece Zero. A way of looking at the Workpiece Zero is like another coordinate system within the machine coordinate system, established by the Home position.

Tool offsets are also considered to be Zero Points as well and are compensated for with tool length and diameter offsets. The tool-setting point for a lathe has two dimensions: the distance on diameter from the tool tip to the centerline of the tool turret, and the distance from the tool turret face to the tool tip. The tool-setting point for the mill is the distance from the spindle face to the tool tip, and the distance from the tool tip to the spindle centerline.

CHAPTER 3
CNC PROGRAMMING

3.1 Introduction Program

A typical CNC program has (3) parts:

1. **Preparation:** This portion of the program selects the work and tool offsets, selects the cutting tool, turns on the coolant, sets spindle speed, and selects absolute or incremental positioning for axis motion.
2. **Cutting:** This portion of the program defines the tool path and feed rate for the cutting operation.
3. **Completion:** This portion of the program moves the spindle out of the way, turns off the spindle, turns off the coolant, and moves the table to a position from where the part can be unloaded and inspected.

3.2 CNC Programming

CNC programming is a method of defining machine tool movements through the application of numbers and corresponding coded letter symbols. As shown in the list below, all phases of production are considered in programming, beginning with the engineering drawing or blueprint and ending with the final product:

- Engineering drawing or blueprint
- Work holding considerations
- Tool selection
- Preparation of the part program
- Part program tool path verification
- Measuring of tool and work offsets
- Program test by dry run
- Automatic operation or CNC machining

3.3 Address Characters Sign & Common Symbols Used in Program

Table 3.1: Address Characters / Specific Meaning Sign Codes

Address Characters / Specific Meaning Sign Codes			
Ser	Sign	Meaning	Description
1.	D	Tool Radius	Tool Radius Offset Number
2.	F	Feed rate	Feed In In/Min Or Mm/Min (F25.)
3.	H	Tool Length	Tool Length Offset number
4.	N	Number	Sequence or Block/Line Number
5.	O	Program number	Program number
6.	P	Second's	Dwell Time And Sequence Number Designation In Subprogram
7.	Q	Pick	Depth of cut, shift of canned cycles
8.	R	Retract	R/Min Calculated From The Preceding Formula
9.	S	Spindle Speed	Spindle-Speed Function (S2000.)
10.	T	Tool	Tool Number (T1)
11.	X	X coordinate	X Axis Selection
12.	Y	Y coordinate	Y Axis Selection
13.	Z	Z coordinate	Z Axis Selection

Table 3.2: Common Symbols

Common Symbols		
Ser	Symbol	Meaning
1.	.	Decimal Point, Designation of fractional portion of a number
2.	;	Semicolon, End-Of-Block character
3.	( )	Parentheses, Used for comments within programs
4.	-	Minus Sign, Used for Negative Values
5.	/	Slash, Used for Block Skip Function
6.	%	Percent Sign, Necessary at program beginning and end for communications only
7.	:	Colon, Designation of Program Number

3.4 Preparatory Functions (G-Codes) For Milling Machine

Table 3.3: Preparatory Functions (G-Codes)

Preparatory Functions (G-Codes)		
Ser	Code	Function / Description
1.	G00	Rapid Motion
2.	G01	Linear Interpolation Motion
3.	G02	CW Circular Interpolation Motion
4.	G03	CCW Circular Interpolation Motion
5.	G04	Dwell (p) (P= Second's)
6.	G12	CW Circular Pocket Milling
7.	G13	CCW Circular Pocket Milling
8.	G17	Circular Motion (XY) Plane Selection
9.	G18	Circular Motion (XZ) Plane Selection
10.	G19	Circular Motion (YZ) Plane Selection
11.	G20	Inch Coordinate Position Selection
12.	G21	Metric Coordinate Position Selection
13.	G28	Return to Machine Zero Thru Reference Point
14.	G40	Cutter Comp Cancel G41/G42/G141
15.	G41	Cutter Compensation Left
16.	G42	Cutter Compensation Right
17.	G43	Tool Length Compensation (+) Direction
18.	G44	Tool Length Compensation (-) Direction
19.	G47	Text Engraving
20.	G49	Tool Length Compensation Cancel G43/G44/G143
21.	G53	None-Modal Machine Coordinate Selection
22.	G54 - G59	Set Work Coordinate System
23.	G90	Absolute Position Command
24.	G91	Incremental Position Command
25.	G98	Canned Cycle Initial Point Return
26.	G99	Canned Cycle "R" Plane Return

3.5 Canned Cycle (G-Codes) Used for Milling Machine

Table 3.4: Canned Cycle (G-Codes)

Canned Cycle (G-Codes)		
Ser	Code	Function / Description
27.	G70	Bolt Hole Circle
28.	G71	Bolt Hole Arc
29.	G72	Bolt Holes Along an Angel
30.	G73	High Speed Peck Drill Canned Cycle
31.	G74	Reverse Tapping Canned Cycle
32.	G76	Fine Boring Canned Cycle
33.	G77	Back Bore Canned Cycle
34.	G80	Cancel Canned Cycle
35.	G81	Drill Canned Cycle
36.	G82	Spot Drill / Counter Bore Canned Cycle
37.	G83	Peck Drill Canned Cycle
38.	G84	Tapping Canned Cycle
39.	G85	Bore in, Bore Canned Cycle
40.	G86 - G88	Boring, Rapid Out Canned Cycle
41.	G87	Back Boring Cycle
42.	G89	Boring, Dwell, Bore Out Canned Cycle

3.6 Miscellaneous Functions (M-Codes) For Milling Machine

Table 3.5: Miscellaneous Functions (M-Codes)

Miscellaneous Functions (M-Codes)		
Ser	Code	Function / Description
43.	M00	Program Stop
44.	M01	Optional Program Stop
45.	M02	Program End
46.	M03	Spindle On CW (S)
47.	M04	Spindle On CCW (S)
48.	M05	Spindle Stop
49.	M08	Coolant On
50.	M09	Coolant Off
51.	M16	Tool Change (Same as M06) (T)
52.	M19	Orient Spindle (P,R)
53.	M30	End of Program & Reset
54.	M88	Thru Spindle Coolant On
55.	M89	Thru Spindle Coolant Off
56.	M95	Sleep Mode
57.	M96	Jump if No Signal (P, Q)
58.	M97	Local Subprogram Call (P,L)
59.	M98	Subprogram Call (P,L)
60.	M99	Subprogram Return or Loop

3.7 Preparation

Table 3.6: Preparation Block in Programming

These are the preparation code blocks in the sample program O02024:

Preparation Code Block	Description
%	Denotes the beginning of a program written in a text editor.
O02024 (Basic program);	O02024 is the name of the program. Program naming convention follows the Onnnnn format: The letter "O", or "o" is followed by a 5-digit number.
(G54 X0. Y0. is top right corner of part);	G54 defines the coordinate system to be centered on the Work Offset stored in G54 on the Offset display.
(Z0 is on top of the part);	Comment
(T1 is a 1/2" Drill);	Comment
(BEGIN PREPARATION BLOCKS);	Comment
T1 M06 (Select tool 1);	Selects tool T1 to be used. M06 commands the tool changer to load Tool 1 (T1) into the spindle.
G00 G17 G40 G49 G90 G54 (Safe startup);	This is referred to as a safe startup line. It is good machining practice to place this block of code after every tool change. G00 defines axis movement following it to be completed in Rapid Motion mode. G90 defines axis movements following it to be completed in absolute mode. G17 defines the cutting plane as the XY plane. G40 cancels Cutter Compensation. G49 cancels tool length compensation. G54 defines the coordinate system to be centered on the Work Offset stored in G54 on the Offset display.
X0. Y0. (Rapid to 1st position);	X0. Y0. commands the table to move to the position X =0.0 and Y=0.0 in the G54 coordinate system.
S2000 M03 (Spindle on CW);	M03 turns the spindle on in a clockwise direction. It takes the address code Snnnn, where nnnn is the desired spindle RPM.
G43 H01 Z0.1 (Tool offset 1 on);	G43 H01 turns on Tool Length Compensation +. The H01 specifies to use the length stored for Tool 1 in the Tool Offset display. Z10. commands the Z Axis to Z=10.
M08 (Coolant on);	M08 commands the coolant to turn on.

