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İSTANBUL KÜLTÜR UNIVERSITY

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GRADUATION PROJECT

REMOTE MICROPHONE FOR AUTOMATED ACOUSTIC MEASUREMENT

Submitted By

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ABSTRACT

Noisy electric device manufacturers are required to test and detect noise levels of their products. The tests are done in a silent room, enclosed with sound absorbing material. The device under test is located in the center of the test room. Then, from specific distances and angles from the device, noise levels are measured via microphone.

The purpose of this thesis is to bring the microphone to the desired position with wireless communication without the need for human power. In this project, we used ESP8266EX based microprocessor WeMosD1, Bipolar 200 step 7.4V Stepper motor, DRV8825 as stepper motor driver and Android based application. ESP8266 is well-known and the cheapest Wi-Fi module that could be used to connecting to the Wi-Fi, also could be a Wi-Fi access point. A WeMosD1 can apply all functionality of ESP8266 module and able to interface with PC without any other component.In this thesis, software to communicate ESP8266 module with Android based application and circuitry between WeMosD1, steepper motor connected to microphone is mentioned and it is indicated that the stepper motor will turn at an angle with by us is used Android based application.

ÖZET

Gürültülü elektrikli cihaz üreticilerinin ürünlerinin gürültü seviyelerini test etmeleri ve algılaması gerekir. Testler sessiz bir odada, ses emici malzeme ile yapılır. Test edilen cihaz test odasının merkezinde yer alır. Ardından, cihazdan gelen belirli mesafeler ve açılardan gürültü seviyeleri mikrofon aracılığıyla ölçülür.

Projemizin amacı insan gücüne ihtiyaç duyulmadan mikrofonu istenilen konuma kablosuz haberleşme ile getirmektir. Bu projede, mikroişlemci olarak ESP8266EX tabanlı WeMos-D1 modülünü, iki kutuplu 200 adım step motoru, step motor sürücüsü olarak DRV8825 ve Android tabanlı bir uygulamayı kullandık. En yaygın kullanılan ve en ucuz Wi-Fi modülü olan ESP8266, hem bir Wi-Fi ağına bağlanabilir hem de bir Wi-Fi erişim noktası olarak kullanılabilir. WeMos-D1 ise ESP8266'nın sahip olduğu bütün özelliklere sahip olmasının yanısıra bilgisayara direkt olarak bağlanabilen bir karttır. Bu tezde Android tabanlı uygulama ile ESP8266 modülü arasındaki iletişimi sağlayan yazılımı ve WeMos-D1, mikrofona bağlı step motordan bahsedilmiştir ve tarafımızdan tasarlanan Android tabanlı uygulama ile step motorun istediğimiz açılarda ve adımlarda döneceği belirtilmiştir.

ACKNOWLEDGEMENTS

First, we would like to thank our instructor Assist.Prof.Dr.Güray GÜRKAN for his guidance and for the time he invested in every aspect of this project from the selection to the completion, to Prof. Dr.Oruç BİLGİÇ, the head of the Electronic Engineering Department for his guidance throughout our graduate education, and to our friends for their support in the design and preparation of this project.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND UNITS

dB: Decibel

V: Volt

A: Amper

mm: Millimeter

MB: Megabyte

Hz: Hertz

bps: Bit Per Second

LIST OF ACRONYMS

IOS: Internetwork Operating System

GUI: Graphical User Interface

USB: Universal Serial Bus

UART: Universal Asynchronous Receiver Transmitter

Wi-Fi: Wireless Fidelity

ID: Identification

IEEE: The Institute of Electrical and Electronics Engineers

SPI: Serial Peripharel Interface

I2C: Inter-Integrated Circuit

PWM: Pulse Width Modulation

GPIO: General Purpose Input/Output

PCB: Printed Circuit Board

PC: Personal Computer

ADC: Analog to Digital Converter

IO: Input/Output

IP: Internet Protocol

LAN: Local Area Network

MIMO: Multiple Input - Multiple Output

1. INTRODUCTION

In recent years, the performance of electronic devices (air conditioner, small household appliances, vacuum cleaner etc.) has been advanced with the development of technology. It has been observed that companies capture excellence in sound measurement which is an important part of performance classifications. New methods have been introduced instead of the old methods used to increase efficiency.

The aim of our project is achieving close to 100% performance in the sound measurement. Instead of human skill, we chose wireless communication technology and the Android application to control this communication with devices such as mobile-phones, computers and tablets. In this way, we planned to provide gain from time and get a measuremet result without any disturbing effect.

Android or IOS application design another important concept in nowadays. These kinds of applications are used nearly in every new pocket size devices. Nowadays, the reason for preferring Android application is the easiness to access Android phones, tablets and computers. Creating a device circuitry which is able to connect to the Wi-Fi is the most important content of the automation systems. Designing easily understandable applications to connect the users with their devices is another important issue.

To reach our purpose, stepper motor is desired to be controlled with a Wi-Fi module. In this project, we chose ESP8266 module, because of its simplicity and low cost. The module gets the incoming data from the Android application to give signal to the DRV8825 stepper motor driver. When the signal is given to the stepper motor driver, the motor starts to run.

