Design System of Coffee Maker with Manual Brew Method and Coffee Sales Monitoring

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Abstract—**Pusat Data dan Sistem Informasi Pertanian Kementrian Pertanian claimed that in 2018 Indonesia coffee consumption has national increase of 2.49%. There is reflected by expantion of coffee shops. Menu that coffee shops offered is Manual Brew Coffee, brewed manually by the barista. If there is a lot of waiting line it will decrease barista performance to making orders. It supports the impact of income earned and get a reduction of customer satisfaction. Motivated by this, a Coffee Maker system that support to monitoring water volume, water temperature, monitor coffee sales to manage time spend for make a coffee also help barista for making a coffee. This system consists of ultrasonic sensor to monitor water stock and temperature sensor to monitor the water temperature. Application on android will display data in real time to user. Results of study obtained test value on temperature sensor with an average value difference of 0.069°C. Ultrasonic sensor test to calculate volume of water produces an error value of 1.2%. The whole system comparing the speed of making coffee between the coffee maker system and manual by barista, average time difference is 1 minute 58 seconds. The value is quite good because it does not exceed the tolerance limit of each sensor, namely ±0.5°C for the temperature sensor and 1cm for the ultrasonic sensor. The obtained value is not much different from the actual coffee dose, with a difference of 0.65gr not exceeding 1gr. The system works much faster than manual coffee brewing by the barista.**

Keywords— ***Coffee, Manual Brew, Microcontroller, Monitoring, Ultrasonic.***

I. INTRODUCTION

The Coffee Organization (ICO) said that in 2015 the increase in coffee consumers in Indonesia reached 8% compared to the world which was only 6%. In 2018, the number of national coffee consumers increased by 2.49% [1]. Meanwhile, according to the Center for Agricultural Data and Information Systems at the Ministry of Agriculture, it is estimated that coffee consumption in Indonesia will increase by an average of 8.22% per year [2]. Along with the number of culinary enthusiasts for coffee drinks, coffee shops began to appear scattered throughout Indonesia. They offer various types of coffee and one of the menus is Manual Brew Coffee. Brewing coffee manually takes a long time [3]. The accumulation of the number of orders will result in a lack of totality of baristas at work. Based on this, it is necessary to have an automatic machine that can help the barista work and monitor sales results by business owners. This system is expected to be able to make coffee with the same taste as manually brewing coffee quickly and efficiently [4], and can send information periodically through applications on Android.

In research [3] in 2020 using the Arduino microcontroller as well can make three menus based on the level of bitterness of coffee. This coffee brewing system is done automatically with arduino. This system consists of selecting a menu made on a smartphone, pouring water and stirring coffee. There are three menu options on the machine namely sweet coffee, regular coffee and bitter coffee with a predetermined dose. Pouring water is pumped using a DC water pump, after the water filled, the DC motor will stir the sugar, water and coffee. Based on this research testing of servo motors the average percentage of measurement error is ± 0.34 gr for coffee grounds. Then research [5] in 2020 uses the ESP8266 microcontroller and uses the web as a medium for monitoring the stock of materials such as sugar, coffee and water. This research [5] using LDR sensor components and LEDs that are used as detectors the presence of cups, stepper motors to create conveyors, servo motors are used as the opening and closing valves for coffee-making materials, sensors ultrasonic is useful for sending data to the server to find out the stock of materials available. The ultrasonic sensor were taken to find out the rest of the material available in the storage container as a reference. In this study, it was found that the percentage of measurement error was coffee as much as ±2 gr, sugar ±1 gr while the accuracy of the water measurement reaches 96.73%. Whereas research [6] in 2021 uses the Arduino microcontroller as a maker coffee with brewed coffee method. In this study will use ESP32 microcontroller because it is equipped with a Wi-Fi module as well has a number of GPIO pins more than ESP32 namely 32 pins for ESP32 and 17 pins for ESP8266 [7].

This system has an impact on business turnover and decreased customer satisfaction. Based on this, it is necessary to have an automatic machine [8] that can help the barista work and monitor sales results by business owners. This system is expected to be able to make coffee with the same taste as manually brewing coffee quickly and efficiently [4], and can send information periodically through applications on Android [9][10]. In the automatic coffee brewing system [11], there is a button available to start it for it to work. After that the sensor

[12] will work according to the program that was previously inputted on the ESP32 [13][14][15].

