Design and Implementation of an Automated PCB Drawing and Drilling System

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Abstract—This paper presents development of a PCB prototyping system that is able to produce trace lines and drill holes on a PCB board. The system consists of 3 main parts: a mechanical setup that can move in X, Y and Z directions, a driving circuitry and a software program that controls overall operation of the whole system. In this initial work, the system is developed such that it produces a trace line on a PCB board and drill holes on two pads at both end of the trace line. We show that our system successfully performs both of the above tasks.

***Index Terms*— PCB machine; PIC 18F452 Microcontroller; Step motors**

I. Introduction

Systems that can assembly electronic cards from their circuit drawings are used in so many places from industry to university labs. Typically, production of a PCB card requires trace lines to be drawn, holes to be drilled and soldering to be done on a circuit board. Nowadays, these processes are done by expensive equipment. The price of these equipment ranges on the order of tens of thousands of dollars. There are many places where there is need for a cheaper device that could automate either all of or some parts of the above mentioned processes. We will brief two related studies below.

Hodges and Richard had developed a cheaply constructed robot mechanism and added a computer vision system to it to obtain a PCB drilling mechanism. With some minor modifications, their mechanism could be used for placement of surface mount components on a PCB as well. They reported that their system drill holes on a PCB with an accuracy of mean error of 0.07 mm. The mean error was calculated by measuring Euclidean distance between the center of each pad and the center of each hole drilled on the application board. Their system also successfully achieved the job of placement of surface mount components onto the PCB. Their aim in that study was to construct a cheap robot and then write sophisticated software for the vision system of the robot such that the robot could achieve jobs that were only achievable by highly expensive robots. The total cost of their system was around 1000 pound. They indicated that their system ran with comparable speed with a commercially available PCB assembly machine with a price of 10000 pound. They also indicated that their system accurately placed surface mount components on a PCB. Further details of their study can be obtained from [1,2,4].

Onwubolu et. al. [3] developed a PC-based computer numerical control (CNC) drilling machine. Both the machine and the driving circuitry were built in house. They have used a PC as a separate front-end interface for the drilling machine. The system they had developed integrated several features such as customized machine control unit, enhanced parallel port communication and neural network based optimizer in order to find the best distance optimized sequence of points to be drilled. They have reported successful drilling of PCBs with their system.

II. Method

This study demonstrates hardware and software implementation of a PCB machine that is able to draw trace lines and drill holes to designated places on a board. The system consists of a mechanical setup of that can move in X, Y and Z directions, a computer, a driving circuit and a software program. The driving circuit is developed to control the mechanical setup as well as to communicate with the computer. The software program is developed to control overall operation of the machine.

In this initial work, we have demonstrated that the machine can produce a trace line on a single layer PCB board and drill holes on two pads that are on both ends of the trace line. We continue studying to enhance different aspects of working of the system as they will be demonstrated in our future works. An actual picture of the system is shown in the Figure 1.

Figure 1: An actual picture of the mechanical setup.

Our PCB card drawing and drilling system is developed by using mechanical setup of an old CNC machine. The mechanical setup has a flat layer on which PCB is put on it to be processed. Above the flat layer, there is a drill that can move along XY axis. The drill can also move up and down for a specified amount of distance. There is a bit connected to the bottom of the drill. Both trace lines and holes are produced using this bit.

To produce a trace line on a single layer PCB, we first adjust the drill such that it only moves down to 0.5 mm below of the surface of the board. We then send starting coordinate of a trace line to the PIC. Upon receiving this signal, PIC moves the drill to the location of starting coordinate. During this movement, the drill is at up position. When the drill receives the specified location, PCB machine puts the drill at down position, starts drilling and move continuously according to the coordinates sent from computer. The coordinates have to belong to edges of a trace line that is to be drawn. During this process, the drill bit carves the copper layer on the surface of the PCB continuously as deep as 0.5 mm. Hence the trace line is separated from the remaining part of the copper on the PCB when the process is completed.

In order to drill a hole on the same PCB, we let the machine to finish up the tracing, and then readjust the drill so that it moves down approximately 2 mm below of the surface of PCB. After that, we specify coordinates and let the drill go to those positions and perform drilling one at a time.

III. DRIVINING CIRCUITRY

We have designed and developed a driving circuit given in the Figure 2 in order to operate the PCB machine.

The driving circuitry is developed using a PIC 18F452 micro controller. It controls and runs specific functions of the machine such as running step motors to move the machine in XY axis, running the drill and enabling or disabling an actuator that moves the drill up or down. It also communicates with computer via LPT1 port. The computer is used to perform specific tasks such as sending coordinates of trace lines and pads to the driving circuitry and receiving acknowledge signals from the PIC. A program is written in Matlab to achieve overall control of the machine and to perform data communication between computer and driving circuitry. Coordinates of trace lines and pads are kept in a text file in the computer. It is also a job of the Matlab program to open this text file, read coordinates and send them to the PIC in order to have the PCB machine to perform desired tasks.

IV. SOFTWARE DESCRIPTION

There are 2 separate programs running in parallel in order to operate the PCB machine. The first program runs in the PIC 18F452. It is written in assembly language of the PIC and performs the actual step motor driving, runs the drill, accomplishes actuator on/off operations and reads data from sensors placed on the PCB machines.