2. SYSTEM OVERVIEW

Mobile microphone for automated acoustic measurement aims to measure the sound from the microphone by going to the desired position by providing 360-degree movement around the electronic device. Many researches have shown that step motor is the most suitable tool for movement. The system overview has 2 parts. The first part contains the software of the mobile application. In the second part, the stepper motor starting circuit includes after the wi-fi module communicating with the antenna. After the method was decided, the mechanical system was designed to move microphone. This system consists of two gear pulleys connected to each other by a trigger belt. It was designed by putting step motor at the end of the first pulley and an aluminum stick at the end of the second pulley. The microphone is connected to the center of the aluminum stick. To control these movement automatically, a microprocessor is used. An Android application is used to make these controlling easier. System overview is shown in Figure 2.1.

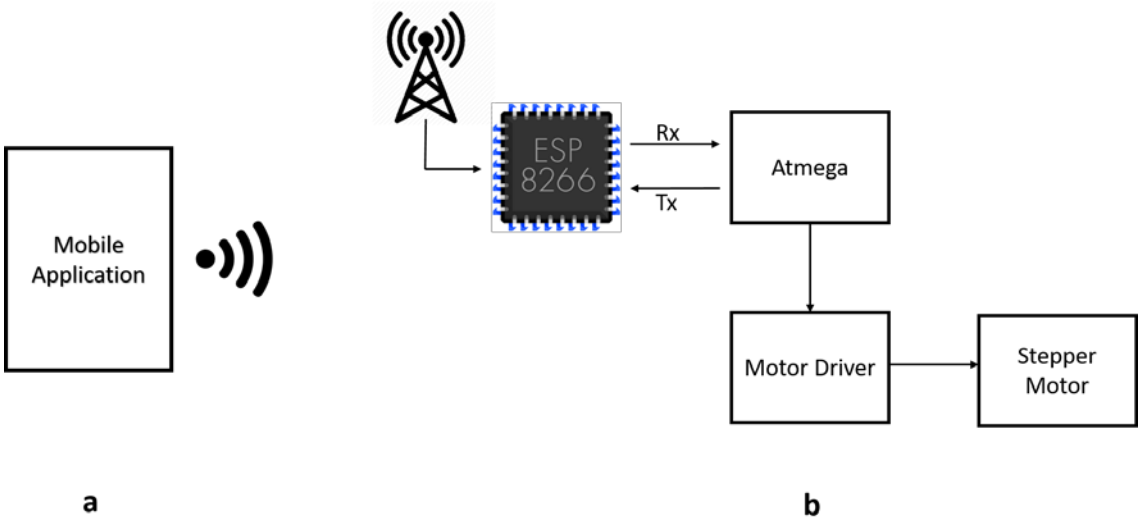

Figure 2.1: System Overview, a) Mobile application on remote phone, b) Receiver and control unit

2.1. Mechanical Part

First of all, bringing a microphone to the desired position without the need for human power is the first objective to be found of this project. Something sensitive is needed to send the microphone around the electronic device to any desired position. The sound output points of each electronic device are different from each other. Motor selection must be stepper motor to ensure precise position movement. It also has to be controllable to every position.