II. METHOD

A. System Block Diagram

Systematically, the system runs are made in the form of a block diagram shown in Fig. 1.

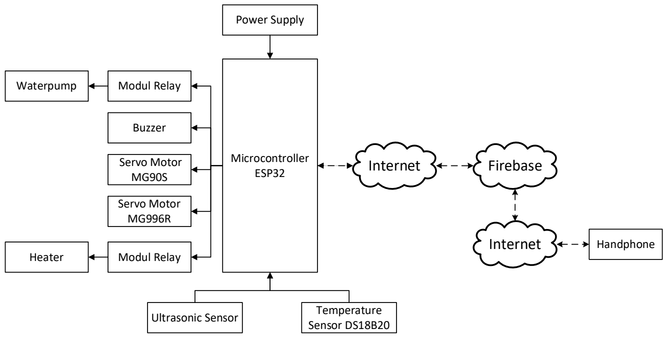

Figure 1. System Block Diagram

Heater is used to heat water. The heater will be activated by the relay module by plugging it into a power source when ESP32 gives a command. The DS18B20 temperature sensor is a sensor used to measure water temperature. After the DS18B20 temperature sensor shows the planned temperature, the water pump will pump water. The pump will be activated by the relay module by plugging into a power source when ESP32 gives a command. The second MG90S Servo Motor is used to turn the water faucet. The MG90S servo motor will rotate according to the command from the ESP32. The MG996R Servo Motor is used to rotate the spiral on the coffee grounds so that the coffee comes out according to the ESP32 command. ESP32 is a control center that controls the system that has been designed. Buzzer serves to signal that the system has not been connected to wifi, is heating the water or the system has finished working. The sound produced by the roots varies according to certain conditions. Ultrasonic sensor is a barrier sensor that functions to monitor the amount of water stock in the container. Internet as a connection that connects ESP32 with firebase which is used as a database. Mobile is useful for monitoring the system and receiving information from the database via an internet.

B. Mechanical Design

The design in Fig. 2 is a front view of the mechanical display that will be realized on the system. The box material used is multiplex wood so it is not too thick but still strong. The glass is placed on a scale to determine the amount of coffee that has fallen from the top of the container. The top of the glass is given a V60 as a coffee filter. The water taps which is rotated using a servo is placed parallel to the coffee container so as not to collide with each other so that the system continues to run properly. The ESP32 circuit is placed in the box so that the circuit is safe and the system looks neat which is located at the top of the display. The push button and buzzer are attached to the outside of the circuit box.

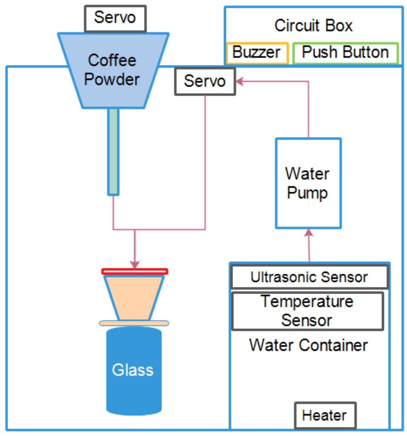

Figure 2. Overall Mechanical Design

C. Schematic Design

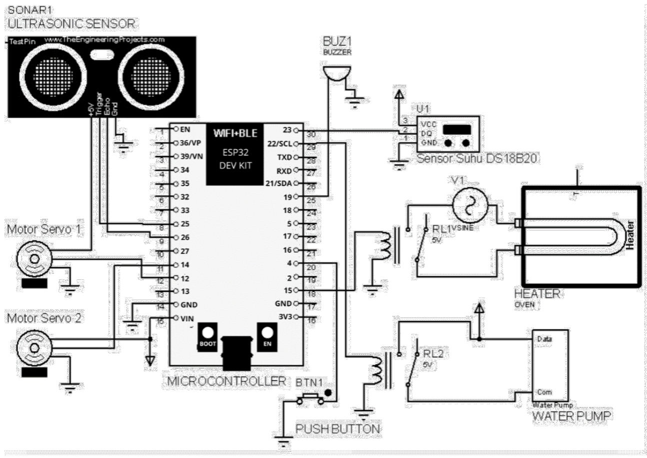

Figure 3. Schematic Design

Fig. 3 is a schematic design that will be implemented. ESP32 is the microcontroller, all of the sensor will connect to microcontroller as in Fig. 4. It contains of HCSR04 sensor, Servo Motor MG90S, Servo Motor MG996S, DS18B20 Sensor, Relay that connected to water pump and heater, buzzer and push button.