3.8 Cutting

Table 3.7: Cutting Block in Programming

These are the cutting code blocks in the sample program O02024:

Cutting Code Block	Description
G01 F200. Z-0.1 (Feed to cutting depth);	G83 Peck Drill Canned Cycle & G98 Canned Cycle Initial Point Return (F- Feed In In/Min Or Mm/Min (F5.) R- R/Min Calculated From The Preceding Formula Q- Depth of cut, shift of canned cycles) defines axis movements after it to be completed in a straight line. The address code F5.0 specifies that the feed rate for the motion is 20 mm/min. Z2.0 commands the Z Axis to Z = 2.0
X-4. Y-4. (linear motion);	X-4. Y-4. Commands the X Axis to move to X = - 4.0 and Commands the Y Axis to move to Y=-4.0

3.9 Completion

Table 3.8: Completion Block in Programming

These are the completion code blocks in the sample program O02024:

Completion Code Block	Description
G00 Z0.1 M09 (Rapid retract, Coolant off);	G00 Commands the axis motion to be completed in rapid motion mode. Z0.1 Commands the Z Axis to Z=0.1 M09 Commands the coolant to turn off.
G53 G49 Z0. M05 (Z home, Coolant off);	G53 define axis movements after it to be with respect to the machine coordinate system. G49 cancels tool length compensation. Z0 is a command to move to Z=0.0 M05 turns the spindle off.
G53 Y0. (Y home);	G53 define axis movements after it to be with respect to the machine coordinate system. Y0 is a command to move to Y = 0.0.
M30 (End program);	M30 ends the program and moves the cursor on the control to the top of the program.
%	Denotes the end of a program written in a text.

3.10 Basic Programing

```
%
O02024 (Basic program);
(G54 X0. Y0. is top right corner of part);
(Z0 is on top of the part);
(T1 is a 1/2" Drill);

(BEGIN PREPARATION BLOCKS);
T1 M06 (Select tool 1);
G00 G17 G40 G49 G54 G90 (Safe startup);
X0. Y0. (Rapid to 1st position);
S2000 M03 (Spindle on CW);
G43 H01 Z0.1 (Tool offset 1 on);
M08 (Coolant on);

(BEGIN CUTTING BLOCKS);
G01 F20 Z-0. (Feed to cutting depth);
X-4. Y-4. (Linear motion);
 (BEGIN COMPLETION BLOCKS);
G80 (Cancel Canned Cycle);
M05 (Spindle off);
G91 G28 Z0. M09 (Z home, Coolant off);
G28 Y0. (Y home);
M30 (End program);
%
```

CHAPTER 4
LITERATURE REVIEW

4.1 Introduction

In this chapter we will discuss some literature review. Here are some of the ideas we got after this project related literature.

4.2 Literature Review

Around 35,000 BCE, Homo sapiens discovered the benefits of the application of rotary tools. This would have rudimentarily consisted of a pointed rock being spun between the hands to bore a hole through another material. This led to the hand drill, a smooth stick that was sometimes attached to flint point, and was rubbed between the palms. This was used by many ancient civilizations around the world, including the Mayans. The earliest perforated artifacts such as bone, ivory, shells and antlers found, are from the Upper Paleolithic Era. Bow drill (strap-drills) are the first machine drills, as they convert a back-and forth motion to a rotary motion, and they can be traced back to around 10,000 years ago. It was discovered that tying a cord around a stick, and then attaching the ends of the string to the ends of a stick (a bow), allowed a user to drill quicker and more efficiently. Mainly used to create fire, bow-drills were also used in ancient woodwork, stonework and dentistry. [1]

Archeologist discovered a Neolithic graveyard in Mehrgrath, Pakistan dates from the time of the Harappans, around 7,500-9,000 years ago, containing 9 adult bodies with a total of 11 teeth that had been drilled. There are hieroglyphs depicting Egyptian carpenters and bead makers in a tomb at Thebes using bow-drills. The earliest evidence of these tools being used in Egypt dates back to around 2500 BCE. The usage of the bow-drills were widely spread through Europe, Africa, Asia and North America, during ancient times and is still used today. [2]

Over the years, many slight variations of bow and strap drills have developed for the various uses of either boring through materials or lighting fires. Micro machining operations play an important role in precision production industries. Out of the various machining processes, micro-drilling is used to produce micro holes in fuel injectors, printed circuit board, aerospace materials etc. So in order to achieve the optimum working conditions various research were conducted by different researchers from across the globe. This report reviews some of the journals published by them regarding optimization processes. [3]

Yogendra Tyagi, Vadansh Chaturvedi and Jyoti Vimal [1] have conducted an experiment on the drilling of mild steel, and applied the Taguchi methods for determining the optimum parameters condition for the machining process using the Taguchi methods and analysis of variance. The work piece used is mild steel (100mm×76mm×12mm) and the tool used is HSS with a point angle of 118° and a diameter of 10 mm. Taguchi L9 orthogonal arrays are used here in order to plan the experiment. The input parameters are fed rate, depth of cut and spindle speed whereas the output responses are surface roughness and metal removal rate (MRR). In case of signal to noise ratio calculation, larger the better characteristics is used for calculation of the S/N ratio for the metal removal rate and nominal and small the better characteristics are used for the calculation of the S/N ratio for surface roughness. [4]

After the analysis of the data obtained it is found that MRR is affected mostly by feed. Confirmation experiment was conducted using the data obtained from S/N ratio graphs and it confirmed by the results of Taguchi methodology. In case of surface roughness analysis same procedure was followed where the significant parameter was found to be the spindle speed. Here too the confirmation experiment was conducted and this confirms the successful implementation of Taguchi methods. [5]

Timur Canel,A. Ugur Kaya, Bekir Celik [3] studied the laser drilling on PVC material in order to increase the quality of the cavity. A Taguchi optimization method was used to obtain the optimum parameters. The material used in the experimental setup is PVC samples with dimensions of 5mm×85mm×4.5mm. The Surelite Continuum Laser is used to form the cavities. The input parameters are wavelength, fluence and frequency and the output response are aspect ratio, circulate and heat affected zone. A Taguchi L9 orthogonal array is used to find the signal to noise ratio. Smaller the better characteristic is used for HAZ, larger the better characteristic is used for aspect ratio and nominal the better characteristic is used for circularity. Variance analysis is performed using the calculated S/N ratio to conclude optimum stage. It is found that most effective parameter for aspect ratio is frequency, second is wavelength and last is fluence. For circularity it is found that the most effective parameter is wavelength, fluence and frequency. For HAZ it is found that the most effective parameter is wavelength, second is frequency and last is fluence. The experimental results are compatible with the Taguchi method with a 93 % rate. [6]

Thiren G. Pokar,Prof. V. D. Patel [5] used gray based Taguchi method to determine the optimum micro drilling process parameters. B. Shivapragash, K. Chandrasekaran, C. Parthasarathy, M. Samuel [6] have tried to optimize the drilling process involving metal matrix composites (MMC) in order to minimize the damage done to it during the process by using Taguchi and gray rational analysis. The work piece used is Al-TiBr2 (MMCs), with dimension of 100mm × 170mm × 15mm.The tool material is HSS with a diameter of 0.6 mm. The input parameters are spindle speed, depth of cut and feed rate, whereas the output parameter is MRR and surface roughness. For finding out the optimal combination of cutting parameters the results are converted into S/N ratios and higher the better type characteristics is used for MMR, and smaller the better characteristics is used for surface roughness. [7]

Wen Jialing and Wen Pengfei [8] used an orthogonal experimental design in order to find out the optimum process parameters for injection molding of the Aspheric plastic lens, to reduce volumetric shrinkage and volumetric shrinkage variation. Six input parameters were taken, each with 5 levels(Fill Time/sec, holding pressure/Mpa, holding pressure/times, cooling time/s, melt temperature/°C, mold temperature/°C.L25(56) orthogonal array is used to plan the above experiment. The parameters affecting both volumetric shrinkage and volumetric shrinkage variation are identified in order. [8]

4.3 Block Diagram

In our project we have set up an **CNC 3 Axis Milling Machine.** In this diagram we will show by block the individual parts.