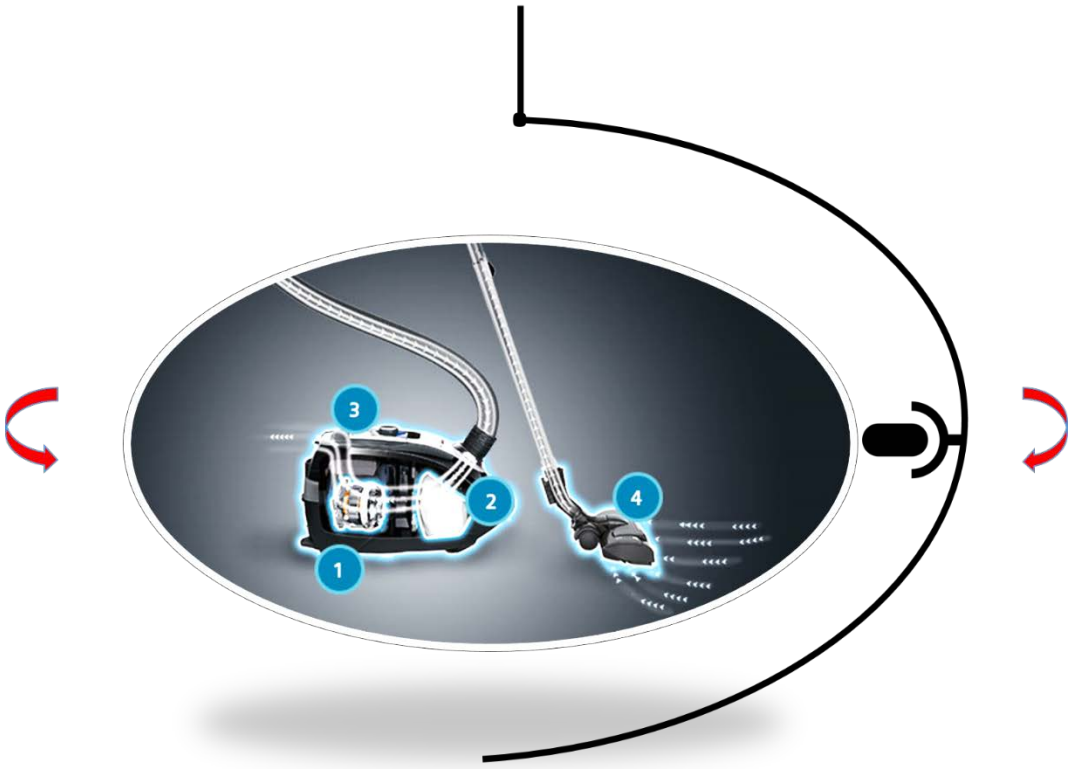

Figure 2.2: Desired positions (1-2-3-4)

The stepper motor has to turn a certain weight microphone smoothly. Therefore, a stepping motor was selected (NEMA 23-size hybrid unipolar/bipolar 7.4 V 1A and 56mm*57mm). This step motor has 9 kg/cm holding torque. Incorrect measurements can be taken if the microphone does not go to the desired position.

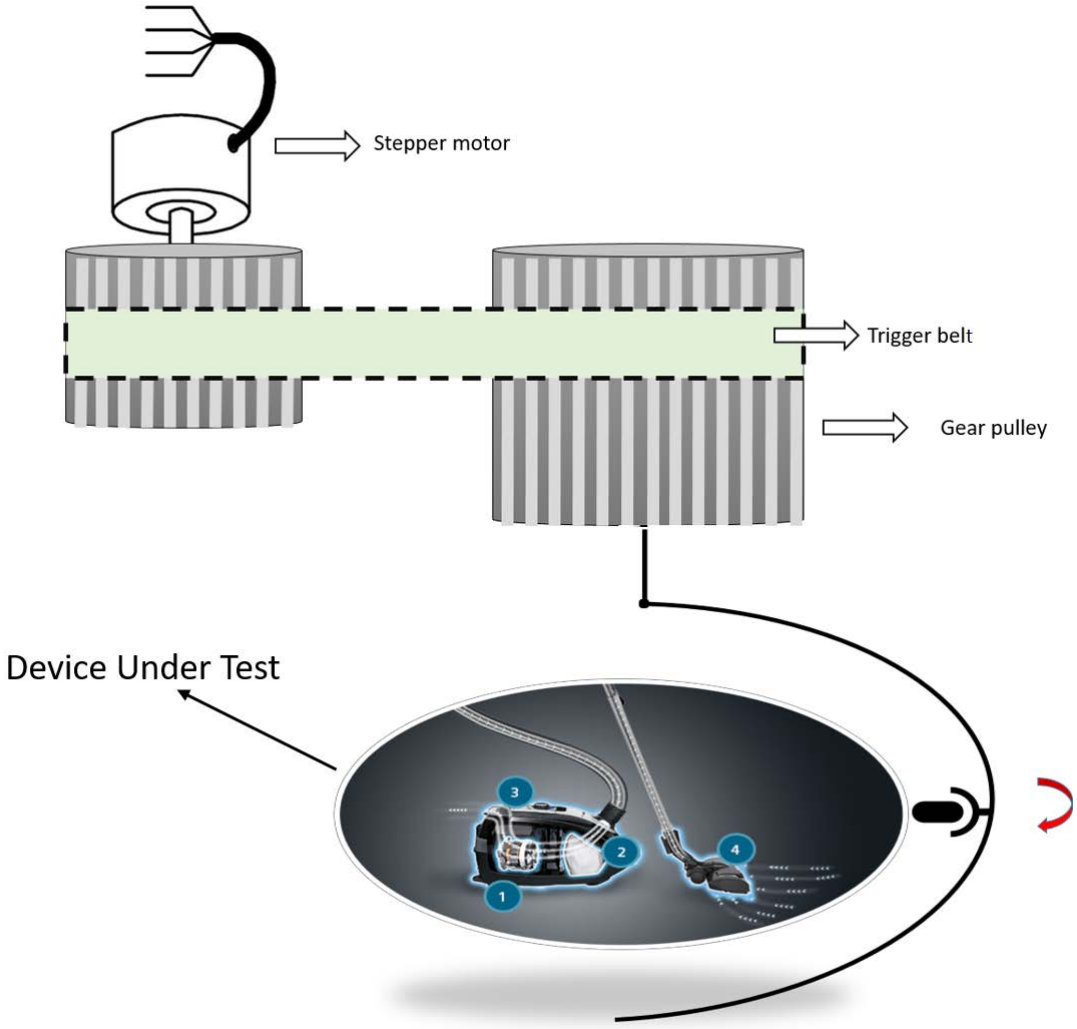

Figure 2.3: Rotation method

The design has to stand in a way that hangs on the ceiling. So, the two gear pulley was fixed on the composite plate. Bolts, bolt nuts were used to fix (Figure 2.4). The small gear pulley will be connected to the stepper motor and the large pulley will be connected to the composite plate (Figure 2.4).