Fig. 4 shows the connected ESP32 microcontroller circuit with the HC-SR04 ultrasonic sensor. Pin connection between microcontroller with sensor can be seen in Table I.

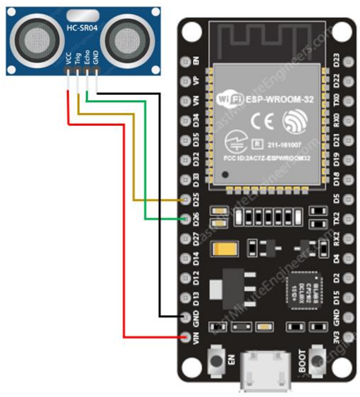

Figure 4. The ESP32 Pin Connection with The HCSR04 Ultrasonic Sensor

TABLE I
CONFIGURATION OF ESP32 AND HC-SR04

ESP32 Pin	HC-SR04 Pin	Colour
GND	GND	Black
VIN	VCC	Red
D25	Trig	Green
D26	Echo	Brown

Fig. 5 shows the connected ESP32 microcontroller circuit with the servo motors for tap water. Pin connection between microcontroller with servo can be seen in Table II.

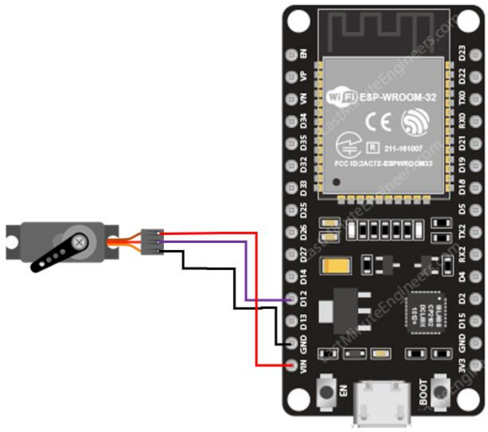

Figure 5. The ESP32 Pin Connection with Servo Motor for Tap Water

TABLE II
CONFIGURATION OF ESP32 AND SERVO MOTOR FOR TAP WATER

ESP32 Pin	Servo Pin	Colour
GND	GND	Black
VIN	VCC	Red
D12	PWM	Dark Purple

Fig. 6 shows the connected ESP32 microcontroller circuit with the servo motors for Coffee Powder Spiral Player. Pin connection between microcontroller with servo can be seen in Table III.

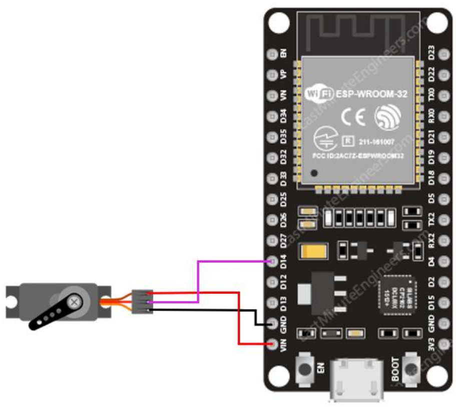

Figure 6. The ESP32 Pin Connection with Servo Motor for Coffee Powder Spiral Player

TABLE III
CONFIGURATION OF ESP32 AND SERVO MOTOR FOR COFFEE POWDER SPIRAL PLAYER

ESP32 Pin	Servo Pin	Colour
GND	GND	Black
VIN	VCC	Red
D14	PWM	Violet

Fig. 7 shows the connected ESP32 microcontroller circuit with the DS18B20 Temperature Sensor. Pin connection between microcontroller with DS18B20 Temperature Sensor can be seen in Table IV.

