

CONCEPT GENERATION AND DEVELOPMENT OF 3 AXIS TABLE TOP DRILLING MACHINE FOR PCB APPLICATION

¹VINOD ARVA, ²KESHAVA P, ³Abhishek M, ⁴Vinod Kumar H P, ⁵Dr.PrakashKR

¹Managing director, Plantek, Mysuru, Karnataka, India.

²Managing director, Plantek, Mysuru, Karnataka, India.

³ 4 them, M .Tech Student, Industrial Automation and Robotics, Department of Mechanical Engineering, The National Institute of Engineering, Mysuru, Karnataka, India

⁴Assistant Professor, Department of Mechanical Engineering, The National Institute of Engineering, Mysuru, Karnataka, India.

⁵Professor, Department of Mechanical Engineering, The National Institute of Engineering, Mysuru, Karnataka, India.

Abstract: In India we have more numbers of small-scale industries in all the sectors and we are having huge demand in low-cost automation in the case of electronic industries the problem for drilling multiple holes at exact dimension in printed circuit boards is a challenging and human labour can skip or miss the drill position and he may drill hole at inaccurate dimension leads to complete termination of PCB. In order to solve these problems, concept generation and development of 3 axis table top drilling machine for PCB application is presented in this project. This project is carried out at PLANTEK Mysore. The project aims at the creation of a 3-axis drilling machine. This machine will have three degrees of freedom and will be capable of drilling holes up to 3mm; this can be helping the small electronics industries which can increase the production rate.

Index Terms—Printed circuit board, Drilling diameter, Computer numerical control, Universal serial bus

I. INTRODUCTION

Along with the paradigm shift from Industry 3.0 to Industry 4.0, industrial manufacturing is going through a process of changing toward flexible and intelligent manufacturing. Everyday new manufacturing process researches are going on to reduce the machine and labour cost also to reduce the manufacturing lead time. The trending manufacturing process like 3D printing, laser machining, table top drilling machines adds some more opportunity to research on these areas young engineers developing new machine with low-cost automation using wide variety controllers, getting in the customizing machine manufacturing with low-cost automation is getting demand in the machine building sector today, we can see plenty number of machines which are operated by using Programmable logic controllers and other controllers.

Machines having wide range of categories, classes, operating environment and type of industries, this paper address the table top drilling machine which is used in electronic industries for drilling holes in PCB in various locations. Drilling holes radially in one direction for location makes repetitive to operator and sometimes the operator may damage the PCB due to laziness which results in termination of PCB this process is the one before the last in the PCB manufacturing process. To overcome this pitfall the concept generation and development of 3 axis table top drilling machine for PCB application is proposed in this paper this machine overcome the drawback of the termination of the PCB, reduces manufacturing lead time, Customization of PCB can be performed at very pace. T Anderi et.al [1] proposed 3 Axis Air foil Maker Machine using Arduino microcontroller based on computerized numerical controller (CNC) machine that are design and construction of machine and programming the motor control algorithm with CAM software and later sent to micro controller. Gyula Hermann et.al [2] proposed a system with high precision probes with accuracy 0.02mm the coordinates are indicated and compared with interferometer the errors of the probe are then calculated and full measurement strategy and design considerations. Mohamed Y. Tarnini et.al [3] proposed controlling of stepper motor, it doesn't need any sensing device to sense the shaft position we control uni-polar stepper motor by a simple decoder (CD4017) ignited from a timer 555 circuit also by using a microcontroller as PIC 16F84A. RassimSuliyevet.al[4] controlled using computer, by setting drawing for engrave. Arduino board has been chosen as a controller part Processing software was used. Graphical User Interface provided for drawing the desired pattern controller converts them to the signals for the motors. Anubhavi S. et.al [5] 3 Axis Drawing Machine using Arduino controller based on computerized numerical controller (CNC) machine and open-source software (G-code and GRBL) for controlling whole operation proposed plan is to reduce time consumed and it reduces human involvement which eventually reduces rate of error.

