

Journal Online Jaringan Pengajian Seni Bina (JOJAPS)

## Mini Etching PCB Machine By Using ARDUINO UNO

Fadzlida Binti Shamsudin, Muhammad Hazmi Hakim Bin Alzahri, &

Muhammad Rafiuddin Bin Yahya

*Department Of Electrical Engineering, Politeknik Port Dickson*

### Abstract

The etching process is a process to remove unwanted copper layers on the surface of the PCB (Printed Circuit Board). During the etching process students are exposed to harmful chemicals that can cause severe skin burns, irritate the nose and throat and cause difficulty breathing if inhaled and can burn holes in the stomach if swallowed. The process also takes between 30-40 minutes where students have to constantly shake the container that is filled with chemicals to produce a circuit on the PCB board. This time-consuming process causes students to get bored and tired. Therefore, the Mini Etching PCB Machine was developed to facilitate the 'Etching process' and reduce accidents that may occur due to hazardous chemicals. The user only needs to insert the PCB in the container then set the time on the keyboard and the motor will move according to the set time. Upon completion of the etching process the buzzer will sound. This Mini Etching PCB Machine uses the Arduino Uno ATmega328P circuit as a microcontroller that is programmed for keypad input as well as a power window motor and buzzer as output. The results of the experiments performed found that the size of the PCB affects the time taken to complete the etching process. The larger the PCB size, the longer the etching process is taken according to the formula of a mixture of hot water and acid. © 2022 Published by JOJAPS Limited

© 2022 Published by JOJAPS Limited

**Keywords:** etching, PCB board, Arduino Uno

### 1.0 Introduction

Project 1 (DEE40082) is a course that must be taken by semester 4 students before being awarded a Diploma. In this course semester 4 students are required to produce a project mini circuit using an Arduino Uno circuit. In the production of a mini circuit project, students have to draw a circuit and transfer the circuit on a PCB (Printed Circuit Board). Then the circuit that has been transferred on the PCB has to go through an etching process.

The etching process is a process to erode the copper layer in areas that are not needed on the PCB. The chemical used in this process is FERRIC III CHLORIDE ACID. Ferric acid III chloride is used to remove the copper. The way to perform the etching process is to dilute this acid by mixing hot water to it to produce a chemical reaction. This mixture should not be too thick as it will bleach the circuit sketch that has been made as a result of the circuit compression from the laser printer. This mixture should also not be too liquid as it will take a long time for this Etching process. The mixture should be 4: 1, where 4 parts are hot water and another part is acid powder. This Etching process should be done in a container that is no longer useful. Plastic containers are the most common containers used in this Etching process.

When PCBs are immersed into this mixture, we must constantly shake the container filled with acid so that the unwanted coppers are detached. At this time, only the circuit printed by the laser printer is left. After the unwanted copper has been removed then the Etching process is completed and the PCB must be rinsed with clean water so that the dirt attached to the PCB during the Etching process is removed. After the etching process is completed, the remaining laser printer ink must be removed by using sandpaper. The trick is to rub sandpaper on the lines from the laser printer so that the lines disappear. In addition, detergent can also be used to remove the printer's laser ink. Now just leave the desired PCB circuit.

## 1.2 Problem Statement

Port Dickson Polytechnic Electrical Engineering Department has 5 programs namely DET (Diploma in Electrical Engineering), DEP (Diploma in Electronic Engineering Communication), DTK (Diploma in Electronic Computer Engineering), DEG (Diploma in Electrical Engineering Green Energy) and DEQ (Diploma in Engineering Electrical Energy Efficiency). All semester 4 students of each program have to create a mini project circuit to fulfil the Project 1 syllabus (DEE40082). This situation caused the Project lab (E012) to be always full of students who wanted to do the etching process for the production of mini project circuits. The etching process takes 30 to 40 minutes depending on the chemical mixture of Ferric Acid III Chloride and the shaking rate of the acid-containing container. This long time causes students to become tired and bored. In addition, students are also exposed to hazardous chemicals. The acids used are highly corrosive chemicals that have the potential to explode in concentrated form. It can cause severe skin burns, can hurt the nose and throat, cause difficulty breathing if inhaled, can cause blindness and can burn the stomach if swallowed. Even by wearing gloves, goggles and protective clothing while mixing concentrated acid, emergency showers and water jets should be provided in areas where the process of mixing concentrated acid is performed.