Figure 2.4: Gear pulley is connected

It was necessary to hole on the large gear pulley to pass the aluminum stick. A 9.4 mm hole was opened using a lathe. The bolt was fixed under the composite plate. A 70-thread T5 series steel-wired trigger timing belt was used. The small gear pulley wassecured to the stepper motor by drilling a 6.3 mm drill hole (Figure 2.5).

Figure 2.5: Gear pulleys are connected via Timing Belt

2.1.1. Electronic Components and Circuitry

A microprocessor and code were needed to control the stepper motor with wireless communication. Therefore, the Esp8266 Wi-Fi module based Arduino WeMos D1 was chosen and the DRV8825 stepper motor driver was chosen to drive stepper motors. To protect the driver from such spikes is to put a large 100 µF electrolytic capacitor across motor power (VMOT) and ground somewhere close to the board. The stepper motor driver was also requested to work by connecting Arduino WeMos D1. A 15 volt power supply was used to drive the stepper motor. Connection design between Arduino WeMos D1, stepper motor driver (DRV8825) and stepper motor is shown below (Figure 2.6).

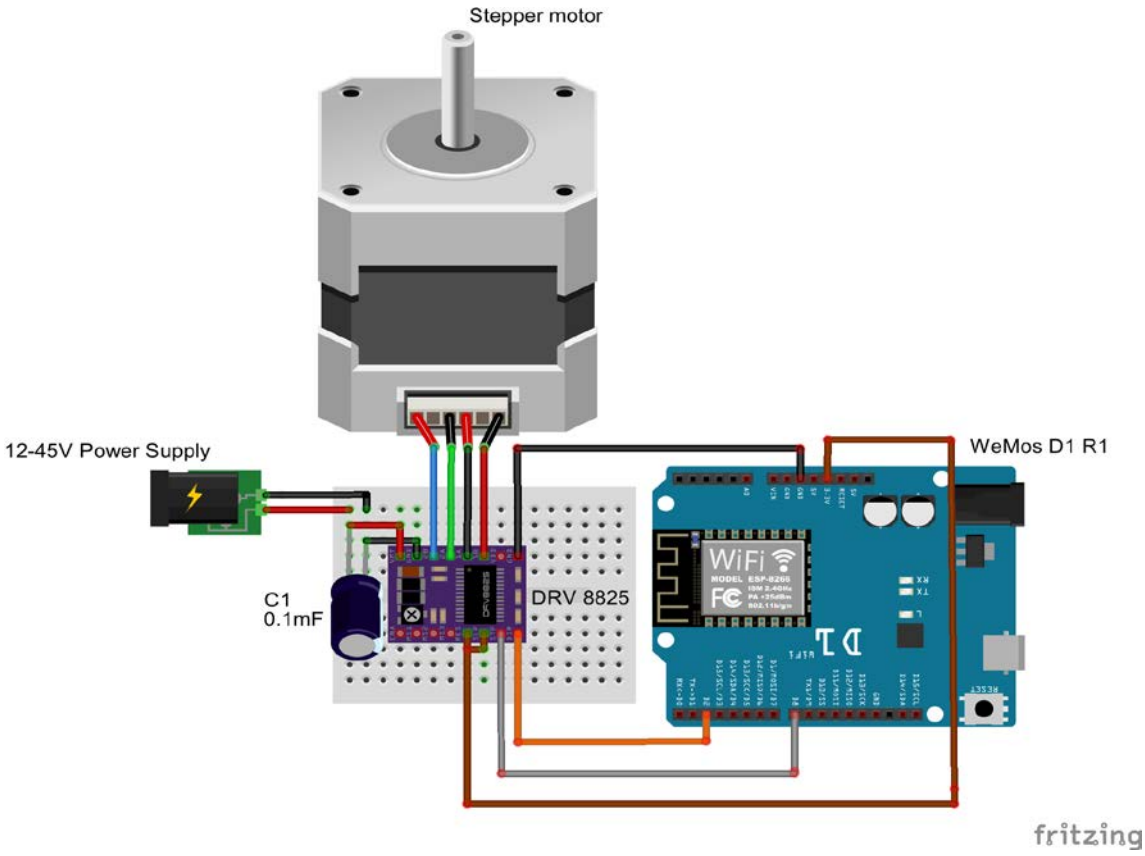

Figure 2.6: Connection between WeMos-D1, DRV8825 and stepper motor

2.1.2. ESP8266 & WEMOS-D1

ESP8266 module is created by Espressif, it is using IEEE 802.11 Wi-Fi protocol to achieve its goal. It is called as module but it is operating as microprocessor, which is another reason for preferring this module. ESP8266 has 4 MB flash memory which has higher capacity than Arduino Uno. The module has SPI, I2C, I2S, UART, PWM, GPIO peripheral bus protocols, which makes ESP8266 very useful for signal processing and communicating with other sensors and devices. Module could operate as a station for Wi-Fi connection and an access point as mentioned before, beyond these characteristics also it can be a station and an access point at the same time.

