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PCB (Printed Circuit Board) Etching Machine Using ESP32-Camera Based Internet of Things

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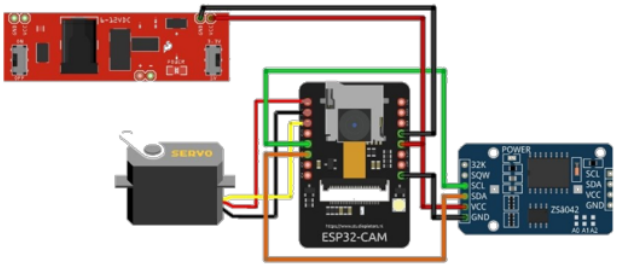
ABSTRACT



The most important factor in the PCB etching process is timeliness and minimizing work on users. Because in general, the PCB etching process itself is still done manually and there is no timeliness and good results. So, the PCB etching machine tool using Internet of Things based Esp32-Cam is made for users in the PCB etching process. Users can monitor the etching process of the internet of things system using telegram. In the telegram there is a choice of time to carry out the etching process. The components used in this tool power supply as a power source in this tool uses a voltage of 5vdc, Esp32-Cam as a microcontroller, camera features on Esp32-Cam as a photo sender after the etching process time has been completed, RTC (Real Time Clock) as a timer for the PCB etching process, servo motor as a box drive containing water and PCB when the etching process time is selected. The conclusion of the results of this tool is that the device or tool works well and can help users on the PCB etching process efficiently, it's just that there are few challenges for the signal network due to delays in bad internet signals.

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1. INTRODUCTION

One of the problems for users or process operators working is still using a manual system [1]. Over time, of course, technology will increase, namely manual systems into automatic systems [2]. For today's growing manufacturing industry in Indonesia, the ability to operate faster, more cost-effectively, and more innovatively has become the main thing. In addition, the greater the potential for Indonesia to increase the volume and quality of its exports by adopting the industrial revolution 4.0 [3].

In this era of Industrial Revolution 4.0, industry players, both public and private, compete with each other in their business processes by utilizing the advantages brought by technology and information systems [4], and directing manufacturing technology to the trend of automation and data exchange [5]. One of them is by utilizing the Internet of Things on Android technology, namely telegram as an automatic system controller [6].

Therefore, PCB etching machine tools are made with the latest technology, one of those technologies is the Internet of Things [7]. IoT (Internet of Things) is an interconnection of sensing and driving devices, which provides the ability to share information across platforms through a unified framework, developing a common operating image so as to enable innovative applications [8]. The internet of things has the property of expanding internet connections that are connected in real time [9]. The etching process is called the copper dissolution process on the PCB board [10]. The PCB etching process certainly uses a chemical solution, namely FeCl3 or can be called *Ferrite Chloride* [11].

The use of ferrite chloride is easy to obtain and the price is affordable and the results in the use of ferrite chloride are very efficient. In addition, *Ferrite Chloride* has a good heat temperature for copper dissolution at PCB [12][13]. Although there is not too much contact with FeCl3, safety aids such as protective goggles, thick clothing, and gloves are recommended [14]. The previous study, entitled "Implementation of Raspberry Camera as a Copper Solvent Concentration Sensor", discussed dissolving copper pcb using a camera to see the saturation level of water color in etching containers [15]. However, time is not discussed because time is very important to minimize work [16].

In the study entitled "Design of Ergonomic Work Facilities in the Dissolution Process of Printed Circuit Board (PCB) Using the Quality Function Deployment Method" discusses the operator's work facilities in the PCB processing process [17][18]. However, the system used is still semi-automatic [19]. So a PCB etching machine was made using the Internet of Things-based Esp32-Cam. The input required in this tool is 5v-12v [20]. The microcontroller used is Esp32Cam [21]. The Esp32-Cam microcontroller features a camera [22].

The Esp32cam has more input and output pins than the Esp32-Cam module [23]. The automatic system on this tool will be Esp32-Cam connected to telegram [24]. Telegram bots are third-party applications that run on the telegram application. Users can interact with the bot by sending messages in the form of commands [25].