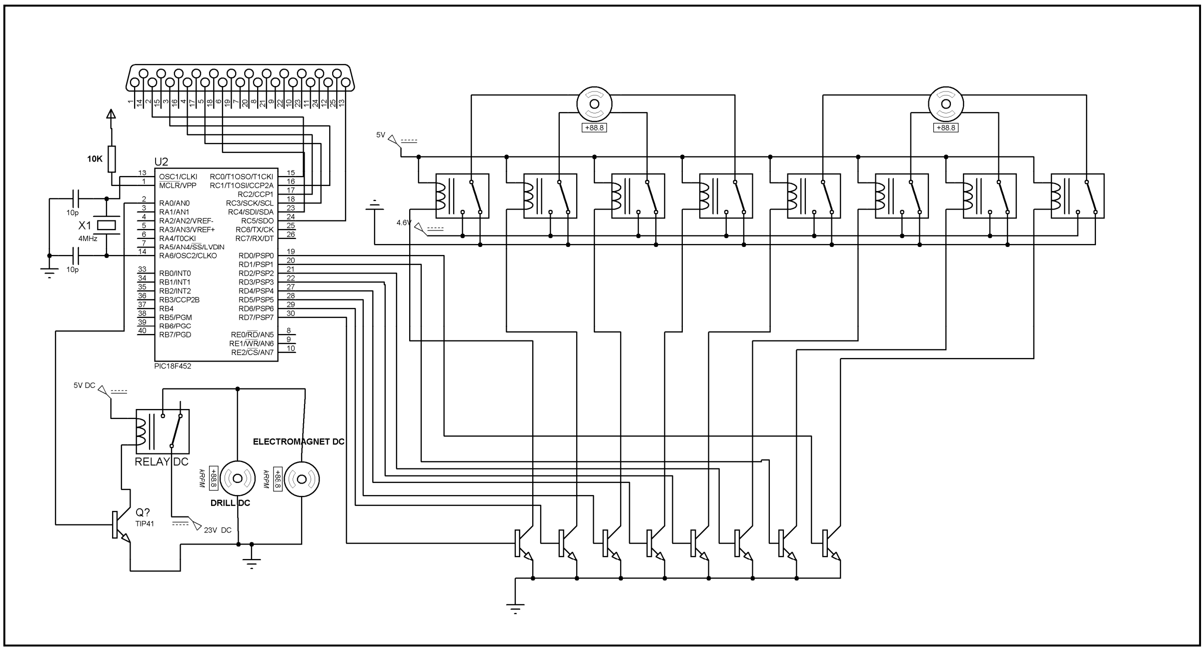

Figure 2: The schematic of the driving circuitry.

The second program runs in the computer and controls overall operation of the whole process. It is written in Matlab. It reads coordinates from a text file, sends them to the PCB machine to be processed and receives data from driving circuitry. It also determines on/off status of the drill, enable/disable status of the drill actuator and sends appropriate signals to PIC to implement these statuses.

The text file containing the coordinates of the traces and pads has a format given below.

Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**
x_1	y_1	x_2	y_2	k
		…		

Table 1. The text file format of coordinates of trace lines and pads.

In the Table 1, (x_1,y_1) pair indicates a coordinate of a pad to be drilled, (x_2,y_2) is a coordinate of a trace line and is a constant value which takes values either 0, 1. When **k** = 0, it indicates the drill is to be up position. When **k** = 1, it indicates the drill is to be at down position. We let the drill run at all times. The Matlab program first processes trace lines. Once traces are drawn on the PCB, it then processes (x_1,y_1) coordinates in order to drill holes to those points.

V. RESULTS

The PCB machine that we have developed performed drawing of a trace line and drilled holes on both end of the trace line successfully. The Figure 3 shows a picture of the processed PCB card.

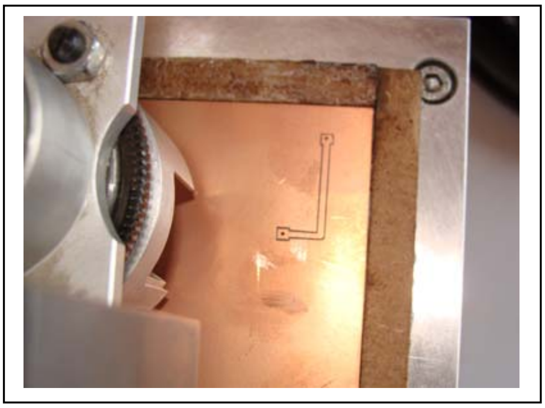

Figure 3: Picture of a PCB card after processed by the PCB machine.

VI. CONCLUSION

We have designed and developed a PCB machine that is able to draw trace lines and drill holes on a single layer PCB board. We have tested our system and showed that the PCB machine successfully draw a trace line and drilled holes on both end of the line. The system is developed for educational purpose and is currently in use at Microprocessor Control and Instrumentation Lab at Kahramanmaras Sutcu Imam University.

In our future works, we will continue to enhance different aspect of the PCB machine in order to have it perform line tracing and hole drilling of a complete circuit schematic on a PCB.

VII. REFERENCES

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