## 1.3 Objectives

This project is developed to achieve certain objectives as below:

- i. To develop a machine that can avoid injuries to the student that may occur as a result of acid exposure during the etching process.
- ii. To build an Arduino Uno circuit that can process one input with three outputs
- iii. To develop an Arduino software that can run the Arduino Uno circuit.
- iv. To interface the Arduino Uno circuits with Arduino software so that they can operate as desired.

## 2.0 Literature Review

The Mini Etching PCB Machine was developed to assist lecturers and students in carrying out the mini circuit construction process of the project. This machine can solve various problems of lecturers and students that may arise when trying to implement the construction of a mini-circuit project. With this machine, it can reduce the workforce, both students and lecturers. This machine has one input which is the keypad. The 12 button keypad provides useful interface components for microcontroller projects. The buttons on the keypad are arranged in rows and columns. The 3x4 keypad has 4 rows and 3 columns. (Krishna Pattabiraman, 2017). The function of the keypad on this project is to enter instructions and set the time. The entered data will be read by the Arduino Uno. The Arduino Uno is a microcontroller that is also open source. It serves as a physical computing platform for researchers to interact with objects. It has a free Integrated Development Environment (IDE). The Arduino IDE is based on the Processing language (Banzi, M., & Shiloh, M., 2014). The Arduino Uno is a micro controller board equipped with a set of digital and analogue input/output pins that can be connected to various other circuit boards. The Arduino Uno has 20 digital input/output pins, which 6 pins can be used as outputs and another 6 pins can be used as analogue inputs, 16 MHz resonators, USB connections, power jacks, circuit system programming heads (ICSPs) and reset buttons (A. Kurniawan, 2015)

Output for Mini Etching PCB Machine is power window motor. Power window motors were originally produced for car power windows. But in recent years, many robot builders are using it to build their robots, especially for combat robots because of its performance and competitive price. The power window motor used in this project uses a voltage of 12 volts. The power window motor will be connected to the 12V relay and will then be connected to the Arduino Uno. The relay acts as a switch that opens and closes the circuit electromechanically or electronically. The relay controls one electrical circuit by opening and closing a contact in another circuit. When the contact relay is normally open (NO), there is an open contact when the relay is not energized.

In addition, this machine also uses an LCD display (16x2) as an output. LCD screen (Liquid Crystal Display) is an electronic display module that has various uses. The 16x2 LCD display is a very basic module and very commonly used in various devices and circuits.

## 2.1 Comparison with Previous Projects

The following is a comparison table between the Mini PCB Etching Machine and DIY PCB Etching Machine

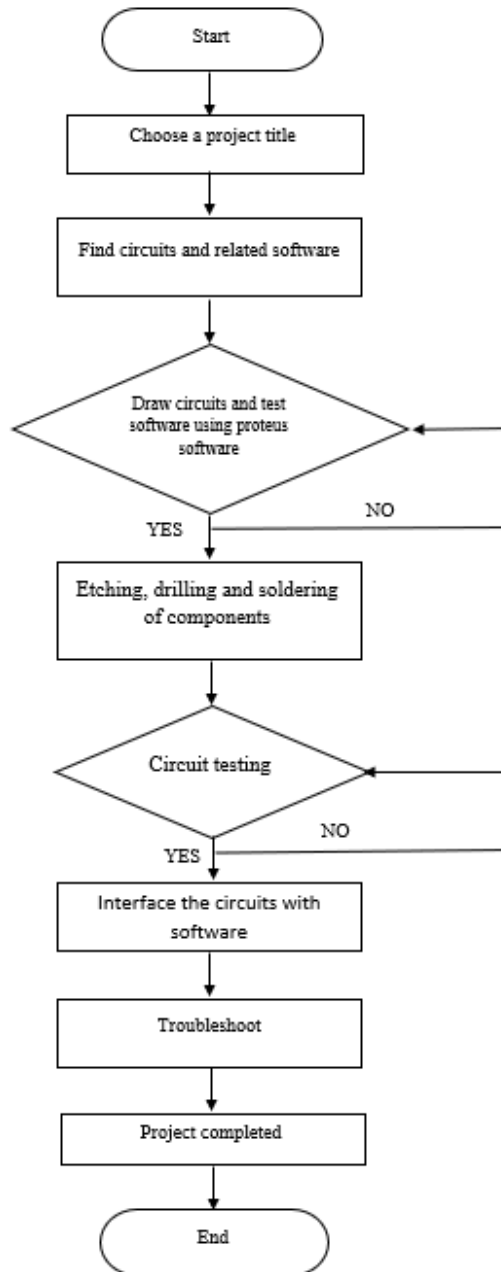
| Project Title | Mini PCB Etching Machine                                                                                                                                                                                                                                                        | DIY PCB Etching Machine                                                                                                                                                                                                                                           |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Objective     | Assist lecturers and students in implementing the etching process                                                                                                                                                                                                               | Help users perform the etching process                                                                                                                                                                                                                            |
| Scope         | This machine is used in the project laboratory (E012) of the Department of Electrical Engineering                                                                                                                                                                               | This system is for all individuals, business users and students who want to make circuits                                                                                                                                                                         |
| How It Works  | Students insert the PCB into the container containing the acid then set the time on the keypad and the Arduino Uno will process the input signal and will send the signal to the power window motor to move for the time that has been set. When finished, a buzzer will sound. | The user inserts the PCB into a container containing acid then when the switch is pressed the LED will light up. When the variable resistor is adjusted the motor will move. Upon completion of the etching process, the user needs to close the switch manually. |
| Hardware      | i. 1 x Arduino Uno ATmega328P<br>ii. 1 x keypad<br>iii. 1 x Buzzer<br>iv. 1 x LCD<br>v. Power window motor<br>v. related electronic components                                                                                                                                  | i. 1 x Dc stepper motor<br>ii. Metal window hinges<br>iii. DC motor speed control board<br>iv. related electronic components                                                                                                                                      |
| Software      | Arduino Uno                                                                                                                                                                                                                                                                     | not applicable                                                                                                                                                                                                                                                    |