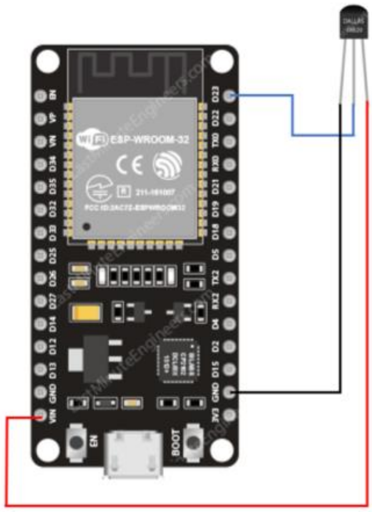

Figure 7. Connection between ESP32 Pin and DS18B20 Temperature Sensor

TABLE IV
CONFIGURATION OF ESP32 AND DS18B20 TEMPERATURE SENSOR

ESP32 Pin	DS18B20 Pin	Colour
GND	GND	Black
VIN	VCC	Red
D23	Data	Light Blue

Fig. 8 shows the connected ESP32 microcontroller circuit with the relay on DC pump. Pin connection between microcontroller with relay on DC pump can be seen in Table V.

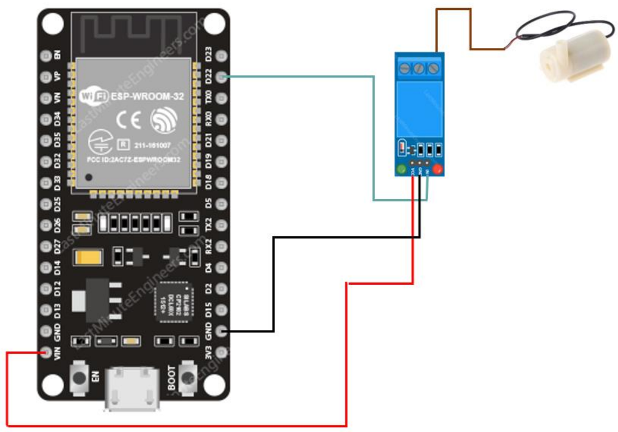

Figure 8. Connection between ESP32 Pin and relay on DC pump

TABLE V
CONFIGURATION OF ESP32 AND RELAY ON DC PUMP

ESP32 Pin	RELAY Pin	Colour
GND	GND	Black
VIN	VCC	Red
D22	In	Light Blue

Fig. 9 shows the connected ESP32 microcontroller circuit with the relay on heater. Pin connection between microcontroller with relay on heater can be seen in Table VI.

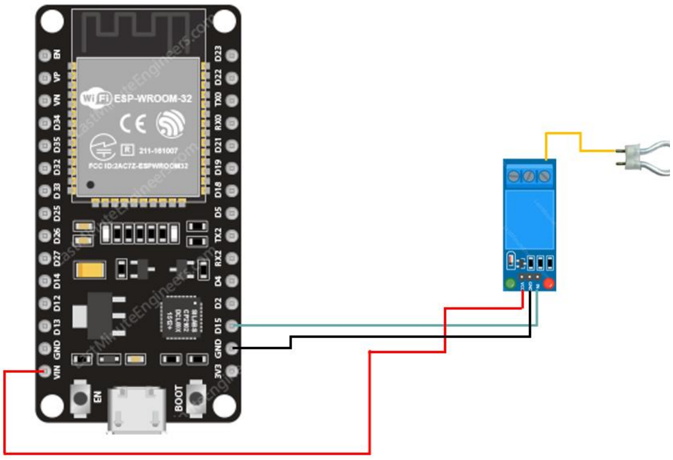

Figure 9. Connection between ESP32 Pin and relay on heater

TABLE VI
CONFIGURATION OF ESP32 AND RELAY ON HEATER

ESP32 Pin	RELAY Pin	Colour
GND	GND	Black
VIN	VCC	Red
D15	In	Tosca

Fig. 10 shows the connected ESP32 microcontroller circuit with buzzer. Pin connection between microcontroller with buzzer can be seen in Table VII.