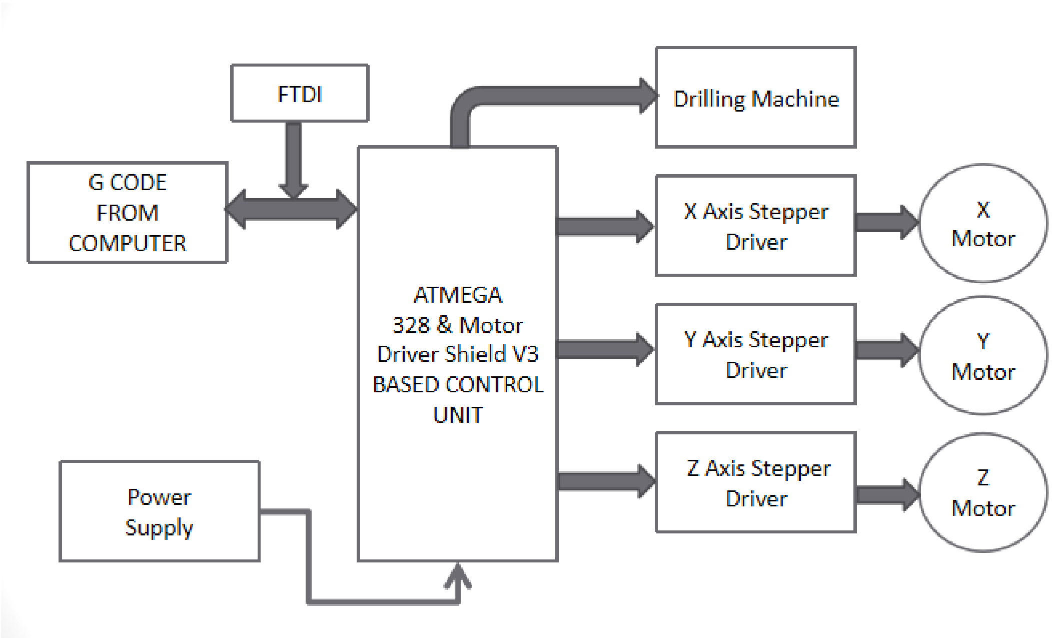

Figure 4.1: Block Diagram Of Of Our System

4.4 Schematic Diagram

The schematic diagram here is representing the electrical circuit and the components of the **CNC 3 Axis Milling Machine.** Here we connect equipment with he smart wire connection.

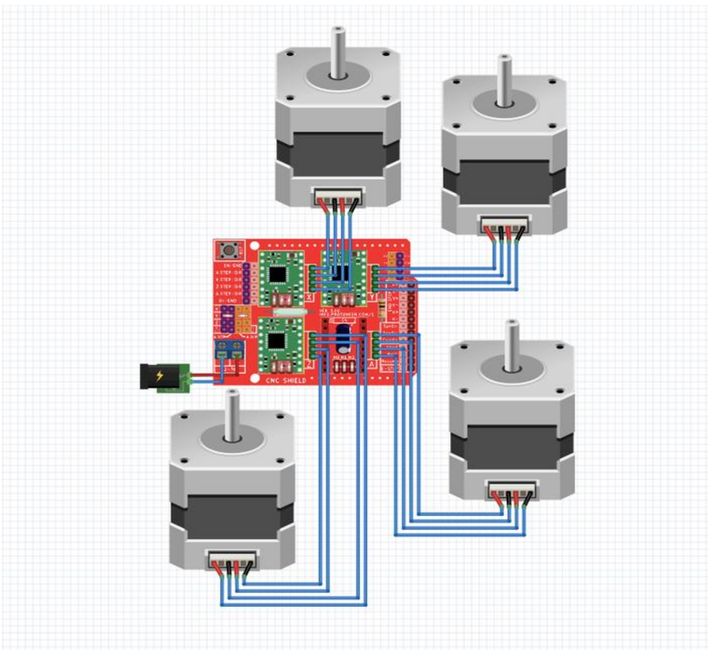

Figure 4.2: Schematic Diagram of our circuit

2.5 Components List:

Hardware Part:

1. Arduino UNO
2. Stepper Motor Nema 17
3. Motor driver shield V3
4. A4988 Motor driver
5. 775 DC motor 12V
6. 12mm linear bearing
7. 12mm shaft Rod
8. 608zz bearing
9. 8mm CNC screw nut & Patch Rod
10. 12V adapter female connector
11. 5*8 mm pulley

Software Part :

1. Arduino IDE Software
2. Easy EDA Software

2.6 Summary

The above discussion gives an idea about the **3 Axis CNC Milling machine.** All that work on this system already been done here, and the results of their work, the use of 3 axis CNC Milling machine in the situation are described in detail. From this we also got the direction of work of the project.

CHAPTER 5
HARDWARE ANALYSIS

5.1 Arduino UNO

The **ArduinoUno** is an open-source microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2010.[2][3] The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.[1] The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.[4] It can be powered by a USB cable or a barrel connector that accepts voltages between 7 and 20 volts, such as a rectangular 9-volt battery. It has the same micro-controller as the Arduino Nano board, and the same headers as the Leonardo board.[5][6] The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available.

Figure 5.1: Arduino UNO

The word "uno" means "one" in Italian and was chosen to mark a major redesign of the Arduino hardware and software.[7] The Uno board was the successor of the Duemilanove release and was the 9th version in a series of USB-based Arduino boards.[8] Version 1.0 of the Arduino IDE for the Arduino Uno board has now evolved to newer releases.[4] The ATmega328 on the board comes pre programmed with a bootloader that allows uploading new code to it without the use of an external hardware programmer.[3] While the Uno communicates using the original STK500 protocol,[1] it differs from all preceding boards in that it does not use a FTDI USB-to-UART serial chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Specification:

- Microcontroller (MCU):[12]
- IC: Microchip ATmega328P (8-bit AVR core)
- Clock Speed: 16 MHz on Uno board, though IC is capable of 20 MHz maximum at 5 Volts
- Flash Memory: 32 KB, of which 0.5 KB used by the bootloader
- SRAM: 2 KB
- EEPROM: 1 KB
- USART peripherals: 1 (Arduino software default configures USART as a 8N1 UART)
- SPI peripherals: 1
- I^2C peripherals: 1
- Operating Voltage: 5 Volts
- Digital I/O Pins: 14
- PWM Pins: 6 (Pin # 3, 5, 6, 9, 10 and 11)[13]
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- Size: 68.6 mm x 53.4 mm
- Weight: 25 g
- ICSP Header: Yes
- Power Sources:
- USB connector. USB bus specification has a voltage range of 4.75 to 5.25 volts. The official Uno boards have a USB-B connector, but 3rd party boards may have a miniUSB / microUSB / USB-C connector.
- 5.5mm/2.1mm barrel jack connector. Official Uno boards support 6 to 20 volts, though 7 to 12 volts is recommended. The maximum voltage for 3rd party Uno boards varies between board manufactures because various voltage regulators are used, each having a different maximum input rating. Power into this connector is routed through a series diode before connecting to VIN to protect against accidental reverse voltage situations.