**Table 1:** Comparison of Mini PCB Etching Machine and DIY PCB Etching Machine

## 3.0 Methodology

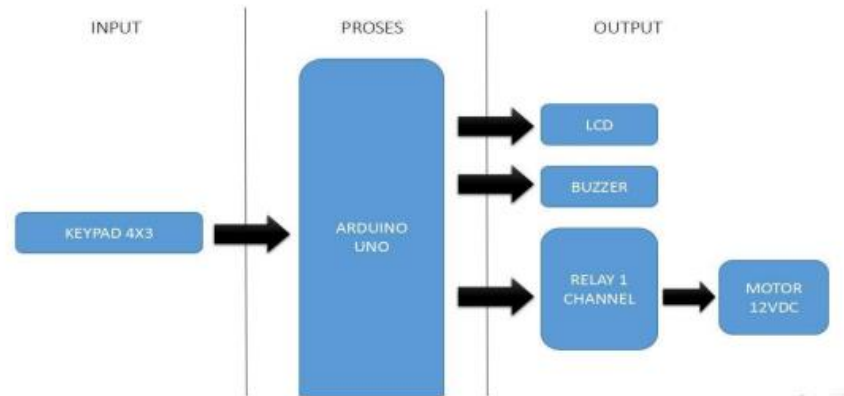
This study is a design and development research. According to Richey and Klein (2007), the study of design and development is the systematic study of design, development and evaluation processes with the aim of establishing an empirical basis for a creation of instructional and non-instructional products and tools and new or enhanced modules that govern their development". It is a systematic study of the design, development and evaluation process with the aim of forming an empirical basis for the construction of instructional or non-instructional products, tools, new or customized modules that determine the development of the product development.

### 3.1 Mini Etching PCB Machine Production Process Flowchart



**Figure 1:** Flow Chart Process for Mini Etching PCB Machine

### 3.2 Block Diagram of Mini PCB Etching Machine



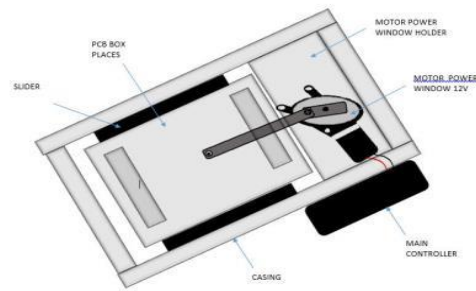
**Figure 2:** Block Diagram of Mini Etching PCB Machine

|                           |                                                                                            |
|---------------------------|--------------------------------------------------------------------------------------------|
| 1. Switch                 | ON and OFF the machine                                                                     |
| 2. keypad                 | Is an input for this machine. Give commands to the arduino or as a time setting as needed. |
| 3. Arduino Uno ATmega328P | Input from the keyboard will be processed then sent to the output                          |
| 4. Motor Power window     | The motor will spin after receiving instructions from the Arduino                          |
| 5. Buzzer                 | The buzzer will sound after the end of the etching process                                 |
| 6. LCD 16 x 2             | Displays the set time                                                                      |