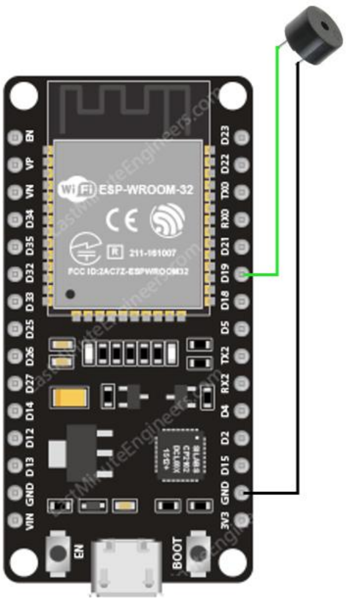

Figure 10. Connection between ESP32 Pin and buzzer

TABLE VII
CONFIGURATION OF ESP32 AND BUZZER

ESP32 Pin	RELAY Pin	Colour
GND	GND	Black
D19	In	Light Green

Fig. 11 shows the connected ESP32 microcontroller circuit with pushbutton. Pin connection between microcontroller with buzzer can be seen in Table VIII.

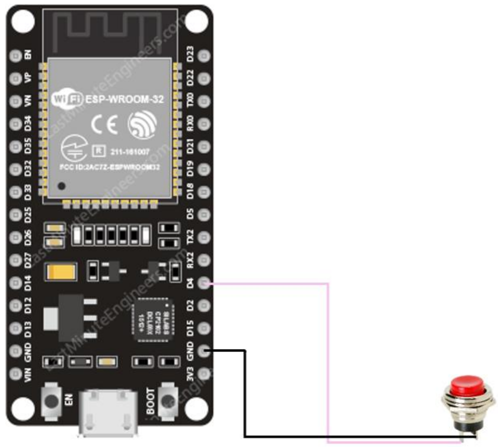

Figure 11, Connection between ESP32 Pin and pushbutton

TABLE VII
CONFIGURATION OF ESP32 AND PUSH BUTTON

ESP32 Pin	RELAY Pin	Colour
GND	GND	Black
D4	In	Pink

III. RESULT AND DISCUSSION

A. *Result of Product*

1) *Mechanical Implementation Result:* The box material used is multiplex wood so it is not too thick but still strong. With height of 45 cm, width 45 cm, and length of 50 cm, as shown in Fig. 12.

Figure 12. Mechanical Implementation Result

Figure 12 shows a front view of the mechanical design that will be realized for the system. The box material used is multiplex wood so it is not too thick but still strong. The glass is placed above scale to measure the amount of coffee that drops from the top chamber. The top of the glass is given a V60 as a coffee filter. Rotating water faucet using a servo placed parallel to the coffee container so that they are not mutually exclusive collide so that the system continues to run properly. ESP32 series placed on the box so that the circuit is safe and the system looks neat on the the top of the view. The push button and buzzer are attached to the outside of the box Suite.

2) *Hardware Implementation Result:* The Fig. 13 shows the contents of the access box which is an implementation of Fig. 3. All of the component is already connected to the microcontroller ESP32.

Figure 13. Hardware Implementation Result

3) *Software Implementation Result:* Figure 14 shows the main page of the android application. The temperature section shows the results of water temperature measurements displayed from the DS18B20 sensor in real time via firebase. Then water displays the results of the volume measured by the HCSR04 sensor in real time via firebase.

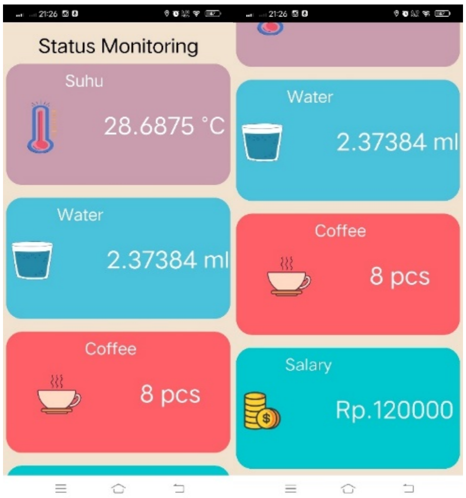

Figure 14. Software Implementation Result

Fig 14 shows a software implementation. An android application is used by users to obtain information from data measurement of water temperature, total volume of water in the container, the amount of coffee served has been made and the sales proceeds from the coffee sold. Users can monitor the information in real time. So that the user can monitor the information wherever and whenever the user has internet access. On the temperature section shows the results of the water temperature measurement displayed from the sensor DS18B20 in real time via firebase. Then water displays the results volume measured by the HCSR04 sensor in realtime via firebase. Meanwhile, the coffee section displays the results of the portion of coffee made and salary displays the income received from the number of copies sold.