VIN pin on shield header. It has a similar voltage range of the barrel jack. Since this pin doesn't have reverse voltage protection, power can be injected or pulled from this pin. When supplying power into VIN pin, an external series diode is required in case barrel jack is used. When board is powered by barrel jack, power can be pulled out of this pin.

5.2 Stepper Motor Nema 17

A **stepper motor**, also known as **step motor** or **stepping motor**,[1] is an electrical motor that rotates in a series of small angular steps, instead of continuously.[2] Stepper motors are a type of digital actuators. A stepper motors is an electromagnetic actuator; it converts electromagnetic energy into mechanical energy to perform mechanical work.[1] A stepper motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can be commanded to move and hold at one of these steps without any position sensor for feedback (an open-loop controller), as long as the motor is correctly sized to the application in respect to torque and speed.

Figure 5.2: Stepper Motor

Switched reluctance motors are very large stepping motors with a reduced pole count, and generally are closed-loop commutated. Brushed DC motors rotate continuously when DC voltage is applied to their terminals. The stepper motor is known for its property of converting a train of input pulses (typically square waves) into a precisely defined increment in the shaft’s rotational position. Each pulse rotates the shaft through a fixed angle.

Stepper motors effectively have multiple "toothed" electromagnets arranged as a stator around a central rotor, a gear-shaped piece of iron. The electromagnets are energized by an external driver circuit or a micro controller. To make the motor shaft turn, first, one electromagnet is given power, which magnetically attracts the gear's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. This means that when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From there the process is repeated. Each of the partial rotations is called a "step", with an integer number of steps making a full rotation.

In that way, the motor can be turned by a precise angle. The circular arrangement of electromagnets is divided into groups, each group called a phase, and there is an equal number of electromagnets per group. The number of groups is chosen by the designer of the stepper motor. The electromagnets of each group are interleaved with the electromagnets of other groups to form a uniform pattern of arrangement. For example, if the stepper motor has two groups identified as A or B, and ten electromagnets in total, then the grouping pattern would be ABABABABAB. Electromagnets within the same group are all energized together. Because of this, stepper motors with more phases typically have more wires (or leads) to control the motor.

5.3 Motor driver shield V3

This expansion board as a driver expansion board, can be used for engraving machines, 3D printers. It has total of four slots, can drive four A4988 stepper motor. The A4988 is a complete micro stepping motor driver with built-in translator for easy operation. It is designed to operate bipolar stepper motors in full-, half-, quarter-, eighth-, and sixteenth-step modes, with an output drive capacity of up to 35 V and ±2 A. The A4988 includes a fixed off-time current regulator which has the ability to operate in slow or mixed decay modes.Each stepper motor only need two IO ports. In other words,six IO ports can be well managed for three stepper motors. It is very convenient to use.

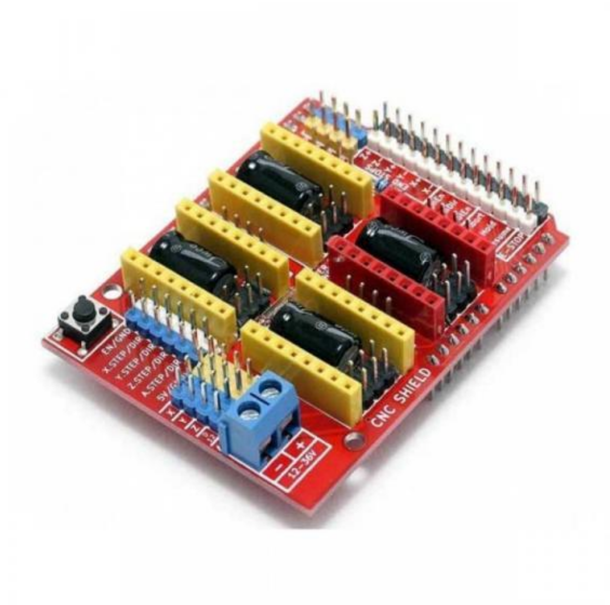

Figure 5.3: Motor driver shield V3

SPECIFICATION:

- GRBL 0.9 compatible. (Open source firmware that runs on an Arduino UNO that turns G-code commands into stepper signals)
- PWM Spindle and direction pins
- 4-Axis support (X, Y, Z , A-Can duplicate X,Y,Z or do a full 4th axis with custom firmware using pins D12 and D13)
- 2 x End stops for each axis (6 in total)

APPLICATIONS:

- 3D Printer
- Engraving machines

5.4 A4988 Motor driver

Description:

The A4988 driver is a commonly used bipolar stepper motor driver that can provide up to 2A current per coil from 8V to 35V. These drivers are used to drive NEMA 17 motors on the Mill One. This driver also allows for up to 16th micro stepping. Each package comes with three drivers with a small heat sink and header pins installed to be used with the CNC V3.0 Shield or other step stick type driver shields/control boards. Motors drive output power of up to 35V and ± 2A. A4988 includes constant outside time current regulator, regulator in modes Slow or mixed decay. A4988 convert is the key for ease of implementation. As long as the "step" inputs one pulse input drives one micro step motor. There are no phase sequence tables, high-frequency control lines, or complex program interfaces. A4988 interface is very suitable for unavailable or overburdened complex processors.

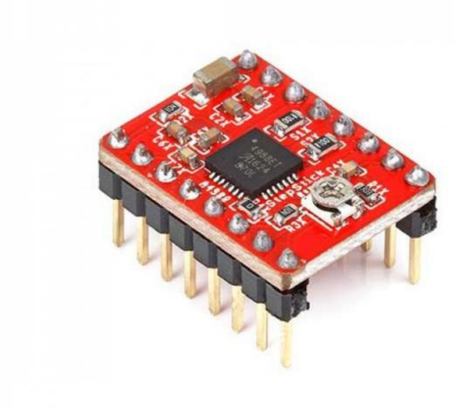

Figure 5.4: A4988 Motor driver

In a small step process, the A4988 cuts off the control inside automatically by determining the current decay mode (slow or mixed). In mixed decay mode, the device is initially set to a static stop in some rapid decay, then the rest of the stop time is slow to decay. Mixed decay current control system results in lower audible engine noise, increased step accuracy, and lower power consumption. Internal circuit monitoring synchronous correction is provided to improve pulse width modulation (PWM) process power consumption.

Inner circuit protection includes: thermal shutdown with deceleration, under voltage lockout (OFLO), and cross-current protection. Special power sequence. A4988 Ships-Con (ABS) package, size 5mm x 5mm, nominal total beam height 0.90mm, with exposed plate to enhance heat dissipation. This package is Lead (Suffix-T), with 100% Matte Tin Lead Coating.

Features:

1. Simple control interface and direction direction
2. Short-to-ground and short-load protection
3. Five different step decisions: full step, half step, quarter step, eighth step, and sixteenth step
4. intelligent chopping controller that automatically chooses the correct current decay mode (decay Fast or slow decay)
5. Over-temperature thermal shutdown, under voltage locking, and crossover-current protection
6. Adjustable current control allows you to set the maximum output current with voltage, which allows you to use voltages above the voltage of your stepper motors In voltage to achieve higher

5.5 775 DC motor 12V

A **DC motor** is an electrical motor that uses direct current (DC) to produce mechanical force. The most common types rely on magnetic forces produced by currents in the coils. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor. DC motors were the first form of motors widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances.

Figure 5.5: 775 DC motor 12V

The universal motor, a lightweight brushed motor used for portable power tools and appliances can operate on direct current and alternating current. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications. A coil of wire with a current running through it generates an electromagnetic field aligned with the center of the coil. The direction and magnitude of the magnetic field produced by the coil can be changed with the direction and magnitude of the current flowing through it.