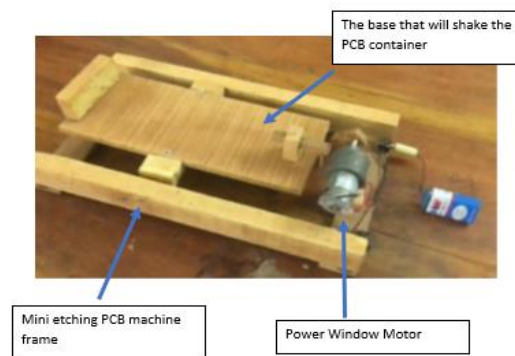
**Table 2:** Operation of the Component in Block Diagram

### 3.3 Prototype of Mini Etching PCB Machine

A prototype is an initial sample, model or product output that is built to test a concept or process being performed. It is a term used in a variety of contexts, including semantics, design, electronics and software programming. Prototypes are typically used to evaluate new designs to improve accuracy by system analysts and users. Prototypes serve to provide specifications for actual working systems rather than theory. In some design workflow models, creating a prototype (a process sometimes called creation) is a step-by-step formalization and evaluation of an idea. Figure 3 show the initial sketch of the prototype and Figure 4 is a prototype of a Mini Etching PCB machine that has been developed.



**Figure 3:** Initial Sketch of the Prototype

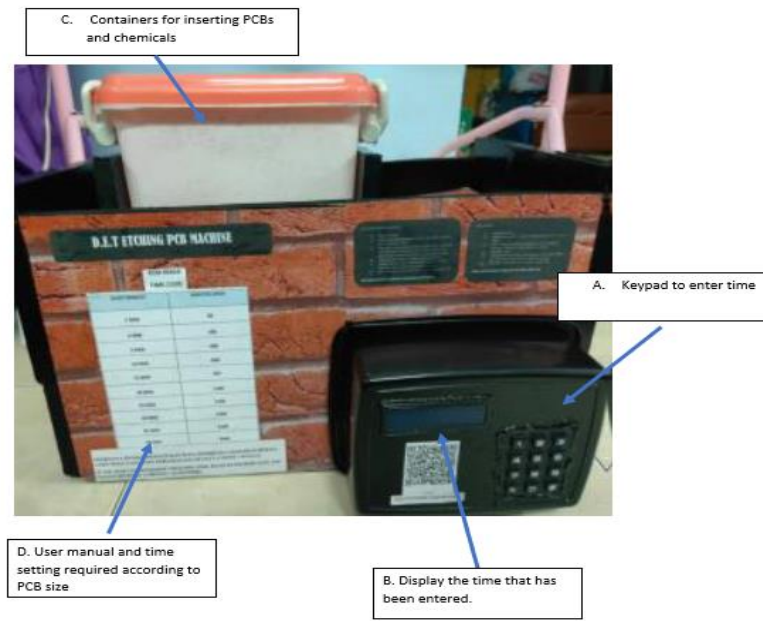


**Figure 4:** Internal framework



**Figure 5:** Side View

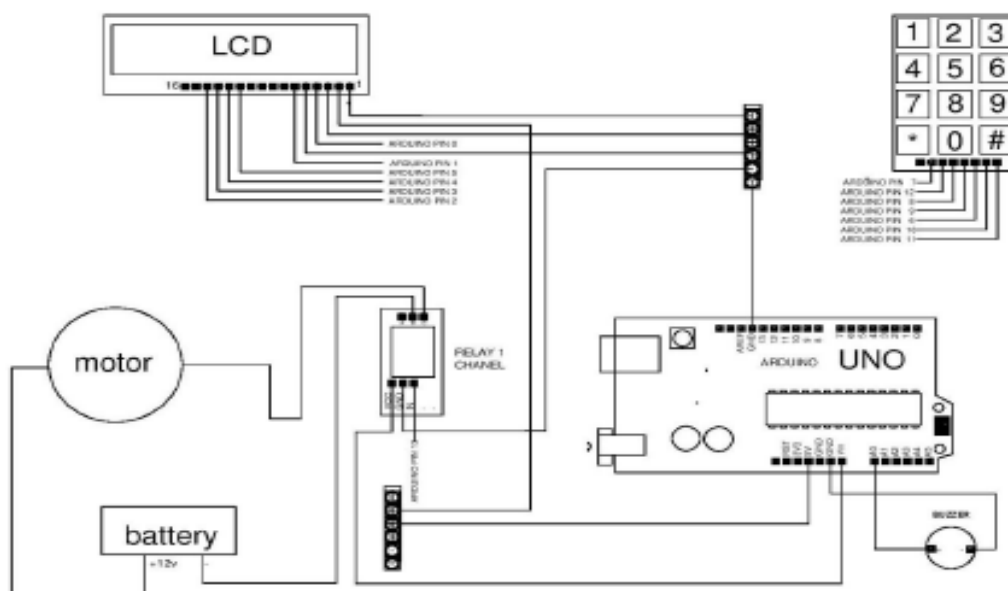
**Figure 6:** Top View



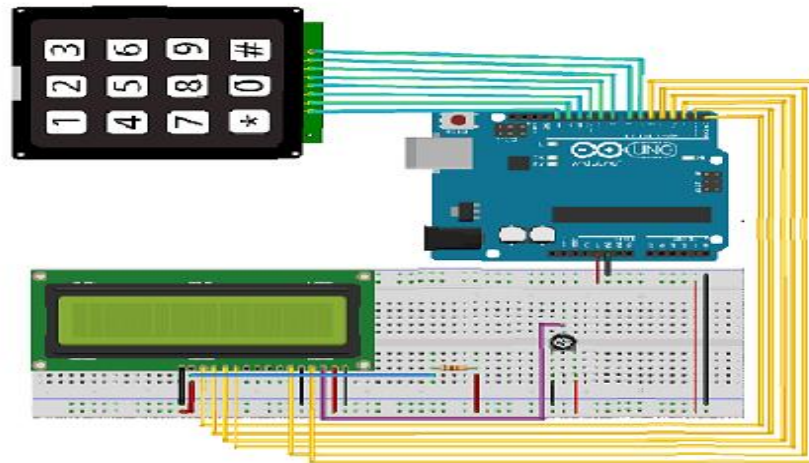
**Figure 7:** Prototype of Mini Etching PCB Machine

### 3.3 Schematic circuit

This circuit uses a 12V power supply. The input used in this circuit is a 3x4 keypad. The keypad is connected to Pins 6, 7, 8, 9, 10, 11 and 12 on the Arduino Uno board. While the output of this circuit