Design and Implementation of an Automated Etching System

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Abstract. **:** Etching is a subtractive method that is used for the production of printed circuit boards (PCBs), where acid is been used to remove unwanted copper from a prefabricated laminate [1]. The manual method of doing this can only be used for a small number of boards and is likely to be messy [2]. Besides this, exposure to some certain kinds of etchants may have adverse effects on one's health. On the other hand, the machines available to do this provide a cleaner and faster means and can etch many boards at a time but they are very expensive. This usually discourages their purchase among small scale Printed Circuit Board (PCB) manufacturers. But the automated etching system presented here aims at providing a method of carrying out the etching process for a PCB board in a simple, clean, safe and cost effective way. The printed circuit board is mechanically designed to support and electrically to connect electronic components using conductive tracks, pads and features etched from copper sheets laminated onto a non-conductive substrate.

Key words: Etching, PCB, Arduino, Air pump

1. Introduction

The application of PCBs includes but is not limited to Air conditioning and ventilating systems, analog meter, analog-to-digital converters, audible signaling devices, audio amplifiers, battery chargers, control relays, convertors, digital meters, digital Signal processors, diode testers, displays, electromechanical controls, electronic ballasts, electronic filters, fans and blowers, feedback devices, fuse blocks, gas and pressure detectors, gauges, heat sinks, LCR meter, metal detectors, industrial controls, instrumentation, position controllers, potentiometers, protectors, read out devices, rectifiers, regulators, signal conditioner, soft starters, solid state relays, spectrograph, spectrum analyzer, surge protection, tachometers, terminals, thermometers, thermostats, time delays, timing devices, torque control and switches, transducers, transformers, transient protection, vector scope, voltage controllers, voltage monitors and weather station instrumentation.

The production of a printed circuit board involves the following phases: preparation, lamination, exposure, etching of the board. The etching phase involves the removal of unwanted or non-circuit copper from board to define the circuit using corrosive chemicals such as Ferric chloride, cupric chloride, ammonium per sulfate, chromic acid, sulfuric acid, etc. This project focuses on the etching phase in the production of PCBs.

2. Components of the Etching System

2.1. *Atmega 328p-pu Microcontroller*

The microcontroller used for this system is the ATMEGA 328P-PU microcontroller. This consists of 32KB ISP flash memory with READ, while WRITE capabilities, 23 general purpose I/O lines, 32 general purpose working registers, 3 flexible timers/counters with compare modes, internal and external interrupts, serial programmable USART, a byte oriented 2-wire serial interface, 2KB SRAM, 1KB EEPROM, SP1 serial port, 6 channel 10-bit A/D converter, programmable watchdog timer with internal oscillator and 5 software selectable power saving modes [3]. This device can operate from 1.8 to 5 volts. The device achieves throughputs approaching 1MIPS. It comprises several parts which is explained below.

2.2. *Liquid Crystal Display LCD 16 *2 (LM016L)*

Hitachi's HD44780 controller are the majorly used character-based LCDs, and they are 1-line, 2-line and 4-line LCDs, and they have only 1 controller which enable them to support at most 80 characters while LCDs with 2 controller have 16 pins [4].

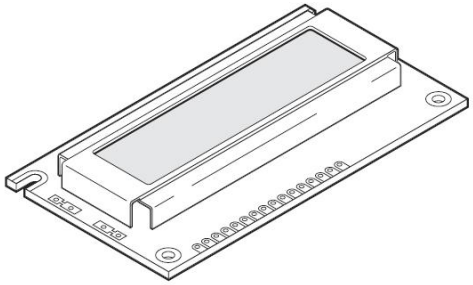

Figure 1. Liquid Crystal Display (LCD)

Table 1: LCD type and HD44780 Pin diagram.

Pin Serial No.	Type	Description
Pin no. 1	VSS	Power supply (GND)
Pin no. 2	VCC	Power supply (+5V)
Pin no. 3	VEE	Contrast adjust
Pin no. 4	RS	0 = Instruction input 1 = Data input
Pin no. 5	R/W	0 = Write to LCD Module 1 = Read from LCD module
Pin no. 6	EN	Enable signal
Pin no. 7	D0	Data bus line 0 (LSB)
Pin no. 8	D1	Data bus line 1
Pin no. 9	D2	Data bus line 2
Pin no. 10	D3	Data bus line 3
Pin no. 11	D4	Data bus line 4

Pin no. 12	D5	Data bus line 5
Pin no. 13	D6	Data bus line 6
Pin no. 14	D7	Data bus line 7 (MSB)

2.3. The Arduino Uno Board

This is a microcontroller board based on the ATMEGA 328P. It has input/output 14 digital pins (out of which 6 can be used as PWM outputs), 6 for analog inputs, a 16-Mhz crystal, a USB connection, a power jack, and an ICSP header and reset button.