B. *Calibration of Temperature Sensor Testing*

Fig. 15 shows the DS18B20 sensor is used to measure the temperature of the water that has been heated by the heating element. The testing process is carried out in a way compare the measurement results of the DS18B20 sensor with the measurement results digital food thermometer. Testing carried out in the normal water temperature range up to 95.44°C. The results of the hot water temperature readings can be calculated the error value and the average error using the Equation (1)(2)(3).

Figure 15. DS18B20 Temperature Sensor and Manual Testing

$$Error\ Value\ \% = \frac{Thermometer\ Value - Temperature\ Sensor\ Value}{Thermometer\ Value} \times 100\% \quad (1)$$

$$Average\ Error\ \% = \frac{Summation\ of\ error\ values\ \%}{Number\ of\ Test} \times 100\% \quad (2)$$

$$Average\ Difference\ Error\ \% = \frac{Summation\ of\ Difference\ Value\ \%}{Number\ of\ Test} \times 100\% \quad (3)$$

TABLE VIII
RESULT CALIBRATION OF TEMPERATURE SENSOR DS18B20

No	Temperature Sensor DS18B20 (°C)	Thermometer (°C)	± Difference (°C)	Error (%)
1	27.37	27.3	0.07	0.25
2	34.44	34.5	0.06	0.17
3	39.81	39.5	0.31	0.78
4	59.94	59.9	0.04	0.06
5	68.19	68.1	0.09	0.13
6	73.94	73.9	0.04	0.05
7	83.56	83.5	0.06	0.05
8	90.25	90.2	0.05	0.07
9	93.12	93.1	0.02	0.02
10	95.44	95.4	0.04	0.04
		Average	0.066	0.162

The measurement results are calculated using Celsius units. The average result of the difference produces an average value of 0.066. While the average error value shows a value of 0.162%. According to the datasheet of the DS18B20 the difference between the sensor values is ± 0.5. So based on this, the DS18B20 test is classified as accurate and good because the average error is not more than 0.5, as shown in Table VIII.

C. Water Volume Testing with Ultrasonic Sensor HCSR04

Figure 16. HCSR-04 Sensor and Manual Testing

TABLE IX
OVERALL SYSTEM TEST RESULT

No	Ultrasonic Sensor HCSR04 (ml)	Measuring (ml)	Error %
1	254.91	250	1.96 %
2	396.43	400	0.89 %
3	615.50	600	2.58 %
4	800.27	800	0.03 %
5	1010.45	1000	1.04 %
6	1317.98	1300	1.38 %
7	1612.56	1600	0.78 %
8	1713.45	1700	0.79 %
9	1831.02	1800	1.72 %
10	2032.64	2000	1.63 %
		Average	1.2 %

The average result of the test error on the volume using the ultrasonic sensor HCSR04 is 1.2%. This value can be said to be good because the value obtained is not much different from the measurement value using a measuring cup, as shown in Table IX and Fig. 16.

D. Testing the Amount of Water in Milli Liter

The result of the average error of testing the water dose in the first steeping is 3.3%. Then the second steeping produces an average error value of 0.6%. In the third brew, the average error value is 2.3%. Furthermore, the overall steeping produces an average error value of 2.12%. The overall average error value generated is 2.08% so that the result is not much different from the actual dose, as shown in Table X and Table XI.