Telegram itself will display a selection of timers for the etching process needed [26]. The timer itself uses RTC (Real Time Clock) which is type DS3231 [27]. Real Time Clock (RTC) is an electronic clock in the form of a chip that can calculate time (from seconds to years) accurately and maintain/store the time data in real time [28].

The DS3231 RTC series is low-power and full binary-coded-decimal (BCD). Data and addresses are transferred sequentially serially via two cables and a bidirectional bus. Clock/Calendar provides seconds, minutes, hours, days, dates, months and year information [29]. The time system has been determined so the drive will work by using a servo to shake the PCB etching container [30].

The servo motor uses s690 series [31]. Then when the servo motor stops according to the specified time. Then there is a photo notification from the telegram sent from the ESP32-Cam Camera [32]. So, in this study the automated system that uses the internet of things makes telegrams as input and output on PCB etching machines. Users or operators in the company can monitor from telegram when the position of the PCB etching process and can do other work during the etching process.

2. METHODS

This system method utilizes IoT (Internet of Things) and telegram technology. IoT functions or is used to make it easier for users or operators to carry out the PCB etching process automatically. Furthermore, there are two types of design, namely hardware design and software design. Hardware design starts from cable design, and block diagrams. While the software includes a flow diagram of the methods used on the system.

2.1. System Design

In the design system of this tool, divided into three parts, the first part includes the design of the wiring design system, where will be described components and pin connections in the system. The second part includes a flowchart, which will explain the overview of the system workflow and the interaction of components at the time of connection. The third section covers the design of the block diagram, explaining the

input components, processes as well as outputs of the system. These three sections provide a very important understanding of the design and operation of tool systems.

2.1.1. Wiring Design

The wiring design as shown in Figure 1 is starting a 5v power supply (possibly DVD power supply), the system uses ESP32-Cam (ESP32-Cam microcontroller board), servo motor (possibly SG90), MG90 servo motor (another type of servo motor), RTC (Real Time Clock) using DS3231. The most precise functioning of the system depends on the results of the program and how the components are connected.

Table 1 shows how pin connections are made between the ESP32-Cam microcontroller and other components in the system, including power supply, servo motor and RTC modules. Table 1 will likely show which ESP32-Cam pins are connected to the input/output pins of each component. The pin connection is made necessary for the system to function properly.

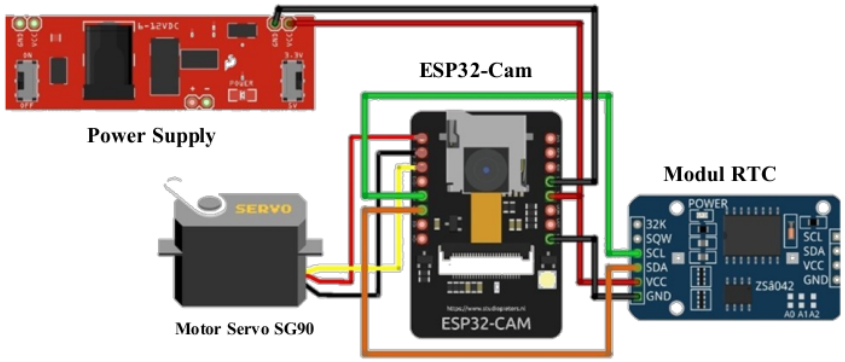

Figure 1. Wiring design

Table 1. ESP32-Cam port usage

No.	Esp32-Cam Port	Usage
1	IO 12	Data PWM Servo
2	IO 14	SDA RTC 3231
3	IO 15	SCL RTC 3231
4	5V	VCC Power Supply
5	VCC	VCC RTC 3231
6	GND	GND Power Supply
7	5V	VCC Motor Servo
8	GND	GND Motor Servo
9	GND	GND RTC 3231

2.1.2. Block Diagram

To facilitate the manufacture of tools, a block diagram of the system as a whole is made. The following is a system block diagram design on PCB etching machine design using ESP32-Cam based Internet of Things as Figure 2 shows.