It may be switched on via a USB connection, or with an external means of supply. The power source is usually selected automatically, and an external supply from 6 to 20 volts can be used to operate the board [5]. But, if supplied with less than 7V, the 5-V pin may likely supply less than 5 volts, and the board may become unstable. However, if the voltage is more than 12V, this may result to overvoltage, and the regulator may become overheated, and as a result damage the board. Therefore, there's need to follow the permissible range, which is from 7 to 12 volts, and the power pins are as stated below:

- Vin: Is the input voltage to the Uno board when it is using an external power supply.
- 5V: The pin outputs which is regulated at 5V from the regulator on the board.
- 3V3: A 3.3-Volt supply which was generated by the on-board regulator; this pin on the Uno board provides the voltage reference with which the microcontroller operates.
- IOREF: This is the pin on the Uno board that provides the voltage reference with which the microcontroller operates.

The Uno has a number of facilities with which it communicates with computer. The Arduino software (IDE), which includes a serial monitor which allows simple textual data to be sent to and from the board. The Rx and Tx LEDs on the board will be activated when the 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).

The Uno can be programmed with the Arduino software (IDE).

2.4. *DHT11 Temperature & Humidity Sensor*

The DHT11 T& H Sensor will feature a temperature & humidity sensor complex with a calibrated digital signal output [6]. To ensure high reliability and excellent long-term stability, there's need to use exclusive digital-signal-acquisition technique, and a temperature and humidity sensing technology. The sensor will require a resistive-type humidity measurement component, temperature measurement component with an NTC, and this will be connected to a high-performance 8-bit microcontroller, that will offer a high quality, excellent, response faster, offer low cost, and an anti-interference ability.

The DHT11 elements are calibrated in the laboratory that are highly accurate on calibration of humidity. The coefficients of calibration of the DHT11 elements are stored as programs in the OTP memory. They are used as internal signal detecting process of the sensor. The system integration can be quick and easy with the help of single-wire serial interface. It is the best choice for various applications, because of its small size, its power consumption is low, and up-to-20 meter signal transmission. This component consist of a 4-pin in a single row pin package, very easy to connect, also clients can request for special packages.

2.5. *Relay*

This is an electromechanical device, i.e. its construction is mechanical, but is energized by electrical current which flows through the coil of the relay. It either energizes or de-energizes the coil. This causes the opening or closing of the circuit.

Their operation is similar to that of remote control switches which are available for many applications because of their simplicity, long life and high reliability.

2.6. *Air Pump*

This is used to speed up the rate of etching by producing bubbles in the etchant at a rapid rate that enables the etchant move in a rotational motion over the PCB. This action of the air pump is likened to the etchant being stirred [7].

3. Design and Working of Automated Etching System

The construction of the system is as shown in Figure 2. It involves assembly of all the components listed above. The Arduino has a microcontroller as the brain. The microntroller receives a signal from the temperature sensor and sends it to the LCD which displays the information on the temperature of the water [8]. The relay, is powered by the Arduino, controls the feed-in voltage from the 220-V AC mains to the heater. i.e. it acts as an electromagnetic switch to the heater, thus helping to regulate the etching process.