is a motor, LCD display and buzzer. The following is the connection of each output on the pin on the Arduino Uno board: LCD on pin 0,1,2,3,4,5 buzzer on pin A0. The motor is connected to the relay and then from the relay is connected to pin 13 on the Arduino Uno board.



**Figure 8:** Schematic circuit for Mini Etching PCB Machine



**Figure 9:** Arduino Uno connection with a keypad and LCD display

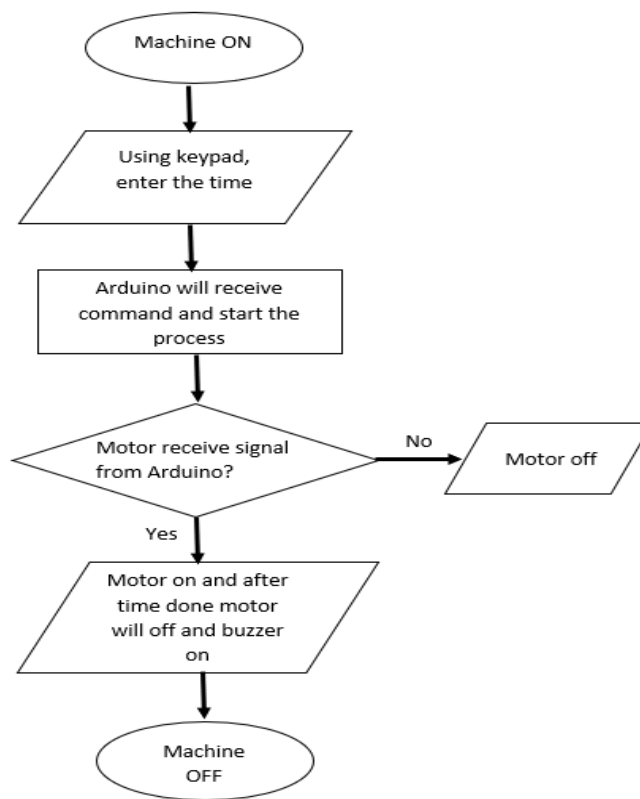
### 3.5 Software

This project, uses Arduino IDE software as the main software. The Arduino Integrated Development Environment (IDE) is an application written in C and C++. It is used to write and upload programs to Arduino boards, but also, with the help of third-party cores, other vendor development boards



**Figure 10:** Arduino Software

### 3.6 Flowchart System and Description



**Figure 11:** Flow chart of the operation Mini Etching PCB machine

This flow chart shows how a Mini Etching PCB machine works. After the machine is ON, the user has to set the time by pressing the number on the keypad. When the time has been set, the Arduino will receive commands from the keypad and start processing. The Arduino will signal to the power window motor, the motor will start moving for a time set by the user. After the etching process is completed, the motor will stop and a buzzer will sound to indicate that the etching process has ended.