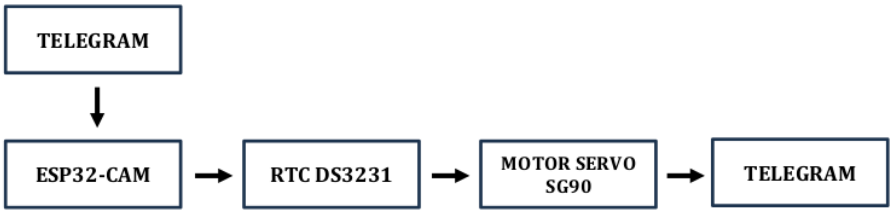

Figure 2. Block diagram system

The design starts with a telegram connected to the ESP32-Cam, then it will give a time command on the RTC DS3231 then the process will run where marked SG90 servo motor works. Then where the process has been completed will send a notification on telegram.

2.2. System Flowchart

The flowchart system in this study is shown in Figure 3. After the ESP32-Cam position has been connected to the telegram, then the user can choose the time to be used in the etching process. In this state, the telegram gives input to telegram, after which the ESP32-Cam gives commands to the servo to work according to the time chosen by the user. Then the servo will stop when the time has reached its limit. Then the telegram will get a photo notification from ESP32-Cam.

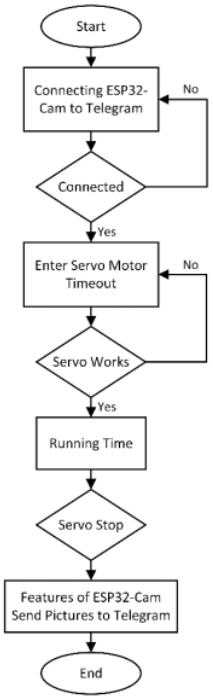

Figure 3. System flowchart

3. RESULT AND DISCUSSION

The following is a display of the realization of the tool on the PCB etching machine research that has been carried out. Where in Figure 4 shows the component using the number: 1. Power supply 5 volts, 2. On/Off switch, 3. S690 servo motor, 4. ESP32-CAM microcontroller, 5. RTC DS3231 (Real Time Clock).

Figure 4. Realization of tools

How to use this tool is as follows:

1. Connect the AC voltage to the wall outlet and then make sure the switch is on. Make sure hotspot is on.
2. If you have a microcontroller, it will connect to the hotspot in the operator's Android notification. Marked

with servo motor will move as notification.

3. If it is finished connecting, the next step is to check the telegram bot that has been created. Click start first on the telegram bot after that there will be a choice of time to etching. When finished the etching process, the servo motor will stop and will get a notification from the image delivery bot processed by the ESP32-Cam microcontroller.

3.1. Power Supply Testing

Table 2 shows five times of testing a 5 volt power supply with a multitester. The test results obtained a deviation of 0.32 and an accuracy of 96.8%. This in the working system has no effect because the voltage of 5 volts interprets as the minimum voltage of the tool, so even if the voltage is large than the minimum voltage will have no effect on the work system. This 5 volt voltage will be used to supply all work systems.

Table 2. Power supply testing

Testing to-	Voltage needed (V)	Multimeter (V)	Deviation (V)	Accuracy (%)
1	5	5.08	0.8	92
2	5	5	0	100
3	5	5.07	0.7	93
4	5	5.01	0.1	99
5	5	5	0	100
Average	5	5.03	0.32	96.8

3.2. Testing of Connection Wi-Fi Internet Networks on ESP32-Cam Microcontroller as Data Communication

Test the connection of the Wi-Fi hotspot to the ESP32-Cam, results of a time between 4 and 5 seconds. The test results are in Table 3. The description in the table shows information if the ESP32-Cam can establish a medium-speed hotspot connection.

Table 3. Testing connection of Wi-Fi internet ESP32-Camera

Hotspot Connection on Esp32 - Camera			
Testing to-	**Condition**	**Waiting Time (s)**	**Speed**
1st Test	Connected	5	Medium
2nd Test	Connected	4	Medium
3rd Test	Connected	5	Medium
4th Test	Connected	5	Medium
5th Test	Connected	5	Medium

3.3. Servo Motor SG90 Testing

Test the servo motor by adjusting the degree rotation on the servo, servo testing using the 0-360 degree option. The test results are in Table 4. In the information as information, the test is fairly successful because the output displays the results as ordered.