A simple DC motor has a stationary set of magnets in the stator and an armature with one or more windings of insulated wire wrapped around a soft iron core that concentrates the magnetic field. The windings usually have multiple turns around the core, and in large motors there can be several parallel current paths. The ends of the wire winding are connected to a commutator. The commutator allows each armature coil to be energized in turn and connects the rotating coils with the external power supply through brushes. (Brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes.)

The total amount of current sent to the coil, the coil's size, and what it is wrapped around decide the strength of the electromagnetic field created. The sequence of turning a particular coil on or off dictates what direction the effective electromagnetic fields are pointed. By turning on and off coils in sequence, a rotating magnetic field can be created. These rotating magnetic fields interact with the magnetic fields of the magnets (permanent or electromagnets) in the stationary part of the motor (stator) to create a torque on the armature which causes it to rotate. In some DC motor designs, the stator fields use electromagnets to create their magnetic fields which allows greater control over the motor. At high power levels, DC motors are almost always cooled using forced air.

Different number of stator and armature fields as well as how they are connected provide different inherent speed and torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature. Variable resistance in the armature circuit or field circuit allows speed control. Modern DC motors are often controlled by power electronics systems which adjust the voltage by "chopping" the DC current into on and off cycles which have an effective lower voltage. Since the series-wound DC motor develops its highest torque at low speed, it is often used in traction applications such as electric locomotives, and trams. The DC motor was the mainstay of electric traction drives on both electric and diesel-electric locomotives, street-cars/trams and diesel electric drilling rigs for many years. The introduction of DC motors and an electrical grid system to run machinery starting in the 1870s started a new second Industrial Revolution.

DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles and today's hybrid cars and electric cars as well as driving a host of cordless tools. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines. Large DC motors with separately excited fields were generally used with winder drives for mine hoists, for high torque as well as smooth speed control using thyristor drives. These are now replaced with large AC motors with variable frequency drives.

5.6 12mm linear bearing

This LM12UU linear bearing offers low friction motion for 12mm shafts – Commonly used on 3D Printers and CNC machines for linear carriage systems. As kids, many of us enjoyed playing with LEGO, Meccano and other fun toys for building little "inventions", but now that we are older, we understand that LEGO may not be the best choice for heavy-duty mechanical projects.

Figure 5.6: 12mm linear bearing

This is why we love awesome Mechanical Components like these LM12UU Long Linear Bearings, which offer a 12mm Inner Diameter and 21mm Outer Diameter, and are perfect for coupling or mounting mechanical parts on Linear Shafts – while allowing for ultra-low friction motion along the shaft.

These bearings are awesome for creating mechanical carriages to move tool-heads, making camera dollies for smooth and precise motion in videography, or even for building custom machinery that has precise, constrained and smooth linear motion for CNC purposes, amongst other projects, offering a rating of up to 657N for dynamic loads and up to 1200N for static loads. So if you've always dreamed of building your own CNC mill or router, or if you have other, grander plans for custom machinery, jigs or further applications, these 12mm ID Linear Bearings are a great choice, and are only made better when used alongside other Linear Motion Components.

Specifications:

- Inner Diameter: 12mm
- Outer Diameter: 21mm
- Length: 30mm

5.7 12mm shaft Rod
12mm stainless steel linear motion shaft SS rod for made from 304 stainless steel. Designed for accurate fit to LM12UU linear bearing and SC12UU/ SBR12UU sliding block. Widely used in 3D printers, and CNC machines, robotics, pick and place machine etc.

Figure 5.7: 12mm shaft Rod

Specifications:

- Material: Stainless Steel
- Diameter: 12mm
- Length: As Selected
- Perfectly fits LM12UU linear ball bearing, SC12UU and SBR12UU sliding blocks

5.8 608zz bearing
A **ball bearing** is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least two races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft). As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were sliding against each other.
Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races. Although bearings had been developed since ancient times, the first modern recorded patent on ball bearings was awarded to Philip Vaughan, a Welsh inventor and ironmaster who created the first design for a ball bearing in Carmarthen in 1794. His was the first modern ball-bearing design, with the ball running along a groove in the axle assembly.[1] Jules Suriray, a Parisian bicycle mechanic, designed the first radial style ball bearing in 1869, [2] which was then fitted to the winning bicycle ridden by James Moore in the world's first bicycle road race, Paris-Rouen, in November 1869. There are several common designs of ball bearing, each offering various

performance trade-offs. They can be made from many different materials, including stainless steel, chrome steel, and ceramic (silicon nitride, Si_3N_4). A hybrid ball bearing is a bearing with ceramic balls and metal races.

Figure 5.8: **608zz Ball bearing**

Angular contact

An *angular contact* ball bearing uses axially asymmetric races. An axial load passes in a straight line through the bearing, whereas a radial load takes an oblique path that acts to separate the races axially. So the angle of contact on the inner race is the same as that on the outer race. Angular contact bearings better support combined loads (loading in both the radial and axial directions) and the contact angle of the bearing should be matched to the relative proportions of each. The larger the contact angle (typically in the range 10 to 45 degrees), the higher the axial load supported, but the lower the radial load. In high speed applications, such as turbines, jet engines, and dentistry equipment, the centrifugal forces generated by the balls changes the contact angle at the inner and outer race. Ceramics such as silicon nitride are now regularly used in such applications due to their low density (40% of steel). These materials significantly reduce centrifugal force and function well in high temperature environments. They also tend to wear in a similar way to bearing steel—rather than cracking or shattering like glass or porcelain. Most bicycles use angular-contact bearings in the headsets because the forces on these bearings are in both the radial and axial direction.

Axial

An *axial* or *thrust* ball bearing uses side-by-side races. An axial load is transmitted directly through the bearing, while a radial load is poorly supported and tends to separate the races, so that a larger radial load is likely to damage the bearing.

Deep-groove

In a *deep-groove* radial bearing, the race dimensions are close to the dimensions of the balls that run in it. Deep-groove bearings support higher loads than a shallower groove. Like angular contact bearings, deep-groove bearings support both radial and axial loads, but without a choice of contact angle to allow choice of relative proportion of these load capacities.

Preloaded pairs

The above basic types of bearings are typically applied in a method of *preloaded pairs*, where two individual bearings are rigidly fastened along a rotating shaft to face each other. This improves the axial runout by taking up (*preloading*) the necessary slight clearance between the bearing balls and races. Pairing also provides an advantage of evenly distributing the loads, nearly doubling the total load capacity compared to a single bearing. Angular contact bearings are almost always used in opposing pairs: the asymmetric design of each bearing supports axial loads in only one direction, so an opposed pair is required if the application demands support in both directions. The preloading force must be designed and assembled carefully, because it deducts from the axial force capacity of the bearings, and can damage bearings if applied excessively. The pairing mechanism may simply face the bearings together directly, or separate them with a shim, bushing, or shaft feature.

5.9 8mm CNC Screw Nut & Patch Rod

A **leadscrew** (or **lead screw**), also known as a **power screw**[1] or **translation screw**,[2] is a screw used as a linkage in a machine, to translate turning motion into linear motion. Because of the large area of sliding contact between their male and female members, screw threads have larger frictional energy losses compared to other linkages.

Figure 5.9: 8mm CNC Screw Nut & Patch Rod

They are not typically used to carry high power, but more for intermittent use in low power actuator and positioner mechanisms. Leadscrews are commonly used in linear actuators, machine slides (such as in machine tools), vises, presses, and jacks.[3] Leadscrews are a common component in electric linear actuators.

Leadscrews are manufactured in the same way as other thread forms (they may be rolled, cut, or ground).

A lead screw is sometimes used with a split nut (also called half nut) which allows the nut to be disengaged from the threads and moved axially, independently of the screw's rotation, when needed (such as in single-point threading on a manual lathe). A split nut can also be used to compensate for wear by compressing the parts of the nut. A hydrostatic leadscrew overcomes many of the disadvantages of a normal leadscrew, having high positional accuracy, very low friction, and very low wear, but requires continuous supply of high pressure fluid and high precision manufacture, leading to significantly greater cost than most other linear motion linkages.