TABLE X
RESULT TESTING BREWING 1 AND BREWING 2

No	Brewing 1			Brewing 2		
	Result (ml)	Original Dose (ml)	Error (%)	Result (ml)	Original Dose (ml)	Error (%)
1	7.5	7.5	0	50	50	0
2	8	7.5	6.6	50	50	0
3	8	7.5	6.6	50	50	0
4	7	7.5	6.6	50	50	0
5	7.5	7.5	0	50	50	0
6	8	7.5	6.6	50	50	0
7	7.5	7.5	0 %	50	50	0
8	7.5	7.5	0	47	50	6
9	7	7.5	6.6	50	50	0
10	7.5	7.5	0	50	50	0
	Average		3.3 %		Average	0.6 %

TABLE XI
RESULT TESTING BREWING 3 AND ALL OF BREWING

No	Brewing 3			All of brewing		
	Result (ml)	Original Dose (ml)	Error (%)	Result (ml)	Original Dose (ml)	Error (%)
1	100	100	0	255	250	2
2	105	100	5	260	250	4
3	105	100	5	258	250	5
4	100	100	0	255	250	3.2
5	100	100	0	250	250	0
6	100	100	0	250	250	0
7	100	100	0	250	250	0
8	95	100	5	245	250	5
9	100	100	0	245	250	2
10	100	100	0	250	250	0
	Average		1.5 %		Average	2.12 %

E. Coffee Dosing Test

TABLE XII
RESULT COFFEE DOSING TEST

No	Result (gr)	Original Dose (gr)	± Difference (gr)	Error (%)
1	14.4	15	0.6	4
2	15.4	15	0.4	2.6
3	14	15	1	2.58
4	16	15	1	6.6
5	13.9	15	1.1	7.3
6	15.6	15	0.6	4
7	14.8	15	0.2	1.33
8	14.3	15	0.7	4.66
9	15.7	15	0.7	4.66
10	15.2	15	0.2	1.63
		Average	0.65	3.93

The average result of the coffee dose test error resulted in 3.93%. This value can be said to be good because the value is not much different from the amount it should be shown in Table XII.

F. System Test

In testing the whole system, a comparison of the speed of making V60 coffee using a coffee maker system was carried out with manual V60 coffee making by a barista. The test was carried out using the same recipe and type of coffee, as shown in Table XIII.

TABLE XIII
RESULT OF SYSTEM TEST

No	System Test Result	Manual Test Result	Difference	Difference (second)
1	3 minute 40 second	5 minute 21 second	1 minute 41 second	101 second
2	3 minute 25 second	5 minute 50 second	2 minute 25 second	145 second
3	3 minute 44 second	5 minute 32 second	1 minute 48 second	108 second
Average			1 minute 58 second	118 second

Based on these tests, the difference is 1 minute 41 seconds or 101 seconds. So that making V60 coffee using a coffee maker system is faster than making manual V60 coffee by a barista. Because the barista needs to measure the ingredients first, while the coffee maker system can measure the ingredients automatically.

IV. CONCLUSION

The implementation of the ESP32 microcontroller to make coffee using the manual brew method and overall monitoring is in accordance with the function and is running well. Ultrasonic sensor and DS18B20 temperature sensor as inputs that provide information. Then the ESP32 microcontroller controls the components to operate according to the command. The system can monitor the water temperature and water volume, automatically heats the water and the dose used is close to the original recipe for making V60 manual coffee. The test results on the DS19B20 temperature sensor produce an average difference value of 0.066°C while the HCSR04 ultrasonic test produces an average difference value of 0.161 cm. Both values are classified as good because they do not exceed the tolerance limit of each sensor. The results for testing the coffee dose get an average error value of 3.93% and the water dose in the first brewing has an average error value of 3.3%, the second brewing 0.6%, the third brewing 2.3%, overall brewing 2.12%. Meanwhile, the measurement of water volume produces an average error value of 1.2%. Testing the whole system by comparing the speed of coffee making between the coffee maker system and the manual by the barista, the average time difference is 1 minute 58 seconds. So that the test results obtained values that are not much different from the actual coffee dose, and the system works faster than coffee making by a barista.

REFERENCES

[1] Pramelani. "Faktor Ketertarikan Minuman Kopi Kekinian Terhadap Minat Beli Konsumen Kalangan Muda," 2020. Jurnal Ilmiah Manajemen, vol. 15, no. 1, pp.121-129, April 2020.