Despite of all these advantages, ESP8266 has disadvantages too. Firstly, the module is not breadboard friendly, without making any it PCB design is hard to use it in this way. Secondly, devices operating between 3.0 – 3.6 V, it is hard to combine this module with other microprocessors like Arduino. Another one is, for programming this tool, a communication port is needed between PC and ESP8266, which is cost money. The last disadvantage is the high current consumption (150mA) while transmitting data, so another microprocessor to power up this module may not be enough.

To overcome these disadvantages, I found a solution with nearly at the same price. I used WeMos-D1 as an ESP8266 breakout-board. The circuit printed as the same board of Arduino Uno, so it is easy to get used to WeMos-D1 if you already use Arduino Uno (Figure 2.7).

WeMos-D1 Arduino Uno

Figure 2.7: Wemos-D1&Arduino Uno

It has a CH340G USB to UART driver to communicate directly with PC. Circuit has own regulator so basically any lithium 9V battery can be used as power source. It has a micro USB socket which allows to power up the card with power banks used for phones. The generic card has 11 digital pins and 1 analog pin, which has 10-bit ADC maximum input voltage is 3.3V. The microprocessor clock is 80 MHz.

Table 2.1: WeMos-D1 Pinouts

WeMos-D1 Pin	Functionality	ESP8266 Pin
D2	I/O	GPIO16
D8	I/O, Pull-up	GPIO0
GND	Ground	GND
3V3	3.3V	3.3V

2.2. Software Development

To operate this system, a code must be written to combine ESP-8266 commands. This code can be divided some steps.

Firstly, we connected WeMos-D1 to Wi-Fi via Wi-Fi id and password and we got the IP Address of WeMos-D1 card and print it via Serial Monitor. Then, we had problems assigning the IP address. The biggest part of these problems was that the wifi module was given avariable IP address at each startup. After many research, static IP address was defined and problems was resolved.

Secondly, the numerical values of the desired positions were defined in the program and movement was performed. In the next step, a code was written so that the stepper motor could turn clockwise or counterclockwise. This direction was determined by the difference of two different position values. If the difference of position values is positive, the stepper motor will turn clockwise. If the difference of position values is negative, the stepper motor will turn counter-clockwise.

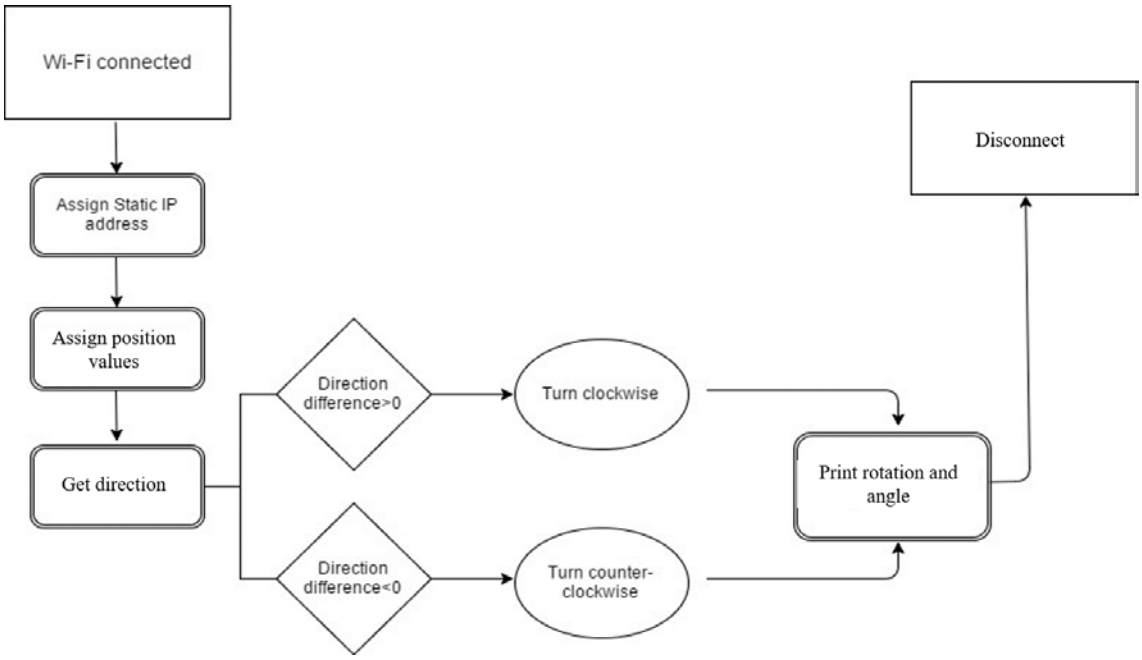

Figure 2.8: Flow Diagram of WeMos-D1 Code

2.2.1. Android Application Development

In the third stage of this project, an Android App GUI named as AYAY was designed to control the stepper motor. MIT App Inventor 2 Application, which enables development and generation of .apk file. Designing interface is simple with the build-in blocks and commands at the pool of App Inventor (Figure 2.9). Functionalizing built interface's every component is possible without writing any code. App inventor already has blocks which are masked codes (Figure 2.10 & Figure 2.11).