Table 4. Servo motor SG90 testing

Testing to-	Servo Motor SG90		Description
	Input	Output	
1st Test	0°	0°	Success
2nd Test	45°	45°	Success
3rd Test	90°	90°	Success
4th Test	180°	180°	Success
5th Test	360°	360°	Success

3.4. ESP32-CAM Testing

Camera test on ESP32-Cam, testing is carried out when ESP32-Cam is connected to telegram using high input logic as the sender of output as a receiver in the form of photos. The test results are in Table 5. Information information is fairly successful because it is in accordance with what is commanded.

Table 5. Esp32-Cam testing

Testing to-	ESP32-Cam		Description
	Input	Output	
1st Test	High	Photo	Success
2nd Test	High	Photo	Success
3rd Test	High	Photo	Success
4th Test	High	Photo	Success
5th Test	High	Photo	Success

3.5. Telegram Testing

This research uses telegram as an interface, users can easily to control the pcb etching process from their mobile phones. The existence of five different time options provides information and controls the PCB etching process. For example, in choosing a time during the etching process, you can choose the available time if the results are still lacking, you can choose which time. If the photo is dark, click on the flash option. Where the flash on the ESP32-Cam will light up. After the time selection is complete, telegram will receive a photo notification of the results of the PCB etching that has been done as shown in Figure 5.

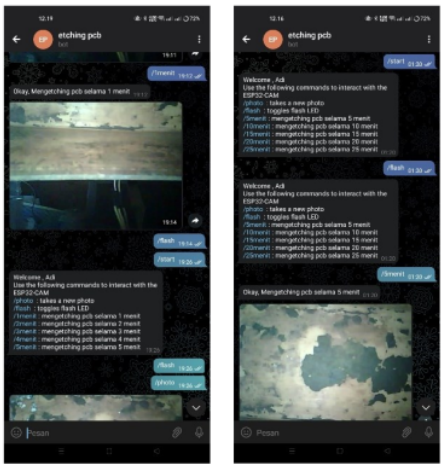

Figure 5. Telegram test

3.6. Time Testing at the Time of Sending Data from Telegram to ESP32-Cam Microcontroller

Test PCB etching time from telegram, in this test using the time option of 1-5 minutes. The test results are in Table 6. The description in the table shows the information as that the test matches what was tested.

Table 6. Testing specified time

Testing to-	Specified Time		Description
	Command Time (Minutes)	Output Time (Minutes)	
1st Test	1	1	Success
2nd Test	2	2	Success
3rd Test	3	3	Success
4th Test	4	4	Success
5th Test	5	5	Success

3.7. Overall Testing

Overall testing means unifying software and hardware design. Testing starts from the power supply, time options, start time and finish time. Results from testing what is Table 7. The time option uses 5-25 minutes and the results in each option are fairly successful. All tests are carried out five times, if there are three tests that show ideal results then it is considered successful. Conversely, if the test below the results are not successful three times, then it is considered unsuccessful.

Table 7. Overall testing

Testing to-	Power supply (V)	Time (Minutes)	Start Time (Minutes)	End time (Minutes)	Description
1th Test	5.08	5	19:20	19:25	Success
2nd Test	5	10	19:45	19:55	Success
3rd Test	5.07	15	20:10	20:25	Success
4thTest	5.01	20	20:40	21:00	Success
5th Test	5	25	21:10	21:35	Success

4. CONCLUSIONS

Based on the results of research on making PCB etching machines using ESP32-Camera and the discussion described earlier, conclusions can be drawn that; First, etching machines that have been made can be used in the PCB Board manufacturing process. Second, PCB manufacturing is easier and efficient because the PCB manufacturing time in the etching process becomes faster. Third, minimize work because the system

used is IoT-based, which can be controlled using Android. Fourth, the system of this tool will turn on when the switch or switch is on and then connect the same wifi or internet if this etching tool can be used. Fifth, for the process of connecting the microcontroller to the data base, it requires a strong and stable signal. If there is a decrease in the internet network signal and if it is not stable, the system on the etching device does not run normally properly.

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ORIGINALITY REPORT

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