V-thread

V-threads are less suitable for leadscrews than others such as Acme because they have more friction between the threads. Their threads are designed to induce this friction to keep the fastener from loosening. Leadscrews, on the other hand, are designed to minimize friction.[5] Therefore, in most commercial and industrial use, V-threads are avoided for leadscrew use. Nevertheless, V-threads are sometimes successfully used as leadscrews, for example on microlathes and micromills.[6]

Square Thread

Square threads are named after their square geometry. They are the most efficient, having the least friction, so they are often used for screws that carry high power. But they are also the most difficult to machine, and are thus the most expensive.

Acme Thread / Trapezoidal Thread

Acme threads have a 29° thread angle, which is easier to machine than square threads. They are not as efficient as square threads, due to the increased friction induced by the thread angle.[3] Acme threads are generally also stronger than square threads due to their trapezoidal thread profile, which provides greater load-bearing capabilities.

Buttress Thread

Buttress threads are of a triangular shape. These are used where the load force on the screw is only applied in one direction.[7] They are as efficient as square threads in these applications, but are easier to manufacture.

5.10 12V Adapter Female Connector

A **DC connector** (or **DC plug**, for one common type of connector) is an electrical connector for supplying direct current (DC) power. Compared to domestic AC power plugs and sockets, DC connectors have many more standard types that are not interchangeable. The dimensions and arrangement of DC connectors can be chosen to prevent accidental interconnection of incompatible sources and loads. Types vary from small coaxial connectors used to power portable electronic devices from AC adapters, to connectors used for automotive accessories and for battery packs in portable equipment.

Figure 5.10: 12V adapter female connector

Small cylindrical connectors come in a variety of sizes. They may be known as "coaxial power connectors", "barrel connectors", "concentric barrel connectors" or "tip connectors". The intended use of these plugs is on the cable connected to an external AC adapter (power supply). The matching jack or socket is permanently fitted to the equipment to be powered. Some of these jacks contain a normally closed contact, which can be used to disconnect internal batteries whenever the power supply is connected, avoiding the risk of battery leakage or explosion posed by incorrect recharging of the batteries.

Cylindrical plugs usually have an insulated tip constructed to accept insertion of a pin. The outer body of the plug is one contact, most often but *not always* the negative side of the supply. Inverted polarity plugs can, and do, damage circuitry when plugged in, even if the voltage is correct; not all equipment is equipped with protection. A pin mounted in the socket makes contact with a second internal contact. The outer plug contact is often called the *barrel*, *sleeve* or *ring*, while the inner one is called the *tip*.

There are a wide variety of sizes and designs for these power connectors, and many appear quite similar to each other yet are not quite mechanically or electrically compatible. In addition to a plethora of generic designs (whose original designer is unknown) there are at least two different national standards—EIAJ in Japan and DIN in Germany, plus the JSBP connector used on some laptop computers. The Japanese EIAJ standard includes five different sizes, with each supporting a specified range of voltages. Most of the other coaxial DC power connectors have no specified voltage association, however. Generic plugs are often named for the pin diameter they are designed to take.

Many non-proprietary co-axial power plugs are 5.5 mm (0.22 in) in outside diameter (OD) and 9.5 mm (0.37 in) in length. Two pin sizes are common in the jacks for this size plug body, 2.1 mm (0.083 in) and 2.5 mm (0.098 in), and the plugs should match. If the size is not known, it is difficult to distinguish by eye or measurement between the 2.1mm and 2.5mm ID plugs; some suppliers suggest simple methods.[1]

Maximum current ratings commonly vary from unspecified up to 5 A (11 A for special high power versions from some companies[2]), with 1 A, 2 A and 5 A being common values.[3] The smaller types usually have lower ratings, both for current and voltage. The 'tip' (i.e., the inner conductor) usually carries the positive (+) pole, but some devices, and their power supplies, use negative tip. Connector size does not usually indicate the voltage. It is not possible, except for some proprietary connectors, to reliably infer any information on power parameters (current, voltage, polarity, even whether AC or DC) by examining the connector.

5.11 Arduino IDE

The digital micro-controller unit named as Arduino Nano can be programmed with the Arduino software IDE. There is no any requirement for installing other software rather than Arduino. Firstly, Select "Arduino Nano from the Tools, Board menu (according to the micro-controller on our board). The IC used named as ATmega328 on the Arduino Nano comes pre burned with a boot loader that allows us to upload new code to it without the use of an external hardware programmer.

Communication is using the original STK500 protocol (reference, C header files). We can also bypass the boot loader and programs the micro-controller through the ICSP (In Circuit Serial Programming) header. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

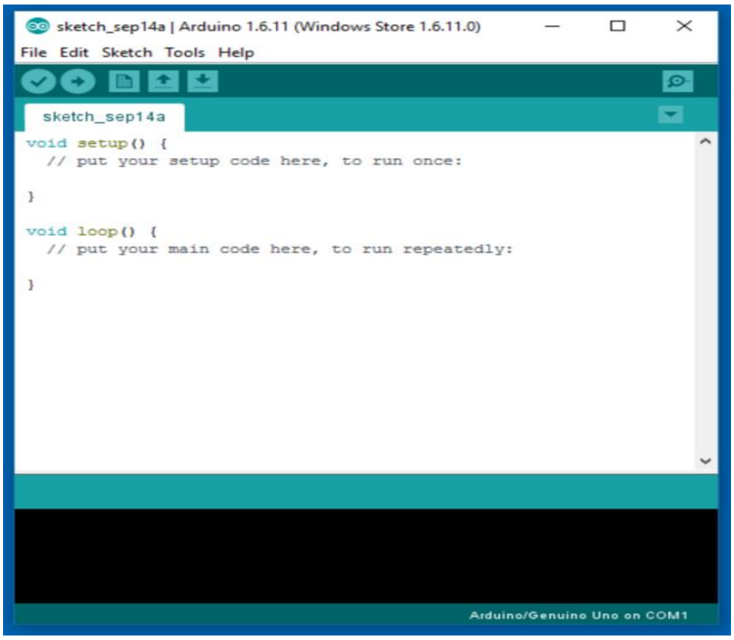

Figure 5.11: Arduino Software Interface IDE

The Arduino Nano is one of the latest digital micro-controller units and has a number of facilities for communicating with a computer, another Arduino, or other micro-controllers. The ATmega328 provides UART TTL at (5V) with serial communication, which is available on digital pins 0 -(RX) for receive the data and pin no.1 (TX) for transmit the data. An ATmega16U2 on the board channels this serial communication over USB and appears as a

virtual com port to software on the computer.
The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .in file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial Communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication.
The Arduino software includes a Wire library to simplify use of the I2C bus. Arduino programs are written in C or C++ and the program code written for Arduino is called sketch. The Arduino IDE uses the GNU tool chain and AVR Lab to compile programs, and for uploading the programs it uses argued. As the Arduino platform uses Atmel micro-controllers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino.The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Writing Sketches

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

Sketchbook

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog. Beginning with version 1.0, files are saved with a .ino file extension. Previous versions use the .pde extension. You may still open .pde named files in version 1.0 and later, the software will automatically rename the extension to .ino.

Tabs, Multiple Files, and Compilation

Allows you to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

Uploading

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx , /dev/ttyUSBx or similar.
Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code.

Third-Party Hardware

Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, bootloaders, and programmer definitions. To install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "arduino" as the sub-directory name or you'll override the built-in Arduino platform.) To uninstall, simply delete its directory.For details on creating packages for third-party hardware, see the Arduino IDE 1.5 3rd party Hardware specification.

Serial Monitor

This displays serial sent from the Arduino or Genuino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial. Begin in your sketch. Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board.