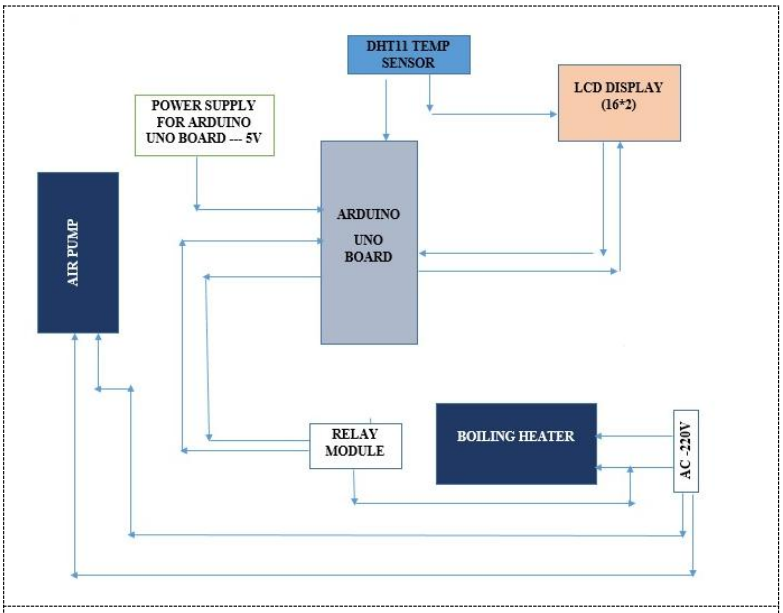

Figure 2. Block diagram of the model

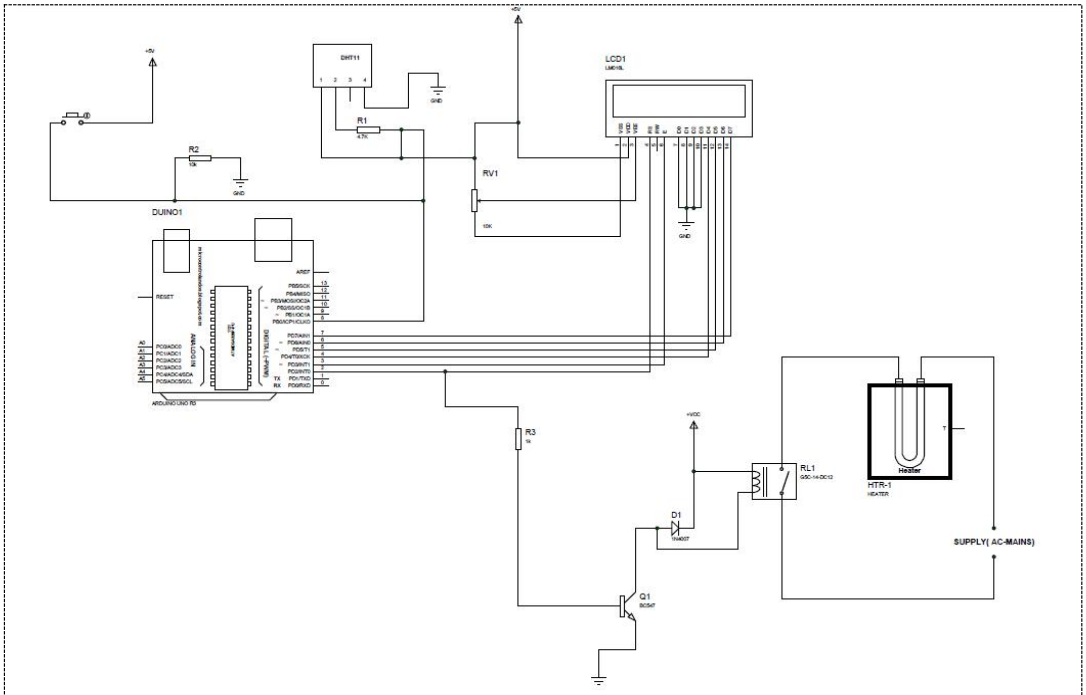

Figure 3. Circuit Diagram

4. Conclusion

In conclusion, it should be noted that the automated etching system presented here can be used only for certain sizes of printed circuit board but the design is done in such a way that it allows for easy modifications. It is the authors' belief that this system, if encouraged, would largely revolutionize the indigenous systems of carrying out etching because of its numerous advantages over it.

Acknowledgements

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References

[1] DIY etching System Available at: <http://www.instructables.com/id/The-Etchinator-low-cost-spray-etcher/>
[2] A Process of Chemically Etching Circuit Boards Application Note by Joshua Myers, ECE 480 - Design Team 5, Michigan State University.
[3] Microcontroller Basics Avalaible at: <http://www.mikrocontroller.net/topic/230574/>
[4] How to etch Availavle at: <http://www.prototrains.com/etch2/etch2.html/>
[5] Pcb Sprayer machine Availaible at : http://web.archive.org/web/20071017083331/http://members.optusnet.com.au/~eseychell/PCB/SprayEtcher/index.html
[6] DHT11 Humidity & Temperature Sensor pdf by D-Robotics UK (www.droboticsonline.com)
[7] Printed Circuit Boards: Design, Fabrication, Assembly and Testing By R. S. Khandpur, McGraw-Hill Education.
[8] LCD 16*2 (LM016L) Available at : <https://embeddedcenter.wordpress.com/2013/11/10/update-description-about-lcd-16x2-

lm016l/>