II. SCOPE

The scope of this machine is to reduce the machine size, manufacturing cost of the machine, improve the production rate and to cater the small electronic industries to get it at affordable price.

III. MATERIALS AND METHODOLOGY

The mechanical design of the project is designed using Solid works software and this are divided in to 3 assemblies. Base assembly axis assembly and Z axis assembly. The base assembly consists of aluminium extrusion which is less corrosion resistance used to make the base platform for the machine it also having good load carrying property the extrusion are cut in the required dimension and assembled by using a guzzet with the help of T nuts and Socket head screws. Guide roads and trapezoidal lead screw are inserted into the extrusion making a hole into required dimension and stopper blocks are used to block the rotation of the guide rod. Trapezoidal Lead screw consist of 30 degree helix angle which engages with nut which is fastened to the work table in turn convert the rotation movement of the screw into linear. The lead screw rotatedcontinously in the flange bearing which are inserted on the both end of Y axis this are coupled to a flexible coupling other end is connected to the stepper motor.

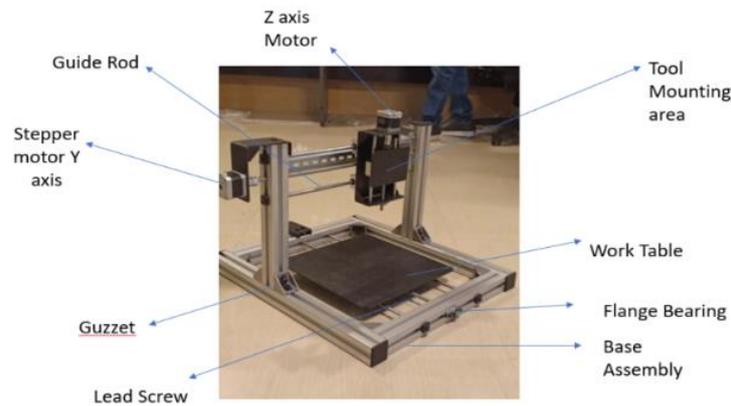


Fig.1: Representation of machine

X axis are raised pillars on the base assembly which are designed using chrome plate rods, lead screw and for electrical connection the din rail are mounted along the longitudinal axis which are used to route the motor cable. The movement of the X axis is major because the tool holding axis is mounted on it which is major for drilling holes in required. Stepper motors are mounted using the motor bracket and it is coupled to lead screw.Z axis is drilling axis the forward movement of the screw, drill the hole at exact position as commanded by the microcontroller, the plated mounted with guide roads and engaged with leadscrew and nut is responsible for the drilling holes in pcb.All the axis in the machine with each position command by the microcontroller is responsible for the drilling ,accuracy is depend on the linear bearing which is mounted in each axis of the guide road which gives smooth movement for the because each bearing inserted with ball bearing which immensely give smooth movements.

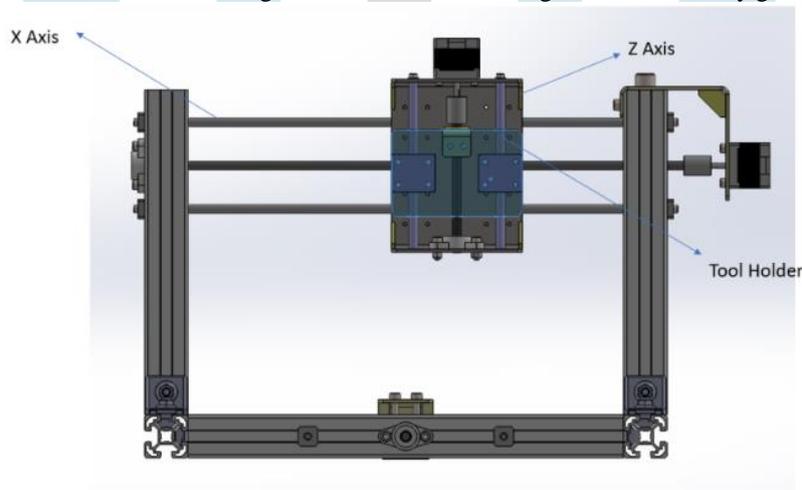


Fig 2: Representation of machine axis

Motor Calculation parameter:

1. Total Mass [M]+Factor of safety [FOS] = 3.5 Kg
2. External Force [FA]=0 N
3. Co-efficient OF Friction [μ]=0.3
- 4 Efficiency [η] =0.9

Force Calculation

$$F = F_A + m \times g (\sin\theta + \mu \cos\theta)$$

$$F = 0 + 3.5 \times 9.81 (\sin 0 + 0.3 \cos 0)$$

$$F = 30.901 N$$

Load Torque Calculation

$$T_L = (FX \mu) / (2 \times \eta)$$

$$T_L = 1.030 \text{ N-m}$$

The machine required selected torque stepper which is shown in above equation and calculation. The mechanical and electrical in machine development plays major role if any of the consideration fails results cannot be achieved even microcontroller communication may affect the accuracy. We used Arduino mega controller which is having digital input and output pins with communication USB 2.0 is used the 16MHZ clock gives the good operation condition, power jack with dc output is well suited for the controller since current flows in one direction this board is based on ATmega2560 controller.

```

1  #include <Arduino.h>
2  #include <Accelstepper.h>
3
4  Accelstepper Stepper(1,8,9);
5  Accelstepper Stepper2(1,10,1);
6  Accelstepper Stepper3(1,12,130);
7
8  //Pins
9  Cons byte Analog_x_pin=A0;
10 Cons byte Analog_y_pin=A10;
11 Cons byte Analog_Z_pin=A11;
12 //variables
13 int Analog_x=0;
14 int Analog_y=0;
15 int Analog_z=0;
16
17 int Analog_x_AVG=0;
18 int Analog_y_AVG=0;
19 int Analog_z_AVG=0;
20

```

Fig 3: Program Using Visual Studio code

Firmware for the machine is programmed using Visual studio code with using Arduino library, this function sends the pulse for the required motor one after other depending on programmed values, and motors are directed supplied power with the power adapters' single phase. The stepper motor having the single phase with both positive and negative steps the stepping pulsation decided by the microcontroller weather it want to move forward backward which intern moves the lead screw hence the machining is carried by out each motor in milliseconds depending on the programming decided by the code. Machine is operated in both incremental and absolute dimension where the user can decide in the programming panel, the reference axis can be taken at the middle or any end of the worktable.

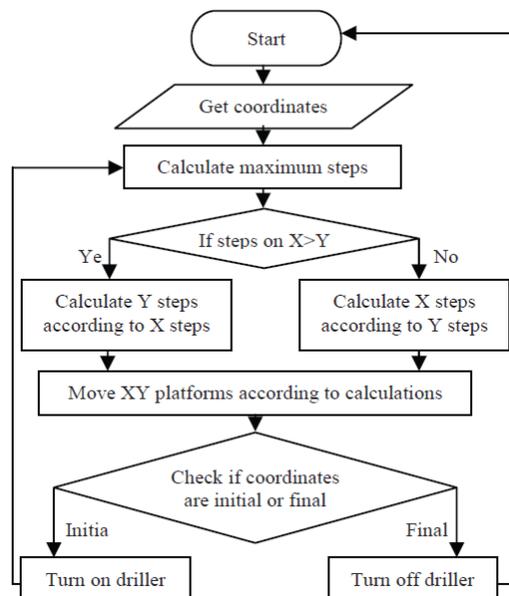


Fig 4: Program Flow chart

IV. RESULTS

The project's goal was accomplished, and it operates effectively and accurately as planned. However, one drawback is that it is