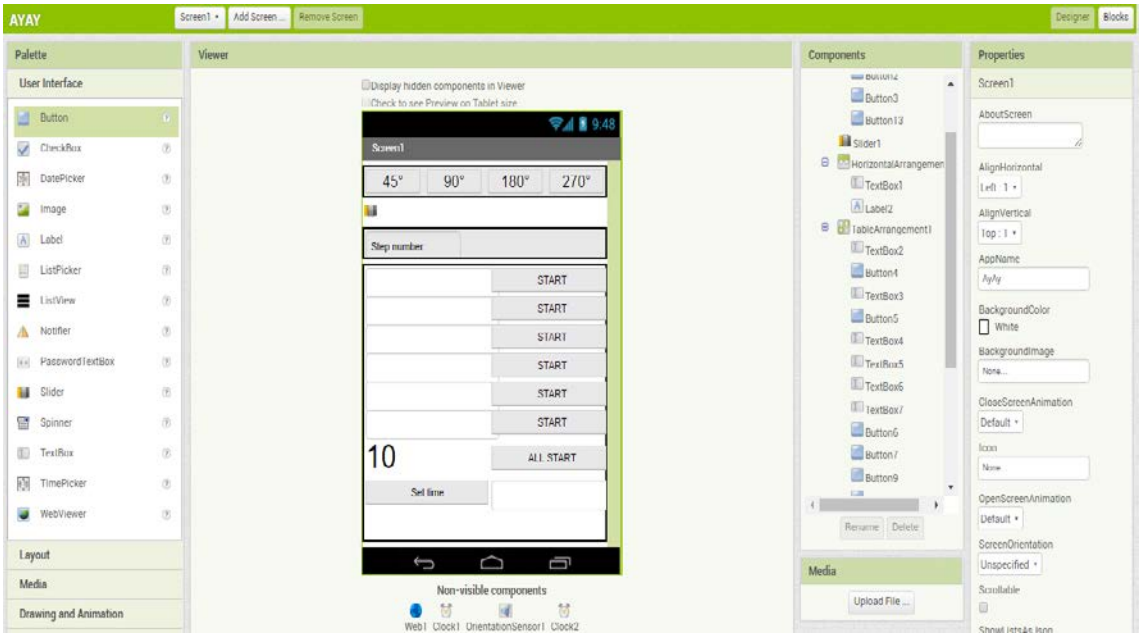

Figure 2.9: MIT App Inventor 2 software development part

At the top of the screen GUI includes four buttons that adjust the position depending on the angle. A slider is located on the bottom line that determines the number of steps from 1 to 200. The reason is that the stepping motor has 200 steps. So that the user can specify any desired position from the slider. There is a textbox showing the number of steps taken in the bottom row. There are six position textboxes for writing six different positions information. Each text box has its own start button. At the bottom of the screen, "set time" textbox exists that is used to determine how long to wait in the position being taken. After setting with set time button, there is all start button to start set time. If the all start button

is pressed after the desired 6 positions and time are entered, the stepper motor will go to the desired position respectively and wait for the entered time.