[2] Fitriani, Utami Adita Evalina. Rahmat Nurcahyo. dan Dachyar M., "Karakteristik dan Strategi Perusahaan Rintisan : Perusahaan Rintisan Kedai Kopi Indonesia," 2019. Seminal dan Konferensi Nasional IDEC, pp.2-3, Surakarta, Mei 2019.

[3] Sihombing, Tionom R., "Rancang Bangun Mesin Pembuat Minuman Kopi Otomatis Dengan Tiga Varian Rasa Berbasis Arduino Dengan Kontrol Android," Universitas Sumatra Utara, Medan, 2020.

[4] Dermawan, Dedek. dan Porman Pangaribuan. "Desain Sistem Mekatronika Pendistribusian Gelas Pada Smart Coffe Maker Menggunakan Metode Finite State Machine," 2021. *e-Proceeding of Engineering,* vol. 8, no. 2, p.949, April 2021.

[5] Yunita, Fira. Porman Pangaribuan dan Willy Anugrah Cahyadi. "Smart Coffee Maker Berbasis Internet of Things," 2020. *e-Proceeding of Engineering,* vol. 7, no. 3, pp.8802-8809, Desember 2020.

[6] Tullah, Rahmat. Rudi Setiyanto dan Maghfaluti Mohamad Rizki. "Alat Penyeduh Kopi Tubruk Otomatis Berbasis Arduino," 2021. Jurnal SISFOTEK GLOBAL, vol. 11, no. 1, Maret 2021.

[7] Setiawan, Andi. dan Ade Irma Purnamasari. "Pengembangan Smart Home Dengan Microcontrollers ESP32 dan MC-38 Door Magnetic Switch Sensor Berbasis Internet of Things (IoT) Untuk Meningkatkan Deteksi Dini Keamanan Perumahan," 2019. Jurnal Resti (Rekayasa Sistem dan Teknologi Informasi), vol. 3, no. 3, pp.451-457, 2019.

[8] H. Kusumah and R. A. Pradana, "Penerapan Trainer Interfacing Mikrokontroler dan Internet of Things Berbasis ESP32 Pada Mata Kuliah Interfacing," CERIA, vol. V, no. 2, pp. 120-134, Agustus 2019.

[9] A. Maier, A. Sharp and Y. Vagapov, "Comparative Analysis and Practical Implementation of the ESP32 Microcontroller Module for the Internet of Things," 2017 Internet Technologies and Applications (ITA), pp. 143-148, 2017.

[10] A. A. Nur Rohman, R. Hidayat and F. R. Ramadhan, "Pemrogaraman Mesin Smart Bartender Menggunakan Software Arduino IDE Berbasis Microcontroller ATmega2560," Prosiding Seminar Nasional Teknik Elektro, vol. VI, pp. 14-21, 2021.

[11] S. K. D. B. a. K. I. R. S. Adarsh, "Performance Comparison of Infrared and Ultrasonic Sensors for Obstacles of Different Materials in Vehicle Robot Navigation Applications," IOP Publishing, Material Science and Engineering, vol. 149, 2016.

[12] M. A. Yani and E. Ridawati, "Pengaruh Perbedaan Ukuran Gilingan Terhadap Seduhan Kopi Arabika Batumirah Dengan Teknik Vietnam Drip," Jurnal Pangan dan Agroindustri, vol. X, no. 2, pp. 93-101, April 2022.

[13] K. Pradipta and K. Fibrianto, "Jurnal Review Perbedaan Air Seduh Terhadap Persepsi Multisensoris Kopi," Jurnal Pangan dan Agroindustri, vol. V, no. 1, pp. 85-91, Januari 2017

[14] A. M. A. K. Gunawan, I. N. Khairunnisa and M. K. Fais, "Paradoks Konsumsi Kopi Terhadap Risiki Kejadian Stroke: Sebuah Kajian Sistematis," SCRIPTA SCORE Scientific Medical Journal, vol. III, no. 3, pp. 51-60, Agustus 2021.

[15] R. A. M. Deval, R. Iskandar and H. Daniati, "Manual Brew House Blend Coklat Khas Indonesia," Jourism Scientific, vol. VI, no. 1, pp. 20-36, Desember 2020.