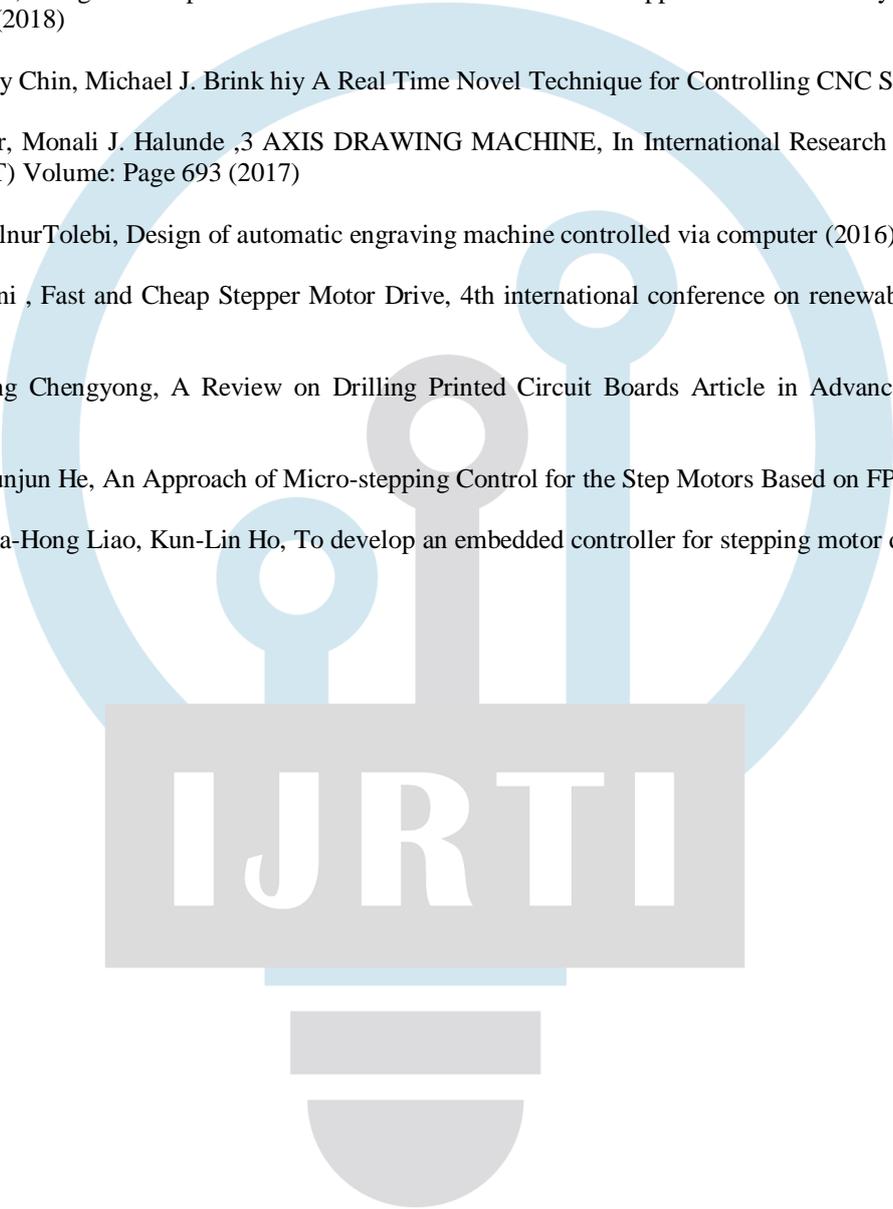
not appropriate for surface mould device drilling.

V. CONCLUSION

The developed 3 Axis drilling machine is a cost effective it will cost around 25000-40000 INR depends on specification. It is a compact in size having a dimension of 300X450mm. In this project Arduino microcontroller is used which is easily interfaced using USB 2.0 with firmware pc to transfer the data as commanded. The machine is capable of drilling holes as commanded by the operator in the programming panel, the machine have the capability to drill hole size of 1 mm to 3 mm, As the machine has traveling length in X-axis is 350 mm, Y-axis is 500 mm, Z- axis is 250 mm. the machine overall weight is 14kg because of less weight the machine is portable.

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