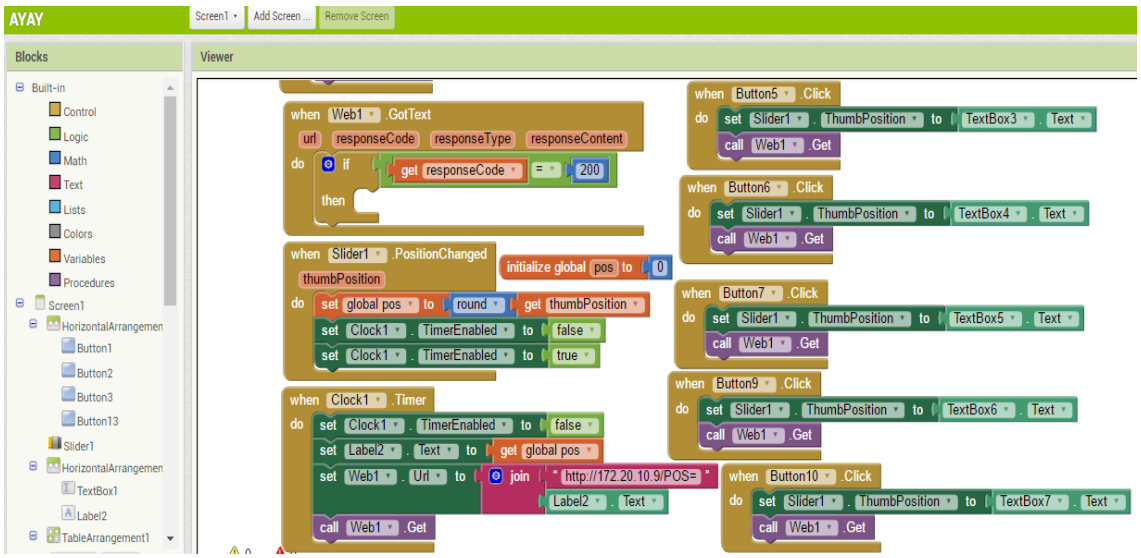

Figure 2.10: MIT App Inventor 2 Blocks Part 1

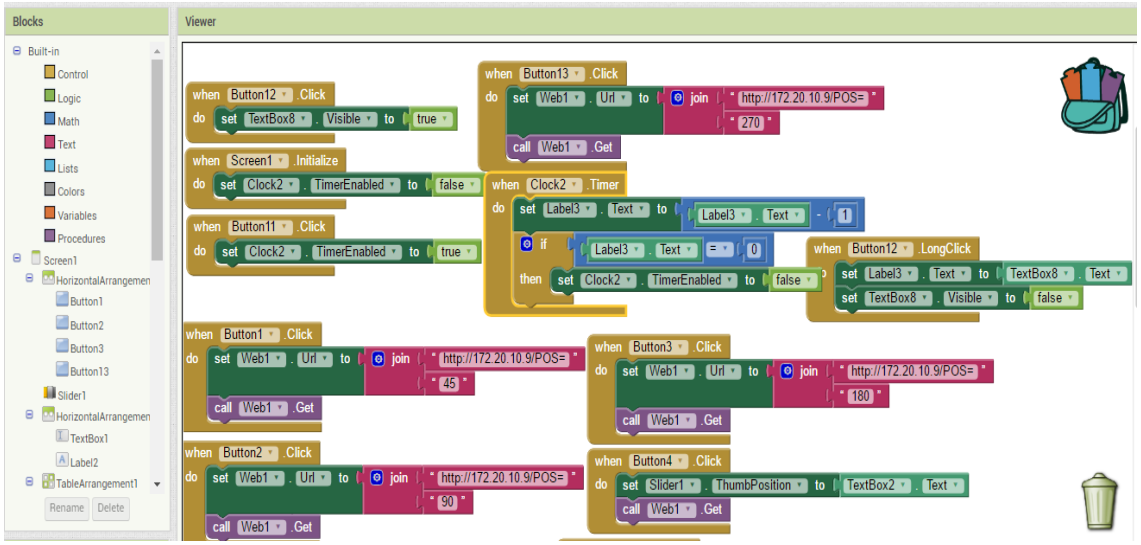

Figure 2.11: MIT App Inventor 2 Blocks Part 2

Value entered in the step number if the first position is entered and the start button is pressed and value entered in the step number if the second position is entered and the start button is pressed is shown (Figure 2.12).

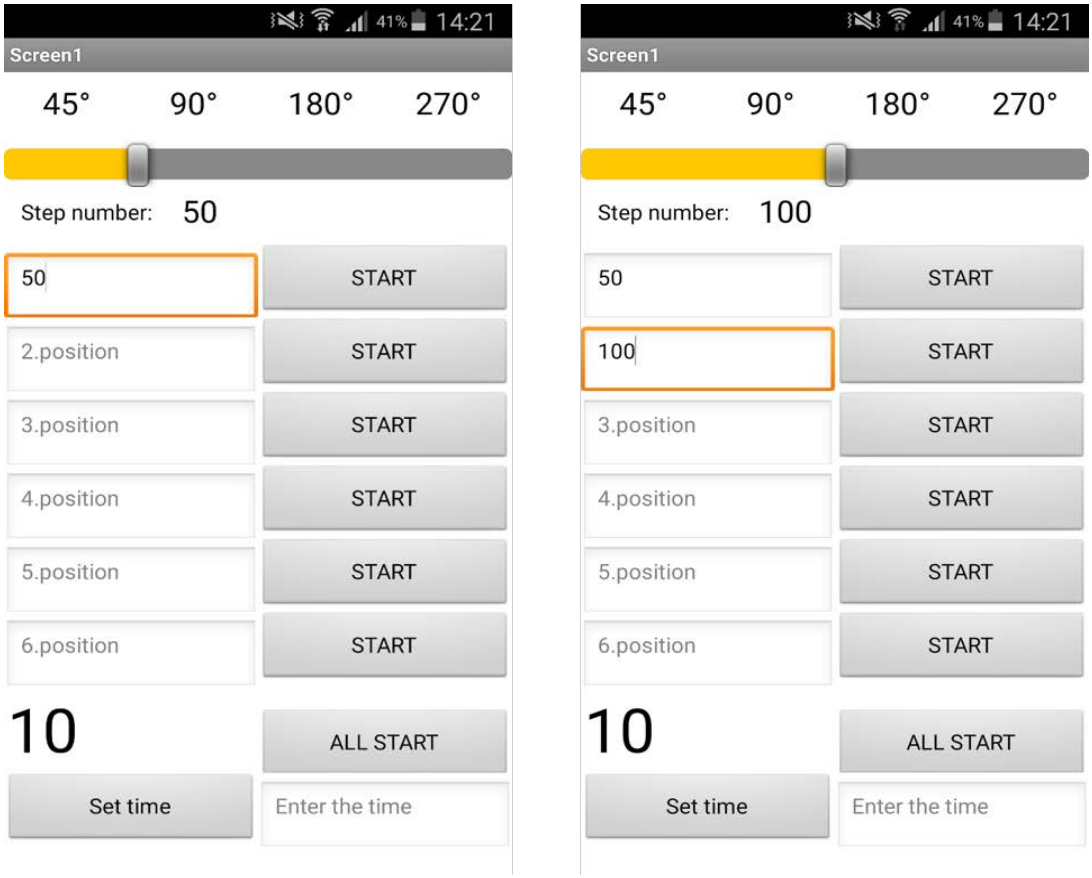

Figure 2.12: AYAY App Responses

For a more captivating look, a simple and lovely icon assign to the App. (Figure 2.13). After the future testing, the application will be published in Google Store.