### 4.0 Analysis and Decisions

In reports, results and discussions may involve an evaluation of the design or methods used. In a feasibility or case study, the results and discussion sections will involve measuring the feasibility or evaluating the success of one or more solutions. This section describes how the process of a project has a fixed value to prove its function is the same as stated in the scope of the study. Analysis is done to ensure that the machine developed can function as planned. Therefore, in this analytical process monitoring of PCB size changes as well as the time required to corrode unnecessary copper is observed. Next, for the etching process method, it is done by using a container provided with 500ml of hot water and 50 grams of Ferric II chloride acid. The observation results for each change in PCB size and time are as shown in Table 3.

| Size PCB (L x W) | Time/min | Time Code/Sec |
|------------------|----------|---------------|
| 4 X 4 cm         | 12 min   | 720 Sec       |
| 7 X 7 cm         | 15 min   | 900 Sec       |
| 10 X 10 cm       | 18 min   | 1080 Sec      |
| 15 X 15 cm       | 21 min   | 1260 Sec      |
| Size PCB (L)     | Time/min | Time Code/Sec |

|           |                |                    |
|-----------|----------------|--------------------|
| 4cm-6cm   | 12 min-14 min  | 720 Sec t-840 Sec  |
| 7cm-9cm   | 15 min-17 min  | 900 Sec -1020 Sec  |
| 10cm-14cm | 18 min-20 min  | 1080 Sec -1200 Sec |
| 15cm-18cm | 21 min- 23 min | 1260 Sec -1380 Sec |

**Table 3:** Observation of PCB Size Change and Etching Time

## 5.0 Discussion

The results of the experiments performed can be seen that the size of the PCB affects the time taken to complete the etching process. The larger the PCB size the longer the etching process is taken according to the formula of a mixture of hot water and acid. The results of the observation that have been recorded will make it easier for users to use this etching machine where users can easily enter the required time code based on the size of the PCB board, they use by referring to the manual pasted on the front of this machine.

As an improvement that can be done in the future to this machine is to add Blynk application. Through this application, this machine can be improved by entering the time set via a smartphone and if the etching process is completed this application will notify the user. Therefore, the user does not have to wait until it is finished while the etching process is done. Users can do other work until they receive a notification over the phone stating that the etching process has been completed

## 6.0 Conclusion

The Mini Etching PCB machine has been able to make a significant contribution to the lecturer's, students and user. This developed project can benefit to who want to do the etching process for the production of a circuit. With this machine, the etching process becomes easier and safer and saves time. Apart from that, the circuit produced is also neat compared to the manual method where students have to shake the container containing acid and the PCB board. This machine has a cover. So consumers don't have to worry about acid getting splashed on clothes or on skin. Moreover, with the help of this machine, users will feel safe and comfortable during the etching process.

## References

- A. Kurniawan (2015), *Arduino Uno: A Hands-On Guide for Beginner* (1<sup>st</sup> Edition).  
Autodesk (2020). *Instructables Circuit*. Retrieved on 2020  
<https://www.instructablescircuit.com>  
Banzi, M., & Shiloh, M. (2014). *Getting started with Arduino: the opensource electronics prototyping platform*.  
Maker Media, Inc.  
Krishna Pattabiraman (2017). *How To Set Up A Keypad On An Arduino* from  
<https://www.circuitbasics.com/how-to-set-up-a-keypad-on-an-arduino/>  
PCB Directory (2020). *PCB Directory*. Retrieved on year 2020  
<https://www.pcbdirectory.com/manufacture?country=China>  
Richey, R.C., & Klein, J.D. (2007). *Design and developmental research*. New York, NY: Routledge  
Wikipedia (2010a) *Methodology*. Retrieved on 20 Sept 2010  
<https://en.m.wikipedia.org.com>  
Wikipedia (2010b) *Etching*. Retrieved on 23 Nov 2010,  
<https://en.m.wikipedia.org.com>