5.12 Easy EDA Software

Easy EDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share - publicly and privately - and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats. Easy EDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription. Registered users can download Gerber files from the tool free of charge; but for a fee, Easy EDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

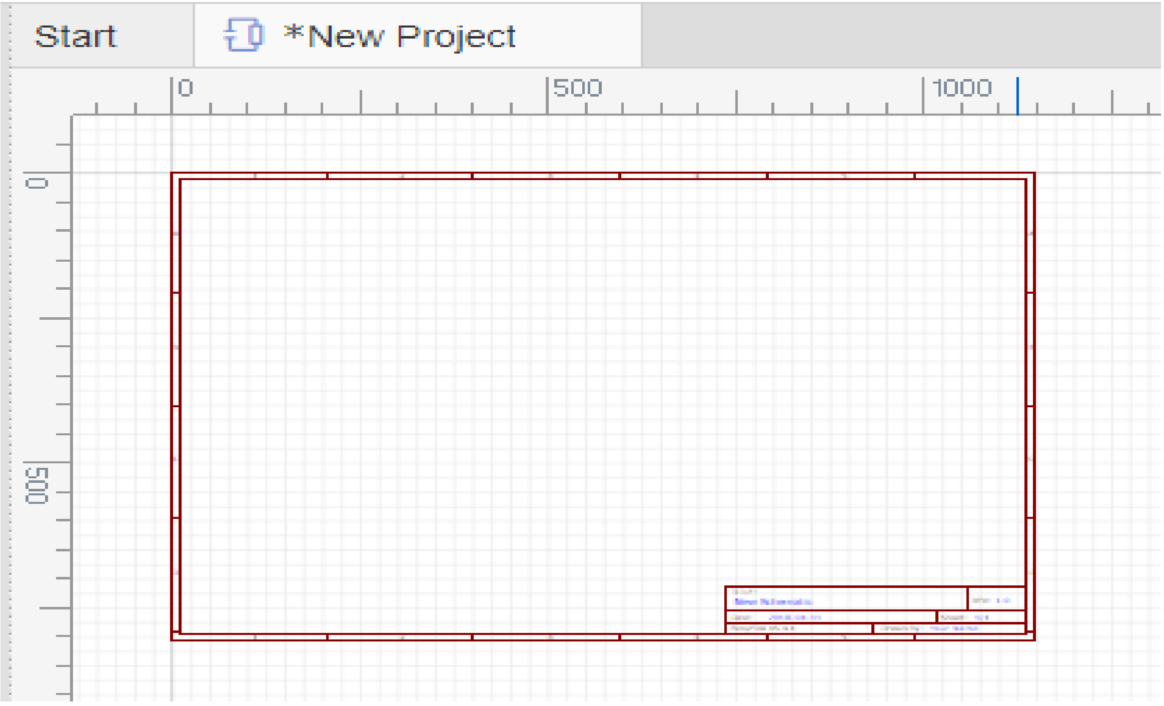

Figure 5.12: Easy EDA Software Interface

CHAPTER 6
METHODOLOGY

6.1 Our methodologies for the project:

Our methodologies for the project:

- Creating an idea for design and construction of an **3 axis CNC Milling machine.** And designing a block diagram & circuit diagram to know which components we need to construct it.
- Collecting all the components and programming the micro-controller to control the whole system.
- Setting up all the components in a PCB board & then soldering. Lastly, assembling all the blocks in a board and to run the system & for checking purposes.

6.2 Our Project Final Image

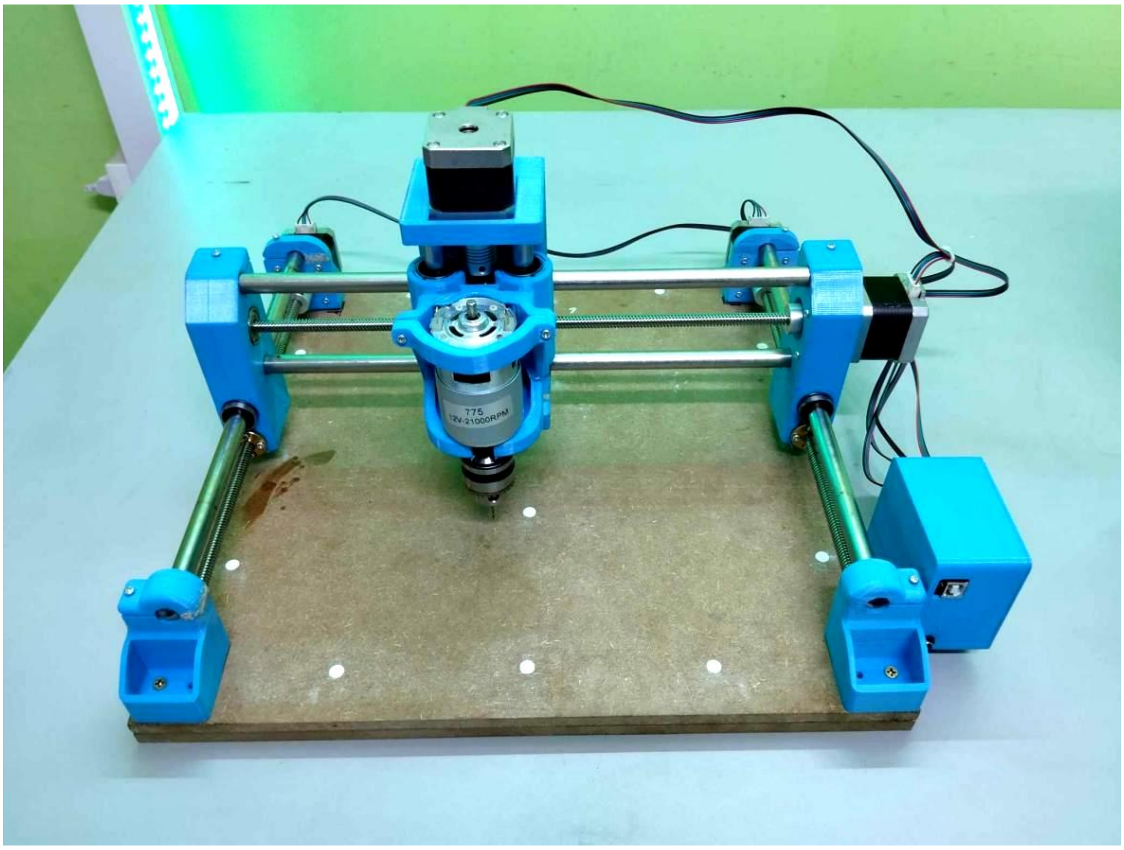

Figure 6.1: Our Final System Overview

6.3 Working Principle

- Computer Control: CNC machines are operated by computer programs that contain instructions for the machining process. These programs are created using computer-aided design (CAD) or computer-aided manufacturing (CAM) software.
- The 3 Axis CNC Milling Machine operates based on a systematic integration of electronic control and mechanical precision.
- The following steps outline the working principle of this CNC system: The process begins with initializing the control system, where the Arduino UNO micro-controller sets up the parameters for the CNC machine.
- This may include defining the work area, programming the tool path, and configuring the motor control settings.
- The stepper motor's ability to move in incremental steps ensures accurate positioning of the tool along the X, Y, and Z axes.
- The linear motion components, including 12mm linear bearings, shaft rods, and 608zz bearings, facilitate smooth and controlled movement of various parts of the CNC machine.
- The 8mm CNC screw nut and patch rod contribute to precise linear motion. The 775 DC motor, operating at 12V, may serve as a spindle motor for rotational tasks.
- The CNC machine follows a predefined tool path programmed into the Arduino UNO.
- The control system ensures that the stepper motor and other components move in a coordinated manner, executing the desired operations on the work piece.
- The Arduino UNO, acting as the brain of the system, controls the timing, speed, and direction of the motors based on the programmed instructions.