Figure 2.13: AYAY App Icon

3. RESULTS

In this project, it is observed that movement the microphone with a stepper motor is an effective solution. Also, it is observed that it takes less time and effort to do so with this system than to manually determine the position of the microphone. After the project was designed, it has encountered a few problems until the last stage, but all problems was resolved. The project has become operational without any problems. It was a work that could be developed with new ideas in the future.

Thanks to the four-year engineering training, the electronic circuit software program has been optimally combined and designed, resulting in a positive way. In addition, with the problem-solving ability gained through engineering education, this project, which is not only based on electronics, has become easier than ever to overcome problems such as mechanical design, fund management and suitable material selection.

Figure 3.1: Mechanical work for Gear Pulleys

Figure 3.2: Mechanical work for connection of gear pulleys on the composite plate

Figure 3.3: Image from silent room

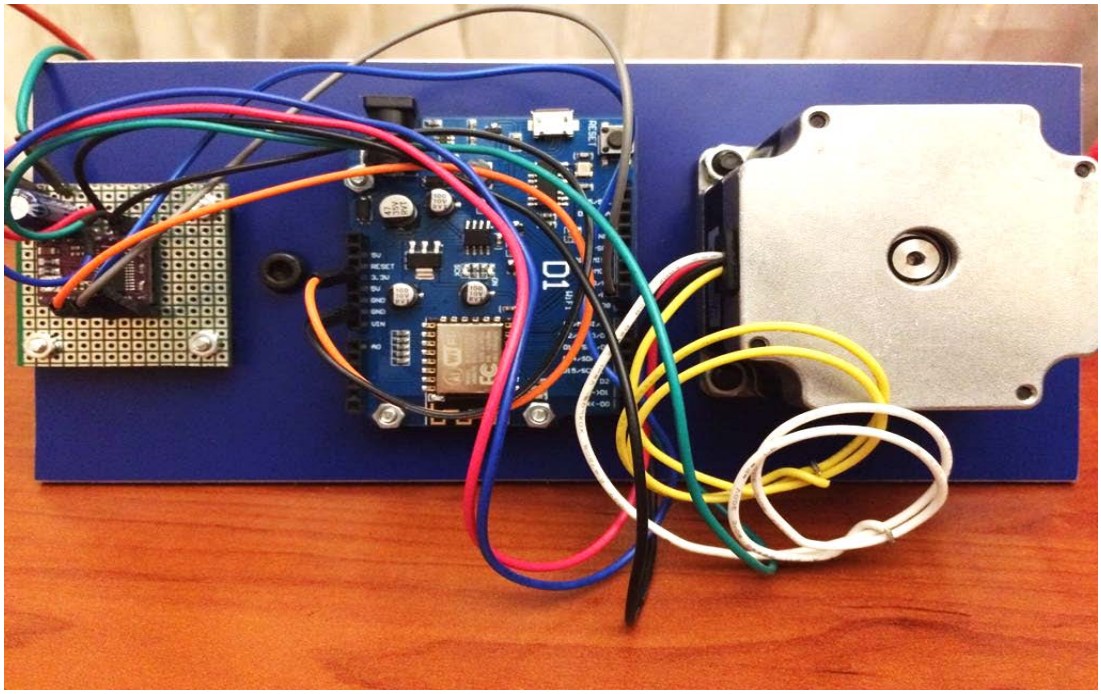

Figure 3.4: Mechanical work for connection of between WeMos, stepper motor and stepper motor driver on the composite plate

4. CONCLUSION

A 10$ Wi-Fi module based Arduino WeMos D1, 50$ powerful stepper motor and 3$ stepper motor driver can be good example of industrial automation system, with efficient coding and creative designing. This thesis work succeed to make easier for the microphone to go to the desired position without the need for human power, by inventing a system in which the user can move the microphone automatically. This system can also be used by anyone with the application.

Before starting the project, was was looking for some challenge and beneficial outcome from making an industrial automation system. After we developed the Android Application, we focused on a GUI which can change the Wi-Fi id and password without using any code for marketing my project, which is still in progress as a future improvement. Designing our Android Application project and industrial automation system is an inspiration for building more complex ones.

New ideas have made it possible to develop the project. One of them is to announce the answer to the operations performed by adding a voice command to the application. The other one is to observe the position of microphone vividly in the quiet room with the camera connected to the microphone.

5. REFERENCES

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6. APPENDICES

The codes can be found in our github pages: https://github.com/ayhanclskn/AYAY

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