6.4 Cost Analysis

In the below table we have summarized our project expenditure.

Table 6.2: Lists of Components with Price.

Sl. No	Product Name	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
01.	Arduino UNO	ATmega328P	1	450	450
02.	Stepper Motor	Nema 17	4	900	3600
03.	Motor Driver Shield	V3	1	380	380
04.	Motor Driver	A4988	4	200	800
05	775 DC Motor	12V	1	780	780
05.	Linear Bearing	12mm	1	280	280
06.	Shaft Rod	12mm, 13 inch & 15 inch	4	300	1200
07.	Bearing	608zz	4	50	200
08.	CNC Screw Nut & Patch Rod	8mm	1	390	390
09	Adapter Female connector	12V	1	160	160
10	pulley	5*8	1	280	280
11.	Others				1850
				Total =	**10,370/=**

CHAPTER 7
RESULTS AND DISCUSSION

7.1 Results

Now, it's time to talk about the results.

- Finally, we have completed our project successfully & check our project its run accurately according to our objective.
- At first, we start our system.
- The CNC machine can be programmed to precisely drill holes at specific locations on a work piece. The stepper motor, linear motion components, and the 775 DC motor (if used as a spindle motor) work together to ensure accurate and controlled drilling operations.
- By changing the tool and adjusting the CNC parameters, the machine can perform engraving or milling operations. This allows for the creation of intricate designs or the removal of material from the work piece to achieve a specific shape.

Table 7.1: **Drill Operation Testing Result & Efficiency Compression**

Drill Operation			
Serial	Types	CNC	Convectional
1.	Time	50s	70s
2.	Depth	25mm	25mm
3.	Feed	20.	12.
4.	RPM	1250	850
5.	Diameter	5mm	5mm
6.	Workpieces	Mild Steel	Mild Steel

Table 7.2: **Engraving Operation Testing Results**

Engraving Operation		
Serial	Types	CNC
1.	Time	150s
2.	Depth	2mm
3.	Feed	25.
4.	RPM	2000
5.	Diameter (End Mill)	2mm
6.	Workpieces	Plastic Board

7.2 Advantages

There are certainly many advantages of our project and some of the major ones have been given below:

- Computer Control
- Precision and Accuracy.
- Automation and Efficiency.
- Versatility.
- Repeatability.
- Multi-axis Capability
- Quality Control
- Just in time (JIT) Manufacture
- Reduced Human Error.
- User-friendly.
- Cost-Effectiveness in Production.

7.3 Disadvantages

There are certainly many advantages of our project and some of the major ones have been given below:

- High initial costs
- Maintenance costs
- Skilled operator requirement
- Programming complexity
- Limited flexibility
- High energy consumption
- Dependence on software
- Size limitations
- Lack of personal touch.

7.4 Limitation

Although our project has many applications and advantages but there are some limitations of the project as well and the good thing is that these limitations are minor and doesn't affect the efficiency of the system. Limitations are given below:

- High Initial Investment.
- Complex Programming.
- Maintenance and Downtime.
- Limited Flexibility for Small Production Runs.
- Material Limitations.

7.5 Applications

This project has applications in many fields due its necessity. We have selected a few of them and they are given below:

- Manufacturing and Prototyping.
- Aerospace Industry.

- Automotive Industry.
- Medical Device Manufacturing.
- Electronic Components Manufacturing.
- Mold and Die Making.

7.6 Discussion

While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

CHAPTER 8
CONCLUSION

8.1 Conclusion

In conclusion, the 3 axis CNC Milling machine stands as a pivotal tool in modern manufacturing and fabrication, offering a multitude of advantages that contribute to its widespread adoption across diverse industries. The integration of advanced electronic control, precision mechanical components, and automation capabilities positions this CNC machine as a versatile and efficient solution for various applications. The advantages of precision, repeatability, and versatility make the 3 axis CNC Milling machine particularly well-suited for tasks ranging from aerospace and automotive manufacturing to medical device production, jewelry crafting, and beyond. Its ability to work on all sides of a work piece enhances its flexibility, allowing for the creation of intricate designs and the machining of complex geometries. While acknowledging the numerous benefits, it is essential to consider the associated challenges, including the initial investment cost, complex programming requirements, and the need for skilled operators. These factors highlight the importance of careful planning, operator training, and regular maintenance to maximize the efficiency and longevity of the CNC system.

8.2 Future Scope

As we have already discussed about the limitations of our project so definitely there's room for improvement and thus we have lots of future scope of work available to us for this project. Some of these are listed below:

- **Integration of Smart Technologies:** The incorporation of smart technologies, such as IOT (Internet of Things) sensors and connectivity, could enable real-time monitoring and diagnostics.
- **Machine Learning and AI Integration:** The integration of machine learning algorithms and artificial intelligence (AI) could lead to smarter and more adaptive CNC machines.
- **Advanced Materials Machining:** As new materials with unique properties emerge, CNC machines will need to adapt to accommodate advanced material machining.

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APPENDIX A

Ser	Short From	Meaning
1.	ATC	Automatic Tool Changer
2.	AVI	Audio Video Interleave
3.	BCD	Binary Coded Decimal
4.	CAD	Computer-Aided Design
5.	CAM	Computer-Aided Manufacturing
6.	CCW	Counter Clock Wise
7.	CD-ROM	Compact Disc – Read Only Memory
8.	CD-RW	Compact Disc – Re-Writable
9.	CDC	Cutter Diameter Compensation
10.	CMM	Coordinate Measuring Machine
11.	CNC	Computer Numerical Control
12.	CPL	Coordinate Position Locator
13.	CPU	Central Processing Unit
14.	CRC	Cutter Radius Compensation
15.	CSS	Constant Surface Speed
16.	CW	Clock Wise
17.	DNC	Direct Numerical Control
18.	DVD	Digital Video Disc
19.	DXF	Drawing Exchange Format
20.	EDM	Electronic Discharge Machine
21.	EOB	End of Block
22.	FBM	Feature-Based Machining
23.	FMS	Flexible Manufacturing System
24.	FPT	Feed Per Tooth
25.	FTDI	Future Technology Devices Intl.
26.	GB	Gigabit
27.	G-Code	Preparatory Functions (commands)
28.	GHz	Gigahertz
29.	HP	Horsepower
30.	HSS	High Speed Steel
31.	ID	Inside Diameter
32.	IPM	Inches per Minute (also in/min)
33.	IPR	Inches per Revolution (also in/rev)
34.	ISO	International Standards Organization
35.	KW	Kilowatt
36.	LAN	Local Area Network
37.	LCD	Liquid Crystal Display
38.	LED	Light Emitting Diode
39.	MB	Megabit
40.	MB1, 2, or 3	Mouse Button 1 = left, 2 = Scroll or 3 = right
41.	M-Codes	Miscellaneous Functions

42. MCS Machine Coordinate System
43. MCT Machine Center Tool (Pocket)
44. MCU Machine Control Unit
45. MDI Manual Data Input
46. MGi Manual Guide i
47. MHz Megahertz
48. Mm Millimeters
49. NC Numerical Control
50. OD Outside Diameter
51. PC Personal Computer
52. PLC Programmable Logic Controller
53. PMI Product Manufacturing Information
54. PSI Pounds per Square Inch
55. RAM Random Access Memory
56. ROM Read Only Memory
57. RPM Revolutions per Minute (also rev/min or r/min)
58. TLO Tool Length Offset
59. USB Universal Serial Bus
60. WCS Work Coordinate System

APPENDIX B

Micro-Controller Program:

```
#include <grbl.h>
```

Note: (These studies suggest that "GRBL" refers to various concepts, including a protein involved in cellular signaling (Grb2), a low-swing global read bit-line in SRAM technology, and an open-source G-code parser for CNC motion control.)